# Service Triggering in MVNO & Multi-Country environments

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## Abstract

*Traditional mobile operators invested huge amounts of money in the 1990s to build the current 2G wireless networks, like GSM networks in Europe. Those networks have proven to be stable. In most cases, their capacity has not yet been exhausted. Furthermore, the marketing departments of mobile operators now consider the commercial possibility of selling mobile subscriptions through new channels, like supermarkets. The concept of Mobile Virtual Network Operator (MVNO) arose. Some of them are just new brands and do not own any tele-communications equipment. Other companies do own part of the network: these are the Mobile Virtual Network Enablers (MVNE). They provide part of the network infrastructure, while the Mobile Virtual Network Operators (MVNO) serve end-customers. Furthermore, in the context of international globalization, it appears more and more meaningful that the same platform in one dedicated country serves end-subscribers from several operators in different countries. When it comes to service triggering, the interactions between three kinds of network are critical. These three kinds of networks are: the home network, which owns the services' platform, the host network, which actually triggers the platform in the home country, and visited networks, where the subscriber may roam abroad. The goal of the present paper is to study these interactions based on an actual implementation example.*

***Keywords: IN, Service Trigger, MVNO, Multi-Country, IMS***

## 1. Introduction

We shall focus on signaling issues for triggering a Value Added Service (VAS) such as an Intelligent Networks (IN) service. The signaling to establish the bearer trunk will not be the central focus of this paper; instead, we shall concentrate on the signaling for the exchanges with the services' platform.

We shall assume that the owner of the services' platform like the MVNE has its own Network Sub-System (NSS), which represents the true *Home Network*. First, it owns the register of its subscribers or Home Location Register (HLR). That is, it has the freedom for provisioning subscribers. In addition, it owns a VAS platform. Finally, it owns a core network, including Mobile Switching Centers (MSC) and Signaling Transfer Points (STP). For the Radio Access Network (RAN) or Base Sub-System (BSS), the MVNE relies on a traditional mobile operator defined as the *Host Network*. The fact that the MVNE owns a VAS platform means that it has the flexibility to offer differentiated services in comparison with other mobile networks including the host network.

A IN prepaid service is a good example of a Value Added Service because it contains both:

1. Originating triggers: a subscriber pays to make a call; thus the prepaid service is triggered for an outgoing call.
2. Terminating triggers: a subscriber might pay to receive calls: for example when he/she is roaming abroad in a *Visited Network*. For such incoming calls, the service is triggered too.

Like in [1], we shall study first the outgoing and terminating case for a single MVNO. To illustrate this, we give an implementation example. Then, we tackle the Multi-Country topic, which may apply when MVNOs are located in different countries, as well as when an international operator has affiliates in various countries. Finally, we shall outline what the interconnections between the home network and external networks could look like in the IMS architecture.

Since many acronyms are used, a terminology can be found at the end of the paper.

## 2. Making outgoing calls from the Host network

The MVNE does not own its Radio Access Network (RAN). Therefore, in the home country a mobile subscriber of the virtual operator is first detected by the RAN of the host network. The Host Network needs to retrieve the subscriber information from the HLR of the MVNE. Based on that information, it will trigger the VAS platform of the MVNE.

Through which protocol? The two usual protocols for value-added services such as IN services are INAP and CAMEL. For interoperability issues, especially in the roaming case (see chapter 3) the CAMEL protocol might be preferred. CAMEL, sometimes called CAMEL Application Part (CAP), as INAP, is built over TCAP [2], which is built itself over SS7, and therefore CAMEL resp. INAP messages transit through the SS7 network by means of Signaling Transfer Points (STP).

If CAMEL is used, the IN platform is triggered as illustrated in Figure 1. This applies to voice calls, as well as to SMS, in case the latter are charged through an SS7-based protocol.

