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TECHNICAL REPORT

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Study on media handling aspects of Radio Access Network (RAN) delay budget reporting in Multimedia Telephony Service for Internet Protocol (IP) Multimedia Subsystem (IMS) (MTSI) (3GPP TR 26.910 version 19.0.0 Release 19)

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Contents

Foreword

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Introduction

During Rel-14, several VoLTE/ViLTE enhancement features were specified at the RAN level (as part of the LTE_VoLTE_ViLTE_enh work item) for RAN-assisted codec adaptation, VoLTE/ViLTE signalling optimization and VoLTE/ViLTE quality/coverage enhancement. In addition, media handling aspects of RAN-assisted codec adaptation functionality were specified in TS 26.114.

As part of the VoLTE quality/coverage enhancement functionality, a delay budget reporting framework was specified at the RAN level so that the VoLTE coverage can be effectively enhanced by relaxing the air interface delay budget. The UE uses RRC signalling to report the delay budget information. Based on the reported delay budget information, when a UE is in good coverage, the eNB can configure longer DRX for power saving purpose or the eNB can reduce DRX cycle in order to help the remote UE and reduce end-to-end delay and jitter, since when the remote UE is in bad coverage, the local eNB of that remote UE can increase the retransmission times in order to reduce the packet loss.

The present document addresses several gaps associated with the use of the RAN delay budget reporting framework requiring suitable media handling recommendations. In particular, the following questions are addressed:

- What are the available mechanisms in TS 26.114 and kinds of information available at the MTSI client that can help towards determining the content of the RAN-level *UEAssistanceInformation* messages with delay budget report information?
- How does RAN-level delay budget reporting work in conjunction with existing media adaptation behaviours in TS 26.114 for MTSI in an end-to-end fashion?
- What kind of MTSI signalling (if any) at the media handling level would facilitate a more coordinated and optimized use of the RAN delay budget reporting framework in an end-to-end fashion?

1 Scope

The present document investigates several MTSI enhancements relevant to the media handling aspects of RAN delay budget reporting. More specifically, the following MTSI enhancements are addressed, and the related gap analysis and conclusions are documented:

1) Potential recommendations for MTSI on the available mechanisms in TS 26.114 to determine the content of *UEAssistanceInformation* messages with delay budget report information including:
   - Relevant end-to-end quality metrics (e.g., round-trip time (RTT), packet loss ratio (PLR), jitter, etc.) in MTSI and other relevant information that can be used to trigger *UEAssistanceInformation* messages.
   - Suitable conditions on the end-to-end delay and jitter to determine:
     - if UE should send *UEAssistanceInformation* with delay budget report information, e.g., suitable RTT thresholds (i.e., with RTT determined by using RTCP sender and receiver reports),
     - what kind of information may be included in the *UEAssistanceInformation* messages based on the available information at the MTSI client.
2) Potential recommendations on how RAN-level delay budget reporting works in conjunction with existing media adaptation behaviours in TS 26.114 for MTSI. Relevant media adaptation behaviours include:
   - Codec rate or mode adaptation via CMR / RTCP-APP messages (for voice).
   - Use of application layer redundancy for increased reliability.
   - Use of packet bundling (a.k.a. frame aggregation).

In particular, potential recommendations are studied on when and how the UEs should use RAN-based delay adjustment mechanisms in an end-to-end fashion also accounting for local radio conditions and when UEs may activate and perform media-layer adaptation. The recommendations provided are flexible enough to enable implementations to optimize how relevant metrics and information, including non-standardized information, are used by the UE.

3) Identification and definition of potential new formats for real-time signalling of delay budget information from an MTSI receiver to an MTSI sender during a multimedia telephony session are also considered.

Furthermore, end-to-end performance evaluations for MTSI are presented, based on end-to-end metrics such as delay, jitter and packet loss rate, in conjunction with RAN-level air interface delay considerations toward developing potential recommendations on MTSI for the areas above.

2 References

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

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

[2] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".

[3] 3GPP TS 36.300: "Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".

[4] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

[5] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[6] 3GPP TS 36.331: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC) protocol specification".

[7] 3GPP TS 26.132: "Speech and video telephony terminal acoustic test specification".

[8] 3GPP TR 26.952: "Codec for Enhanced Voice Services (EVS); Performance characterization".

[9] IETF RFC 4585 (2006): "Extended RTP Profile for Real-time Transport Control Protocol (RTCP) - Based Feedback (RTP/AVPF)", J. Ott, S. Wenger, N. Sato, C. Burmeister and J. Rey.

[10] 3GPP TR 26.959: "Study on enhanced Voice over LTE (VoLTE) performance".

[11] Report ITU-R M.2135, "Guidelines for evaluation of radio interface technologies for IMT-Advanced", 2008.

[12] 3GPP TS 26.442: "Codec for Enhanced Voice Services (EVS); ANSI C code (fixed-point)".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in 3GPP TR 21.905 [1].

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

ANBR	Access Network Bitrate Recommendation
CDRX	Connected Mode DRX
CMR	Codec Mode Request
DRX	Discontinuous Reception
E2E	End-to-End
JBM	Jitter Buffer Management
MTSI	Multimedia Telephony Service over IMS
PLR	Packet Loss Ratio
POLQA	Perceptual Objective Listening Quality
RTCP	RTP Control Protocol
RTT	Round-trip time
SDP	Session Description Protocol
UL	Up-link
VoLTE	Voice over LTE

4 Overview of RAN Delay Budget Reporting

4.1 Background

During Rel-14, several VoLTE/ViLTE enhancement features were specified at the RAN level [3] to [6] (as part of the LTE_VoLTE_ViLTE_enh work item) for RAN-assisted codec adaptation, VoLTE/ViLTE signalling optimization and VoLTE/ViLTE quality/coverage enhancement. In addition, media handling aspects of RAN-assisted codec adaptation functionality were specified in TS 26.114 [2].

As part of the VoLTE quality/coverage enhancement functionality, a delay budget reporting framework was specified at the RAN level so that the VoLTE coverage can be effectively enhanced by relaxing the air interface delay budget. The UE uses RRC signalling to report the delay budget information, as specified in TS 36.331 [6]. Based on the reported delay budget information, when a UE is in good coverage, the eNB can configure longer DRX for power saving purpose or the eNB can reduce DRX cycle in order to help the remote UE and reduce end-to-end delay and jitter, since when the remote UE is in bad coverage, the local eNB of that remote UE can increase the retransmission times in order to reduce the packet loss.

4.2 Use Cases

In Figure 4.2.1, one use case on RAN delay budget reporting functionality is presented. Here, UE1 (MTSI receiver) is in good radio condition and configured with 40 ms CDRX. UE2 (MTSI sender) is in bad radio condition and configured with no CDRX. The scenario in Figure 4.2.1 happens in the following sequence:

1) UE2 detects bad-radio condition (e.g., high BLER), it does many HARQ retransmissions, which cause long jitter and E2E delay at the receiver UE1.

2) UE1 detects that VoLTE quality is bad (e.g., large jitter or delay), hence it suggests eNB1 to de-configure CDRX or shorten CDRX cycle. As a result, end-to-end delay and jitter are reduced.

3) UE2 detects that VoLTE E2E delay has dropped. UE2 reports larger delay headroom to eNB2, so eNB may apply more eMTC repetitions (or more HARQ retransmissions).

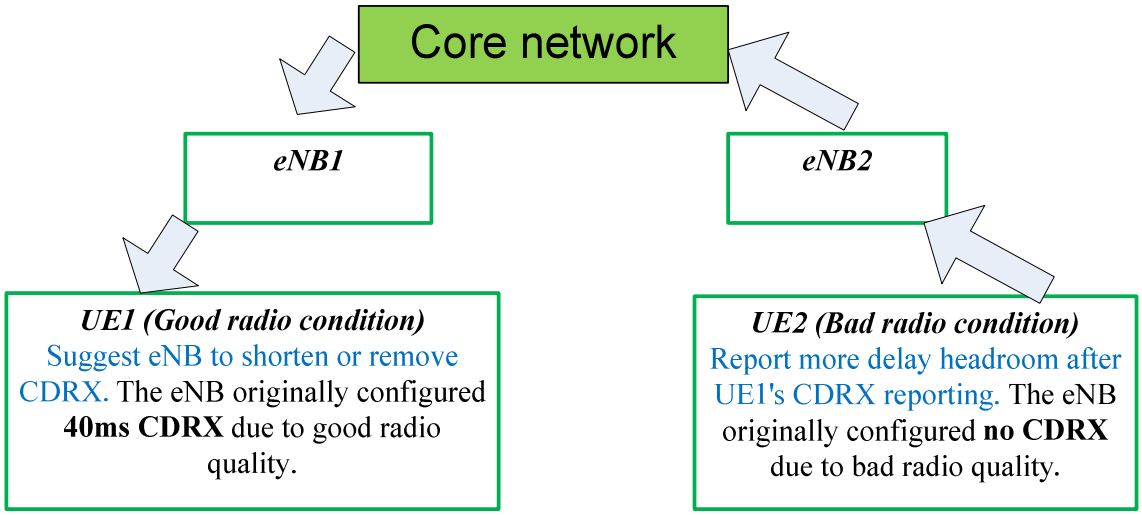


Figure 4.2.1: UE1 shortening CDRX cycle for a degraded VoLTE call

Essentially, UE1, despite its good coverage conditions, requests and if granted by the eNB, achieves the shortening of its CDRX cycle, in order to be able to provide more delay budget for UE2 so that UE2 can better tackle its poor coverage conditions and increase the reliability of its uplink transmissions. As such, the end-to-end quality of an MTSI call can be improved through reduced end-to-end delay and jitter. Such a capability requires that the UE is able to indicate to the eNB a CDRX cycle value that is different than the configured CDRX cycle value, for instance the UE may indicate preferred CDRX cycle length via a new RRC message.

