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Technical Report

3rd Generation Partnership Project;
Technical Specification Group Services and System Aspects;
System enhancements for the use of IP Multimedia Subsystem (IMS) services in local breakout and optimal routeing of media
(Release 10)

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Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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Introduction

Due to the increasing volume of data traffic exchanged by mobile users and the rapid decrease of roaming rates that is being imposed by the regulator, mobile operators will most likely have to revisit their roaming agreements, moving towards a more extensive usage of local breakout. This will allow to reduce the cost per bit of data traffic exchanged by roaming customers, since at least part of it will be handled directly by the visited operator, with no need to waste bandwidth on the international links between home and visited networks; moreover, local breakout would allow to offer better performance to the customers.

Based on the analysis of the requirements on local breakout and on the increasing number of the services controlled by IMS that operators are expected to face, it has been proposed that system enhancements are needed to enable extensive usage of IMS services in local breakout.

Furthermore, international communications and terminal roaming introduce a number of scenarios where sessions may traverse multiple IMS networks. The use of Border Control Function makes both the signalling and bearer path traverse through the same networks path and could make the media path not optimized.

In order to ensure Quality of Service (QoS) and, in certain cases, minimal routeing costs, there is a need to enable the routeing of media traffic via an optimal path between those networks, without necessarily being linked to the path that the signalling flow needs to take. The optimal media path between two endpoints may involve IP transit networks, which in normal circumstances are not included in the SIP signalling path. Current QoS reservation is negotiated based on the SIP pre-conditions model, and hence the lack of SIP signalling in the transit network presents a problem for the negotiation of QoS between the end-points.

1 Scope

This study intends to investigate the general problem of system enhancements for the use of IMS services in local breakout and optimal routeing of media.

In particular the above issues will be addressed identifying

- solutions for the home operator to control
  - whether the IMS user may connect to a PDN in the visited network, and
  - whether connections to PDNs provided from the home and visited network may exist in parallel;
- solutions to enable the IMS network to be aware of whether local breakout can be invoked or not;
- solutions to allow the home operator to determine which of the IMS sessions (for a given UE) can be handled in local breakout and which in home routed mode, and what information (e.g. operator's policies, customer's subscription profile, UE connectivity, and location of the remote end terminal/service) is needed for the decision;
- solutions to allow the UE to concurrently use IMS services through local breakout and other IMS services through home routeing;
- the feasibility of having the local breakout option in IMS service nodes:
  - is there a need for a P-CSCF at both PDN accesses?
  - if one P-CSCF is enough, what requirements are there for connectivity between the PDNs?
- if methods are necessary to discover an additional P-CSCF in the visited network after the UE has moved to the visited network, even if the network-layer mobility mechanisms can sustain IP connectivity to the previously discovered P-CSCF in the home network;
- the exact location of the decision point in the home network whether to use local breakout (application or delegated to IP-CAN);
- solutions for SIP/SDP signalling related to the use of IMS services through local breakout.
- interactions with network entities such as NAT (as specified in TS 23.228 [8]) when providing IMS services through local breakout;
- interactions with and support of PCC to provide IMS services through local breakout;
- security implications if there is need for multiple P-CSCFs per UE.

Moreover:

- describing a set of scenarios where the selection of an alternative media path (i.e., different to the signalling path) provides benefits to IMS operators by reducing the number of network entities in the media path;
- providing requirements for suitable mechanisms to achieve optimal media routeing;
- analysing the potential solution(s) to solve those scenarios in line with IMS procedures, while taking into account any impact of extensions required to existing functions/procedures (e.g., NAT, transcoding, Security, PCC, BCF, LI, etc.);
- reducing the number of options for solving the same requirement and agree on a preferred solution.

In the end this study will provide conclusions with respects to what further specification work is required in order to fulfil the requirements for the use of IMS services through local breakout and achieve optimal routeing of media.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 22.258: "Service requirements for the AIPN".

[3] 3GPP TS 22.278: "Service requirements for evolution of the 3GPP system".

[4] 3GPP TS 23.401: "GPRS enhancements for E-UTRAN access".

[5] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".

[6] 3GPP TS 23.203: "Policy and charging control architecture".

[7] GSMA PRD IR.34: "Inter-Service Provider IP Backbone Guidelines".

[8] 3GPP TS 23.228: "IP Multimedia Subsystem (IMS)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the definitions given in TR 21.905 [1] and the following apply:

IP gateway: The node in the operator's network that is responsible for allocating an IP address to a subscriber.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

EPC Evolved Packet Core
EPS Evolved Packet System
GW GateWay
IP Internet Protocol
P-CSCF Proxy-Call Session Control Function
SDP Session Description Protocol
UE User Equipment
LBO Local Breakout
OMR Optimal Media Routeing

4 Overall Requirements

The overall requirements to provide IMS services through local breakout are defined in TS 23.401 [4].

5 Architectural Requirements and Assumptions

The following general architecture principles shall be used when developing solutions for LBO and OMR:

- Radio impacts/Access network procedures like IDLE mobility should not be affected;
- S-CSCF is the service control entity for IMS, as per current IMS core principle; even though media may be routed according to LBO or OMR procedures; (except for emergency case where E-CSCF is used as described in TS 23.167);
- Backward compatibility with Rel-7 (e.g. Rel-8 Terminal shall be able to connect to a Rel-7 IMS system and Rel-7 terminal shall be able to connect to Rel-8 IMS) shall be maintained and impacts from the development within Rel-8 IMS system shall be addressed before reaching final conclusion;
- UE battery consumption and complexity/cost of impacts must be considered;
- An UE shall not use the same IP address simultaneously across multiple accesses;
- Any solution(s) developed should work in single PLMN scenario as well as roaming scenarios.

NOTE: According to current specifications, LBO can not be used when GPRS-IMS Bundled Authentication is used.

In addition to the general requirements above, the following requirements shall be used when developing solutions for Optimal Media Routeing (OMR):

- OMR shall apply to IMS systems that use IBCF and TrGW for interconnection.
- OMR shall establish an optimal media path for each of the media streams of an IMS session, subject to the Home operator's policy, system constraints (such as transcoding function location) and the information available within SIP signalling;
- All media components of a session that traverse the same un-optimized sequence of IBCFs/TrGWs and networks shall, subject to Home operators' policy, traverse the same optimized sequence of IBCFs/TrGWs and networks. This ensures similar end to end path delay characteristics for media components that may be synchronized;
- Where end points are located within the same residence or enterprise network, OMR should be able to support the routeing of the media path such that it does not egress that network;
- OMR should be capable of optimizing the media paths for a session where the same interconnect network is used for multiple legs of the un-optimized media path;
- OMR should be capable of optimizing the media paths for a session between two UEs where the same serving network is used by the UEs;
- Home operators (of both calling and called UE) may be informed, upon session establishment/modification, of the successful enforcement or removal of OMR for that session;
- On session establishment, OMR shall establish an optimal media path separately for each remote endpoint of the session;
- OMR should re-establish an optimal media path for a session in the event of session modification (SDP offer/answer exchange);
- Impacts on IMS shall be minimized. Solutions should be based on existing IMS functional entities, use existing message flows and avoid the addition of new protocols or new messages between network elements;
- A single bandwidth reservation mechanism shall be used (for both roaming and non-roaming cases and for optimized and non-optimized sessions);
- Entities in one network shall not need to be aware of the internal structure of other networks;
- The routeing of media within a network shall not be constrained by OMR;

- OMR shall not be dependant on the direct peering of policies across a network boundary. No peering of Policy and Charging Rules Function (PCRF) [6] across network boundaries shall be required (since this does not represent a likely commercially acceptable solution);
- The service disruption of an on-going session when establishing OMR should be minimised;
- The impacts of OMR on the transport layers shall be minimised;
- The effects of introducing OMR on EPS shall be minimised;
- OMR shall provide mechanisms supporting media optimizations across multiple transit networks supporting homogenous interconnect agreements (e.g. IPX [7]);
- The originating or terminating networks shall be able to apply OMR on a session by session basis (e.g. for lawful intercept reasons, for media streams that need transcoding, or for services that require announcements to be played from the home network);

6 Scenarios and Solutions for local breakout

6.1 Scenarios

Editor's Note: PCC considerations are for FFS in following the scenarios.

6.1.1 P-CSCF located in home network – dual IP address

The user has the subscription through home operator H. The user is roaming and is currently served by a different operator. Figure 6.1.1-1 shows the signalling and media paths for this scenario. In this scenario, the UE uses two distinct IP addresses, one for IMS signalling and one for media. The IP address allocated by the home network is used for IMS signalling and the IP address allocated by the local IP gateway in the serving network is used for the media.

NOTE: The scenario where both IP addresses (e.g. one from home network and one from local IP gateway) are identical (e.g. overlapping private IP address) is out of the scope of this study.

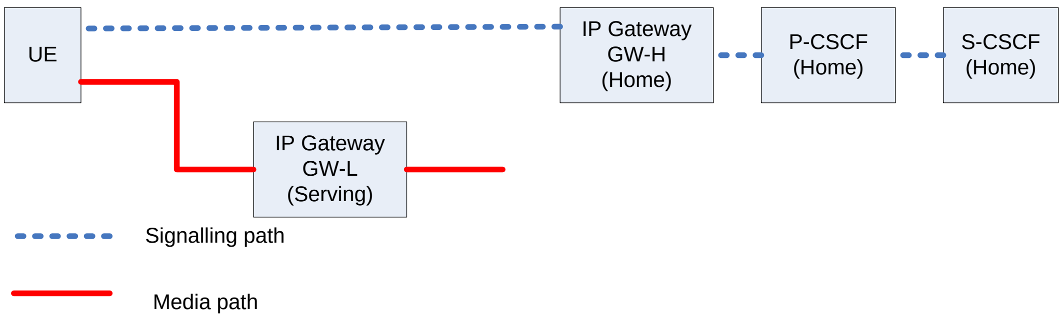

Figure 6.1.1-1: P-CSCF located in home network – dual IP address

Before starting IMS sessions, the UE sets up IP connectivity. In this scenario, the UE roams to a local access network, is assigned an IP gateway (GW-H) in the operator H's network and obtains an IP address (IP-H). Regarding the establishment of connectivity to the local IP gateway for local breakout, the UE can set up IP connectivity with the local IP gateway before IMS registration based on policies pre-configured on the UE. In this case, the UE is assigned an IP gateway (GW-L) in the local network and obtains an IP address (IP-L) for local breakout of IMS sessions. After that, the UE discovers a P-CSCF in the operator H's network and performs IMS registration. Alternatively, the UE performs IMS registration before establishing connectivity with a local IP gateway, and upon indication by the IMS, it sets up IP connectivity with the local IP gateway.

Editor's Note: The method for indication by the IMS is FFS.

When the user wishes to establish an IMS session with another user and this session uses local breakout, the UE indicates, in the SDP offer, IP-L as the address to which media is to be sent. Operator H authorizes the use of local breakout for the user for this session. The other user accepts the offer and indicates its own IP address as the address to which media is to be sent.

After the IMS session is established, the media does not traverse through the network of operator H, but is handled by the local IP gateway in serving operator's network.

This scenario permits the home operator to exercise control over the utilization of local breakout on a per IMS session basis.

This scenario is also applicable when operator H provides service over a large geographic area. The main difference from the above is that the GW-L will be in operator H's administrative domain and may even have IP connectivity to the P-CSCF.

6.1.2 P-CSCF located in home network – single IP address

The user is roaming and is currently served by the operator L. Figure 6.1.2-1 shows the signalling and media paths for this scenario. In this scenario, the UE uses the same IP address for both IMS signalling and the media. This IP address is allocated by the local IP gateway in the serving network.

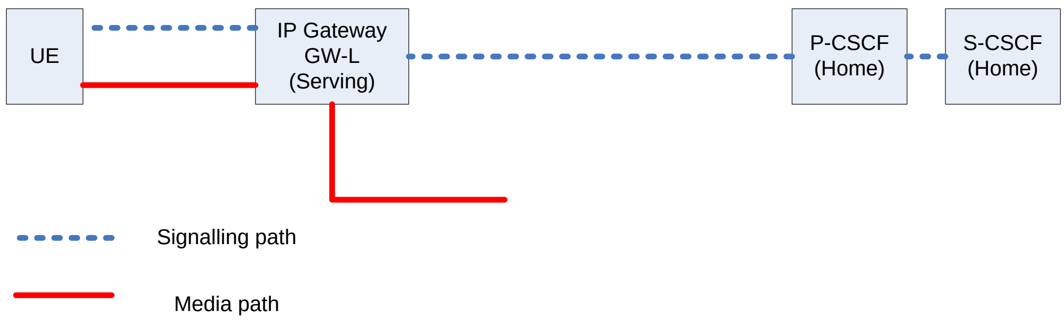

Figure 6.1.2-1: P-CSCF located in home network – single IP address

The UE discovers an IP gateway (GW-L) in the operator L's network and obtains an IP address (IP-L). Then the UE discovers a P-CSCF in the operator H's network and performs IMS registration.

The user wishes to establish a session with another user and indicates, in the SDP offer, IP-L as the address to which media is to be sent. The other user accepts the offer and indicates its own IP address as the address to which media is to be sent.

After the session is established, the media does not traverse through the network of operator H, but is handled by the local IP gateway in the serving operator's network.

This scenario assumes that the operator H has authorized the UE to utilize local breakout for all the IMS sessions.

Some non-3GPP IMS networks provide the capability to locate the P-CSCF in the home network even when the UE is roaming.

6.1.3 P-CSCF located in serving network

The user has the subscription through home operator H. The user is roaming and is currently served by operator L. Figure 6.1.3-1 shows the signalling and media paths for this scenario. In this scenario, the UE uses the same IP address for both IMS signalling and media. This IP address is allocated by the IP gateway (GW-L) in the serving network.

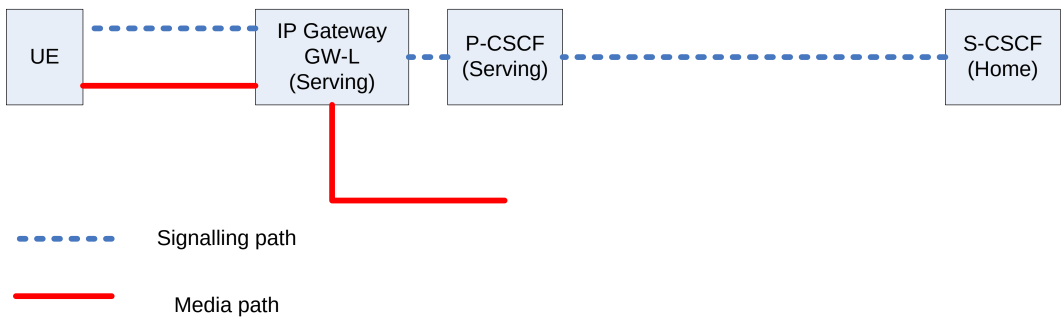

Figure 6.1.3-1: P-CSCF located in serving network

The UE discovers an IP gateway (GW-L) in the serving operator's network and obtains an IP address (IP-L). Then the UE discovers a P-CSCF in the serving operator's network and performs IMS registration.

The user wishes to establish a session with another user and indicates, in the SDP offer, IP-L as the address to which media is to be sent. The other user accepts the offer and indicates its own IP address as the address to which media is to be sent.

After the session is established, the media does not traverse through the network of the home operator, but is handled by the local IP gateway in the serving operator's network.

This scenario assumes that the operator H has authorized the UE to utilize local breakout for all the IMS sessions.

6.2 Alternative 1: Dual IP address

6.2.1 Description

In this scenario, there are two PDN GWs:

- PDN GW 1 used for anchoring of SIP signalling and IMS bearer traffic; it is located in the Home network;
- PDN GW 2 used for anchoring of IMS bearer traffic and located in the Visited network.

For the sake of simplicity, only 3GPP access and trusted non-3GPP access is depicted in Figure 6.2.1-1. S7c is present only with PMIP-based S8 (S8b).

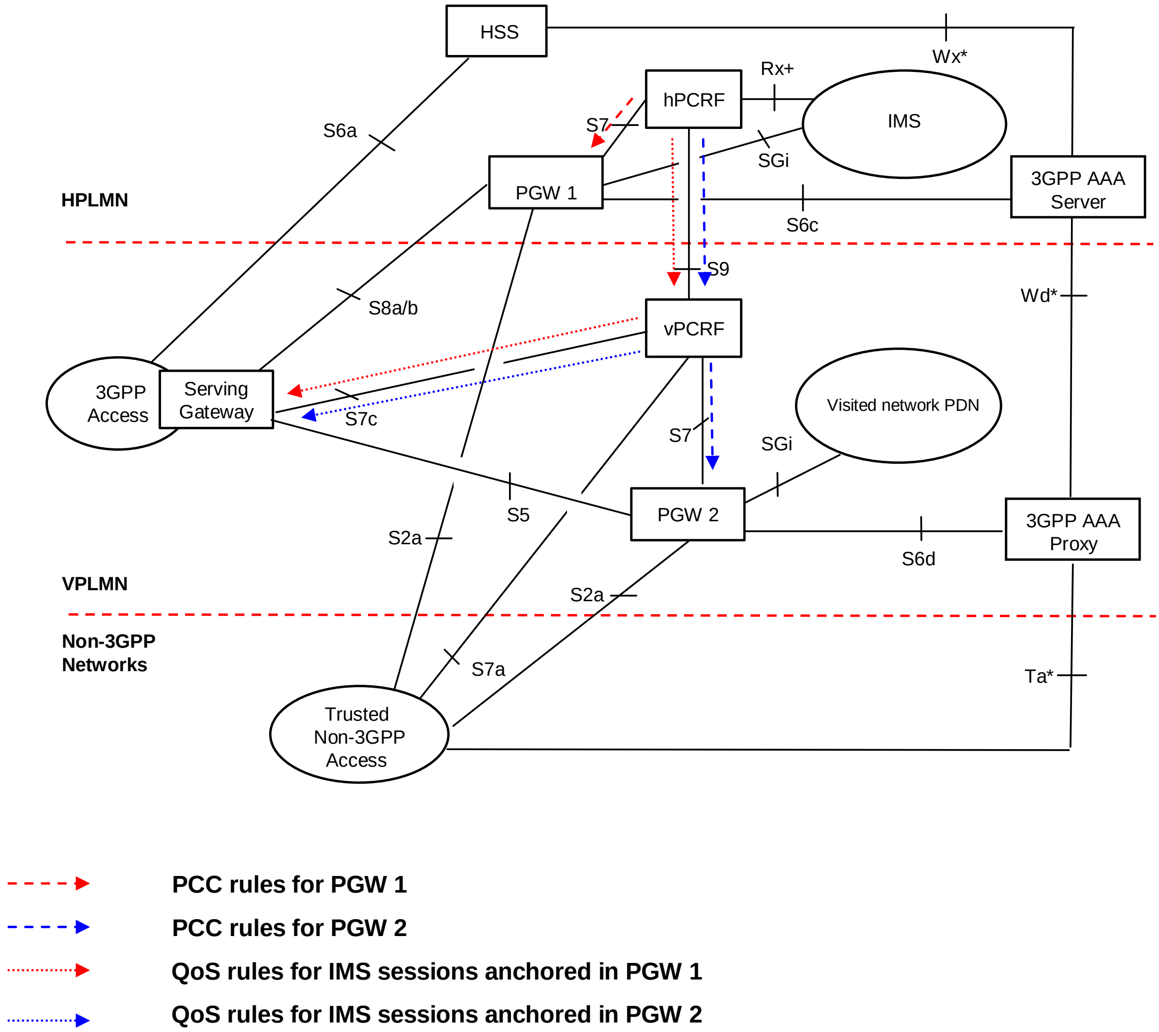

Figure 6.2.1-1: Local Breakout for IMS services with Dual IP addresses

From EPS perspective this looks like concurrent access to Multiple PDNs.

S9 is used in order to provide PCC rules to the vPCRF function in the Visited network, which then distributes the PCC information towards PDN GW2 via S7. In addition, in case of PMIP-based S8, S9 is also used for conveyance of QoS rules to the Serving GW or the trusted non-3GPP access via S7c and S7a, respectively.

Inter-PLMN handovers are supported by re-assigning a new PDN GW2 in the target VPLMN (note that PDN GW1 is not re-assigned).

For intra-PLMN handovers involving Serving GW change it may be possible to defer the re-assignment of a new PDN GW2 until the completion of any ongoing calls.

Figures 6.2.1-2 and 6.2.1-3 illustrates the two types of handovers involving Serving GW relocation:

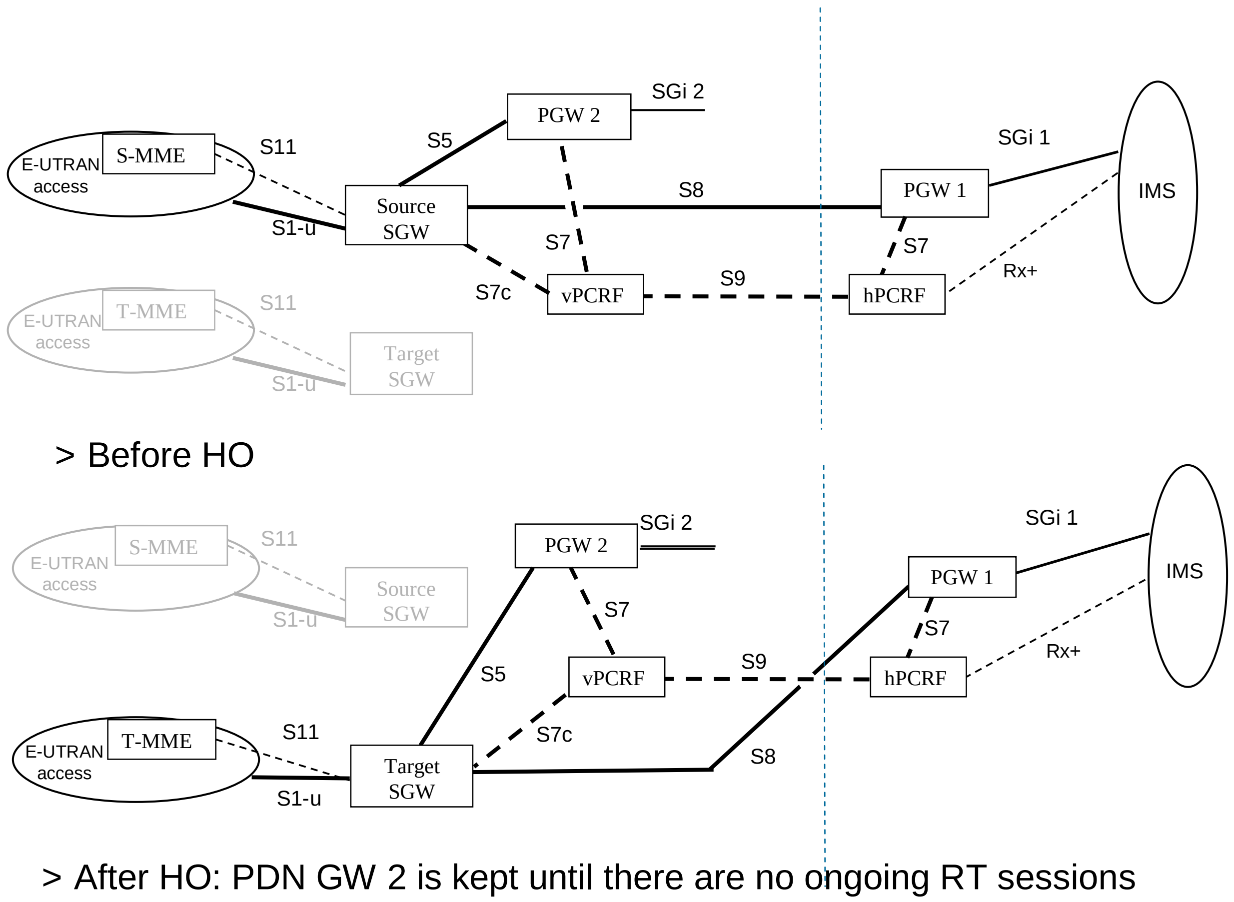

Figure 6.2.1-2: Handover involving Serving GW relocation: PDN GW2 relocation is postponed until there are no ongoing RT sessions

In Figure 6.2.1-2 the Serving GW is relocated while keeping the original PDN GW2. This is achieved by instantiating an S5 interface between the target Serving GW and the original PDN GW2. The bearer path after handover in this approach may thus not be optimised, however the advantage of this approach is that it minimises the service break, which is in particular important for real time traffic (e.g. VoIP). Once the ongoing VoIP sessions are terminated, it should be possible for the network to trigger a streamlining procedure by which the old PDN GW2 is released and a new PDN GW is assigned in order to optimise the bearer path for future VoIP sessions.

