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TECHNICAL REPORT

**TETRA and Critical Communications Evolution (TCCE);
Study into the provision of
speech services over QAM channels**

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Contents

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee TETRA and Critical Communications Evolution (TCCE).

Modal verbs terminology

In the present document "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Introduction

The present document contains the results a study by ETSI TC TCCE WG4 into the extension of QAM channels in TETRA to carry speech in a native manner.

The reason for such a study was to investigate a further evolution of TETRA to improve its capabilities and take advantage of more flexible use of capacity and range/sensitivity of the TEDS QAM channels. Such a solution would allow closer integration of voice and data to improve site channel efficiency.

The advantages that were foreseen in undertaking the study are as follows:

a) To provide more flexibility for system designers, allowing the use of lower rate modulation schemes to obtain improved ranges, or higher rate modulation schemes to provide more capacity from a base station.

b) To allow the use of increased bit rate per spectrum bandwidth of higher modulation schemes to allow more calls within a given bandwidth from a single site, provided that the altered carrier to interference radio is managed.

c) To improve efficiency by allowing speech and data calls to be carried on the same carrier, with each timeslot being allocated to speech or data payload on a slot by slot basis on uplink and downlink.

NOTE: This does not imply that channel allocation for voice calls needs to be sent or changed on a slot by slot basis.

d) To allow simultaneous speech and packet data by sending both together in the same timeslot, or by more flexible management of timeslots.

e) To improve support for end to end encrypted speech, and also to enable the use of alternative codecs, by taking advantage of increased bandwidths for speech calls.

This study is the result of deliberations in TCCE WG4, and represents the concepts and ideas discussed up to the time of publication which could be the basis of further work, which in turn could lead to change requests to [i.1] to introduce this functionality. However further work would be required to determine solutions to standardizing this functionality, and the standardization process could diverge from the concepts presented in the present document.

1 Scope

The present document contains the results of a study into the extension of QAM channels in TETRA to carry speech in a native manner. The areas where change can be foreseen to the TETRA standard [i.1] to date in order to add this functionality are described at a high level.

NOTE: The present document is not sufficient to enable change requests to be generated against [i.1], and further standardization work would be needed to arrive at a solution. A standardized solution could differ from the concepts presented in the present document.

The main body of the present document describes the requirements that are satisfied and the mechanisms envisaged within this study that could fulfil this extension of TETRA. Annex A presents some possible modifications which could be needed for PDUs and information elements specified in [i.1] and Annex B refers to [i.1] on a clause by clause basis to indicate which clauses could require changes in order to implement these mechanisms.

2 References

2.1 Normative references

Normative references are not applicable in the present document.

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication ETSI cannot guarantee their long term validity.

The following referenced document is not necessary for the application of the present document but it assists the user with regard to a particular subject area.

[i.1] ETSI EN 300 392-2/TS 100 392-2 (latest version of either applies): "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 2: Air Interface (AI)".

[i.2] ETSI EN 300 392-7: "Terrestrial Trunked Radio (TETRA); Voice plus Data (V+D); Part 7: Security".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in [i.1] and the following apply:

U-plane: plane for user traffic signalling

TM-SDU: SDU from the layer above MAC (i.e. LLC)

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ACELP Algebraic Code-Excited Linear Prediction
BS Base Station

CCH	Control CHannel
CLCH	Common Linearization CHannel
CMCE	Circuit Mode Control Entity
codec	Coder-decoder
D8PSK	Differential 8 Phase Shift Keying
DL	DownLink
DQPSK	Differential Quadrature Phase Shift Keying
DTX	Discontinuous Transmission
IP	Internet Protocol
LLC	Logical Link Control
MAC	Medium Access Control
MCCH	Main Control CHannel
MCCH-Q	Main Control CHannel-QAM
MLE	Mobile Link Entity
MS	Mobile Station
PDU	Protocol Data Unit
QAM	Quadrature Amplitude Modulation
SCCH	Secondary Control CHannel
SDU	Service Data Unit
SNDCP	SubNetwork Dependent Convergence Protocol
SwMI	Switching and Management Infrastructure
TDMA	Time Division Multiple Access
UL	UpLink

4 Services for speech in QAM channels

4.1 Purpose

The purpose in extending QAM channels to prove a native speech mode service are as follows:

a) Lower rate modulation schemes such as 4-QAM offer better receiver sensitivity, thus leading to a higher range compared with phase modulation channels, if the average transmitted power remains the same across phase modulation and 25 kHz QAM channels.

