I n t e r n a t i o n a l   T e l e c o m m u n i c a t i o n   U n i o n

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TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

G.799.2

(12/2009)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital terminal equipments – Other terminal equipment

Mechanism for dynamic coordination of signal processing functions

Recommendation ITU-T G.799.2

ITU-T

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Recommendation ITU-T G.799.2

Mechanism for dynamic coordination of signal processing functions

Summary

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

The concerns about the interaction of signal processing 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 by the local operators may not extend to all the nodes in call scenarios such as inter-system links. The traditional "static" approach to the coordination of signal processing functions, such as those found in voice enhancement equipment, may not meet the requirements of modern call topologies, which tend to be dynamic. Lack of coordination of the signal processing functions may result in voice quality degradation.

Recommendation ITU-T G.799.2 defines a generic framework for a coordination mechanism intended to minimize undesirable interactions of signal processing functions present on bearer paths of a communication link. The goal of this Recommendation is to provide a mechanism that can be used to optimize the end-to-end voice quality.

History

Edition	Recommendation	Approval	Study Group
1.0	ITU-T G.799.2	2009-12-14	16

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications, information and communication technologies (ICTs). The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g., interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words does not suggest that compliance with the Recommendation is required of any party.

INTELLECTUAL PROPERTY RIGHTS

ITU draws attention to the possibility that the practice or implementation of this Recommendation may involve the use of a claimed Intellectual Property Right. ITU takes no position concerning the evidence, validity or applicability of claimed Intellectual Property Rights, whether asserted by ITU members or others outside of the Recommendation development process.

As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

CONTENTS

Recommendation ITU-T G.799.2

Mechanism for dynamic coordination of signal processing functions

1 Scope

This Recommendation applies to signal processing functions that are intended for use in a communication link between terminal devices through network connections.

Examples of signal processing functions are echo cancellers, acoustic echo control, automatic level control and noise reduction. Communication networks include GSTN, IP networks, wireless mobile networks and any combination of them.

This Recommendation defines a generic framework for a coordination mechanism intended to minimize undesirable interactions of signal processing functions present on bearer paths of a communication link. The goal of this Recommendation is to provide a mechanism that can be used to optimize the end-to-end voice quality.

The signal processing functions subject to coordination by using this Recommendation could be present in the terminal devices and/or the communication networks. The mechanism performing dynamic coordination of signal processing functions includes the following components: capability announcement, capability identification, capability interaction resolution and 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. The implementation aspects of this mechanism will be defined in other ITU-T Recommendations.

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] Recommendation ITU-T G.160 (2008), *Voice enhancement devices*.

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

[ITU-T G.168] Recommendation ITU-T G.168 (2009), *Digital network echo cancellers*.

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

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

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 acoustic echo [ITU-T G.160]: 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.

3.1.2 automatic level control device [ITU-T G.161]: An automatic level control device (ALC) 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).

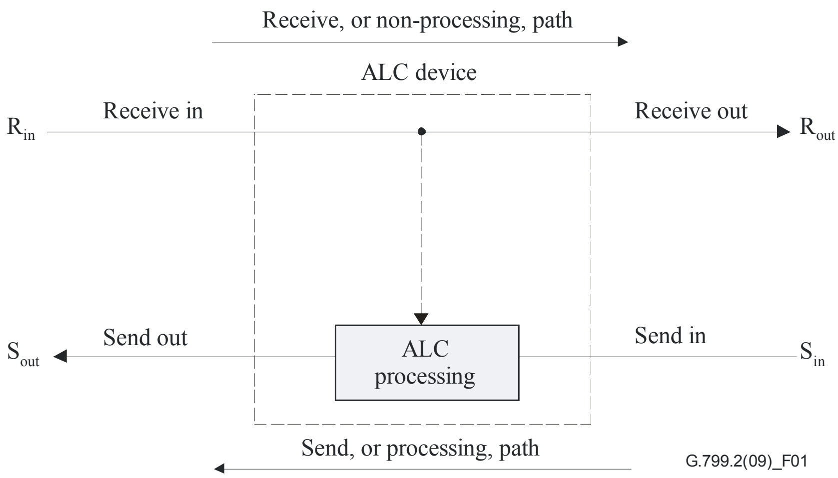


Figure 1 – Block diagram of an automatic level control device [ITU-T G.169]

3.1.3 cancelled end [ITU-T G.161]: 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.

3.1.4 network acoustic echo controller [ITU-T G.161]: Network acoustic echo controllers are devices placed in the 4-wire portion of a circuit and used for reducing cancelled-end acoustic echo.

3.1.5 network echo canceller [ITU-T G.161]: 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).

