Mobility aware Multimedia X.400 e-mail:
A Sample Application Based on a Support Platform for Distributed Mobile Computing

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Abstract

The paper describes the design and implementation of a distributed system to enable the use of X.400 e-mail with multimedia extensions in an mobile environment. This system is a example for how to extend standard applications with mechanism for handling special problems of nomadic computing and mobile communications. This paper outlines the need of a generic software support for „mobile applications“. Based on these considerations, we describe a model for a generic software support platform for distributed mobile computing. It addresses the specific aspects of mobility by providing application-independent and reusable support services. In particular, it offers a framework for organizing distributed mobile applications into manageable domains, it equips mobile stations with enhanced functionality for location, resource and bandwidth management, and it uses industry standard RPC communication facilities for enhanced portability. The implementation of the mobile X.400 e-mail system is the first comprehensive validation of the support platform. First experiences are discussed at the end of this paper.

Keywords: Mobile computing, mobile communication, e-mail systems, multimedia transport systems, distributed systems, distributed applications

1. Introduction

Electronic mail is a rather traditional kind of application that has been in use for several decades. However, in the context of mobile computing, a number of interesting new aspects and requirements are associated with it:

- *Bandwidth management:* E-mail has recently been augmented with multimedia extensions within dedicated X.400 extensions, for example within the MMM (Multimedia Mail) project of DeTeBerkom /ADH93/. The transfer of the respective multimedia body-parts such as audio files, images, and video clips in a mobile environment requires careful consideration of bandwidth management aspects. This can be supported by dedicated information management support, in particular by separating body-parts and by applying a variety of compression techniques.
- *Disconnection:* Due to the widespread use of e-mail, it is a key acceptance criterion to provide rich e-mail functionality on mobile stations, also in the context of disconnection. When a mobile station is operating in disconnected mode, the user expects at least an emulated e-mail functionality. Moreover, upon reconnection, transparent access to received e-mails as well as transparent transfer of sent e-mails is required.
- *Dynamic configuration:* Mobile hosts dynamically move between various subnetworks and organizational domains. Therefore, frequent changes of the overall system structure result /KAT94/. A mobile e-mail application must reconfigure itself under consideration of the actual system and network environment. The users should not be involved in this process.

- *Quality of communication mechanisms:* In mobile environments, the quality of communication facilities also varies significantly /MEW93, DPB94/. The throughput, delay and costs of cellular WANs like GSM, wireless LANs and conventional networks are very different. The e-mail system software should incorporate these aspects as a base for optimizing the message transport /ATD93/.
- *Security:* Finally, advanced security requirements arise from mobile computing /AZD94/. While the problems of link tapping have been solved to a high degree by encryption techniques and spread spectrum technologies, dynamic attachment to different networks imposes new requirements concerning account and password management and authentication /MST94/. Therefore, solutions for cross-domain account management are required. Moreover, cached data on notebooks are much more sensitive to loss or theft of such equipment; that is, additional security techniques are recommended.

One way to consider these problems is the implementation of a new e-mail system from scratch. But this could lead to a very low user acceptance. That's why we prefer the extension of existing standards and standard applications by introducing new functionality. To support existing applications without changing the binaries, a midleware concept is recommended.
Due to the similarity to other applications concerning disconnection and bandwidth management, mobile security and related issues, it is important to build the components of a mobile e-mail support in a reusable way. For example, mobile database access, mobile message passing support, or mobile document management can make use of the generic functionality discussed above. Based on this requirement we developed a model for a generic support platform for mobile applications discussed below.

2. Generic System Support

Overall Structure

The distributed environment is divided into organizational units. We call them domains. A domain is a base for generic mobile application support and resource management. A domain may consist of various subnets and a number of fixed and mobile stations (fig. 1). However, it is important to note that a domain is a logical rather than a physical construct; therefore, it can also include widely dispersed subnets or stations if they are considered to be organizationally close. Each domain is controlled by a domain manager. This component manages an information base with:

- all stations that are currently members of the domain,
- global application-level services and resources of the domain that are offered via RPC,
- an abstract representation of the network topology belonging to the domain,
- and a dynamically adaptable list of other domains

Each station comprises a station manager that is responsible for station-specific management tasks including planning of remote communication and resource access, caching of information, and interactions with the domain manager. (Fixed) stations provide services and resources to the distributed environment. This functionality is detailed in the following section. A station is a member of at most one domain. Although stations usually interact directly with each other via RPC at the application level (i.e. without involvement of the domain manager), communication with the domain manager is required for various specific tasks.

