A MOBILE AGENT-BASED APPROACH FOR THE UMTS/VHE CONCEPT

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Abstract: The provision and delivery of personalised services across network and terminal boundaries with the *same look and feel* is currently a challenging issue for service provisioning in future telecommunication networks like UMTS (Universal Mobile Telecommunication System). This paper describes an advanced mobile agent-based approach for realisation of the VHE (Virtual Home Environment) concept considering two main aspects namely *service roaming* and *terminal independence*. The first one implicates the accessibility of personalised services in any network the user roams to, while the latter deals with the adaptation of the service presentation to the corresponding end device (mobile phone, Laptop, PDA,...) according to its capacity and system features as well as the specific user profile. The implementation of some service prototypes are described which were developed in the framework of the ACTS CAMELEON project [11,12].

1. INTRODUCTION

The concept of a Virtual Home Environment (VHE) for UMTS (Universal Mobile Telecommunication System) was introduced into the standardisation process for the provision and delivery of personalised

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The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35581-8_35

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services across network and terminal boundaries with the *same look and feel*. This concept allows the user to be consistently presented with the same personalised features, user interface customisation and services in whatever network, with whatever terminal (within the capabilities of the terminal), and wherever the user may be located.

The ability to provide such flexible service provisioning has many implications for the network in terms of management, control of services, and signalling. A user request for an unknown service will require some means to locate where that service request can be handled or where information can be found on how to handle the service request itself. This may imply that service control is distributed in the system giving rise to complex network management protocols and stringent security requirements.

Current developments in GSM such as CAMEL(Customised Applications for Mobile networks Enhanced Logic), MexE (Mobile station application Execution Environment) and SAT (SIM Application Toolkit) are expected to meet some requirements of the VHE and they will also be adopted for UMTS. However, there is scope for other techniques to be employed to meet all the requirements of the VHE.

In the last few years agent technology has spread to many areas, including user interface, personal assistance, mobile computing, information retrieval, telecommunication services and service/network management.

This new technology offers a promising solution to cope with the complexity of open environments, since agent-based solutions can:

- reduce the traffic load (via the autonomy and asynchronous operations of the agents)
- enable on-demand provision of customised services (via dynamic agent migration from the provider system to the current user terminal)
- increase the flexibility, reusability and effectiveness of the software-based problem solutions
- offer the potential to distribute service related processing and a mechanism for nodes in different networks to co-operate in order to provide a service to a user

With these advantages agent technology can be used in the following areas of the VHE concept.

- Usage of agents for value added service subscription and provision to the user, such as dynamic migration of applications between the user's mobile terminal and the value added service provider. A mobile software agent transports the software to the current terminal and executes it there.

- Usage of agents for mobile communication service provision to the user, such as dynamic downloading of customised mobile communications service logic into terminals. The idea is to provide customised communication capabilities dynamically to the user and increase the intelligence of the terminal.
- Usage of agents for user and service roaming. A mobile software agent can follow the roaming user, even between different mobile communication systems, to represent the user in the foreign network and provide the user's subscribed services.

However, this technology is relatively new and its suitability for solving telecommunications problems needs to be proven in implementations and through performance analysis. This paper deals with a possible service architecture for personalised service portability in UMTS based on agent technology.

2. AGENT TECHNOLOGY

An *agent* is defined as a piece of software that is able to perform a task autonomously on behalf of a user or application, using its intelligence to access distributed resources. A *place* is an execution environment for agents at a specific location. Two types of agents are distinguished: Provider Agents (PA) and Service Agents (SA). A provider agent is permanently available at a fixed location and offers access to local resources. More than one provider agent can exist at a place. The agent that has been given a certain mission and will be using the services of a provider agent is called the *service agent*. The mission of the service agent is a user-defined abstract set of rules in which the agent should act. A service agent can either be generated at a place locally (possibly out of a pool of ready-programmed usable objects) or can be a visitor that has been created elsewhere and was moved to the place, carrying with it the previous state of execution.

2.1 Voyager as underlying agent platform

The development and prototyping of CAMELEON services are based on the *Voyager* [13] agent platform. The ObjectSpace Voyager platform is a development platform and object request broker for distributed Java-based applications. It allows the usage of a regular message syntax to construct remote objects, messaging between distributed objects and code migration.

