University College London
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MSc in Telecommunications

Intelligent Networks and Services

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Contents

1 Introduction

Digital cellular mobile telephony networks are already a story of business success. The number of subscribers has soared to hundreds of millions and coverage is coming to reach universal scale. In the two dominant markets, US and Europe, the underlying network technologies are different. The European Telecommunications Standards Institute (ETSI) has developed and standardised the Global System for Mobile Telecommunications (GSM), which has been adopted by many network operators within and outside Europe. In the US and some other countries, there have been deployed networks using Time and Code Division Multiple Access (TDMA and CDMA), and, recently, GSM networks, though not using the same frequencies as the European standard.

One of the main reasons for the success of digital wireless mobile networks, was that they were designed to support *roaming*. Subscribers can still be reached under their number and make calls when visiting regions distant than the one they initially subscribed, provided the network technology is compatible, and there is a roaming agreement between the visited and the home network operators. However, with the current architectures, they cannot access the network operator specific value added services, when not in the range of their Home Public Land Mobile Network (PLMN).

The increasing customer awareness on telecommunications, including Personal Communications Services (PCS), pulls the demand for availability of advanced services to higher levels. In wireline networks, the Intelligent Network (IN) architecture delivers such services in a call-and-request based way. However, the requirement for terminal mobility in PCS, makes the application of IN slightly different, as services might be requested while the subscriber is not involved in a call. The two approaches to this application are Customised Applications for Mobile Enhanced Logic (CAMEL), developed by ETSI, and Wireless IN (WIN), proposed by American bodies.

In this document, main focus will be given to CAMEL and GSM networks. Some differences with WIN will be highlighted in the following section. It is worth mentioning that the goal for both approaches is to offer an open platform where customers will benefit from service providers' competition, and operators will benefit from increased usage of the network.

2 CAMEL Architecture and Business Drivers

2.1 GSM Overview

The GSM standard introduced many innovations in its network architecture, by incorporating research results from European institutes. Some of its main components and features that play significant role in the CAMEL architecture are summarised below [1].

- *MS* The mobile station consists of the handset and the Subscriber Identity Module (SIM). The SIM is a smart card uniquely identifying the subscriber's account number independently of the equipment used. Its adoption fostered competition among equipment manufacturers, and cheaper equipment prices were achieved.
- *BSS* The Base Station System is the physical equipment providing the radio coverage of a cell.

- *MSC and GMSC* The Mobile Switching Centre carries out the switching functions for all the MS located within its area. The Gateway MSC is providing the interface of GSM to the fixed Public Switched Telephone Network (PSTN).
- *VLR* The Visitor Location Registers are databases located in the MSCs, and holding information needed to handle call setup and reception, and MS location within the MSC range.
- *HLR* The Home Location Register is the database responsible for the mobile subscriber's records. It holds information related to basic and value added services, according to the subscriber's profile. It also stores the current location information of the MS, which is retrieved by the VLR. Communication with the VLR is done via SS7 Mobile Application Part (MAP) messages.

Typical GSM supplementary or value added services include call forwarding and diverting to other fixed or mobile terminal, voice mail, data and fax service, emergency call service, call screening, prepaid card, and detailed billing. Users subscribing to GSM and fixed networks can combine the services of both, provided both operators and the regulator agree. Some operators offer Mobile Virtual Private Networks (VPN) and mixed GSM/DECT packages to corporate customers [2]. The availability of these services can be extended outside the Home PLMN with CAMEL, as shown in the following paragraph.

2.2 CAMEL Phase 1

The first phase will support roaming of a subset of the IN Capability Set 1 (CS-1) services, particularly those applicable to mobile networks. Such include short numbering, which is a subset of mobile VPN, call screening and time and location dependent call forwarding [3]. In Figure 1 the integrated approach is depicted, an alternative would be to have standalone Service Switching Points, not integrated in the MSCs.

