Jambala Mobility Gateway—Convergence and inter-system roaming

André Bertrand

As business becomes truly global and international, the need to communicate anytime, anywhere becomes more crucial. The demand for international roaming has grown spectacularly and is expected to continue growing into the new millennium.

With the tremendous installed base of GSM and TDMA/AMPS wireless networks in the world, international roaming has evolved to require inter-system roaming capability; that is, roaming between GSM and TDMA/AMPS networks. In addition, operators seeking to enter established wireless markets are increasingly requiring the use of inter-system roaming to enable them to use the cellular coverage offered by partners in the same or neighboring areas.

The author describes the Jambala Mobility Gateway, a new application from Ericsson that provides the level of convergence necessary to interface GSM and TDMA/AMPS networks.

The Mobility Gateway provides what is referred to as interworking location register (ILR) functionality. This functionality is needed because different networks use different protocols to communicate between nodes, such as the home location register (HLR) and the mobile switching center (MSC). Specifically, GSM networks use the mobile application part (MAP) protocol, whereas TDMA/AMPS networks use the American National Standards Institute ANSI-41 protocol (Figure 1).

To ensure a truly open environment that supports multi-vendor connectivity, messages implemented in the Mobility Gateway conform to TDMA/AMPS (IS-41, revisions B and C, and ANSI-41, revision D) and GSM standards (MAP versions 1 and 2). Furthermore, the Mobility Gateway does not impose any modifications on individual network components, such as HLRs and MSC/VLRs in current GSM and TDMA/AMPS environments.

The mapping of MAP and ANSI-41 protocols allows for the exchange of information needed to provide basic mobility management across different networks, thus permitting users to roam from one network to another. Consequently, the protocols and interfaces associated with service delivery in

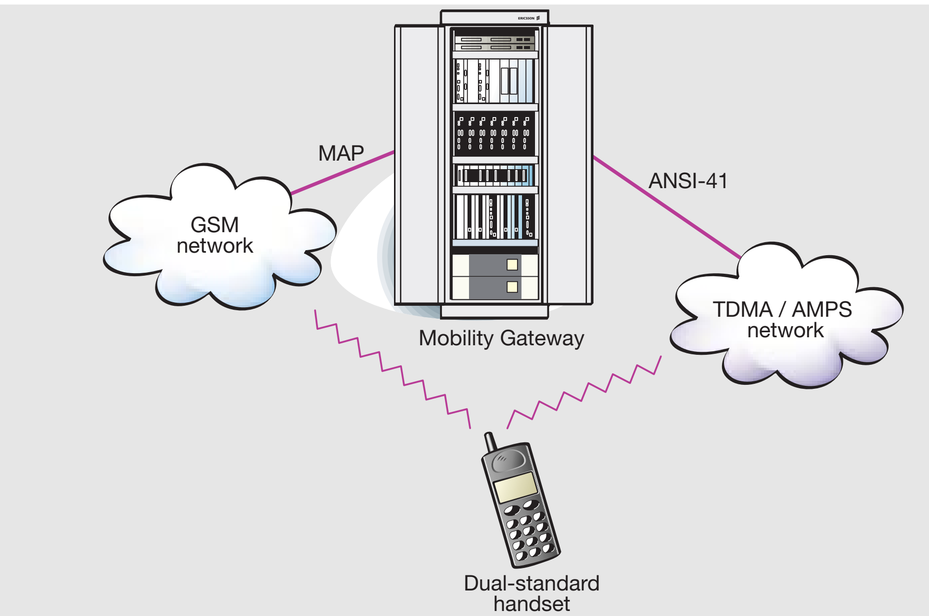

Figure 1
Inter-system roaming.