In Figure 6.2.1-3 the visited PDN GW (PDN GW2) is relocated at the same time as the Serving GW. This would typically be the case in inter-PLMN handovers. In this approach a new visited PDN GW (PDN GW3) is assigned, which implies a new IP address for the bearer plane (hosted on SGi 3), as well as relocation of the S7/S7c legs.

Editor's Note: The change of local IP address requires that the UE shall send a re-INVITE (or UPDATE) to the remote party to inform of the new media stream IP address for any established media streams using local breakout. The service interruption in the Figure X3 case is therefore longer than in the Figure X2 case. Nevertheless, as SA2 has already pointed out in a liaison reply to RAN3 (S2-062566): "However SA2 believe that MME/UPE relocation should be a relatively infrequent event, and does not need to have the same performance as intra-UPE handover, which should be the main way of supporting intra-LTE handover".

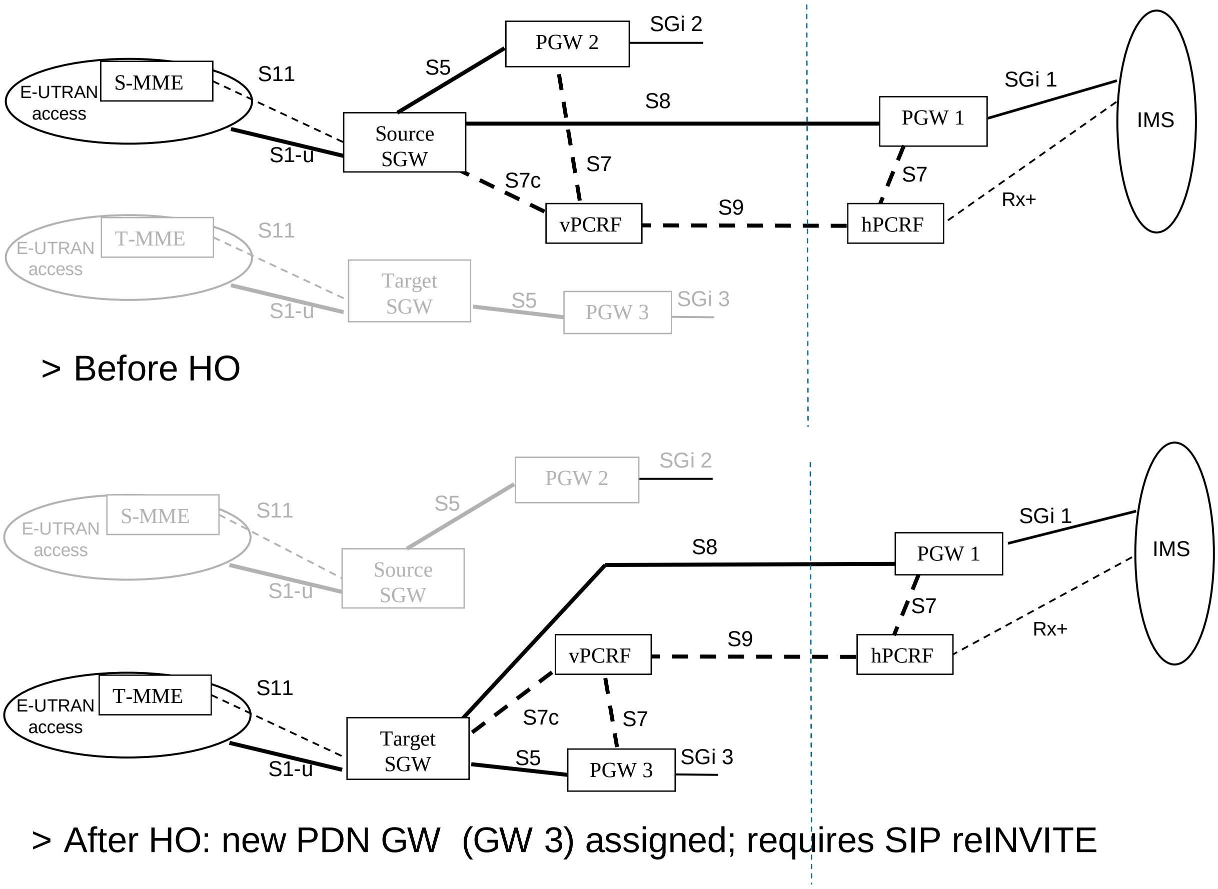

Figure 6.2.1-3: Handover involving Serving GW relocation: the visited PDN GW (PDN GW2) is relocated at the same time (e.g. Inter-PLMN handover)

6.2.2 Impact on IMS

Rel-7 IMS supports the usage of different IP addresses for the SIP signalling and for the bearer traffic, so there is no IMS impact from that perspective.

The decision on whether a particular IMS media stream should be home routed or routed in local breakout is made by the IMS in the home network. How this is achieved is FFS.

It is FFS whether the IMS in the home network indicates to the UE upon registration whether it needs to establish connectivity with a local PDN GW for local breakout.

6.2.3 Impact on EPS

It is FFS whether the two PDN connections can be set up as part of the Attach procedure.

Among the two approaches for NAT traversal described in TS 23.288, only the ICE and Outbound approach is applicable for the IMS bearer traffic breaking out of the visited PDN GW (PDN GW2), given that in this solution the P-CSCF is assigned in the home network.

It is FFS whether and how EPS is involved in dynamic decisions on whether a particular IMS session should be home routed or broken out locally.

6.2.4 Impact on UE

How the IMS client in the terminal is instructed about the usage of the two IP addresses is FFS. For example, the IMS client in the terminal may be instructed about the usage of the two IP addresses either based on the pre-configured policy or during the IMS registration.

In case of handover involving PDN GW change (e.g. inter-PLMN handover), the IMS client may have to manage the change of the IP address in the bearer plane (e.g. by sending SIP re-INVITE to the remote party).

6.3 Comparison of the scenarios

The following table summarizes the differences between the three scenarios and identifies areas where additional work is needed.

	Dual IP address	Single IP address - Home P-CSCF	Single IP address - Visited P-CSCF
Number of IP addresses obtained by the UE	2	1	1
IMS signalling anchored in the Home	Yes	No	No
NAT traversal for media	ICE/Outbound	ICE/Outbound	IMS ALG or ICE/Outbound
Serving network support of IMS	Not needed	Not needed	Needed
PCC impact	FFS	None	S9 may need to include both Rx and Gx functionality (FFS)
UE impact	Handling of two IP addresses	None	None
IMS impact	Indication for establishment of local PDN connectivity during IMS registration (FFS); Decision about Local Breakout on per-session basis (FFS)	Procedures for discovery of a P-CSCF in the home	None
Other EPS impact	Establishment of additional PDN connectivity upon Attach (FFS)	None	None

NOTE: The Dual IP address scenario allows for co-existence of IMS signalling anchored in the home network, along with media streams anchored in the home network, in the visited network or in both.

7 Scenarios and Solutions for optimal routeing of media

Editor's Note: This clause i) will identify the possible scenarios where the selection of an alternative media path (i.e. different to the signalling path) provides benefits to IMS operators by reducing the number of network entities in the media path and ii) will document the detailed reference architectures, including network elements, interfaces and reference points, suitable to carry out the identified scenarios.

7.1 Scenarios

The following scenarios are considered to be priority for OMR:

a) UE A and UE B are in the same visited network.

b) The visited networks of UE A and UE B are close by (e.g. same country/area).

c) UE A is visiting the home network of UE B or vice versa.

d) UE A is visiting a close by network of the Home of UE B or vice versa.

e) UE A is in a visited network and connects to UE B via PSTN gateway in the same visited network.

Where Close-by above is limited to cases of direct interconnect (or indirect interconnect with similar properties, such as transparent mode).

Optimizations of scenarios that traverse the same network multiple times on the path could be considered but with lower priority.

NOTE: Using interconnects without direct interconnect property can impose problems e.g. due to intermediate proxies, which may have properties impacting potential solution that cannot be foreseen.

7.2 Alternative 1: Extension to SDP for TrGW bypass

7.2.1 Introduction

The IP Multimedia Subsystem has the option to deploy TrGWs between the IP realms defined by each network. Within an IP realm every endpoint is reachable from any other endpoint using a common address space. Each of these TrGWs typically provides a firewall or Network Address Port Translator (NAPT) to limit access to endpoints within a realm. An Interconnection Border Control Function (IMS-ALG) controls each TrGW to allocate new IP addresses and ports as necessary for each SDP media line and updates the SDP connection and port information in each forwarded SDP offer and answer to effectively insert the TrGW into each end-to-end multimedia stream.

The media path associated with a multimedia stream may traverse an arbitrary number of IP realms between endpoints. If the TrGWs in the media path only have connections to its directly connected IP realms on the media path then the media path cannot be optimized using the allocated TrGW resources. However, if either of the endpoints, or any TrGW on the path, also has direct access to one of the other IP realms on the path then a shorter media path exists.

A sequence of IMS-ALGs implementing the proposed procedures (where each IMS-ALG can determine the IP address and port information for entities on the media path in its interconnected IP realms) will be able to establish a media path with the minimum number of TrGWs without compromising any of the access controls associated with the TrGWs on the path.

If one or more IMS-ALGs on the signalling path do not implement these proposed procedures then some TrGW bypass can still occur but some potentially bypassable TrGWs may remain in the media path.

This solution works by adding information to existing SDP offer/answer messages. It is thus an extension to SDP and builds on IMS-ALG/TrGW NAT traversal.

The solution requires two SDP extension attributes and some extensions to IMS-ALG procedures for forwarding SDP offers and answers. IMS-ALGs on the path manipulate the SDP as necessary within a single end-to-end SDP offer/answer transaction to minimize the number of TrGWs on the end-to-end media path. The SDP extension attributes describe media connection and port information for each IP realm on the path that is a candidate to bypass one or more TrGWs on the path.

The base algorithm, while requiring the use of IMS-ALGs, has the following advantages:

- avoids the need to deploy STUN servers.
- requires no additional signalling beyond what is needed for a single end-to-end SDP offer/answer transaction.
- applies independently to each media stream established by an SDP offer/answer transaction.
- applies to media streams established between any types of endpoints (e.g., UEs, media servers, media gateways).
- applies to media streams established using SIP 3pcc procedures.
- requires no new procedures to be supported by endpoints.
- allows TrGWs to limit access to known IP source addresses.
- allows TrGWs to predictably manage aggregate bandwidth usage for all sessions.

It should also be noted that this solution can still provide optimization of the media path, even if not all of the networks involved in the signalling path have deployed TrGWs. As long as at least two TrGWs have been deployed the algorithm may be able to optimize the media path. If only one TrGW is deployed, no optimization is possible.

Within the context of the base algorithm, an IMS-ALG may also include information about secondary TrGWs that may provide additional opportunities for optimization.

In addition to the base algorithm, an "active-bypass" option is also described. This provides the ability to attempt to find a shorter media path segment between existing TrGWs associated with the path. This option shares most of the advantages of the base algorithm, but requires additional SIP signalling to establish a SIP dialog for each alternate media path segment candidate. Due to this additional signalling overhead, this option should only be used when it can be determined that dramatic improvement is possible for a media path segment.

7.2.2 Reference Architecture

The following figures show existing 3GPP architecture figures. In the description of this solution the term IMS-ALG has been used, rather than referring to IBCFs or P-CSCFs. The first figure is taken from Annex I of TS 23.228 [8], and shows the IMS Border Control Functions.

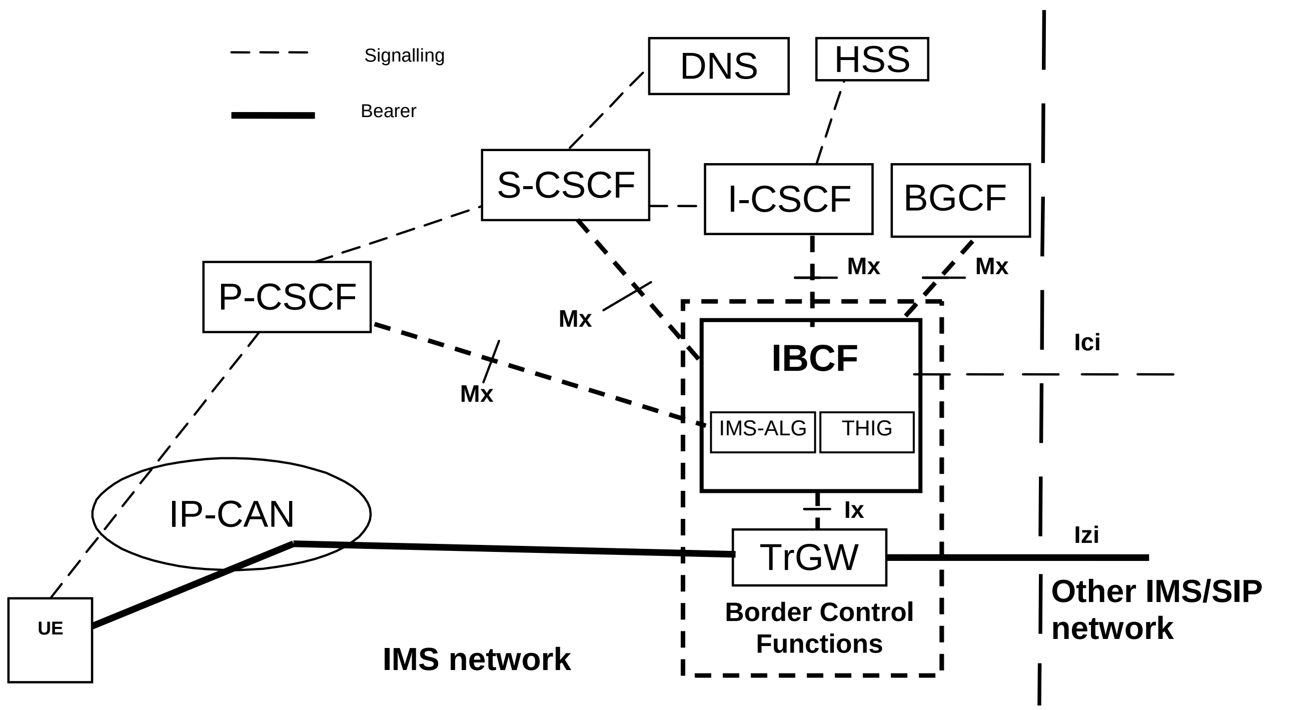

Figure 7.2.2-1: Border Control Functions

In addition, TS 23.228 [8] Annex G contains NAT traversal reference models as shown below:

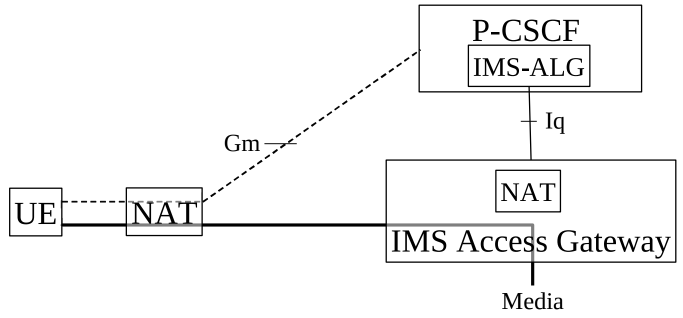

Figure 7.2.2-2: Reference model for IMS access when both the signalling and media traverses NAT

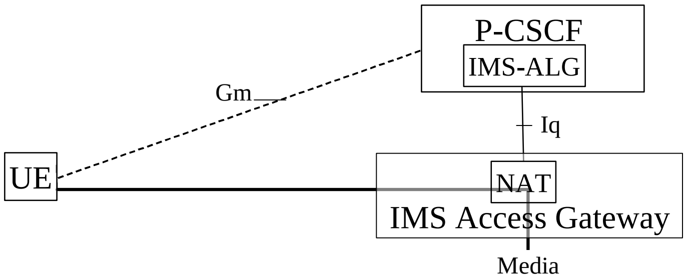

Figure 7.2.2-3: Reference model for IMS access when NAT is needed between the IP-CAN and the IMS domain

7.2.3 Description of base algorithm

7.2.3.1 Overview

Figure 7.2.3.1-1 shows a typical call configuration between endpoints UE1 and UE2, where the SIP signalling goes between the UEs via at least one IMS-ALG (four are shown) and other SIP servers not shown, and one RTP multimedia stream goes between the UEs via the TrGWs and possibly a residential gateway/NAT (RG) associated with each UE (only one RG is shown associated with UE2). Each TrGW is controlled by its corresponding IMS-ALG. R1, R2, etc., in the figure represent the IP realms associated with each segment of the media path.

The media path for each multimedia stream between the UEs is established via an end-to-end SDP offer/answer exchange where each IMS-ALG may choose to modify the connection and port information associated with each media line in the SDP to insert its TrGW in the media path according to normal IMS-ALG procedures. Each IMS-ALG may also identify when one or more TrGWs and/or RGs can be bypassed and to modify the forwarded SDP messages to implement the corresponding changes in the media path to bypass the TrGWs.

The example in figure 7.2.3.1-1 shows UE1 and UE2 as the endpoints for a single media stream, but the algorithm applies independently to each media stream (media line) established by an SDP offer/answer transaction, and to any combination of media stream endpoints including UEs, media servers and media gateways, even when the SDP offer/answer transactions are interworked between SIP dialogs using SIP 3pcc procedures.

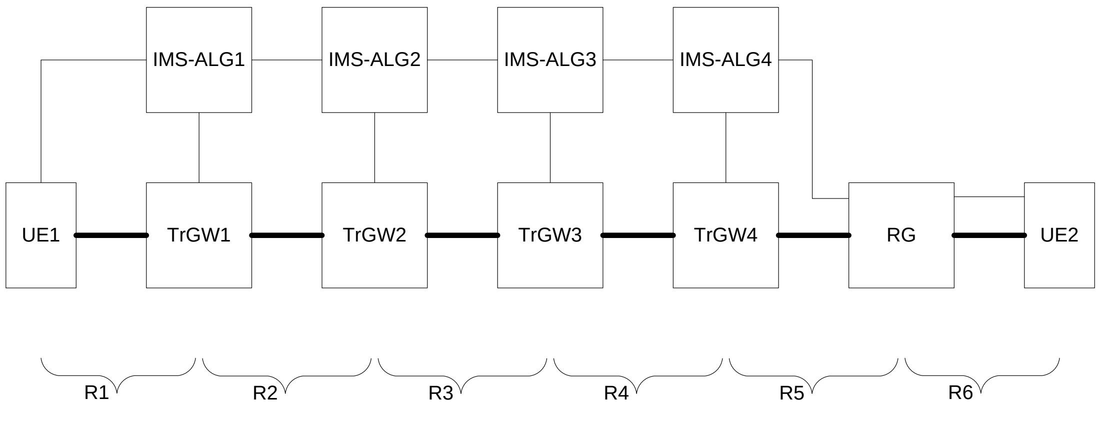

Figure 7.2.3.1-1: Example Call Configuration

The TrGW bypass base algorithm assumes that ICE is not used by any entity in the architecture. Although hybrid procedures are possible, they are beyond the scope of this document.

It is assumed that the UAs participate in standard SDP offer/answer negotiation by presenting standard connection and port information for each media line according to RFC 4566 [x], RFC 3264 [x] and possibly other extensions.

The TrGW bypass base algorithm is only implemented by the IMS-ALGs, also considering the reference model shown in Figures 7.2.2-2 and 7.2.2-3. A basic assumption for the algorithm is that IMS-ALGs are pre-configured with a list of peer networks, which allow the optimization of the media path. The procedures have no impact on any aspect of SDP offer/answer negotiation other than the connection and port information associated with each media line.

An SDP extension attribute 'visited-realm' provides connection and port information for an IP realm on the signalling path associated with a single media line. Each instance of visited-realm associated with a media line has a unique instance number, a realm identifier, connection/port data, and optional cryptographic signature computed using an algorithm private to each IP realm so as to ensure the integrity of the visited-realm data. There may be a separate visited-realm attribute inserted in the SDP for each media line and for each unique IP realm visited during an SDP offer/answer transaction.

Pre-configuration of the IMS-ALGs with a list of peer networks allows for simplification of the base algorithm, based on realm information.

The realm attributes in received offers assist IMS-ALGs in the determination of TrGWs to be bypassed. Upon inspection of the realm attribute, IMS-ALGs may decide on the TrGW allocation.

If an IMS ALG decides that previous TrGWs can be bypassed, it indicates this to their controlling IMS-ALGs based on the realm identifier in the SDP answer.

For example in Figure 7.2.3.1-1, if IMS-ALG2 is an egress node and IMS-ALG4 is an ingress node in the same domain, based on the SDP offer/answer transaction IMS-ALG4 will detect a media path optimization based on the detection of the realm identifier in the realm attribute, determining that TrGW controlled by intermediate nodes (i.e. IMS-ALG3, IMS-ALG2), as well as its own can be bypassed and unnecessary resources can be released.