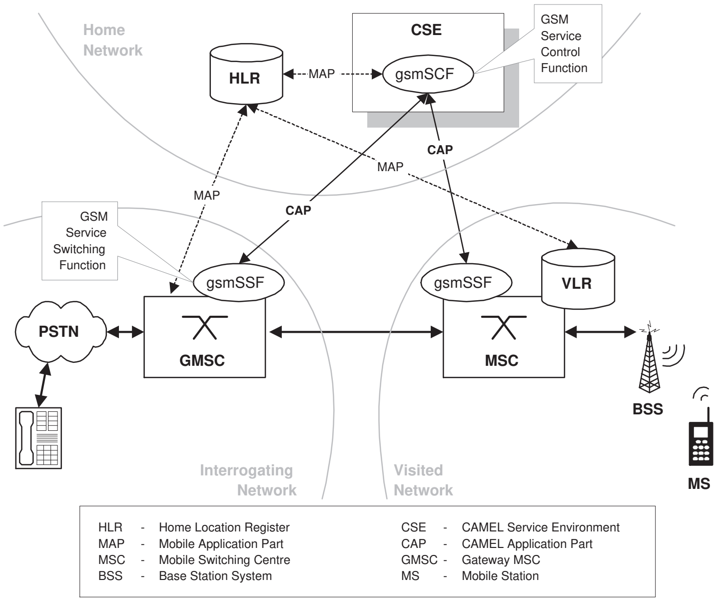

Figure 1: CAMEL phase 1 functional architecture

As shown in Figure 1, CAMEL capability is added to the network without major modifications to the classic GSM functional entities and communication protocols. The new network *evolves* from the old one, by adding a service switching and a service control function and by defining a new protocol stack, CAMEL Application Part (CAP), for their communication. CAP is based on the core ETSI Intelligent Network Application Part (INAP). The service logic resides at the CAMEL Service Environment (CSE).

The HLR stores the Originating and Terminating Camel Service Identifiers (O-CSI and T-CSI) for every CAMEL subscriber. The CSI contains fields identifying the service logic, the address of the CSE to be contacted, and parameters controlling the call handling, for example, identifying detection points on which service triggering will take place. The O-CSI is relayed to the VLR when a CAMEL subscriber is visiting the corresponding network. The O-CSI or the T-CSI are transferred to the GMSC as well, as shown in the scenarios in the following paragraphs.

The CSE should know the current status of a CAMEL subscriber from time to time, so as to handle incoming service requests. At this point, the difficulty of applying the fixed IN concept to mobile networks surfaces. Although there is no call in progress, the CSE should be updated with the appropriate subscriber records. This is accomplished by the Any Time Interrogation (ATI) procedure, as shown in Figure 2.

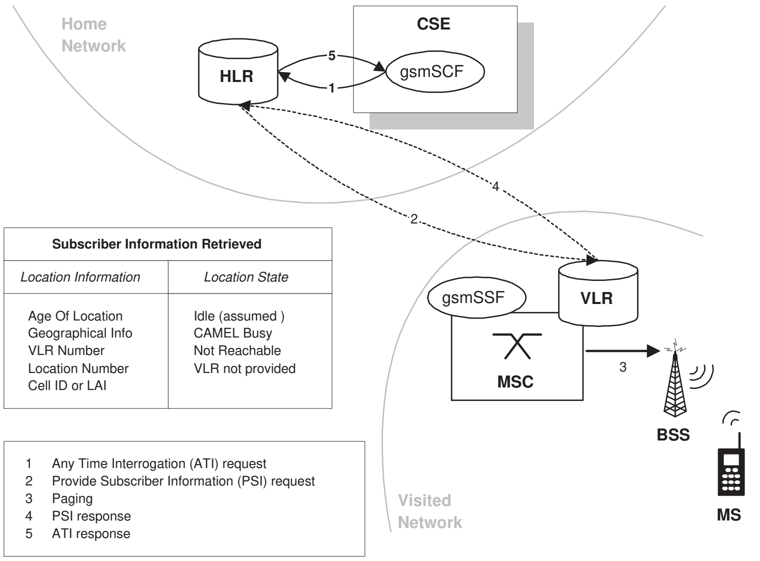

Figure 2: Any Time Interrogation sequence diagram

2.3 Roaming Scenarios

2.3.1 Mobile Terminating Call

The sequence of messages exchanged during a call from the PSTN to the roaming CAMEL subscriber is shown in Figure 3. Messages 2 and 3 are executed normally under classic GSM, but in the case the called party is a CAMEL subscriber, the HLR attaches the T-CSI to its acknowledgement. The GMSC then knows it has to suspend the call and consult its Service Switching Function (gsmSSF), which will establish communication with the CSE according to the parameters contained