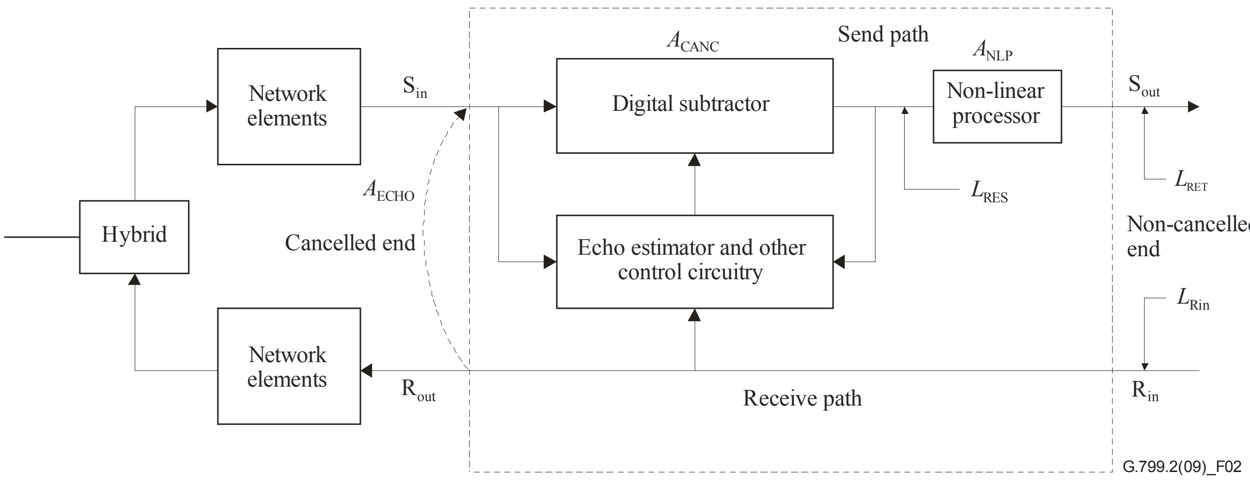


Figure 2 – Block diagram of an echo canceller [ITU-T G.168]

3.1.6 network echo suppressors [ITU-T G.161]: A 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.

3.1.7 terminal acoustic echo controller [ITU-T G.161]: 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.

3.1.8 voice enhancement device [ITU-T G.161]: 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 tandem free operation (TFO) and interworking function (IWF) signals.

3.1.9 voice gateways [ITU-T G.161]: A voice gateway is a subset of a gateway that deals with voice and voiceband traffic only, and not data or video traffic.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 automatic listener enhancement (ALE) device: An automatic listener enhancement (ALE) device is defined as any signal processing function located in the digital transmission path that adjusts the level of a signal in one transmission direction based on the measurements of signal in the other transmission direction with the purpose of enhancing audibility in high environmental noise conditions. Devices that 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 ALE devices.

NOTE – The performance requirement for this function is outside the scope of this Recommendation.

3.2.2 signal processing equipment (SPE): A stand-alone physical entity that supports one or more signal processing functions. Examples of signal processing equipment are signal processing network equipment (SPNE) [ITU-T G.161] and signal processing terminal devices.

3.2.3 signal processing function: A software component or a hardware entity that performs voice processing such as, but not limited to, electric or acoustic echo control, noise reduction or automatic level control.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

AEC	Acoustic Echo Control
ACM	Address Complete Message
ALC	Automatic Level Control
ALE	Automatic Listener Enhancement
ANM	Answer Message
BSC	Base Station Controller
CNG	Comfort Noise Generation
EC	Echo Canceller
ECD	Echo Control Device
GSTN	General Switched Telephone Network
IAM	Initial Address Message
IP	Internet Protocol
IWF	Interworking Function
LSB	Least Significant Bit
MGW	Media Gateway
MS	Mobile Station
MSB	Most Significant Bit
MSC	Mobile Switching Centre
NR	Noise Reduction
SC	Switching Centre
SPD	Signal Processing Device
SPE	Signal Processing Equipment
SPID	Signal Processing equipment Identifier
SPF	Signal Processing Function
SPNE	Signal Processing Network Equipment
TCE	Transcoder Equipment
TFO	Tandem Free Operation
VED	Voice Enhancement Device
VoIP	Voice over Internet Protocol
VQ	Voice Quality

5 Dynamic coordination mechanism

5.1 Levels of support

Signal processing equipment (SPE) 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 SPE that is equipped and capable of offering signal processing functions (SPFs). In active support, an SPE 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 SPE shall be capable of relaying the capability lists, after appropriate modification, between the interfaces.

– **Passive support**: Passive support is provided by an SPE or a network element that does not offer SPFs listed in Table A.1 to the bearer traffic. In passive support, an SPE or a network equipment is capable of receiving and relaying capability lists between two interfaces.

– **No support**: In no support, an SPE or a network equipment does not support the dynamic coordination mechanism and will not initiate, receive or relay capability lists. While this type of SPE or network equipment will disrupt the capability list exchange, it does not cause any disruption in the traffic.

5.2 Functions

The SPFs subject to the compliance of this Recommendation are AEC, ALC, EC, ALE and NR as listed in Table A.1.

In this Recommendation, the ALC and ALE functions to be used for coordination should not include the modification of the frequency response or spectral content of the signal.

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 SPEs. Two capability lists are required for all active-support SPEs, for application to bearers flowing in each direction.

NOTE – A total of four capability lists is required for the two directions of a connection.

The capability lists collect the SPF capabilities of the SPEs. One list is passed in the downstream direction and the other list is passed in the upstream direction, with respect to the direction of traffic flow.

Each capability list can have multiple entries with each entry corresponding to one particular SPF. The capability lists should be comprehensive enough to cover the SPFs supported by an SPE as listed in Table A.1. A posting marks the capabilities supported by an SPE. An SPE posts its support of an SPF in a list typically when the SPF is not already posted by other SPEs. If marking of a certain capability was made by a preceding SPE, the current SPE will not apply further marking of that capability, although it has that capability. Furthermore, if an active SPE does not have any SPF as listed in Table A.1 in the voice traffic direction, it should relay the capability lists without modifying their content. Each posting may also contain a set of attribute characteristics (to be defined) of the SPE and its SPF.

Figure 3 illustrates the flow of the two capability lists for voice traffic going from left to right. All SPFs 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 SPF postings from left to right and the lower list (reverse list) is for the SPF postings from right to left. In the lists, the letters "A", "B", etc., denote specific SPFs and the subscripts identify the posting SPEs in the call path. It is noted that these notations are defined for illustration purposes only. The implementation of a capability list is given in Annex A.

