Mobile services over short range communication

Jens Kammann, Thomas Strang, Kai Wendlandt

***Abstract*—This paper highlights issues of migrating from mobile internet access towards a distributed service platform. Starting with an analysis of different bearer services the paper surveys integration aspects of location and situation aware services on programmable mobile devices, based on a typical scenario.**

***Keywords*—Bluetooth, Location dependent and situation aware services, Wireless Networks, Java phones**

I. Introduction

Upcoming mobile devices capable of using multiple access networks require new approaches to build up distributed computing networks. It is a challenge to provide seamless and interesting services with these heterogeneous infrastructures. Therefore we analyze different access networks and focus on short range communication based on Bluetooth. On the basis of a typical scenario we have done some research on selected aspects of services in mobile networks. The concept of services becomes especially interesting in conjunction with Java equipped smart phones. Research revealed the necessity of a framework managing content and dynamic adaptation to changing network conditions.

II. Methods of mobile Internet Access

Internet access networks can be grouped into wired and wireless with wireless being further divided into fixed wireless, wireless LAN and Public Land Mobile Networks. Due to the focus of this paper on mobile services, only the latter two will be discussed:

A. Public Land Mobile Networks (PLMN)

Circuit switched networks establish data links by a system-dependent link between the mobile user and the mobile switching center (MSC) (e.g. using Radio Link Protocol (RLP) in GSM) and a standard data link between the MSC and the service provider. This can be either modem links according to V.32 or ISDN links according to V.110 (bit rate adaptation). Channel bundling can be used to increase throughput (HSCSD).

Packet switched networks like GPRS are characterized by an 'always-on' connection, i.e. if using IP, the mobile device is assigned an IP address once the connection is being established, but the radio resource is only used when payload data is transmitted. Crossover to data networks like the Internet or X.25 is usually provided by the network operator and services are accessed via the public data network.

All Authors: Institute for Communications and Navigation; German Aerospace Center (DLR); P.O. Box 1116; D-82230 Wessling, Germany (fax: +49 8153 28 1442, e-mail: <firstname>.<lastname>@dlr.de)

Third Generation Mobile Networks (UMTS): The current second generation of mobile networks have been developed mainly for voice communication and data transfer at low speed (<100 kBit/s). Future UMTS networks have been specified with data applications in mind and provide packet switched communication of up to 2 Mbit/s indoors and 384 kbit/s outdoors with efficient spectrum use.

B. Short Range Wireless

Today's most common access is via Wireless LAN, either according to IEEE802.11 or HiperLAN. Both standards have developed during the past years and offer high speed data transfer up to 11 Mbit/s in the 2.4 GHz ISM frequency band. However, wireless LAN is still expensive and resource demanding which limits its use mainly to portable computers. A couple of other industry standards like Home RF or DECT MMC is suited for data transfer as well, but their proprietary nature prevent their use in a public access scenario. A new standard - Bluetooth - stands a good chance of becoming widely spread within all kinds of mobile devices such as PDAs, smart phones and mobile computers, due to its low cost.

III. Bluetooth

The Bluetooth technology was primarily designed for replacing cables between electronic devices such as computers, printers, digital cameras etc. It uses the license free ISM frequency band at 2.4 GHz and provides data rates up to 723 kbit/s per cell.

Bluetooth devices use different power classes: 0 dBm with a range of aprox. 10 m and 20 dBm to provide wider coverage up to 100 m. Due to the limited range, upcoming mobile services based on Bluetooth have to take into account that the user is not always connected with its receiver. Consequently, there is a need for an architecture to handle these limitations as described later in this paper.

Recently, the first mobile devices (e.g. mobile phones and PDAs) with integrated Bluetooth modules have been introduced. Their wireless technology is used to transfer any kind of data onto the device. Also mobile access to the Internet and other services are possible with appropriate access points.

A. Bluetooth Profiles

Profiles are used to match interfaces between devices. They are defined by the Bluetooth Special Interest Group (SIG) [1]. All of the supported profiles are negotiated using the Service Discovery Protocol (SDP). Depending on the number of profiles supported by each device and the total number of involved devices, this service discovery procedure may take very long.

