

3G service control

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The huge investment in 3G mobile licences is an incentive to develop extra services above and beyond basic telephony and data services. Service control provides an infrastructure to deliver services, particularly those of a real-time nature. This paper focuses on the progress in developing service control in the context of the 3GPP Release 4/5 network. To achieve the objectives for service evolution, mass service development and cost-effective services, three technologies are being pursued for service control. These are CAMEL, APIs and SIP service extensions.

1. Introduction

Service control is about controlling network resources to provide services in real time. This paper concentrates on the opportunities for service control in future mobile, third generation (3G) networks. In particular, the focus is on the all-IP network, defined by the 3G Partnership Project (3GPP) [1] as the Release 4/5 network.

The subject is covered in three parts. Firstly, the business approach to services and the network architecture for the Release 4/5 network are discussed. Secondly, the intelligence strategy being used to direct the service control work is described. The last section brings together the preceding parts and describes how they are being pursued for service control in Release 4/5.

Service control encompasses the evolution of today's intelligent network, but also embraces the many new ways of providing real time services. This includes terminal capabilities and IP technologies. It is used to refer to the software and signalling messages that control how a service functions above and beyond the ability for two parties to communicate using voice or data.

Mobile companies have invested hugely in 3G licences. To obtain a profitable return on this investment there must be added value in terms of applications and services. It is unlikely that customers will pay the corresponding revenues just for voice. The suite of services above and beyond basic voice will include multimedia (content), mCommerce, information and entertainment, conversational services, and the integration of combinations of these into complete solutions. There is a huge opportunity in non-voice 3G terminals — everything from personal digital assistants, MP3 players, car-management systems and vending machines.

One of the desired concepts of the UMTS/3G network is the virtual home environment (VHE) [2]. VHE should allow a customer to access their services via different network interfaces, different terminals and while roaming. The concept of a personal service environment allows users to configure the properties and delivery of the service from a common, home-based, profile. Service control in 3G sets out to provide the flexibility and configurability to support the VHE concept.

The terms CS domain, PS domain and IM domain are used extensively in this paper:

- CS domain is the circuit-switched signalling and switching network based on GSM,
- PS domain is the packet-switched data services introduced into GSM networks using a standardised overlay general packet radio service (GPRS) network,
- IM domain is the IP multimedia (IM) domain and includes GPRS enhancements for the support of real-time IP-based voice and data (multimedia) services.

Service control is one of the least developed aspects of the Release 4/5 architecture. Therefore, while this paper builds upon the network architecture that is being developed in the 3GPP standards, the majority of the service control concepts discussed here represent proposals that have yet to be agreed in the standards. These concepts draw upon supplier directions and developments in bodies other than 3GPP (e.g. IETF [3]) — hence there is some justification for them being proposed.

2. Background

Before the future of service control can be defined it is useful to review the current technology for providing service control to see what lessons can be learnt. It is also essential to consider what the future mobile network will look like to know which resources and components the service control will be acting upon. Most importantly there needs to be a clear idea of what services are required and the level of demand to be met.

2.1 Appraisal of intelligent networks

Mobile networks have built upon the work of intelligent networks (IN) [4] from the fixed networks and developed their own variation called CAMEL [5]. CAMEL provides a means to link into the set-up or management of calls in the mobile switching centre (MSC) and control the operation of the call. The GSM CAMEL feature has been developed so that operator-specific services can be supported for customers who roam to foreign GSM networks.

IN in the fixed world is mature and is currently responsible for delivering a range of profitable services; but IN has never really lived up to its promise of providing an efficient, rapid mechanism for reusable services. Many services now exist, indeed in BT's UK fixed network there are many IN platforms providing a complete raft of services. IN, in general, has been complex to implement. This is in part due to the disparity in PSTN implementations, which has meant that while typically the majority of an IN service is standard, some part always needs some form of specialist development to the switch or interface and this often delays service roll-out and increases the cost. Mobile networks are more standardised and hence should not suffer from the same problems.

IN distributes previously switch-embedded functions across network components allowing open procurement for different components. Thus service execution and interactive voice response (IVR) platforms may be bought separately from switch manufacturers and from suppliers that are more computing oriented. However, this distribution has introduced complexity due to interworking between switch features and the IN, and a distributed service design which necessitates expensive non-circuit-related signalling networks.

The technology that is used in IN has attempted to be more IT in nature, but has always been particular to the telecommunications industry. Consequently, while the concepts are similar, the telecommunications world has developed its own niche solutions, making them expensive.

In summary IN/CAMEL solutions have been a success in providing a means to realise services in 2G and fixed networks. However, while the concepts of open control

interfaces and interaction with call set-up are reusable in 3G networks, service control needs to be less specialised in the technologies it uses so that there is an improvement upon IN.

2.2 Future network architecture

The focus for this paper is on the 3G Release 4/5 (from the 3GPP standards) networks that are expected to be deployed circa 2004. Bale and Fuller [6] describe the IM domain for voice in a Release 4/5 network. This network will be a VoIP network with managed quality of service, using the GPRS nodes (SGSN, GGSN) to provide mobile IP access to an IP core.

The VoIP network, as standardised in 3GPP, will use the session initiation protocol (SIP) [7]. SIP is an open Internet protocol for session initiation, following the model of HTTP (similar model and message structure). It is enabled to provide mobility, and aims to deal with the signalling associated with establishing sessions between end devices. Once a session is established then many different types of media exchange may be used.

3G operators will continue to offer GSM (2G) solutions for a considerable time, partly because of the investment that has been put into 2G and 2.5G (includes WAP and GPRS), and because 2G will still be required to provide complete geographical coverage.

New radio technologies in the UTRAN (GSM EDGE and UMTS WCDMA) mean that from a radio perspective roaming is becoming more complex. New core network technologies, such as PS and IM, mean that, from a service control perspective, roaming is also becoming more complex. Continuing the success of roaming achieved in GSM is a significant challenge and will be dependent on continued effort by operators and manufacturers in creating the necessary high-quality standards for UMTS.