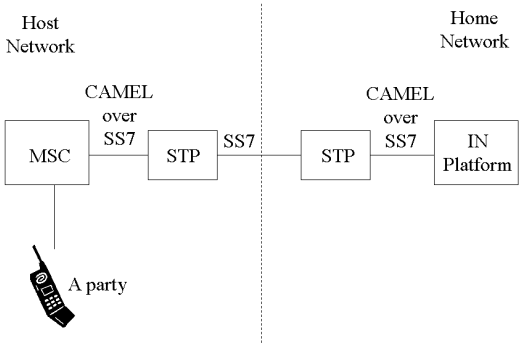


Figure 1. *„Home" Mobile Originating Call*

The A-party is known in the host network. At registration time, the VLR gets the information from the HLR of the MVNE about the Originating CAMEL Subscription Information (O-CSI) for that subscriber. The O-CSI contains, among other things, the SS7 address or Global Title (GT) of the IN platform belonging to the MVNE. The MSC retrieves that information in turn from the VLR. Based on that information, the MSC of the host network builds and forwards the service triggering message to the IN platform in the home network. In fact, the message is built by the Service Switching Functionality contained in the MSC. That functionality is called SSF or gsmSSF as described in [3]. The message later transits through the STP nodes of the SS7 network.

In the case of GPRS resp. UMTS networks, the role of the MSC consisting in triggering the Value Added Service would be played by the SGSN, which would contain also an SSF, called this time gprsSSF instead of gsmSSF. For more details, the reader can refer to [4].

We might call this scenario a "home" call since the subscriber is in its home country. However, the call is handled partly by the host network. So in reality, it is not completely a "home" call.

When the subscriber moves within the host network from one area to another, the VLR corresponding to the current area for the subscriber is updated with the service triggering information related to the A-party. The local MSC retrieves the updated information from the VLR and is still able to contact the IN platform in order to trigger the Value Added Service.

The reader who wishes to get more information on that topic can refer to the chapter 'Mobility Procedures' in [5].

## 3. Making outgoing calls from a visited network

The main reason why the CAMEL protocol is preferred is that it is fully standardized. You cannot find so many various implementations as with INAP. Consequently, while a subscriber is visiting a mobile network abroad, the Visited MSC (V-MSC), which monitors the call legs, can talk directly through CAMEL with the IN Platform of the MVNE. That latter provides the instructions for handling the call.

In CAMEL, there are different subsets of capabilities or *Phases*, where the next phase is a superset of the previous one. The actual CAMEL phase to handle the call should be the minimal phase supported by both the visited MSC and the IN platform of the MVNE. For example, if the IN platform supports Phase 2, but the visited MSC only supports Phase 1, then Phase 1 will be the relevant phase to handle the call.

The IN platform is triggered as illustrated in Figure 2. In case data traffic was charged through an SS7-based protocol like CAMEL Phase 3, the scenario described would still apply.

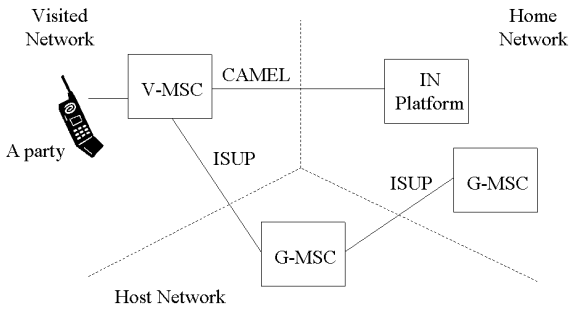


Figure 2. *Roaming Mobile Originating Call*

The IN platform can only be triggered once the A-party has been identified as a subscriber of the MVNE. When the MVNE subscriber roams abroad, the VLR is updated with the O-CSI of that subscriber. From the visited VLR, the visited MSC retrieves the GT of the IN Platform belonging to the MVNE, so that it can get instructions from the IN platform on how to handle the call. Once that information is retrieved, the V-MSC can monitor the call. The bearer trunk is established through the ISUP protocol, from the visited network to the host network, which forwards the call to the G-MSC of the home network. In case the MVNE is officially registered at regulatory authorities, and does not operate under the umbrella of a well-established operator, it can happen that the bearer trunk transits directly from the visited network to the home network through an international carrier, thus bypassing the host network.