Profiles for network access (see figure 1):

- *Serial Port Profile*
  Enables a transparent serial connection based on RFCOMM, the serial port emulation of Bluetooth.
- *Dial-up Networking Profile (DUN)*
  The DUN profile uses PPP over a virtual modem linked to RFCOMM. This profile is implemented in most of today's available devices. It establishes a point-to-point link on an already established link based on RFCOMM.
- *LAN Access Profile (LAN)*
  The LAN profile is similar to DUN profile with exception of the absence of the modem emulation.

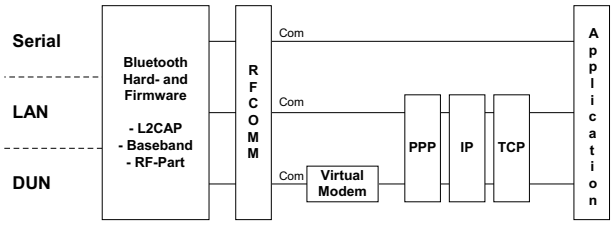

Fig. 1. Different access profiles a client can use.

Clients such as desktop PCs and handhelds mostly use the Point-to-Point Protocol (PPP) to connect to the Internet. The user may authenticate himself for accounting purpose. This procedure takes between three to six seconds, dependent on the type of wireless access network. Then, the device gets an IP address assigned and can start using TCP/IP over PPP.

The DUN profile is the most common profile used in today's user devices although this PPP connection is actually dispensable for plain data exchange of e.g. XML encoded files. This is because of the fact that the Bluetooth link already has built-in features for encryption and authentication and the Serial Port Profile already provides a point-to-point connection between applications. According to this, the Serial Port Profile offers a faster link establishment together with a higher throughput without the overhead of PPP and IP.

B. Type of Connection

Bluetooth provides an ad-hoc master-slave cell based topology called piconets. Two types of connections between the devices are defined:

- *Point-to-Point Mode* – Direct connection between two devices which is for exclusive use between these devices (replacement of IrDA and other serial links)
- *Point-to-Multipoint Mode* – One device acts as master of a piconet. Up to 7 clients with active links can be served simultaneously and more than 200 clients in park-mode can be attached to one master. This mode was designed for communication of a host and its nearby peripherals.

There is no mode for data broadcast, although this would be highly desirable for the scenario described in the next chapter. So far, the master always has to establish a separate connection to each slave.

IV. Scenario

We assume a scenario of a mobile user accessing services within a heterogeneous network. The user is equipped with a smart phone capable of establishing data links via Bluetooth in high frequented places or the Public Land Mobile Networks outside the coverage area of short range communication. In contrast to standard cell phones, a smart phone is capable of executing platform independent JAVA programs which can get downloaded via the air interface. Heywow [2] specifies a platform for an intelligent exchange of these programs which provide various m-commerce related services such as interactive travel planning with real-time updates to the user. Network access and handover happens transparent to the user but affects the capability of the services. Unlike current WAP services, offline operation is supported by interaction with the local JAVA application.

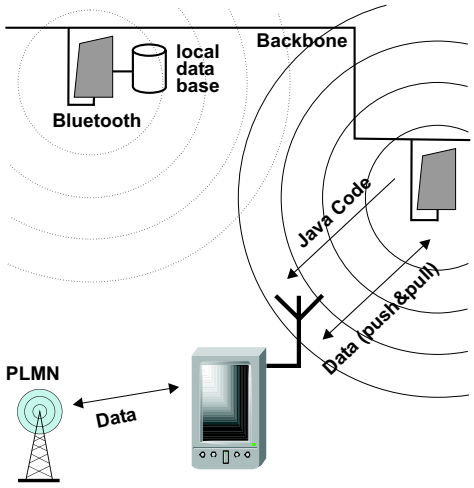

Fig. 2. Scenario.