The main emphasis of this paper is on mobile networks but there are still many benefits that accrue both to the customer and to a combined fixed/mobile network operator, such as BT, from attempting to share common infrastructure components between networks. Seamless services have been much discussed but the concept runs into problems due to detailed network disparity, different network governance, and product portfolios. While not necessarily attempting to use the same network components between fixed and mobile networks, it is clear that there are many similarities in the technologies adopted by the fixed network.

As forecast by Ovum [8], by 2005 a quarter of the calls that would have been made on fixed lines (today) will instead be made by mobile. Telephony is currently the most important real-time service and is the most demanding of

service control technologies. Hence, with telephony moving to mobile networks, the demand for service control is the greatest in mobile networks.

2.3 What services?

Service control is required to provide services — so what are the real-time services required in 2004?

Within BT a number of customer scenarios have been identified (e.g. for the youth and SME markets). These attempt to provide a description of how the future 3G network will be used in terms of representative individuals for different market sectors. To fulfil these customer requirements, three service categories can be identified which contribute to delivering the scenarios:

- inherent from the network (connectivity, addressing, mobility, location, supplementary services),
- applications (distinction here is for non-real time, e.g. browsing, games, eCommerce),
- real-time services (pre-pay, call/session re-routing, call queuing, conferences).

It is the provision of the real-time services and the integration of these with the applications and network services where service control has a role.

The objective is not to predict all the individual services that will be required and directly design the network to deliver those identified. Instead the emphasis is on establishing the type of resources, data models, control interfaces and performance that will be required from the service infrastructure.

While the services introduced above are oriented primarily towards the customer, there are other network capabilities for which the network provider will use service control. These include routing optimisation, internetwork call accounting and operator/customer service.

2.4 Wholesale at every level

Given the huge investment in 3G licences, there is some debate as to whether operators should open their networks to third party service providers or not. Keeping them closed means that operators singularly control the delivery of services and content — but will this approach allow customer demand to be satisfied and will it ensure sufficient network usage? It is unlikely that a single operator will be able to provide the transmission and radio infrastructure as well as all the rich content (and all pieces in the middle). Using a combination of owned services, partnered services and third party services will allow all customer requirements to be satisfied — from the customers you own, through the technologies you understand, to the customers

you did not know existed or market sectors and technologies with which you are not familiar.

IP networks are more open since the protocols available at the access are the same as used in the 'core', and, so long as physical access to the IP is available, a service provider is at far less a disadvantage compared to the network provider. However, if the network operator supports the service provider, it can provide more of the infrastructure that represents value-add than can be charged for.

For network operators to satisfy the wide range of customer demands it is preferable that they do not take a 'walled garden' approach to their networks — better to embrace the access to third party service providers to deliver the complete range of services. It is wise to construct the 3G network such that wholesaling (access by third parties) is available at every level, e.g. access to fibre, access to call control, access to applications or provision of content. This will ensure efficient utilisation of the network infrastructure. Service control is included as one of these levels. There are specific technologies that allow access to be provided to service control components, in a secure and managed way. These include the network API, Parlay (the variant specified by 3GPP), open services architecture (OSA) and the Java variant, JAIN. These technologies are discussed in more detail in Stretch [9].

Providing wholesale access as an afterthought is difficult. It needs to be considered when a network is designed and implemented — in this way the same interface can be used for retail as well as wholesale, capacity expansion is easier, and interfaces can be made sufficiently secure and appropriate for third party use.

3. Intelligence strategy

Over the past year an intelligence strategy has been put together within BT that defines how network operators can use their assets in IN, how they can adopt new service techniques given the changing nature of networks. The following subsections outline the strategy.

3.1 Evolution of IN

In the 3G network there will still be services offered today by IN platforms that will need to be continued. Customers will expect to see some services continuing to be offered by both the CS and IM domains. Hence services will naturally need to span the CS and IM domain. A good example is pre-pay — customers will not expect to have different credit accounts to deal with roaming between CS and IM domains, particularly when they have no control over where the domain coverage exists. Pre-pay is currently being implemented in many mobile networks via CAMEL, since it provides one of the most appropriate means of realising a secure implementation of pre-pay.

The evolution stage needs to be treated with great care. Any services evolved into the future network should be carefully selected, as there is a need to limit 'baggage' while providing the new service packages that are expected from UMTS.

3.2 IP service control

The clear focus of the strategy is to take advantage of IP as the underlying network technology and to use IP-oriented technologies to provide service control. In particular, this means looking at the way services are implemented using SIP. One of the most important attributes of VoIP is the separation of bearer control (media) from signalling control. This avoids one of the main restrictions of Signalling System No 7 (SS7) networks such as the PSTN. In CS networks, service nodes are a self-contained means of providing service control, but they suffer from the major cost penalty of having to trombone the voice circuits for the duration of the call, even if they only want to be involved in the call set-up phase. Many SIP service-control platforms can be involved in the establishment of the session with the eventual media stream only needing to be connected between the end terminals (or gateways). This optimal use of media streams and the simplicity of SIP signalling means that service platforms can be cascaded together with little cost or performance penalty for the duration of the call.

3.3 Service control is not just about voice

Service control provides flexible mechanisms to create and execute control of real-time services. Packet-based network elements now have interfaces that allow for control of them in real time — to control admission, quality of service and packet priority. In general, this capability can be termed policy control and can be implemented via protocols such as the common open policy service (COPS) [10]. Hence this part of the strategy is to combine the service control capabilities and apply them to the policy control interfaces, i.e. data intelligence.

3.4 Choice of technologies

To enable reductions in the cost and wider access to a larger development community, it is preferable to buy service solutions not from specialist industries such as telecommunications suppliers but instead from the much larger industry. To allow this to happen the technologies that are used to build the 3G network should be more compliant with the software industry. A simple test of this is to consider how many developers exist that can develop applications for SS7 interfaces compared to the number that can develop applications in Java and HTML. Given the move to an IP infrastructure, it is possible to use more software-industry-compliant technologies.