Having a CAMEL dialogue between the visited and the home networks means of course that the visited MSC has CAMEL capabilities. However, CAMEL is not necessarily implemented by all roaming partners, and even if it is, it may not be in the right phase. For example, in order to play announcements, CAMEL Phase 2 is required. And in order to charge data traffic, CAMEL Phase 3 is required. Consequently, if the visited MSC has only Phase 1 at its disposal, then the home network might better control the call itself. For that purpose, the control of the call needs to be passed over to the home network. We will study how this could work in Chapter 4.

## 4. CAMEL Rerouting

Let us consider the case in which the V-MSC offers CAMEL Phase 1, and the control of the call is passed over to an MSC in the home network.

When a subscriber is abroad, the V-MSC takes care of all outgoing calls. The V-MSC knows which IN platform to trigger when the subscriber tries to make a call since the VLR is updated with the O-CSI from the HLR of the MVNE. Once triggered, the IN platform of the MVNE can instruct the V-MSC to connect the call to a dummy destination number belonging to the home network. That dummy number could contain a sequence number in order to identify the call later. When the ISUP 'Initial Address Message' (IAM) to set up the voice call reaches the G-MSC of the home network, the G-MSC could trigger again the IN platform of the MVNE. Based on the sequence number defined earlier, the IN platform would be able to correlate the incoming voice call with the service triggering message previously received, and would thus take control of the call in this fashion.

This is illustrated in Figure 3.

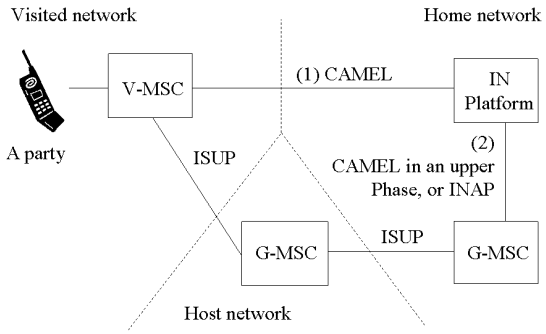


Figure 3. *CAMEL Rerouting*

When the G-MSC of the home network triggers the IN platform the second time, it can use INAP. It is not necessary to use CAMEL anymore since the MSC and the IN platform belong to the same network. Therefore, the rerouting scenario is also a way to control an originating call using INAP.

There could be also a rerouting scenario for home calls between the host network and the home network. There would be a first trigger to the IN platform from the host network. Later, a second trigger would come from the G-MSC of the home network. As the first trigger comes necessarily from the host network, INAP could be used also in order to trigger the IN platform the first time from the host MSC. It would only be a matter of agreement between the host and the home networks, not with other partners.

## 5. Receiving calls

In the terminating case, the called number or B-Party is one of the subscribers of the MVNE, which is

not necessarily the case for the A-Party. The network, where the A-party is located, is called the *Interrogating Network*. For more information on that topic, the reader might refer to [3], especially the chapter 'Architecture'.

As in the originating case, the G-MSC of the interrogating network needs to set up the connection to the B-party and get the CAMEL subscription information from the HLR of the MVNE. In that case, it is not the Originating but the Terminating CAMEL Subscription Information (T-CSI). That piece of information contains again the GT of the IN platform belonging to the MVNE. Consequently, there can be a CAMEL dialogue between the G-MSC of the interrogating network and the IN platform, as illustrated in Figure 4.