Note that the connection and port information in each SDP offer/answer transaction within a SIP dialog must be handled the same way, re-allocating and de-allocating TrGWs as necessary with each SDP offer/answer transaction to accommodate any potential changes in the IP realms associated with the session endpoints.

7.2.3.2 Use of secondary TrGWs

Figure 7.2.3.2-1 shows another example call configuration where secondary TrGWs are used to establish a media path with fewer TrGWs. IMS-ALG1 through IMS-ALG5 initially allocate TrGW1a, TrGW2, TrGW3, TrGW4 and TrGW5a as IMS-ALGs forward the initial SDP offer towards UA2 from UA1. These TrGWs enable traversal of unique IP realms R1 through R6 (not labelled in the figure). Since these TrGWs do not create any loop in the media path, it is not possible to bypass any of them if the algorithm is limited to finding loops in a fixed media path.

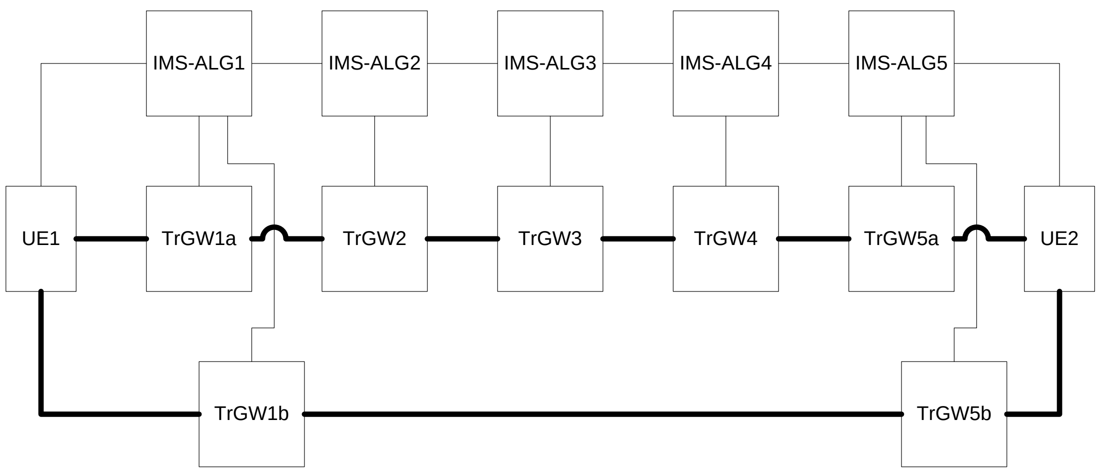

Figure 7.2.3.2-1: Example Configuration using Secondary TrGWs

While forwarding the initial SDP, if an IMS-ALG along the way, such as IMS-ALG1, controls TrGW(s) that have access to IP realm(s) other than those IP realms that it controls on the default media path (i.e. not R1 or R2), then the IMS-ALG can advertise its ability to access additional IP realm(s) by including information about them in the forwarded SDP.

An SDP extension attribute 'secondary-realm' is also proposed that provides connection and port information for secondary IP realms associated with the signalling path. The secondary-realm attribute includes the same types of information as the visited-realm attribute.

If a subsequent IMS-ALG (e.g., IMS-ALG5) determines that it controls a TrGW (e.g. TrGW5b) that has a direct connection to an IP realm accessible from a TrGW controlled by a previous IMS-ALG in the path (e.g., IMS-ALG1 and TrGW1b), then the IMS-ALG may choose to use this alternative media path if it appears to be an improvement over the initial path. In this example, the algorithm establishes an alternative media path from UA1 to UA2 via TrGW1b and TrGW5b while significantly reducing the number of TrGWs traversed. Note that the IP realm between TrGW1b and TrGW5b in the example (R7) will not match any of the IP realms R1 through R6. If the connections exist, the algorithm may also generate alternative paths either via TrGW1a and TrGW5b, via TrGW1b and TrGW5a, or via TrGW1a and TrGW5a, for example (not shown).

7.2.3.3 Procedures and call flows

7.2.3.3.1 Example flow for base algorithm

Figure 7.2.3.3.1-1 shows a call flow that corresponds to the configuration in figure 7.2.3.2-1.

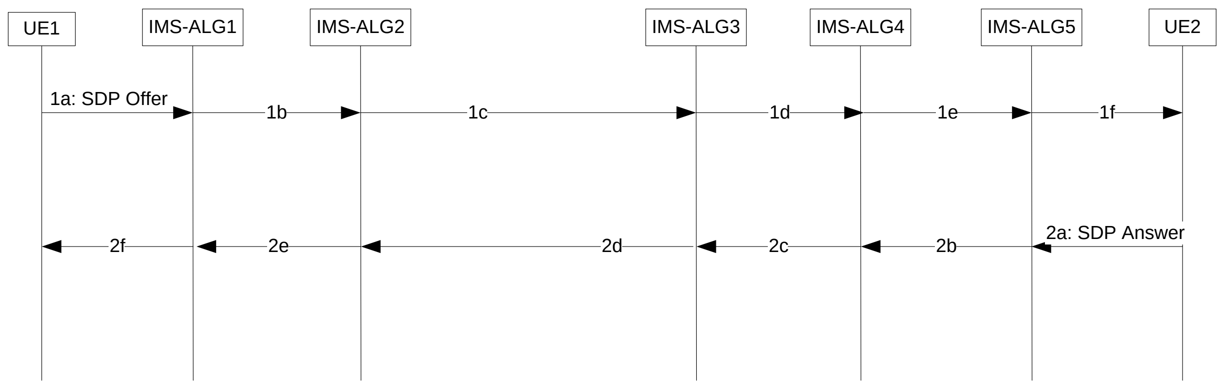

Figure 7.2.3.3.1-1: Example Flow with base algorithm

Steps 1a to 1f describe the progression of SDP offers via the IMS-ALGs from UA1 to UA2 and steps 2a to 2f describe the corresponding progression of SDP answers according to the base algorithm.

1a. UE1 (or other SIP user agent) sends an SDP offer associated with a controlled media resource.

1b. IMS-ALG1 determines that the outgoing IP realm is different from the incoming IP realm and allocates a TrGW for each media line based on existing procedures. The IMS-ALG1 adds visited-realm attributes for the incoming and outgoing IP realms to the forwarded SDP for each media line and changes the connection information in the forwarded SDP to match the allocated TrGW. The IMS-ALG1 may allocate secondary TrGWs for alternate outgoing IP realm options for each media line and add the corresponding secondary-realm attributes to the forwarded SDP. No TrGWs are bypassed.

1c. If IMS-ALG2 determines that the outgoing IP realm is different from all visited-realm and secondary-realm attributes associated with a media line, and the IMS-ALG2 controls no TrGW with access to an earlier visited-realm or secondary-realm, it allocates a TrGW for the media line based on existing procedures. The IMS-ALG2 adds a visited-realm attribute for the outgoing IP realm to the forwarded SDP for the media line and changes the connection information in the forwarded SDP to match the allocated TrGW. The IMS-ALG2 may allocate secondary TrGWs for alternate outgoing IP realm options for each media line and add the corresponding secondary-realm attributes to the forwarded SDP. No TrGWs are bypassed.

If IMS-ALG2 determines that the outgoing IP realm matches a visited-realm or secondary-realm attribute associated with the media line, it deletes any visited-realm and secondary-realm attributes for the media line with instance number greater than the matching attribute and changes the connection information in the forwarded SDP to that of the matching attribute. Note that the IMS-ALG2 does not allocate a TrGW, effectively bypassing its own TrGW and zero or more previous TrGWs.

If IMS-ALG2 determines that it controls a TrGW with access to an earlier visited-realm or secondary-realm associated with a media line, it allocates the TrGW, deletes any visited-realm and secondary-realm attributes for the media line with instance number greater than the matching attribute, and changes the connection information in the forwarded SDP to that of the allocated TrGW. Note that the IMG-ALG2 effectively bypasses one or more previous TrGWs.

1d through 1f. Each subsequent IMS-ALG applies the same algorithm as IMS-ALG2 in step 1c.

2a. UE2 (or other SIP user agent) responds to the received SDP offer by sending an SDP answer with a media line associated with a controlled media resource. UE2 ignores visited-realm and secondary-realm attributes for the media line in the received SDP offer.

2b. If IMS-ALG5 previously allocated a TrGW for the media line and bypassed no previous TrGWs for the media line when previously handling the SDP offer, it changes the connection information for the media line in the forwarded SDP answer to that of the allocated TrGW.

If IMS-ALG5 previously bypassed its own TrGW and zero or more previous TrGWs for a media line when previously handling the SDP offer, it adds a visited-realm attribute for the previous connected IP realm to the media line in the forwarded SDP answer, and changes the connection information for the media line in the forwarded SDP answer to the unspecified address.

If IMS-ALG5 previously allocated a TrGW for a media line and bypassed one or more previous TrGWs for the media line when previously handling the SDP offer, it adds a visited-realm attribute for the incoming side of the allocated TrGW to the media line in the forwarded SDP answer, and changes the connection information for the media line in the forwarded SDP answer to the unspecified address.

2c. If IMS-ALG4 receives valid connection information for the media line in the received SDP answer, it applies the same algorithm as IMS-ALG5 in step 2b.

If IMS-ALG4 receives the unspecified address as the connection information for a media line in the received SDP answer, and the visited-realm for the media line in the received SDP answer matches the incoming IP realm for the media line of the previously received SDP offer, it changes the connection information for the media line in the forwarded SDP answer to the connection information in the visited-realm for the media line from the received SDP answer. IMS-ALG4 now de-allocates and bypasses its TrGW if it has not already done so.

If IMS-ALG4 receives the unspecified address as the connection information for a media line in the received SDP answer, and the visited-realm for the media line in the received SDP answer matches an earlier visited-realm or secondary-realm previously received in the SDP offer, it forwards the received SDP answer for the media line without change. IMS-ALG4 now de-allocates and bypasses its TrGW if it has not already done so.

2d and 2e. Each subsequent IMS-ALG applies the same algorithm as IMS-ALG4 in step 2c.

2f. IMS-ALG1 applies the same algorithm as IMS-ALG4 in step 2c, but always forwards valid connection information for each media line in the forwarded SDP answer, since IMS-ALG1 never bypasses itself during the previous processing of the SDP offer for the media line. The TrGW associated with IMS-ALG1 may or may not be bypassed depending on which case applies.

7.2.4 Description of active bypass option

7.2.4.1 Overview of Operation of the Active-Bypass Option

The Active-Bypass option can be used in addition to the proposal described above to discover alternative paths not discovered by the base algorithm.

Figure 7.2.4.1-1 shows an example of the use of the base algorithm with the active-bypass option. If the initial TrGW allocations traversing IP realms R1 through R6 do not offer an opportunity to bypass any TrGWs (as in figure 2), and if no connections exist to offer any of the alternative options available in the base algorithm, then the active-bypass option can discover additional alternative(s). Note that in this case TrGW1b and TrGW5b do not share a common IP realm (in fact, all of the IP realms are different in this example), so the active-bypass option creates a new signalling path via IMS-ALG6 to establish a new media path segment via TrGW6.

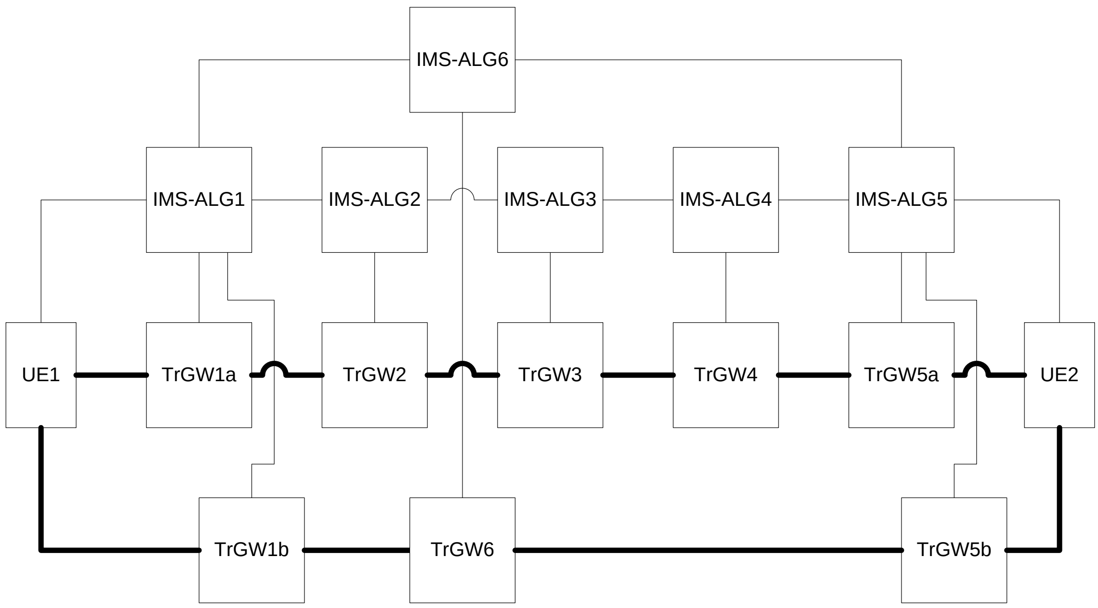

Figure 7.2.4.1-1: Example Configuration with Active-Bypass Option

When implementing the active-bypass option, the following additional information may be included in each visited-realm and secondary-realm attribute generated by the base algorithm for an SDP offer, if available: the approximate geo-location of the corresponding TrGW; the approximate delay of IP packets on the previous media path segment between this TrGW and the immediately preceding TrGW or endpoint; the approximate packet loss rate on the same media path segment; and if the IMS-ALG is reachable via a globally unique host name, then a globally reachable address of the IMS-ALG with a unique instance id for the corresponding SIP dialog and media line, in the form of a temporary GRUU [8].

Each IMS-ALG should include the geo-location, delay and loss information in the first visited-realm attribute that it generates for an SDP offer, and may include them for other visited-realm or secondary-realm attributes if the information differs significantly from the first. Each IMS-ALG may include the GRUU in the first visited-realm attribute that it generates for a media line in an SDP offer. There is no need to repeat the GRUU in subsequent visited-realm or secondary-realm attributes for the same media line.

When processing the SDP answer in the second phase of the base algorithm, after determining which TrGWs (if any) are to be bypassed as a result of the base algorithm, each IMS-ALG that still controls a TrGW determines if there is the possibility that a significantly shorter media path segment can be established via another IMS-ALG reachable via a GRUU. Each IMS-ALG makes this determination based on the available geo-location, delay and packet loss information associated with each TrGW and media path segment.

If an IMS-ALG determines that it may be able to establish a shorter media path segment, the IMS-ALG (e.g., IMS-ALG5) sends a SIP INVITE request to the "best" IMS-ALG reachable via a GRUU (e.g., IMS-ALG1) to establish a separate dialog and corresponding alternate media path segment (e.g., via IMS-ALG6 and TrGW6). If the IMS-ALG is successful in establishing the alternate media path segment and it appears to be significantly better than the corresponding one determined by the base algorithm, then the IMS-ALGs instruct the TrGWs to insert the shorter path segment into the overall media path.

7.2.4.2 Example flow for Active Bypass Option

Figure 7.2.4.2-1 shows a call flow that corresponds to the configuration in figure 7.2.4.1-1.

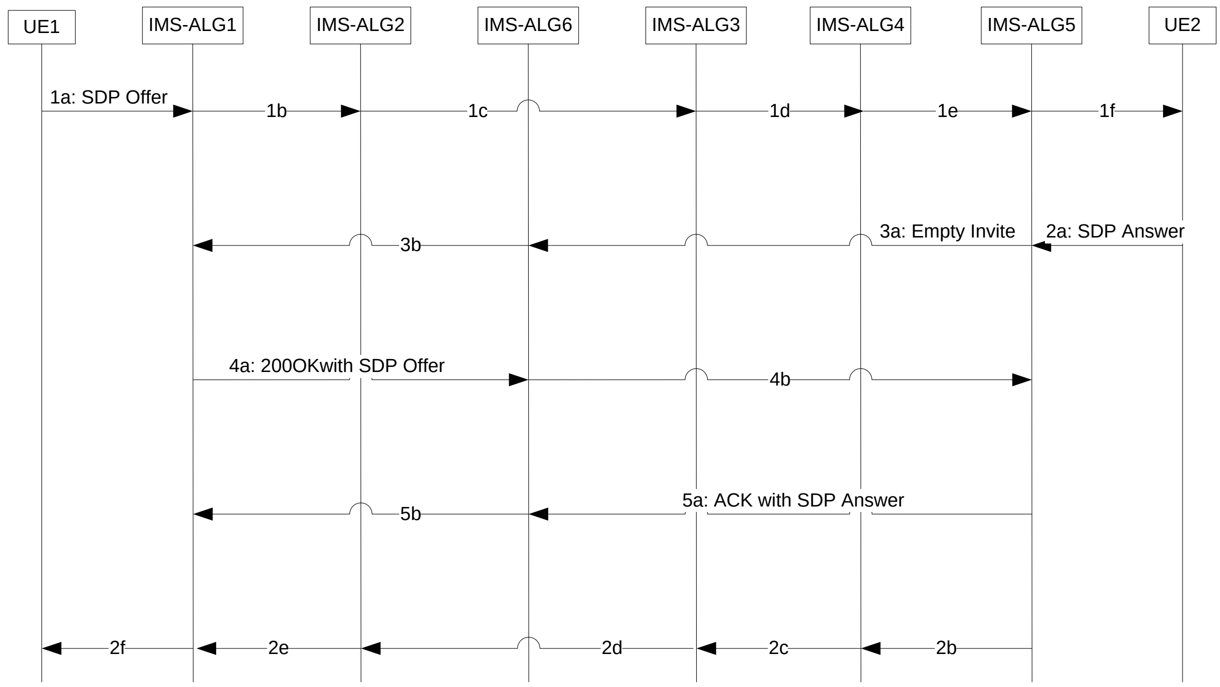

Figure 7.2.4.2-1: Example Flow with Active-Bypass Option

Steps 1a to 1f describe the progression of SDP offers via the IMS-ALGs from UA1 to UA2 and steps 2a to 2f describe the corresponding progression of SDP answers according to the base algorithm. After step 2a, IMS-ALG5 determines that it may be able to establish a shorter media path segment via IMS-ALG1 and sends an empty SIP INVITE request to IMS-ALG1 via IMS-ALG6 in steps 3a and 3b. Steps 4a, 4b, 5a and 5b describe a new SDP offer/answer transaction between IMS-ALG1 and IMS-ALG5 via IMS-ALG6 which attempts to establish an alternate media path segment. If an alternate media path segment is successfully established and is a significant improvement, IMS-ALG5 signals the selection of the alternate media path segment to IMS-ALG1 in steps 2b through 2e. IMS-ALG1 incorporates the alternate media path segment into the media path for the primary dialog before forwarding the final SDP answer to UA1 in step 2f.

1a through 1f. See steps 1a through 1f of figure 7.2.3.3.1-1.

2a. See step 2a of figure 7.2.3.3.1-1.

3a. If IMS-ALG5 retains TrGW5a for a media line after processing of the base algorith, if IMS-ALG5 determines that a shorter media path may exist to an earlier IP realm remaining in the path based on geo-location, delay and error rate information available from visited-realm and secondary-realm attributes previously received in the SDP offer for the media line in step 1e, and if there is a temporary GRUU available from the visited-realm or secondary-realm attribute associated with the earlier IP realm, then IMS-ALG5 may attempt to initiate the active-bypass option for the media line by sending an empty SIP INVITE request to the IMS-ALG (IMS-ALG1) associated with the earlier IP realm by setting the Request URI to the temporary GRUU for the media line associted with IMS-ALG1.

3b. IMS-ALG6 forwards the empty SIP INVITE request to IMS-ALG1.

4a. IMS-ALG1 responds to the empty INVITE request by sending an SDP offer in a 200 OK response. The SDP offer includes a media line for each media line forwarded in the SDP offer of the original dialog in step 1b for which IMS-ALG1 previously allocated a TrGW. Each media line in the new SDP offer includes a copy of the codec information from the previously forwarded SDP offer, connection information for TrGW1b, and a visited-realm attribute with temporary GRUU.

4b. IMS-ALG6 forwards the 200 OK response to IMS-ALG5.

5a and 5b. IMS-ALG5 responds to the 200 OK response with the ACK request including an SDP answer to establish the alternate media path segment between TrGW1b and TrGW5b.

2b. If the geo-location, delay and error information associated with the alternate path segment for the media line indicates that it is substantially better than the corresponding media path segment established by the original dialog, then IMS-ALG5 forwards the SDP answer for the media line from step 2a after changing the connection information to the unspecified address and including a visited-realm attribute with unique connection information indicating that there is no matching IP realm along the original media path.

2c through 2e. Since the visited-realm attribute in the received SDP answer does not match any of the IP realms associated with the IMS-ALGs, the IMS-ALGs forward the SDP answer without change, de-allocating TrGWs along the way if necessary.

2f. IMS-ALG1 waits for receipt of both of the SDP answers in steps 5b and 2e. If the visited-realm attribute for the media line in step 2e indicates no matching IP realm on the original media path, then IMS-ALG1 completes the insertion of the alternate media path segment into the original media path by substituting connection information for TrGW1b into the forwarded SDP answer.

7.2.5 Interactions with Transcoding

7.2.5.1 Transcoding with the base algorithm

The existing IBCF procedures for transcoding in TS 23.228 [8] either allow the IBCF to add codec options to an SDP offer before forwarding (called proactive transcoding), or allow the session to fail if none of the initial Codecs are supported by the terminating side, in which case the IBCF adds codec options to a second SDP offer (called reactive transcoding).

With reactive transcoding, the IMS-ALG adds the transcoding function and anchors its TrGW only when transcoding is needed. The alternative 1 OMR procedure is fully consistent with reactive transcoding and supports the same degree of media optimization whether or not transcoding is used for a particular session.

With proactive transcoding, the IMS-ALG may or may not allocate a TrGW at the beginning of the SDP offer/answer transaction, and may need to add or remove the TrGW when the SDP offer/answer transaction completes by initiating a second SDP offer/answer transaction.

If the IMS-ALG does not allocate a TrGW and forwards the received connection information in the SDP offer, it should also forward any OMR SDP extension attributes to allow full OMR to occur. This assures that if the terminating side selects one of the original Codecs and no transcoding is needed, the media path can be correctly established with OMR in one SDP offer/answer transaction. If the terminating side selects one of the additional Codecs, the IMS-ALG allocates a TrGW for transcoding and anchors the TrGW in the media path during the second SDP offer/answer transaction without forwarding any OMR extension attributes for prior IP realms in the forwarded SDP offer. This assures that OMR is separately applied to the incoming and outgoing media legs of the anchored TrGW.