b) Higher rate modulation schemes allow more capacity on a single carrier, allowing one base station carrier to carry more calls. Thus, when taken together with the previous point, the system designer can have more flexibility in trading off the capacity and range of base stations within the overall system design.

c) The increased bit rate per spectrum bandwidth of higher modulation schemes will allow more calls within a given bandwidth from a single site, provided that the altered carrier to interference ratio is managed.

d) Voice and data calls can be carried on the same carrier, and channel allocation can allow optimized channel efficiency by allocating each timeslot to speech or data payload on a slot by slot basis on uplink and downlink. This will give increased flexibility compared with the channel allocation schemes currently possible on phase modulation channels.

NOTE: This does not imply that channel allocation for voice calls needs to be sent or changed on a slot by slot basis.

e) Simultaneous speech and packet data can be achieved by sending both in the same timeslot, or by more flexible management of timeslots.

f) Improved support for end to end encrypted speech can be provided where more channel bandwidth is available to the end to end encrypted call, which will enable encryption synchronization to be sent without stealing from speech frames.

g) Alternative codecs could be supported, as different channel bandwidths can be provided.

4.2 Services

A scheme providing speech on QAM channels will support the following existing TETRA speech services:

a) Individual call - duplex and semi duplex

b) Telephone call

c) Group call

d) Variants of these, such as broadcast calls.

The scheme will also support the following TETRA supplementary services:

a) Late entry

b) Talking party identity

c) Calling party identity

d) Further supplementary services as required.

The scheme will also maintain support for security services such as authentication, air interface encryption and end to end encryption.

Although the principles described in the present document were primarily intended to support speech calls on QAM channels, they are equally applicable to other forms of media or data where a regular allocation of uplink and/or downlink data is required. These include possibilities such as video and telemetry.

5 Principles of the studied solution

The principles of the solution proposed as a result of this study are described in this clause.

Speech will be carried in existing physical layer uplink and downlink QAM slots, and will make use of the QAM rates, bandwidths and error correction mechanisms already defined for signalling and data.

Speech frames will be packed into timeslots using a new form of MAC PDU and sent directly in the channel timeslots, and will not be encapsulated in IP when carried over the air interface. This avoids the overheads associated with IP headers. It will be possible to carry signalling and user data within the same timeslots, where there is capacity available.

The channel allocation for assigning a speech call to timeslots on a QAM channel will use a modified version of the existing MAC channel allocation.

The slot grant will allow different timeslot repetition rates to be used, to take advantage of packing more (or less) than two audio frames into a timeslot - e.g. to allocate one timeslot in 8 to carry a call if 4 audio frames are packed into a timeslot on one of the higher rate channels.

The slot grant will specify a start timeslot and a repetition rate for timeslots for the call. It will be finite, so that the MS will lose the allocation if it does not receive 'top-up' grants which allocate further timeslots to the call. There will also be a mechanism to cancel granted slots, e.g. at the end of a speech item.

A similar process will allocate sets of timeslots on the DL for reception of the call, by defining a start slot and repetition rate. The MS will be able to save power ('snooze') between slots, and there will be the possibility of staying awake beyond a slot that is designated for speech reception in order to receive data. The process will be based on Napping, but changed from the current Napping procedures.

The uplink channel allocation may be independent from the downlink allocation, either within the associated carrier, or by making an allocation on a different carrier. The uplink allocation may specify a subslot and a bandwidth which is different from the bandwidth of the downlink.

The BS will not to permit link adaptation signalling by an MS receiving in a group call, as any MS could reduce the throughput for all MSs; and it is assumed that network design will enable an MS to find a better cell for the call if the link for a received group call is marginal. Link adaptation could be possible under command of the BS in an uplink transmission, and in both directions in an individual call.

The solution will permit end to end encryption of speech, and will also support alternative codecs. The extra available bandwidth of some channels may permit encryption synchronization to be sent without needing to steal bandwidth from the accompanying encrypted speech.

6 Mechanisms

6.1 General

This clause describes additional mechanisms to those specified in [i.1], or modifications to the mechanisms specified in [i.1] that might be needed in order to carry speech or other forms of media efficiently on QAM channels that are assigned to carry data.