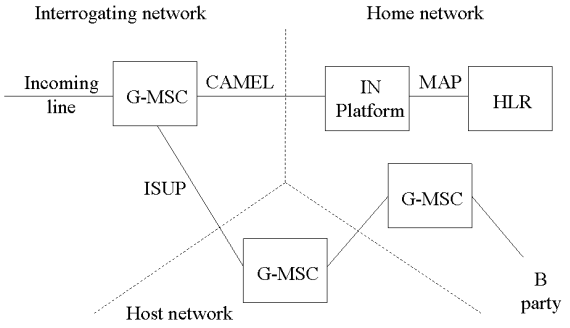


Figure 4. *Mobile Terminating Call*

Again, this assumes that the G-MSC has CAMEL capabilities and that the supported CAMEL phase is sufficient to provide the desired service to the end-subscriber.

The host network is involved in the terminating scenario, too, since the B-Party, which is a subscriber of the MVNE, is seen as belonging to the host network by any foreign network.

In order to avoid the problem with CAMEL compatibility, the T-CSI can be disabled in the HLR, and the G-MSC of the MVNE can trigger the IN platform itself based on the incoming ISUP message to set up the voice call, similar to the second trigger in the CAMEL re-routing concept. It is possible because the bearer trunk will always reach an MSC of the home network in the terminating scenario. This is illustrated in Figure 5.

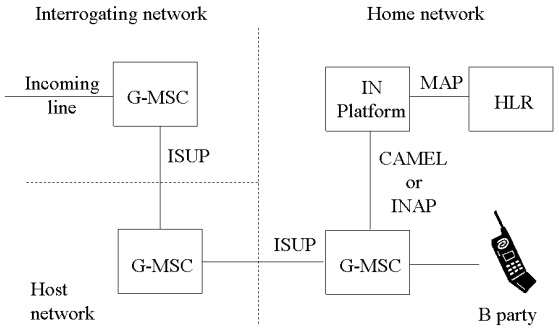


Figure 5. *Mobile Terminating Call*

In that case, the terminating call is monitored by the G-MSC of the MVNE itself, with instruction from the IN platform.

## 6. Implementation

The present chapter describes an actual implementation of an IN prepaid platform at the MVNE *Vistream* in Germany in 2006.

### 6.1 Making outgoing calls

For outgoing calls from the host network, CAMEL Phase 2 has been used in order to have the capability to play announcements to the end-subscriber.

Here is the log for an Initial DP message, which is the initial CAMEL message in order to trigger the IN platform:

```
TRACE: cml!initial_dp_received(
transaction_id= 1576,
[...],
calling_party_number=cml_calling_party_number(
present=true,nature_of_address=anoa_internatio
nal_number,number_incomplete=false,numbering_p
lan_indicator=cmlnp_isdn,presentation_indicato
r=iapi_restricted,screening_indicator=isi_netw
ork_provided,address_signals=4915701234518),
[...],
called_party_bcd_number=cml_called_party_bcd_n
umber(present=true,type_of_number=cmlcs_unknow
n,numbering_plan_indicator=cmlbnp_isdn,address
_signals=015701234593),
[...],
event_type_bcsm=cml_p2_event_type_bcsm(present
=true,value=cmlp2etb_collected_info)
[...],
msc_address=cml_isdn_address_string(present=tr
ue,nature_of_address=cmnt_international_number
,numbering_plan_indictator=cmlbnp_isdn,address
_signals=491770381000),
[...]
)
```

Please note that only the transaction identifier, the calling party number, called party number, event type and MSC address have been kept from the original message log. The other parameters have been removed for the sake of clarity.

In the present log, a MVNE subscriber, whose number (without Country Code) is 015701234518, calls another subscriber from the MVNE, whose number is 015701234593. The 01570 prefix is characteristic for the MVNE. The present trigger relates to the A-party of the call i.e. 015701234518 since the IN platform has been triggered in Detection Point (DP) 'Collected Info' in accordance with the Basic Call State Model (BCSM) defined in [3].

The GT of the MSC, which sent the CAMEL message, is an address in the host network: 491770381000. That piece of information needs to be passed over to the IN platform since it is relevant in order to rate the call to know whether the call comes from abroad or not. If the subscriber were roaming in a foreign network, the MSC address would have another Country Code other than 49 for Germany, and the call would be more expensive for the calling party.

