TOWARDS REFERENCE MODELLING OF MOBILE SCENARIOS IN THE WIRELESS WORLD

Xiaosong Zheng and Petri Pulli

Department of Information Processing Science, University of Oulu, FIN-90570 Oulu, Finland

Abstract: *Reference modelling is regarded as one of the fundamental approaches in many industries including telecommunications, software development, Manufacturing, aircraft and aerospace etc. It is particularly expressive and versatile also in modelling the specification of a complex mobile scenario. However, while the modelling of the static part of a mobile scenario results well suited and expressive, in the modelling of mobile scenarios there is a growing consensus on the fact that in the real world mobile scenarios are dynamic in nature and they are better represented with dynamic modelling. In this paper it first comes up with introduction of a reference model which forms the basis in Wireless Strategic Initiative (WSI) research project. The CyPhone system is then presented and it is followed by both static and dynamic reference modelling, which are drawn from CyPhone outdoor navigation scenario. The dynamic models explicitly portray several environmental objects, subsystems and events to describe a complete mobile service scenario. This paper contributes to the understanding of the generic reference model and static and dynamic reference modelling in the wireless world. This paper ends up with a conclusion and future work is outlined.*

Keywords: *reference, dynamic, modelling, mobile scenario, wireless world, cyberworld, CyPhone, communication*

1. INTRODUCTION

The latest work on reference modelling of the wireless world is reflected by Wireless Strategic Initiative (WSI) reference model [1, 2]. This model is based on Wireless World Research Forum (WWRF) service architecture for the wireless world which can be found in WWRF Book of Visions 2001 [8]. The WSI reference model (Fig. 1) consists of four basic building blocks namely *Cyberworld*, *Open Service Platform*, *Interconnectivity* and *Access*. It 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.

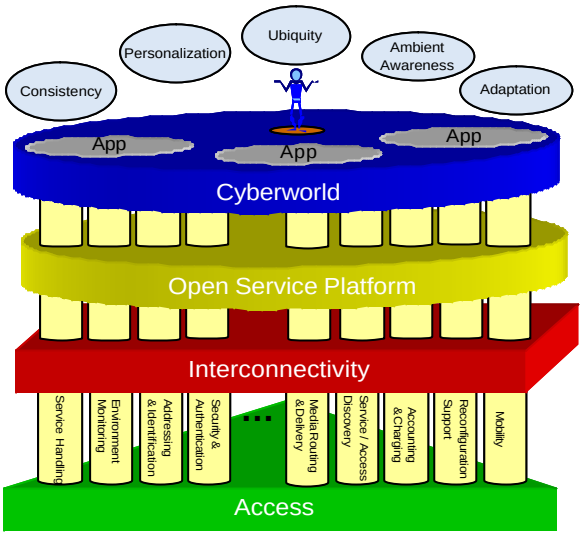

Fig. 1. WSI reference model for the wireless world

Following the reference model the communication element (CE) for the wireless world is defined which can be understood as the representation of a certain device or node in the wireless world as visualized in Fig. 2 [4, 5]. 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 Quality of Service (QoS) parameters and need to span all building blocks in order to provide true end-to-end QoS for end users.

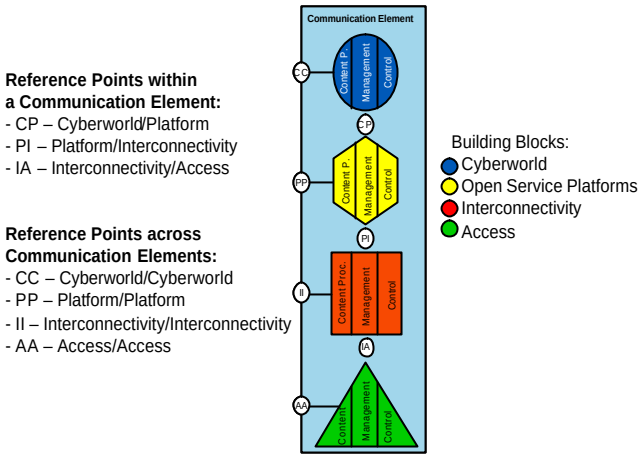

Fig. 2. Structure of Communication for the wireless world

1.1 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. 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:

- Those which provide an interface between different building blocks in one communication element.
- Those which "virtually" link equal building blocks of different CEs, thereby possibly spanning one or more spheres.

