Draft 8 of ITU-T Recommendation G.MDCSPNE

Mechanism for Dynamic Coordination of Voice Enhancement SPNE

Summary

As a result of the evolution of the telecommunications networks in recent years, signal processing features for voice quality enhancement may now be found in different communication nodes, and combined in different ways on a bearer path. However, instead of the intended enhancements, signal processing enhancement functions deployed on the same bearer path could cause overall voice quality degradation due to undesirable side-effects of the interaction of the individual enhancement functions.

The interaction concerns of voice enhancement functions can be mitigated if the communication nodes are properly coordinated and controlled to provide the end-to-end communication with the optimal placement of signal processing functions. Whilst local operators may have direct control of some of the equipment, this control may not extend to all the nodes in call scenarios such as inter-system links. The traditional "static" approach to the coordination of voice enhancement signal processing function may not meet the requirements of modern call topologies, which tend to be dynamic. Lack of coordination of the voice enhancement functions may result in voice quality degradation.

This recommendation defines a generic framework for a coordination mechanism intended to minimize undesirable interactions of VE-SPNE present on bearer paths of a communication link, for the purpose of improving overall end-to-end voice quality. A voice enhancement signal processing function that supports this recommendation will be better equipped to ensure that the pre-existing standard of overall voice quality is not compromised when it is installed in the network. Performance deviations from the standards are avoided or minimized by following this recommendation.

1 Scope

This Recommendation applies to Voice Enhancement Signal Processing Functions/Devices (VE-SPFs/SPDs) that are intended for use in a communication link between terminal equipment through network connections.

Examples of VE-SPFs/SPDs are echo cancellers, acoustic echo control, automatic level control and noise reduction. Communication network includes GSTN, IP network, wireless mobile network and any combination of them.

This recommendation defines a generic framework for a coordination mechanism intended to minimize undesirable interactions of VE-SPFs/SPDs present on bearer paths of a communication link, for the purpose of improving overall end-to-end voice quality. The VE-SPFs/SPDs subject to the coordination by using this Recommendation could be present in the terminal equipment and/or the communication network. The mechanism performing dynamic coordination of VE-SPFs/SPDs includes the following functions: capability announcement, capability identification, capability interaction resolution and local capability change.

This recommendation does not define the protocol to implement the coordination mechanism, but rather defines all the elements and information to be exchanged in support of the coordination mechanism.

A VE-SPF/SPD that supports this recommendation shall be equipped to ensure that the pre-existing standard of overall voice quality is not compromised. Performance deviations from the standards are avoided or minimized by following this recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions, which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published.

The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation

[ITU-T G.160] ITU-T Recommendation G.160 (2008), *Voice Enhancement Devices*.

[ITU-T G.161] ITU-T Recommendation G.161 (2004), *Interaction aspects of signal processing network equipment*.

[ITU-T G.168] ITU-T Recommendation G.168 (2004), *Digital network echo cancellers.*

[ITU-T G.169] ITU-T Recommendation G.169 (1999), *Automatic level control devices.*

[ITU-T G.799.1] ITU-T Recommendation G.799.1 (2004), *Functionality and interface specifications for GSTN transport network equipment for interconnecting GSTN and IP networks.*

3 Definitions

This Recommendation defines the following terms:

3.1 acoustic echo: Acoustic echo is the reflected signal resulting from the acoustic path between the earphone/loudspeaker and microphone of a terminal, hand-held or hands-free mobile station.

3.2 automatic level control device: An automatic level control device is a signal processing function located in the digital transmission path which automatically adjusts the level of a signal towards a predetermined value. Devices which modify the frequency response or spectral content of the signal in such a way as to affect the overall level of the signal are also defined as ALC devices for the purpose of this Recommendation. An ALC device is designed to process signals in one direction of transmission (see Figure 1).

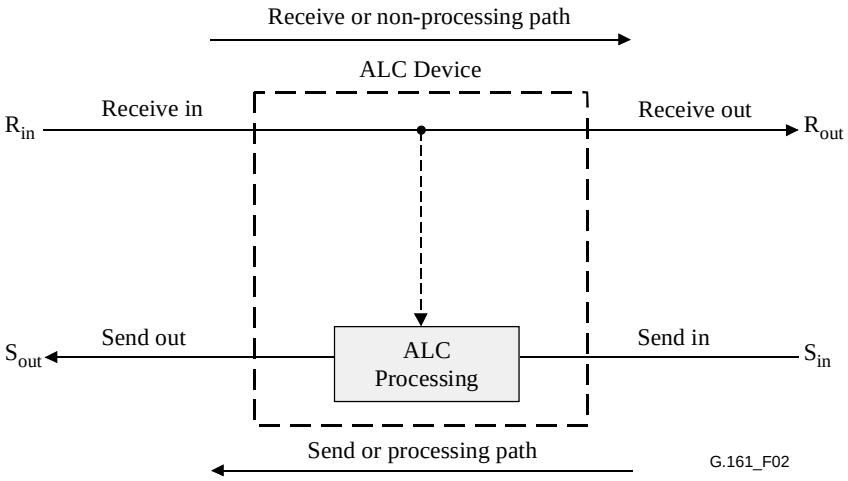


Figure 1 – Block diagram of an automatic level control device (G.169)

3.3 cancelled end: The side of an echo canceller which contains the echo path on which this echo canceller is intended to operate. This includes all transmission facilities and equipment (including the hybrid and terminating telephone set) which is included in the echo path.

3.4 network echo canceller: An network echo canceller is a voice operated device placed in the 4-wire portion of a circuit and used for reducing the cancelled-end echo present on the send path by subtracting an estimation of that echo from the cancelled-end echo (see Figure 2).

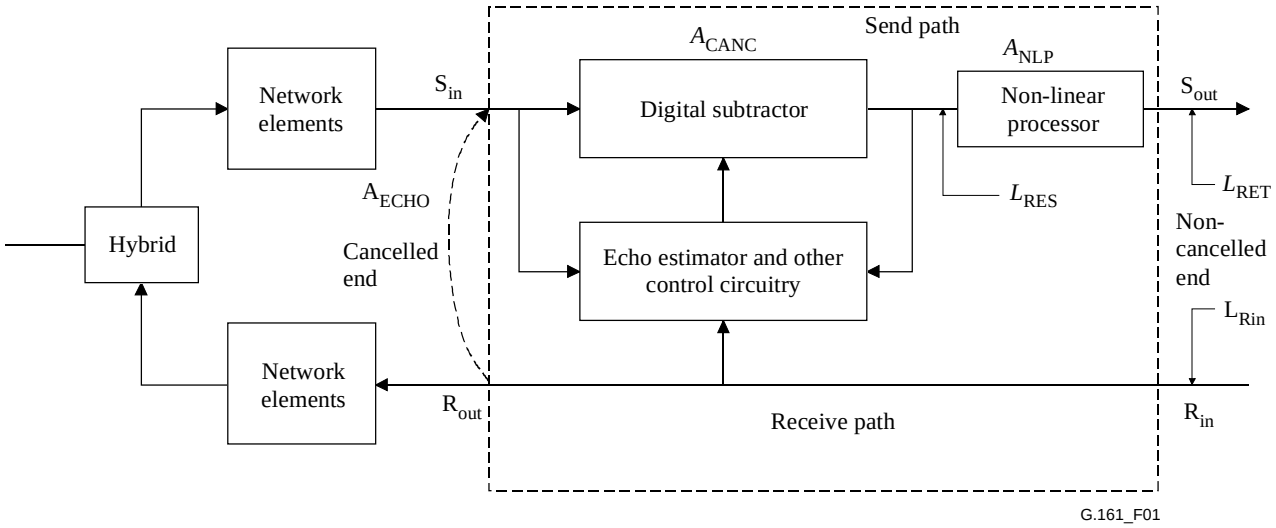


Figure 2 – Block diagram of an echo canceller (G.168)

3.5 network echo suppressors: An network echo suppressor is a voice-operated device placed in the 4-wire portion of a circuit and used for inserting loss in the transmission path to suppress echo. The path in which the device operates may be an individual circuit path or a path carrying a multiplexed signal.

3.6 network acoustic echo controller: Network acoustic echo controllers are devices placed in the 4-wire portion of a circuit and used for reducing cancelled-end acoustic echo.

3.7 terminal acoustic echo controller: Terminal acoustic echo controllers are voice operated devices installed in audio terminals on the customer premises, used for the purpose of eliminating

acoustic echoes and protecting the communication from howling due to acoustic feedback from loudspeaker to microphone.