If the IMS-ALG allocates a TrGW and forwards the TrGW connection information in the SDP offer, it shall not include any OMR extension attributes for prior IP realms. This assures that if the terminating side selects one of the additional Codecs associated with the TrGW, the media path can be correctly established with OMR separately applied to the incoming and outgoing media legs of the anchored TrGW within one SDP offer/transaction. If the terminating side selects one of the original Codecs and transcoding is not needed, the IMS-ALG may remove the TrGW during a second SDP offer/answer transaction,. The alternative 1 OMR procedure performs the appropriate optimizations to the entire media path during the second SDP offer/answer transaction.

For both reactive and proactive transcoding, if a second SDP offer/answer transaction is required to establish the optimized session, the IMS-ALG that allocates the transcoding function initiates and completes the second SDP offer/answer transaction on the outgoing leg before returning an SDP answer for the first SDP offer/answer transaction. If an active-bypass is created during the first SDP offer/answer transaction that becomes invalid or is modified during the second SDP offer/answer transaction, the IMS-ALG establishing the active-bypass during the first SDP offer/answer transaction ensures that it is deleted or modified as necessary during the second SDP offer/answer transaction.

For both reactive and proactive transcoding, the alternative 1 OMR procedures apply without change to the existing SDP offer/answer transactions.

7.2.5.2 Codec-aware option

7.2.5.2.1 General

While the base algorithm provides media path optimization with or without transcoding, certain improvements are possible by sharing information about codec changes made by the IMS-ALGs. By allowing an IMS-ALG to report codec changes it makes to subsequent IMS-ALGs, the following improvements can be made to the base algorithm without loss of any functions or options associated with the base algorithm:

- For the proactive transcoding methods, it is possible for an IMS-ALG to remove the transcoding options associated with a previous IMS-ALG and offer a codec list with the same or a different set of transcoding options. This allows for either the deletion of a potential transcoding point on the media path, or the relocation of a potential transcoding point from an earlier TrGW on the media path to a later TrGW on the media path. This may be desirable, for example, if the second TrGW is anchored anyway, thus allowing the bypass of an extra TrGW. This may also be desirable if anchoring of the second TrGW rather than the previous TrGW can be identified as leading to a shorter end-to-end media path.

- An IMS-ALG has the option to restore Codecs deleted by a previous IMS-ALG if the previous IMS-ALG can be bypassed.

- If an IMS-ALG invokes the proactive transcoding method with gateway reservation and a later IMS-ALG that anchors its own TrGW in the media path then determines that transcoding is not needed, the later IMS-ALG may be able to bypass the earlier TrGW allocated for transcoding without requiring a second SDP offer/answer transaction.

- If an IMS-ALG invokes the proactive transcoding method with gateway reservation and a later IMS-ALG that does not anchor a TrGW in the media path then determines that transcoding is not needed, the later IMS-ALG may be able to initiate a second SDP offer/answer transaction to update the terminating side and bypass the earlier TrGW allocated for transcoding. While not eliminating the second SDP offer/answer transaction in this case, it reduces the required signalling.

While not eliminating all need for a second SDP offer/answer transaction in transcoding scenarios, the codec-aware option provides the greatest potential for reduction in signalling when used with the proactive transcoding method with gateway reservation. Furthermore, the codec aware option has the potential to reduce the number of calls where transcoding or even multiple occurrences of transcoding are applied, to reach a more optimal allocation of transcoding points and to reach a shorter end-to-end media path.

7.2.5.2.2 Procedures

The changes required to the base algorithm for the codec-aware option are as follows:

1. While processing an SDP offer, an IMS-ALG may add or delete Codecs in the codec list for a media line according to local policy. When adding Codecs for potential transcoding, the IMS-ALG may use the reactive method, the proactive method without gateway reservation, or the proactive method with gateway reservation, according to local policy. The IMS-ALG choosing to modify the codec list for a media line shall include a copy of the media line for the incoming SDP offer in the visited realm attribute and alternate realm attribute(s) for the realms associated with the outgoing SDP offer.

NOTE 1: There may be more than one visited realm or alternate realm attribute associated with the same realm, and there may be separate attributes for the incoming and outgoing SDP offer if there is a change in the codec list for the media line even if no gateway is reserved and they are associated with the same realm.

When processing an SDP answer, if an IMS-ALG that offers transcoding according to one of the three transcoding options is not bypassed by a later IMS-ALG, it may perform a second SDP offer/answer transaction as needed according to the transcoding option selected and the base algorithm.

2. While processing an SDP offer, if an IMS-ALG identifies a previous TrGW in the media path that is associated with additions to the codec list (i.e., transcoding options) for a media line and that can be bypassed if the additions are not needed (i.e., an earlier visited realm is reachable), and if the IMS-ALG determines according to local policy either that the codec additions are not needed or that the IMS-ALG can offer the codec additions locally (e.g., by providing transcoding options via a TrGW), then the IMS-ALG may bypass the previous TrGW, thus removing its codec additions, and optionally make other codec additions locally before forwarding the SDP offer.

In effect, this allows for either the deletion of a potential transcoding point on the media path, or the relocation of a potential transcoding point from an earlier TrGW on the media path to a later TrGW on the media path. This may be desirable, for example, if the second TrGW is anchored anyway, thus allowing the bypass of an extra TrGW. This may also be desirable if anchoring of the second TrGW rather than the previous TrGW can be identified as leading to a shorter end-to-end media path.

If a previous TrGW adding Codecs to a media line in an SDP offer also deletes any of the original offered Codecs, the IMG-ALG bypassing the previous TrGW may restore any of the deleted Codecs to the forwarded SDP offer according to local policy before making other local codec additions.

NOTE 2: A previous TrGW in the media path that adds to the codec list shall not otherwise be bypassed during processing of the SDP offer.

3. While processing an SDP offer, if an IMS-ALG identifies a previous TrGW in the media path that is associated with deletions to the codec list (and no additions) for a media line, the IMS-ALG shall treat the previous TrGW as a candidate for bypass according to the base algorithm. If the IMS-ALG bypasses the previous TrGW, it may restore any of the Codecs deleted by the previous TrGW to the forwarded SDP offer according to local policy.

4. When processing an SDP answer, if an IMS-ALG anchoring a TrGW on the media path identifies a previous TrGW that could have been bypassed according to the base algorithm but was not bypassed due to the addition of Codecs for potential transcoding, and the IMS-ALG determines that none of the additional Codecs associated with the previous TrGW were selected in the SDP answer, then the IMS-ALG may bypass the previous TrGW.

   When the IMS-ALG associated with the previous TrGW in this case uses the proactive transcoding method with gateway reservation, this procedure avoids the second SDP offer/answer transaction that would otherwise be required to remove the previous TrGW from the media path.

5. When processing an SDP answer, if an IMS-ALG that does not anchor a TrGW on the media path 1) identifies a previous TrGW that could have been bypassed according to the base algorithm but was not bypassed due to the addition of Codecs for potential transcoding, 2) determines that none of the additional Codecs associated with the previous TrGW were selected in the SDP answer, and 3) determines that the IMS-ALG associated with the previous TrGW used the proactive transcoding method with gateway reservation, then the IMS-ALG may bypass the previous TrGW after initiating and completing a second SDP offer/answer transaction on the outgoing leg with the media line and connection information associated with the earliest reachable realm prior to the previous TrGW according to the base algorithm.

   This procedure allows an IMS-ALG closer to the SDP answerer to initiate and complete the second SDP offer/answer in this case, rather than requiring this to be done by the IMS-ALG offering the transcoding options, thus reducing the signalling needed to remove the previous TrGW from the media path.

7.2.6 Interworking with PSTN

Since many IMS sessions will be interworked with the CS domain, it would be beneficial to apply optimization to the entire path between endpoints. Alternative 1 applies throughout interconnected IMS networks until the point of interworking with the CS domain (typically the MGCF), but not within the existing CS domain. In the future, IMS may provide more of the transit infrastructure for the CS domain using features like ICS, or by collocating MGCF and MSC functionality, but media optimization within the CS domain is out of scope.

7.2.7 Interaction with local breakout

There are no special considerations when applying OMR to the single IP address form with visited P-CSCF, and the dual IP address form of local breakout is not recommended. This discussion focuses on the single IP address form of local breakout with home P-CSCF. In this case, the UE will normally be assigned a globally reachable public IP address to avoid the use of a NAT between the visited and home networks.

The use of IMS-ALGs and TrGWs in the home network raises the concern that the media path for a session using local breakout may be anchored in the home network if an OMR algorithm cannot remove the TrGWs allocated in the home network, thus limiting the potential for media path optimization. Nevertheless, the home network may have legitimate security concerns requiring the use of IMS-ALGs and TrGWs at its border to protect internal network resources. If the home network allocates media resources for a session to provide a media function such as transcoding, conferencing or announcements, any TrGW allocated at the home network border serves the purpose of protecting the internal network resources and shall not be subject to bypass.

To achieve OMR for sessions that traverse the home network without need of an internal media function, an OMR algorithm must identify this case and ensure that TrGWs are either not allocated at its border or are de-allocated. In the most common case where the home network can interconnect to other networks using globally reachable public IP addresses, then Alternative 1 provides the means to ensure that OMR can be achieved. The Alternative 1 algorithm identifies that since both the UE and the next interconnected network are reachable using public IP addresses, the media path for the session can bypass the home network and its TrGWs altogether. Thus the Alternative 1 OMR algorithm allows for the complete bypass of any network that does not provide media functions for a session, particularly when each network has available globally reachable public IP addresses for external media connections.

7.2.8 Protecting network resources

It is necessary to assure that a TrGW cannot be bypassed when it is allocated to protect a network media resource such as a transcoder or conference bridge. Alternative 1 only bypasses a TrGW when an authorized alternate media path exists. If a media resource is allocated within a network, Alternative 1 can assure that the media resource can only be accessed either from another endpoint within the network or via a TrGW protecting access from another network. This is accomplished by labelling media connection information with a realm name that is only valid within its network.

7.2.9 Network interconnect issues

Alternative 1 assumes that interconnect agreements are in place to allow the application of the algorithm at the boundary between networks. Media may completely bypass a home or transit network when no media resources are needed in the network. Interconnect agreements must allow for transit of the SDP extensions needed for Alternative 1 and for transit of SIP signalling with or without associated media. Every ALG in a supporting network must support the algorithm. Alternative 1 allows any network to force the media through its network if necessary for media functions or to satisfy regulatory requirements, by either terminating the session at a media server or endpoint, or by removing the SDP extensions from forwarded SDP.

Since Alternative 1 is based on a proposed SDP extension, any non-supporting network should ignore the extension according to standard procedures and use the connection information normally populated in SDP. The result is that any media resource or endpoint in the non-supporting network will be anchored in the path and not subject to bypass. If the non-supporting network introduces no media function in the media path, then it should transit the SDP messages without change, maintaining the ability to apply OMR to the end-to-end media path.

If some peer networks have interoperability issues with the proposed SDP extension, there may be a local policy in the IMS-ALG to delete the OMR SDP extension attributes from SIP messages towards these networks. This policy should be applied selectively since opportunities for media optimization may be lost if the non-supporting network inserts no media functions in the media path.

The extension is not consistent with ICE, but since ICE requires the cooperation of both endpoints, Alternative 1 will take precedence and apply throughout the supporting portions of the end-to-end path.

7.2.10 Resource admission control

Resource admission control in the RAN is triggered by the completion of the SDP negotiation. Since the Alternative 1 algorithm is concurrent with the SDP negotiation and completes by the end of the SDP offer/answer signalling, resource admission control begins only after media optimization completes, thus assuring correct resource allocation.

7.2.11 Lawful Intercept

Alternative 1 allows a network to insert a non-bypassable media resource, such as one needed for lawful intercept, in the path of any IMS session as necessary. Since this media resource cannot be bypassed, it reduces options for media optimization. Optimization is still separately possible on the media legs from the resource to the two endpoints.

Insertion of a media resource in a media path may be visible by an endpoint as a change in connection information if there is no intervening TrGW in the path, compared to a similar session without the media resource.

Editor's note: Whether this possibility of detection is an issue for the use of Alternative 1 with LI is FFS, even though there are many possible valid reasons for a network to manipulate connection information in an IMS session.

7.2.12 Charging

Charging records should include sufficient information to capture the allocation and/or bypass of TrGWs in the media path of an IMS session. This information should be used to facilitate reconciliation of charging data between networks.

7.2.13 Common transit scenario

The most common transit scenario for a network is to use globally reachable IP addresses to reach peer networks. Thus any network on the path that deploys IMS-ALGs and TrGWs at its border to protect internal media resources has the ability to bypass the TrGWs for sessions that do not require the allocation of media resources within the network. Figure 7.2.13-1 shows how Alternative 1 ensures that TrGWs are bypassed in this case.

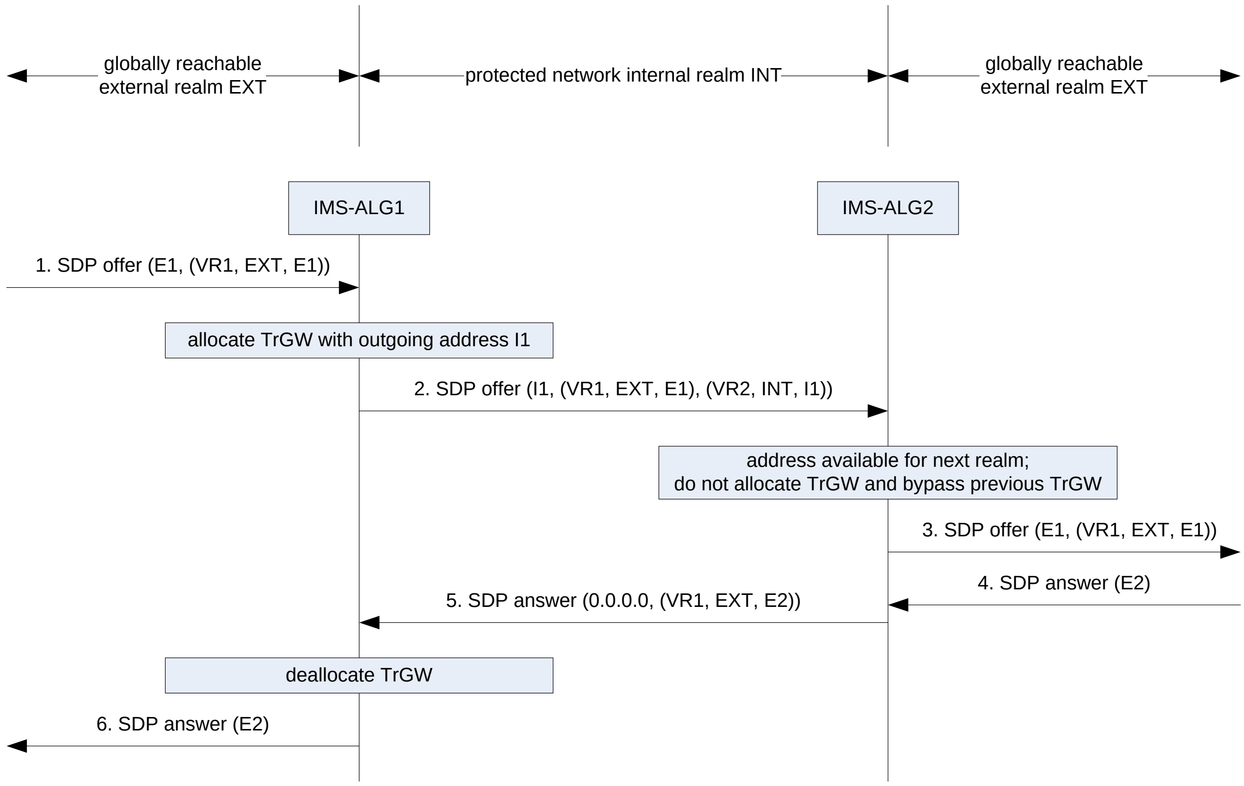

Figure 7.2.13-1: TrGW bypass in common transit scenario

- IMS-ALG1 receives an incoming SDP offer from external realm EXT. The SDP offer includes IP address E1 within the external realm EXT and a visited realm attribute for the same address. IMS-ALG1 and IMS-ALG2 are associated with the incoming and outgoing IBCFs for a protected network with realm INT.

- IMS-ALG1 allocates a TrGW with outgoing address I1 and forwards an SDP offer with address I1 that is valid within the realm INT and two visited realm attributes associated with the incoming and outgoing SDP offers.

- IMS-ALG2 notes that a visited realm attribute from the incoming SDP offer includes an address that is valid in the outgoing realm. IMS-ALG2 does not allocate a TrGW, remembers that it must bypass the previous TrGW, and forwards the address E1 that is valid in the outgoing realm EXT.

- The terminating side returns an SDP answer with a valid address E2 in the realm EXT.

- IMS-ALG2, recalling that it must bypass the previous TrGW, forwards an unspecified address (0.0.0.0) for realm INT in the SDP answer and includes a visited realm attribute with a valid address for realm EXT.

- Upon receiving an SDP answer with an unspecified address for realm INT, IMS-ALG1 extracts the valid address E2 for realm EXT from the visited realm attribute and forwards the SDP answer with address E2.

7.3 Alternative 2: Transcoding aware

7.3.1 Description of the base algorithm

This alternative introduces a transcoding aware procedure for OMR, that is, identify when one or more TrGWs and/or RGs can be bypassed, or, an alternative media path can be used, during SDP answer forwarding phase.

During SDP offer forwarding phase, each IMS-ALG supporting OMR shall provide IP realm information on the incoming signalling path in the forwarded SDP offer for each media stream. If an IMS-ALG along the signalling path controls additional TrGW(s), and the additional TrGW(s) has access to the IP realm(s) other than those IP realms that it controls on the default media path, then the IMS-ALG can advertise its ability to access additional IP realm(s) by appending the related information in the forwarded SDP offer for the media stream, which can help the later IMS-ALG(s) to find the secondary optimized media path. The information of the additional IP realm(s) is on the outgoing signalling path.

NOTE 1: If an IMS-ALG does not provide TrGW for a media stream, then the IMS-ALG can forward the IP realm(s) information for the media stream received in the SDP offer or the SDP answer.

The IP realm information for the default media path and the additional TrGW(s) contains at least realm identifier, connection/port data, and the codec number. The codec number stands for the quantity of Codecs in the SDP offer received by the IMS-ALG, which is the vital information to determine whether proactive transcoding can be applied by previous IMS-ALG or not.

NOTE 2: If auxiliary formats such as DTMF and comfort noise included in the SDP offer, then if auxiliary formats are well known, e.g. telephone-event, the auxiliary formats must not be counted into the codec number, otherwise, the IMS-ALG(s) providing transcoding options must move the auxiliary formats to the bottom and correct the codec number of the received IP realms, which are successive from the end and have identical codec number.

A new SDP media-level attribute "realm" can be used for providing IP realm information. The new attribute shall include a sequence number. The IP realm(s) provided by an IMS-ALG should be included in one "a=realm:" attribute line.

Another new SDP session-level attribute "pathp" can be optionally included to contain the Path Parameters for all media lines, such as connection data of the media line(s). The "pathp" attribute shall include a sequence number corresponding to the "realm" attribute, and may include cryptographic signature to ensure the integrity of the IP realm data and Path Parameters data. If the Path Parameters related to an IMS-ALG contains connection data, there is no need to repeat the connection data in the IP realms related to the IMS-ALG for all media lines if they are same.

During SDP answer forwarding phase, each IMS-ALG may identify one or more TrGWs and/or RGs can be bypassed, or, an alternative media path can be used. The optimized alternative media path is determined based on the received IP realm(s) information during SDP offer phase, all the IP realms information for a media stream makes up an ordered IP realm list.

When an IMS-ALG receives an SDP answer, the IMS-ALG shall:

1. if a media line in the SDP answer does not contain IP realm, check the IP realm list from the beginning and:

   a. identify whether a controlled TrGW has a direct connection to an IP realm, which is on the outgoing or incoming signalling path;

NOTE 3: If the IMS-ALG provides transcoding options, and a transcoding option is selected, do not consider the IP realm on the outgoing signalling path (i.e. the TrGW controlled by the IMS-ALG is included in the media path).

   b. if an IP realm is identified, copy the Codecs of the received SDP offer one by one from beginning into a codec list until the quantity of Codecs in the codec list equals to the codec number of the identified IP realm; and,

   c. if the selected codec (indicated in the SDP answer or selected by the IMS-ALG) is in the codec list, then provide an IP realm for the media line in the forwarded SDP answer, and

      - if the identified IP realm is on the outgoing signalling path, provide the connection information of the SDP answer in the IP realm to bypass the controlled TrGW; or

- if the identified IP realm is on the incoming signalling path, use the connection information of the identified IP realm and provide connection information of the controlled TrGW in the IP realm.

- set the sequence number of the "realm" attribute line containing the IP realm to that of the "realm" attribute line containing the identified IP realm.

NOTE 4: The IMS-ALG must release the controlled TrGW if it can be bypassed, and in order to release the bypassed TrGW(s) prior to the controlled TrGW, the IMS-ALG must set the connection information of the media stream in the SDP answer to the unspecified address.

d. otherwise, proceed with step a - c until no IP realm can be identified.

2. if a media line in the SDP answer contains an IP realm:

a. if the sequence number of the "realm" attribute line containing the IP realm is the same as that of the added "realm" attribute line in the forwarded SDP offer, and the realm identifier of the IP realm is the same as that of the added IP realm(s) in the forwarded SDP offer, then:

NOTE 5: IP realm data may be encrypted, so, it is better to check the sequence number first.

- if the IP realm is on the incoming signalling path, forward an SDP answer with the connection information of the IP realm and bypass the controlled TrGW. The IMS-ALG shall remove the IP realm and corresponding Path Parameters from the forwarded SDP answer; or,

- if the IP realm is on the outgoing signalling path, use the connection information of the IP realm and forward an SDP answer with the connection information of the controlled TrGW. The IMS-ALG shall proceed with step 1 for IP realm on the incoming signalling path before forwarding the SDP answer.

b. otherwise, forward an SDP answer with the IP realm to bypass the controlled TrGW.

If an IMS-ALG is the last one to the remote UE or is the last one in an OMR domain (successive IMS-ALGs supporting OMR consist of an OMR domain), and the TrGW controlled by the last IMS-ALG can be bypassed, and the connection information of the identified IP realm is different from that of the forwarded SDP offer, then an extra SDP offer/answer exchange is required.

An IMS-ALG can determine that it is the last one based on deployment. Another alternative is that each IMS-ALG includes IP realm information in the SDP answer. If an IMS-ALG receives an SDP answer without IP realm, the IMS-ALG decides that it is the last one. And if an IMS-ALG receives an SDP answer that carries IP realm information containing unspecified address, which means that the next IMS-ALG can not find out an optimized media path or an alternative media path and the IP realm is an invalid IP realm, then the IMS-ALG proceeds with step 1.