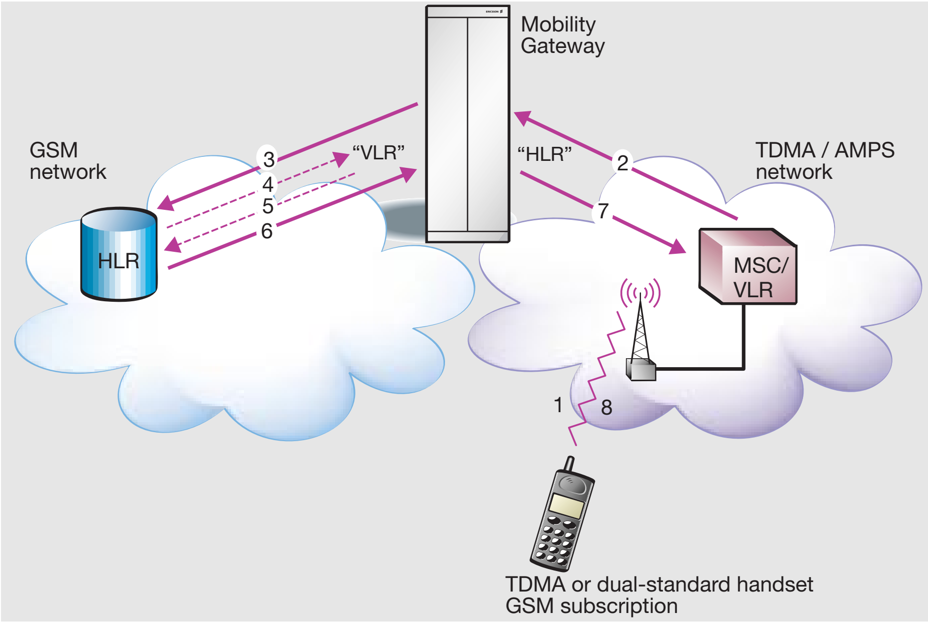

Figure 2
Registration/location update of a GSM subscriber roaming in a TDMA/AMPS network.
Key:
1 = Registration access
2 = Registration notification invoke
3 = Update location invoke
4 = Insert subscriber data invoke
5 = Insert subscriber data result
6 = Update location result
7 = Registration notification return result
8 = Registration accepted message

different networks begin to look increasingly similar, even though the physical network elements are different.

The presence of a GSM subscriber in a TDMA/AMPS network is indicated by the Mobility Gateway receiving a *registration notification invoke* message from the serving MSC (Figure 2). For the roaming subscriber, the Mobility Gateway is perceived as a TDMA HLR (with respect to the serving TDMA MSC), translating the registration notification message into a corresponding GSM *update location* message and sending it to the subscriber's GSM HLR. As viewed from the GSM HLR, the Mobility Gateway functions as a GSM VLR. Information received in *insert subscriber data* messages is saved in the subscriber's profile in the Mobility Gateway and mapped onto the appropriate data used in the *registration notification return result* message. After the *update location result* is received in the Mobility Gateway, it generates the *registration notification return result* and sends it to the serving MSC.

It is important to note that the Mobility Gateway does not replace existing HLRs in GSM and TDMA/AMPS networks. For a subscriber roaming between these networks, there will always be only one subscription, either in a GSM HLR or in a TDMA HLR, but not in both. The Mobility Gateway contains the information necessary to identify the subscriber when either network is being used. If the subscriber is roaming in the other network type, the Mobility Gateway accesses the HLR in the subscriber's home network and forwards the information to the other network using ANSI-41 and GSM MAP messages as appropriate.

Reduced signaling load

To reduce the signaling load, the Mobility Gateway stores subscriber profiles based on received and derived information while mapping and transferring information between GSM and TDMA/AMPS networks. The subscriber profile is then available in the Mobility Gateway and can be sent to serving VLRs without accessing the HLR each time. When the profile of a TDMA subscriber changes in the subscriber's HLR while the subscriber is roaming in a GSM network, the serving GSM VLR is notified (and the Mobility Gateway transparently updates its record). Figure 3 illustrates the