### 6.2 Receiving calls

For mobile terminating calls, the decision has been taken to have the G-MSC of the MVNE triggering the IN platform using CAMEL Phase 2.

Here is the log for an initial DP message:

```
TRACE:   CAMEL_PROT_FSM[85874]:   call_id   =
'553658458'   state  =  'CML_IDLE'   event  =
'LLS_cml_initial_dp_receivedTyp'

TRACE: cml!initial_dp_received(
transaction_id=1605,
[...]
calling_party_number=cml_calling_party_number(
present=true,nature_of_address=anoa_national_s
ignificant_number,number_incomplete=false,numb
ering_plan_indicator=cmlnp_isdn,presentation_i
ndicator=iapi_allowed,screening_indicator=isi_
network_provided,address_signals=01638080080),
[...],
called_party_number=cml_called_party_number(pr
esent=true,nature_of_address=anoa_national_sig
nificant_number,internal_network_number_indica
tor=iini_route_to_number_allowed,numbering_pla
n_indicator=cmlnp_isdn,address_signals=0157012
34518),
[...],
event_type_bcsm=cml_p2_event_type_bcsm(present
=true,value=cmlp2etb_term_attempt_authorized),
[...],
msc_address=cml_isdn_address_string(present=tr
ue,nature_of_address=cmnt_international_number
,numbering_plan_indictator=cmlbnp_isdn,address
_signals=491570012360),
[...]
)
```

In this example, the GT of the MSC, which sent the CAMEL message, is an address from the MVNE: 49**1570**012360. Again, we recognize the prefix (0)1570. The present trigger relates to the incoming call for the B-Party: 015701234518 since the DP is 'Terminating Attempt Authorized'. The A-Party number, 01638080080, is not a number of the MVNE.

In the case of a Mobile Terminating call, the IN platform needs to know the location of the B-Party. If the latter were in the home country, the call would most probably be free of charge: the subscriber then would not need to pay to receive calls in the home country. It would certainly not be the case if the B-Party were abroad.

In order to know the location of the B-party, the IN platform sends a MAP Any Time Interrogation (ATI) message to the HLR. The reader might have a look again at Figure 5, and refer to [5] for further information.

Here is an example of an ATI message:

```
TRACE: mapss7!send_anytime_interrogation(
[...],
msisdn=map_v2_isdn_address(present=true,noa=mn
t_international_number,np=mnp_isdn_telephony,d
igits=4915701234518)),
requested_info=map_requested_info(location_inf
ormation=true,subscriber_state=true,current_lo
cation=false),
[...]
) call_id=553658458
```

This way, the IN platform knows in which country the called party is and can rate the call accordingly.

## 7. Multi-country MVNO

Given that the aim of an MVNE is offering services to multiple MVNOs, it can happen that these MVNO have different partnerships with mobile network operators, thus leading the MVNE home network to interface with more than one host network. It is especially the case in the context of international globalization, where MVNO can be located in different countries. One example would be when an international supermarket chain with subsidiaries in different countries wants to launch parallel MVNO offers.

For an MVNO located in another country than the MVNE, it makes sense that the MVNO relies on a local host network, in order to avoid some interconnection costs. This makes it necessary for an MVNE to interface with multiple host networks. It is represented in Figure 6.

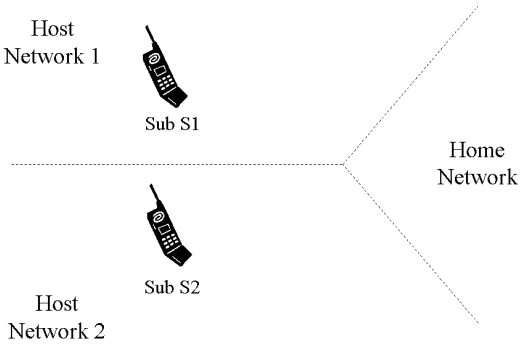


Figure 6. *Multiple Host Networks*

In the case that two host networks are not located in the same country, it can also happen that S2, a subscriber of an MVNO relying on Host Network 2 is roaming to Host Network 1. This is represented in Figure 7.