4.3 RAN Feature Description

In order to realize the use cases above, the following RRC signaling was adopted in TS 36.331 [6] based on the *UEAssistanceInformation* message with the semantics shown in Table 4.3.1 that allows the UE to signal to the eNB delay budget reporting information carrying desired increment/decrement in the Uu air interface delay or connected mode DRX cycle length.as follows:

1) A UE in good coverage indicates a preference to the eNB to reduce the local air interface delay by sending a *UEAssistanceInformation* message with *delayBudgetReport* value and indication of *type1* to decrease the connected mode DRX cycle length, so that the E2E delay and jitter can be reduced.

2) The peer UE in bad coverage can send a *UEAssistanceInformation* message with *delayBudgetReport* value and indication of *type2* to its eNB to indicate a preference on Uu air interface delay adjustments.

When the UE detects changes such as end-to-end MTSI voice quality or local radio quality, the UE may inform the eNB its new preference by sending *UEAssistanceInformation* messages with updated contents on *delayBudgetReport*.

The eNB then decides which CDRX cycle to use. A prohibit timer is configured by the eNB to prevent the UE from sending the indication too frequently.

Table 4.3.1: Semantics of the *UEAssistanceInformation* message for RAN delay budget reporting

***UEAssistanceInformation* field descriptions**
delayBudgetReport Indicates the UE-preferred adjustment to connected mode DRX or coverage enhancement configuration.
type1 Indicates the preferred amount of increment/decrement to the connected mode DRX cycle length with respect to the current configuration. Value in number of milliseconds. Value ms40 corresponds to 40 milliseconds, msMinus40 corresponds to -40 milliseconds and so on.
type2 Indicates the preferred amount of increment/decrement to the coverage enhancement configuration with respect to the current configuration so that the Uu air interface delay changes by the indicated amount. Value in number of milliseconds. Value ms24 corresponds to 24 milliseconds, msMinus24 corresponds to -24 milliseconds and so on.

5 MTSI Impacts of RAN Delay Budget Reporting

5.1 Technical Aspect 1: End-to-End Delay and Quality Enhancements with RAN Delay Budget Reporting

5.1.1 Description

RAN delay budget reporting allows air interface delay adjustments at MTSI sender and/or MTSI receiver, so that the end-to-end delay and quality performance can be enhanced. Considering the use case described in clause 4.2, a good coverage UE on the receiving end to reduce its air interface delay, e.g., by turning off CDRX or via other means. This additional delay budget can then be made available for the sending UE, and can be quite beneficial for the sending UE when it suffers from poor coverage. The sending UE would request the additional delay from its eNB, and if granted, it would utilize the additional delay budget to improve the reliability of its uplink transmissions in order to reduce packet loss, e.g., via suitable repetition or retransmission mechanisms.

Toward developing an end-to-end operational perspective for the MTSI sender and MTSI receiver, the consideration of two modes are relevant:

1) *Autonomous mode:* MTSI sender and MTSI receiver independently use RAN delay budget reporting mechanisms toward adjusting air interface delay in their respective RANs. As such, there is no coordination between them. In the meantime, both sending and receiving UEs utilize available end-to-end metrics and other information available at their MTSI client to trigger RAN delay budget reporting.

2) *Coordinated mode:* MTSI sender and MTSI receiver trigger and use RAN delay budget reporting mechanisms in a coordinated fashion, and exchange delay budget information with each other, as they work toward adjusting air

interface delays in their respective RANs. In particular, in the coordinated mode (i) an MTSI receiver can indicate available delay budget to an MTSI sender, and (ii) an MTSI sender can explicitly request delay budget from an MTSI receiver. Detailed description of the potential solutions to signal delay budget availability information between the MTSI sender and receiver may be found in Clause 5.1.5.2. Both sending and receiving UEs utilize available end-to-end metrics at their MTSI client and other relevant application layer signalling received from the remote MTSI client to trigger RAN delay budget reporting.

As it will be more evident in the forthcoming signalling flows, the shortcomings of the autonomous mode are as follows:

1) While the MTSI sender and MTSI receiver UEs may both be independently able to adjust their air interface delays based on the information in their MTSI clients, they are never aware of the capabilities or actions of the other UE. For example, while an MTSI receiver in good coverage may turn off cDRX to create delay budget for an MTSI sender, it may be the case that the MTSI sender does not even support delay budget reporting, or that the MTSI sender's eNB may not grant the additional delay budget to the MTSI sender, so the effort of the MTSI receiver may not deliver any end-to-end performance gain, and end up wasting the battery power of the MTSI receiver UE. Likewise, an MTSI sender in poor coverage may increase its air interface delay in an attempt to perform further retransmissions to mitigate against packet losses, without any knowledge of the possible detrimental impacts on the MTSI receiver, e.g., packets being dropped at the jitter buffer management (JBM) level.

2) When UE-1 and UE-2 independently adjust their air interface delays, they rely on the end-to-end measurements available at their MTSI clients, e.g., by monitoring reception of RTP packets and RTCP sender and receiver reports, and knowledge of their local radio conditions. Purely relying on this information, an MTSI receiver may not be able to correctly detect the need for additional delay budget at the MTSI sender, e.g., as it may be the case that the losses are caused in the network. An explicit indication from the MTSI sender as would be enabled by the coordinated mode can help the MTSI receiver make the right conclusion. Moreover, the MTSI receiver may not be able to determine exactly how much additional delay budget is needed on the air interface for the MTSI sender UE. Likewise, an MTSI sender may not be able to determine exactly how much additional delay budget it could ask from its eNB in the autonomous mode, in the absence of any signalling from the MTSI receiver.

3) With the use of the coordinated mode, delay budget adaptation and consequent larger number of retransmissions can be done faster via the real time exchange of delay budget information using RTP/RTCP signalling compared to the autonomous mode which would have to rely on measurements and inference at the UEs based on packet statistics, collection of which requires a certain observation period and averaging window, so this is another advantage of the coordinated mode over autonomous mode.

5.1.2 Implications on MTSI

Air interface delay adjustments made through RAN delay budget reporting impact the end-to-end delay and quality performance of MTSI in TS 26.114.

5.1.3 Recommended Requirements

It is recommended that in MTSI it is specified how RAN delay budget reporting can be used in order to improve end-to-end delay and quality performance.

It is recommended that suitable trigger conditions at the MTSI client are specified in TS 26.114 to determine:

- if UE should send *UEAssistanceInformation* with delay budget report information based on end-to-end metrics at the MTSI client, e.g., via suitable packet loss ratio (PLR) (e.g., based on monitoring of RTP receive statistics) or RTT thresholds (e.g., with RTT determined by using RTCP sender and receiver reports),

- what kind of values may be included in the *UEAssistanceInformation* messages (as per Table 4.3.1) based on the available information at the MTSI client. Such information includes end-to-end metrics at the MTSI client and relevant application layer signalling received from the remote MTSI client or network.

It is recommended that new formats are defined in TS 26.114 for real-time signalling of delay budget information from an MTSI receiver to an MTSI sender and vice versa during a multimedia telephony session, towards facilitating a more coordinated and optimized use of the RAN delay budget reporting framework in an end-to-end fashion.

5.1.4 Gap Analysis

MTSI as in TS 26.114 currently does not specify when and how the UEs should use RAN-based delay adjustment mechanisms in an end-to-end fashion.

5.1.5 Potential Solutions

5.1.5.1 Signaling Flows on RAN Delay Budget Reporting Usage in MTSI

The below signaling flows describe RAN delay budget reporting usage in MTSI for voice for the autonomous and coordinated modes.

In Figure 5.1.5.1.1, a signaling flow for RAN delay budget reporting usage in MTSI for the autonomous mode is presented. The "Request" message is a generalized application level rate request message that corresponds to CMR or RTCP-APP for voice.