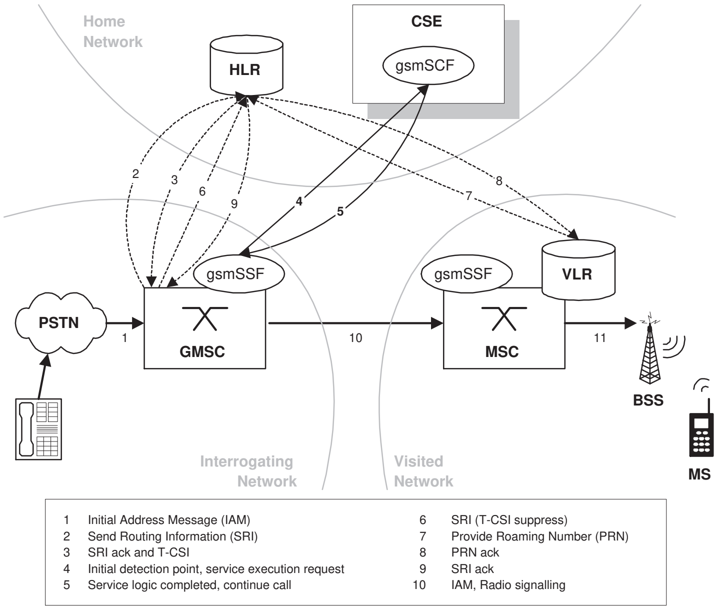

Figure 3: Mobile terminating CAMEL call sequence diagram

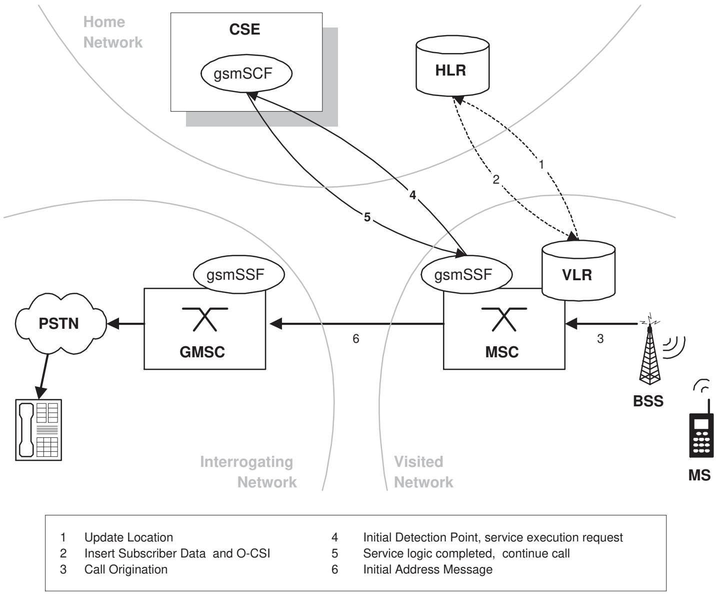

Figure 4: Mobile originating CAMEL call sequence diagram

in the T-CSI. After service execution, the CSE responds with a continue, conditional continue, redirect, or release signal. In the scenario depicted, a successful call to the roaming subscriber takes place.