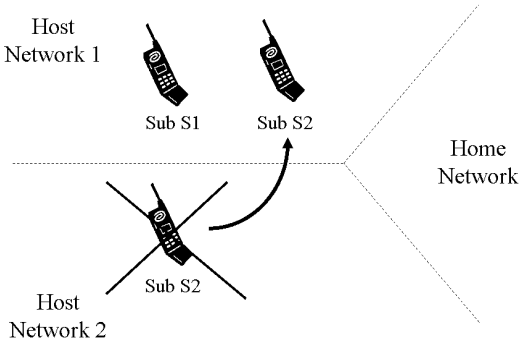


Figure 7. *Subscriber roaming to another Host Network*

Will the two triggering messages for S1 and S2 be different given that they may come from the same SSP in the same Host Network, possibly using the same protocol?

## 7.1 MVNO Differentiation

Regarding the originating SSP in the Host Network, the SCP is indeed able to identify it.

The incoming triggering message, which is for whatever IN triggering protocol a TCAP message [2], provides the following information:

| SS7 Protocol | Available parameter |
|---|---|
| TCAP | Application Context |
| SCCP | Originating GT |
| MTP | Originating PC |

Nevertheless, this information depends on the originating SSP only, not on the MVNO. Consequently, the MVNO distinction cannot be done by the "network", unless it is done at an upper level like CAMEL i.e. while the SSP retrieves the subscriber-specific application information, which is the O-CSI in the case of an outgoing CAMEL trigger.

Please note that this MVNO differentiation at Application level is valid not only when two MVNO rely on two hosts networks located in two different countries, but also if there are two MVNO relying on the same host network in the same country because in this case, the triggering information coming from the SSP might be the same also.

If we look at the O-CSI, the following parameters are available according to [3]: gsmSCF Address, Service Key, Default Call Handling, TDP List, DP Criteria, CAMEL Capability Handling. If we do not use different gsmSCF addresses (Global Titles) to identify in reality the same IN platform, the relevant parameter for MVNO differentiation would be the Service Key. In other words, MVNO1 would use Service Key 1, while MVNO2 would use Service Key 2 when triggering the IN platform.

This means that two service instances, triggered by two different service keys, would coexist on the SCP. Attached to each of the instance, there would be a different data set: this can make data configuration complex!

Another option is to have the subscriber differentiation not coming from the network, but from the SCP: subscriber S1 would be stored in the SCP with an MVNO "Identifier" (ID), or "Community" ID, or "Class of Service", or whatever the name is, equal to 'MVNO1', while subscriber S2 would be stored with MVNO_ID 'MVNO2'. Based on the subscriber data on the SCP, the service logic, especially the rating, could be different.

Whether data separation relies on a Service Key or on an MVNO ID, it is recommended for a service's platform to support data segmentation: MVNO1 should have the capability to access or modify its data in a secure way, without the risk of access or modification by MVNO2.

## 7.2 Roaming consideration

Nevertheless, the MVNO ID information stored at SCP level does not tell whether the subscriber is currently roaming or not! If we take the case of multiple host networks located in different countries but belonging to the same international group, it could be an asset to define the same service logic i.e., the

same service key with variations depending only on the originating country and whether the subscriber is currently roaming or not. For example, some menu options like the call history could be barred to roaming subscribers to avoid interconnection fees with the host network, but allowed for calls made in the same country as the local host network.

In this case, the MVNO ID would not be sufficient anymore, but the Country Code of the Country "where the subscriber is not considered as roaming" would be required at SCP level too, so that the service logic, by comparing this Country Code with the Country Code of the originating SSP, knows in the end whether the subscriber is indeed roaming. This means that it can be an asset for a services' platform to store the "home" country of any subscriber as part of the subscriber data.

Otherwise, it could make sense to add an additional parameter, a kind of "roaming flag", in the service triggering message coming from the network, but this would need extending IN protocols.