In the IM domain, the adoption of IP as a transport implies that there is no need for the specialist hardware (E1 interfaces) currently used for switches and IN platforms. While there is still a very demanding requirement for high

performance and availability, there is an opportunity to implement call servers and application servers on standard computing platforms and data centres or 'telecoms hotels' (see Young et al [11]). This has three potential implications for the 3G network:

- the adoption of a common platform to host telecommunications and Internet applications forces the two communities to share the same infrastructure, thus easing integration,
- the data centres provide network management (NM), provisioning and security facilities which will avoid the replication of separate telecommunications management systems — the current experience of implementing IN is that OSS and NM represent a significant cost, whereas operating from a common applications platform will allow these costs to be shared between the (data centre) users,
- many operators have data centres across the globe — by hosting a network component in a foreign country, it provides a mechanism to provide 'home' servers that are physically more local to visited locations, thus helping to reduce the cost and delay of returning signalling to a home environment.

3.5 Terminal intelligence

Mobile terminals are increasing in intelligence and computing facilities. Already, via embedded microcode, the SIM tool-kit, WAP and MExE (mobile station application execution environment) services can already run directly on the terminal. The service provider has the opportunity to implement services either via service control in the network or in the terminal. The real opportunity is to use the two together, leveraging the individual strengths.

4. 3GPP service control

The 3GPP Release 4/5 architecture, which delivers the all-IP network, identifies the need to link service control into the call control and GPRS components, but it has been the least well defined part of the architecture. This section describes some of the ideas being pursued in 3GPP to standardise the service control interfaces.

4.1 Service control in the CS and PS domains

CAMEL is the main standardised capability in the core network for control of operator-specific services when roaming. It is based on IN capability sets (CS-1/CS-2). CAMEL has been developed in phases, each phase adding new capabilities while retaining backward compatibility with earlier phases.

Figure 1 illustrates the CAMEL Phase 3 network architecture. CAMEL Phase 3 supports circuit-switched voice and data services at the gateway MSC (GMSC) (mobile terminated calls and unconditional forwarded calls) and visited MSC (VMSC) (mobile originated calls and

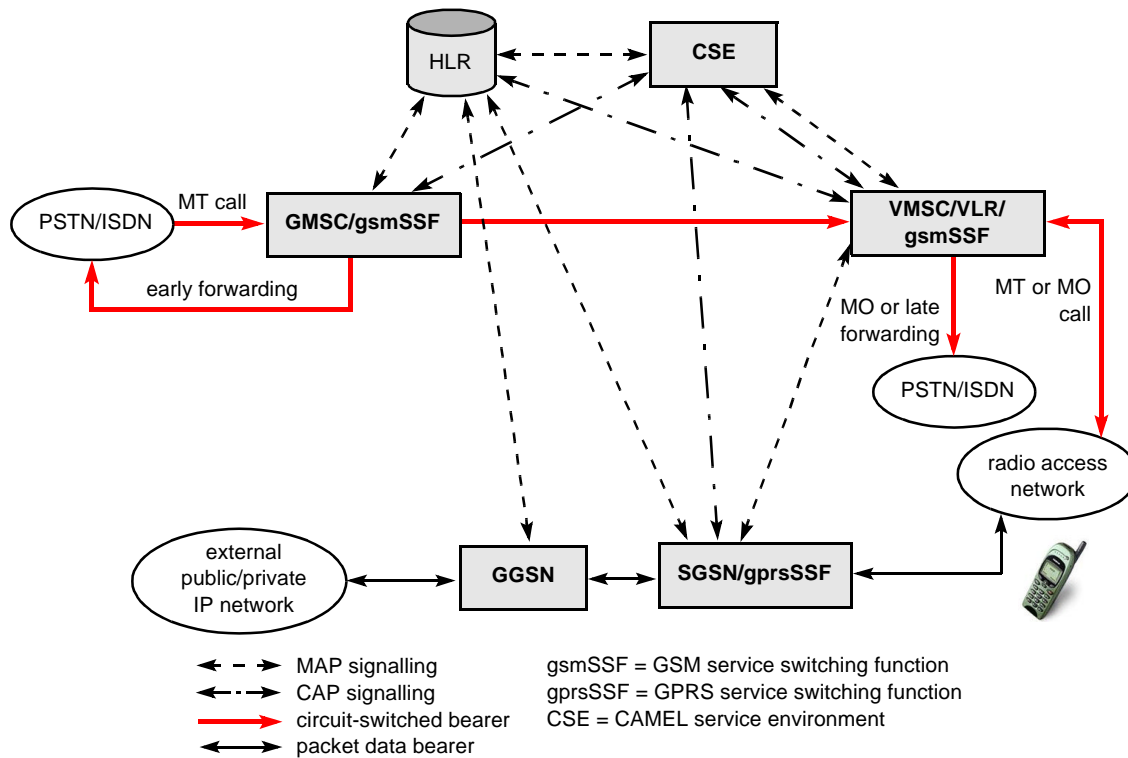


Fig 1 CAMEL Phase 3 network architecture.

conditional forwarded calls). Many different services can be controlled using CAMEL. Some of the most common services include location services, pre-pay, mobile VPN, and short code number translation services. CAMEL also includes access to a specialised resource function (gsmSRF) which provides user interaction mechanisms such as announcements and voice recognition (not shown in Fig 1).

Services in the PS domain are controlled through interworking with GPRS at the SGSN (gprsSSF). Services that can be supported in the PS domain include pre-pay, barring, and location services. The server has control of GPRS PDP contexts and GPRS attach/detach at the SGSN using CAMEL capabilities.

Access for third party service control is supported using a CSE-based API such as OSA.

4.2 IM domain network architecture

Figure 2 focuses on the architecture of the IM domain, illustrating key network functional entities and interfaces. This diagram reflects current thinking and so may not represent the final design.

The architecture in Fig 2 is depicted from the perspective of a mobile-initiated multimedia session. SIP signalling is used from the terminal through to the S-CSCF (serving call state control function) via the SGSN (serving GPRS support node) and GGSN (gateway GPRS support node). The GSNs are enhanced GPRS network entities based on earlier GSM specifications. The CSCF provides the call-control, resource-control and registration services.