V. Applications and Services in Mobile Networks

Applications on mobile devices such as cellphones and PDAs are somewhat different from standard client-server applications. They have to deal with temporary, bandwidth limited wireless network connections. The design of this kind of application is always influenced by the restricted capabilities of the user's device regarding processing power, memory consumption, limited or no persistent storage etc.

While this sounds like very restrictive, it is also an opportunity to use the different characteristics of the different types of wireless networks to combine sources of position information to build up location dependent services. It also should be kept in mind that PDAs and cellphones are highly personalized devices, which have much "knowledge" about the user (personal address book, priority settings for different phonebook entries etc.). Such knowledge can be used to create services which base on the current personal situation of the user, so called situation aware services.

A. Location Dependent Services

One focus of Heywow is the integration of position information from various sources, such as satellite navigation systems,

wireless positioning technologies, inherent position information resulting from short-range communication devices (local service points), indoor navigation systems or user input. These sources deliver position information at different level of accuracy. Each system varies also in terms of coverage and availability. By integrating them in a harmonized way as described in [3] as a base service of the platform itself, a wide variety of location dependent services can be offered by using such position information. Examples of those services are carrier independent route planning, realtime traffic schedules, restaurant guides, etc. up to mobile reservation and shopping services (M-commerce) [4]. The introduction of a new service using position data by third parties is specifically very easy when using a positioning service already integrated in the platform. Services can be offered to the mobile user with regard to the local relevance of the service itself (e.g. when using a restaurant service, you may see only a few attributes such as "Italian food" when walking around in a city, but getting the full menu when you enter the nearby area of the restaurant).

B. Situation Aware Services

As a PDA or mobile phone already has access to personal data of the user, a service framework on the device may collect, evaluate and use this kind of information to provide better services for the user. The framework may preselect services and data according to the current situation, so the user is only required to make decisions on the subset of all the available options.

This becomes clear with a small example: Imagine a traveller being notified of a major delay of his flight, which has been previously booked with his PDA. At the same time his device is able to suggest an alternative starting time for a planned train trip to the airport. Because the device "knows" of the updated flight time, it may suggest a starting time for the train which fits the requirements to reach the flight with a comfortable buffer. The user is not required to enter individual route, date and time information, the device is able to adapt this from its knowledge about the current situation.

VI. Mobile Networking with Java equipped Devices

Mobile networking with cellphones today means in most cases mobile Internet access by using technologies like WAP over GSM or GPRS. Short range communication via Bluetooth or IrDA is used to exchange small amounts of data such as vCards between two customer devices. PDAs are restricted to local computing if not attached to a cellphone due to their lack of integrated communication facilities. This class of devices receive a totally new quality through the introduction of Java on the phone or PDA. The creators of Java took the limited resources and processing power and other restrictions of that class of devices into account by splitting up Java in different editions for different types of devices to host the Java Virtual Machine (VM). Java2 Micro Edition (J2ME) is specifically designed for the target group of PDAs and cellphones (see figure 3).

With Java the devices become programmable by the user, the manufacturer and also third parties.

Even if programmability is a huge improvement, the distributed network computing by using all different kinds of available bearer services like GSM, GPRS, SMS, Bluetooth etc. is an even greater

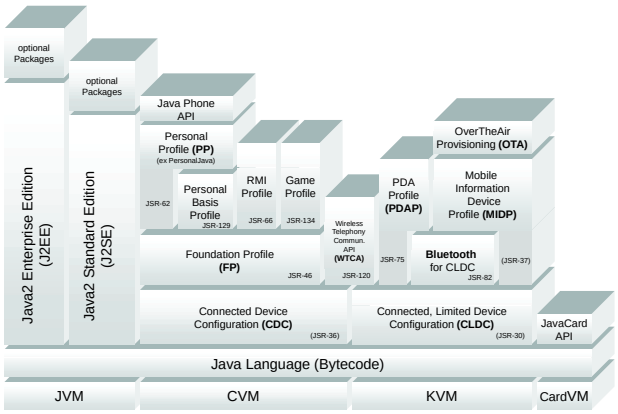

Fig. 3. Java2 Family Tree.

advantage. All applications have access to any other service in a backbone network when connected through one of the bearer services, and must be able to do their (may be restricted) work in a self-governed way in times without connection. That makes the approach very different in comparison to other applications like WAP. For instance, a traveller may enter the minutes of the delay for his flight, and the phone is able to calculate new train departure times to reach the flight on time due to the stored data on the phone even without any network connection.