3.8 voice enhancement device: Voice enhancement devices are intended for use in digital network-based equipment for mobile applications. Voice enhancement functions include the control of acoustic echo generated by wireless handsets, noise reduction, and the recognition and accommodation of TFO and IWF signals.

3.9 voice gateways: A voice gateway is a subset of a gateway that deals with voice and voiceband traffic only, and not data or video traffic.

[Editor's Note: Define FB-ALC and add a remark that the requirements of this function is for further study]

4 Abbreviations

This Recommendation uses the following abbreviations and acronyms:

AEC Acoustic Echo Control

ALC Automatic Level Control

CNG Comfort Noise Generation

EC Echo Canceller

FB-ALC Feedback Automatic Level Control

GSTN General Switched Telephone Network

IP Internet Protocol

IWF Interworking function

NR Noise Reduction

SPNE Signal Processing Network Equipment

TCE Transcoder Equipment

TFO Tandem Free Operation

VED Voice Enhancement Device

VQ Voice Quality

VE-SPNE Voice Enhancement Signal Processing Network Equipment

5. Dynamic Coordination Mechanism

5.1 Levels of Support

An SPNE can be designed or configured to provide active support, passive support or no support of the dynamic coordination mechanism on all or a subset of its interfaces.

Active Support:

Active support is provided by an SPNE that is equipped and capable of offering VE-SPF/SPD services.

In active support, an SPNE is capable of initiating, receiving, modifying, and interpreting capability lists through at least one communication interface. In case active support is provided

at more than one interface, the SPNE shall be capable of relaying the capability lists, after appropriate modification, between the interfaces.

Passive Support:

Passive support is provided by an SPNE that does not offer VE-SPF/SPD services to the bearer traffic.

In passive support, an SPNE is capable of receiving and relaying capability lists between two interfaces.

No Support:

In no support, an SPNE does not support the dynamic coordination mechanism and will not initiate, receive, or relay capability lists through an interface with the external network. This type of SPNE ignores capability lists at an input interface and does not cause any disruption in the traffic.

5.2 Functions

The signal processing functions or devices subject to the compliance of this Recommendation are AEC, ALC, EC, FB-ALC and NR.

5.3 Methodology

5.3.1 Method for Information Exchange

The approach to achieve dynamic coordination is through the use of capability lists for information exchange among different SPNEs. Two capability lists are required for all active-support SPNEs, for application to bearer flowing in each direction[1]. The capability lists collect the VE-SPF/SPD capabilities of the SPNEs. One list is passed in the downstream direction and the other list is passed in the upstream direction.

Each capability list can have multiple entries with each entry corresponding to one particular VE-SPF/SPD. The capability lists should be comprehensive enough to cover all standard-defined VE-SPF/SPDs supported by a SPNE. A posting marks the capabilities supported by a SPNE. A SPNE posts its support of a VE-SPF/SPD in a list typically when the VE-SPF/SPD is not already posted by other SPNEs. If marking of certain capability was made by a preceding SPNE, the current SPNE will not apply further marking of that capability, although it has that capability. Furthermore, if a SPNE does not have any VE-SPF/SPD capability or it is not an active-support SPNE, it should relay the capability lists without modifying their content. Each posting also contains a set of attribute characteristics of the SPNE and its VE-SPF/SPD.

Figure 3 gives the conceptual diagram that illustrates the flow of the two capability lists for voice traffic going from left to right. All VE-SPF/SPDs posted in the two lists are to be applied for the voice traffic in this direction only. The upper list (forward list) is for the VE-SPF/SPD postings from left to right and the lower list (reverse list) is for the VE-SPF/SPD postings from right to left. In the lists, the letters “A”, “B”, etc. denote specific VE-SPF/SPDs and the subscripts identify the posting SPNEs in the call path. It is noted that these notations are defined for illustration purposes only. An example for the implementation of a capability list is given in Appendix A.

[1] A total of four capability lists is required for the two directions of a two-party connection.

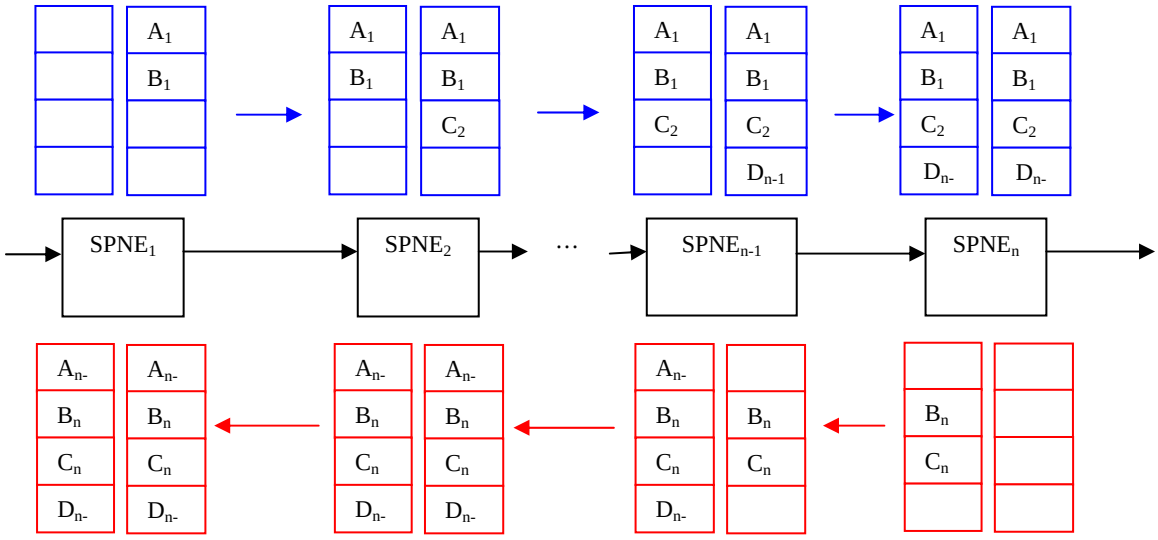


Figure 3 – An example of achieving information exchange through capability lists

VE-SPF/SPDs currently identified and considered by ITU are in general better to be activated near the traffic source. In some situations, however, it is more desirable to activate VE-SPF/SPDs that are away from the source.

NOTE – An example of VE-SPF/SPDs that are most suitable for activation away from the source is as follows. Consider the voice traffic flowing from left to right, and assume that $SPNE_1$ and $SPNE_n$ have feedback ALCs, as denoted by "B" in Figure 3. Feedback ALC is defined here as an ALC that dynamically adjusts its level according to the background noise level at the destination. Furthermore, assume that the destination end (right-side) is a mobile telephone, and $SPNE_n$ has NR VE-SPF/SPD for the traffic coming from the destination. When $SPNE_n$ provides NR function to suppress the background noise on bearer traffic from the remote end-equipment, feedback ALC processing would be most effective if it is applied near the remote end-equipment (destination) before the background noise in the reverse direction is suppressed or modified. Consequently, activating the feedback ALC in $SPNE_n$ is more preferable than activating the feedback ALC in $SPNE_1$ although $SPNE_1$ is closer to the source of traffic.