The home subscriber server (HSS) is a database that can be accessed by the SGSN, GGSN, S-CSCF and multimedia applications server (MAS). The HSS may include HLR functionality so that IM domain customers may roam to GSM networks that do not support the IM domain.

The terminal must register with a CSCF known as the serving CSCF (S-CSCF), before network or third party applications can be accessed. The HSS will be used to store user profiles in addition to the location and registration data. The S-CSCF may be part of the home network or visited network. If it is part of the home network then a CSCF incorporating a proxy server is used in the visited network to route SIP messages to the S-CSCF.

The proxy CSCF is a SIP proxy server; however, the proxy CSCF must perform other functions not normally associated with a SIP proxy. The proxy CSCF must handle emergency calls, charging and resource allocation, such as access to media gateways. The proxy CSCF does not have any knowledge of the customer's identity.

4.3 Service control in the IM domain

Within the 3G Release 4/5 network the three most significant components from a service control point of view are the terminal, the CSCF and the HSS.

A user will want to access services from their home network and take advantage of any local services from the visited network. A network operator wants to offer services

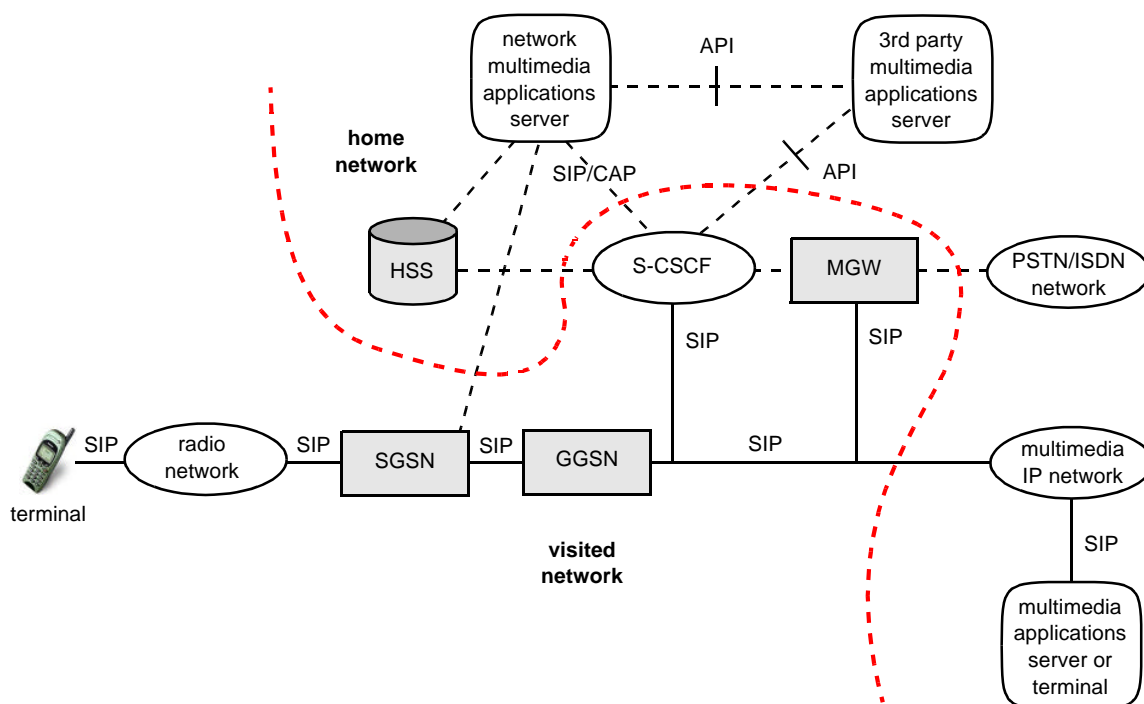


Fig 2 Simplified 3GPP network architecture for the IM domain.

to its own customers but there is also an opportunity to offer services to roaming customers. The combinations of how service control can be accessed from serving and proxy CSCFs is shown in Fig 3.

In Fig 3(a), the serving CSCF is in the home network and calls are triggered to the home MAS.

In Fig 3(b), the user has elected to use the visited CSCF as the serving CSCF but actually receives services from the home-based MAS. This intra-country network service control interface is currently being realised in 2G networks using CAMEL. This configuration would allow a user to dial the normal simple code to pick up voice messages, e.g. 901.

In Fig 3(c), the serving CSCF is in the visited network but the user elects to receive service from the local operator's MAS. This configuration could be used, for example, to bill all calls to a temporary credit account being used in the visited network.

In Fig 3(d), the serving CSCF is in the home network but the user is accessing services from the proxy CSCF. The proxy has no knowledge of the user, hence they cannot be profile based (although some form of profile may be received from the terminal — see section 4.7). However, there are many services that could be provided. For example, the simple service of 'find local restaurants' could be provided from the proxy — there would be little point receiving this service from the home network. In addition, this figure shows service control also being applied to the serving CSCF, and, with all these configurations, all combinations are possible.

In Fig 3(e), the serving CSCF is in the home network but the user receives services from a local MAS. The user is likely to be in the same network as the MAS but it could be that network/service providers make their services available, outside their network, irrespective of where the user is located.

As each of the options (a) to (e) in Fig 3 can apply to the caller or calling party, there are actually many combinations when the end-to-end call is considered, e.g. the calling party may be using configuration 3(a) while the called party is using 3(b). These configurations make no distinction whether the service is being provided by the network operator or by a third party (via a network operator).

4.4 Service control interfaces

The interfaces that need to be defined for service control are shown in Fig 4.

Given the requirements for the evolution of CAMEL, support for third party interfaces and the desire to exploit IP technology, the approach has been to adopt a flexible approach on the interfaces available and to support three different types of service control interface at the CSCF:

- SIP,
- CAMEL (although using IP as the signalling transport),
- application programmable interfaces (APIs).