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.

1.2 Spheres of the Wireless World

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 introduce the spheres used in WSI project and they are *Personal Sphere*, *Local Sphere* and *Global Sphere* (Fig. 3).

It must be emphasized that this three-sphere classification is quite general in nature. However it captures the essential distinctions between different communication spheres. Yet further work is to be done with regard to the clear definitions of features and functionalities within each communication sphere.

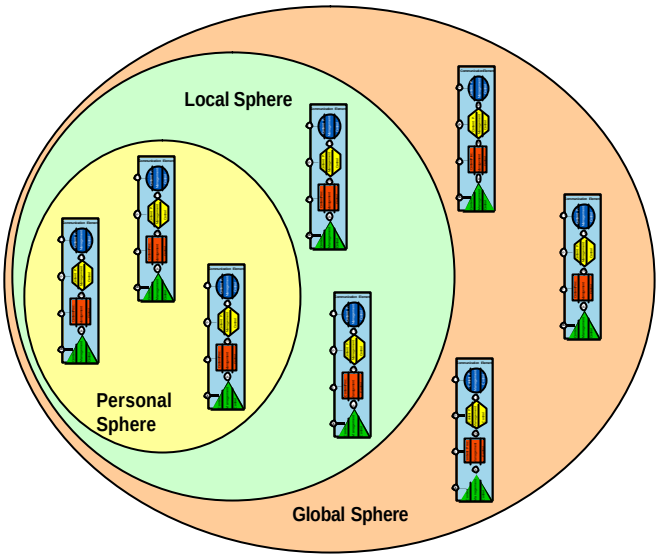

Fig. 3. Sphere definition for the wireless world

2. REFERENCE MODELLING FOR CYPHONE NAVIGATION

In order to illustrate the reference modelling procedure of mobile scenarios in the wireless world the CyPhone outdoor navigation case is used here. The CyPhone is a small sized combination of a digital stereo camera, a notepad computer and a cellular phone [6]. The CyPhone network is backboned by the picocellular technologies that allowing transmission of high bandwidth of data. The CyPhone framework can be used as a platform for some promising mobile services that can be classified as annotation services, telepresence services and monitoring and maintenance etc. (Fig. 4 & 5).

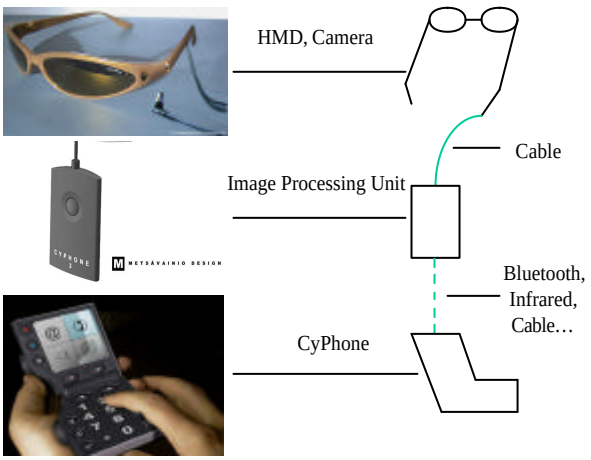

Fig. 4. Introduction of CyPhone framework

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.

Fig. 5. Introduction of CyPhone services

The proposed reference modelling procedure is demonstrated in Fig. 6. It models the CyPhone outside navigation scenario which is from the CyPhone project [7]. It starts from the initial informal model, followed by the sphere model drawn on the informal model. Communication elements with linkages are then added into the sphere model. After this the informal model is removed which results in a clear reference model with only 3 spheres, communication elements and linkages. A trial has been made to look into the communication element and reference points details with this CyPhone example. Internal dynamic modelling and peer to peer (P2P) dynamic modelling are two different examples to give a micro and macro perspective respectively in modelling user scenarios.