The core item of any agent system designed using the Voyager development platform is the host and execution environment called the

Voyager server. Starting a Voyager server is a prerequisite for running Java programs that use the remote functions provided by the Voyager system. The Voyager server is the „place“ that hosts permanent *provider agents* and temporary *service agents*.

In a distributed computing scenario, it is necessary to have a Voyager server installed on every machine that will take part in order to play the role of a „place“ for permanent and temporary agents. A Java Development Kit (JDK) has to be available on any such machine as well. Voyager servers can be invoked manually or from within a Java program. In both cases, a user must have the authority to log into that machine in order to start the server. A server cannot be started remotely. However, once started, the server allows execution of remote software objects from users that have no authority to log into the machine hosting the server.

Voyager servers can act either as a "server" or a "client". A Voyager server acting as a *client* exerts the function of a „home place“. It allows, e.g., the launching of agents, their dispatching to other places and it also enables them to return. However, acting as a client it cannot receive messages or host software objects other than the ones created there. A Voyager server acting as a *server* can host any remote software object, handle messages to those objects and even act as a code server to distribute class files for remote locations.

The main features of the ObjectSpace VoyagerPro are described in the following:

Using remote objects: A remote object can be used within a local Java program, if a handle to this object exists. In VoyagerPro this handle is called a *proxy*, meaning that it exists locally and the methods of the remote object can be used as if they were local.

Remote construction: It is possible to create a remote instance of any class and obtain a proxy to the newly created object. The proxy implements the same interfaces as the created object and the proxy class is generated dynamically if it doesn't already exist.

Naming service: The VoyagerPro naming service is called *Namespace.* Each object that wants to make its methods available to other objects must bind its URL (Uniform Resource Locator as used for the World Wide Web) to the Namespace. When a program looks up a remote object in this namespace, the URL must be given and, upon finding the object, a proxy to the object is returned. VoyagerPro also supports other naming services like: CORBA, JNDI, RMI registry, etc..

Messaging: VoyagerPro distinguishes between two kinds of messaging: *Remote Messaging* and *Advanced Messaging*. Remote Messaging is defined as method calls made to a proxy, that are forwarded to its object. If the object is in a remote program, the arguments are serialised and later de-serialised at the destination. Advanced Messaging is a VoyagerPro messaging mechanism for synchronous and asynchronous messaging.

Autonomous mobile agents: With VoyagerPro autonomous mobile agents can be created that move themselves between different hosts and continue to execute upon arrival.

Dynamic class loading: Classes can be dynamically loaded from one or more locations when necessary. This allows to set up class repositories that serve a distributed system with Java applications.

3. INTEGRATION OF MAT INTO UMTS

The introduction of Mobile Agent Technology (MAT) to UMTS assumes some enhancements of the existing network components. As UMTS is an evolutionary concept, which means that it should benefit from the research activities and experiences made within GSM, it is interesting to ask, in how far current network components should be replaced or enhanced to new interfaces. In Phase 2+ of GSM the CAMEL Technology, based on IN concepts, is being introduced. Therefore it is reasonable to keep the existing functionality of CAMEL, but to implement different interfaces corresponding to the MAT.