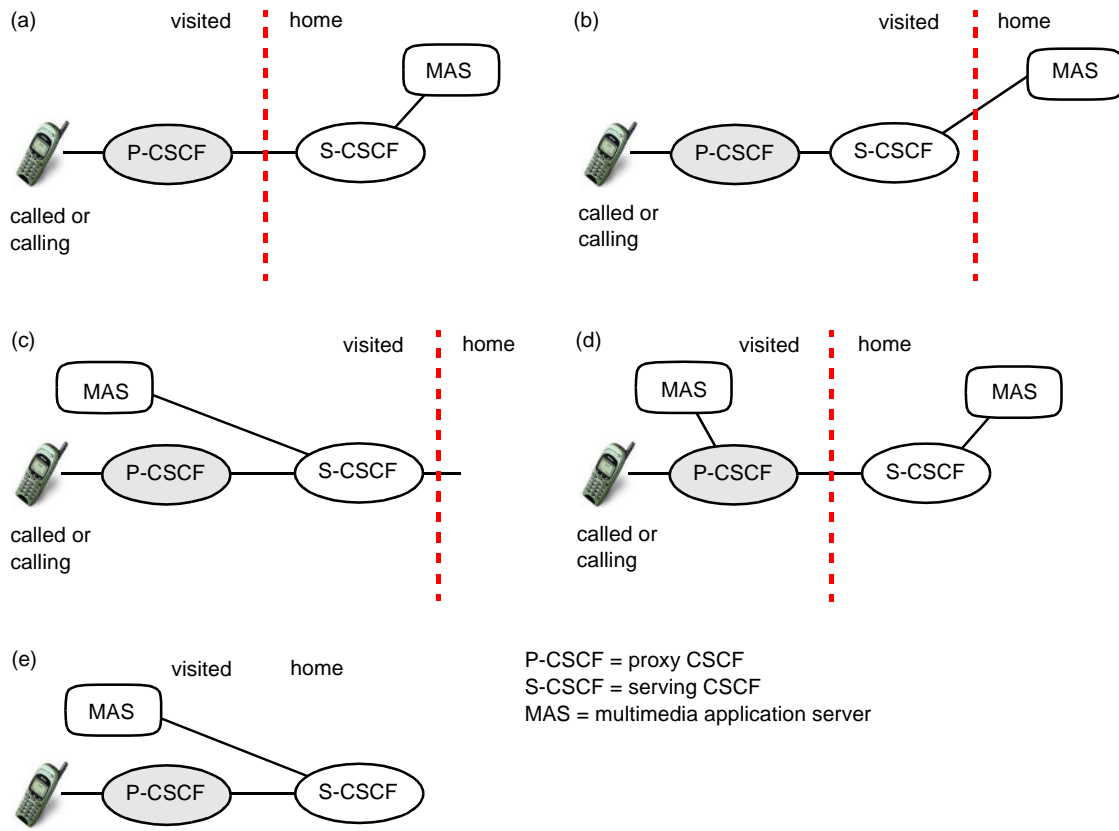


Fig 3 Configurations for connecting service control.

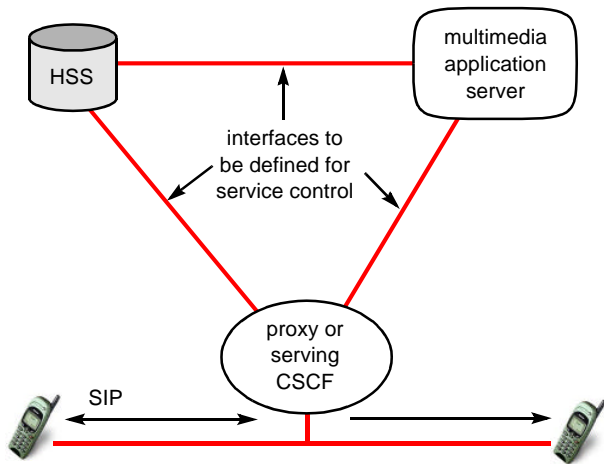


Fig 4 Key service control interfaces.

The implementation of these interfaces is not mandatory.

In order to support these service control interfaces some form of model of the CSCF is required that determines how these interfaces interact with the session set-up. A simple model has been proposed for the CSCF and is shown in Fig 5. This is not meant to design or standardise the implementation of the CSCF but does determine the data necessary for the operation of the service control interfaces. Here the IN concept of triggering can be seen being applied. There must be a method of defining the criteria for

interrupting session set-up while another function is referred to determine how future aspects of the session are achieved.

Illustrated in Fig 5 are the proposed S-CSCF internal functions and external interfaces. The session control function decides how a SIP invite is to be handled, i.e. it determines which service control will be used — CAMEL, API or SIP server. The decision is based on information contained in the SIP invite message, such as caller identity, service data and customer profile data. Customer profile data is downloaded from the HSS to a local serving profile database (SPD) when the customer registers with the CSCF. The SPD is effectively a cached version of the data from the HSS.

It is very likely that a given call may want to have multiple interactions, i.e. triggers with the service control, e.g. triggering to the CSE over CAP to do pre-pay, followed by triggering to the MAS over SIP to perform conditional-based routing. Therefore on receiving a response from one trigger the resulting invite must refer to the session control to see where the session is next sent.

The IpSSF provides the interworking between the interface to the SIP server and the CAMEL protocol. The IpSSF exhibits a call state model to the CSE, e.g. allowing dynamic event-detection points to be enabled and generally support the CAMEL operation set.