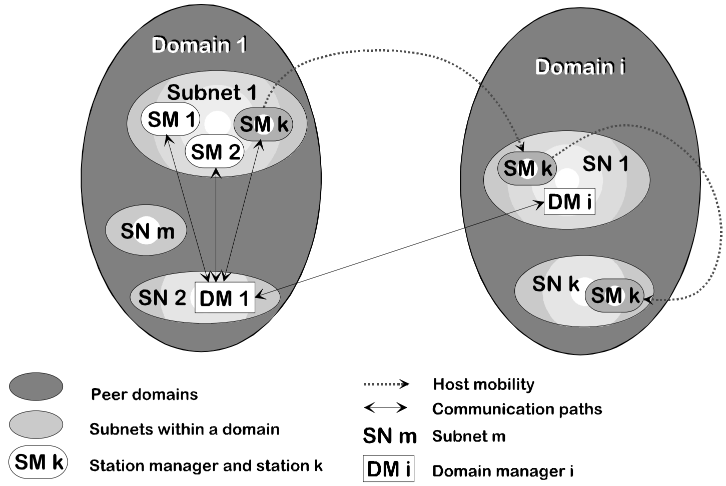

Fig. 1: Overall structure of the generic approach

Stations are able to dynamically enter and leave domains and to locate services and resources. When a station enters a domain, it registers itself with the domain manager and transfers descriptive information about itself to it. Upon leaving a domain, the domain manager deletes the station from its list of domain members and adapts the corresponding resource information. The domain managers themselves interact via a domain interaction protocol. It implements the exchange of information about member stations which offer services and resources. Most of this information is only exchanged on demand.

Station Structure

Station management enables the applications on a given (fixed or mobile) station to make use of our mobile support environment. A major goal is to provide a relatively system- and application-independent generic support that is operational on a large number of platforms and for a large number of applications. Therefore, the station manager offers techniques that support mobile computing and communication in a generic way rather that implementing specific mobile application services (such as mobile e-mail as a self-contained service). The station manager is structured internally according to /SCK95/ and comprises the following components: Location service (LOC) and resource broker (RB), Bandwidth and cost management service (BCMS), Application data mobilizer and manager (ADMM), Disconnected operation handling service (DOHS), Registry service (RS) and authentication and encryption service (AES). The related data about users and applications are managed by an active database (ADB). It handles all queries of other components. A detailed description off all components can be found in /SCK95/.

3. Example Implementation: Mobile X.400 e-Mail System

In the following, we describe the architecture and implementation of a mobile X.400 system on top of our support environment (see fig. 2). We assume that the reader is basically familiar with the general concepts of X.400 e-mail.
In the mobile system extensions, the so called *UA-Proxy (UA-P)* gains access to the stored messages within the X.400 Message Store (MS) in substitution for the original remote user agent (rUA). It resides within the home domain of the mobile user and acts as mediator between Message Handling System (MHS) and our platform. By using the MS, the messages are continuously available; so conventional rUA's can retrieve them.

After retrieval, the UA-P copies the messages to the current location (domain) of the respective user. Therefore two cases possible:

1. *Message retrieval on demand*: The user claims the UA-P to retrieve new messages after registration in the new domain.
2. *Look ahead delivery based on user specific mobility profiles*: The UA-P delivers the messages to all possible locations of the specific user. After arrival in one of the predicted locations, the user can immediately read his or her mails. The garbage collection at the other locations belongs to the realm of the intelligent queuing service of our architecture. If the user relocates to a domain which isn't in the delivery-list, case 1 occurs and after a timeout period all other copies will be discarded.