2.3.2 Mobile Originating Call

In order to make use of CAMEL for a mobile originated call, the Visited MSC should be informed that the calling party is a valid CAMEL subscriber. This is accomplished with a MAP dialogue between the VLR and the HLR; the latter responding with a slightly modified PSI record, containing the O-CSI. When the CAMEL subscriber requests service, the visited MSC suspends the call, notifies the CSE, and only resumes control after its response. The action to be taken depends on the CSE response. The procedure is depicted in the sequence diagram of Figure 4, which shows a successful mobile originated call to a PSTN subscriber.

2.4 CAMEL Phase 2

The second phase of CAMEL will be a superset of the first. It will provide, among others, support of Specialised Resources (gsmSRF) via integrated or standalone Intelligent Peripherals, as depicted in Figure 5. With this function, voice dialling and voice guided services will be possible. The SRF could reside to the Home PLMN only and accessed via CAP messages to the SCF, or, more efficiently, it could be present in all the involved networks. Access to the SRF could take place at any time during a mobile originated/terminated call.

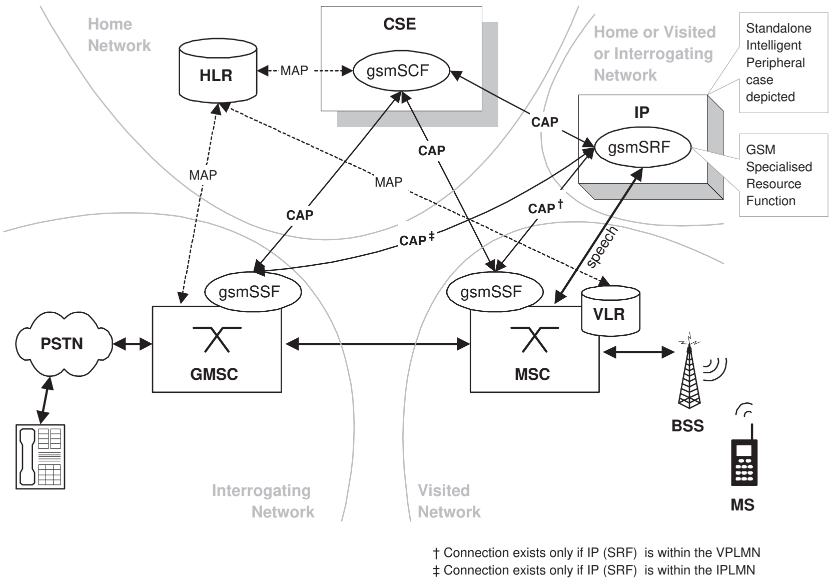

Figure 5: CAMEL phase 2 functional architecture

Other services supported by the second phase are charge-related services, such as Advice of Charge (AoC), online charging, pre-paid cards. Yet another class of services includes security related and fraud control services, which are very important for the network operators.

2.5 Comparison with WIN

The main difference between the CAMEL and the WIN architectures is the objectives of their designers. In CAMEL, there was a relatively advanced, semi-intelligent network as GSM, which is gradually enhanced by the phased approach adopted by ETSI. WIN, on the other hand, was developed in a more close to the ultimate goal of fixed-wireless integration way. This becomes obvious by inspecting Figure 6, which is a proposed WIN architecture with a standalone HLR (SHLR).