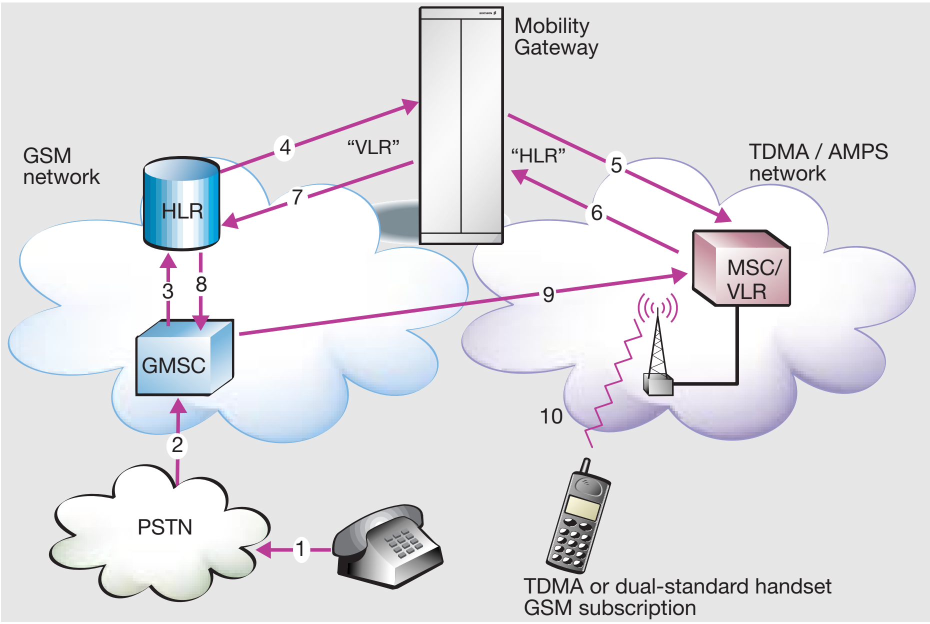

Figure 3
Call delivery to a GSM subscriber roaming in a TDMA/AMPS network.
Key:
1, 2 = Call
3 = Send routing information invoke
4 = Provide roaming number invoke
5 = Routing request invoke
6 = Routing request return result
7 = Provide roaming number result
8 = Send routing information result
9 = Call delivery (voice trunk)
10 = Mobile terminal call setup

scenario in which a call is delivered to a GSM subscriber roaming in a TDMA/AMPS network.

The roaming GSM subscriber is reached by calling his or her directory number (mobile station ISDN number, MSISDN). Assuming the call comes from the public switched telephone network (PSTN), it is routed to the gateway mobile switching center (GMSC), whose task is to interrogate the subscriber's HLR in the home GSM network to determine how the call is to be routed. Essentially, this involves asking the HLR for a routable number to which the call can be delivered. In this example, since the GSM HLR previously received an *update location* message from the Mobility Gateway that serves as a GSM visitor location register (VLR), the HLR initiates a *provide roaming number invoke* message to the Mobility Gateway. The Mobility Gateway then initiates conveyance of the ANSI-41 equivalent message, which is called *routing request invoke*, to the "real" serving MSC/VLR in the TDMA/AMPS network. The response to the routing request, which contains a routable number, is translated and sent back to the GSM HLR and transferred to the GMSC. With this information, the GMSC can de-

BOX A, ABBREVIATIONS

AC	Authentication center (TDMA)
AMPS	Advanced mobile phone service
ANSI	American National Standards Institute
AUC	Authentication center (GSM)
CAS	Customer administration system
CORBA	Common object-request broker architecture
GMSC	Gateway mobile switching center
GSM	Global system for mobile communication
HLR	Home location register
ILR	Interworking location register
ITU	International Telecommunication Union
MAP	Mobile application part
MSC	Mobile switching center
MSISDN	Mobile station ISDN number (Note: the terms mobile station and mobile terminal are used interchangably.)
OA&M	Operation, administration and maintenance
PDA	Personal digital assistant
PSTN	Public switched telephone network
SCP	Service control point
SS7	Signaling system no. 7
TDMA	Time division multiple access (name of products and services based on the TIA/EIA 136 standard)
TMN	Telecommunications management network
VLR	Visitor location register
WAP	Wireless application protocol