5.3.2 Capability List Initiation and Response

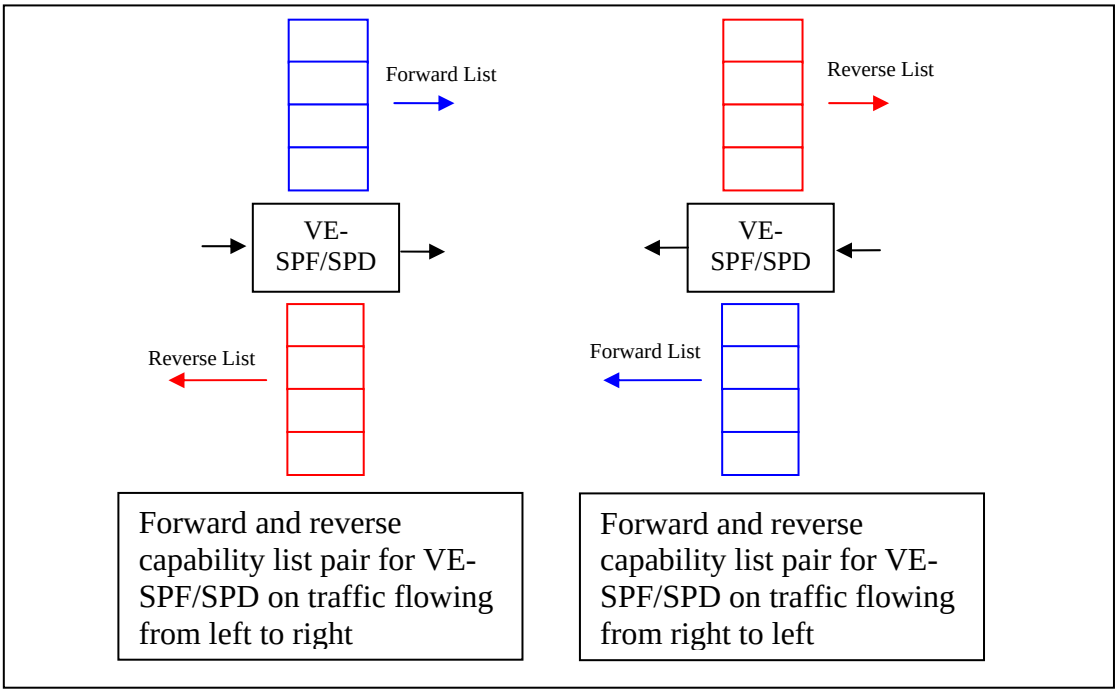
A communication call path is subject to changes which could affect the presence, absence or deployment of VE-SPF/SPD functions in the call path. Changes that can affect VE-SPF/SPD may include topology changes due to reasons such as call transfers and call handoffs. These changes may also include capability updates internal to a VE-SPNE. In the event of such modifications, it is necessary to initiate dynamic update of the VE-SPF/SPD deployment to all active VE-SPNEs in the call path to issue an update.

This sub-clause defines a set of criteria on the initiation and response of capability-list exchanges in order to provide timely update of the VE-SPF/SPD deployment to all active VE-SPNEs in a call path. The criteria are also defined with a second objective of avoiding extraneous and unnecessary capability-list exchanges.

5.3.2.1 Capability List Initiation

1. After call setup or insertion into a call path, an active VE-SPNE node sends two pairs of forward and reverse capability lists for VE-SPF/SPD functions supported by the SPNE, one pair for VE-SPF/SPD functions on traffic flowing in each direction[2].

   Figure 4 illustrates the requirement.



NOTE – the SPNE containing the VE-SPF/SPD is assumed to be not an originating or terminating SPNE. If it is known to be at the originating or terminating SPNE, only one capability list will be sent out in each direction.

Figure 4 – Capability list releases on call setup or SPNE insertion

2. After an internal update of local VE-SPF/SPD functions and capability (NOT enabling or disabling as a result of dynamic VE-SPF/SPD coordination), an active VE-SPNE sends an updated pair of capability lists for each bearer flow subject to the VE-SPF/SPD update. The pair of capability lists includes

   - The forward capability list of VE-SPF/SPD functions supported by the local and other active SPNEs upstream on traffic flowing in the direction affected by the update. The capability list is sent downstream in the same direction of the bearer flow affected by the update.
   - The reverse capability list of VE-SPF/SPD functions supported by the local and other active SPNEs downstream on traffic flowing in the direction affected by the update. The capability list is sent upstream in the direction opposite to the bearer flow affected by the update.

   Figure 4 illustrates this operation.

[2] Only two-party SPNEs are assumed.

3. On detecting a change in the identity of a peer SPNE node, such as a change of the peer IP address in the case of VoIP, an active SPNE sends a pair of up-to-date capability lists to the newly identified peer. This action is undertaken to cause an update of the capability information in cases where a new node is inserted in the call path, or a node removed from it. The pair of capability lists include:

   - The up-to-date forward capability list for VE-SPF/SPD functions on traffic flowing to the new peer.
   - The up-to-date reverse capability list for VE-SPF/SPD functions on traffic flowing away from the new peer.

   Figure 5 illustrates the operation in this case.

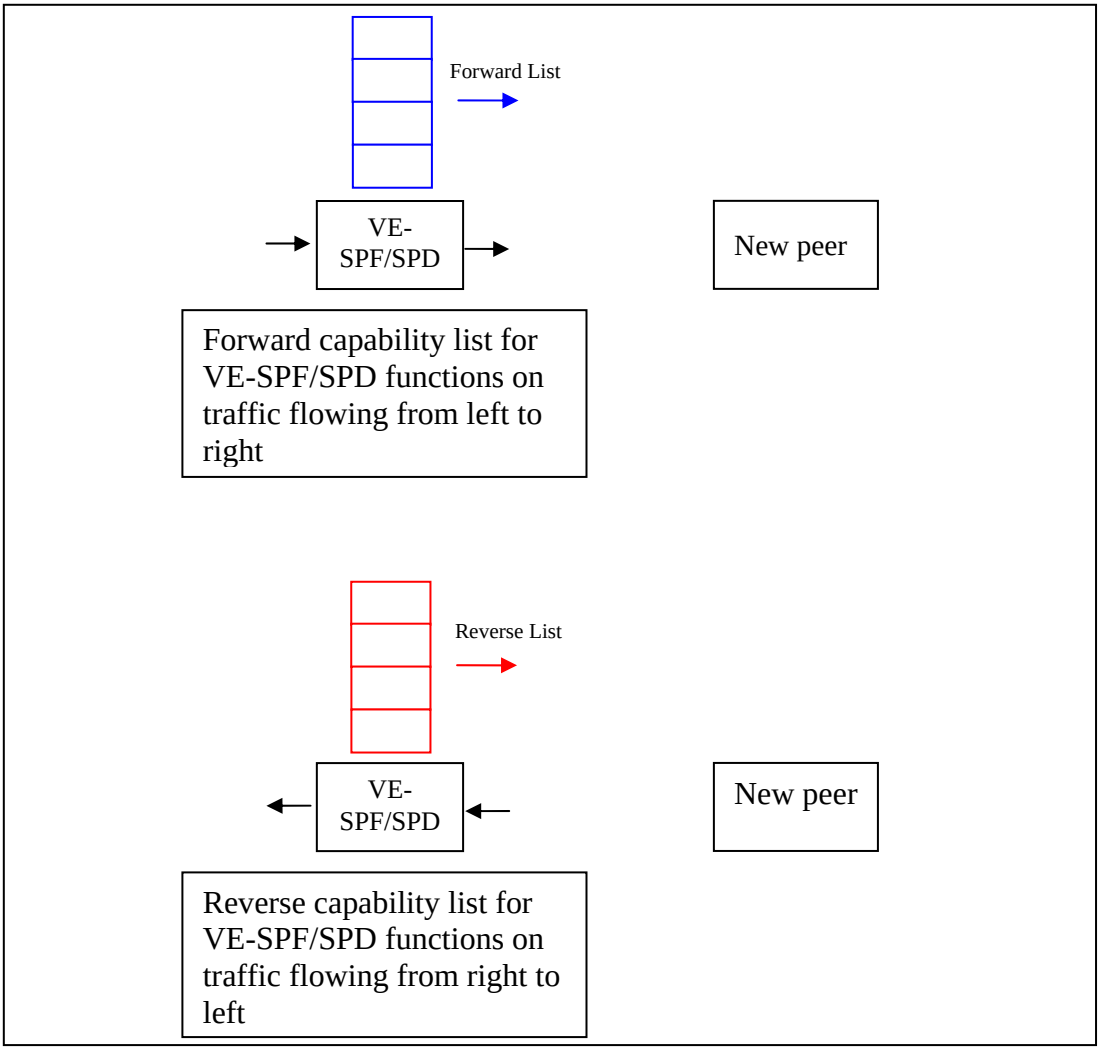


Figure 5 – Capability list releases on change of peer

5.3.2.2 Capability-List Responses

1. When receiving a capability list that is different from the previously-received capability list at the same input termination Ta, an active SPNE

   - replies to the sending SPNE with the capability list received from the other side and updated with VE-SPF/SPD functions supported by the local SPNE on traffic flowing in the direction defined by the list received at Ta.

- relays to the SPNE on the other side the received capability list updated with VE-SPF-SPD functions supported by the local SPNE on traffic flowing in the direction defined by the list received at Ta.

Figure 6 illustrates the processing.

2. When receiving a capability list that is identical to the previously received capability list at the same input termination, the active SPNE does not respond with a capability list release from any terminations, in order to avoid unnecessary transmission.