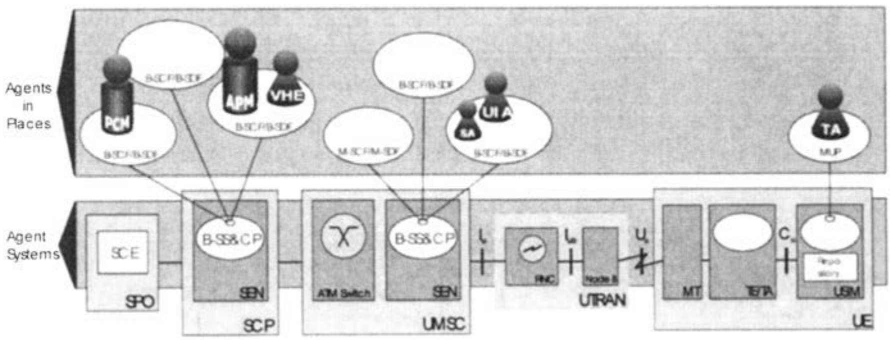

Figure 1. Agents in UMTS

The overall architecture of UMTS integrating the MAT with the corresponding agents is illustrated in figure 1. It contains the network components with MSC (Mobile Switching Center) functionality known from the GSM architecture like mobility management, bearer control, etc.. However, the MSC in UMTS will be more integrated than in GSM. It should manage different access networks, e.g., existing GSM BSSs (Base Station Subsystem) and UMTS RANs (Radio Access Network). It is also foreseen to integrate an SGSN (Serving GPRS Support Node) node. The transport technology for Signalling and Data over the I_u interface is expected to be ATM. The core network will be based on ATM technology as well. These integrated MSCs called UMSCs will be connected to one or more SCPs (Service Control Point), which are able to provide CAMEL functionality.

The user will be equipped with a terminal which contains the required components managing the radio interface MT (Mobile Termination) and indicating the information TE/TA (Terminal Equipment/Adapter). As mentioned before, for the integration of MAT into UMTS the SSPs (Service Switching Point) and SCPs of the UMSCs should be enhanced by additional interfaces. Hereby, the functionality of SCFs (Service Control Function) and SDFs (Service Data Function) are partially merged together for providing a distributed architecture. These combined SCFs and SDFs are called B-SCF/B-SDF, which provide interfaces for broadband communication services. For an agent-based mobility management the so called M-SCF/M-SDF are required, providing an execution environment for an agent migrating to corresponding UMSCs in case of a location update. Additionally, the SENs (Service Execution Node) should provide an execution platform for agent systems called B-SSP/SCPs. The corresponding agent execution environment should also be provided by the USIM or by the TE/TA. The logical conjunction of the distributed agent execution environments (DAE) mentioned above contains the required agents and their service logic residing in different places and communicating through the B-SCF/B-SDF interfaces.

To provide the accessibility of personalised services in any network the user resides in, a so called VHE agent can follow its associated user wherever he roams to. The VHE agent contains the list of a user's subscribed services and its configurations. A Provider Agent (PA), which resides within every serving environment, contains the knowledge of all services provided by this network. So the VHE agent has to connect the provider agent when the user roams to a new serving environment in order to get information on new services provided by the visited network.

As mentioned above the UMSCs have to provide an execution environment (place) which allows the corresponding agents to perform their tasks. This is the assumption for the VHE agent, in order to roam between the different UMSCs.

Additionally, as another strategy the VHE agent may be placed on the user terminal and migrate to the network after a connection establishment in a new network.

In order to choose the best strategy performance analysis is necessary. Within the framework of the CAMELEON project a performance study was carried out which considers the possible options for the placement and employment of the agents involved in the corresponding scenarios. The performance assessment results are presented in [8,9].

4. AGENT-BASED SERVICE PROVISIONING

For the adaptation of the service presentation to the corresponding end device (mobile phone, Laptop, PDA,...) according to its capacity and system features as well as the specific user profile a so called (APM) Adaptive Profile Manager has been developed and prototyped within the framework of the CAMELEON project. The APM focuses mainly on the terminal independent service provisioning which is an essential aspect of the VHE concept and will offer the following capabilities:

- Flexible service provisioning
- Remote, network and platform independent modification of all user profiles for different services
- Handling of different terminals with different capabilities for service access
- Automatic download of updated services

A terminal agent (TA) on the currently used terminal provides an interface to the user to authenticate himself and request a service (see Figure 2). The terminal agent maintains knowledge of the user terminal profile of the corresponding end device considering its capacity and system features (display type, memory, available bit rate etc.).

On the service provisioning side the APM Provider Agent (APM-PA) manages the user authentication, the profile adaptation and service requests. It is connected to a central register, where all user data are stored. Each service to be accessed by the user should be registered at a APM. This is performed by the communication between the APM-PA and a so called Service Specific Provider Agent (SS-PA). The services could be implemented on different platforms running on different operating systems, only the APM-PA and SS-PA have to communicate and understand each other.

Before responding to a service request the APM-PA has to verify whether the terminal agent on the connected terminal is up-to-date or should be updated. If so, the new version of the terminal agent or sub-agents for specific features can migrate to the terminal and replace the old ones. This automatic version control enables the user to always have the current version of the terminal agent without the need of manual downloading.