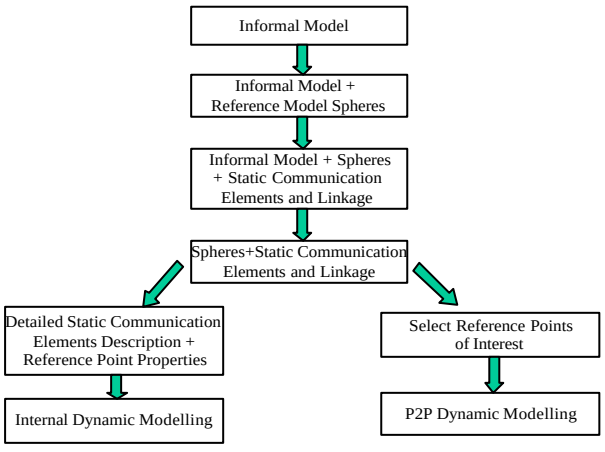

Fig. 6. Reference modelling procedure for mobile scenarios in the wireless world

Fig. 7 to Fig. 14 shows the reference modelling procedure in Fig. 6 step by step by using CyPhone scenarios, which, as a result, are better understood by both service providers and end users.

Fig. 7 is the initial CyPhone navigation layout model which identifies a number of essential scenario components including navigation service elements and enabling technologies. In this example there are two navigation scenarios: indoor navigation for a printer and outdoor navigation for a hotel. The indoor navigation scenario is to find a printer inside the airport when a user arrives in a foreign city. The outdoor navigation scenario is about finding a suitable hotel when the user is in a taxi leaving the airport for downtown.

Fig. 8 then further classifies these scenario components into the three spheres. The *Personal Sphere* includes the user and the printer. The *Local Sphere* consists of the indoor navigation elements and enabling technologies and in our example they are *wireless LAN, VRE-server, indoor orientation and positioning system, bluetooth technology* etc. The most out sphere is *Global Sphere* and the outdoor navigation elements and enabling technologies reside in this sphere. These include *the hotel, GPS system, base stations, UMTS technology, geographical information system* etc. By using the three spheres different navigation communication contexts are clearly described with the user in the centre of spheres, demonstrating the user-centric approach in the wireless world research.

