A mobile system integration architecture

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1 Introduction and Overview

The mobility of users made possible by wireless networks and portable computers opens up new possibilities, but not without raising some challenges. When using these technologies, one has to deal with properties like slow but expensive wireless connection lines, frequent disconnection and limited host performance [IMI94]. Integration of mobile users and their devices into existing hardwired networking environments raises some questions which have to be considered carefully. The unforseeable location of hosts connecting to unknown and changing network environments for using local resources opens up potential security holes and raises new issues of accounting.

Despite of this prerequisites a mobile user should be provided with the additional functionality embedded in his familiar environment without compromising stability or security. The restrictions of wireless connection lines should be best possible hidden and their bandwidth optimal utilized.

In this paper, a system architecture that aims to fulfill these goals is presented. The different new tasks are accomplished by small sets of functions, which are compiled together to form an integrated environment.

Concerning communication over different network systems, several factors have to be thought of. The most limiting factors for mobile communications are the possibly low bandwidth and the high costs if using an analog or wireless connection line. In order to predict the price and the duration of the transmission, it is important for the system to know how much data has to be transmitted.

Every telecommunication application needs a minimal bandwidth and a fitting carrier to provide the user with a useful result [FOR94]. Running an application that requests high data rates over a low bandwidth net normally results in insufficient quality of service and high costs.

To support a mobile user within the framework outlined above, a set of services has to be provided handling the problems which arise from his mobility [JON95].

In the next section we discuss requirements for such services and describe some basic tasks which the services have to implement. We finally present the services themselves.

2 Architecture

2.1 Requirements for mobile services

Requirements for mobility services are stability, bandwidth/cost considerations, integration into the familiar environment, application transparency, security and extendibility [SCH95]. In particular:

- *Stability:* Especially with wireless connection lines frequent unintentionally disconnection can occur. The services must recognize this situation and react accordingly without causing the whole system to crash.

- *Awareness of changing bandwidth and costs:* Depending on the connection line available (a wireless one when out in the field, the telephone line in a hotel or the LAN in the home office, etc.) the services must enable the user to adjust the amount of data to be transmitted accordingly.

- *Integrated into the familiar environment:* The services should be as transparent to the user as possible.
- *Application transparency:* The application should not be aware of the different available connection lines.
- *Security:* The services must not introduce new security holes: neither must they allow the user host to be attacked, nor provide users with unjustified access rights in foreign network domains.
- *Extendibility:* An overall architecture must allow new services to be added to match future additional requirements and tasks.

2.2 Basic Tasks

From these requirements we can derive several tasks:

- *Connection management* including: Checking for the availability of lines, selecting the best suited one, watching the line thus noticing line disruption and in such cases following a certain strategy including attempts to reconnect.
- *Line parameter management* including: Determining the Quality of Service (QoS) and cost parameters, comparing them with given requirements, notifying the user in case of problems and providing a set of alternatives.
- *Caching:* Copying a certain amount of data (determined directly by the user or by predicted access probabilities) onto the mobile device, providing strategies for situations of simultaneous update or inconsistencies.
- *Authentication and encryption.*
- *Localization management* including: Locating required resources in a foreign environment and tracking the user if required.
- *Accounting:* Negotiating the costs of the usage of resources in foreign domains.
- *Profiling:* Adapting the system onto the needs and habits of the user.

Apart from the basic tasks there are other more specialized tasks for example supporting distributed database access over slow connection lines.

2.3 Mobility Services

The tasks described are fulfilled by mobility services (sets of specific functions usually executed as distinct processes). Some mobility services have to be distributed over the network and are implemented as client/server subsystems. Three different kinds of services can be distinguished: Services providing functionality to meet the basic requirements (Common Mobility Services, CMS), services concerning about management tasks used by all mobile users (Mobility Management Services, MMS) and services implemented to handle more specialized, high level tasks (Special Mobility Services, SMS). The proposed system architecture for the support of mobility is based on the mobility services as its building blocks. A great benefit of this architecture is, that existing "non-mobility" services can be "mobilized" by extending them with the functionality provided by CMSs. Examples for activities to be supported by SMSs are remote database access, Web browsing or electronic mail.

3 The Integrated Environment

Mobility services have to be embedded in an overall networking environment. A relays structure forms the system basis for them. It provides an integrate concept for mobility services. The environment is divided into three different parts:

- The *backend*. This is the station where server-applications for special mobility services are executed. There is always one special backend for every mobile host, the *home backend*, which is physically located at the user's home domain. It is responsible for holding security and accounting information concerning the mobile host. Every other backend from which a mobile host requests resources will first contact the corresponding home backend to exchange accounting and authentication information.

- The mobile host (*mobile frontend*). On this computer client applications are executed, which access services from the backend using the mobility service system. It is characteristic for a frontend that it changes its position and net-access point frequently.

- The *mobility service relay*. If a mobile host has no direct access to its home backend one or more relays between frontend and backend are needed. A relay tunnels service requests from frontend to backend, using special knowledge about the structure and state of the connection lines being used. The relay is responsible for first accessing the home backend of a mobile host to ask for authentication. It also supports services like SMS routing, service security, accounting and billing. Mobility service relays are not necessarily located on gateways. Using a relay, service requests will overcome gateways and routers, which usually do not route data from unknown hosts. This is possible because the data are sent indirectly from frontend to backend: The frontend sends a service request to the relay, which encapsulates the request and forwards it, maybe over many gateways, to the backend.

It is easy to imagine that every host in our system must support CMSs, because they enable mobility service communication. In addition every hosts must support SMSs. The frontend needs a client for SMS, additionally every relay needs a client and a server interface of the SMS to be able to tunnel the service requests. On the backend the server-part of a SMS must be executed.

A short description of the procedure of a service request (the request of a mobility service client from its server) from a frontend clarifies the relay structure. If a service request from the mobile host occurs from outside the home location, the call is first handled by a relay. The relay contacts the responsible home backend, maybe indirect using other relays, to receive an authentication token for the frontend. After successful authentication, the relay contacts the service backend. If the connection to the backend is established, service requests received from the frontend are tunneled to the backend.

4 Conclusion

The presented architecture and environment structure is currently being implemented using Windows NT as operating system for backends and relays and Windows 95 for the mobile hosts. As a first goal, a mobile ODBC (Open Database Connectivity, Microsoft's standard for database access) is realized by mobilizing the existing ODBC service, enabling remote database queries over instable connection lines.

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