3. An active SPNE discards capability lists from its input if a more up-to-date list of the same type has already been received. This is necessary to reject out-dated lists received over a connection-less network when out of order transmissions occur.

4. If possible, an active SPNE should update and send capability lists to its neighbouring SPNEs, with its local VE-SPF/SPD de-listed from the capability lists before it departs a call path.

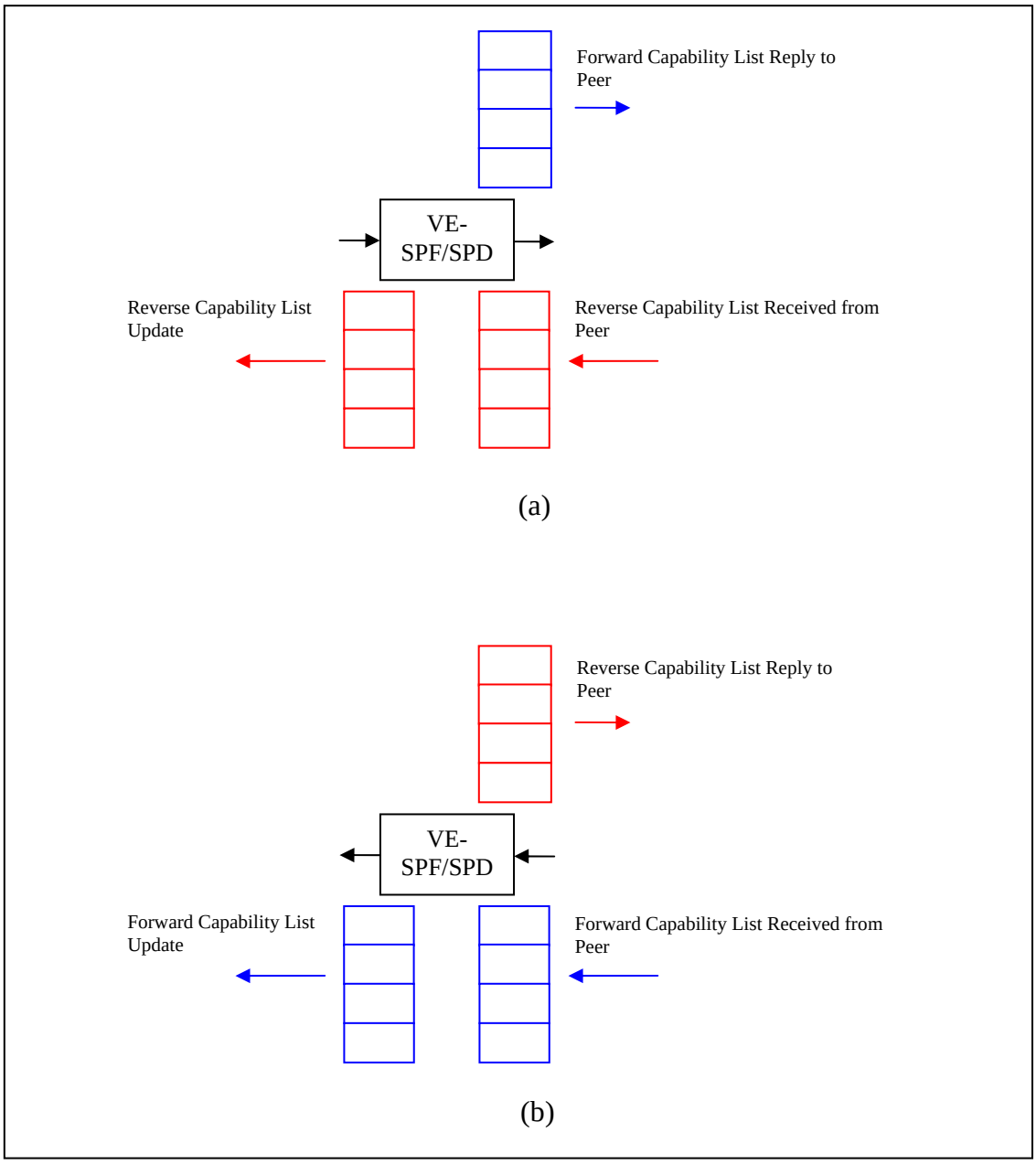


Figure 6 – (a) Forward and reverse capability list releases in response to the reception of a reverse capability list update, (b) Forward and reverse capability list releases in response to the reception of a forward capability list update

5.4 Information to be Exchanged

[Editor Note: This section defines the information to be exchanged among different VE-SPNE for the purpose of achieving dynamic coordination]

5.5 Protocol Requirement

[Editor Note: This section illustrates the requirements for a protocol being used to implement the dynamic coordination mechanism]

5.6 Enabling/Disabling VE-SPNE Functions

The presence and deployment of VE-SPF/SPD functions in a communication path are identified with the use of capability lists (see clause 5.3). Each SPNE providing active support to dynamic VE-SPF/SPD coordination determines the desired enabling or disabling of the VE-SPF/SPD functions under its own control by applying the coordination rules (clause 6) based on the information collected from the capability lists. Actual enabling/disabling of a VE-SPNE function/device is performed by the active support SPNE individually. The method and mechanism to perform the enabling/disabling belong to the design and implementation of the individual SPNE. No other control signal is required or defined to be exchanged between nodes for this purpose.

[Editor Note: This section describes the specific method to disable/enable VE-SPNE functions]

5.7 Compatibility with TFO

[Editor Note: This section describes the specifics about the compatibility with TFO in the coordination mechanism]

6. Coordination Rules

[Editor Note: This section defines the rules based on the preferred locations of VE-SPNE for coordinating them dynamically]

The location to deploy various VE-SPFs/SPDs along the call path will affect the voice quality. It is therefore important to identify the preferred locations for voice enhancement SPFs/SPDs in order to achieve better voice quality. The preferred locations for AEC, ALC, EC, NR and FB-ALC are given below.

Acoustic Echo Control (AEC)

The preferred location of the acoustic echo control is as close as possible to the source of acoustic echo, e.g., mobile handset. The rationale for this is similar to echo canceller, and is based on the echo path delay requirement consideration. For landline connection, acoustic echo is not noticeable. In case of landline hands-free phones, since such phones have been around for a long time, their performance is considered acceptable and hence, acoustic echo control may be disabled along the path in the case of landline connections.

Automatic Level Control (ALC)

The preferred location for Automatic Level Control is as close as possible to the signal source. However, in call topologies that include echo cancellation, it is preferable to deploy ALC before R_{in} or after S_{out} of the echo canceller, in order to prevent adverse effects on the echo canceller performance due to the non-linearity/time-variance introduced by ALC.

Echo Canceller (EC)

The preferred location for the deployment of echo canceller is as close as possible to the local loop, in order to minimize the length of the echo path that the echo canceller needs to handle, and to reduce potential for non-linear elements in the echo path.. In cases where there is no local loop in the path, e.g., mobile-to-mobile call, an echo canceller is not desirable in the entire call path.

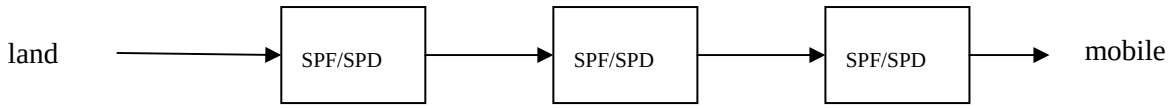
Feedback ALC (FB-ALC)

The preferred location for feedback ALC is as close as possible to the destination. However, in call topologies that include echo cancellation, it is preferable to deploy FB-ALC before R_{in} or after S_{out} of the echo canceller, in order to prevent adverse effects on the echo canceller performance due to the non-linearity/time-variance introduced by FB-ALC.

Noise Reduction (NR)

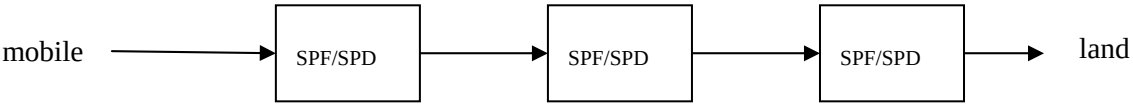
The preferred location for Noise Reduction is as close as possible to the signal source. However, in call topologies that include echo cancellation, it is preferable to deploy NR before R_{in} or after S_{out} of the echo canceller, in order to prevent adverse effects on the performance of echo canceller due to the non-linearity/time-variance introduced by the process of noise reduction.