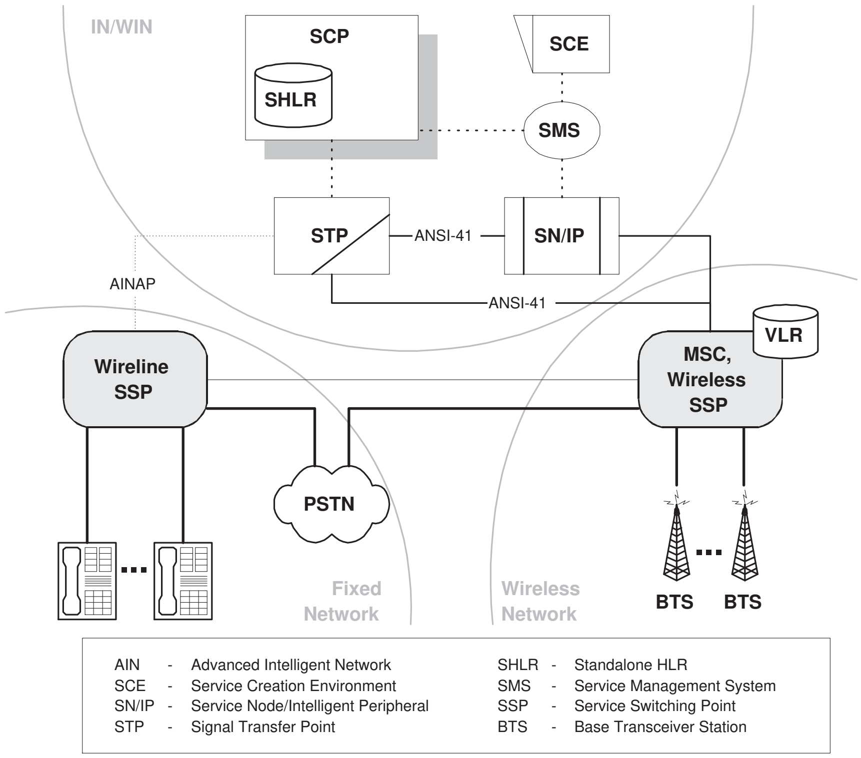

Figure 6: Wireless Intelligent Network architecture, source: [4]

The distribution of the functional entities in CAMEL and WIN is nearly the same, as both architectures use the international IN standards as guideline. However, ETSI designers declined some of the IN components as no functional in the context of GSM, while WIN maintains all the basic AIN components, from physical elements, to functional elements [4].

CAMEL may be a solution for the European market, where there is unanimity on the network technology used, but in the segmented American market a more revolutionary approach as this of the WIN could prove more efficient.

2.6 Business Drivers

CAMEL standards are updated concurrently with ITU-T IN Capability Sets (CS), leading to GSM-IN convergence. Therefore, the business drivers for CAMEL are the same as those for IN.

In the design of the architecture, business related factors as minimisation of the upgrade costs and of the impact on GSM classic services were taken into account, resulting to the phased approach. Some of the business related benefits of introducing IN to GSM networks for each of the parties involved in the network are summarised below.

Users could enhance their reachability, and boost their business interests by tailoring the advanced services services according to their needs. At the personal level, services as call screening, and enhanced call forwarding according to time and location are extremely attractive. Corporate subscribers will highly appreciate (and buy) services as mobile Virtual Private Networks, mixed mobile and CTI solutions, and hybrid GSM/DECT networks.

Service providers have an opportunity to provide an increasing range of services in a competitive environment, without the huge cost of equipment ownership. CAMEL enables rapid service development and deployment, eases service maintenance by reducing operating costs, and encourages service differentiation, broadening the market for value added services. There is also an opportunity for non-telecommunication companies, as those in the software industry, to provide supplementary services.

Network operators could exploit the open multivendor architecture of CAMEL, and cut equipment and service provider costs significantly. With CAMEL, network operators selectively establish service roaming agreements with partners, imposing tighter control on their subscribers. Flexible charging enables the use of prepaid cards and other facilities outside the Home PLMN, increasing the revenue of the home operator. Fraud control and security ensure the minimisation of revenue leakages and system integrity hazards.

Equipment manufacturers could benefit, as provision of advanced services in the network will be a market pull for more advanced mobile terminals in the short term, and network and signalling equipment in the middle-long term.

3 CAMEL Implementation

3.1 Problems and Arguments

Since CAMEL is the vehicle for the convergence of GSM and IN, there is a clear long-term advantage for those implementing services using CAMEL architecture. However, there are arguments to the immediate adoption of such an architecture, since roaming services increase significantly the signalling between the GSM and CAMEL nodes. According to this point of view, the signalling capacity in GSM is not adequate for large scale CAMEL deployment, and operators should stick with the current technology for value added services. Enhanced roaming agreements using proprietary protocols, could offer CAMEL-like features.