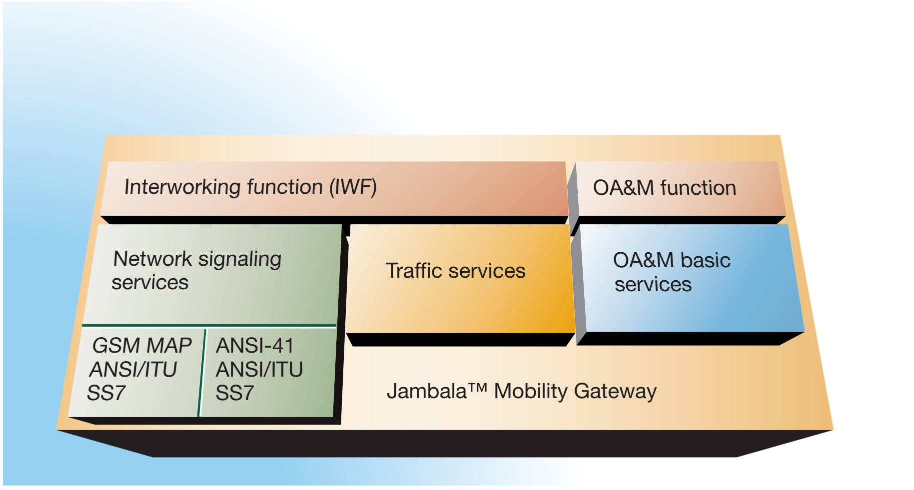

Figure 4
Components of the Mobility Gateway.

liver the call to the serving MSC in the TDMA/AMPS network.

Subscribers are thus able to have a single subscription and directory number for both networks. This can be achieved even if two different mobile terminals are used (one for GSM and one for TDMA/AMPS). Note: Dual-standard handsets offering GSM 1900 and AMPS 800 are already being used in certain markets.

For simplicity, the above examples have only shown the traffic scenarios of a GSM subscriber roaming into a TDMA/AMPS network. The Mobility Gateway also supports roaming in the other direction from TDMA/AMPS into a GSM network.

The Mobility Gateway consists of an interworking function that uses Jambala's network signaling and traffic services to convert application-level messages (Figure 4); for example, *update location to registration notification*. The interworking function also populates and maintains roaming subscriber profile data in messages received from the HLR

BOX B, JAMBALA OVERVIEW

The article, *Jambala—Intelligence beyond digital wireless*[1], introduced the new Jambala application platform. The following is a summary of the Jambala application platform.

The JAMBALA application platform is built on years of extensive research in open systems. The platform, which consists of Ericsson's new TelORB operating system/middleware and a multiprocessor hardware platform, offers the following features suitable for real-time, fault-tolerant telecommunication applications:

- a multiprocessor execution environment;
- a real-time, object-oriented execution environment;
- a fault-tolerant, real-time, memory-resident, object-oriented database;
- multiprocessor database distribution;
- software fault tolerance through application distribution;
- zero-downtime software upgrade;
- zero-downtime hardware upgrade;
- a TMN-based OA&M model;
- a CORBA 2.0-compliant interface for interoperability;
- support for C, C++, and Java applications;
- off-the-shelf hardware components;
- *N+1* hardware redundancy;
- geographical redundancy; and
- application platform resource scalability.

Automatic software error recovery
The execution environment provides mechanisms for handling faulty code and erroneous data that can lead to execution failures. These mechanisms ensure that execution failures are automatically corrected or terminated without affecting the operation of the network node. This is achieved by terminating individual processes rather than letting them hang.

Data fault tolerance and redundancy
All data is replicated; thus, if a processor goes down, all data is accessed from its replicate. Once the processor is rebooted, all the data is re-transferred.

On-line backup
The application data, which is stored in the database, is log-marked for on-line backup at regular intervals. Backups can be performed automatically by the backup scheduler or be initiated manually by a system administrator. When backup is initiated, application data is copied to disk and sorted into files in a backup archive partition of the file system. The hardware platform configuration is scaled to eliminate the effect of backups on application performance if additional hardware resources are used.

Adaptive hardware configuration
When a processor board is added to the platform, the platform's configuration manager automatically reallocates its data and processes to the new processor, according to the platform's configuration data. The configuration manager monitors the platform's processors and triggers the appropriate alarms, should a failure occur. It also attempts to recover the processor if a failure is detected. Recovery involves the automatic reloading of processor data and processes from replicas kept on other processors.

Smooth software upgrade
Upgrading software does not require any system downtime; the new version of the software coexists with the incumbent version during software upgrades. The platform allows for the concurrent execution of both old and new software in the same processor at the same time. All software processes that have to be executed while an upgrade is being performed are allowed to continue using the old software, while all new processes are directed to the new software.