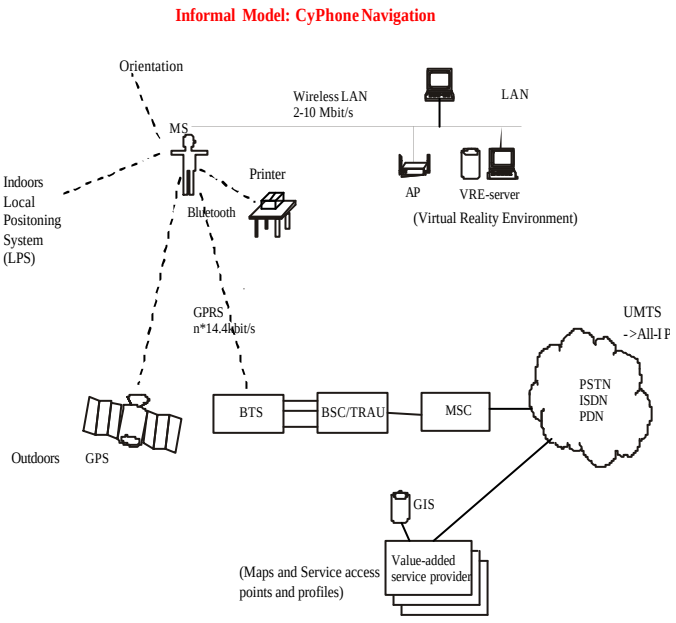

Fig. 7. Informal model of CyPhone navigation

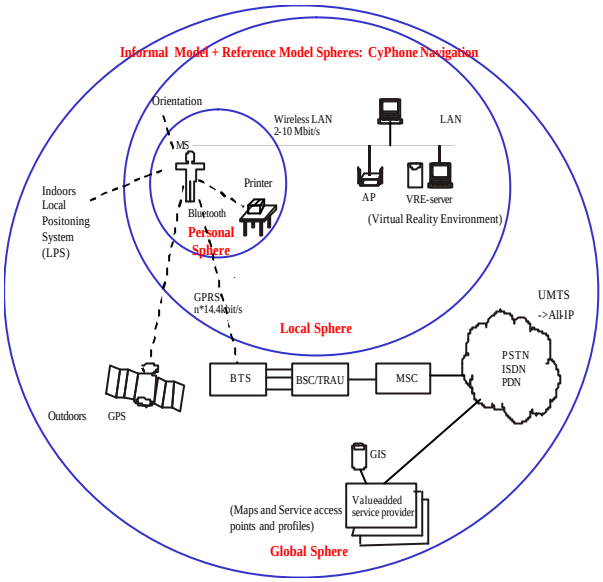

Fig. 8. Informal model with spheres: CyPhone navigation

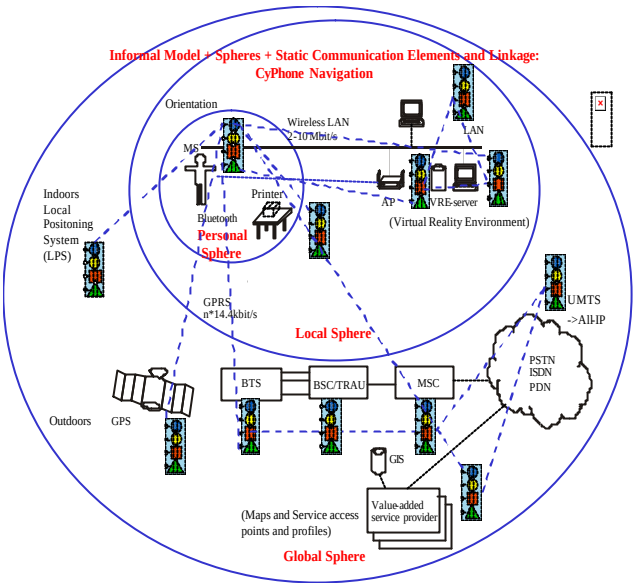

Fig. 9. Informal model with spheres, static communication element and linkage: CyPhone navigation

In Fig. 9 the *Communication Elements* are added into the sphere model. Each of the scenario components is represented by a communication element besides it. Within every communication element there are four building blocks i.e. *Cyberworld*, *Open Service Platform*, *Interconnectivity* and *Access* which represent four different building blocks in the wireless world. These building blocks represent different functionalities of mobile services in the wireless world. A scenario component primarily offers one of the four functionalities, thus the corresponding communication element is connected to another one through its functionality building block.

In Fig. 9 all of the scenario component communications are indicated through proper linkages among communication elements. The interesting thing here is that every component in the scenario can be represented by the same communication element with different functionality from within the communication element. In order to clearly show the navigation communication picture all of scenario components are removed with only spheres, communication elements and their linkages left (see Fig. 10). The resulted model emphasizes the functionality of every scenario component in the wireless world, which is reflected through linkages to and from its communication element's functionality building block.

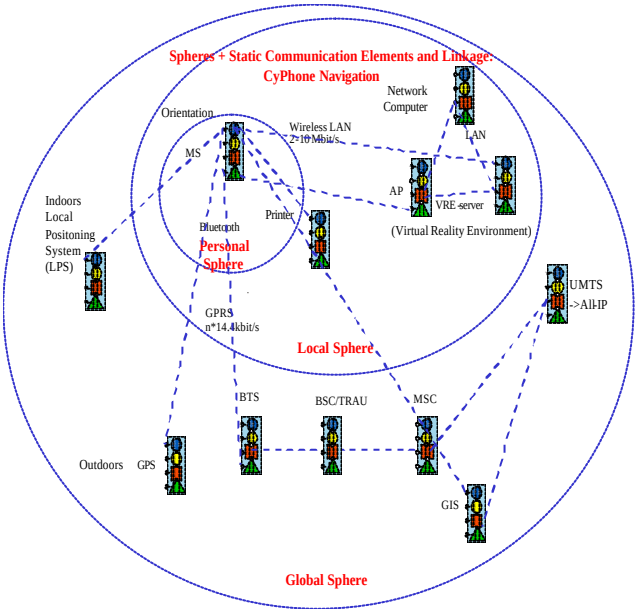

Fig. 10. Spheres with static communication element and linkage: CyPhone navigation

Fig. 11 deals with the reference points in and between communication elements. Fig. 11 is an example to look into reference points associated with *Cyberworld* building block. *CC* means the *Cyberworld-Cyberworld* reference point between two communication elements. *CP* means the *Cyberworld-Open Service Platform* reference point within a communication element. In Fig. 11 a number of functionality properties for reference points *CC*, *CP* and *Cyberworld* building block are listed which are drawn from CyPhone navigation scenarios.

These properties may vary in different wireless communication cases.