NOTE: PDUs referred to in this clause are defined in [i.1].

6.2 Channel allocation

6.2.1 Existing TETRA mechanisms

In current packet data mechanisms, the MS may receive a change of allocated channel to enable it to receive a data transmission. This may be an augmented channel allocation, indicating the relevant parameters of a QAM channel. The MS would expect to receive signalling on the channel after it arrives. It does not expect to receive advance notice of a DL data transmission. It may receive a separate slot grant when on the new channel if it needs to send UL signalling.

If the MS is already residing on the channel where a call is to be received, no channel allocation need be sent in the MAC RESOURCE PDU, just indication of which slots in which to receive the call, although the use of channel allocation to put the MS into assigned mode may still be needed. The same is true when granting slots for transmission.

6.2.2 Potential mechanisms

For QAM speech, if a different channel is to be used to carry the call, it is expected to be possible to send a channel allocation and slot grant (for transmission) or repetitive reception information (for reception) together in the interests of efficiency. As slot and frame numbering has to be the same on all carriers of the base station according to [i.1], there would not be a synchronization issue for the MS in counting timeslots until the first intended reception slot, or first granted slot for transmission.

NOTE 1: Where a channel is shared between cells, the slot assignment needs to be synchronized between cells to avoid any potentially conflicting channel allocation. An implementation may prefer to avoid doing this, and to send slot grants or repetitive reception information on the shared channel itself.

The channel allocation and MAC RESOURCE PDU would be group addressed in the case of a group call, and could move all MSs in the call to a different channel from that on which they currently reside. Each MS would need to decide whether to complete any ongoing data exchange, or abandon it in favour of this new channel allocation, or continue it on the new channel.

NOTE 2: The actual mechanisms are for further study.

At the end of a call, the MSs could remain on the same channel, for example if the channel is being used as both common CCH and an assigned channel. Alternatively a fresh MAC RESOURCE PDU could be sent with a channel allocation to a different channel, or to go to an appropriate common control channel, which could be combined with CMCE signalling terminating the call.

NOTE 3: It is for further study what will happen if the MS was also involved in a non-speech data transmission during a speech call, and the MS is sent to a different channel at the end of the speech call before that data transaction has completed.

Link adaptation is possible in an individual call, but not in a group call. In an individual call, the MS could perform random access and send the L2-LINK-FEEDBACK-INFO PDU. The BS could respond and change the channel allocation (and slot grant); the MS can be informed that the new allocation replaces the previous one. Alternatively the BS could use the L2-LINK-FEEDBACK-CONTROL PDU to terminate (and ignore) the feedback, or even use a new value of 'Link feedback control type' to temporarily deny the request and prevent the MS from sending more requests for some period of time. It could be useful for the BS to indicate whether feedback would be possible or not during the call when it sent call set up signalling.

In a group call, any MS could affect the rate and throughput for all MSs. It is better therefore that the mechanism is not allowed to change the rate of the downlink in a group call.

6.3 Independent uplink

In addition to the normal uplink which is currently described in [i.1], where the frequency of the uplink of a channel is indicated in system related broadcast information as a duplex offset from the downlink frequency, an alternative uplink channel can be assigned that is different from this normal uplink. This will allow several low channel bandwidths, lower data rate uplinks to be used in conjunction with a higher bandwidth downlink channel allocation. This will allow the MS to maximize its available transmit power to give the best possible energy in each transmitted symbol. By allowing the BS to provide greater frequency separation between different MS uplink transmitters, it could also reduce the probability of a weak uplink signal being degraded by adjacent channel effects from another strong uplink signal.

The mechanism could be used for QAM data transmissions as well as speech.

6.4 Slot granting

The requirements for allocating slots on an uplink channel for voice calls are:

a) To provide a delay until the first slot allocated to the call, indicated as a delay from the current timeslot

b) An allocation of a half slot or one or more full slots on the UL to carry the call

c) A regular repetition (which is likely to be different to the initial delay)

d) A number of slots for which the allocation is valid

e) A means of 'topping up' the slot grant to extend its period

f) The replacement of earlier grants with later ones such that grants can overlap, and the end of the granted slots is defined as the furthest end point from any of the grants

g) Late entry to the granted slot pattern

h) Indication whether the slot counts for initial delay and repetition include the 18th frame

Whereas it might be possible to create a repeating pattern by using the current multiple slot granting mechanisms in [i.1] by sending several separate basic slot grants in a multiple slot granting element, possibly changing the rules for granting slots in Frame 18 so that the slot counts can be made or signalled to jump over Frame 18, the mechanism would be limiting and would lead to a large element with large numbers of basic slot grants if a reasonable grant period (several seconds) was desired.