Of course, another way to avoid this issue is to physically assign a different SCP per MVNO. Therefore, if MVNO1 is routed to SCP1, while MVNO2 is routed to SCP2 with two different GT, GT1 and GT2, it is possible to define the "home" country on SCP1 as the country of Host Network 1, and differently on SCP2 as the country of Host Network 2. It can make maintenance easier, since a downtime for MVNO1 on the SCP1 machine would have no impact on MVNO2 which runs on SCP2. However, it means additional hardware investment for the MVNO, and this needs to be considered in the business case.

Please note that all these considerations regarding the multi-country topic are not relevant only to MVNO, but also to any international operator, with affiliates in various countries, wishing to store subscribers from different countries on the same platform centrally located in a specific country.

## 8. Service triggering in IMS networks

Let us see what the MVNE scenario could look like in the IMS architecture. The reader might refer to [6] and [7] to get information on the IMS concepts.

The User Equipment (UE) of the A-party first contacts the Proxy Call State Control Function (P-CSCF) of the visited network, as described in [7] in the paragraph 'Roles of Session Control Functions'. Similarly to the V-MSC in the GSM case, the P-CSCF sees the subscriber as belonging to the host network (instead of the home network) and therefore sends a SIP message to the Interrogating Call State Control Function (I-CSCF) of the host network. The latter is able to make the distinction between its own subscribers and the ones from the MVNE. Consequently, the SIP message is sent finally to the home network.

It makes sense that the MVNE owns an I-CSCF capability. This way, the host network does not need to know how the MVNE subscribers are dispatched onto the different S-CSCF of the home network. Otherwise, the host network needs to be informed every time the distribution changes.

If the I-CSCF belongs to the MVNE, as well as the S-CSCF, which corresponds to option 3 in [8], the service triggering scenario is described in Figure 8.

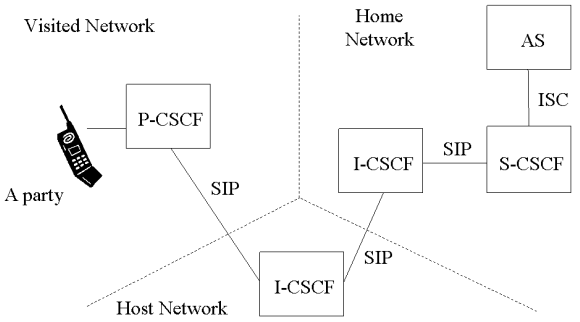


Figure 8. *MO Call by an MVNO Subscriber in IMS*

This means that as soon as the MVNE owns equipment at Session layer, an originating call resp. session is always controlled by an S-CSCF in the home network. The Application Server (AS) will never control a CSCF in the visited network like a Service Control Point (SCP) could do against a visited MSC in traditional GSM networks.

Another option for the MVNE would be that the I-CSCF and S-CSCF belong to the host network. In other words, the MVNE does not own any equipment at Session layer, only at Application layer. It corresponds to option 1 or 2b or 2c in [8].

The service triggering scenario in that case is described in Figure 9.

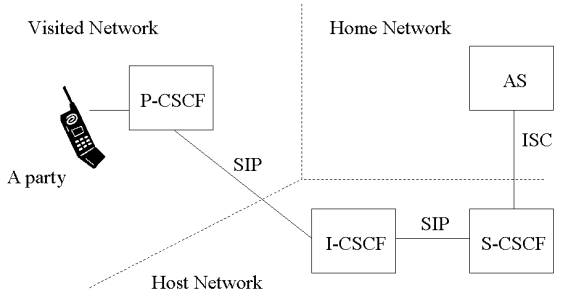


Figure 9. *MO Call when the MVNO only owns the Service Layer*

Please note that in case SMS or more generally data traffic is not charged by means of an SS7-based protocol, but by means of an IP-based protocol, like Diameter, the triggering scenario would be similar. The SMS-C resp. GGSN would forward the charging request to an SMS-C resp. GGSN located either in the home network or in the host network, depending on whether the home network has its own SMS-C resp. GGSN. Finally, the home or host SMS-C resp. GGSN would start a dialogue with the Application Server.