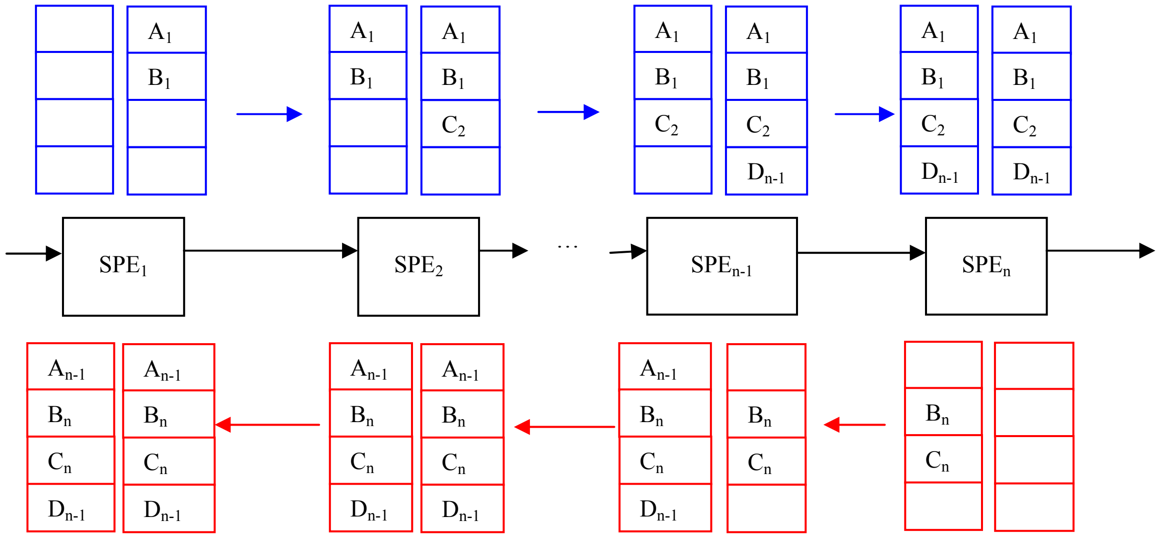


Figure 3 – An example of achieving information exchange through capability lists

5.3.2 Capability list initiation and response

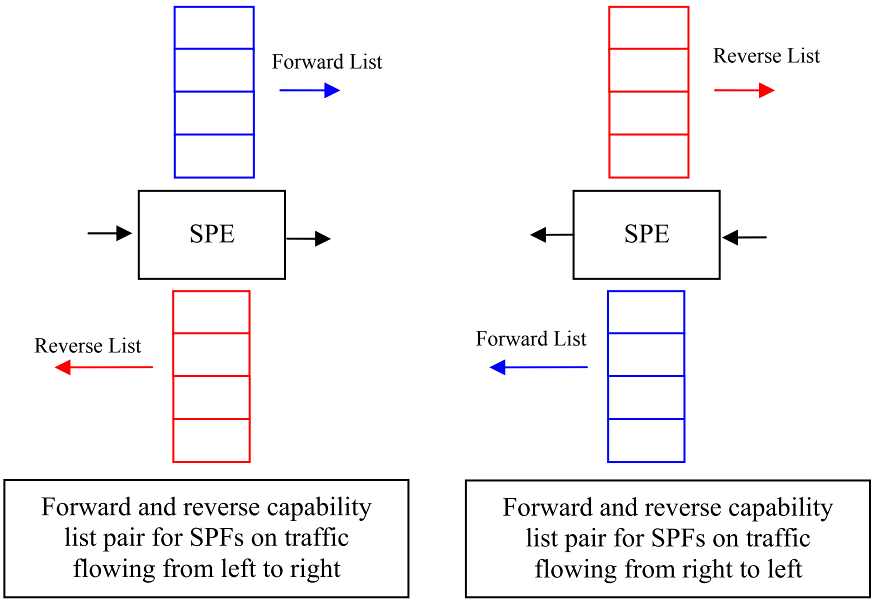
A communication call path is subject to changes which could affect the presence, absence or deployment of SPFs in the call path. Changes that can affect SPF may include topology changes for reasons such as call transfers and call handoffs. These changes may also include capability updates internal to an SPE. In the event of such modifications, it is necessary to initiate dynamic update of the SPF deployment to all active SPEs in the call path to issue an update.

This clause defines a set of actions to be taken on the initiation and response of capability-list exchanges in order to provide timely update of the SPF deployment to all active SPEs in a call path. The actions 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 set-up or insertion into a call path, an active SPE node sends two pairs of forward and reverse capability lists for SPFs supported by the SPE, one pair for SPFs on traffic flowing in each direction.

   Figure 4 illustrates the requirement.



NOTE – The SPE containing the SPFs is assumed not to be an originating or terminating equipment. If it is known to be at the originating or terminating equipment, only one capability list will be sent out in each direction.

Figure 4 – Capability list releases on call set-up or SPE insertion

2) After an internal update of local SPFs and capability (not enabling or disabling as a result of dynamic SPF coordination), an active SPE sends an updated pair of capability lists for each bearer flow subject to the SPF update. The pair of capability lists includes:

- The forward capability list of SPFs 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 SPFs supported by the local and other active SPEs 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.

3) On detecting a change in the identity of a peer SPE node, such as a change of the peer IP address in the case of VoIP, an active SPE 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 is removed from it. The pair of capability lists include:

- The up-to-date forward capability list for SPFs on traffic flowing to the new peer.
- The up-to-date reverse capability list for SPFs on traffic flowing away from the new peer.

Figure 5 illustrates the operation in this case.