Figure 7 gives an example for preferred locations of SPF/SPDs for land to mobile call, and Figure 8 gives an example for preferred locations of SPF/SPDs for mobile to land call.



SPF/SPD	Preferred Location		
ALC	High Preference	Medium Preference	Low Preference
EC	High Preference	Medium Preference	Low Preference
FB-ALC	Low Preference	Medium Preference	High Preference

Figure 7 – SPF/SPD Preferred Locations for a land to mobile call, bearer traffic flowing from left to right.



SPF/SPD	Preferred Location		
AEC	High Preference	Medium Preference	Low Preference
ALC	High Preference	Medium Preference	Low Preference
NR	High Preference	Medium Preference	Low Preference

NOTE – the first SPF/SPD on the left could be located in a mobile handset or a hands-free terminal.

Figure 8 – SPF/SPD Preferred Locations for a mobile to land call, bearer traffic flowing from left to right.

7. Interaction and Harmonization with Network Management and Operator Policy (for further study)

[Editor Note: This clause defines the procedures for the interaction and harmonization of the coordination mechanism with network management, operator policy, subscriber profile verification and services resource and admission control]

Annex A

Format and structure for capability list implementation

(This annex forms an integral part of this Recommendation)

Figure A.1 gives the structure of capability list payload. The figure does not show the control information required for specific transport protocol support, e.g. IP protocol header. The capability list payload has two parts: common part and entry part.

7	6	5	4	3	2	1	0	Descriptions
V			F		N			Common Part
SID								
Length								
Reserved					ID			Entry 1
Reserved					Len			
Attribute								
Reserved					ID			Entry 2
Reserved					Len			
Attribute								
…								…

Common part:

V (3 bits): Version number

F (1 bit): Forward / Reverse flag

1 for forward capability-list in the same direction as the VE-SPF/SPD

0 for reverse capability-list in the opposite direction as the VE-SPF/SPD

N (4 bits): Number of entries

SPID (TBD bits): SPNE Identifier

This field contains a random identifier pattern used to identify the SPNE when releasing the capability list. A SPNE compares the value of this field from an incoming capability list to the local identifier. In the event of a match, the incoming capability list shall be discarded to avoid accepting a list looped back by a node in the network. In the event of a match, the SPNE shall also choose a new identifier and release the most up-to-dated capability list to the peer SPNE.

Length (8 bits): Capability-list size in bytes (common + entries)

Entry part:

ID (4 bits): Entry identification

Len (4 bits): Entry size in bytes, including the entry ID byte and the entry Len byte and the attribute bytes

Attribute: Entry attribute information with zero, one or multiple bytes (To be defined)

Reserved: Reserved field with a value of 0x00

[Editor Note: need to define the number of bits/bytes for the SPID field]

Figure A.1 – An implementation of capability list pay load

The capability list payload needs to satisfy the following requirements:

– Each VE-SPF/SPD entry is identified by a unique identification.

– Each entry for a VE-SPF/SPD consists of a known size. An entry corresponding to a particular SPF will be added to the list if it is supported by a SPNE. An entry corresponding to a

particular SPF will be absent from the list if it is not supported by any SPNE. Each entry carries only information relevant to VE-SPF/SPD control.

– The overall capability list payload size is adaptive to the actual number and type of VE-SPF/SPDs supported by the SPNEs in a call path to minimize bandwidth usage.

– When a SPNE adds an entry to a list, the SPNE has to adjust the payload size. If a SPNE is not adding any entry to a list, the SPNE can just relay the capability list to the next SPNE in the appropriate direction.

The entry identifications of various SPF/SPDs are shown in Table A.1 below.

Table A.1 – Entry identification of various SPFs

SPF	Entry Identification
AEC	0 0 0 1
ALC	0 0 1 0
ECAN	0 0 1 1
FB-ALC	0 1 0 0
NR	0 1 0 1

An example of the capability list pay load that contains AEC and ALC is shown below, where the IDs for AEC and ALC are 0x1 and 0x2, and they do not have attributes.

7	6	5	4	3	2	1	0	Descriptions
0	0	1	1	0	0	1	0	Common Part
0	0	0	0	0	1	1	0	
0	0	0	0	0	0	0	1	Entry 1: AEC
0	0	0	0	0	0	1	0	
0	0	0	0	0	0	1	0	Entry 2: ALC
0	0	0	0	0	0	1	0	

Figure A.2 – Example of a forward capability list with two entries: AEC and ALC

Appendix I

Network Scenario Examples for Operating G.MDCSPNE

(This appendix does not form an integral part of this Recommendation)

The coordination mechanism requires knowledge about the voice enhancement abilities of individual SPNEs in a call-path. Capability list has been defined in G.MDCSPNE as a means to convey this information through the call-connection to enable the coordination. The preferred ways to transport the capability lists may depend on the network scenarios, and some network scenarios may be more favourable for the implementation and application of G.MDCSPNE.

The following three network examples are described.

- Packet Network to Packet Network
- Circuit-Switched Network to Circuit-Switched Network
- Packet Network to Circuit-Switched Network

For convenience, in the examples below voice processing function configuration using existing ITU-T recommendations [b-ITU-T Q.115.0], [b-ITU-T Q.115.1], [b-ITU-T Q.115.2], [b-ITU-T Q.52], [b-ITU-T Q.55], [b-ITU-T Q.56], [b-ITU-T Q.762], [b-ITU-T Q.763], [b-ITU-T Q.764] and possibly other associated recommendations is simply referred to as "voice processing function configuration using [b-ITU-T Q.115] specifications".

I.1 Packet Network to Packet Network

This section presents an example of a mobile-to-mobile call where end-to-end media traffic is exchanged over an IP packet network in non-Transcoding Free Operation.

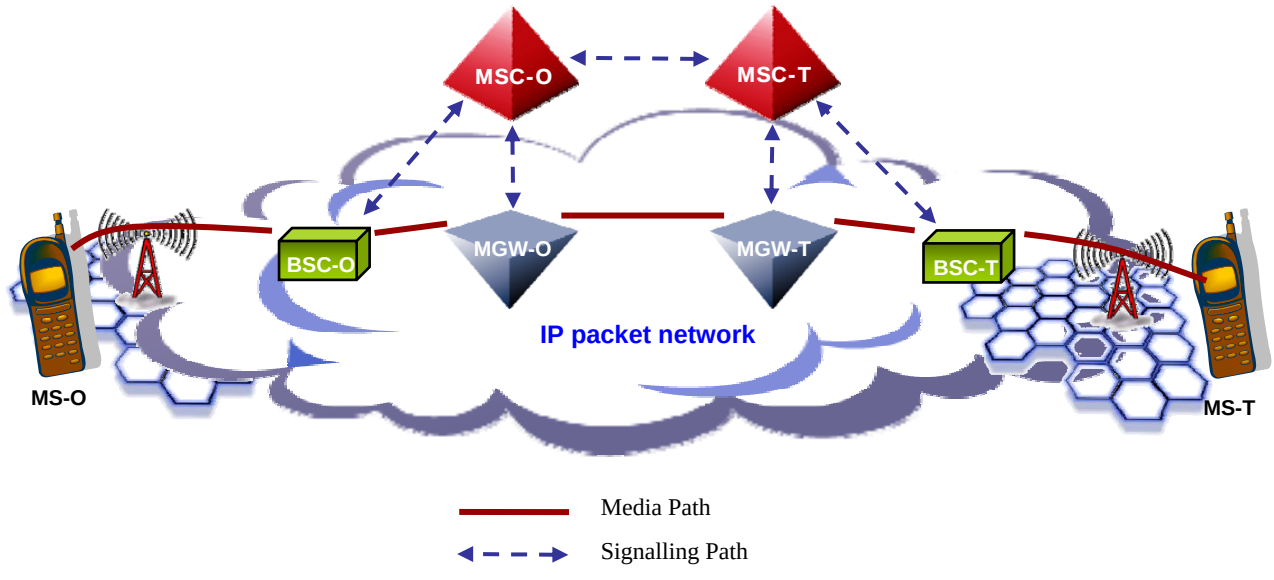


Figure I.1 – Mobile-mobile non-Transcoder Free Operation VoIP call

Call Configurations

Figure A-1 highlights an inter-system mobile-to-mobile call where media traffic traverses over IP packet networks. The call configuration is generic and is for illustration purposes only. It is not

intended to be representative of any specific wireless technology. In this example, the originating and the terminating sides use incompatible voice compressions and media traffic is exchanged between the originating and terminating media gateways (MGW-O, MGW-T) in G.711 format.