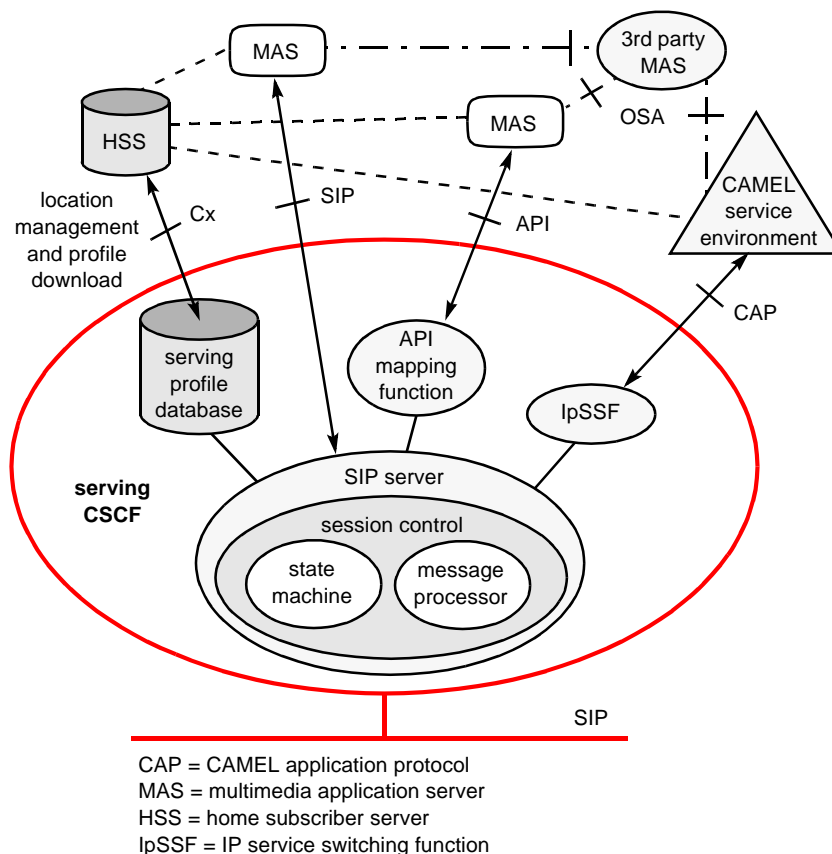


Fig 5 CSCF model for service control.

The mapping function would encapsulate the SIP server and present it to the MAS in whatever API format required; this would include dealing with the distributed computing environment being used, e.g. CORBA or remote method invocation (RMI). For the SIP interface no interworking or translation function is considered necessary. In practice, some SIP services (e.g. call-processing language (CPL) scripts) may actually execute inside the CSCF.

Each of the MASs may expose their service capabilities to third parties using APIs such as OSA. The MAS is therefore acting as a gateway.

The following sections describe in more detail the intentions for exploiting the three service control interfaces — CAMEL, APIs and SIP.

4.5 CAMEL in 3G

This CS domain capability has been extended to include the control of services in the PS domain for GSM networks. It is being further extended to include control of multimedia services in the IM domain for UMTS networks. Extending CAMEL allows network operators to provide customers with services that behave consistently when the customer roams between islands of UMTS and GSM.

Developments for CAMEL interworking in the IM domain are currently focused mainly on IP telephony. CAMEL Phase 3 for controlling services in the CS and PS domains is currently being enhanced to CAMEL Phase 4. Phase 4 includes new capabilities for the CS domain and new capabilities to support voice over IP and multimedia calls in the IM domain. Service control is achieved by introducing a new interface between the CSE and the S-CSCF based on the CAMEL protocol. This work is at an early stage of development in 3GPP.

One of the challenges for CAMEL in the IM domain is that during the life of a session extra media interactions can be added into the session. Although CAMEL is well able to control telephony communication, it is, however, less able to control, for example, a chat session. There are multiple possible solutions to this problem. The CSCF may block any additional non-telephony service requests if CAMEL is already active in a session. Alternatively the IpSSF could monitor subsequent SIP transactions and, if it detects a media exchange which it does not understand, it would drop out of the session in a clean way.

4.6 Network APIs in 3G

Application programming interfaces (APIs), such as Parlay, JAIN (Java integrated network) or open services

architecture (OSA), provide an interface which is readily integrated into application software that allows the application to use the services of a network without being concerned with the exact nature of the network.

These APIs have capabilities via their framework elements to allow the API to be accessed by third parties. These capabilities include authentication, discovery and security. An operator can choose to either use an API for their own applications or make the interface available to third parties. If it is to be made available to third parties, it is advisable that this is done via some gateway function that will allow the framework capabilities to be suitably implemented.

The inclusion of an API interface into the CSCF also reflects a supplier trend in application server technology. Suppliers want to encourage application writers to use their platforms and they also want to reuse the application server with multiple networks, i.e. SIP, H.323, PSTN. This portability capability is provided to allow for the control of multiple network interfaces. By adopting middleware and API architectures, they can provide programmability platforms that allow the rapid adaptability to different network types and allow the application writer to be divorced from the specific network technology. Offering an API interface on the CSCF allows for easy integration into programmability platforms.

APIs are already being offered on top of SIP stacks. As the next section describes, services can be written directly to SIP interfaces but some of these interfaces appear very raw and low level. Encapsulating the SIP interfaces with OSA can provide value by providing abstracted building blocks for putting services together.

4.7 SIP services

The most attractive of all the service control interfaces is the use of SIP. This is due to the wide-scale adoption of SIP and the simplicity and ubiquity of the technology it uses to realise services.

One of the real appeals of the SIP service technologies is that they can be integrated into WWW technologies that are used widely today. Through the adoption of these technologies the 3G network will be able to provide rapid and inexpensive services and, probably most importantly, there will be a mass of people with the ability to provide the wealth of services desired. In effect the 'dot.com' creative spirit can be applied to the UMTS network.

There are at least five technologies for providing service control that are available when using SIP. Any combination of these technologies can be used together. As these technologies are defined as extensions to the basic SIP protocol, there is no guarantee that they will be provided by a network operator. Even if it is agreed in 3GPP to include them, it is likely that it will not be mandatory to support them. All the SIP technologies under consideration [3] are shown in Fig 6.

SIP CGI

In the WWW, the common gateway interface (CGI) has been very successful in allowing dynamic applications to be linked into the otherwise static content-only information of a Web page. Using CGI the WWW is able to react to the user-initiated events and trigger eCommerce payments, reservations, telephony calls, etc. Due to the similarity of HTML and SIP it has been a natural extension to apply CGI to SIP.