Wireless networks differ from wired networks in various ways, e.g. concerning reliability and throughput. Thus, existing Java network libraries will have to be adapted to these conditions, and this has not been completed in any case for J2ME so far, like the Bluetooth access from the VM. Some useful assumptions as well as a proprietary implementation has to be done in parallel to the standardization work of the according JSR [5] group, if some aspects of the scenario have to be evaluated today. As example, we presented in [6] a way of accessing Bluetooth out of Java, mainly to have a reference for comprehensible evaluation measurements within an emulation testbed. We used this as a proof of concept of three different states a connection between a wireless information device (WID) and a local service point (LSP, short range communication equipment) or global service point (GSP, wide range communication equipment) may have (see figure 4).

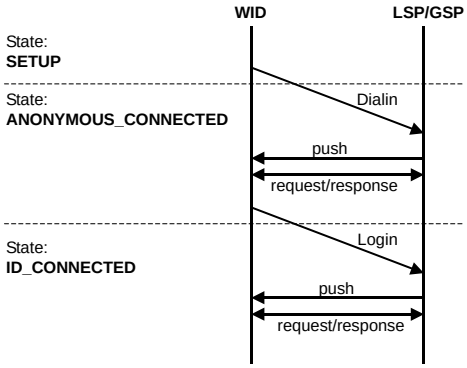

Fig. 4. Connection States.

In the *setup* state, the WID is looking for possible peers, no connection peer is available, and only local processing is possible. When approaching coverage area of a short range communication peer or when covered by a wide range wireless network (eg. GSM), the WID may dial-in to the peer and change to a *anonymous connected* state. In this state, the peer may push non personalized information like the name of the peer device, its capabilities or its geographical position to the mobile device. On request other services free-of-charge, for instance static maps of the surrounding area, are available. For obtaining personalized information such as notifications about previously subscribed events, it is necessary to login to the peer device and change to the *id connected* state. In this state, all queued events may be pushed to the mobile device, or any other service, especially non-free-of-charge, is available to the mobile user. As long as the connection remains established, any service (code and data) may be downloaded to the device for future use.

VII. Handover

Handover is required to provide a seamless service to the user. Preferably this handover takes place within the network transparent to the user. If this is not possible, e.g. because the user is leaving the coverage area of one network, a handover can take place at other layers within the protocol stack. The following three service examples shall demonstrate the handover requirements:

Browsing the Internet: WWW content is retrieved using the HTTP protocol, which is mainly a request-response protocol. If required, a handover could happen by disconnecting the link and reestablishing it with a new service point closer to the user. This usually means a change of the dynamically assigned IP address. This works well with all static websites but imposes problems on session based sites that rely on a fixed IP address. Note that this type of web sites also encounter problems if access happens from users behind a router with Network Address Translation (NAT).

Telnet & File Transfer: Both applications keep a TCP connection open which would terminate as soon a change of IP address takes place. This can be avoided by using a Virtual Private Network (VPN) which keeps the IP address at the client side the same, but usually requires additional software.

Streaming Multimedia: Usually uses UDP for data transfer and applications typically do not tolerate an change of IP address.

A. Intranetwork Handover

Handover within public mobile networks works reasonably well. This means that most specifications like GSM, IS-95 support seamless handoff, but the actual implementation limits this sometimes to voice calls or within a geographical region (e.g. the coverage area of a mobile switching center). Seamless roaming (i.e. handover between networks from different operators) could technically work, but is typically not implemented due to the lack of roaming agreements or unsolved billing issues. However, there are few exceptions where seamless roaming works for well for both voice and data calls.