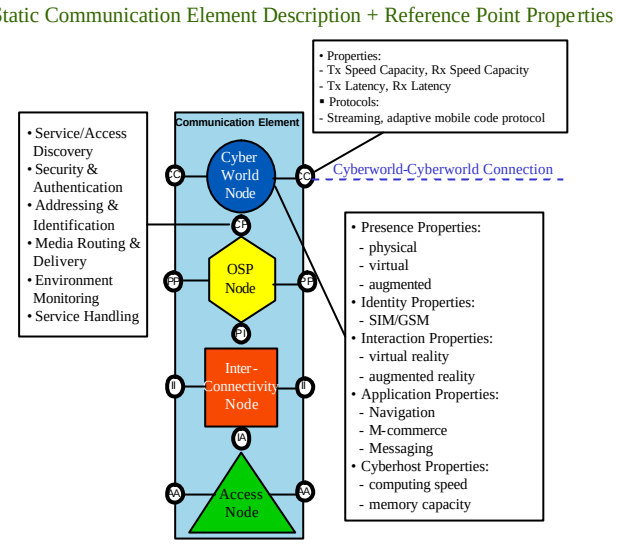

Fig. 11. Static communication element description with reference point properties

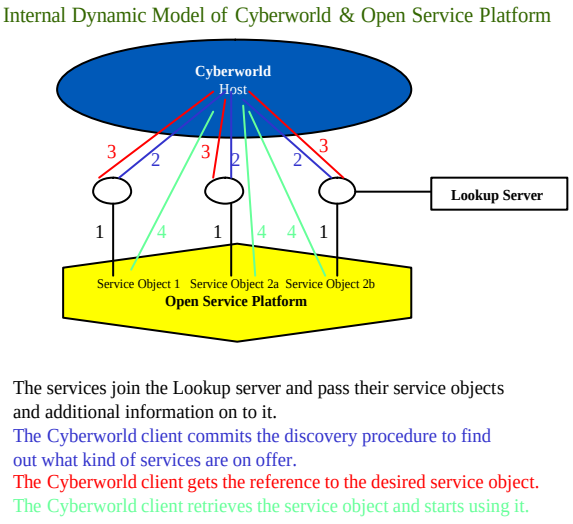

Fig. 12. Internal dynamic model of Cyberworld and Open Service Platform

Fig. 12 is an example of internal dynamic modelling between two building blocks *Cyberworld* and *Open Service Platform.* It describes the dynamic communications between the two building blocks for service discovery. In Fig. 12 services reside in *Open Service Platform* in the form of various service objects. Lookup servers act as the reference points between the two building blocks. The services first join the Lookup servers and pass their service objects and additional information onto Lookup servers. Then the *Cyberworld* client commits the service discovery procedure to find out what kind of services are on offer. After communicate with Lookup servers the *Cyberworld* client gets the reference to the desired service objects and it then retrieves the service objects and starts using them. The internal dynamic model gives a micro dynamic view within a communication element for wireless services and applications.

Fig. 13 and 14 illustrate the peer to peer (P2P) dynamic modelling procedure. It starts with selecting the reference points of interest for modelling. In Fig. 13 six reference points are identified for indoor and outdoor navigation modelling and they are User (CyPhone), Local Positioning System (LPS), Global Positioning System (GPS), Virtual Reality Environment (VRE) server, Geographical Information System (GIS) server and the Printer.