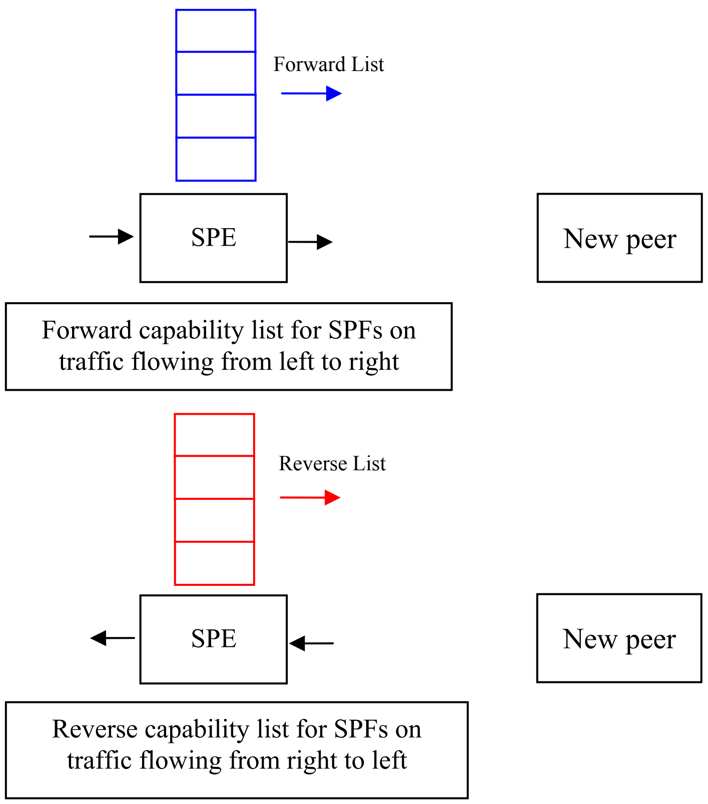


Figure 5 – Capability list releases on change of peer

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 SPE:

   – Replies to the sending SPE with the capability list received from the other side and updated with SPFs supported by the local SPE on traffic flowing in the direction defined by the list received at Ta.

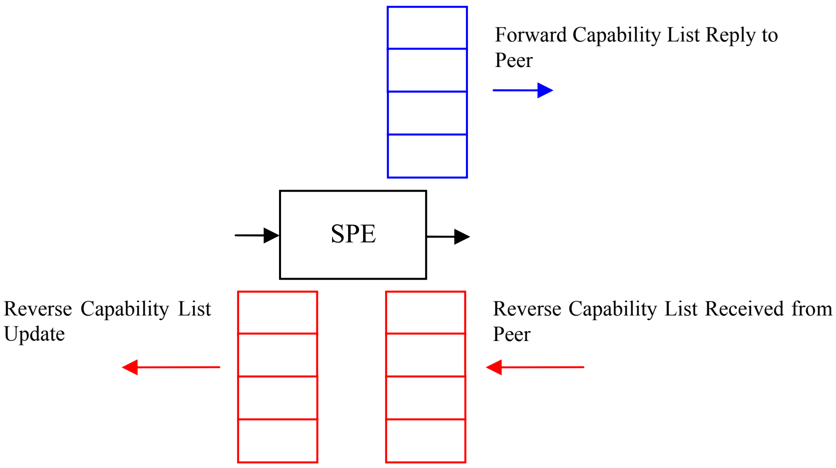
   – Relays to the SPE on the other side the received capability list updated with SPFs supported by the local SPE on traffic flowing in the direction defined by the list received at Ta.

   Figure 6 illustrates the processing.

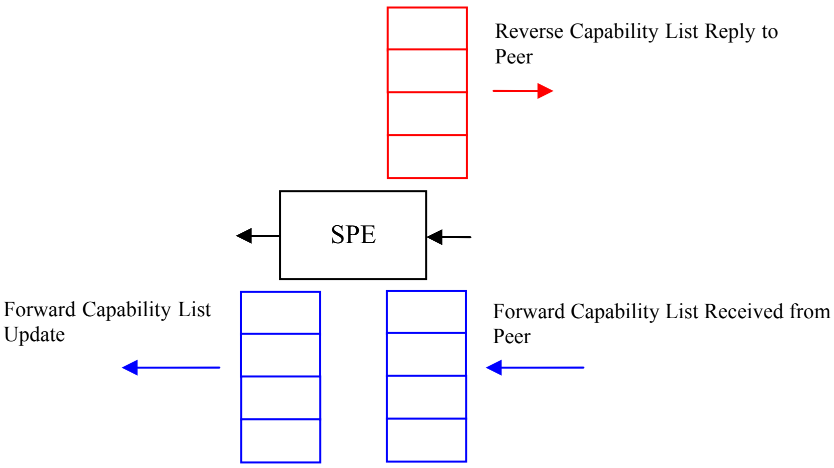
2) When receiving a capability list that is identical to the previously received capability list at the same input termination, the active SPE does not respond with a capability list release from any terminations, in order to avoid unnecessary transmission.

3) An active SPE 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) An active SPE should update and send capability lists to its neighbouring SPE, with its local SPF de-listed from the capability lists before it departs a call path.



(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

Figure 6 – Forward and reverse capability list releases

5.4 Information to be exchanged

Information to be exchanged is described in the capability format and structure shown in Annex A.