Table I.1 summarizes the voice enhancement processing functions supported by the mobile terminals and the media gateways. For illustration purposes, only functions applied to media traffic in the originating to terminating direction are listed. Voice processing functions applied to media traffic in the terminating to originating direction can be coordinated using the same approach.

Table I.1 – Voice processing functions applied to media in the originating to terminating direction before coordination

Voice enhancement processing functions	MS-O	MGW-O	MGW-T	MS-T	Tandem
Acoustic Echo Control (AEC)	Yes	Yes	No	No	Yes
Automatic Level Control (ALC)	No	Yes	Yes	No	Yes
Automatic Feedback Level Control (FALC)	No	Yes	No	Yes	Yes

Assumptions

For illustration purposes, this example further assumes the following:

- The mobile stations (MS) and media gateways (MGW) actively support G.MDCSPNE capability-list exchange.
- The base station controllers (BSC) passively support G.MDCSPNE (do not offer voice processing functions but provide the relay of the capability lists between two interfaces).
- Capability-list exchange over the IP core network is based on RTP/UDP/IP protocol stack. Definition of the capability-list format over the IP core network is a subject for further study.
- Capability-list is exchanged over the IP core network after call connection is established.
- Definition of the capability-list format over the access network is a subject for further study.
- Voice enhancement function coordination is based on the preference rules defined in Clause 6 of G.MDCSPNE.

Voice Processing Function Coordination

The following figures illustrate the forward and reverse capability-list exchanges between the nodes. A forward capability list is transmitted and received in the direction of the media flow whereas a reverse capability list is transmitted and received in the opposite direction of the media flow. Both are required for the coordination of voice processing functions applied to media flowing in a given direction.

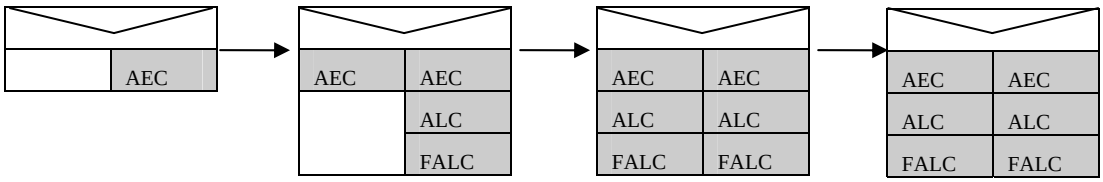


Figure I.2 – Forward capability-list exchange and update, from MS-O to MS-T

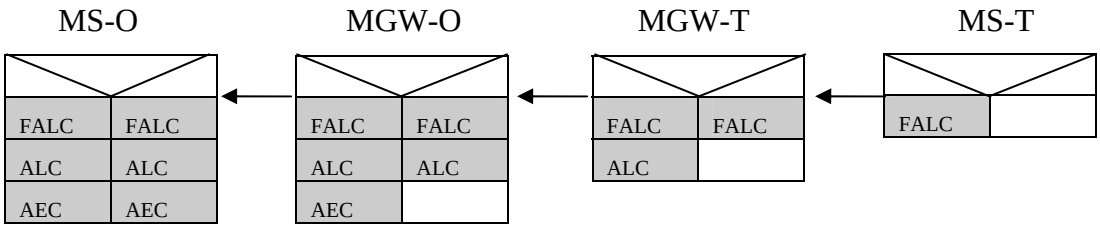


Figure I.3 – Reverse capability-list exchange and update, from MS-T to MS-O

Analyses of the forward and reverse capability lists in Figures I.2 and I.3 result in the following information for each device:

MS-O

1. Forward list:
   - o First device supporting voice processing functions
   - o First device supporting AEC
2. Reverse list:
   - o Other devices downstream supporting FALC, ALC and AEC
3. Coordination results:

   Based on the preference rules, MS-O keeps internal AEC enabled

MGW-O

1. Forward list analyses:
   - o First device supporting ALC and FALC
   - o Other device(s) upstream supporting AEC
2. Reverse list analyses:
   - o Last device supporting AEC
   - o Other devices downstream supporting FALC and ALC

3. Coordination results:
   - Based on the preference rules, MGW-O disables internal AEC, to avoid tandeming with AEC upstream
   - Based on the preference rules, MGW-O keeps internal ALC enabled
   - Based on the preference rules, MGW-O disables internal FALC to avoid tandeming with FALC downstream

MGW-T

1. Forward list analyses:
   - Other device(s) upstream supporting AEC, ALC, and FALC
2. Reverse list analyses:
   - Last device supporting ALC
   - Other devices downstream supporting FALC
3. Coordination results:
   - Based on the preference rules, MGW-T disables internal ALC to avoid tandeming with ALC upstream

MS-T

1. Forward list analyses:
   - Other device(s) upstream supporting AEC, ALC, and FALC
2. Reverse list analyses:
   - Last device supporting voice processing functions
   - Last device supporting FALC
3. Coordination results:
   - Based on the preference rules, MS-T keeps FALC enabled

Table I.2 summarizes the voice processing functions enabled after the exchange of capability lists and application of the preference rules. Voice enhancement function tandeming is avoided, and the active functions are optimally placed according to the preference rules.

Table I.2 – Voice processing functions applied to media in the originating to terminating direction after coordination

Voice processing functions	MS-O	MGW-O	MGW-T	MS-T	Tandem
Acoustic Echo Control (AEC)	Enabled	Disabled	No	No	No
Automatic Level Control (ALC)	No	Enabled	Disabled	No	No
Automatic Feedback Level Control (FALC)	No	Disabled	No	Yes	No

Summary

G.MDCSPNE considers all voice processing functions available in the call path. It results in the globally optimal deployment of the functions according to the preference rules.

I.2 Circuit-Switched Network to Circuit-Switched Network

This section presents an example of a call where end-to-end media traffic is exchanged over the circuit-switched network.

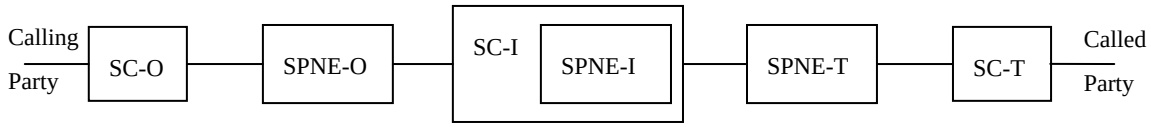


Figure I.4 – Two-party land-to-land call over the circuit-switched network

Call Configurations

Figure I.4 highlights an inter-system land-to-land call where end-user media traffic traverses the circuit-switched network. In this example, media traffic is exchanged between the originating (calling) and terminating (called) switching centres (SC-O, SC-T) through an intermediate switching centre (SC-I) in G.711 format. Switching centres SC-O, SC-T and SC-I control SPNE-O, SPNE-T, and SPNE-I, respectively, which provide voice enhancement processing functions. Table I.3 summarizes the voice processing functions supported by the SPNEs.

Table I.3 – Voice processing functions available in the SPNEs before application of control logic

Voice processing functions	SPNE-O	SPNE-I	SPNE-T	Tandem
Echo Cancellation (EC-O) for S_{in} from the calling party	Yes	Yes	No	Yes
Noise reduction (NR-O) for media from the calling party	Yes	Yes	Yes	Yes
Echo Cancellation (EC-T) for S_{in} from the called party	No	No	Yes	No
Noise reduction (NR-T) for media from the called party	No	Yes	Yes	Yes

Voice Processing Function Coordination

Assuming that the switching centres and/or SPNEs support G.MDCSPNE capability-list exchange and the preference rules, the voice processing functions in the circuit-switched call path can be dynamically coordinated in the same way as in clause I.1 above. Please refer to clause I.1 for details.

Detailed capability list exchange mechanisms and formats may vary for different transport networks. For example, capability list exchange over circuit-switched networks could be in-band or out-of-band based. They are subjects for further study. There are challenges to be resolved to support G.MDCSPNE over circuit-switched networks.

We shall describe below the coordination of voice processing functions using [b-ITU-T Q.115] specifications, an alternative (out-of-band) method, for this call configuration.