Therefore use of the currently reserved element in multiple slot granting is preferred, to create a different type of slot grant more suitable for the purpose of transmitting streaming media. A possible redefinition of the element, with future extension, is shown in Annex A.

An MS may receive a conventional slot grant as well as a repeating slot grant, to allow transmission of data during a speech transmission to provide a simultaneous speech and data service.

6.5 Repetitive reception

To allow receiving parties to make efficient use of battery power during call reception, the BS can indicate to the MS during which timeslots it will need to be awake to receive call information, and the MS is allowed to immediately return to a power saving mode following reception of each timeslot. However to help with BS downlink scheduling, the BS could be allowed to slip a DL speech frame into a following slot, hence if the MS expected to receive something in a particular timeslot but nothing was sent, the MS remains awake until something was received in the call (subject to end of call timeouts, etc.). The MS will return to power saving once the information has been received, waking in the originally granted slot pattern.

The BS may also signal to the MS within a designated reception timeslot that it is expected to remain awake beyond that designated slot if there is further information (e.g. data) to send to that MS.

The slip of information transmission into a following slot by the BS, or transmission of further data in subsequent slots, will not cause any slip of the subsequent receiving pattern, and if the BS does need to change the slots in which information is received, it will need to cancel an existing pattern and send a new one to the MS.

The same mechanism will also be applied to the transmitting MS, to inform the MS when to wake in case of downlink signalling.

A new mechanism, referred to as 'snoozing', is defined in the present document as the napping mechanisms defined in [i.1] do not readily adapt to the repetitive reception process. The element is included in the revised channel allocation element shown in Annex A.

6.6 Access assignment

The Access Assignment Channel is used in [i.1] to indicate whether the (normal) uplink of a timeslot is reserved or available for random access. No changes are foreseen as a result of this study, despite the change in purpose of the uplink on a control/data channel to allow streamed media to be carried. This study does not propose dividing the uplink of the channel into sub-channels in the frequency domain, hence the Access-assign PDU will remain valid for the entire timeslot.

6.7 MAC traffic format

The existing MAC, LLC and MLE headers used for data transfer would be inefficient to carry speech or other media due to the number of header bits required in addition to the speech or media. Therefore the traffic frames will be placed in new MAC PDU types directly, with internal headers relating to the traffic contents.

A MAC DATA PDU containing user data may also be contained in the same timeslot following speech; this also allows fragmentation into following timeslots.

7 Protocol revisions

7.1 General

In this clause, the modifications considered to the protocols specified in [i.1] that would implement the mechanisms described in clause 6 within the study are described. Where PDU and information element modifications have been considered, the modifications considered within the study are presented in Annex A.

7.2 Channel allocation

Channel allocation will be extended to provide the MS with a revised slot grant process, information about an independent uplink where relevant, and information about repetitive timeslot patterns for reception. This will be achieved by extending the channel allocation element in downlink MAC PDUs, with the appropriate extension of procedures. The channel allocation and slot granting mechanisms need to indicate the following information to the transmitting party:

a) The downlink channel allocated for the call

b) Any independent uplink channel allocated to the call, if at a non standard duplex spacing

c) The characteristics of the uplink channel - bandwidth and modulation rate

d) The first slot in which the transmitting party will send speech frames, and the repetition rate

e) Snoozing information, which tells the transmitting party in which slots it will wake to listen for any DL signalling

f) The validity period of the grant, such as the number of slots for which the grant is valid

g) A reference for the call (e.g. usage marker or equivalent)

To achieve this, 'further augmentation' of the channel allocation element specified in clause 21 of [i.1] will be used, which allows definition of additional elements which do not conflict with current elements, and also causes an MS that does not understand the further augmentation flag to discard the PDU.

Possible additional elements foreseen in the channel allocation element are shown in Annex A.