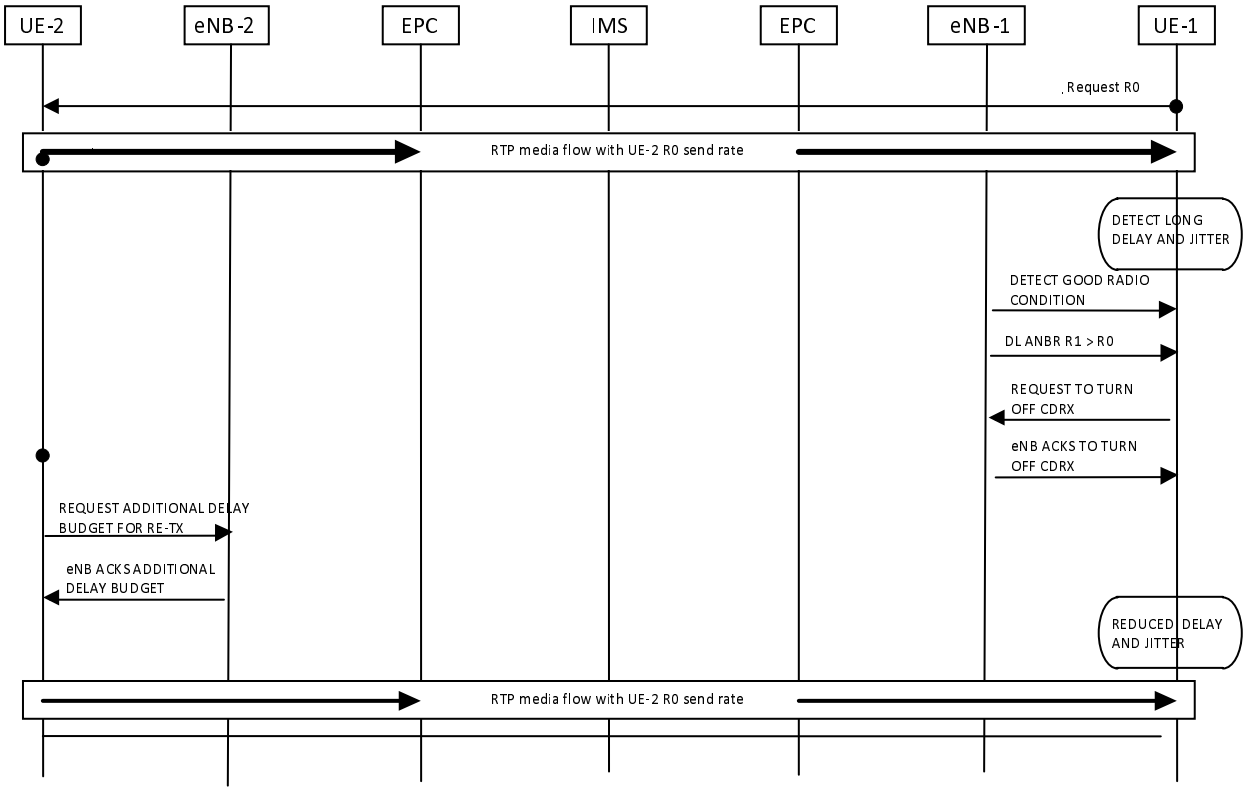


Figure 5.1.5.1.1: Signaling flow on usage of RAN delay budget reporting in MTSI in the autonomous mode

Step 1: UE-1 sends UE-2 rate request via CMR or RTCP-APP for voice at bitrate R0.

Step 2: UE-2 sends RTP media flow for voice with bitrate R0.

Step 3: UE-1 detects good radio conditions locally, e.g., eNB-1 sends a DL access network bitrate recommendation (ANBR) of bitrate R1 > R0 to UE-1, and UE-1 measures low block error rate (BLER) over the local radio link based on the monitoring of successful downlink packet transmissions, and it may also measure downlink throughput over the radio air interface that is much higher than the received bitrate (after accounting for the relevant headers). In the meantime, UE-1 detects high packet losses after monitoring reception of RTP packets (also by monitoring RTCP sender and receiver reports) and applying the highest possible jitter buffer according to the reference Jitter Buffer Management (JBM) in TS 26.114 (subject to the JBM compliance requirement of MTSI). Hence, UE1 concludes that UE2's local radio conditions are poor.

Step 4: UE-1 sends a *UEAssistanceInformation* message to eNB-1 with type-1 to turn off CDRX. It is assumed that eNB-1 grants this request and turns off CDRX for UE-1. Turning off cDRX is relevant only when PLR is high, which is the conclusion of UE-1 in this example, as per Step 3. It should however be noted that UE-1 can increase the JBM depth to compensate the delay for high jitter. In this scenario, delay budget request from UE-1 to eNB-1 is not necessary and *UEAssistanceInformation* message may not be sent. Moreover, due to other considerations, UE-1 may choose not to turn cDRX off, e.g., when saving battery power is critical.

Step 5: UE-2 detects high packet losses on its uplink due to poor coverage conditions, e.g., it may measure high BLER over its local radio link based on the monitoring of successful uplink packet transmissions, e.g., by monitoring the HARQ acknowledgements received. UE-2 requests additional delay budget from eNB-2 in order to perform additional re-transmissions to increase the reliability of its UL transmissions. When requesting this additional delay budget, UE-2 may also consider end-to-end RTT measured based on RTCP reports. It is assumed that eNB-2 grants this request. Because UE-1 has already turned its cDRX off, it is unlikely that the JBM constraint at UE-1 will lead to packet losses in response to the increase air interface delay over the RAN corresponding to UE-2.

Step-6: UE-1 measures reduced end-to-end delay and jitter, and packet losses are also reduced.

It should be noted that the actions of UE-1 in Steps 3-4 above and actions of UE-2 in Step 5 above are completely independent and these are not necessarily sequential, as there is no coordination between the two UEs for this autonomous mode of operation.

In Figure 5.1.5.1.2, a signaling flow for RAN delay budget reporting usage in MTSI for the coordinated mode is presented.

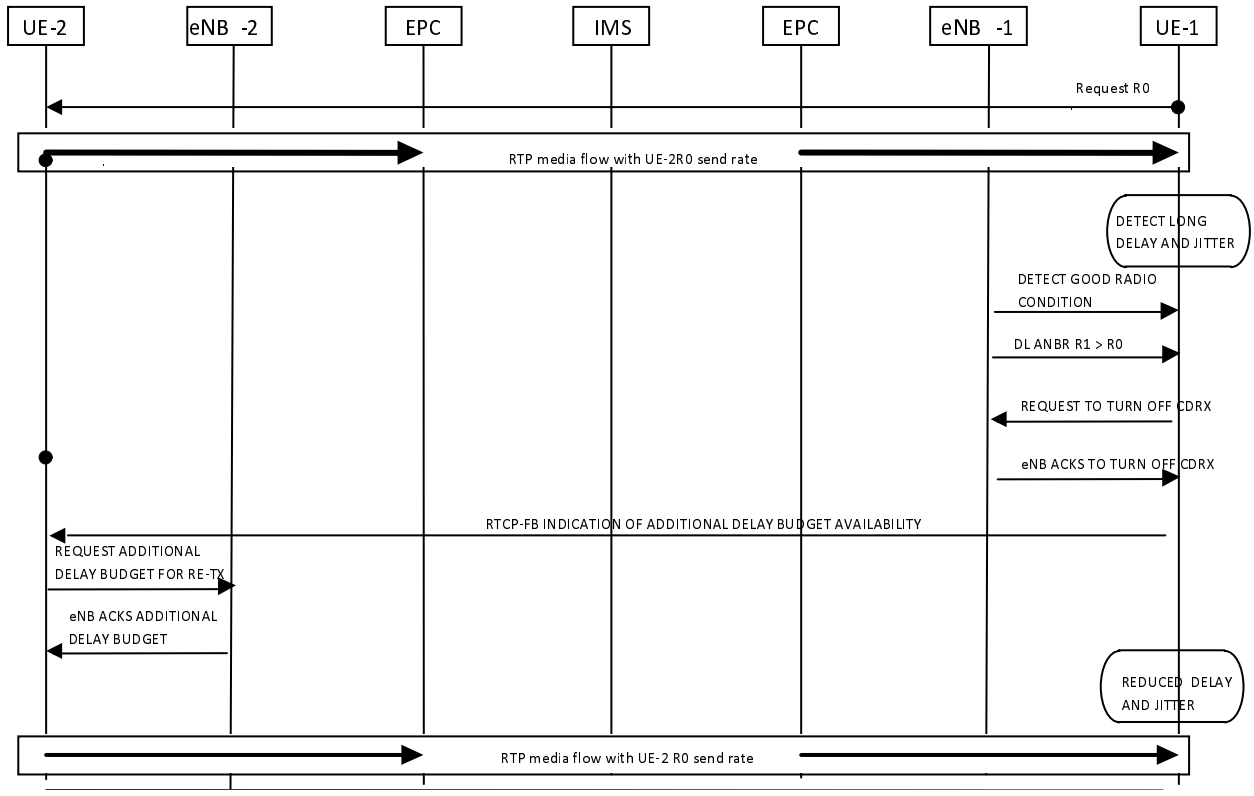


Figure 5.1.5.1.2: Signaling flow on usage of RAN delay budget reporting in MTSI in the coordinated mode