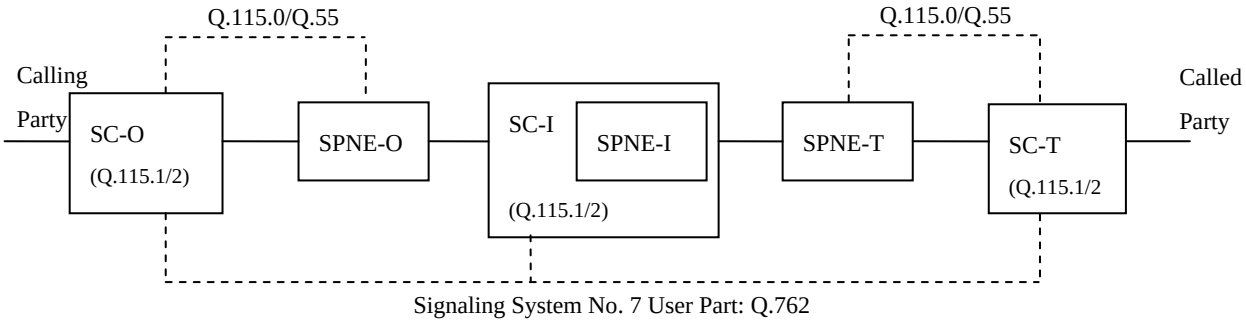


Figure I.5 – Two-party land-to-land call over the circuit-switched network

Voice Processing Function Coordination Using [b-ITU-T Q.115]

Voice processing function configuration using [b-ITU-T Q.115] specifications typically takes place at call setup time using out-of-band messages. Voice processing functions can be reconfigured using [b-ITU-T Q.115] specifications after the call has been answered, e.g. call transfer or multi-party call. The list below highlights the procedure.

1. At call setup time, SC-O for the calling party executes the voice processing function control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2].
2. SC-O enables EC-O and NR-O in SPNE-O with a message to SPNE-O per [b-ITU-T Q.115.0]
3. SC-O informs the switching centre SC-T for the called party of the SPNE-O voice processing function configuration using forward messages defined in [b-ITU-T Q.762], [b-ITU-T Q.763], and [b-ITU-T Q.764].
4. SC-I receives the forward messages from SC-O. SC-I executes the voice processing function control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2].
5. SC-I chooses to keep EC-O and NR-O disabled in SPNE-I
6. Per [b-ITU-T Q.762], [b-ITU-T Q.763] and [b-ITU-T Q.764], SC-I receives and relays the forward messages to SC-T without modifying message parameters set by SC-O unless SC-I does add locally supported forward direction functions not already provided by SC-O.
7. SC-T receives the forward messages from SC-O. SC-T executes the voice processing function control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2].
8. SC-T keeps NR-O disabled and enables EC-T and NR-T in SPNE-T with a message per [b-ITU-T Q.115.0]
9. SC-T informs the switching centre (SC-I) of the SPNE-T voice processing function configuration using backward messages defined in [b-ITU-T Q.762], [b-ITU-T Q.763], and [b-ITU-T Q.764].
10. Per [b-ITU-T Q.762], [b-ITU-T Q.763] and [b-ITU-T Q.764], SC-I receives and relays the backward messages to SC-O without modifying the message parameters set by SC-T, unless SC-I does add locally supported backward direction functions not already provided by SC-T
11. NR-T in SPNE-I remains disabled by default

Table I.4 summarizes the voice processing functions enabled at the completion of call setup. Voice enhancement function tandeming is avoided.

Table I.4 – Voice processing functions provided by the SPNEs after application of control logic and protocol

Voice processing functions	SPNE-O	SPNE-I	SPNE-T	Tandem
Echo Cancellation (EC-O) for S_{in} from the calling party	Enabled	Disabled	No	No
Noise reduction (NR-O) for media from the calling party	Enabled	Disabled	Disabled	No
Echo Cancellation (EC-T) for S_{in} from the called party	No	No	Enabled	No
Noise reduction (NR-T) for media from the called party	No	Disabled	Enabled	No

NOTE - Configuration is performed in a sequential manner starting by the calling party switching centre and then ending by the called party switching centre for voice processing functions in the forward path and vice versa for the voice processing functions in the backward path.

I.3 Packet Network to Circuit-Switched Network

This section presents an example of a mobile-to-land call where end-to-end media traffic is exchanged through an IP packet network and a circuit-switched network.

This example illustrates the inter-working of voice processing function dynamic coordination using G.MDCSPNE and configuration using [b-ITU-T Q.115] specifications. It is assumed that equipments operating over the IP mobile network support G.MDCSPNE, and equipments interfacing the circuit-switched network support voice processing function configuration using [b-ITU-T Q.115] specifications.

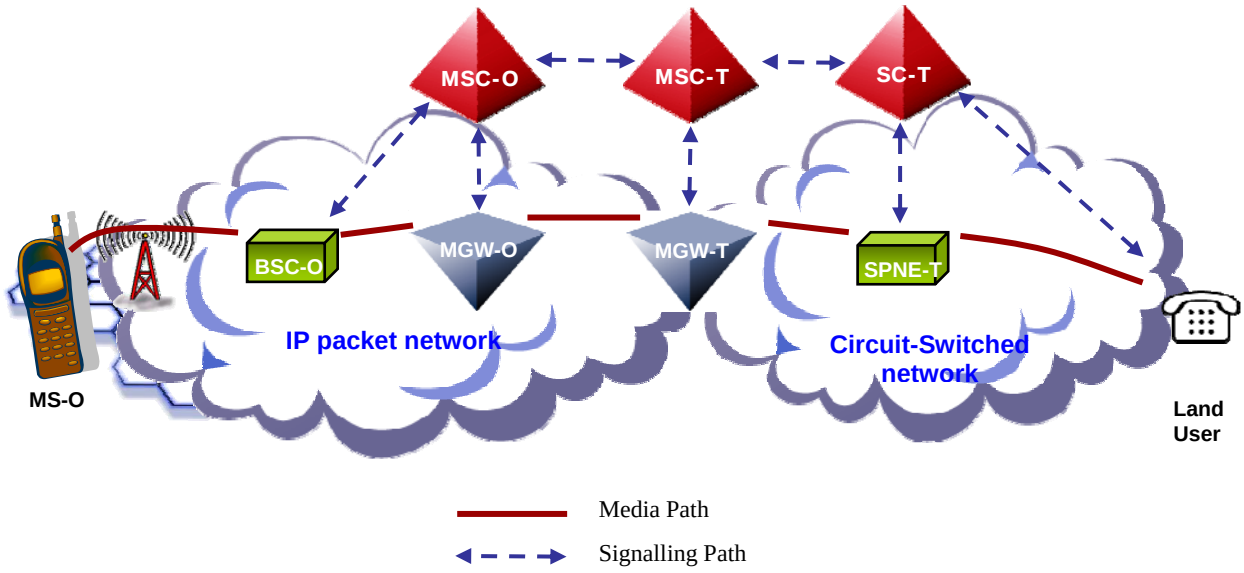


Figure I.6 – Mobile-to-land call through an IP packet network and a circuit-switched network

Call Configuration

Figure I.6 highlights an inter-system mobile-to-land call where media traffic traverses through packet and circuit-switched networks. The call configuration is generic and is for illustration purposes only. It is not intended to be representative of any specific wireless technology.

Table I.5 summarizes the voice enhancement processing functions assumed to be available in the mobile terminal and network equipments in this example.

Table I.5 – Availability of the voice processing functions before Q115 configuration

Voice enhancement processing functions	MS-O	MGW-O	MGW-T	SPNE-T	Tandem
Acoustic Echo Control (AEC)	Yes	Yes	No	No	Yes
Noise reduction (NR-O) for media from the mobile user	Yes	Yes	Yes	Yes	Yes
Echo Cancellation (EC) for S_{in} from the land user	No	No	Yes	Yes	Yes
Noise reduction (NR-T) for media from the land user	No	Yes	Yes	Yes	Yes

Assumptions

For illustration purposes, this example further assumes the following:

- The mobile station (MS-O) and media gateways (MGW) actively support G.MDCSPNE capability-list exchange.
- The base station controller (BSC-O) passively supports G.MDCSPNE.
- Capability-list exchange over the IP core network is based on RTP/UDP/IP protocol stack. Definition of the capability-list format over the IP core network is a subject for further study.