7.3 Independent uplink information

Where an independent uplink is used to carry uplink traffic, the channel allocation procedures will be extended to provide details of this uplink channel. A new independent uplink information element can provide this information, and needs to provide an offset from the expected centre frequency of the UL associated with the DL (i.e. offset from the UL defined by DL + duplex spacing). The element will indicate the bandwidth of the channel and the number of timeslots assigned the channel, as well as its frequency.

If the independent UL element is not present, the MS is granted slots on the conventional uplink, and can assume that it has use of the full channel bandwidth. If the BS wishes to grant a narrower channel bandwidth on the conventional uplink, and accepts that the remaining channel capacity is wasted (e.g. allocates 50 kHz on a 100 kHz channel) then the independent uplink element will be sent, and will indicate the position of the granted allocation by means of the offset and bandwidth; thus it will be valid for the independent uplink to be defined within the existing uplink.

Note that the QAM rate on the uplink is provided in the revised slot grant element, shown later in the present document, rather in the uplink related information.

7.4 Slot granting

The slot granting procedures will be extended to allow a new form of slot grant, which indicates a delay from the current timeslot to the first slot of the grant, the width of each transmission grant (half slot, full slot or multiple full slots), and the slot repetition rate. A length of grant will also be provided which will ensure that the MS ceases transmission after a defined period if it does not receive further signalling. The revised slot grant will also indicate to the MS whether it will include slots in the 18th frame in its slot count; this will allow more flexibility in the choice of codec and any additional date rate, for example to provide extra bandwidth for encryption synchronization.

A currently reserved value in the multiple slot grant element can be repurposed to indicate a new form of slot grant, and the new slot grant defined to allow the required parameters to be sent to the MS.

A new repetitive grant will overlay a previous repetitive grant (except where the new grant cancels all previous grants on this channel), and new grants are expected to be sent more frequently than old grants expire to ensure that an MS does not lose transmit opportunity because a grant is lost due to signalling failure.

EXAMPLE 1: The SwMI might grant 100 transmit opportunities each time that 25 transmit opportunities have elapsed to ensure signalling resilience, but the MS never has more than 100 (the value of the latest grant) in hand.

A grant can be cancelled, e.g. by setting 'maximum grant length' to zero. Procedures could also allow a slot grant to be cancelled by CMCE on reception of an appropriate PDU such as D-TX WAIT, D-TX INTERRUPT or D-TX GRANTED with parameter 'granted to another' (unless such a CMCE PDU is always be received with a MAC channel allocation and slot grant which sets the number of granted slots to zero). In this case, CMCE can issue a CONFIGURE primitive which switches transmission off; the lower layers will use this to cancel any remaining slot grant.

If the MS receives a new repetitive grant for a different channel then it will consider the previous repetitive grant to be cancelled and replaced by the new grant. The MS will be able to receive a separate (conventional, non repetitive) grant which it may use in addition to the repetitive grant (e.g. for data transmission).

NOTE 1: The behaviour with multiple grants and grant cancellation is for further study. It may be preferable to require an existing grant to be cancelled before a new grant is sent. The cancellation mechanism needs more study, including consideration of the case where a cancellation command is missed.

If the MS is allocated both a repetitive uplink grant and a conventional slot grant, and one or more slots from both grants are coincident, the MS could be allowed to transmit either data related to the repetitive grant or to the 'conventional' grant, or both within the coincident slot. The MAC header will distinguish the types of data (and would allow both speech and data to be sent in some circumstances). If the MS fails to transmit any data relating to the repetitive grant (e.g. speech call), the recipient of the information will have to apply some sort of mitigation for the lost data.

It would be an advantage to be as flexible as possible and allow the MS to send speech or data in either type of grant - thus speech could be sent in a slot allocated to the MS outside the repetitive grant procedure if the MS has information ready to send.

A further extension to the slot granting procedure is to allow the MS to transmit in opportunities defined for linearization on the uplink, i.e. in CLCH timeslots. This allows transmission of information in all timeslots including in the 18^{th} frame.

NOTE 2: Many TETRA MSs do not need to use the CLCH for linearization, and this will allow more uplink capacity on a channel.

The slot grant may also be extended to indicate the QAM rate which the BS expects to receive from the MS. This will be decided by the BS in conjunction with the characteristics of the call, and is intended allow sufficient bandwidth for all of the media that the MS needs to send. However the MS will be allowed to send information at a lower QAM rate if it does not need as much capacity as the BS expects to receive, and thus improve channel resilience.