## 9. Conclusion

In traditional GSM networks, the interaction between a home network and a visited network is a known field. It corresponds to the roaming scenario. At this point, it has been standardized and implemented for years. Through the CAMEL protocol, there can be a direct control of a network component in the visited network by a services' platform in the home network.

With the irruption of the MVNO, which own part of the network equipments, the concept of host network has been introduced between the visited and the home network. However, there can still be control of the visited network by the home network with regard to value-added services. If there can be multiple host networks between the visited and the home network, MVNO differentiation must be done at Application level.

In the IMS architecture, which relies on standard IP protocols like SIP or Diameter, the component that monitors the call resp. session and the services' platform are always within the home network. This is valid even in the roaming case, unless the MVNO owns only the services' platform and no equipment at all at Session level. Consequently, the interactions between the home network and external networks are less critical in IMS when it comes to service triggering.

## Terminology

| | |
|---|---|
| 2G | Second Generation |
| 3G | Third Generation |
| 3GPP | 3G Partnership Project |
| AS | Application Server |
| ATI | Any Time Interrogation |
| BCSM | Basic Call State Model |
| BSS | Base Sub-System |
| CAMEL | Customized Applications for Mobile networks Enhanced Logic |
| CAP | CAMEL Application Part |
| CSCF | Call State Control Function |
| DP | Detection Point |
| G-MSC | Gateway MSC |
| GGSN | Gateway GPRS Support Node |
| GPRS | General Packet Radio Service |
| GSM | Global System for Mobile communications |
| GT | Global Title |
| HLR | Home Location Register |
| IAM | Initial Address Message |
| I-CSCF | Interrogating-CSCF |
| ID | Identifier |
| IMS | IP Multimedia Subsystem |
| IN | Intelligent Networks |
| INAP | Intelligent Network Application Part |
| IP | Internet Protocol |
| ISC | IMS reference point between CSCF and AS |
| ISDN | Integrated Services Digital Network |
| ISUP | ISDN User Part |
| MAP | Mobile Application Part |
| MO | Mobile Originating |
| MSC | Mobile Switching Center |
| MTP | Message Transfer Part |
| MVNE | Mobile Virtual Network Enabler |
| MVNO | Mobile Virtual Network Operator |
| NSS | Network Sub-System |
| O-CSI | Originating CAMEL Subscription Information |
| P-CSCF | Proxy-CSCF |
| PC | Point Code |
| RAN | Radio Access Network |
| SCCP | Signaling Connection Control Part |
| SCF | Service Control Function |
| SCP | Service Control Point |
| SIP | Session Initiation Protocol |
| SMS | Short Message Service |
| SMS-C | SMS Center |
| SMPP | Short Message Peer-to-Peer protocol |
| SS7 | Signaling System No 7 |
| SSF | Service Switching Function |

| | |
|---|---|
| STP | Signaling Transfer Point |
| TCAP | Transaction Capabilities Application Part |
| TDP | Trigger Detection Point |
| T-CSI | Terminating CAMEL Subscription Information |
| UE | User Equipment |
| UMTS | Universal Mobile Telecommunications System |
| VAS | Value Added Service |
| VLR | Visited Location Register |
| V-MSC | Visited MSC |

## Acknowledgements

Much of the source material used for this paper derives from work accomplished together with the technical teams of Alcatel-Lucent, E-Plus and Vistream. The author would like to especially thank Robert Bakker, Angelo Lattuada, Ian Logan, Carlos Martinez Garcia, Kun Pang, Wolfgang Pein, from Alcatel-Lucent; Dietmar Kohnenmergen from E-Plus; Jan Geiger, Peter Mros from Vistream; Jon Hill, Ulrich Bellmann, Martin Löffler.

The author would like to thank Michelle Gansle for her review.

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