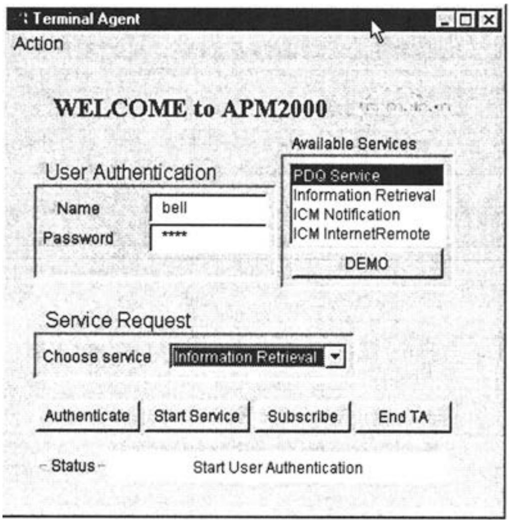

Figure 2. Terminal Agent

Once the suitable version of the terminal agent is available on the terminal the user is informed about the currently available services, after a successful authentication process. If there are some new services which the user doesn't yet know he has the possibility to get a demo version of the selected service in order to decide whether he wants to subscribe to it or not.

If the user subscribes to a new service it will be added to the list of subscribed services within the TA (see Figure 2) and the required data for the service subscription are sent from the TA to the APM-PA to be stored in the central register.

Starting a subscribed service, the TA sends the service request to the APM-PA to check whether the user is authorised to access the required service. If so, the APM-PA instructs the so called User Interface Agent (UIA) to transfer the appropriate service specific GUI to the requesting terminal.

The chosen GUI is adapted to the network capabilities and the features of the currently used terminal. The required data concerning the network and terminal capabilities are delivered by the terminal agent when connecting the APM-PA at the beginning of the session.

After the UIA arrives at the terminal the data connection to the APM-PA can be dropped. Here, it can be distinguished between 2 possibilities depending on the realisation of the requested service:

First, the complete service logic can be moved to the terminal; second, the service logic is partially moved to the terminal, in this case a connection (RMI or messaging) between the UIA and the SS-PA is required.

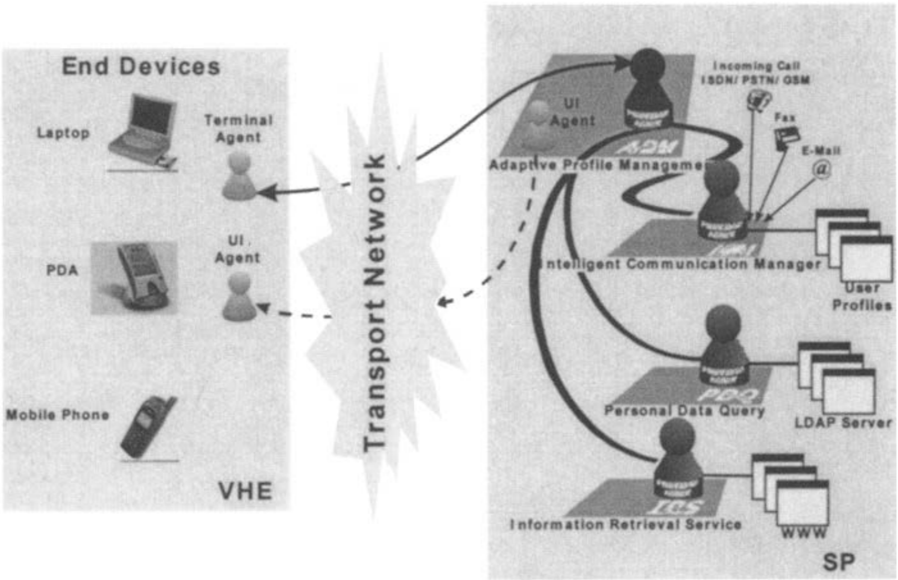

Figure 3. Terminal independence service access

The performance can be enhanced by different methods, e.g., using caching mechanisms to keep the agent code for future service requests and just move the data.