EXAMPLE 2: The BS allocates slot bandwidth for two or more frames of speech, and MS only wishes to send one frame of DTX related information.

7.5 Repetitive reception

Repetitive reception performs a similar function to the repetitive slot grant, and informs the MS when it needs to be awake in order to receive call information. A new repetitive reception element will be contained in the channel allocation element and will indicate the first slot(s) and periodicity of reception slots for reception of a streamed media call. The MS is able to snooze during slots not indicated for repetitive reception, to save battery life.

The reception slot length will indicate to the MS that the information in this call could span 1, 2, 3 or 4 slots. There is no need to indicate only that only half (or a part) of a full slot is used; the MS will expect to receive information somewhere in the slot and look for it within the information received in that timeslot.

If the MS does not receive call information in the designated slot(s) the MS will remain awake and examine subsequent timeslots for the expected information. Once information is received, the MS can snooze again until the next designated slot in the pattern. Late reception of one slot does not move subsequent slots to a later position. If the MS fails to receive any information until the following slot, it can snooze again from that slot. Failure to receive any information following a number of attempts will indicate to the MS that it has missed the end of the call, and so the MS will return to an appropriate mode and channel.

Conversely, if the BS sets the 'immediate napping permission flag' (the use of which is mandatory on a QAM channel) in one of the DL MAC PDUs addressed to an MS following this process, the MS will be able to snooze again following reception of data addressed to it in this timeslot.

Following reception of a channel allocation element providing a repetitive reception pattern, the MS will remain awake until the first nominated receiving slot, in case any additional signalling is to be sent prior to the traffic information in the call.

The repetitive reception function will indicate to the MS whether it is expected to count slots including those in the 18^{th} frame, or ignore these in its slot counting, to allow flexible use of the channel. If the SwMI uses the 18^{th} frame to send information, the MS has to mitigate if necessary if downlink speech is missed because of a mandatory broadcast. Alternatively the MS could remain awake across at least frame 1 (following the 'missed information' rule) in case the BS is able to find an opportunity to send it. The rules for reception in the 18^{th} frame will need to consider other factors such as scanning, etc.

NOTE: In the case of delayed information, the MS has to consider how to manage speech delay.

7.6 Speech/media traffic encapsulation

Speech and other forms of traffic will be encapsulated directly in a new MAC PDU. This will make a solution as efficient as possible, as the overheads of an IP header, and the existing headers in MLE, LLC and SNDCP would otherwise have a significant impact on the number of bits of traffic that could be sent.

The size of MAC traffic PDU will be variable to allow one or several frames of ACELP information to be included, or other information such as U-plane stolen frames to be encapsulated. A simplification of the variation in possible lengths can be made if the packaged traffic packets are made the same length. As an ACELP speech frame is 137 bits long, but a stolen frame is 121 bits of data, the stolen frame could be padded with additional or spare information bits to 137 bits (plus any frame specific header), thus allowing the PDU length to be signalled in multiples of (137 + header) bits of content, plus MAC PDU header information length, in a look up table. This will be efficient at the air interface.

It is possible to use the extra bandwidth of QAM channels to transport information which is contained in stolen frames on a phase modulation channel as additional data sent together with the speech information, instead of stealing the data. For example, where end to end encryption is used on phase modulation channels, the encryption synchronization is sent in U-plane stolen frames. In a QAM channel, the synchronization information could be sent in addition to the encrypted traffic, which would reduce any quality loss caused by the stealing process. If such information was sent in this way on QAM channels, but the call also needed to be sent over phase modulated channels, the frame of audio following the additional stolen frame information could be stolen at the base station prior to transmission and replaced with the additional stolen frame contents, thus ensuring that the transmission process conforms to the expected traffic formats for phase modulation.

NOTE: The exact mechanism, including the audio frame to be stolen when sending such extended information over phase modulation channels would be defined in further standardization activity.

On the uplink, multiple traffic frames can be carried in a single MAC PDU. On the downlink, if there is sufficient capacity in the QAM channels, single traffic frames could be placed in individual PDUs, which might assist the base station in packing traffic across different downlink timeslots.

A potential format for the MAC traffic PDUs is shown in Annex A.

Annex A: PDU and element tables

A.1 General

This annex describes PDU and element formats which could be applied to carry speech and other media natively in QAM channels. The tables and formats in this Annex include modifications which could be applied to existing PDUs and elements, and new PDU or element formats where appropriate.