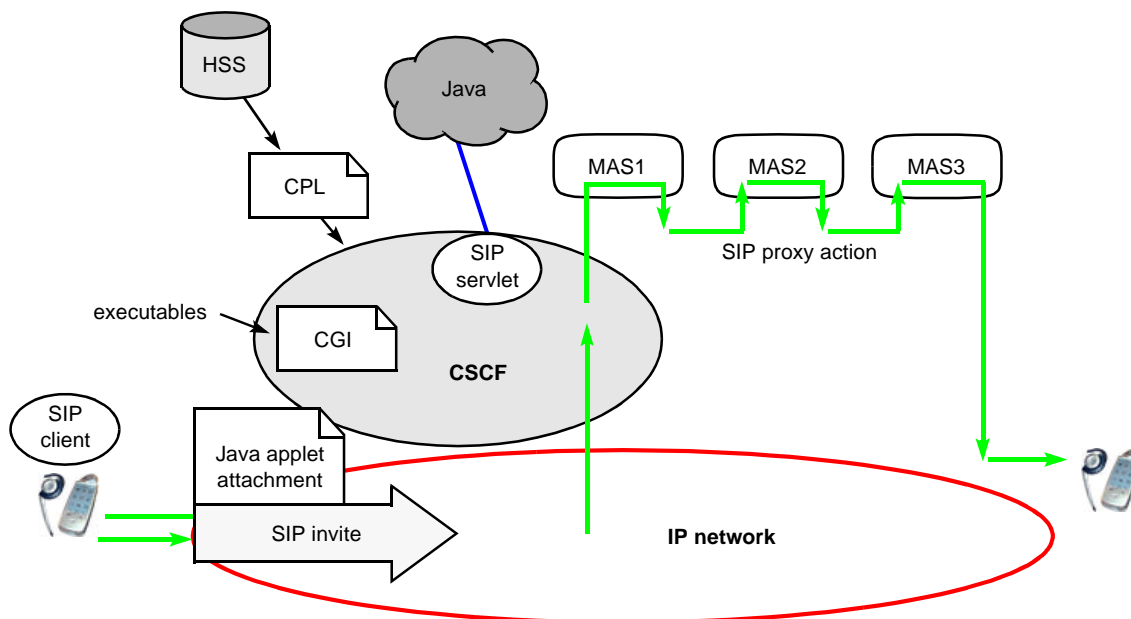


Fig 6 The SIP service opportunities.

A SIP CGI script has a number of key attributes. It can expose the content of all headers in a SIP request (this is essential, as within SIP headers are of great importance, carrying critical information about the session, including caller, callee, subject, registration parameters, call routes, etc). It can also create all parts of a response, including headers and message bodies.

A single CGI script may execute a number of times during a transaction and, by use of CGI triggers, can specify at which point it will have control for the remainder of the transaction. These triggers can include timers and triggers within the headers of the SIP request. Alternatively the script can be set to execute on every message.

The actual script could be any executable produced by languages such as C and Visual Basic or script languages such as PERL. The similarity with HTML CGI means that existing developers will be readily able to develop SIP CGI scripts.

Upon receiving a SIP request the server will pass the body of the message to the script and set up environment variables containing the information on the message headers. The script will then generate some output data which is then processed by the server to create a response message if required.

SIP call-processing language

Call-processing language is a very simple XML-based language that can be used to describe and control Internet

telephony services. It is actually protocol independent (i.e. it could also be used with H.323), but it fits particularly well with SIP. The aim of CPL is to provide a secure and straightforward method of providing simple call services that can be easily created by graphical tools, e.g. by tabular WWW entry. In the context of 3G service control this provides an appropriate way of implementing some of the personal profile concepts associated with VHE.

A CPL script is built around call-processing actions. A call-processing action is a structured tree that describes the decisions and actions the server performs on a call event. There are two types of call-processing action — top-level actions, which are triggered by signalling events, and sub-actions, which can be called from other actions and are grouped into definitions and references. Sub-actions are effectively like sub-procedures in normal computing languages.

Top-level actions can be divided into incoming (an action when the call destination is the script owner) and outgoing (an action when the call originator is the script owner). The CPL script could be downloaded into the serving CSCF from the HSS when a user registers. The four categories of CPL nodes are switches, location modifiers, signalling actions and non-signalling actions.

Table 1 summarises the list of node types available and demonstrates the compactness, yet power, of the language.

Table 1 CPL node types and function.

CPL node type	CPL node	Description
Switches	Conditional branching based on information from the original request or from the call.	
	Address switch	Based on one of the addresses in the call request.
	String switches	Based on free-format text in the call request.
	Time	Based on time and date. Includes extensive sub-parameters.
	Priority	Based on the priorities specified in SIP, e.g. emergency, urgent.
	Otherwise	Special: If none of the other cases match.
	Not present	Special: If switch variable not present in the request.
Location modifiers	The set (could be multiple forked destinations) of locations to which a call should be directed.	
	Explicit	Specified locations to add to the location set.
	Look-ups	Refers to locations defined in an external source.
	Filters	Remove locations from the set.
Signalling actions	Proxy	Forward the call to the current set of locations. The result of the forward can have further cases specified of: timeout, busy, no-answer, redirection, failure, recursion, reordering.
	Reject	Reject the call attempt.
	Redirect	Redirect the call attempt to the current set of locations.
Non-signalling actions	Mail	Mail the status of the CPL script to the user.
	Log	Log information about the call to some form of storage.

CPL is designed to be easily created and edited by graphical tools and, as it is XML based, it is easily parsed. It is considered safe as a scripting language as it does not permit loops, just conditional statements.

It is worth noting the power and simplicity offered by CPL compared with embedded switch control and IN concepts in current 2G networks. For example, it is not inconceivable that a network provider could allow third parties to provide CPL scripts to be loaded into the S-CSCF. The safety of CPL combined with the fact that it can be verified without execution makes this a plausible possibility. A service provider would then need only a portal to create new customers and a Web page to allow users to create, modify and delete their call-handling services. The service provider simply downloads the CPL script to the HSS (for onward distribution to the CSCF). The addition of the OSA framework could provide a means to provide authentication, security and discovery. By comparison, in 2G networks a service provider has no choice but to develop real-time applications or acquire a complete service node to offer similar functionality.