- Capability-list is exchanged over the IP core network after call connection is established
- Definition of the capability-list format over the access network is a subject for further study.
- Voice enhancement function coordination over the IP packet network is based on the preference rules in Clause 6 of G.MDCSPNE.
- In addition to supporting G.MDCSPNE over the IP core network, the terminating mobile switching center (MSC-T) and the terminating media gateway (MGW-T) support voice processing function configuration using [b-ITU-T Q.115] specifications over the circuit-switched network[3].
- MGW-T applies configuration results received from the MSC-T in [b-ITU-T Q.115.0], [b-ITU-T H.248.1] SPNE packages to capability-list exchanges over the IP core network. Capability marking by MGW-T in capability-list exchanges represents the voice processing function configuration in the circuit-switched network after configuration using [b-ITU-T Q.115] specifications. In other words, the capability markings reflect only the voice processing functions that were activated per [b-ITU-T Q.115] specifications.
- MGW-T is capable of reconfiguring voice processing functions that are activated or updated using [b-ITU-T Q.115], per G.MDCSPNE. Harmonization and inter-action between G.MDCSPNE and [b-ITU-T Q.115] specifications is a subject for future study.

Voice Processing Function Coordination

Voice processing function configuration using Q.115 specifications during call setup:

1. At call setup time, MSC-T executes the voice processing function control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2] based on the information received from its MGW-T and from the SC-T.
2. MSC-T enables EC and the forward function NR-O in MGW-T with a [b-ITU-T H.248] SPNE package message per [b-ITU-T Q.115.0].
3. MSC-T informs the switching centre SC-T of the MGW-T voice processing function configuration using forward messages defined in [b-ITU-T Q.762], [b-ITU-T Q.763], and [b-ITU-T Q.764] (e.g. IAM (outgoing ECD included)).
4. SC-T receives the forward messages from MSC-T. SC-T executes the voice processing function control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2].
5. SC-T keeps NR-O disabled and enables EC and the backward function NR-T in SPNE-T with a message to SPNE-T
6. SC-T informs MSC-T of the SPNE-T voice processing function configuration using backward messages defined in [b-ITU-T Q.762], [b-ITU-T Q.763], and [b-ITU-T Q.764] (e.g. ACM/ANM (incoming ECD included)).
7. MSC-T receives the backward messages from SC-T. MSC-T executes the voice processing function control logic per Q.115.1 and Q.115.2
8. MSC-T disables EC in MGW-T with a [b-ITU-T H.248] SPNE package message. NR-T in the backward direction remains disabled by default.

[3] If all switching centres, SPNEs and media gateways actively support G.MDCSPNE, the voice processing functions in the mobile-to-land call path can be dynamically coordinated uniformly as in example A above.

Table I.6 shows the voice processing function configuration committed to the configuration after call setup. It is noted that voice processing functions between MGW-T and SPNE-T over the circuit-switched network are not in tandem. Voice processing functions in the end-to-end call path are still in tandem.

Table I.6 – Voice processing functions available and operational after application of Q.115 and associated specifications

Voice enhancement processing functions	MS-O	MGW-O	MGW-T	SPNE-T	Tandem
Acoustic Echo Control (AEC)	Yes	Yes	No	No	Yes
Noise reduction (NR-O) for media from the mobile user	Yes	Yes	Yes	Disabled	Yes
Echo Cancellation (EC) for S_{in} from the land user	No	No	Disabled	Yes	No
Noise reduction (NR-T) for media from the land user	No	Yes	Disabled	Yes	Yes

Voice processing function dynamic coordination using G.MDCSPNE after call setup:

The following figures illustrate the forward and reverse capability-list exchanges between MS-O, MGW-O and MGW-T for voice processing functions for media flowing from the mobile subscriber to the land user.

A forward capability list is transmitted and received in the direction of the media flow whereas a reverse capability list is transmitted and received in the opposite direction of the media flow. Both are required for the coordination of voice processing functions applied to media flowing from the mobile subscriber to the land user.

Voice processing functions applied to media traffic in the land-to-mobile direction can be coordinated using the same approach.

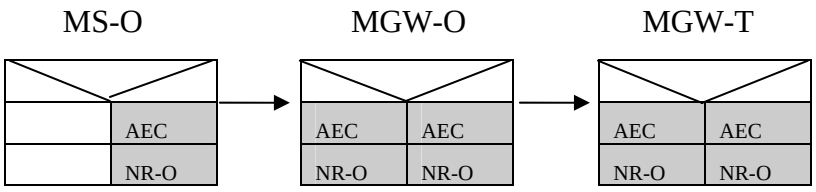


Figure I.7 – Forward capability-list exchange and update, from MS-O to MGW-T

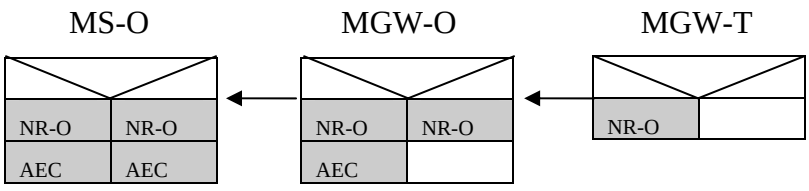


Figure I.8 – Reverse capability-list exchange and update, from MGW-T to MS-O

Analyses of the forward and reverse capability lists in Figures I.6 and I.7 result in the following information for each device:

MS-O

1. Forward list:
   - o First device supporting voice processing functions
   - o First device supporting AEC and NR-O
2. Reverse list:
   - o Other devices downstream supporting AEC, and NR-O
3. Coordination results:
   - o Based on the preference rules, MS-O keeps internal AEC and NR-O enabled.

MGW-O

1. Forward list analyses:
   - o Other device(s) upstream supporting AEC and NR-O
2. Reverse list analyses:
   - o Last device supporting AEC
   - o Other devices downstream supporting NR-O
3. Coordination results:
   - o Based on the preference rules, MGW-O disables internal AEC and NR-O, to avoid tandeming with upstream functions

MGW-T

1. Forward list analyses:
   - o Other device(s) upstream supporting AEC, and NR-O
2. Reverse list analyses:
   - o Last device supporting NR-O
3. Coordination results:
   - o Based on the preference rules, MGW-T disables internal NR-O to avoid tandeming with NR-O upstream.

Table I.7 summarizes the operational state of the voice processing functions after G.MDCSPNE coordination in both media flow directions. Voice enhancement function tandeming is avoided, and the active functions are optimally placed according to the preference rules.

Table I.7 – Voice processing functions available and operational after G.MDCSPNE coordination in both media flow directions

Voice processing functions	MS-O	MGW-O	MGW-T	SPNE-T	Tandem
Acoustic Echo Control (AEC)	Enabled	Disabled	No	No	No

Voice processing functions	MS-O	MGW-O	MGW-T	SPNE-T	Tandem
Noise reduction (NR-O) for media from the mobile user	Enabled	Disabled	Disabled	Disabled	No
Echo Cancellation (EC) for S_{in} from the land user	No	No	Disabled	Enabled	No
Noise reduction (NR-T) for media from the land user	No	Disabled	Disabled	Enabled	No

Summary

[b-ITU-T Q.115] specifications and G.MDCSPNE are exercised independently, resulting in the activation of the valid set of voice processing functions, for call configurations spanning IP and circuit-switched networks. [b-ITU-T Q.115] and associated specifications are typically invoked during call setup in order to determine the disposition of voice processing functions in accordance with subscriber profiles and operator policy. G.MDCSPNE is invoked after the call-path is established, for optimal placement of voice processing functions that are enabled and for avoiding tandem of such functions.

Bibliography

[b-ITU-T H.248.1] ITU-T Recommendation H.248.1 (2005), Gateway control protocol

[b-ITU-T Q.55] ITU-T Recommendation Q.55 (1999), Signalling between signal processing network equipments (SPNE) and international switching centres (ISC)

[b-ITU-T Q.115.0] ITU-T Q.115.0 (2002), Protocols for the control of signal processing network elements and functions

[b-ITU-T Q.115.1] ITU-T Q.115.1 (2002), Logic for the control of echo control devices and functions

[b-ITU-T Q.115.2] ITU-T Q.115.2 (2007), Logic for the control of voice enhancement devices and functions

[b-ITU-T Q.762] ITU-T Q.762 (1999), Signalling System No. 7 – ISDN User Part general functions of messages and signals

[b-ITU-T Q.763] ITU-T Recommendation Q.763 (1999), Signalling System No. 7 – ISDN User Part formats and codes

[b-ITU-T Q.764] ITU-T Recommendation Q.764 (1999), Signalling System No. 7 – ISDN User Part signalling procedures