7.3.2 Procedures and call flows

7.3.2.1 Call flow for base algorithm

Figure 7.3.2.1-1 shows a call flow for transcoding aware OMR that the last TrGW can not be bypassed.

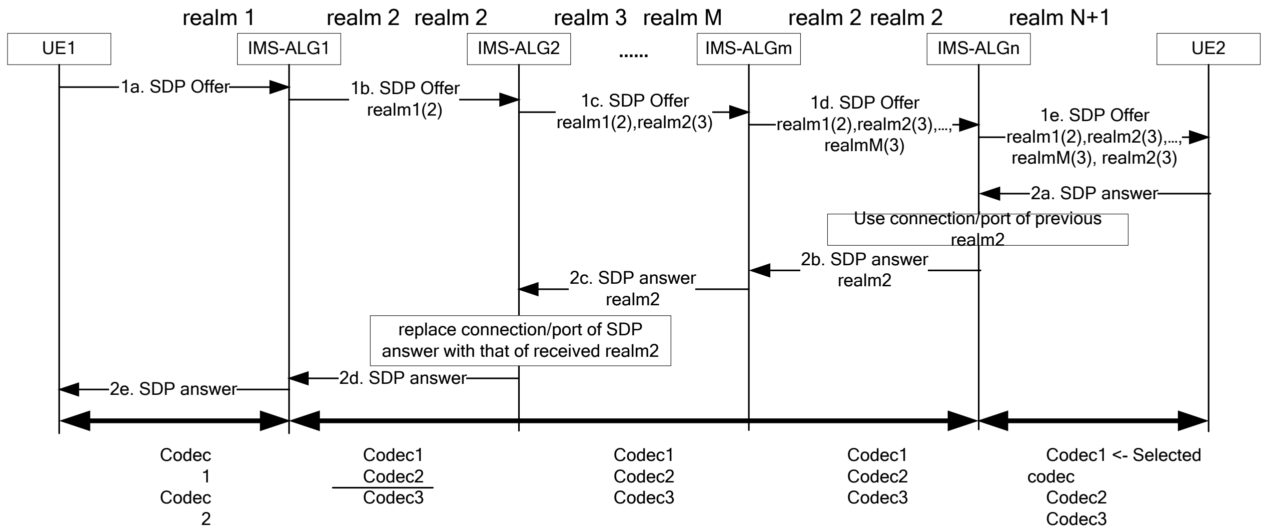

Figure 7.3.2.1-1: Transcoding aware

NOTE: The number in the brackets is codec number of the IP realm. The Codecs at the bottom of the figure show the Codecs in the corresponding SDP offer. The codec below the line is added by IMS-ALG1. Remote UE2 selects Codec1 in the SDP answer.

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2. The IMS-ALG1 adds Codec3 as transcoding option. Steps 2a to 2e describe the corresponding progression of SDP answers according to the algorithm.

The TrGW controlled by each IMS-ALG has two IP realms, one is on the incoming signalling path that needs to be recorded in the SDP offer during SDP offer phase, and the other is on the outgoing signalling path. In the flow, IMS-ALGn identifies that the IP realm identifier on the incoming signalling path of IMS-ALGn (realm2) is the same as that of IMS-ALG2 (realm2), then IMS-ALGn gets a codec list containing Codec1 and Codec2, because selected codec Codec1 is in the gotten codec list, so TrGWs controlled by IMS-ALG2, IMS-ALG3 … and IMS-ALGm can be bypassed. The connection/port data in the IP realm of step 2b, 2c, and 2d represent the transport address of TrGW controlled by IMS-ALGn.

7.3.2.2 Last TrGW can be bypassed

Figure 7.3.2.2-1 shows a call flow for transcoding aware OMR in case that the last TrGW can be bypassed without additional signalling.

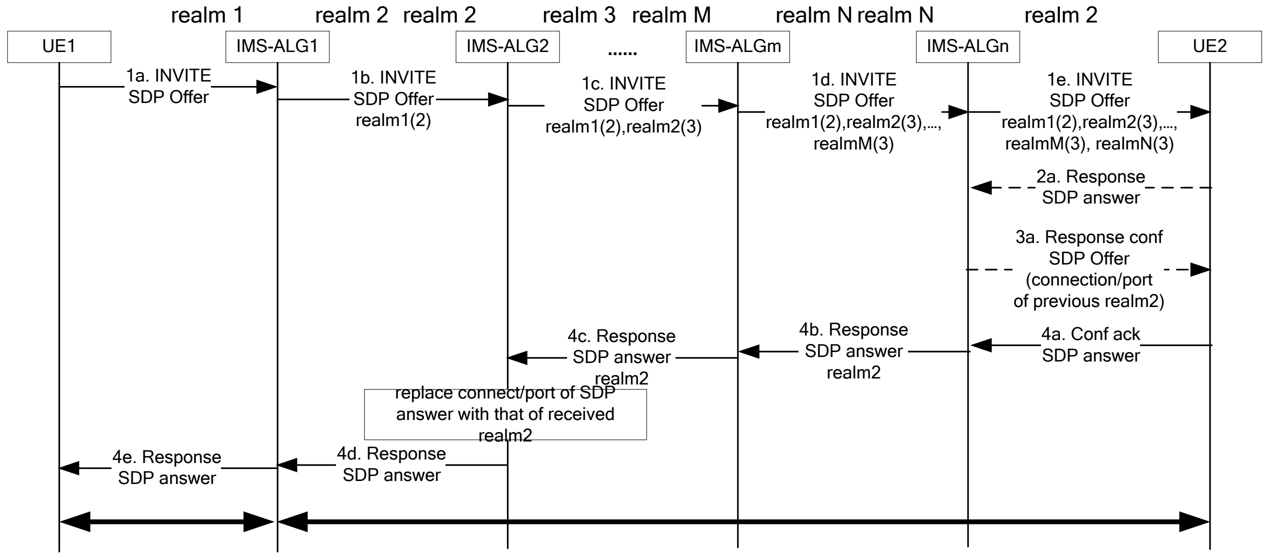

Figure 7.3.2.2-1: Transcoding aware - last TrGW can be bypassed without additional signalling

NOTE 1: The number in the brackets is codec number of the IP realm. If IMS-ALGn does not provide TrGW for the media, then last TrGW is controlled by IMS-ALGm, and realm N is realm 2, and the SDP offer in step 1e does not carry realmN(3).

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2, step 2a describes the SDP answer from UE2, step 3a describes the new SDP offer with connection/port information of previous IP realm 2, and steps 4a to 4e describe the corresponding progression of SDP answers according to the algorithm.

NOTE 2: If the IMS-ALGn knows that an UPDATE transaction is needed, steps 2a and 3a are optional and then the confirmation ACK of step 4a can be SIP 18x response, otherwise, the UE1 will send out a PRACK request without SDP after step 4e, the IMS-ALGn must stop forwarding the PRACK request and send out 200 OK response to the PRACK request. In some case, the PRACK request may contain SDP offer, if terminating UE support UPDATE method, then the IMS-ALGn must send out UPDATE request to terminating side, otherwise the IMS-ALGn must follow the procedure shown in figure 7.3.2.2-1 after receiving answer message.

In the flow, the IP realm identifier on the outgoing signalling path of IMS-ALGn (realm2) is the same as the IP realm identifier on the incoming signalling path of IMS-ALG2 (realm2), so TrGWs controlled by IMS-ALG2 to IMS-ALGn can be bypassed. Because the IMS-ALGn is the last IMS-ALG to the remote UE, an extra SDP offer/answer exchange is needed as shown in step 2a and 3a. The connection/port data in the IP realm of step 4b, 4c, and 4d represent the transport address of UE2.

Figure 7.3.2.2-2 shows another call flow for transcoding aware OMR that the last TrGW can be bypassed with additional signalling cost.

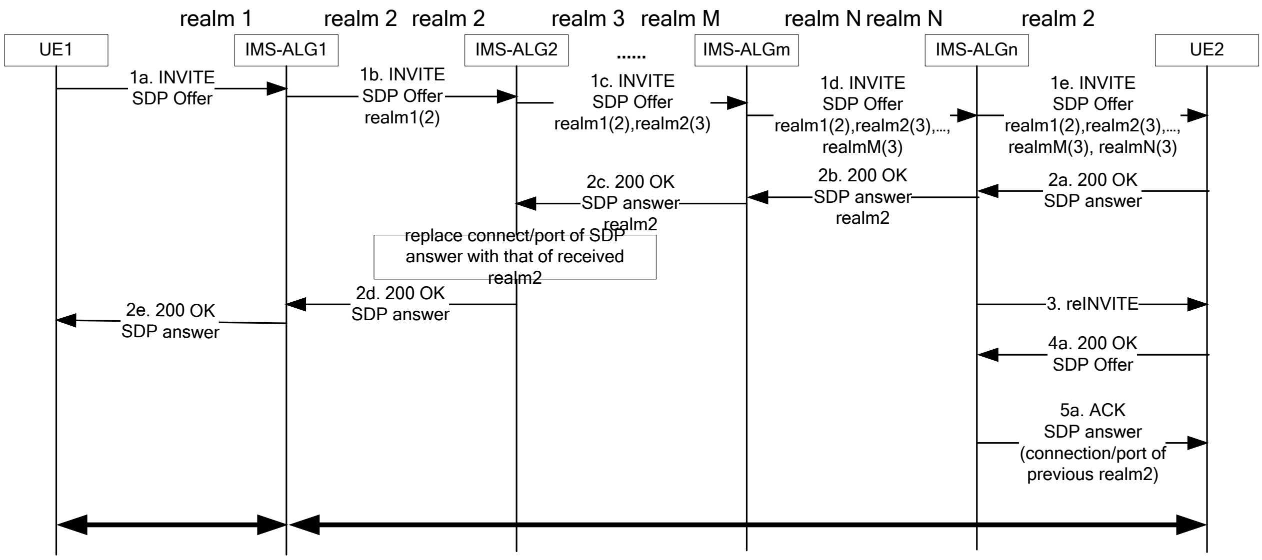

Figure 7.3.2.2-2: Transcoding aware - last TrGW can be bypassed with additional signalling cost

NOTE 3: The number in the brackets is codec number of the IP realm. If IMS-ALGn does not provide TrGW for the media, then last TrGW is controlled by IMS-ALGm, and realm N is realm 2, and the SDP offer in step 1e does not carry realmN(3).

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2, steps 2a to 2e describe the SDP answer from UE2 to UE1, step 3 describes that IMS-ALGn requests UE2 to initiate an SDP offer/answer transaction, step 4a describes the new SDP offer from UE2, and step 5a describes the new SDP answer with connection/port information of previous IP realm 2 and selected codec indicated in SDP answer of 2a.

NOTE 4: SDP offer in step 4a is SDP answer in step 2a with additional Codecs, so, SDP answer in step 5a is SDP offer in step 1d with replaced connection information and selected Codecs.

7.3.2.3 IMS-ALG controls additional TrGW(s)

Figure 7.3.2.3-1 shows a call flow for transcoding aware OMR in case that an IMS-ALG has additional TrGW(s).

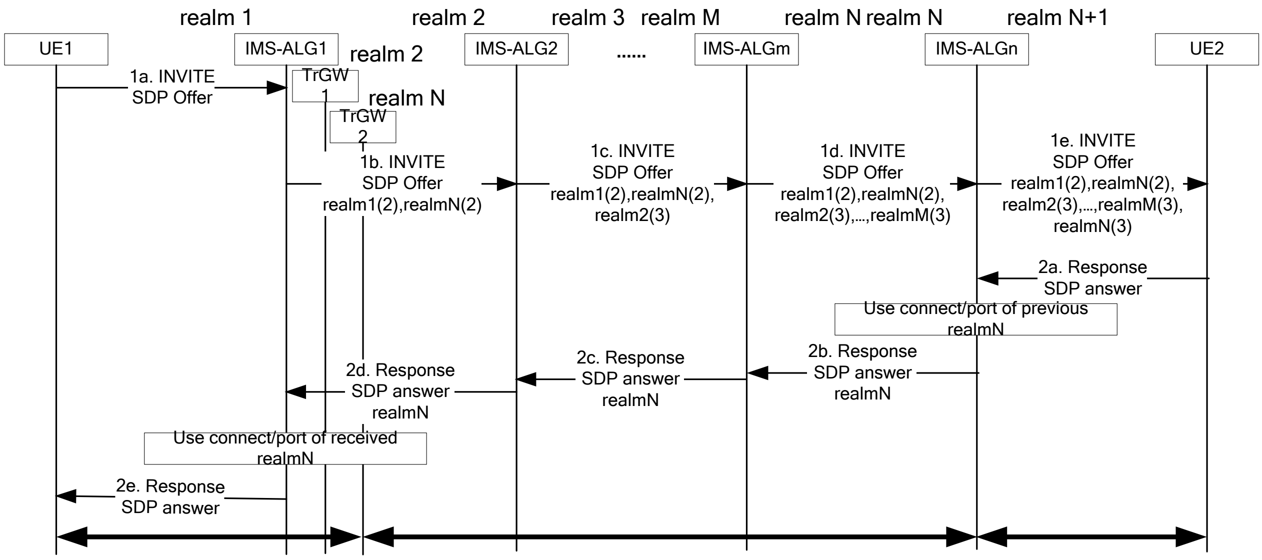

Figure 7.3.2.3-1: Transcoding aware - additional TrGW provided

NOTE: The number in the brackets is codec number of the IP realm.

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2. The TrGW1 controlled by the IMS-ALG1 is default TrGW for the media path, the additional TrGW2 controlled by the IMS-ALG1 can access IP realm N on the outgoing signalling path. Steps 2a to 2e describe the corresponding progression of SDP answers according to the algorithm.

7.3.3 Handling of removed codec

If an IMS-ALG decides to remove some codec from the received SDP offer per local policy, the IMS-ALG shall record the removed codec and the related position in the last IP realm in the forwarded SDP offer.

NOTE 1: If the IMS-ALG does not provide TrGW for the media, then the IMS-ALG will not add IP realm in the forwarded SDP offer, the IMS-ALG will recode the information of the removed codec into the last IP realm received in the SDP offer.

During SDP answer forwarding phase, if an IMS-ALG receives an SDP answer that a media line does not contain IP realm, the IMS-ALG shall apply procedures as specified in clause 7.3.1 with following additions:

- after identifying an IP realm and before getting a codec list, restore the removed Codecs in the IP realms after the identified one (including the identified one) into the Codecs of the received SDP offer.

NOTE 2: The restoration must be performed as restoration of incremental backup, so that if two or more IP realms containing information of removed codec, the removed Codecs can be correctly restored. For example, if original Codecs are C1, C2, and C3, firstly C2 is removed by some IMS-ALG, the position of C2 is 2, secondly C3 is removed by another IMS-ALG, the position of C3 also is 2, then the IMS-ALG first restore C3 in the second place, then restore C2 in the second place and move C3 to the third place.

NOTE 3: If the IMS-ALG provides transcoding options, and a transcoding option is selected, and the transcoding option is a removed codec by previous IMS-ALG, the TrGW controlled by the IMS-ALG may be bypassed, i.e. the IP realm on the outgoing signalling path still need to be considered.

Figure 7.3.3-1 shows an example flow of recording information of removed codec in the IP realm, which shows that a transcoding option is selected, and the transcoding option is removed by previous IMS-ALG, and the optimized media path does not involve transcoding.

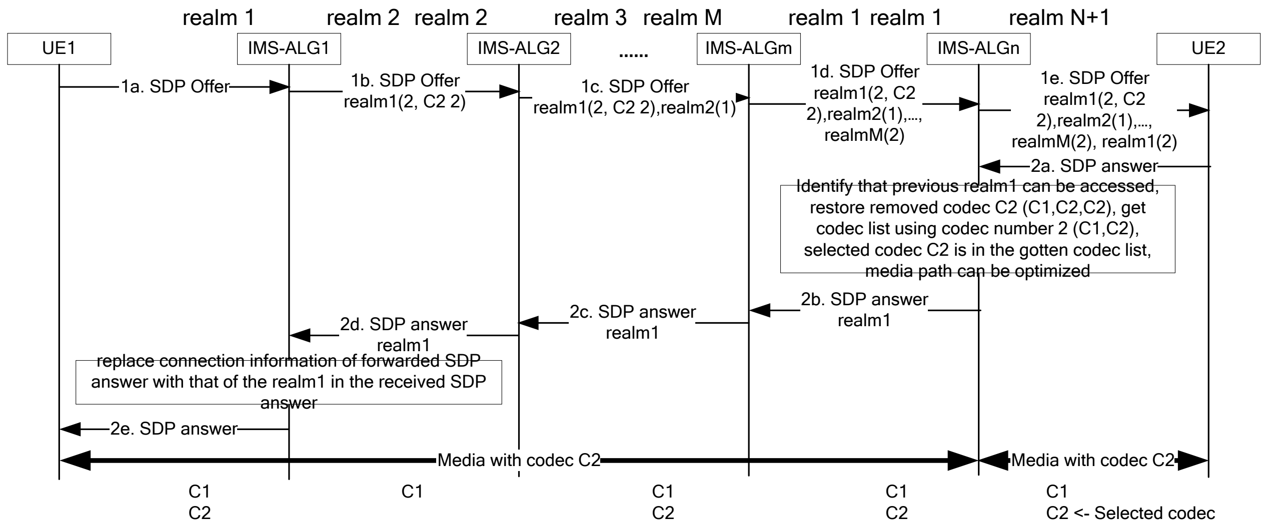

Figure 7.3.3-1: Handling of removed codec - record information of removed codec in the IP realm

NOTE 4: The number in the brackets is codec number of the IP realm. The Codecs at the bottom of the figure show the Codecs in the corresponding SDP offer. Remote UE2 selects codec C2 in the SDP answer.

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2. The IMS-ALG1 removes codec C2 and records C2 and the related position of 2 in the forwarded IP realm. The IMS-ALG2 adds codec C2 again as transcoding option. Steps 2a to 2e describe the corresponding progression of SDP answers according to the algorithm.

In this case, the UE2 select codec C2, UE1 can use codec C2 for the media stream, and TrGW controlled by IMS-ALGn can have directly access to UE1 (both of them can access IP realm 1), so the best optimized media path only includes the TrGW controlled by IMS-ALGn. The algorithm can get the best optimized media path.

7.3.4 Interactions with Transcoding

In TS 23.228 [8], IBCF is allowed to use proactive transcoding (provide transcoding options in the first SDP offer) and reactive transcoding (provide transcoding options after first SDP offer has been rejected for the reason that no codec can be used).

For reactive transcoding, when the first SDP offer has been rejected, the algorithm has been aborted for the first SDP offer/answer transaction, and will be applied during another SDP offer/answer transaction. The IMS-ALG, who initiates the second SDP offer/answer transaction for providing transcoding options, shall remove all the SDP extensions and unspecified Codecs from the forwarded SDP offer.

For proactive transcoding, when the IMS-ALG provides additional transcoding options in the first SDP offer, the behaviour of the IMS-ALG can be categorized as follows:

A. allocates TrGW for transcoding when forwarding SDP offer, and triggers second SDP offer/answer transaction when no transcoding option is selected;

B. allocates TrGW for transcoding when forwarding SDP offer, and does not trigger second SDP offer/answer transaction when no transcoding option is selected;

C. does not allocate TrGW for transcoding when forwarding SDP offer, and triggers second SDP offer/answer transaction when transcoding option is selected.

D. does not allocate TrGW for transcoding when forwarding SDP offer, and does not trigger second SDP offer/answer transaction when transcoding option is selected.

If the IMS-ALG provides proactive transcoding options, the IMS-ALG shall include behaviour indication in the last added IP realm.

Addition to the procedure as specified in clause 7.3.1, if:

- the behaviour indication of an IP realm in the checked IP realms (excluding the identified IP realm) is Category A, and no transcoding option need to be applied in this realm; or,

- the behaviour indication of an IP realm in the checked IP realms (excluding the identified IP realm) is Category C, and transcoding option need to be applied in this realm.

NOTE: In these cases, the transcoding IMS-ALG will initiate an extra SDP offer/answer transaction. If the selected codec is in the codec list generated based on the Codecs in the received SDP offer and the codec number of the IP realm, then no transcoding option is needed in this realm, otherwise, transcoding option is needed.

The last IMS-ALG shall not initiate the second SDP offer/answer transaction, and shall apply procedures as specified in clause 7.3.5.1.

7.3.5 Enhancement of the algorithm

7.3.5.1 Improvement to successive SDP exchanges

During the first SDP offer/answer transaction, the IMS-ALG, who found an optimized media path, shall save the position of the identified IP realm in the received IP realm list and related realm identifier.

During the successive SDP offer/answer transactions, before forwarding the other SDP offer, the IMS-ALG shall check whether the IP realm at the position in the received IP realm list contains the same realm identifier as the saved one. If they are same, then the IMS-ALG shall:

- if the IP realm is on the outgoing signalling path, replace connection information in the forwarded SDP offer with that of the IP realm;

- if the IP realm is on the incoming signalling path, use the connection information of the IP realm.

When an SDP answer is received, the IMS-ALG shall provide an IP realm in the forwarded SDP answer. The provided IP realm can be directly connected by the TrGW controlled by previous IMS-ALG.

Figure 7.3.5.1-1 shows a call flow for the second SDP offer/answer transaction.

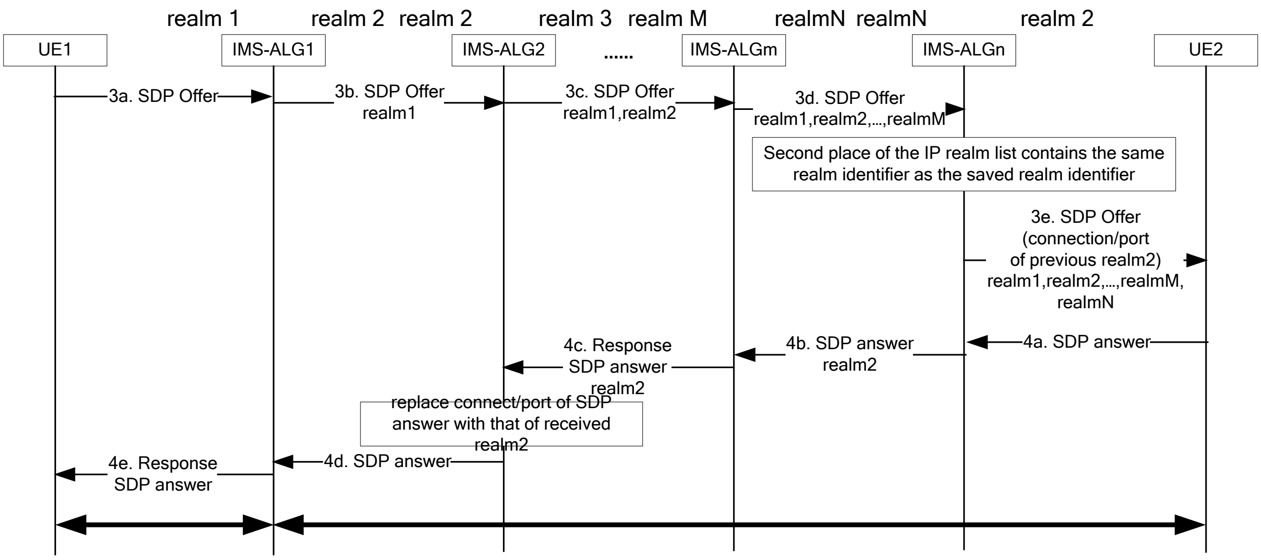

Figure 7.3.5.1-1: Transcoding aware - Second SDP offer/answer transaction

Steps 3a to 3e describe the progression of the second SDP offers via the IMS-ALGs from UE1 to UE2, SDP offer in step 3e uses the connection information of the received IP realm2, and steps 4a to 4e describe the corresponding progression of SDP answers according to the algorithm.