5. SERVICE PROTOTYPES

Currently, the APM provides access to three services namely ICM (Intelligent Communication Manager), PDQ (Personal Data Query), and IRS (Information Retrieval Service) which can be accessed terminal independently and can be presented adaptively to the capabilities of the current terminal and network connection. However, more new services may be added flexibly to the system (see Figure 3).

5.1 Intelligent Communication Manager - ICM

The ICM is the core service of the APM system providing a personal communication environment to the user in order to have a flexible and personalised mechanism to control the reachability for all subscribed communication services.

This service offers to the user the possibility to organise and automatically control any kind of incoming communication requests (voice, fax, email, SMS, etc.). The management of personal communication is based on the specification of special conditions (caller/sender, time, subject, etc.) in the so called user profiles (filter scripts), that can be configured remotely and adapted to the current requirements of the user.

The ICM's main features are as follows:

- Call (voice, fax, email) recording
- Call rejection
- Caller/application interactions via DTMF-detection or voice menu
- Call forwarding/deflection
- User registration/de-registration
- User notification, e.g., via pager service, SMS, or email
- Conversion of recorded voice- and fax messages for sending them as email
- Forwarding of incoming email to a fax machine

A multi-media mailbox informs the user about the recent personal communication activities performed by the ICM, e.g. in order to view the received faxes or emails and to play the recorded voice messages [4].

5.2 Personal Data Query - PDQ

This service offers to the user the possibility to query data from a personal database by SMS (e.g., address, telephone/fax/mobile phone number, email address, birthdays and others).

The personal data are stored in an LDAP (Lightweight Directory Access Protocol) database which can be accessed by the PDQ service through JNDI (Java Naming and Directory Interface).

This information can either be stored on a local LDAP server or on any LDAP server which is accessible via the Internet.

An incoming SMS contains a personal data query which should be performed by the LDAP server. The results in turn will be sent to the user via SMS [7].

There are several possibilities to send and receive SMS messages:

- Via air interface if the server is connected to a GSM module
- Sending and receiving SMS messages as email
- Using the ISDN gateway of the SMSC to send SMS messages

5.3 Information Retrieval Service - IRS

This service itself is a totally agent-based service offering the user an efficient retrieval service for information, that is distributed over different platforms in heterogeneous networks. An example is the automatic booking of flights or other travel arrangements in the Internet. The user delegates certain functions, e.g., find a flight at a date and time to a certain city, without having to know about details of the task execution. Any information service (e.g., WWW pages, LDAP databases, etc.) with data important for the user can be accessed. The mobile agent with a certain degree of autonomy collects the information and returns with an evaluated result back to the current terminal of the user.

6. IRS SCENARIO

All services (ICM, PDQ and IRS) explained above can be accessed over the APM offering the adaptation of the service presentation according to the end device specific parameters [1,2,7].

The following scenario describes the usage of the Information Retrieval Service through the APM illustrated in Figure 4.

After the user authentication and service request through the terminal agent (TA) on a Laptop the corresponding GUI is transported to the terminal (Laptop) by the user interface agent (UIA). Now the user enters the data he is looking for (e.g. find the best flight offer to London on next Monday). After sending the agent with the query (mission) the connection can be dropped. After a while the IRS service agent will come back to the IRS provider agent to deliver the found information. To present the retrieved result on the terminal the UIA has to move to the terminal. As the terminal is not connected to the network the UIA is set to the *wait* status by the APM-PA and the results are stored. The next time, the user logs into the system via the TA - it could be another terminal like a PDA for example- the UIA is alerted by the APM-PA and migrates with the appropriate GUI accordingly to the currently used terminal to present the retrieved results.