5.5 Enabling/disabling SPFs

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

6 Coordination rules

The location to deploy various SPFs along the call path will affect voice quality. It is therefore important to identify the preferred locations for SPFs in order to achieve better voice quality. The preferred locations for AEC, ALC, EC, NR and ALE 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., a mobile handset. The rationale for this is similar to that for echo cancellers, and is based on the echo path delay requirement consideration. For landline connections, acoustic echo is not noticeable. In case of landline hands-free telephones, since such telephones 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 cancellers 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., a mobile-to-mobile call, an echo canceller is not desirable in the entire call path.

Automatic listener enhancement (ALE)

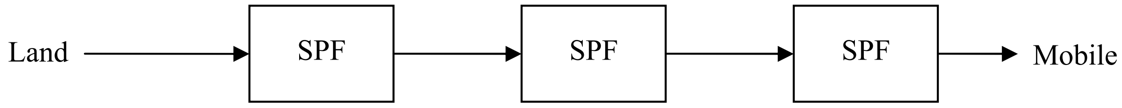
The preferred location for ALE is as close as possible to the destination. However, in call topologies that include echo cancellation, it is preferable to deploy ALE before R_{in} or after S_{out} of the echo canceller, in order to prevent adverse effects on the echo canceller performance due to the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

NOTE – ALE 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.

Noise reduction (NR)

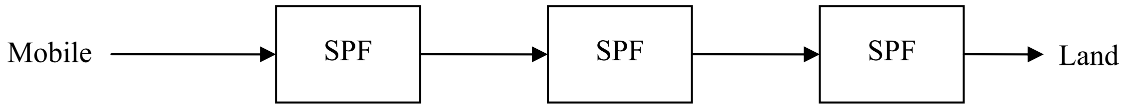
The preferred location for noise reduction is as close as possible to the signal source. However, in call topologies that include echo cancellation, it is preferable to deploy NR before R_{in} or after S_{out} of the echo canceller, in order to prevent adverse effects on the performance of the echo canceller 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 a landline to mobile call, and Figure 8 gives an example for preferred locations of SPF/SPDs for a mobile to landline call.



SPF/SPD	Preferred Location		
ALC	High Preference	Medium Preference	Low Preference
EC	High Preference	Medium Preference	Low Preference
ALE	Low Preference	Medium Preference	High Preference

Figure 7 – SPF preferred locations for a landline to mobile call (bearer traffic flows 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 preferred locations for a mobile to landline call (bearer traffic flows left to right)

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 the 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
SPID								
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 SPF
	0 for reverse capability list in the opposite direction from the SPF
N (4 bits)	Number of entries
SPID (16 bits)	SPE identifier This field contains a random identifier pattern used to identify the SPE when releasing the capability list. An SPE 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, and the SPE shall also choose a new identifier and release the most up-to-date capability list to the peer SPE.
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, 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

Figure A.1 – An implementation of capability list payload

The capability list payload needs to satisfy the following requirements:

– Each SPF entry is identified by a unique identification defined in Table A.1.

– Each entry for an SPF consists of a known size. An entry corresponding to a particular SPF will be added to the list if it is supported by an SPE. An entry corresponding to a particular SPF will be absent from the list if it is not supported by any SPE. Each entry carries only information relevant to SPF control.

– The overall capability list payload size is adaptive to the actual number and type of SPFs supported by the SPEs in a call path to minimize bandwidth usage.

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

The entry identifications of various SPFs are shown in Table A.1.

Table A.1 – Entry identification of various SPFs

SPF	Entry identification
AEC	0 0 0 1
ALC	0 0 1 0
EC	0 0 1 1
ALE	0 1 0 0
NR	0 1 0 1

An example of a capability list payload that contains AEC and ALC is shown in Figure A.2, 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	ID for AEC
0	0	0	0	0	0	1	0		Len (MSB...LSB)
0	0	0	0	0	0	1	0	Entry 2	ID for ALC
0	0	0	0	0	0	1	0		Len (MSB...LSB)

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

Appendix I

Network scenario examples for operating dynamic coordination mechanism among SPEs

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

The coordination mechanism requires knowledge about the signal processing function abilities of individual SPEs in a call path. The capability list has been defined in this Recommendation 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 the dynamic coordination mechanism defined in this Recommendation.

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, an SPF 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 "SPF configuration using ITU-T Q.115.x specifications".

I.1 Packet network to packet network

This clause 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.