***N+1* hardware redundancy**
Redundancy exists in signaling links, Ethernet switches, O&M processors and all other hardware. Therefore there is no single point of failure.

Hot-swappable hardware replacement
Hot-swappable hardware replacement allows for the smooth replacement of any hardware component. Hardware can be swapped without affecting the system, thereby eliminating the need to turn off the power.

Geographical node redundancy
Geographical node redundancy allows a stand-by Jambala node to be deployed in a different area. The secondary node is capable of assuming the primary node's functions in the event of an active node failure, thereby ensuring that the faulty node does not have any impact on overall network performance.

and serving MSC/VLR. Authentication messages are passed from the Mobility Gateway to the appropriate authentication center functionality for the roaming subscribers. The authentication centers, TDMA AC and GSM AUC, are provided with the Mobility Gateway and co-located with it on the Jambala platform. Several other advanced subscriber services, such as message waiting notification and short message service (SMS) are also supported through the Mobility Gateway when subscribers roam into the other type of network.

The Mobility Gateway is a pure signaling node, meaning that no voice trunks are connected to it. The two signaling systems involved are the ANSI SS7 and the ITU SS7 (formerly called C7). It is possible to utilize all four signaling and protocol combinations or any subset thereof on the same Mobility Gateway node:

- GSM MAP over ITU SS7;
- GSM MAP over ANSI SS7;
- TDMA ANSI-41 over ITU SS7; and
- TDMA ANSI-41 over ANSI SS7.

The Mobility Gateway also includes an operation, administration and maintenance (OA&M) function that uses Jambala's basic OA&M services to give the operator or customer administration system (CAS) the necessary capabilities to operate, monitor, and control its operation.

Other Jambala applications

The Mobility Gateway is one of many applications developed on the Jambala application platform. A TDMA HLR and an authentication center have already been implemented. A TDMA service control point (SCP) is also being developed to offer intelligent network (IN) services.

An HLR is a database that handles subscriber data, which includes the service profile, location information, and activity status. The HLR also passes information on the subscriber and the subscriber's location to other network elements. An authentication center is the network node required to authenticate mobile terminals. An SCP contains wireless IN service programs that allow the operator to deploy customized services quickly. The software resident in the SCP functions as an interpreter for executing service programs.

Furthermore, a wireless application protocol (WAP) gateway is being developed. The WAP gateway is a network node that serves as a bridge between the wireless network and the Internet. It converts and optimizes Internet information to meet the unique constraints of current wireless transport and devices such as smart phones and personal digital assistants (PDA).

Multiple application support

The Jambala platform supports many different applications that run concurrently on the same Jambala node. For example, it is possible to run the Mobility Gateway application concurrently with an HLR application. Indeed, there are no implicit limitations to the number of service offerings that can be run on the same platform. Limitations, if any, are indirectly dictated by traffic patterns (the number of transaction requests) and data use (memory capacity).

Conclusion

Ericsson's Jambala Mobility Gateway extends the boundaries of domestic and international roaming by allowing inter-system roaming—by means of the interworking location register functionality—between GSM and TDMA/AMPS networks.

The Mobility Gateway does not impose any modifications on individual network components, such as HLRs and MSC/VLRs in current GSM and TDMA/AMPS environments.

The Mobility Gateway, which is a pure signaling node, consists of an interworking function that uses Jambala's network signaling and traffic services to convert application-level messages. Messages implemented in the Mobility Gateway conform to TDMA/AMPS and GSM standards. The mapping of MAP and ANSI-41 protocols allows for the exchange of information needed to provide basic mobility management across different networks. Consequently, the protocols and interfaces associated with service delivery in different networks begin to look increasingly similar, even though the physical network elements are different.

The Mobility Gateway uses Jambala's basic OA&M services, which gives the operator or customer administration system the necessary capabilities to operate, monitor and control its operation.

The advantages of the Jambala application platform are optimum scalability, modularity, performance and cost-effectiveness.

REFERENCES

1 Jones, F.: Jambala—Intelligence beyond digital wireless. Ericsson Review Vol. 75(1998):3, pp.126–131.