7.3.5.2 Pre-identify method

Base algorithm in clause 7.3.1 identifies the IP realm during SDP answer forwarding phase, but during SDP offer forwarding phase, if an IMS-ALG does not provide transcoding options, or provides transcoding options with Category C or D way, the IMS-ALG may pre-identify an IP realm as follows:

- check the IP realms in the received IP realm list from the end;
- if an IP realm containing behaviour indication with value of Category A or B can be found, then continue pre-identify procedures for the checked IP realm list (excluding the found one);

NOTE 1: This assures that if the terminating side selects one of the additional Codecs, the media path can be correctly established with OMR applied to the outgoing media legs of the transcoding TrGW within one SDP offer/transaction. If the terminating side selects one of the original Codecs and transcoding is not needed, the procedures as specified in clause 7.3.1 will get a best optimized media path, and in this case, when both the TrGWs controlled by the IMS-ALG and the transcoding provider can be bypassed, an extra SDP offer/answer transaction may be needed between the IMS-ALG and terminating UE.

- otherwise, continue pre-identify procedures for the whole received IP realm list;

NOTE 2: This assures that if the terminating side selects one of the original Codecs and no transcoding is needed, the media path can be correctly established with OMR in one SDP offer/answer transaction. If transcoding options are provided and the terminating side selects one of the additional Codecs, the procedures as specified in clause 7.3.1 will get a correct optimized media path, and in this case, if Category C proactive transcoding is provided, an extra SDP exchange will be initiate by the transcoding provider, if Category D proactive transcoding is provided, and both the TrGWs controlled by the IMS-ALG and the transcoding provider were bypassed during SDP offer forwarding phase, the extra SDP offer/answer transaction may be needed between the IMS-ALG and terminating UE.

Continuing pre-identify procedures for an IP realm list, when forwarding an SDP offer, the IMS-ALG shall identify whether a controlled TrGW has a direct connection to an IP realm in the IP realm list. If an IP realm can be identified and the IP realm is for the outgoing signalling path, the IMS-ALG shall apply procedures as specified in clause 7.3.1 with following additions:

- replace connection information of the forwarded SDP offer with that of the identified IP realm.

According to interworking agreement, an IMS-ALG can know whether it is the boundary of an OMR domain. If an IMS-ALG is a boundary of an OMR domain on the side of outgoing signalling path or is in visited network of the terminating UE, especially collocated with P-CSCF, and the IMS-ALG applies pre-identify method, then additional SDP offer/answer transaction can be eliminated or improved when the last TrGW can be bypassed.

Figure 7.3.5.2-1 shows an example flow for transcoding aware OMR that an IMS-ALG applies pre-identify method.

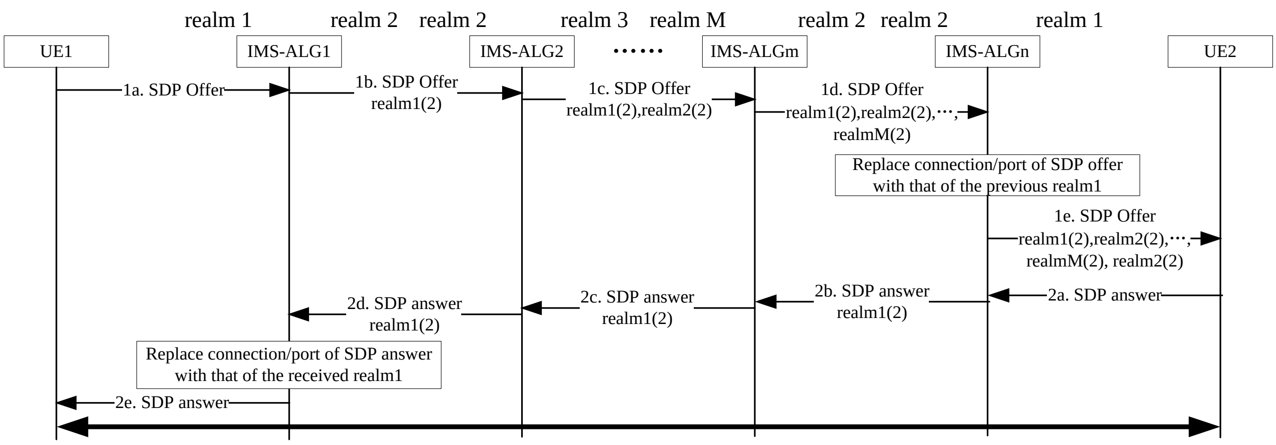

Figure 7.3.5.2-1: Transcoding aware - IMS-ALGn applies pre-identify method

NOTE 3: The number in the brackets is codec number of the IP realm.

Steps 1a to 1e describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2 and steps 2a to 2e describe the corresponding progression of SDP answers according to the algorithm.

7.3.6 Improvement to proactive transcoding

7.3.6.1 Prevent additional SDP exchange

If an IMS-ALG decides to provide transcoding options per local policy when forwarding an SDP offer, in additional of applying procedures specified in clause 7.3.1, the IMS-ALG shall allocate a TrGW for transcoding, and include two additional IP realms in the forwarded SDP offer. Both additional IP realms contain the realm identifier on the outgoing signalling path. One of them contains the connection information for the default media path, and the codec number is the quantity of Codecs in the received SDP offer. The other, which shall be the last IP realm in the forwarded SDP offer, contains the connection information of the TrGW for transcoding, and the codec number is the quantity of Codecs in the forwarded SDP offer. The IMS-ALG shall not include the behaviour indication in any of the IP realms added in the forwarded SDP offer, and shall forward the connection information for the default media path in the SDP offer.

NOTE 1: If a TrGW controlled by a next IMS-ALG can access the IP realm identified by the additional IP realms, the additional IP realm for default media path will be checked first, and this will make sure that media path not containing transcoding TrGW(s) has priority.

An IMS-ALG may control more than one TrGWs at an IP realm boundary, some of them are for media relay, and some of them are for transcoding. If a TrGW for transcoding has corresponding TrGW for media relay, then the TrGW for media relay has priority to be used except it can not support the selected codec. If the IMS-ALG controls additional TrGWs for transcoding and they have corresponding TrGWs for media relay, then during SDP offer forwarding phase, the IMS-ALG may apply procedures as specified in clause 7.3.1 to provide IP realms for the corresponding TrGWs for media relay, and add other IP realms for the additional TrGWs for transcoding after the two additional IP realms.

During SDP answer forwarding phase, the IMS-ALG shall apply procedures as specified in clause 7.3.1 with following additions:

- if transcoding option is selected, then use the TrGW for transcoding in the media path;

NOTE 2: To use the TrGW for transcoding in the media path, the IMS-ALG must forward an SDP answer with the connection information of the TrGW. If the IMS-ALG is the last one in an OMR domain, an extra SDP offer/answer transaction may be needed.

Figure 7.3.6.1-1 shows an example call flow for preventing extra SDP offer/answer transaction.

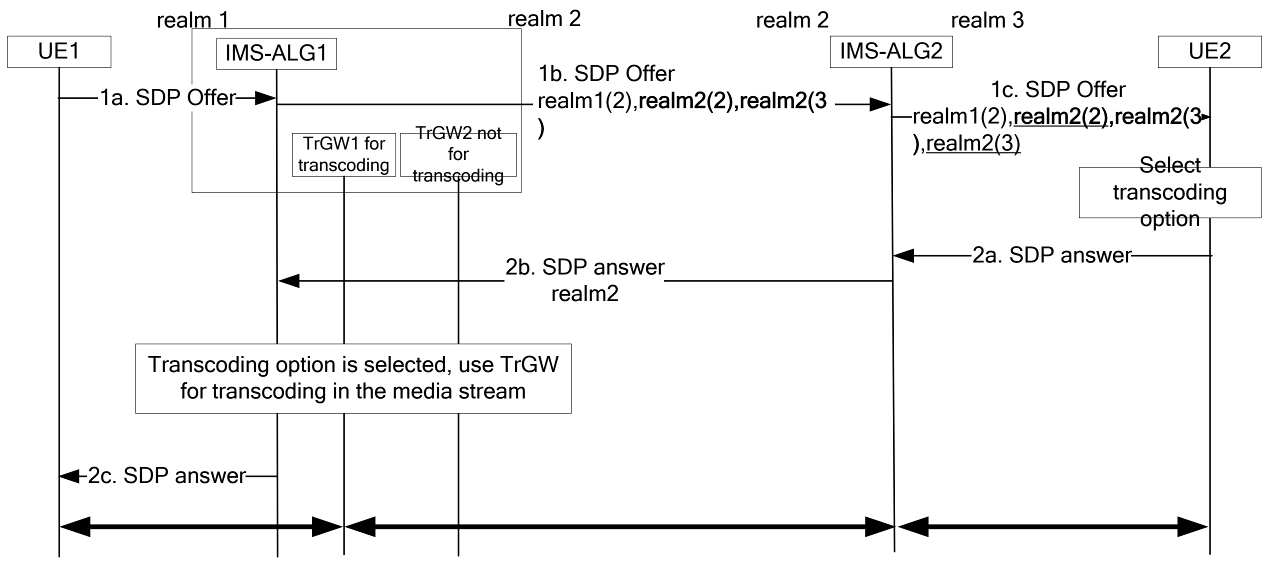

Figure 7.3.6.1-1: Transcoding aware – prevent extra SDP exchange

NOTE 3: The number in the brackets is codec number of the IP realm. The IP realms in bold are the additional IP realms, and the first contains the connection information of the TrGW2 on outgoing leg, the second contains the connection information of the TrGW1 on outgoing leg. The IP realms with under-strike contain same connection information because the SDP offer in step 1b carries the connection information of the TrGW2 on outgoing leg too. If IMS-ALG1 does not provide TrGW2 for the default media path (IP realm 1 and IP realm 2 are same), then the first bold realm2 contains connection information of UE1.

Steps 1a to 1c describe the progression of SDP offers via the IMS-ALGs from UE1 to UE2, steps 2a to 2c describe the corresponding progression of SDP answers according to the algorithm.

7.3.6.2 Move transcoding options close to the end

During SDP offer forwarding phase, an IMS-ALG may check the IP realms in the received IP realm list one by one from the beginning, if an IP realm contains behaviour indication, and the value of behaviour indication is not Category A or B, the IMS-ALG may decide to prevent previous IMS-ALG(s) to perform transcoding as follows:

NOTE: If an IMS-ALG provides Category B proactive transcoding, when transcoding option is not selected, then the IMS-ALG may use the TrGW for transcoding in the media path. If a next IMS-ALG executes transcoding function, then there will be two TrGWs for transcoding in the media path, it's a kind of wasting we need avoid.

- get the codec number of the IP realm;
- replace the codec number from the identified IP realm to the last IP realm with the gotten codec number, and also remove all the behaviour indication;
- offer the additional transcoding options.

This improvement has the advantage that an IMS-ALG closer to the terminating UE, that presumably has more knowledge about the terminating networks properties (e.g. access type, policies, terminal capabilities, etc) than upstream nodes can influence if upstream nodes perform transcoding. For instance, if a call was routed back to the original network only the policies in that network could be used to select Codecs, irrespective of any policies in intermediate networks.

This improvement has the disadvantage that the original media path may not be optimized even if it could be optimized without the improvement. An example is when IMS-ALG2 provides transcoding options, and TrGWs controlled by from IMS-ALG3 to IMS-ALG6 could be bypassed, but IMS-ALG5 applies the improvement and transcoding option is selected.

7.3.6.3 Eliminate additional SDP exchange based on the knowledge of terminating networks

If an IMS-ALG, who does not provide transcoding options, has enough knowledge about the terminating networks properties (e.g. access type, policies, terminal capabilities, etc), and transcoding options have been provided in the received SDP offer, and the IMS-ALG can determine whether it is better for the terminating UE to select transcoding options or not, then the IMS-ALG may apply procedures as specified in clause 7.3.5.2 with following additions:

- if it is better not to use transcoding options, and the transcoding options are provided using Category A or B behaviour, then remove transcoding options from the forwarded SDP offer and continue pre-identify procedures for the whole IP realm list;

NOTE 1: This assures that the terminating side will selects one of the original Codecs, and the transcoding provider will not initiate an extra SDP exchange, and the media path can be correctly established with OMR in one SDP offer/answer transaction.

- if it is better to use transcoding options, and the transcoding options are provided using Category C behaviour, then remove original Codecs from the forwarded SDP offer and not continue pre-identify procedures;

NOTE 2: This assures that the terminating side will selects transcoding options, and the transcoding provider will initiate an extra SDP exchange, procedures as specified in clauses 7.3.1 and 7.3.5.1 are enough.

- if it is better to use transcoding options, and the transcoding options are provided using Category D behaviour, then remove original Codecs from the forwarded SDP offer and continue pre-identify procedures for the checked IP realm list;

NOTE 3: This assures that the terminating side will selects transcoding options, and the transcoding provider will not initiate an extra SDP exchange, and the media path can be correctly established with OMR applied to the outgoing media legs of the transcoding TrGW within one SDP offer/answer transaction.

8 Evaluation of the Solutions

Editor's Note: This clause will evaluate the solutions identified in clauses 6 and 7.

8.1 Evaluation Criteria

8.2 Evaluation Results

8.2.1 Relationship between local breakout and optimal media routeing

The scenarios for local breakout documented in Clause 6.1 are not equally effective in order to perform optimal routeing of media.

Let's consider a couple of users "User A" and "User B" that are roaming in Serving A and Serving B networks respectively (see Figure 8.2.1-1) and let's suppose that scenario with "P-CSCF located in home network – dual IP address" or scenario with "P-CSCF located in home network – single IP address" applies.

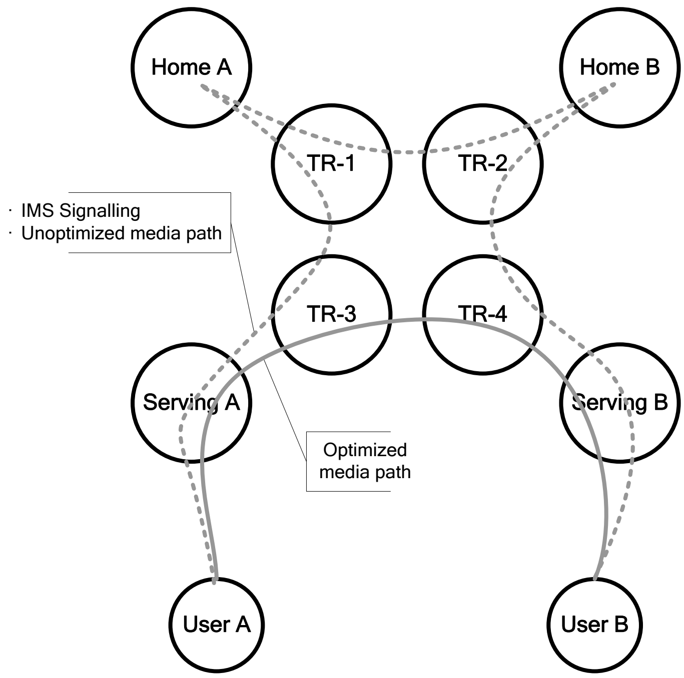

Figure 8.2.1-1: Optimal media routeing in roaming case

Scenario with "P-CSCF located in home network – dual IP address" or scenario with "P-CSCF located in home network – single IP address" are characterized by IMS signalling that is transported from the UE (in VPLMN) to the P-CSCF (in HPLMN) in a completely transparent way across the (visited and transit) networks in between: in both scenarios IMS signalling is encrypted on the Gm reference point and, in addition, in scenario with "P-CSCF located in home network – dual IP address" signalling is tunnelled (e.g. into GTP). This arrangement has an architectural drawback: if UE A and UE B are assigned globally routable IP addresses from their respective visited networks and no SDP manipulation is performed by any IMS node, the media could go directly from User A to User B and vice versa, according to the best optimal routeing scenario. However, when performing this kind of OMR, we will have a media stream crossing networks Serving A, TR-3, TR-4 and Serving B with no associated usable IMS signalling (i.e. plain and not tunnelled) that these networks could potentially handle to provide the appropriate authorisation of bearer resources, QoS management and charging functions; this could lead to serious problems for the home operators when they have to negotiate the roaming agreement with Serving networks and the commercial agreement with the carriers owner of the Transit networks. Furthermore in these scenarios OMR does not rely on IMS routeing within the crossed (Serving and Transit) networks, but only on IP routeing and IP routeing policies of the carriers: in the worst case, the media could even be routed from Serving A to Serving B through other transit networks different from TR-3 and TR-4, which are also routeing the signalling; this would considerably add complexity to the commercial settlements between involved operators and carriers. Note that this is true of these LBO scenarios even without OMR since the home network has no control of the transit networks used by the serving network.

On the contrary, in scenario with "P-CSCF located in serving network – single IP address" IMS signalling passes through the P-CSCF in VPLMN and, e.g. a sequence of IBCFs that can manipulate IMS signalling itself, forcing the media stream to follow the same path as signalling. In the same way, i.e. manipulating IMS signalling, the networks (Serving, Home or Transit) can optimize the media stream path in a way potentially controlled by the home operators and, in any case, making the serving and the transit networks service aware in a way that there are no more problems of resource reservation and charging.

Summarizing:

- when the user is roaming and is currently served by a different operator, scenario with "P-CSCF located in home network – dual IP address" and scenario with "P-CSCF located in home network – single IP address" limit the ability of network elements on the signalling path to control QoS and charging for the media path; on the contrary scenario with "P-CSCF located in serving network – single IP address" enables the best control of QoS and charging for the media path. OMR applies similarly in both cases as long as NATs are not used in the serving network.

- when IP GW-H and IP GW-L belong to the same serving network there is no need to cross border elements (e.g. IBCFs) to complete an MMTel call to another user in the same serving network; manipulation of IMS signalling is no more needed to achieve the required QoS or charging detail, cause within the same serving network standard IP routeing is enough.

9 Conclusions

9.1 Conclusion on LBO dual IP address solutions

Considering that:

- LBO single IP address solutions introduced in Rel-8 [8] allows for co-existence of IMS signalling anchored in the home network, along with media streams anchored in the home network, in the visited network or in both

- LBO dual IP address solutions may prevent the routeing optimization of media or limit its effectiveness

it is recommended to not further develop in Rel-9 any LBO dual IP address solution for the roaming case as currently described in clause 6.1.1, i.e. with IP GW-H and IP GW-L belonging to serving networks owned by different operators.

9.2 Conclusion on OMR

It is recommended that a combination of Alternative 1 and Alternative 2, which are described in clauses 7.2 and 7.3, respectively, should be used as the basis for specification of an OMR solution, as guided by the principles below. Any remaining issues identified in clauses 7.2 and 7.3 that are still applicable should be addressed during specification work.

1. Whenever possible, optimisation decisions should be made during the forwarding of the SDP offer to minimize the amount of TrGW allocation and signalling required.

2. When an IMS-ALG uses the proactive transcoding method with gateway reservation, further optimisation decisions should be made during the forwarding of the SDP answer to minimize the need for a second SDP offer/answer transaction under some cases and to otherwise reduce the signalling required for optimisation.

3. When a second SDP offer/answer transaction is required for optimisation during transcoding, it is preferred to complete the second SDP offer/answer transaction before forwarding the SDP answer for the first SDP offer/answer transaction. SIP procedures sometimes make this difficult. This problem is associated with the proactive transcoding solutions and not specific to OMR. Solutions should be agreed for proactive transcoding and should then be applicable to OMR with transcoding.

4. IMS-ALGs making codec list changes should clearly represent the changes in the forwarded SDP in a robust way to represent additions, deletions and reordering of Codecs in the list, as well as unambiguous handling of auxiliary Codecs. The details of representing the codec changes are deferred to stage 3 work.

5. The description of SDP extensions required for OMR should be functional with representation details deferred to stage 3 work.

6. Means of handling forking are not yet addressed and details will be handled during specification work.

7. The Active Bypass option is not recommended for standardisation.

8. During the forwarding of the SDP answer, the first IMS-ALG to recognize that a second SDP offer/answer transaction is required for further optimisation and that is able to successfully complete the required optimisations will initiate the second SDP offer/answer transaction.

9. All SDP offer/answer procedures associated with OMR will follow RFC 3264 and other relevant specifications.

There may be actions at interconnect that affect OMR and examples of these are discussed in Annex B.

Annex A:
OMR use cases

A.1 Discussion

The following clauses describe use cases to be included in the OMR feasibility study. Figure A.1-1 below shows a configuration of networks that is used as the basis for the use cases.

In this example the transit network (TR) provides interconnect between all of the other networks. The dotted line shows the media path without OMR procedures.

In each of the following use cases:

- A network, in this context, is a network bounded by IBCF's/TrGW's.
- The signalling path is not shown.
- It is a precondition that services are subject to local breakout.

It should be noted that all of the configurations are examples only, and other configurations are possible. It is not required that all networks in a configuration have deployed TrGWs, but in order for optimization to be applicable, at least two TrGWs need to have been deployed.