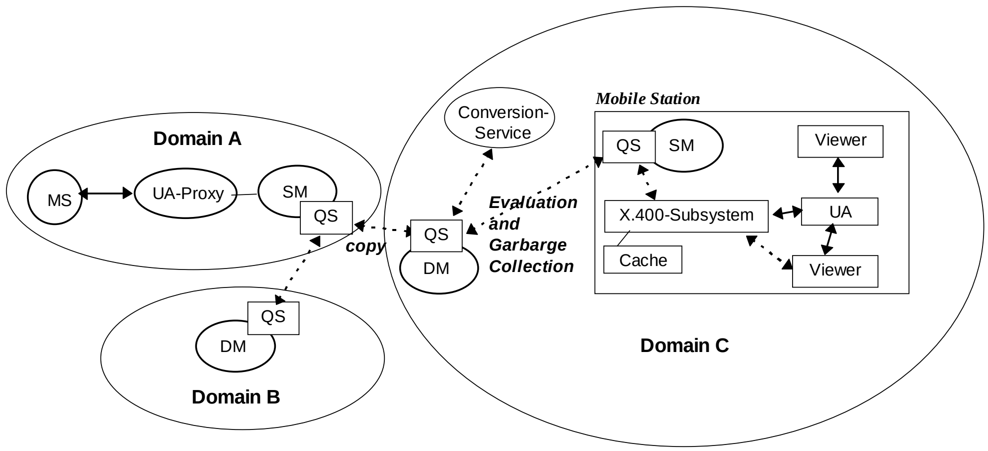

Fig. 2: The mobile X.400 email example

The queuing service as part of the disconnected operations handling also offers some other specific functionality. The forwarding of data (i.e. mails in our example) operates reliably; when a mail is passed from a sender queue to a receiver queue or to an intermediate queue at a domain manager´s site, explicit confirmations that are imbedded into a two-phase protocol are exchanged and enable recovery after transmission failures. Moreover, multicast queues are already supported by our implementation. Finally, priorities can be used to control the transfer of data between queues.

After delivery to the actual domain (Fig. 2: Domain B), the X.400 subsystem which resides on the mobile station is able to receive the messages and to hand them out to the user. A conventional rUA equipped with an additional viewer acts as a user interface. In the context of message delivery (to the destination domain and station) our architecture supplies assistance for the evaluation of the link-quality (cost and bandwidth evaluation). In the case of a high bandwidth and low cost link (e.g. Ethernet),all messages will be transferred without compression. In the worst case (expensive and low bandwidth link) only the textual parts of the messages and our special body part (which includes the description of the multimedia parts) will be fetched (preview). Afterwards, the multimedia body-parts (video, audio, etc.) can be transferred in a (not necessarily quality-preserving) conversion into a compressed format in order to reduce the amount of data. The compression method is chosen by the user (options dialog offered by our viewer). After the selection of a specific compression format a compression service encodes the data (/SCK95/). We currently support audio attachments in WAV format, pictures in JPEG format, video clips in MPEG format, postscript files and selected formats of DeTeBerkom MMM /ADH93/. The receiving station caches all transferred data.

4. Experiences

Most of the required functionality maps rather naturally onto the generic components of our support platform. Of specific importance for the mail application is the disconnected operation service; specific instantiations of the caching and queuing service have been on top of this facility. The information representation concerning applications, users, available network bandwidth, and other system data is handled by the active database of the generic support architecture. The queuing service complies with all requirements of mobile multimedia transport systems.
Major general experiences with this prototype implementation are as follows:

- *Distribution transparency:* It became obvious that a very high level of transparency of distribution (as addressed by conventional client/server solutions) is not possible nor desirable anymore in mobile environments. However, flexible software support for mobile distributed applications with varying levels of distribution transparency is a central issue. The bandwidth and cost management component illustrates a possible solution.

- *Generic support:* Explicit and generic support for bandwidth management, disconnection handling, and resource access and location management is therefore required. Our experiences confirm that it is possible and reasonable to imbed this into a generic support architecture so that it can be reused by several applications such as mobile e-mail and mobile database access.

- *Network information:* It is sufficient to represent the network-related information at a rather high level as a basis for semi-automatic decisions concerning resource access (rather than using low-level network management information).

- *Standards.* The use of established client/server-based industry standards, namely DCE, is crucial for achieving good acceptance of application developers and end users. The use of RPC has significantly simplified the integration of workstation and PC platforms based on the interoperability of DCE and Microsoft RPC using NDR (Network Data Representation). However, obvious potential for optimizing the performance of RPC exists based on dynamic adaptation of block sizes at the transport layer.

5. Conclusion and Future Work

This paper presented an overview of a support platform for mobile computing in conjunction with a mobile X.400 e-mail application. We outlined that generic support for mobile computing is desirable and technically feasible to a large degree. Moreover, we illustrated that conventional applications such as e-mail require significant enhancements in order to achieve proper functionality in mobile system environments. Currently, we are working towards the completion of our prototype, to be displayed at CeBIT ´95. Related research projects within our group are focusing on quality of service for multimedia transmission, enhancements of remote procedure call for mobile environments, and advanced client/server applications.

The final paper will include performance data, a detailed description of selected parts of of the support platform which are most important for the e-mail application and it will introduce a model and toolkit for handling multimedial data under consideration of non-technical (subjective, human) parameters.

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