SIP servlets

SIP servlets are effectively a Java extension API for SIP servers. It is a chunk of Java code that interacts with a SIP server to control or influence session processing. Incoming requests and responses are associated with the servlets.

The CSCF communicates to the servlet (running on the MAS) by passing objects representing SIP messages. The servlet has access to all parts of the SIP message (headers and body as well as request and status line) via the objects. The servlet can then answer, proxy requests (to multiple destinations if required), create responses, forward incoming requests or handle them directly. Servlets can also initiate new SIP transactions of their own. The CSCF will effectively pass an object representing the request to a servlet. The servlet then decides whether to respond to it, proxy it, or let the CSCF perform its default action.

While servlets provide a suitable abstraction of SIP it may be necessary to further encapsulate them into a network API, perhaps JAIN given the Java environment, to make it easier for the application writer.

Java-enhanced SIP

Another possible solution is the Java-enhanced SIP (JES). SIP messages are extended to carry Java applets (plus their state and run-time contexts if needed). These Java mobile objects are run before the CSCF takes any other action. A 'require' message is used within all JES SIP messages to indicate that JES must be supported to process the message. The Java applet or Java mobile agent is stored

either in a multipart MIME section of the message body or at a URL pointed to within the message.

The receiving CSCF retrieves the mobile agent within a SIP message and it must immediately extract it and execute it on a virtual machine before processing the SIP message any further (or if the content is a URL, it must retrieve the agent from the URL). The agent can then interact with the proxy and instruct the proxy to carry out commands.

A Java SIP API provides an interface into a SIP proxy to allow applets and agents access to SIP messaging functions on the proxy. This is a similar approach to SIP servlets.

The use of JES in 3GPP is yet to be agreed. Like CPL it provides a mechanism for users to apply their profile. However, given that the applets are executable, there is more power to support a greater range of services, but at the same time more challenges in terms of security.

SIP proxy capability

One of the fundamental mechanisms of SIP is to proxy on a request to another proxy server where further processing can take place. Hence a very simple but powerful way to provide service control is for a CSCF to forward the SIP invite to the MAS. The MAS can then provide some form of service, which again could be CAMEL, APIs or one of the SIP service technologies, and ultimately it too can further forward the message on to another MAS.

There are two basic configurations for proxying MAS in relation to the CSCF.

In Fig 7(a) the CSCF proxies invites in turn to a series of MASs. This allows the sequence of services (resident on the MASs) to be determined from the user profile held in the HSS. In practice, it may not be the CSCF but a separate distribution server which has access to the HSS. Some services may only want to be involved in modifying the location, for example MAS1, hence it requests the CSCF to redirect the invite to MAS2 such that MAS1 is dropped out of the list of locations and does not see future transactions. MAS3 may want to see future transactions, e.g. the termination of the session in a pre-pay service, and therefore adds its own location into the record route so that future transactions are returned to it.

In Fig 7(b) the CSCF forwards the invite to a series of MASs. The preceding MAS needs to know at least the next hop in the chain. In this configuration the sequence and list of services is not controlled from a single profile.

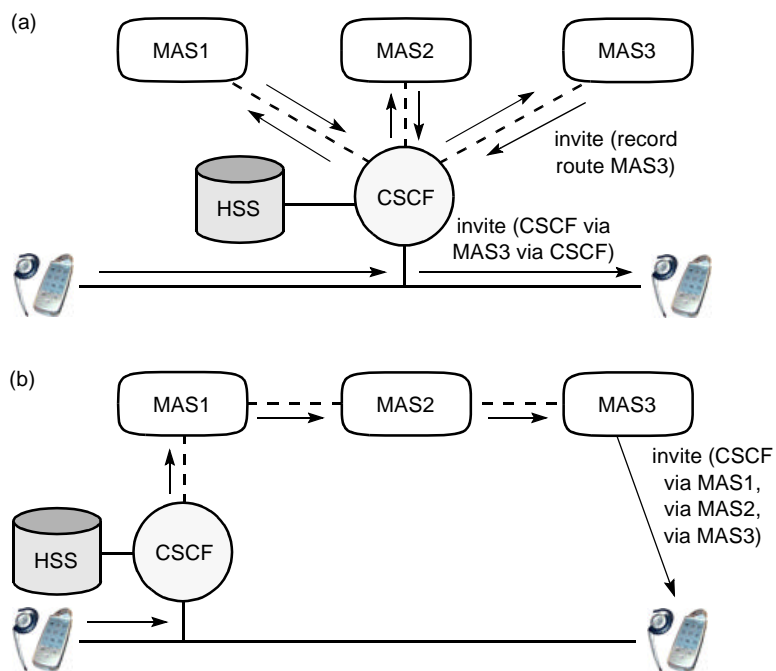


Fig 7 MAS proxy configurations.

In practice, both of the configurations in Fig 7 can be used together, where the MAS locations shown in the (b) configuration are actually islands of (a). This would allow a user to receive services from different service environments provided by different operators.

5. Conclusions

Real-time service control has a major part to play in realising an integrated, useful and stimulating experience for the customer and as a secure, profitable, and flexible tool for the network and service provider. The strategy being followed in developing service control in the Release 4/5 network is encouraging flexibility to allow for the evolution of CAMEL, inclusion of programmable API platforms and using the power of SIP technologies.

The paper has described service control architectures that demonstrate a user-centric view, allowing the services to be selected from a user profile and in collaboration with the user's terminal.

The richest service environments will be those having an open approach to providing services. Adopting standard interfaces that are attractive to the application developer community allows the operator to have access to a broad set of services. Additionally the interfaces should be open so that third party service providers can add to the services provided by the network operator, increasing the attractiveness of subscribing to a particular network and accessing a greater range of innovative services.

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