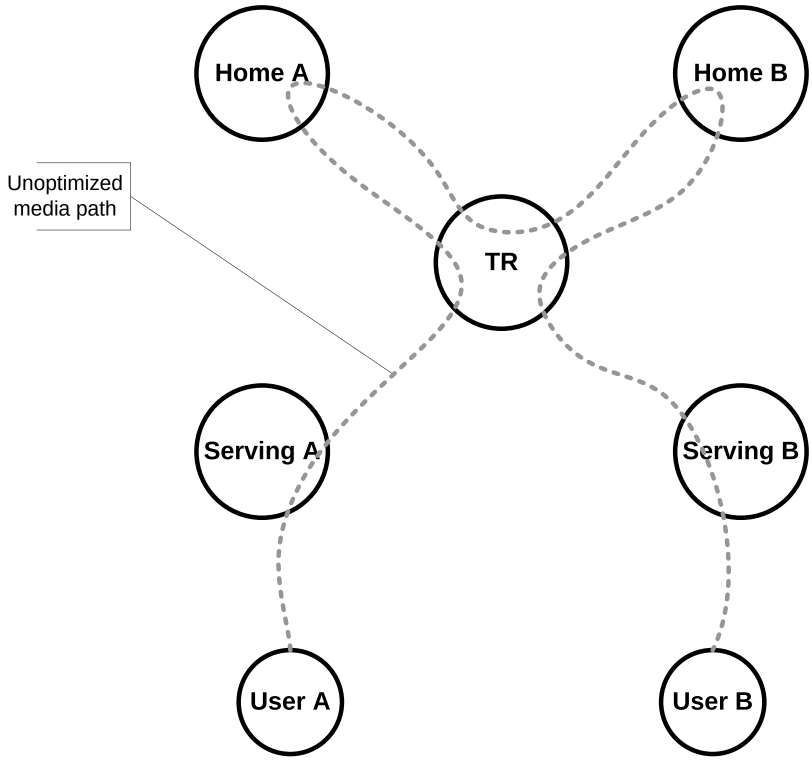

Figure A.1-1: Example of network configuration

A.2 Common Transit Network

In this example the transit network provides interconnect between all of the other networks. In Figure A.2-1 below, if a connection exists between Serving A and B then the alternative optimized media path is possible, as shown.

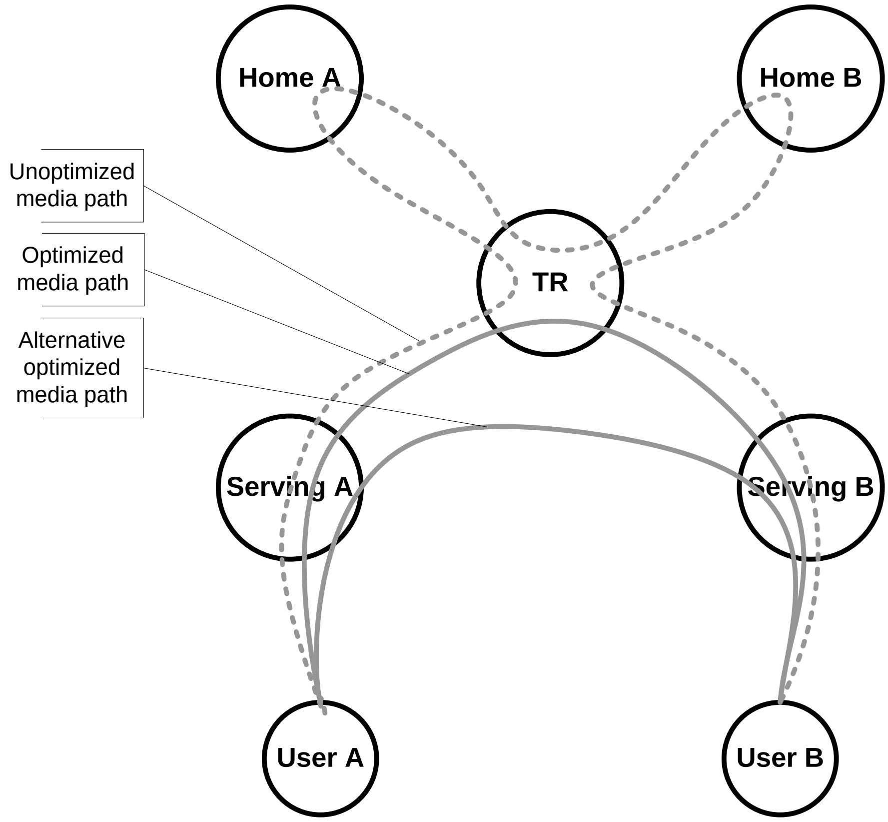

Figure A.2-1: Common transit network example configuration

A.3 Common Serving Network

In this example the transit network provides interconnect between all of the other networks. A common serving network is being used by both users, allowing the media path to stay within the same network.

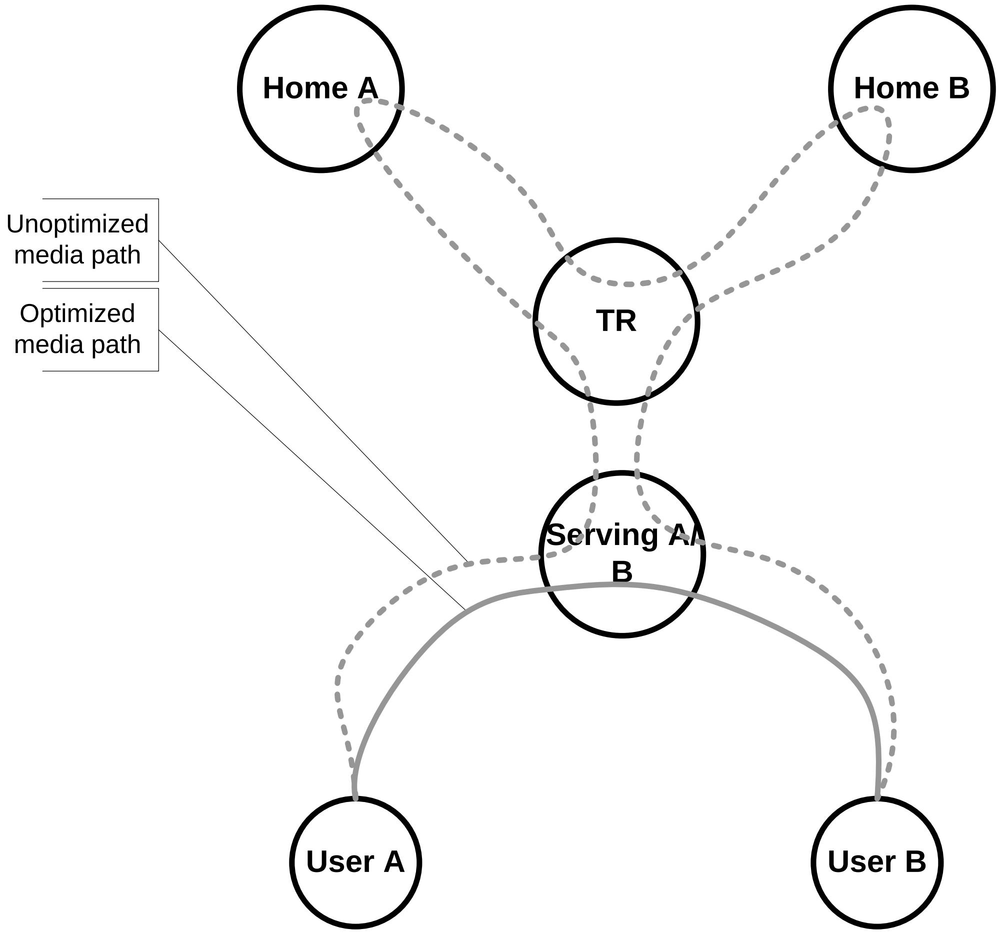

Figure A.3-1: Common serving network example configuration

The media path may be further optimized where the users are in the same residential or enterprise network (see Figure A.3-2). The priority for support of this further optimization is lower than for supporting the optimization through the serving network.

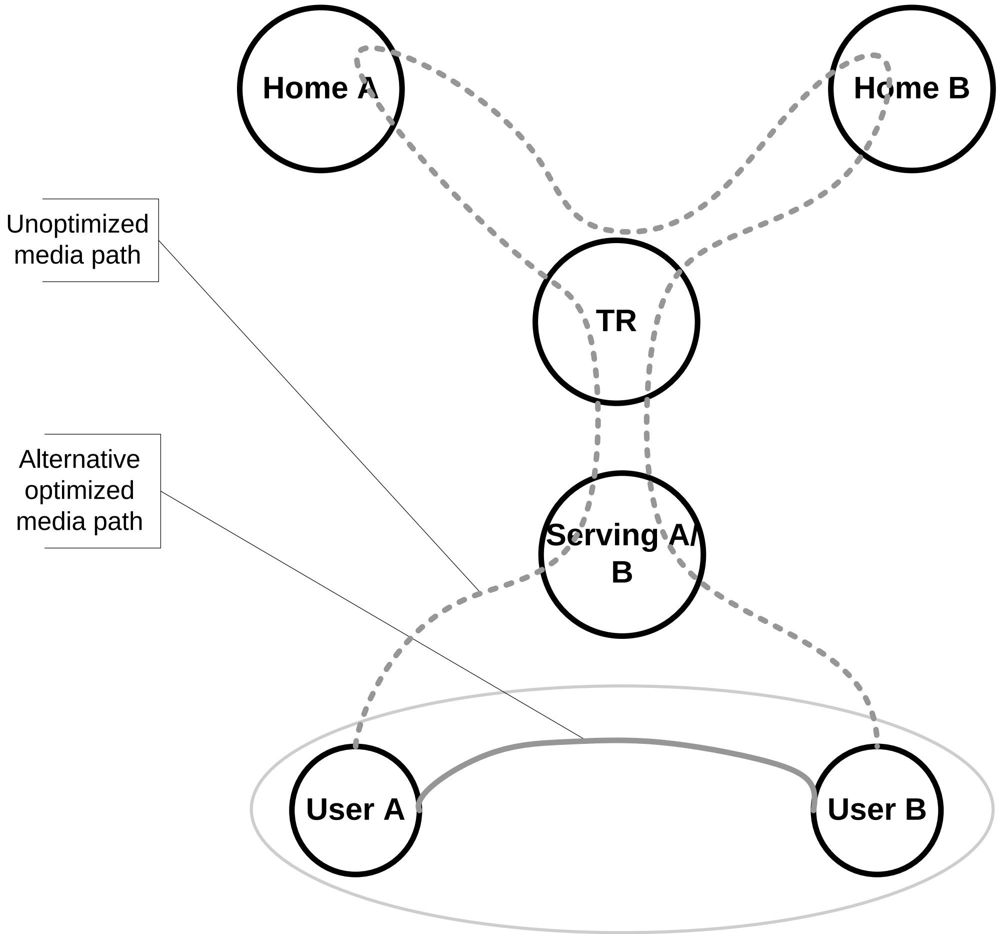

Figure A.3-2: Users in same residential/enterprise network

A.4 Two Transit Networks (1)

In this example TR-1 provides interconnect between all of the other networks but for restricted scenarios in the case of Home A and Home B, so TR-2 also provides interconnect between those networks.

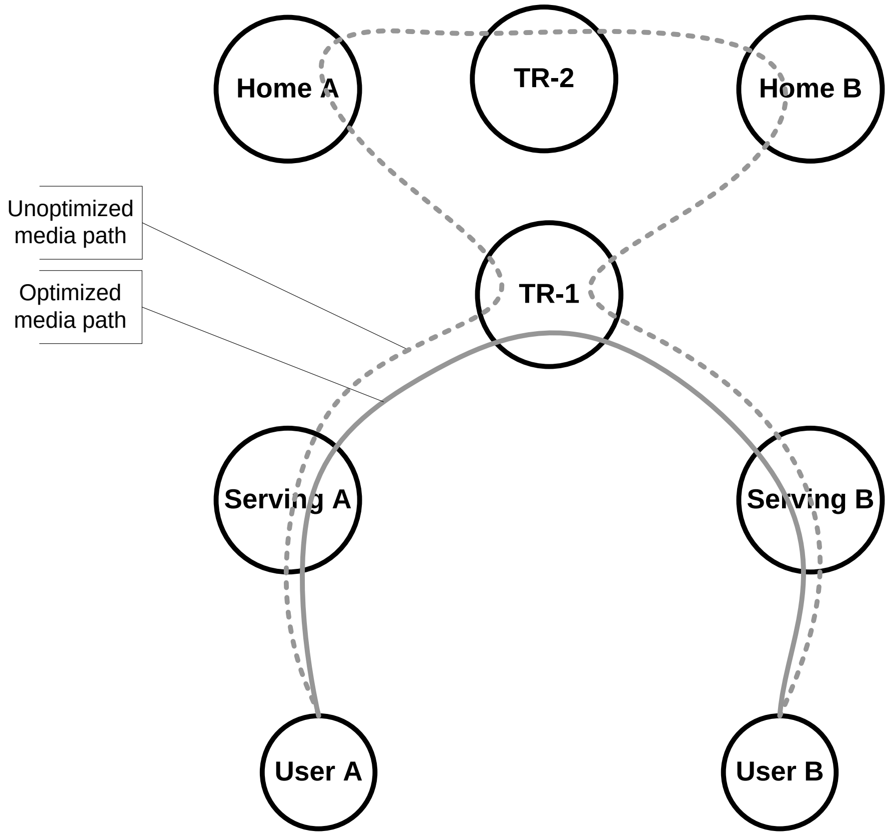

Figure A.4-1: Two transit networks example configuration (1)

A.5 Two Transit Networks (2)

A.5.1 Two Transit Networks (2) – Example optimization

In this example TR-1 provides interconnect between Serving A and the two home networks and TR-2 provides interconnect between Serving B and Home B only.

The optimal media path will depend on which connections are available between networks. The media path shown by the solid line is certainly possible, and more optimal paths are possible. For example, if there is a connection available between TR-1 and TR-2 then the path via Home B can be eliminated.

Other optimizations are possible. They are dependent on connections existing between networks and are shown in clause A.5.2.

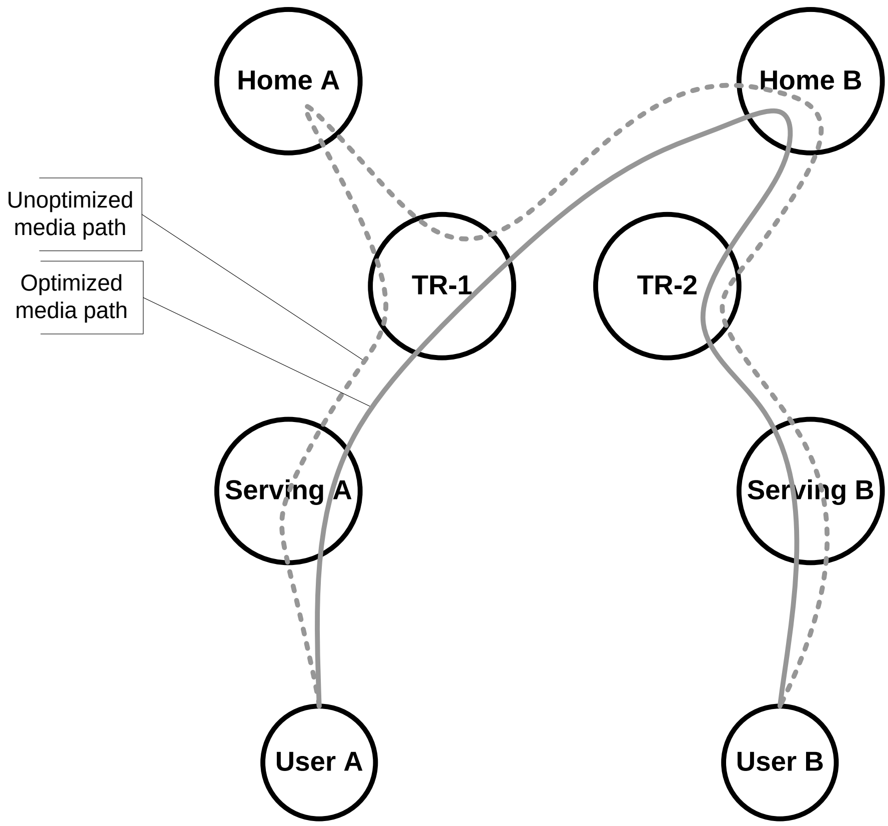

Figure A.5.1-1: Two transit networks example configuration (2)

A.5.2 Two Transit Networks (2) – Alternative optimizations

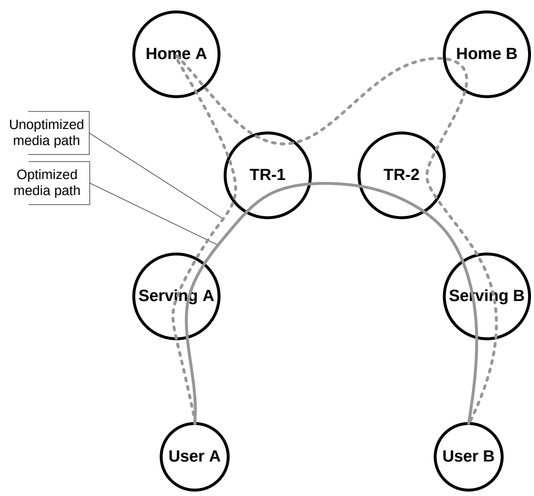

Figure A.5.2-1: Connection between TR-1 and TR-2

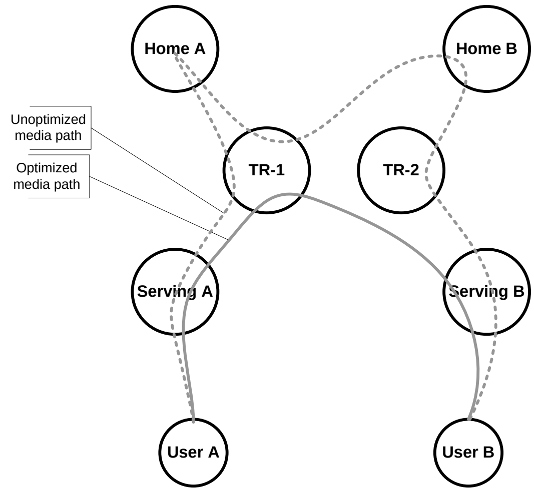

Figure A.5.2-2: Connection between TR-1 and Serving B

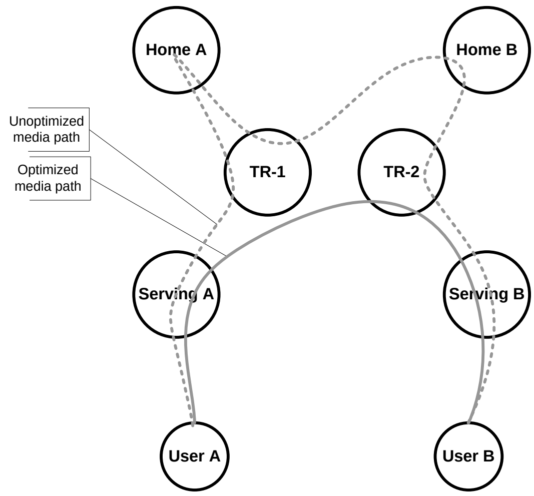

Figure A.5.2-3: Connection between TR-2 and Serving A

A.6 Four transit networks

In this example the four transit networks are fully interconnected. This is envisaged as a likely scenario since each of the home and serving networks is served by a transit network and each of the transit networks is interconnected with the others. An optimization avoiding Home B will always be possible.

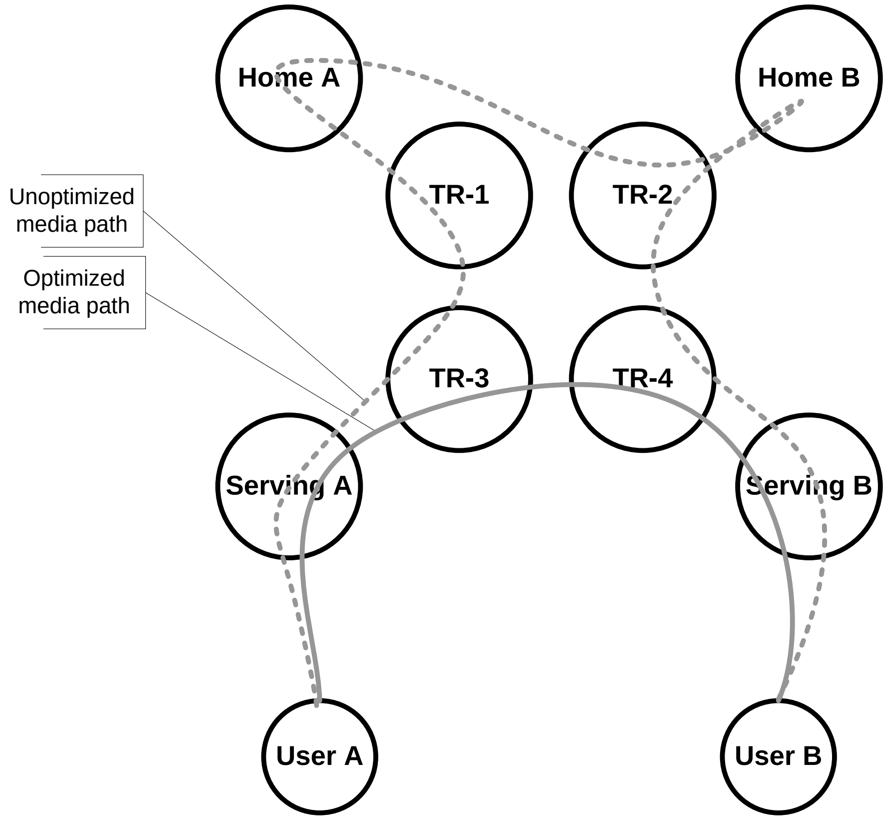

Figure A.6-1: Four transit networks example configuration

The alternative optimization shown below is dependent on a connection existing between Serving A and TR-4. Other optimizations are possible, depending on additional connections existing between home/serving networks and transit networks.

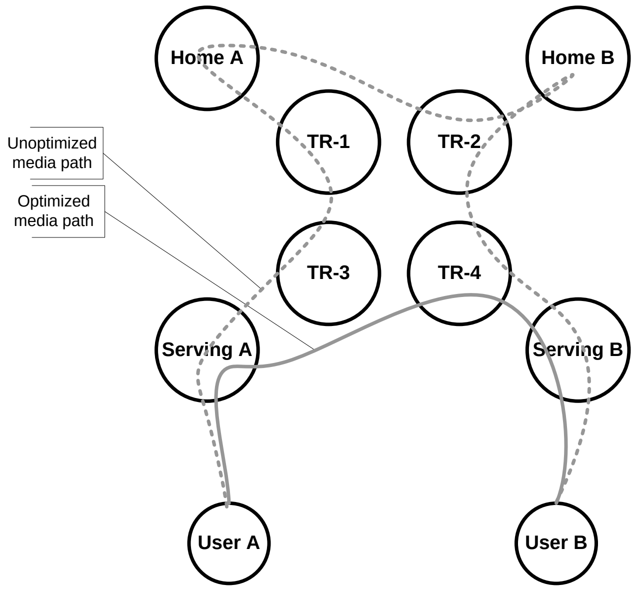

Figure A.6-2: Optimization when connection exists between Serving A and TR-4

A.7 User performs SC

In this example TR-1 provides interconnect between all of the other networks but for restricted scenarios in the case of Home A and Home B, so TR-2 also provides interconnect between those networks.

Access A and Access A' belong to the same operator. If User A changes access network (using Service Continuity procedures as specified in TS 23.237) the new un-optimized and optimized media paths will be via Access A'.