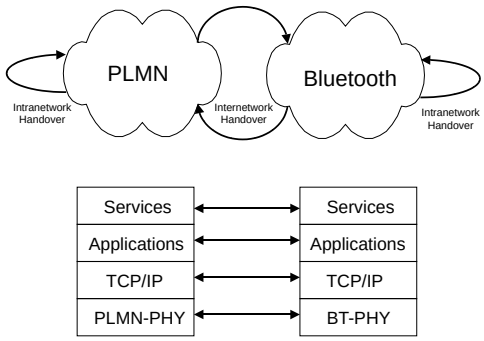

Fig. 5. Handover.

Bluetooth was specified as a cable replacement protocol, and intranetwork handover has not been specified yet. Current implementations of piconets can not support it, as there is only one master and up to seven slaves in one piconet. Every attempt to change the master results in a drop of all connections. In a scatternet scenario with multiple master and slaves which also supports dynamic change of role could technically handle a handover. However, as long there is no specification for this available and only proprietary solutions exist, handover in a public access scenario is not yet possible.

B. Internetwork Handover

Coverage of short range wireless networks will be limited to areas of high demand of capacity at low cost (hot spots like airports, commuting areas or shopping malls). In order to provide continuous service, seamless handover to the Public Land Mobile Network (PLMN) is mandatory. Handover between these networks has not yet been specified. One solution is a VPN connection, which gets established in either network and switches to another as soon the first link fails, keeping the IP address for upper layers the same. However, if the PLMN is circuit switched (e.g. GSM, HSCSD), data transfer gets interrupted for several seconds while the connection is being established, which may timeout TCP connections. This can get solved by using packet switched networks like GPRS where available, but still, the round-trip delay for packets changes significantly, causing trouble to TCP adjusting the throughput. Additionally the overhead of the VPN tunnel translates directly to additional cost as packet switched networks use volume dependent billing.
Another solution for internetwork handover is to perform the handover on the application level: Although the number of Internet applications is huge, only few are commonly used – especially on mobile devices like PDAs or smart phones. A restriction to HTTP, FTP, SMTP and POP3/IMAP4 will cover most use cases and an application handover can be implemented by local proxies [7], also avoiding additional overhead on the wireless link. Depending on the operating system, these proxies can be written in standard programming languages like JAVA whereas the VPN solution requires a network driver at system level.

VIII. Summary

Using today's heterogeneous networks requires different approaches for access of the infrastructure. From the user's perspective short range communication such as Bluetooth is preferred where available due to lower cost at higher bandwidth. Outside of hot spots, where no short range communication is available, fallback to cellular mobile networks enables continuous work. This requires a platform able to manage the integration of different bearer types transparent to the user. The significantly increased computing power of today's mobile devices gives the opportunity to migrate from user driven online access of WWW content towards a distributed device driven service approach. Combination of programmable end devices and consideration of location information as well as other information regarding the context of the user are a base for totally new services. In a best effort sense these services may use any available network which requires both intranetwork and internetwork handover. Standalone applications are required in order to continue to work offline if the network is temporarily unavailable. Future research has to be done to better integrate these aspects into a common framework.

References

[1] Bluetooth Specification (Bluetooth SIG). http://www.bluetooth.com.

[2] Michael Angermann, Patrick Robertson,Alexander Steingaß, "Integration of navigation and communication services for personal travel assistance using an java and jini based architecture," in *Proc. GNSS1999*, (Genua, Italy), 1999.

[3] M. Angermann, J. Kammann, P. Robertson, and A. S. and Thomas Strang, "Software representation for heterogeneous location data sources within a probabilistic framework," in *International Symposium on Location Based Services for Cellular Users - Locellus 2001*, pp. 107–118, February 2001.

[4] M. Angermann, J. Kammann, and T. Strang, "Heywow - eine plattform für den m-commerce," *Technik in Bayern*, no. 01, 2001.

[5] *The Java Community Process Programm*. http://www.jcp.org.

[6] T. Strang, *Technical Report: Bluetooth integration into CLDC/MIDP*. http://www.heywow.com/publications, February 2001.

[7] J. Kammann, "Proposal for a mobile service control protocol," in *Proc. PDCS '01*, (Anaheim, USA), August 2001.