Such scepticism is helping to identify possible pitfalls and weaknesses of the CAMEL architecture. Performance bottlenecks can be located at the HLR, which, has to deal with much more information, such as CSI, and has to handle with at least double the requests than that it is handling in GSM, as shown in Figure 3. Upgrading the databases may be the solution, but the signalling capacity problem remains.

Another potential bottleneck is in the CSE, in which the service logic is executed. Some services may require a lot of resources, and dealing with all of them simultaneously could lead to large delays or even to request rejection. There is also the problem with ATI requests, which should be kept to a reasonable frequency, as they increase the load on both the CSE and the HLR.

3.2 What CAMEL responds

The advantages of the centralisation of the service mechanism compared to peer-to-peer agreements are basic arguments for the CAMEL-IN concept. First, the time from the conception of a new service to its final deployment, is dramatically reduced. Second, the management and control of centralised resources is much more efficient. Third, centralisation enables the access of advanced services from everywhere, and ensures that the outcome of the service execution will be the expected.

The signalling capacity problem is definite in GSM, but this was taken into account in the development of CAMEL. First, the phased approach was selected for the deployment of CAMEL services, allowing for a trial period of the technology. Second, CAP was developed as a subset of the INAP, eliminating any functionality not relevant to GSM, and keeping the protocol to a reasonable scale.

Of course, the main point CAMEL is stressing is the potential for delivering services, that would be extremely difficult to implement by using the current GSM infrastructure, and peer-to-peer roaming agreements. Such agreements, might work well for a small number of operators, but today's requirements are driving for global reach of all services. Furthermore, it is very difficult to enable multivendor environments in the service provision sector, with the current architecture.

4 CTI in Mobile Networks

4.1 Third Party CTI Overview

The third party Computer Telephony Integration (CTI) basic architecture is depicted in Figure 7 paralleled with IN, in order to illustrate the similarities of the architectures. That is the reason why third party CTI is sometimes called 'Private IN' [5]. The signalling connection between the computer and the telephone switch is usually a proprietary protocol, as the European Computers Manufacturers Association (ECMA) developed Computer Supported Telephony Applications

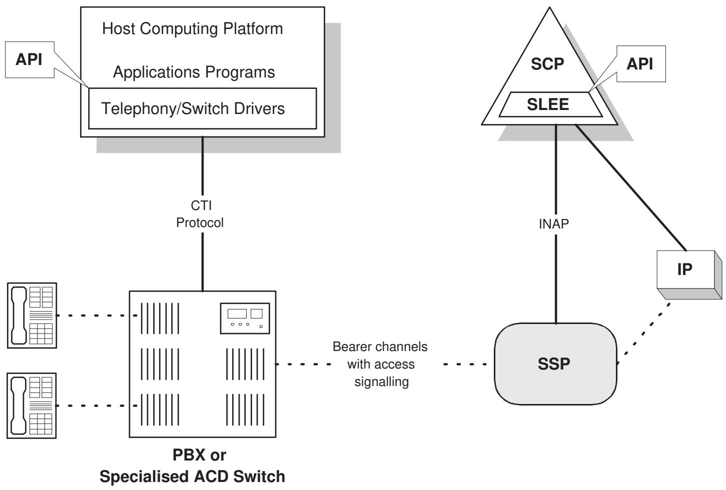

Figure 7: Third Party CTI and IN architectures, source: [5]

(CSTA), and ANSI's Switched Control Applications Interface (SCAI). These INAP-like protocol stacks provide capabilities which are very similar to the CS-1.

Between the communication protocol and the computer applications lies the Application Programming Interface (API). The *de facto* standard for third party CTI APIs is Novell's Telephony Server API (TSAPI). The computer hosting TSAPI could be connected to a LAN or an inter/intranet, thus being part of a client-server or other distributed architecture.

The primary services delivered by CTI systems include call screening, call routing by criteria, conference calls, call scheduling and reminders, voice dialling, calling line identity (CLI) presentation. The system is usually accessible via user-friendly, point-and-click interfaces.