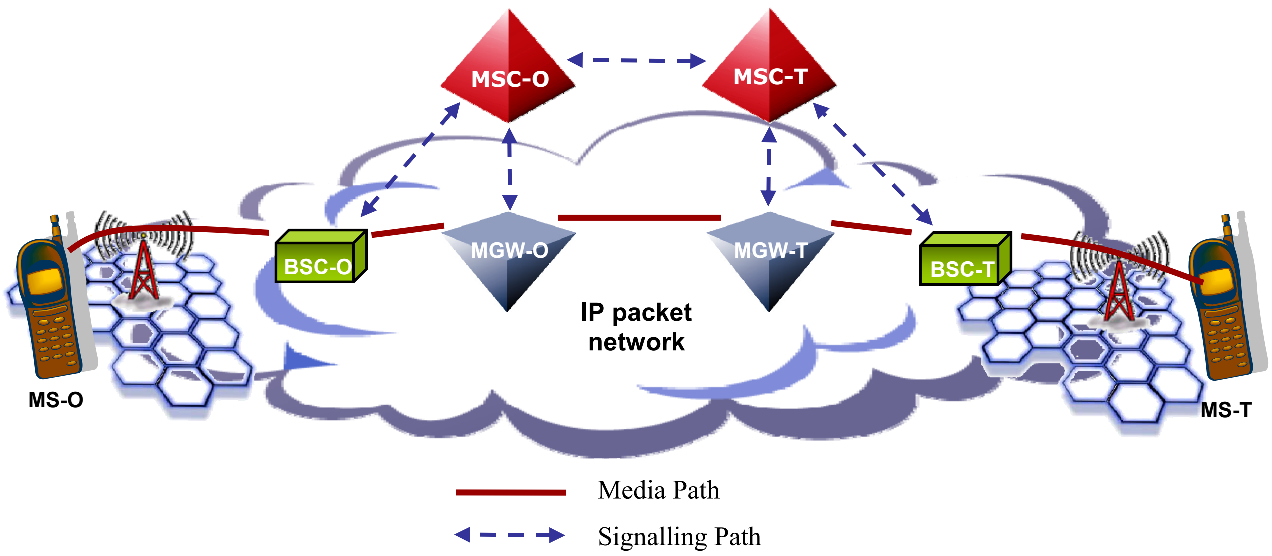


Figure I.1 – Mobile-mobile non-transcoder free operation VoIP call

I.1.1 Call configurations

Figure I.1 highlights an inter-system mobile-to-mobile call where media traffic traverses 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 compression and media traffic is exchanged between the originating and terminating media gateways (MGW-O, MGW-T) in the format defined in [b-ITU-T G.711].

Table I.1 summarizes the voice enhancement signal 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. SPFs applied to media traffic in the terminating to originating direction can be coordinated using the same approach.

Table I.1 – SPFs applied to media in the originating to terminating direction before coordination

Signal 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 listener enhancement (ALE)	No	Yes	No	Yes	Yes

I.1.2 Assumptions

For illustration purposes, this example further assumes the following:

– The mobile stations (MS) and media gateways (MGW) actively support capability list exchange.

– The base station controllers (BSCs) passively support the coordination mechanism (do not offer SPFs, 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.

– SPF coordination is based on the coordination rules defined in clause 6 of this Recommendation.

I.1.3 SPF coordination

Figures I.2 and I.3 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 SPFs applied to media flowing in a given direction.

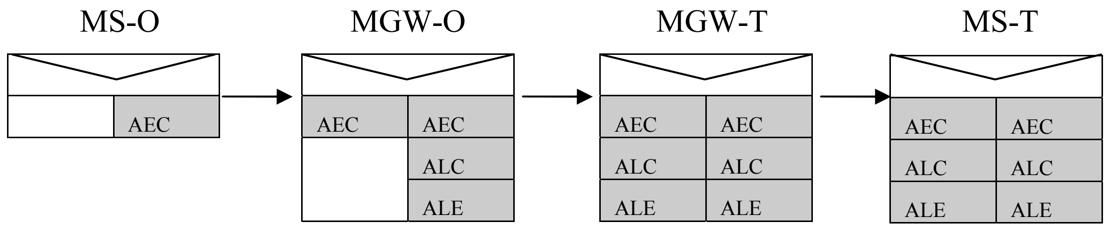


Figure I.2 – Forward capability list exchange and update, from MS-O to MS-T

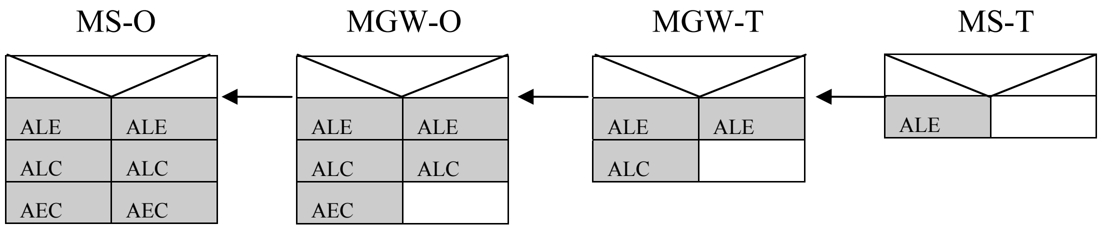


Figure I.3 – Reverse capability list exchange and update, from MS-T to MS-O

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 analyses:
   - First device supporting SPFs.
   - First device supporting AEC.
2) Reverse list analyses:
   - Other devices downstream supporting ALE, ALC and AEC.
3) Coordination results:
   - Based on the coordination rules, MS-O keeps internal AEC enabled.

MGW-O

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

MGW-T

1) Forward list analyses:
   - Other device(s) upstream supporting AEC, ALC and ALE.
2) Reverse list analyses:
   - Last device supporting ALC.
   - Other devices downstream supporting ALE.
3) Coordination results:
   - Based on the coordination 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 ALE.
2) Reverse list analyses:
   - Last device supporting SPFs.
   - Last device supporting ALE.
3) Coordination results:
   - Based on the coordination rules, MS-T keeps ALE enabled.

Table I.2 summarizes the SPFs enabled after the exchange of capability lists and application of the coordination rules. The tandeming of SPF is avoided, and the active SPFs are optimally placed according to the coordination rules.

Table I.2 – SPFs applied to media in the originating to terminating direction after coordination

Signal 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 listener enhancement (ALE)	No	Disabled	No	Yes	No

I.1.4 Summary

In this example, the coordination mechanism defined in this Recommendation considers all SPFs available in the call path. It results in the globally optimal deployment of the functions according to the coordination rules.

I.2 Circuit-switched network to circuit-switched network

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

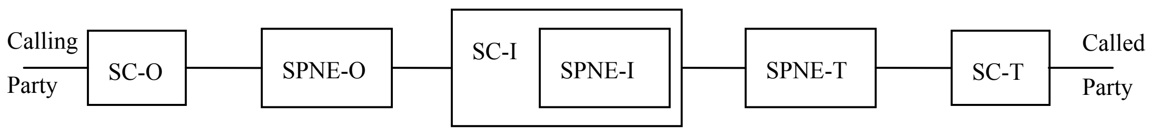


Figure I.4 – Two-party land-to-land call over the circuit-switched network

I.2.1 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 ITU-T 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 SPFs. Table I.3 summarizes the SPFs supported by the SPNEs.