Steps 1-4: Identical to the earlier signalling flow corresponding to the autonomous mode

Step 5: If delay budget information signalling is supported between UE-1 and UE-2, UE-1 sends an RTCP feedback (RTCP-FB) message to UE-2 indicating the availability of additional delay budget due to cDRX being turned off. It should be noted that an RTP header extension message may also be used instead to indicate the availability of additional delay budget. Relevant details on the potential signalling solutions for the coordinated mode to communicate available delay budget information can be found in clause 5.1.5.2. A concrete delay number may also be reported as part of the RTCP-FB message that corresponds to the air interface delay reduction on UE-1's RAN after turning off cDRX, which would essentially be now available for UE-2 to improve the reliability of its uplink transmissions. The reported delay

number may also be determined considering UE1's JBM constraints and can be based on its assessment of how much additional delay it can tolerate.

Step 6: UE-2 detects high packet losses on its uplink due to poor coverage conditions. UE-2 requests additional delay budget from eNB-2 in order to perform further re-transmissions to increase the reliability of its UL transmissions. When requesting the additional delay budget from eNB-2, UE-2 may also consider the RTCP-FB message it received from UE-1 on the availability of delay budget from UE-1's perspective. It is assumed that eNB-2 grants this request.

Step-7: UE-1 measures reduced end-to-end delay and jitter, and packet losses are also reduced.

In this example, the available delay budget may be computed by the UE-1 (MTSI receiver) based on network delay, jitter, packet loss rate (PLR) and potentially other parameters. It may also take into account constraints on JBM (i.e., based on reference JBM in TS 26.114). In this respect, the following observations can be made on the expected UE behaviour:

a) Allowing UE-2 to use more retransmission will increase the jitter. This may potentially create more packets dropped at the JBM for UE-1.

b) On the other hand, more retransmission also allows UE-2 to reduce packet losses in its RAN uplink and this means more end-to-end reliability. So there is a fine balance here, while it would also be expected that the end-to-end performance is limited by the high packet losses on the UL, and hence more retransmissions will help improve the end-to-end quality and delay performance.

c) UE-1 turning off cRDX will help to reduce end-to-end delay. In the meantime, if UE-1 needs to save on battery power and it is critical that cDRX is kept on for this purpose, then UE-1 may choose not to turn cDRX off. Even with cDRX off, if UE-1 decides that it can tolerate any further delay or jitter at its JBM, it may indicate this available delay budget via the RTCP-FB or RTP header extension message.

d) It is up to UE-1 to signal any additional delay budget to UE-2. If UE-1 thinks that it is already close to its JBM constraint and cannot tolerate any additional delay or jitter (as this would lead to more packets being dropped), it may not signal additional delay availability to UE-2.

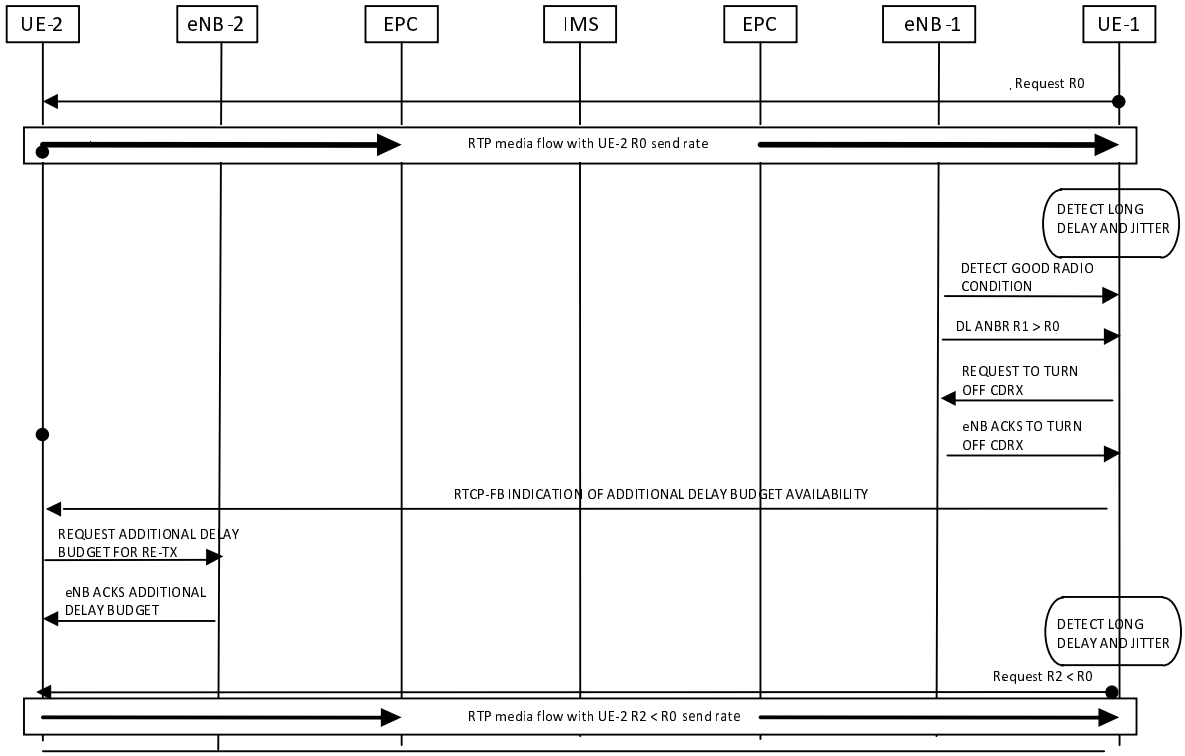


Figure 5.1.5.1.3: Another signaling flow on usage of RAN delay budget reporting in MTSI in the coordinated mode

The signaling flow in Figure 5.1.5.1.3 is identical to the one in Figure 5.1.5.1.2, except that there is another stage:

Stage 8: UE-1 still suffers from high packet losses and measures high end-to-end delay and jitter. Thus UE-1 sends UE-2 rate request via CMR or RTCP-APP for voice at bitrate R2 < R0. Other kinds of adaptation may also be invoked, for instance the use of application layer redundancy or transitioning to a more robust codec mode based on the negotiated codecs (e.g., channel-aware mode for EVS), in case the receiver side detects major packet loss but delay and jitter are within desired bounds.