Extending these capabilities, complex services can be built using the relatively easy to program general purpose computing platforms. Such a service is the presentation of data associated with an incoming call to the person who answers it, for example, when a customer calls in, customer records are automatically displayed on the sales representative's or the helpdesk assistant's screen. Another very important service is the unification of messaging for a user. Fax, electronic and voice mail are all stored into a common inbox. A very interesting service for large companies' telemarketing or helpdesk departments is virtual call centres, distributing incoming calls to geographically dispersed agents.

4.2 CTI and GSM

Such services as those mentioned above, could be supported by the current GSM architecture within the range of the Home PLMN. There has to be a direct interface of the PBX with the MSC, in a similar way to the one shown in Figure 7. With this connection, the PBX acquires SSF functionality, from the GSM network point of view. The signalling protocol used could be a version of MAP, and there has to be some kind of authentication of the mobile terminals requesting service through the PBX. This service could be offered as a value added service to large corporate customers by the GSM operator.

From the CTI point of view, the mobile terminal is seen as just another fixed terminal, and as far as it concerns mobile terminating calls all the primary services supported by the host computer, for example, incoming call screening, can be offered. If the mobile terminal has enhanced data display capabilities, as Personal Digital Assistants (PDAs) have, the unified messaging service can also be offered. However, for mobile originating calls, there has to be some kind of call suspending and detection point triggering in the MSC, which is very complex to be implemented with the current architecture. There are also unresolved problems when the subscriber is roaming. Some of these are addressed by CAMEL, as described in the following paragraph.

4.3 CTI and CAMEL

A possible combination of a CAMEL based GSM network and a CTI system, could be implemented by connecting the PBX to the gsmSSF function of the nearest MSC. In this case, they should talk in CAP. A basic service will then be installed in the CSE, providing authentication of the mobile user who is subscribed to both the corporate network and CAMEL. The detection points in the user's basic call model will remain the same, but when a valid advanced service is required, the CSE will forward it automatically to the CTI SCF. With this solution, there is no intervening in the

CAMEL architecture, therefore, all services are supported even when roaming outside the Home PLMN.

Due to the extra signalling required and the delay introduced by the decentralisation of the service logic, it is not practical to move basic CAMEL procedures as ATI to the periphery. Some classic GSM services, as paging, could also be offered by the network operator's infrastructure. However, client specific advanced services, as corporate private numbering plan and mobile VPN, conference calls, calling name and associated data presentation, could be supported from the CTI system. The computer in the periphery could also handle advanced personal communication services, as unified mailbox, call screening and enhanced call redirection, reminders and scheduling.

Roaming does not hinder access to these services, since CAMEL ensures the delivery of requests to the CTI SCF. CAMEL also facilitates the correct charging and operator control of such services, unlike classic GSM. Decentralisation enables tailored solutions for corporate customers, taking the burden off the CSE.

However, there are more drawbacks apart from the increased delay and signalling volume required. Subscriber related drawbacks are the need to develop and maintain complex services in a very low level, in most of the cases requiring major upgrades of the equipment and software of their CTI solution. Network operator related drawbacks are possible security and network integrity pitfalls, since the subscriber is given privileged access to the infrastructure. In such a low level, bad behaviour of service code and unexpected service interactions could cause great damage to the telecommunications service.

5 Conclusion

The key word in the communications world is *convergence*. Particularly, convergence of all the telecommunications technologies with respect to the services offered to the subscriber. The IN architecture provides the means to accomplish this. CAMEL is just another instance of an interim technology, adapting an existing technology, in particular GSM, to the common future IN platform.

What is really boosting CAMEL, is the large demand from all parties involved to the GSM network. As all of them will benefit from its deployment, difficulties concerning modifications and upgrade of GSM infrastructure, will be easily overcome.

Mobile CTI is an example of what can be achieved with CAMEL. With CTI, the location of the network intelligence is blurred, some residing in the centre, and some in the periphery. This is a proof that the standard can cater even for solutions which are far from its basic centralisation concept.

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