Table I.3 – SPFs available in the SPNEs before application of control logic

Signal 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

I.2.2 SPF coordination

Assuming that the switching centres and/or SPNEs support capability list exchange and the coordination rules defined in this Recommendation, the SPFs 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. To support the coordination mechanism defined in this Recommendation over circuit-switched networks, there remain several items for further study.

The coordination of SPFs using ITU-T Q.115.x specifications, an alternative (out-of-band) method, for this call configuration is described below.

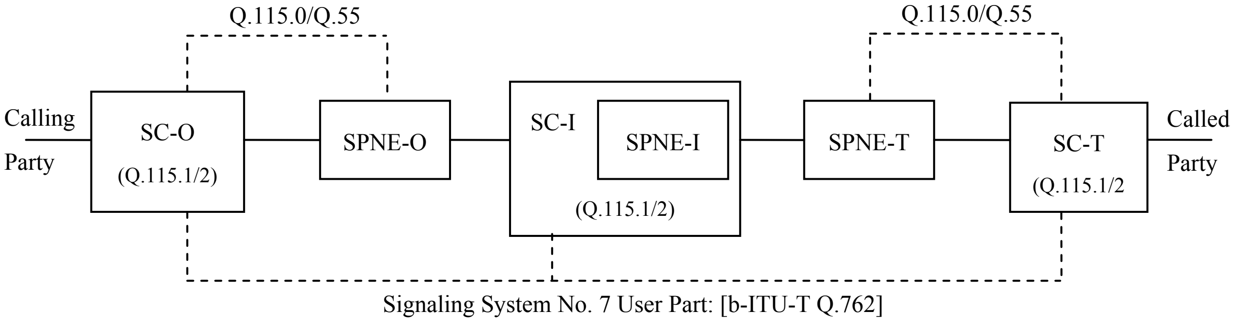


Figure I.5 – Land-to-land call over a circuit-switched network

I.2.3 SPF coordination using ITU-T Q.115.x specifications

SPF configuration using ITU-T Q.115.x specifications typically takes place at call set-up time using out-of-band messages. SPFs can be reconfigured using ITU-T Q.115.x specifications after the call has been answered, e.g., call transfer or multi-party call. The list below highlights the procedure.

1) At call set-up time, SC-O for the calling party executes the SPF 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 SPF 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 SPF 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 locally adds supported forward direction functions not already provided by SC-O.

7) SC-T receives the forward messages from SC-O. SC-T executes the SPF 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 SPF 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 locally adds 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 SPFs enabled at the completion of call set-up. The tandeming of SPF is avoided.

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

Signal 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 – Coordination is performed in a sequential manner starting by the calling party switching centre and then ending by the called party switching centre for SPFs in the forward path and vice versa for the SPFs in the backward path.

I.3 Packet network to circuit-switched network

This clause 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 SPF dynamic coordination using this Recommendation and configuration using ITU-T Q.115.x specifications. It is assumed that SPEs operating over the IP mobile network support the coordination mechanism defined in this Recommendation, and SPEs interfacing the circuit-switched network support SPF coordination using ITU-T Q.115.x specifications.

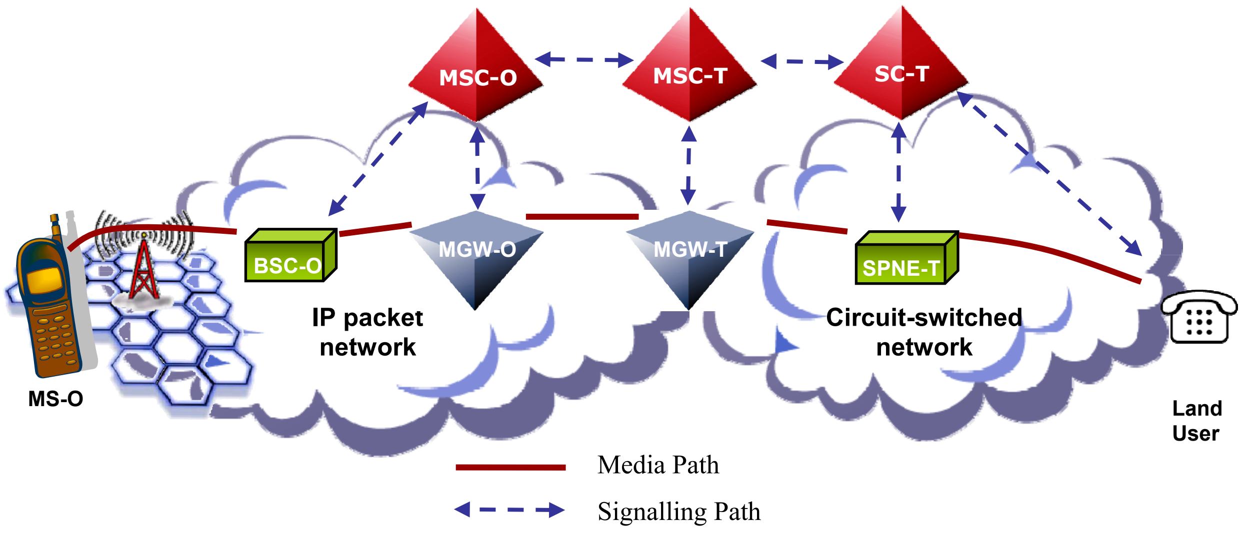


Figure I.6 – Mobile-to-land call through an IP packet network and a circuit-switched network

I.3.1 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 SPFs assumed to be available in the mobile terminal and network equipment in this example.