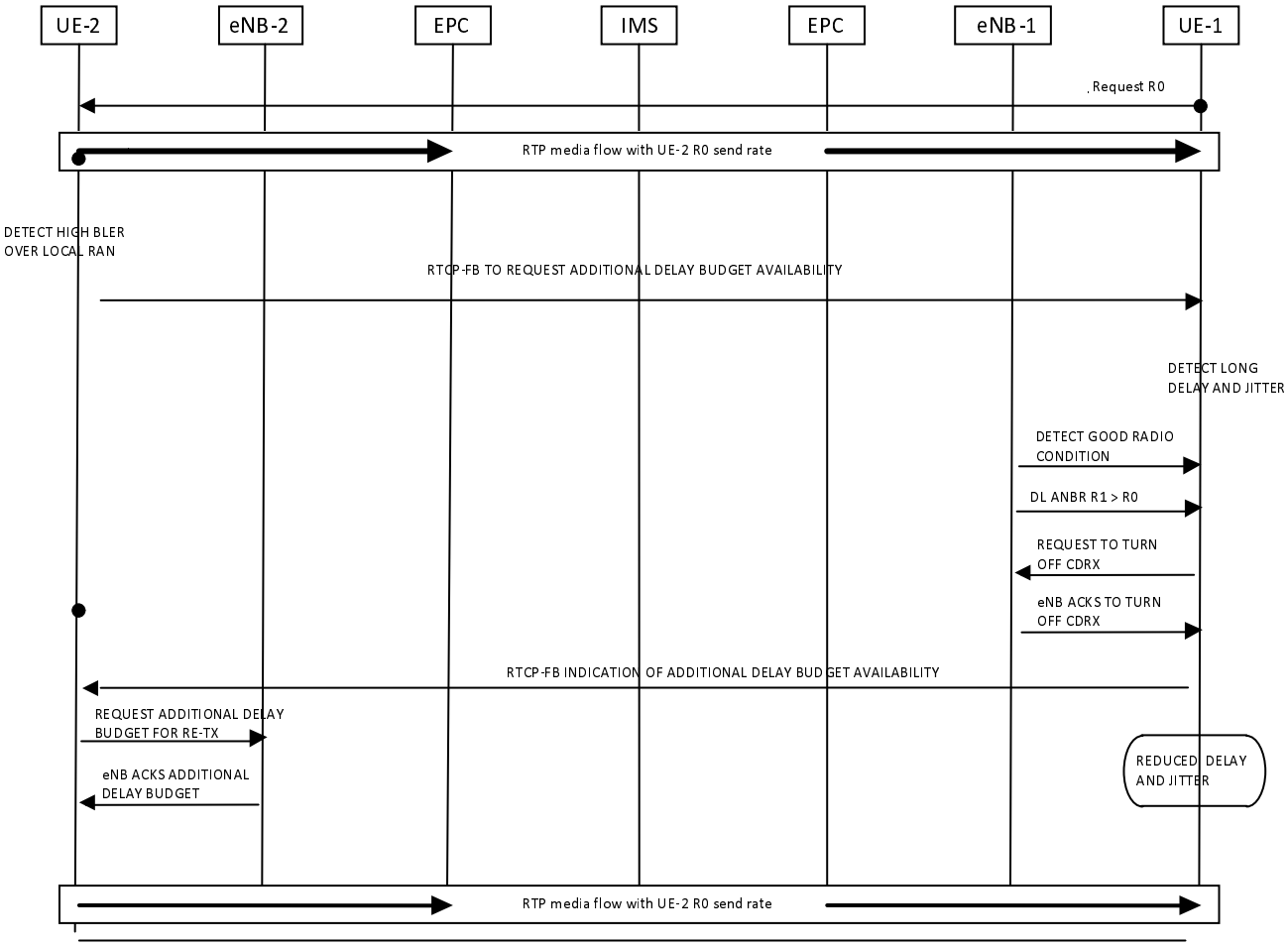


Figure 5.1.5.1.4: Signaling flow on usage of RAN delay budget reporting in MTSI in the coordinated mode with bi-directional exchange of delay budget information

The signalling flow in Figure 5.1.5.1.4 is a variant of the one in Figure 5.1.5.1.2, where UE-2 requests additional delay budget from UE-1 during the media flow, e.g., via the use of an RTCP-FB message or an RTP header extension message, after having detected poor radio conditions (e.g., high BLER) over the local RAN. The presence of this request message may further inform UE-1 that the radio conditions on UE-2's side are poor (in addition to its own detection, e.g., based on monitoring of RTP receive statistics). Another benefit of the bi-directional exchange of delay budget information between the two UEs is that this could help in identifying the scenario where the packet losses are introduced by neither of the RANs of UE1 and UE2 (i.e., both UEs enjoying good radio conditions) but rather by the network. In the meantime, it should be noted that the dominant cause of packet losses is expected to be from RAN impediments and the likelihood that the packet losses are caused by the network is quite small.

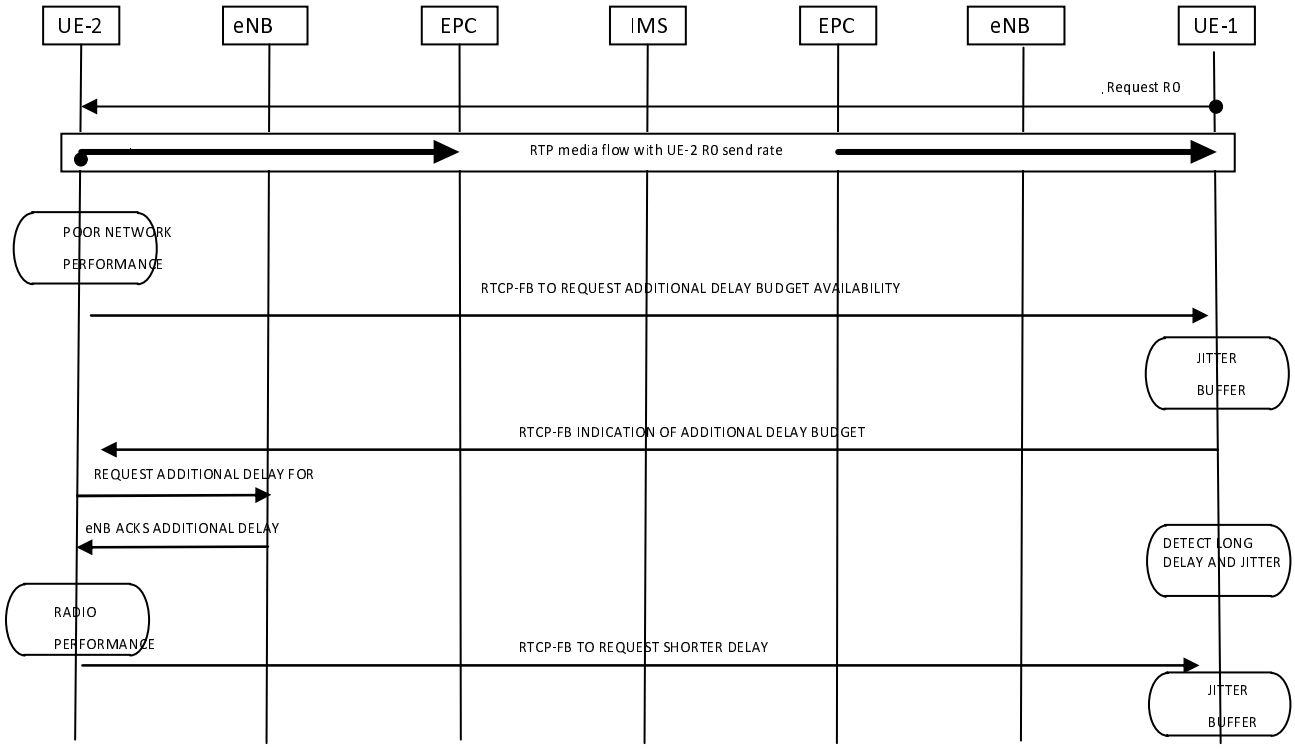


Figure 5.1.5.1.5: Signaling flow on usage of RAN delay budget request in MTSI in the coordinated mode with jitter buffer adjustment.

The signalling flow in Figure 5.1.5.1.5 is a case of jitter buffer adjustment where UE-2 is suffering from poor network performance, e.g. under continuous weak coverage. UE-2 requests additional delay budget from UE-1 during the media flow, e.g., via the use of an RTCP-FB message or an RTP header extension message, where a certain amount of expected extra delay is indicated. After receiving the request, jitter buffer in UE-1 may be extended to allow the sender to perform more uplink retransmissions and feedback to UE-2 how much additional delay is available for the uplink retransmissions after jitter buffer adjustment. When UE-2 detects radio performance improved, it could notify UE-1 that it does not need an additional delay and then UE-1 can shorten the jitter buffer.

5.1.5.2 End-to-End Signaling of Delay Budget Information for Coordinated Mode

While RAN-layer delay budget reporting allows UEs to locally adjust air interface delay, such a mechanism does not provide coordination between the UEs on an end-to-end basis. To alleviate this problem, the following RTP/RTCP signaling may be defined to signal delay budget information across UEs:

1) A new RTCP feedback (FB) message type to carry available additional delay budget information during the RTP streaming of media (signalled from the MTSI receiver to the MTSI sender).

2) A new SDP parameter on the RTCP-based ability to signal available additional delay budget information during the IMS/SIP based capability negotiations.

3) A new RTP header extension type to carry query signal for available additional delay budget information during the RTP streaming of media (signalled from the MTSI sender to the MTSI receiver).

4) A new SDP parameter on the RTP-based ability to signal available additional delay budget information during the IMS/SIP based capability negotiations.

RTCP feedback messages signalled from the MTSI receiver to the MTSI sender may also carry available delay budget information for the reverse link, i.e., for the sent RTP stream. In this case, the use of RTP header extension messages may not be necessary.

RTP header extension messages signalled from the MTSI sender to the MTSI receiver may also carry available delay budget information for the reverse link, i.e., for the received RTP stream. In this case, the use of RTCP feedback messages may not be necessary.

The signalling of available additional delay budget information may use RTCP feedback messages as specified in IETF RFC 4585 [9]. As such, the RTCP feedback message is sent from the MTSI receiver to the MTSI sender to convey to the sender about the available additional delay budget information from the perspective of the receiver. The recipient UE (MTSI sender) of the RTCP feedback message may then use this information in determining how much delay budget it may request from its eNB over the RAN interface, e.g. by using RRC signalling based on *UEAssistanceInformation*.