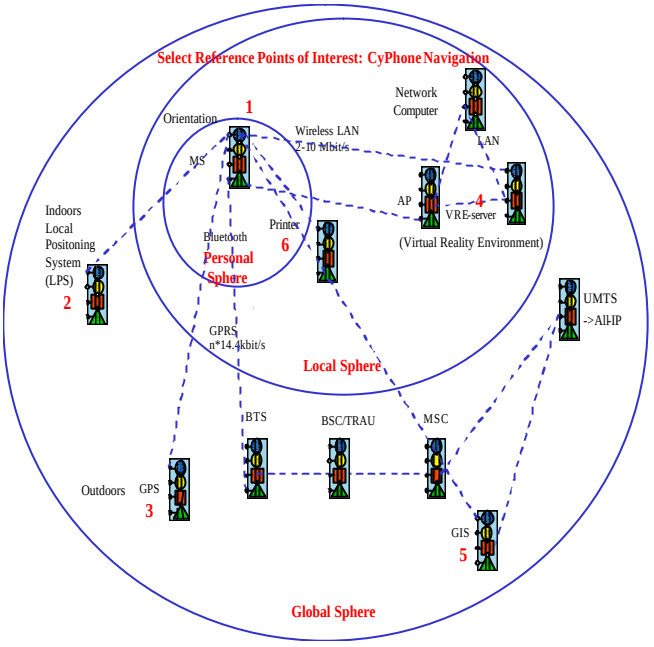

Fig. 13. Selected reference points of interest: CyPhone navigation

In Fig. 14 we use Message Sequence Chart which is an efficient method to model dynamic real time systems [3]. Fig. 14 is the final model of peer to peer dynamic modelling of CyPhone indoor navigation for the printer and outdoor navigation for the hotel. Reading the model is easy. The user first powers on the CyPhone and it will automatically establish global positions by activating the global GPS. The local positioning system is then launched for specific mobile services. The local positioning data are displayed through the CyPhone. Now the CyPhone system is ready for navigation services. Following the command “guide to printer”, the CyPhone system will enable VRE

capability. A request is sent to the VRE server for direction to the printer and the feedback is displayed through CyPhone Augmented Reality (AR) system. This request and feedback process is carried out regularly at a predefined rate. When the user is close enough to the printer the document data are sent to the printer for printing. When the user finally reaches the printer the demanded documents are ready to pick up. The outdoor navigation for the hotel has the similar dynamic communication process by using the GIS system. The peer to peer dynamic model gives a system perspective of reference modelling, hence, it is helpful in analyzing and understanding wireless and mobile communications at a system level.

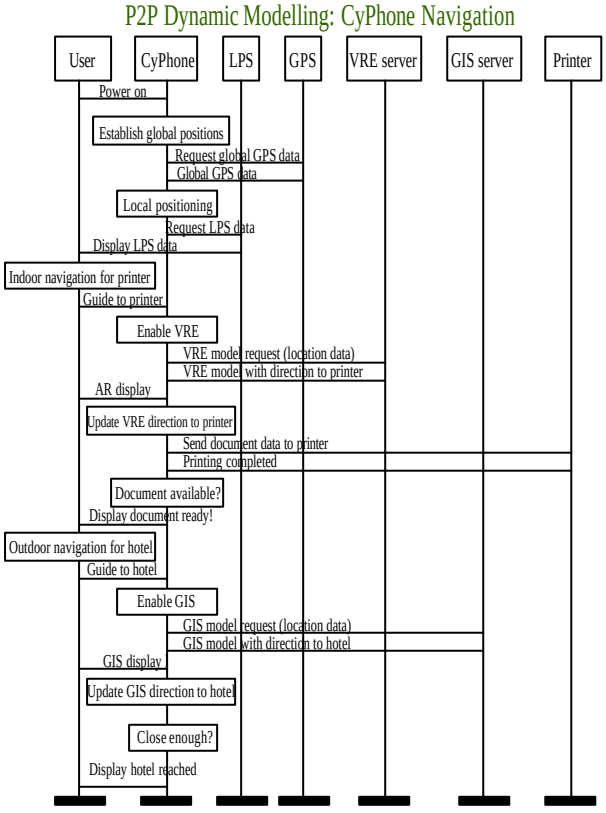

Fig. 14. Peer-to-peer dynamic modeling: CyPhone navigation

3. CONCLUSION

In this paper the challenging task for reference modelling of the CyPhone outdoor navigation scenario has been achieved successfully. The static reference model as well as the dynamic internal model and dynamic peer to peer model have been established. The dynamic reference models expressively describe the interaction among communicating entities over time. Static and dynamic models are complementary in a way that could be used to give a comprehensive view of mobile scenarios for design and development purpose. The dynamic reference modelling approach is being increasingly used in research in diverse areas. The unique characteristic of this approach is its ability to represent the real dynamic world, thus justification its role in modelling community.

4. FUTURE WORK

In the near future a well-defined generic reference model is expected to specify the basic components and their interrelationships in the wireless world. This model should be concise while expressive in defining the future wireless systems. A number of key issues in reference modelling need to be addressed are:

- A formal description of the semantics of the reference points.
- Methodologies to define communications via the reference points.
- Refinement/sub modelling of the grand building blocks of the reference model.
- Methodologies to dynamically model key applications for systems beyond 3G in the wireless world.
- More details of possible business models.

The established reference model is targeted to provide a basis for mobile scenario modelling, analysis and development in the wireless world. The reference model will be applied on modelling some future mobile scenarios for wireless systems beyond 3G to demonstrate and get a better understanding of key applications in the wireless world.

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