Table I.5 – Availability of the SPFs before ITU-T Q.115.x configuration

Signal 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

I.3.2 Assumptions

For illustration purposes, this example further assumes the following:

– The mobile station (MS-O) and media gateways (MGW) actively support the capability list exchange defined in this Recommendation.

– The base station controller (BSC-O) passively supports the coordination mechanism defined in this Recommendation.

– 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.
– SPF coordination over the IP packet network is based on the coordination rules in clause 6 of this Recommendation.
– In addition to supporting the dynamic coordination mechanism defined in this Recommendation over the IP core network, the terminating mobile switching centre (MSC-T) and the terminating media gateway (MGW-T) support SPF configuration using ITU-T Q.115.x specifications over the circuit-switched network.

  NOTE – If all switching centres, SPEs and media gateways actively support this Recommendation, the SPFs in the mobile-to-land call path can be dynamically coordinated uniformly as in the example described in clause I.1.
– MGW-T applies configuration results received from the MSC-T in [b-ITU-T Q.115.0], ITU-T H.248.1 SPNE packages to capability list exchanges over the IP core network. Capability marking by the MGW-T in capability list exchanges represents the SPF configuration in the circuit-switched network after configuration using ITU-T Q.115.x specifications. In other words, the capability markings reflect only the SPFs that were activated per ITU-T Q.115.x specifications.
– MGW-T is capable of reconfiguring SPFs that are activated or updated using ITU-T Q.115.x specifications, per this Recommendation. Harmonization and interaction between the dynamic coordination mechanism defined in this Recommendation and ITU-T Q.115.x specifications is a subject for future study.

I.3.3 SPF coordination

SPF configuration using ITU-T Q.115.x specifications during call set-up:

1) At call set-up time, MSC-T executes the SPF 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 an ITU-T H.248.1 SPNE package message per [b-ITU-T Q.115.0].
3) MSC-T informs the switching centre SC-T of the MGW-T SPF 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 SPF 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 SPF 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 SPF control logic per [b-ITU-T Q.115.1] and [b-ITU-T Q.115.2]
8) MSC-T disables EC in MGW-T with an ITU-T H.248 SPNE package message. NR-T in the backward direction remains disabled by default.

Table I.6 shows the SPF configuration committed to the configuration *after* call set-up. It is noted that SPFs between MGW-T and SPNE-T over the circuit-switched network are not in tandem. SPFs in the end-to-end call path are still in tandem.

Table I.6 – SPFs available and operational after application of ITU-T Q.115.x and associated specifications

Signal 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

SPF dynamic coordination using this Recommendation after call set-up:

Figures I.7 and I.8 illustrate the forward and reverse capability list exchanges between MS-O, MGW-O and MGW-T for SPFs 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 SPFs applied to media flowing from the mobile subscriber to the land user.

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

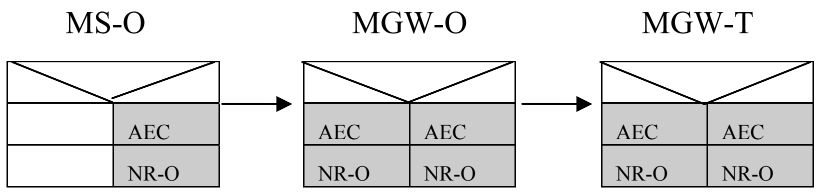


Figure I.7 – Forward capability list exchange and update, from MS-O to MGW-T

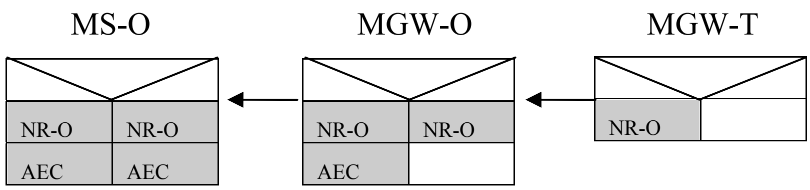


Figure I.8 – Reverse capability list exchange and update, from MGW-T to MS-O

Analyses of the forward and reverse capability lists in Figures I.7 and I.8 result in the following information for each device.

MS-O

1) Forward list analyses:
   - First device supporting SPFs.
   - First device supporting AEC and NR-O.
2) Reverse list analyses:
   - Other devices downstream supporting AEC and NR-O.

3) Coordination results:

- Based on the coordination rules, MS-O keeps internal AEC and NR-O enabled.

MGW-O

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

MGW-T

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

Table I.7 summarizes the operational state of the SPFs after coordination using this Recommendation in both media flow directions. The tandeming of SPF is avoided, and the active functions are optimally placed according to the coordination rules.

Table I.7 – SPFs available and operational after coordination using this Recommendation in both media flow directions

Signal processing functions	MS-O	MGW-O	MGW-T	SPNE-T	Tandem
Acoustic echo control (AEC)	Enabled	Disabled	No	No	No
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

I.3.4 Summary

ITU-T Q.115.x specifications and this Recommendation are exercised independently, resulting in the activation of the valid set of SPFs for call configurations spanning IP and circuit-switched networks. ITU-T Q.115.x specifications and associated specifications are typically invoked during call set-up in order to determine the disposition of SPFs in accordance with subscriber profiles and operator policy. The dynamic coordination mechanism defined in this Recommendation is invoked after the call path is established, for optimal placement of SPFs that are enabled and for avoiding tandeming of such functions.

Bibliography

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

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