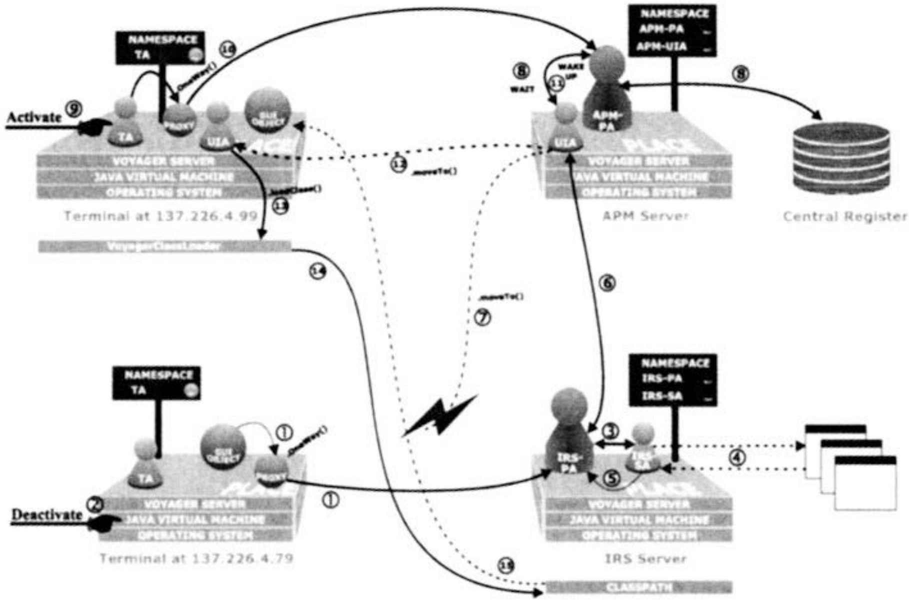

Figure 4. Using the IRS service

All steps through this scenario are described in the following:

1. The UIA sends the entered information to the IRS-PA
2. The user terminates the TA on his current terminal
3. The IRS-PA activates the IRS-Service Agent
4. The IRS-Service Agent moves to the corresponding content provider in order to accomplish its task
5. The found results are passed to the IRS-PA
6. The UIA is instructed to bring the results to the user
7. First, the UIA attempts to move to the terminal from which the user sent his query
8. The UIA is set in the *waiting* mode, as the user is not available at his former terminal any more
9. The user starts the TA on another terminal
10. The user and terminal data are sent to the APM-PA
11. The UIA is alerted by the APM-PA and receives the updated user and terminal data
12. The UIA moves to the current terminal of the user
13. The UIA attempts to load the required classes
14. The classes are loaded from the IRS server
15. The results can be presented according to the capacities of the current terminal

7. CONCLUSION

Pre-UMTS systems have largely standardised the complete set of tele-services, applications and supplementary services. As a consequence, re-engineering is often required to enable new services to be provided and this makes it more difficult for operators to differentiate their services. UMTS will standardise service capabilities and not the services themselves.

The results and experiences in the CAMELEON project have shown that agent technology is a very promising field which can be integrated with other technologies (e.g., MExE, SAT, CAMEL/IN) in order to allow flexible service provisioning, execution and access for future telecommunication networks and services. These agents can use the same mechanisms for communication and thus allow a very flexible service architecture. This will lead to more reliable and performant services. Mainly security and further performance aspects should be investigated for a widespread and efficient employment of these technologies in future networks.

ABBREVIATIONS

APM	Adaptive Profile Manager
APM-PA	Adaptive Profile Manager-Provider Agent
AWT	Abstract Window Toolkit
BSS	Base Station Subsystem
CAMEL	Customised Applications for Mobile networks Enhanced Logic
CAMELEON	Communication Agents for Mobility Enhancements in a Logical Environment of Open Networks
DAE	Distributed Agent Environment
GSM	Global System for Mobile communications
GUI	Graphical User Interface
ICM	Intelligent Communication Manager
IN	Intelligent Network
IRS	Information Retrieval Service
JDK	Java Development Toolkit
JNDI	Java Naming and Directory Interface
LDAP	Lightweight Directory Access Protocol
MAT	Mobile Agent Technology
MExE	Mobile station application Execution Environment
MSC	Mobile Switching Center
MT	Mobile Termination
PDA	Personal Digital Assistant
PDQ	Personal Data Query
RAN	Radio Access Network
SA	Service Agent
SAT	SIM Application Toolkit
SCF	Service Control Function

SCP	Service Control Point
SDF	Service Data Function
SDP	Service Data Point
SEN	Serving Execution Node
SGSN	Serving GPRS Support Node
SMS	Short Message Service
SMSC	Short Message Service Center
SS-PA	Service Specific-Provider Agent
TA	Terminal Agent
TE/TA	Terminal Equipment/Terminal Adapter
UIA	User Interface Agent
UMTS	Universal Mobile Telecommunication System
VHE	Virtual Home Environment

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