It is also possible that Access A and Access A' are connected to different transit networks.

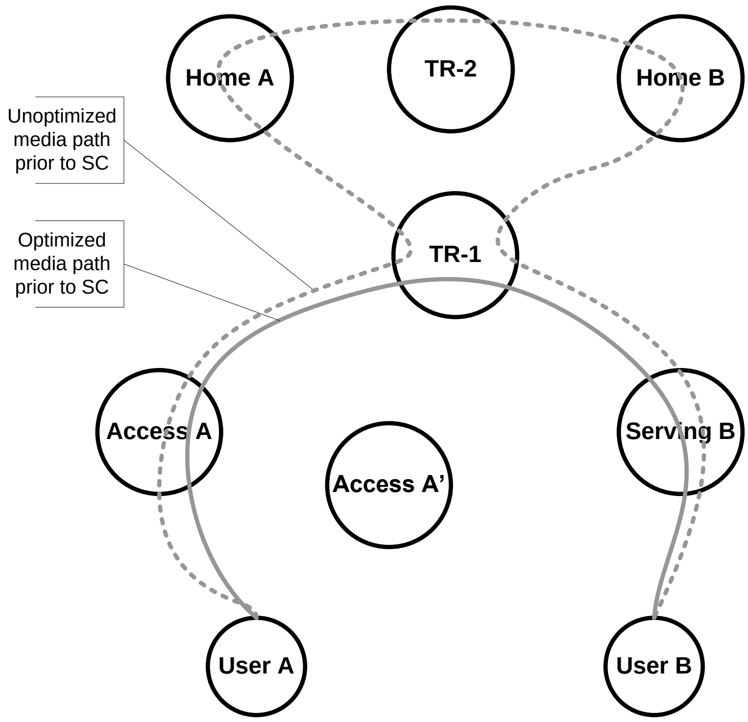

Figure A.7-1: Before Service Continuity

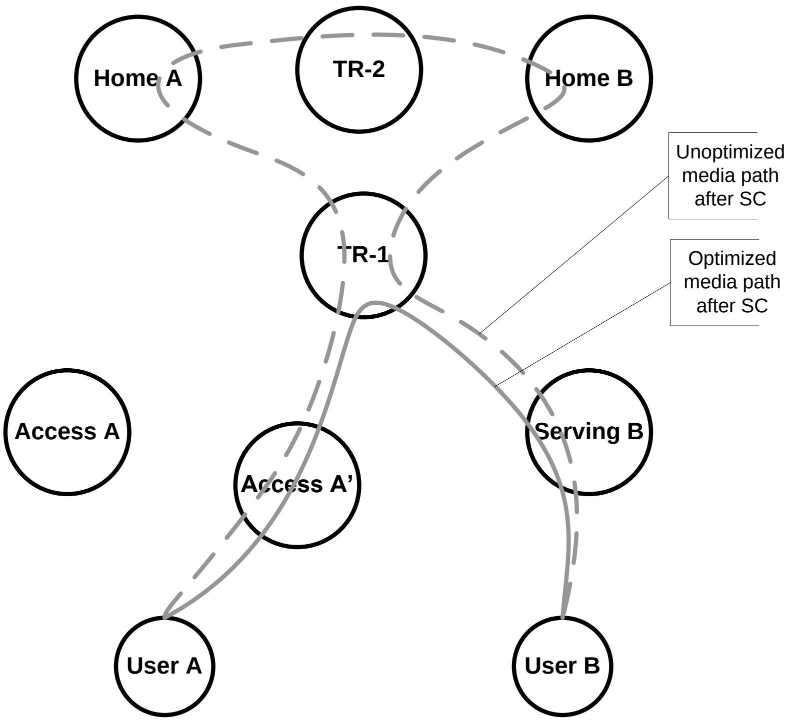

Figure A.7-2: After Service Continuity

A.8 User splits media across access networks

In this example TR-1 provides interconnect between all of the other networks but for restricted scenarios in the case of Home A and Home B, so TR-2 also provides interconnect between those networks.

User A is using both Serving A1 and Serving A2 to carry media, one for audio and one for video.

It is also possible that Serving A1 and Serving A2 are connected to different transit networks.

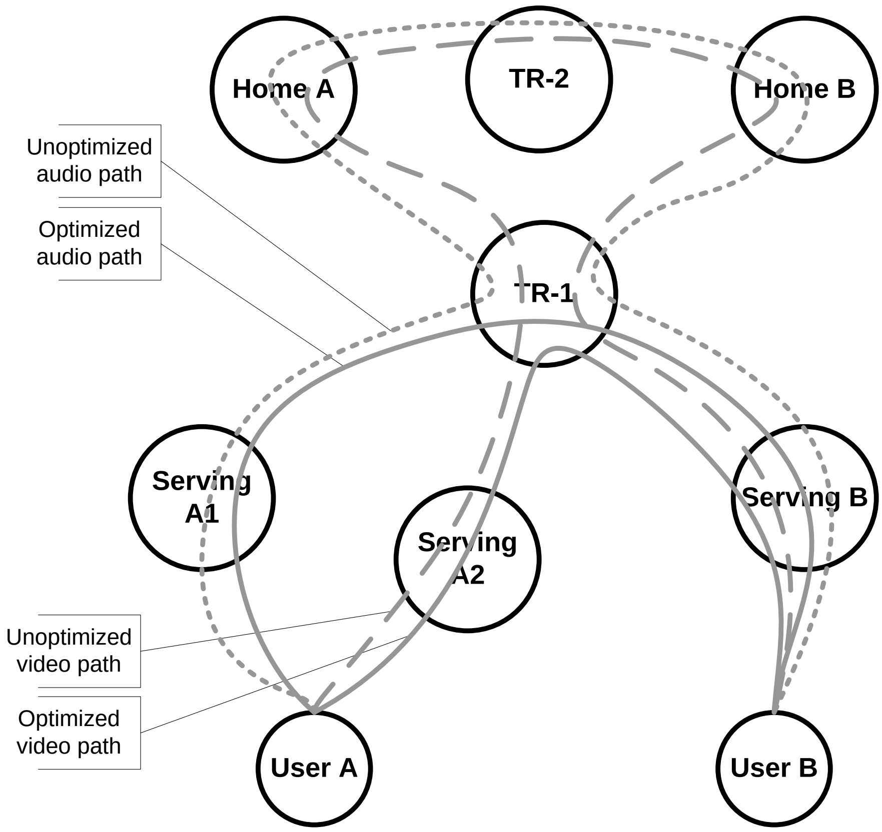

Figure A.8-1: User splits media across access networks example configuration

A.9 Media server in Home A

This use case may occur in the case of a conference call being hosted in User A's home network. TR-1 provides interconnect between all of the other networks, but configurations involving more than one transit network are also possible.

An MRF exists in User A's Home network. The path from User A to the MRF is already optimal but the path from User B to the MRF can be optimized by eliminating the loop through User B's Home network.

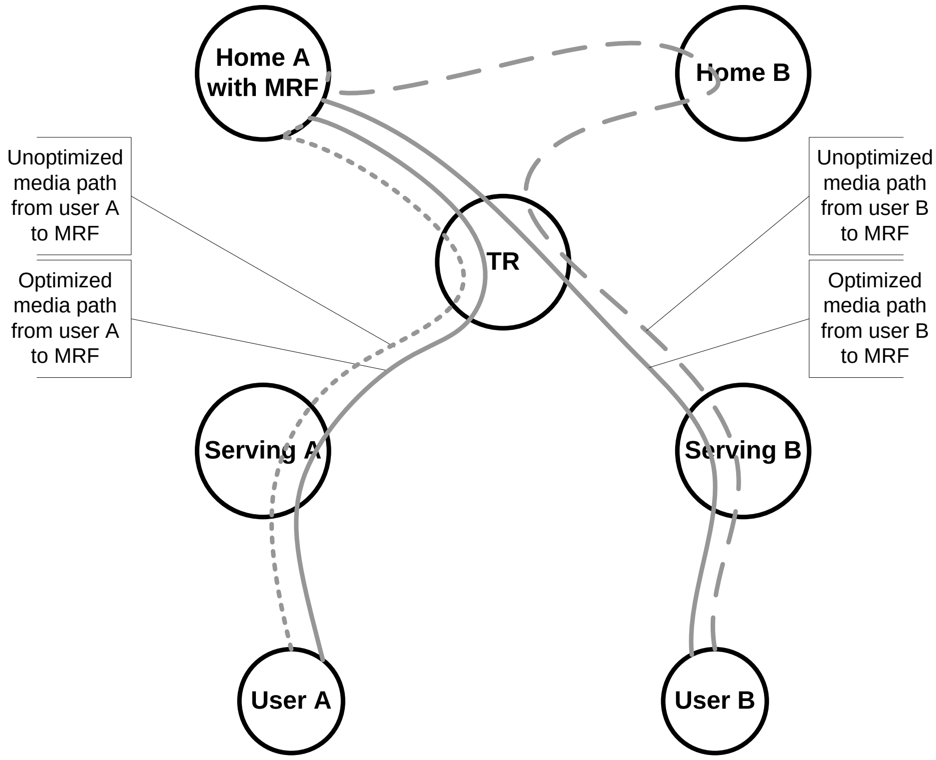

Figure A.9-1: Media server in Home A example configuration

A.10 No Transit networks

In this example no interconnect networks are used.

The optimal media path will depend on which connections are available between networks. The dotted line shows the unoptimized media path. The solid line traversing all of the networks is the case where no optimization is possible because there are no other interconnections. More optimal paths are shown by the solid lines. For example, if there is a connection available between Home A and Serving B then the loop through Home B can be eliminated.

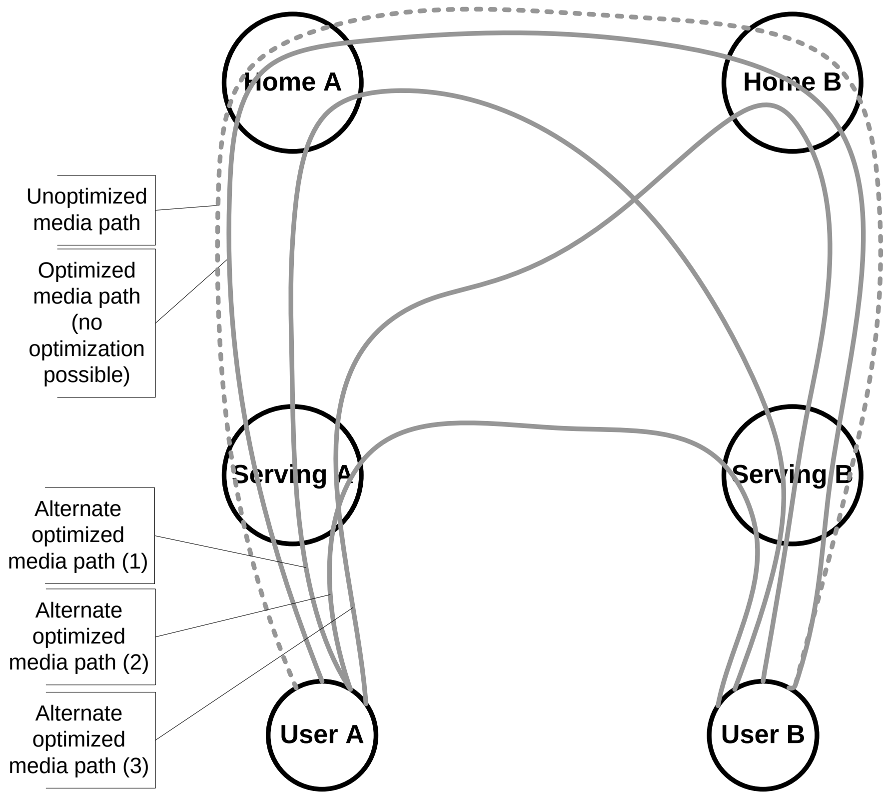

Figure A.10-1: No transit networks example configuration

A.11 Optimal media routing in PSTN local breakout

Optimal media routing based on PSTN interworking should be considered based on the local breakout scenario documented in Clause 6.1.3 involving a PSTN interconnected with the Visited network.

It is assumed that the SIP signalling is routed from the home network back to the visited network using existing BGCF functionality. However, to prevent that media are also routed through the home network, a new OMR solution is required.

Figure A.11-1 describes a local breakout scenario with PSTN interworking, where User A is in an access network served by the Serving or Visited IMS network, and establishes a session with User B via a PSTN connected to the same Serving or Visited IMS network.

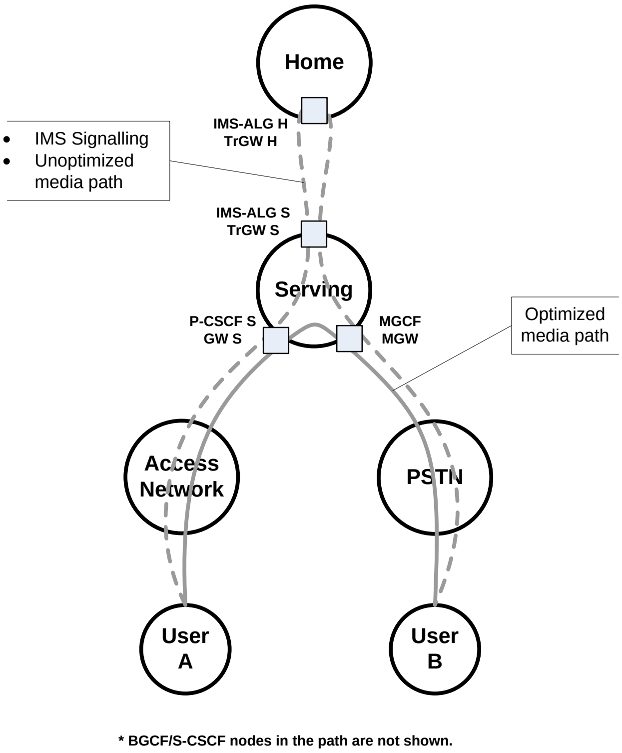

Figure A.11-1: Optimal media routing in a roaming case with PSTN interworking

The following description illustrates how the base OMR algorithm in clause 7.2.3 is applied in this scenario.

Each IMS-ALG involved in the signalling path will check the passing SDP offer and add extension attributes defined in the base algorithm (clause 7.2.3) to indicate the IP realms it connects in the signalling path.

In Figure A.11-1 IMS-ALG S detects possible media path optimization, based on matching realm identifier in the realm attribute in the SDP offer and determines gateways that can be bypassed. In this particular case TrGWs associated with IMS-ALG H and IMS-ALG S can be bypassed for media path optimization.

Annex B: Interconnect Assumptions

B.1 Direct Interconnects

Direct interconnections may take different forms, but in principle this type of interconnect does not require intermediate signalling functions between the border functions of the two networks.

For direct interconnects, it is worth to note the geographical aspects. It is of course possible to have a single direct interconnect between the core sites of two networks. Though it is also common that several interconnects in different geographical areas are used to interconnect two Service providers. Furthermore, one operator cannot normally make any assumptions on how the other operator has organized the network. Figure B.1 give a example of this.

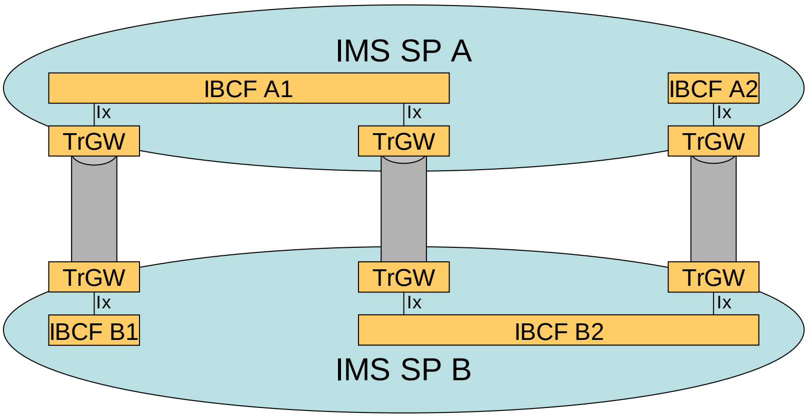

Figure B.1: Direct inter-connects between networks (using multiple connection points)

B.2 In-direct Inter-connects

B.2.1 Interconnection over "Internets"

Two Service providers may of course agree to interconnect by tunnelling over the Internet. However, when interconnecting over internet it may problematic to provide other types of QoS than Best effort.

As no service awareness is possible, and due to security reasons some kind of tunnels would be used between the SPs. This type of interconnect can from an OMR perspective be seen as comparable to direct inter-connects.

B.2.2 Interconnections over IPX networks

B.2.2.1 General

By IPX networks, we mean here managed IP networks that provide connectivity between Service provider networks only. There may be many different IPX networks globally, but the general concept is that the connectivity between the service provides is provided by one or more IPX carriers, and that the "traditional" business models of the telecommunication world will be kept.

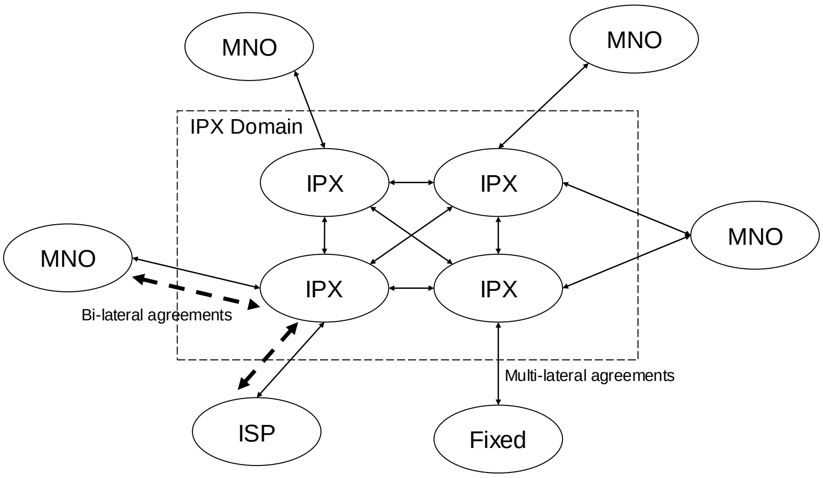

Figure B.2: Example overview of a GSMA IPX interconnect scenario.

Even though there may be several different IPX networks, the rules and architectures of the IPX networks could be expected to be built on the GSMA IPX principles (as depicted in Figure B.2).

For the IPX, three different interconnect modes have been defined

- Transport mode.
- Service transparent mode.
- Hubbing mode.

B.2.2.2 Transport mode

In this mode the IPX provides a "tunnel" between two Service providers that have a bilateral agreement. In this case the both Service provider would pay fees to the IPX carrier(s) based on traffic volume on IP-level, and any call termination fee are exchanged between the SPs without involvement of the IPX.

This case can be seen as a variant of the direct interconnect, although the SPs may utilise some service provided by the IPX like the IPX ENUM/DNS service.

B.2.2.3 Service transparent mode:

Also in this mode the basis is a bi-lateral agreement between the two Service Providers. In this scenario, the IPX networks take active part in establishing both the control plane and media plane connection.

To traverse and route the call across an IPX network, an IPX proxy is used. The exact details of what an IPX proxy is, is not settled, and the requirements of the IP Proxy is currently undergoing a review in GSMA.

B.2.2.4 Hubbing mode

In this mode, the originating and terminating service providers does not have any bilateral agreements between each other. Instead the SPs have an SLA with their IPX carrier(s). The similar SLA exists between all IPX carriers which provide a "cascade" SLA between the two Service providers.

Also in this case an IPX proxy is used to traverse an IPX carrier network.

In this case the settlement method would be that SP1s IPX provider directly or via a second IPX carrier would provide connectivity to the terminating SP. I.e. the originating party pays transit, and termination fees to the IPX carrier and the IPX carrier pays the terminating fee to the terminating SP.

B.2.2.5 Roaming Interconnections

Although the GSMA have not studied use of the interconnect modes in other scenarios that for interconnection between Home networks, it is expected that at least the two first modes, based on bi-lateral agreements could be expanded to cater for roaming as well.

The main differences would be in the settlement model, where instead of a termination fee from the originating to the terminating SP, there would be a roaming fee from the home SP to the visited SP.

B.2.3 Interconnection using IMS transit functionality

In additions to the IPX networks, an IMS service provider may also to some extent offer interconnect services by means of the IMS transit routeing capabilities. From an interconnect perspective, there would be little difference between using IMS transit functionality, and using IPX based interconnect in Hubbing mode.

B.2 Actions at Interconnects that may affect OMR

B.2.1 General

An obvious potential action at interconnects that may have effects on OMR is the need for monitoring controlling the media streams at different interconnect points.

The reason for monitoring media streams may be for several different reasons,

- Security.
- Charging.
- QoS monitoring.

B.2.2 Security

Secure is a basic function of interconnects and used to protect from unauthorised access and misuse of the network. Different interconnects may have different levels of trust between the parties involved. Border Controllers are deployed on interconnects for the purpose of providing security. The functions that can be used for security are among others, Access Control Lists, Signalling/Media Inspection, NAT/NAPT, etc.

The deployment of Border Controllers to implement these functions will tend to enforce that the media path follows signalling path, which can in some cases work against OMR.

In particular, the deployment of Border Controllers or other intermediate nodes within an Interconnect network needs to be considered. When an interconnect network is provided by multiple Carriers, (e.g. GSMA IPX), then it is possible that Border Controllers or other intermediate nodes are deployed within the interconnect network and will try to enforce that the media path follows the signalling path.

The deployment of Intermediate nodes can make it more difficult to establish if there are alternate connectivity paths between the two endpoints.

B.2.3 Charging

Interconnect agreements will include tariff and settlement arrangements. The current models are based upon the assumption that the media path follows the signalling path, and the signalling is used to generate CDRs that are used in settlement. It is unclear how Interconnect Agreements would be set up where the signalling goes across one set of Carriers, but the media path goes across a different set of Carriers.

B.2.4 QoS Monitoring

Interconnect Agreements will include QoS KPIs as part of the SLA. Carriers need to be able to show that they are meeting the QoS KPI aspects of the SLA. The QoS monitoring may be done via passive or active monitoring. It is unclear where SLA responsibility lies if the media path is separately negotiated and involves other Carriers. Even if Carriers were to contribute QoS KPI information to a central repository that is visible to all Carriers, it may be difficult to associate signalling paths with media paths.

The same sort of problems occurs for troubleshooting, following customer complaints about poor media QoS.

Annex C: Change history

Change history							
Date	TSG #	TSG Doc.	CR	Rev	Subject/Comment	Old	New
2009-11	SP#46	SP-090802	-	-	MCC Update to version 2.0.0 for presentation to TSG SA for approval	1.3.0	2.0.0
2009-12	SP#46	-	-	-	MCC Update to version 10.0.0 after approval at TSG SA#46	2.0.0	10.0.0