The RTCP feedback message may be identified by PT (payload type) = PSFB (206) which refers to payload-specific feedback message. FMT (feedback message type) may be set to the value 'Y' for available additional delay budget information. The RTCP feedback method may involve signalling of available additional delay budget information in both of the immediate feedback and early RTCP modes.

The FCI (feedback control information) format can be as follows. The FCI may contain exactly one instance of the available additional delay budget information, composed of the following parameters (`delay` parameter is mandatory but others are optional and may not be present):

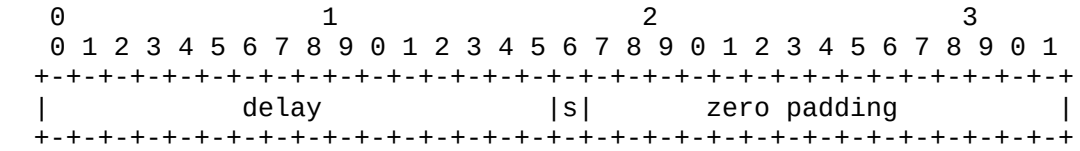
- Available additional delay budget `delay` - specified in milliseconds (16 bits)
- Sign 's' for the additional delay budget `delay` and whether this is positive or negative– specified as a Boolean (1 bit) (optional parameter)
- Query 'q' for additional delay budget – specified as a Boolean (1 bit) (optional parameter)

The sign of the additional delay budget may be positive or negative. Essentially, when the additional delay parameter takes a positive value, the UE indicates that there is additional delay budget available. In case the additional delay parameter takes a negative value, the UE indicates that the delay budget has been reduced. As such a sequence of RTCP feedback messages may be sent by the UE to report on the additional delay budget availability in increments.

When the MTSI receiver sends RTCP feedback messages addressing the available delay budget for the received RTP stream, the query parameter is not to be included or is to be set to '0'. When query parameter is included and set to '1', the purpose of the RTCP feedback message is to ask for additional delay budget for the reverse link, i.e., for the sent RTP stream. This is an alternate to the RTP header extension signalling method described below. This signalling option however relies on the presence of a bi-directional link, i.e., it would not work in case of sendonly or recvonly streams. When the query bit is set to '1', the delay budget value `delay` may be interpreted as the additional delay budget requested by the sender of the RTCP feedback message (i.e., MTSI receiver) for the reverse link (i.e., sent RTP stream).

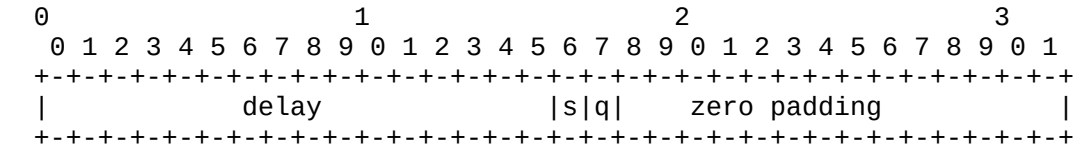
It should be noted that this FCI format is for illustration purposes, and other formats can also be defined to convey available additional delay budget information.

The FCI for the proposed RTCP feedback message can follow the following format where (i) 's' stands for the single-bit message on the sign of the additional delay parameter and (ii) without the query signal is not included:



The high byte may be followed by the low byte, where the low byte holds the least significant bits.

The FCI for the RTCP feedback message with the query signal may be as follows ('q' stands for the single-bit message on query):



A 3GPP MTSI client (based on TS 26.114) supporting this RTCP feedback message can offer such capability in the SDP for all media streams containing video / audio. The offer can be made by including the a=rtcp-fb attribute in

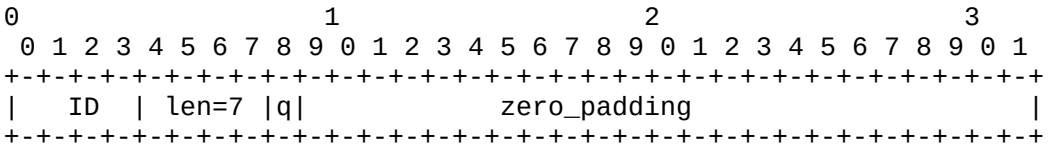
conjunction with the following parameter: 3gpp-delay-budget. A wildcard payload type ("*") may be used to indicate that the RTCP feedback attribute applies to all payload types. Here is an example usage of this attribute:

a=rtcp-fb:* 3gpp-delay-budget

The ABNF for rtcp-fb-val corresponding to the feedback type "3gpp-delay-budget"can be given as follows:

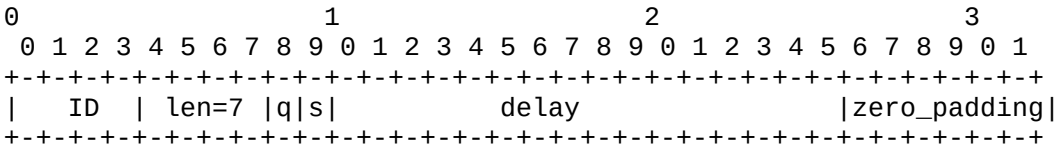
rtcp-fb-val =/ "3gpp-delay-budget"

In some settings, the query for requested additional delay budget information may be signalled by the MTSI sender to the MTSI receiver as part of the transmitted RTP stream using RTP header extensions. An example format is as follows:



In another example format is shown below, the query from the MTSI sender may also contain the additional delay budget requested, as follows:

- Requested additional delay budget `delay` - specified in milliseconds (16 bits)
- Sign 's' for the additional delay budget `delay` and whether this is positive or negative– specified as a Boolean (1 bit) (optional parameter)



When the MTSI sender signals RTP header extension messages addressing the requested delay budget for the sent RTP stream, the query parameter is always to be included and set to '1'. When query parameter is not included or set to '0', the purpose of the RTP header extension message is to indicate the available additional delay budget for the reverse link, i.e., for the received RTP stream. This is an alternate to the RTCP feedback message signalling method described above. This signalling option however relies on the presence of a bi-directional link, i.e., it would not work in case of sendonly or recvonly streams. When the query bit is omitted or set to '0', the delay budget value `delay` may be interpreted as the available additional delay budget indicated by the MTSI sender for the reverse link (i.e., received RTP stream).

A 3GPP MTSI client (based on TS 26.114) supporting this RTP header extension message can offer such capability in the SDP for all media streams containing video / audio. This capability can be offered by including the a=extmap attribute indicating a dedicated URN under the relevant media line scope. The URN corresponding to the capability to signal query for available additional delay budget information is: urn:3gpp:delay-budget-query. Here is an example usage of this URN in the SDP:

a=extmap:7 urn:3gpp:delay-budget-query

The number 7 in the example may be replaced with any number in the range 1-14.

5.1.5.3 SDP-based Exchange of RAN Capabilities for Autonomous Mode

As observed in clause 5.1.1, a shortcoming of the autonomous mode is that while the MTSI sender and MTSI receiver UEs may both be independently able to adjust their air interface delays based on the information in their MTSI clients, they are never aware of the capabilities or actions of the other UE. One way to alleviate this issue may be for the MTSI sender and receiver UEs to exchange RAN capability information during the SDP offer-answer negotiations. As such, during SDP capability negotiation, each UE would include a 'RANCapabilities' attribute to describe its capabilities on delay budget reporting. Other radio capabilities may also be indicated in the 'RANCapabilities' attribute, including RAN-assisted codec adaptation, TTI bundling, RAN frame aggregation, etc.

After the SDP offer and answer exchange, each UE knows the other UE's radio capabilities, and use this knowledge to determine its actions. For instance, upon learning during the SDP exchange that the remote UE (say, MTSI sender) supports delay budget reporting and TTI bundling, a local UE (MTSI receiver) may decide to turn off cDRX when it detects good radio conditions locally, but high packet loss on an end-to-end basis after monitoring RTP reception statistics. But if the remote UE (MTSI sender) does not support delay budget reporting as indicated in the SDP 'RANCapabilities' attribute, then the local UE (MTSI receiver) may decide not to turn off cDRX, since even if it did, the remote UE will not be able to make use of the additional delay budget.

In addition to indicating whether various RAN capabilities are supported, the 'RANCapabilities' attribute may also contain parameters that describe specific RAN configurations (e.g., that may be configured by the UE's local eNB) in the UE that may be relevant in influencing the remote UE's adaptation and impact the end to end quality of the VoLTE call.

6 End-to-End Performance Evaluation Results

6.1 Evaluation Methodology

6.1.1 Performance Metrics

- End-to-end delay and jitter, i.e., at RTP level, excluding JBM impacts.
- End-to-end delay and jitter, i.e., at RTP level, including impact when using reference JBMs for EVS and AMR-WB.
- Packet loss statistics, with considerations on both per-link (DL/UL) and end-to-end packet loss ratio (PLR).
- Voice quality in terms of POLQA.

6.1.2 Codec Configurations

- EVS WB 7.2kbps
- EVS WB 9.6kbps
- EVS WB 13.2kbps
- EVS WB-CA 13.2kbps
- EVS SWB 13.2kbps
- EVS SWB-CA 13.2kbps
- EVS SWB 24.4kbps
- AMR-WB 12.65 kbps

6.1.3 RAN Configurations

For DL or good coverage UE (UE1):

- cDRX on/off (for DL / good coverage UE), DRX cycle length (if on): 40ms. OnDurationTimer and InactivityTimer are also to be specified (e.g., 4ms for both).

For UL or poor coverage UE (UE2):

- Initial BLER Values (for poor coverage UE): 0.4 - 0.95
- HARQ, number of retransmissions 0-6, RTT values 8, 16, [24], [32], 48, 64ms
- Rel-12 TTI bundling, Rel-14 PUSCH enhancement bundle sizes 4, 8, 12, 16, 24, 32

- RAN-level frame aggregation, of length = 20 ms, 40 ms, 60 ms, 80 ms
- Residual BLER (after retransmissions) range: 1% - 10%

6.1.4 Application Layer Considerations

- Application layer frame aggregation
- Application layer redundancy

6.1.5 Test Scenarios

Scenario 1:

- Good DL coverage for receiving UE (UE1)
- Poor UL coverage for sending UE (UE2)

Table 6.1.5.1: Set of Relevant RAN Configurations for Scenario 1

#	UE2 (poor coverage)					UE1 (good coverage)	
	RAN-level frame aggregation	iBLER	HARQ retr.	HARQ RTT [ms]	TTI bundle size	DRX cycle [ms]	rBLER
1	1	0.4	4	8	1	0	0
2	2	0.4	4	8	1	0	0
3	1	0.4	2	8	1	40	0
4	2	0.4	2	8	1	0	0
5	1	0.4	4	8	1	40	0
6	2	0.4	4	8	1	40	0
7	1	0.4	2	8	1	0	0
8	2	0.4	2	8	1	40	0
9	2	0.4	0	16	4	0	0
10	2	0.4	0	16	4	40	0
11	1	0.8	2	16	4	0	0
12	1	0.8	4	16	4	0	0
13	1	0.8	2	16	4	40	0
14	1	0.8	4	16	4	40	0
15	2	0.8	2	16	4	0	0
16	2	0.8	4	16	4	0	0
17	2	0.8	2	16	4	40	0
18	2	0.8	4	16	4	40	0
19	2	0.9	6	16	4	0	0
20	2	0.9	6	16	4	40	0
21	2	0.89	4	16	8	0	0
22	2	0.89	4	16	8	40	0
23	3	0.91	1	48	24	0	0
24	3	0.91	1	48	24	40	0
25	4	0.93	1	64	32	0	0
26	4	0.93	1	64	32	40	0

6.1.6 Power Consumption Considerations

It is desirable to ensure that the overall power consumption of the UE does not increase drastically when UE keeps cDRX off for more percentage of time, i.e., when attempting to provide additional delay budget for a remote UE in poor coverage. So, further evaluations on overall power consumption, i.e., when changing the cDRX configuration are necessary. In particular, it will be useful to quantify how likely a good coverage UE may need to turn off cDRX when paired with a poor coverage UE on the remote end in an MTSI session in order to improve end-to-end quality and how much additional overall battery power consumption results in consequence.

A power consumption analysis requires consideration of a certain adaptation logic in the UE to decide when to switch between cDRX on/off. As such, simulating the fixed set modes in Table 6.1 individually (which is sufficient for obtaining the performance metrics in clause 6.1.1) is not sufficient for the power consumption analysis and additional considerations are needed. There may be multiple possibilities here on when cRDX should be turned off, e.g., it could be for only for the lowest bitrate, or it could be at an intermediate bitrate, etc. Such variety of algorithms need to be determined and documented as part of the power consumption analysis.

6.1.7 eNB Implementation Considerations

It is important to recognize that end-to-end performance characterization in terms of delay and jitter can be dependent on the eNB implementation (e.g., scheduler, reaction and reaction time to request messages). Interpretation of any results and conclusions drawn from these should factor in variations in eNB implementations.

Such considerations can include the following:

- Reaction time of the eNB to requests from the UE are to be considered (e.g., minimum of 100ms processing time + accounting for pre-emption by more critical eNB processing such as handovers).
- How the eNB reacts to requests from the UE can be modeled (e.g., what if the eNB does not change the cDRX configuration?)

In the meantime, it should be understood that modeling of the eNB is an implementation specific issue, so the purpose of this evaluation is simply to demonstrate that the end to end delay budget adjustments can deliver performance enhancements for a wide range of possible eNB behaviors based upon its processing capabilities and corresponding delays.

6.1.8 Mobility Considerations

Dynamics of the system can be properly modeled to account for changes in the E2E delay and the frequency of adaptation signalling, i.e., a system-level simulation with mobility may be used.

6.2 Performance Results for Technical Aspect 1: End-to-End Delay and Quality Enhancements with RAN Delay Budget Reporting

This clause presents the performance results on Technical Aspect 1 that was introduced in Clause 5.1, namely end-to-end delay and quality enhancements with RAN delay budget reporting.

Based on the evaluation methodology described in clause 6.1, Tables 6.2.1 and 6.2.2 present the delay, jitter and PLR statistics at RTP level as well as POLQA scores and end-to-end delay (after JBM operation) for the 26 relevant RAN configurations listed in Table 6.1, considering the EVS WB 13.2 kbps and EVS WB-CA 13.2 kbps, respectively. The additional aspects on the test methodology toward obtaining these results are as follows. Four sentence pairs from P.501 Annex D were concatenated 7 times to form a 182 sec test sequence. This audio signal was encoded using 3GPP reference encoder in TS 26.442. The encoded packets were impaired using the delay profiles based on the test scenarios listed in Table 6.1. The impaired bitstream was then decoded using 3GPP reference decoder and JBM in TS 26.442 to obtain a decoded signal. The decoded waveform was then split for each sentence pair and the POLQA scores and delay values were computed. The POLQA scores and delay values were then averaged among these 28 sentences pairs. The RTP-level statistics were obtained by analysing the delay profiles generated by the network simulator.

Table 6.2.1: Delay and jitter statistics and POLQA scores for the 26 relevant RAN configurations listed in Table 6.1 for EVS WB 13.2 kbps

Mode#	POLQA Score	Mean End-to-End Delay (ms)	Mean RTP-level Delay (ms)	RTP-level Jitter (ms)	RTP-level PLR (%)
1	4.05	242	154	10	1.2
2	3.86	248	164	21	1.2
3	3.2	275	191	20	6.6
4	3.05	241	163	21	6.4
5	3.95	281	193	23	1.2
6	3.86	291	206	22	1.2
7	3.19	221	153	8	6.6
8	3.04	266	204	20	6.4
9	3.63	221	160	20	2.6
10	3.62	266	204	20	2.6
11	3.24	246	158	16	6.9
12	4.15	266	161	22	1.1
13	3.25	285	199	23	6.9
14	3.99	306	202	29	1.1
15	3.08	262	168	23	7
16	4	276	171	25	1.1
17	3.09	306	208	24	7
18	3.93	321	211	26	1.1
19	3.2	310	185	33	5.5
20	3.22	352	226	35	5.5
21	4.06	276	172	25	1
22	3.83	321	212	26	1
23	3.99	295	181	31	0.9
24	3.89	336	225	33	0.9
25	3.89	325	195	37	0.9
26	3.82	371	236	39	0.9

Table 6.2.2: Delay and jitter statistics and POLQA scores for the 26 relevant RAN configurations listed in Table 6.1 for EVS WB-CA 13.2 kbps

Mode#	POLQA Score	Mean End-to-End Delay (ms)	Mean RTP-level Delay (ms)	RTP-level Jitter (ms)	RTP-level PLR (%)
1	4.04	241	154	10	1.2
2	3.97	248	164	21	1.2
3	3.61	278	191	20	6.6
4	3.71	241	163	21	6.4
5	3.99	281	193	23	1.2
6	3.9	292	206	22	1.2
7	3.68	221	153	8	6.6
8	3.64	280	204	20	6.4
9	3.92	240	160	20	2.6
10	3.79	279	204	20	2.6
11	3.59	246	158	16	6.9
12	4.07	248	161	22	1.1
13	3.5	289	199	23	6.9
14	3.95	306	202	29	1.1
15	3.62	262	168	23	7
16	4.09	268	171	25	1.1
17	3.57	307	208	24	7
18	3.92	321	211	26	1.1
19	3.71	311	185	33	5.5
20	3.6	356	226	35	5.5
21	4.08	274	172	25	1
22	3.89	321	212	26	1
23	4.06	289	181	31	0.9
24	3.95	334	225	33	0.9
25	3.94	322	195	37	0.9
26	3.89	366	236	39	0.9

From the data, the following can be observed for the autonomous mode of operation described in clause 5.1:

1) Turning off cDRX on downlink does help reduce end-to-end delay, e.g., as seen by comparing the end-to-end performance results in Tables 6.2.1 and 6.2.2 for modes 3 and 7, and those for modes 4 and 8.

2) Ability to perform more UL retransmissions by the sending UE at poor coverage provides significant improvement in PLR performance, which also helps increase POLQA scores, e.g., as seen by comparing the end-to-end performance results in Tables 6.2.1 and 6.2.2 for modes 3 and 5, and those for modes 1 and 7.

3) Turning off cDRX on its own does not yield PLR and POLQA performance improvements. The PLR reduction and consequent POLQA gains come from the additional retransmissions or other kinds of robustness mechanisms employed by the MTSI sender. Turning off cDRX purely helps create the additional delay budget for using such robustness enhancement mechanisms.

It can be concluded that even for the autonomous mode of operation where the UEs independently perform delay budget reporting without any coordination, it is possible to realize significant gains in end-to-end delay and quality performance. However, it should be noted that the use of autonomous mode has certain shortcomings, as described in clause 5.1.

For the coordinated mode of operation described in clause 5.1, the right comparison to make when turning off CRDX on downlink is to consider a higher reliability scheme on UL that takes advantage of this additional delay budget, signalled from the MTSI receiver to the MTSI sender. For example, if cDRX is turned off for downlink, up to 40ms of additional delay budget would be available for uplink and signalled to the MTSI sender, and this could be used for additional uplink retransmissions. Accordingly, the relevant data points to compare would be as follows:

1) Turning off DL CDRX enables 4 retransmissions on UL, where originally there were 2 retransmissions with cDRX on, as seen by comparing the end-to-end performance results in Tables 6.2.1 and 6.2.2 for modes 1 and 3, those for modes 2 and 8, those for modes 12 and 13, and those for modes 16 and 17.

2) Turning off DL CDRX enables 4 retransmissions on UL, where originally there were 0 retransmissions with cRDX on, as seen by comparing the end-to-end performance results in Tables 6.2.1 and 6.2.2 for modes 2 and 10.

It can be concluded that one can not only see the end to end performance enhancement in terms of PLR and delay reduction, but also in terms of POLQA scores that results from the availability of additional delay budget for the uplink.

In order to assess the implications on power consumption considered in clause 6.1.6, the coverage analysis presented in clause 8.2.2.4 of TR 26.959 [10] (and associated Figure 8.2.2 of TR 26.959 [10]) may be used. In particular, this coverage analysis is based on the IMT-Advanced evaluation methodology [11] for the various UEs experiencing PLRs in the range of 1%-10%, at mobility levels 3 km/h (UMa), 30 km/h (UMa) and 120 km/h (RMa), and shows that on average 96.3% of the UEs experience 0% PLR, 2.1% of the UEs experience PLRs in the range of 0-10% and 1.6% of the UEs experience PLRs above 10%. The analysis also indicates that the same coverage conditions on average will persist in the order of several seconds considering all three mobility levels, i.e., speeds of 3 km/h and 30 km/h for the Urban Macrocell (UMa) and 120 km/h for the Rural Macrocell (RMa) deployment models. From this data, it can be inferred that roughly 2.1% of the UEs experiencing poor coverage would need to rely on additional delay budget to improve end-to-end quality (for the other 1.6% experiencing PLRs above 10%, it is assumed that SRVCC handover would have to be triggered) and assuming that all of these poor coverage UEs are paired up with good coverage UEs (likely outcome considering that 96.3% of the UEs are in good coverage), only a small percentage, i.e., 2.1% of the good coverage UEs would have to turn their cDRX off in order to provide additional delay budget for poor coverage UEs. In other words, there would be no power consumption impact of the above mentioned cDRX deactivation for 98% of the UE population at any given time. And for those 2% of the UEs that are impacted, even if the instantaneous power penalty can be large when CDRX is disabled, the overall average battery drain remains low considering the low probably of occurrence, i.e., on the average only 2% of call time will suffer the power penalty from CDRX being disabled. This seems like a small price to pay for the potential returns in terms of end-to-end quality improvements and possible avoidance of an SRVCC handover.

Moreover, there may be further factors such as the following in effect, which may mean even less than 2% of the UEs are impacted with the additional power consumption due to turning cDRX off:

- Turning off cDRX is not the only way to allow additional budget for retransmission. The JBM of the UE in good coverage could decide to extend the JBM depth to accomodate the extra jitter. As such, when the UE believes that it can tolerate any further delay or jitter at its JBM, this can open up additional delay budget for the remote UE to perform additional retransmissions. If the good coverage UE makes such a choice, it will not suffer any power penalty as the additional delay budget is created without turning cDRX off. The good coverage UE can still use the RAN delay budget reporting to indicate that it can absorb additional jitter and it may also use the RTP/RTCP signalling in the coordinated mode to inform the remote UE on the additional delay budget.
- The UEs agree on using (or prioritizing) other adaptation mechanisms prior to applying the delay budget adjustments, e.g., rate adaptation, application layer redundancy or transitioning to a more robust codec mode

based on the negotiated codecs (e.g., channel-aware mode for EVS), and such adaptation mechanisms may help to sufficiently improve end-to-end quality. As such, the use of delay budget adjustments may be used as the last resort option, only if other adaptation mechanisms are unable to provide sufficiently good end-to-end quality.

- The good coverage UE may initially ask its cDRX be turned off, but the retransmissions performed by the (remote) poor coverage UE with the additional delay budget provided may still not help the end-to-end performance to sufficiently improve, and thus SRVCC handover may have to be triggered anyway. If that happens, good coverage UE would ask that its cDRX is turned back on, toward minimizing the incurred power penalty.

- If good coverage UE is close to running out of battery, UE may opt out of offering additional delay budget by cDRX deactivation.

In regards to eNB implementation considerations, as indicated by the above cited analysis in TR 26.959, same coverage conditions on average will persist in the order of several seconds considering all three mobility levels, i.e., speeds of 3 km/h and 30 km/h for the Urban Macrocell (UMa) and 120 km/h for the Rural Macrocell (RMa) deployment models. If the UEs are static, such coverage conditions tend to persist for a longer time, i.e., potentially for the entire duration of the MTSI voice session. This means that eNB processing delays in the order of ~100ms will have negligible impact on the potential end-to-end performance benefits to be extracted out of delay budget adaptation, such that the performance gains in terms of quality and reliability should persist for at least several seconds in all mobility conditions and for even longer periods for static UEs.

7 Conclusions

The present document investigated several MTSI enhancements relevant to the media handling aspects of RAN delay budget reporting. In particular, toward developing an end-to-end operational perspective for the MTSI sender and MTSI receiver, two modes were studied in clause 5.1, namely autonomous and coordinated modes, and corresponding potential solutions were described in clause 5.1.5. End-to-end performance evaluation results were documented in clause 6, demonstrating that RAN delay budget reporting can allow air interface delay adjustments at MTSI sender and/or MTSI receiver, so that the end-to-end delay and quality performance can be enhanced.

Based on the findings of the present document, it is recommended to conduct normative work toward specifying the following functionality in TS 26.114:

1) Recommendations on when and how the UEs in an MTSI session should use RAN-based delay adjustment mechanisms in an end-to-end fashion also accounting other factors such as local radio conditions, various RAN capabilities and configurations, jitter buffer considerations, and UE battery constraints, considering the signalling flows described in clause 5.1.5.1 and analysis in clause 6.2 of the present document.

2) Recommendations on when and how the various kinds of end-to-end quality metrics and other relevant information in the MTSI client could be used to trigger RAN delay budget reporting, considering the signalling flows described in clause 5.1.5.1 and analysis in clause 6.2 of the present document.

3) SDP-based exchange of RAN capabilities in regards to delay budget reporting, considering the potential solutions described in clause 5.1.5.3.

4) RTP/RTCP-based indication of available additional delay budget and requested delay budget information, considering the potential solutions as per clause 5.1.5.2.

Annex A:
Change history

Change history							
Date	**Meeting**	**TDoc**	**CR**	**Rev**	**Cat**	**Subject/Comment**	**New version**
06-2018	80	SP-180281				Presented to TSG SA#80 (for information)	1.0.0
09-2018	81	SP-180658				Presented to TSG SA#81 (for approval)	2.0.0
09-2018	81					Approved at TSG SA#81	16.0.0
2022-04	-	-	-	-	-	Update to Rel-17 version (MCC)	**17.0.0**
2024-03	-	-	-	-	-	Update to Rel-18 version (MCC)	**18.0.0**
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History

Document history		
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