NOTE: The formats shown are provided as an input to future standardization work in which final PDUs and elements could be designed..

A.2 Channel allocation

Table A.1 shows how the channel allocation element could be modified to provide the additional information needed by the MS to recognize a repetitive reception pattern and to be provided with any additional uplink information. Red text indicates the values that existing elements would need to take, or indicates new or revised element values. Grey text indicates options not suitable for use in the scenario of speech on QAM channels. The 'usage' column provides additional notes.

Table A.1 is based on 'Table 21.87: Channel allocation information element contents' from [i.1] version 3.7.1.

Table A.1: Possible revision to channel allocation information element

Information element	Length	Type	Value	Remark	Usage
Allocation type	2	M	00_2	Replace current channel with specified channel	
			01_2	Additional channel allocation	
			10_2	Quit current channel and go to specified channel	
			11_2	Replace current channel with specified channel plus carrier specific signalling channel in slot 1	
Timeslot assigned	4	M	0000_2	Go to appropriate common control channel (MCCH, MCCH-Q or common SCCH)	
			0001_2	Timeslot number 4	This element allocates the total width of the available channel (separately from the bandwidth of resources granted to carry any call) - i.e. normal usage rules apply, and any width is possible.
			0010_2	Timeslot bit map	
			etc.	etc.	
			1110_2	Timeslot bit map	
			1111_2	All four timeslots	
Up/downlink assigned	2	M	00_2	Augmented channel allocation (see note 1)	Augmented allocation will be used.
			01_2	Downlink only	
			10_2	Uplink only	
			11_2	Both uplink and downlink	
CLCH(-Q) permission	1	M	0	No immediate CLCH(-Q) permission	
			1	Immediate CLCH(-Q) permission	
Cell change flag	1	M	0	No cell change	
			1	Cell change	
Carrier number	12	M		Carrier frequency number	
Extended carrier numbering flag	1	M	0	No extended carrier numbering	
			1	Extended carrier numbering	
Frequency band (see note 2)	4	C		Provision for different frequency bands	

Information element	Length	Type	Value	Remark	Usage
Offset (see note 2)	2	C	00_2	0 kHz offset	
			01_2	+6,25 kHz offset	
			10_2	-6,25 kHz offset	
			11_2	+12,5 kHz offset	
Duplex spacing (see note 2)	3	C		Provision for different duplex spacing	
Reverse operation (see note 2)	1	C	0	Normal	
			1	Reverse	
Monitoring pattern (see clause 9)	2	M	00_2	No monitoring pattern	Monitoring will be achieved by MS working with the new repetitive reception element.
			01_2	One monitoring pattern	
			10_2	Two monitoring patterns	
			11_2	Three monitoring patterns	
Frame 18 monitoring pattern (see note 3)	2	C	00_2	No monitoring pattern	The standard frame 18 monitoring pattern can be used independently of snoozing. This element present if 'monitoring pattern' = 00_2.
			01_2	One monitoring pattern	
			10_2	Two monitoring patterns	
			11_2	Three monitoring patterns	
Up/downlink assigned for augmented channel allocation (see note 4)	2	C	00_2	Reserved (see note 5)	
			01_2	Downlink only	
			10_2	Uplink only	
			11_2	Both uplink and downlink	UL and DL assigned for both transmitting and receiving parties.
Bandwidth of allocated channel (see notes 4 and 6)	3	C	000_2	25 kHz	
			001_2	50 kHz	
			010_2	100 kHz	
			011_2	150 kHz	
			100_2	Reserved	
			etc.	etc.	
			111_2	Reserved	
Modulation mode of allocated channel (see note 4)	3	C	000_2	π/4-DQPSK	
			001_2	D8PSK	
			010_2	QAM	Speech is carried in QAM channels.
			011_2	Reserved	
			etc.	etc.	
			111_2	Reserved	
Maximum uplink QAM modulation level (see notes 7 and 8)	3	C	000_2	Reserved	See note below table.
			001_2	16-QAM	
			010_2	64-QAM	
			011_2	Reserved	
			110_2	etc.	
			111_2	Reserved	
Reserved (see note 9)	3	C		Reserved, value shall be set to 000_2	

Information element	Length	Type	Value	Remark	Usage
Conforming channel status (see note 4)	3	C	000_2	Conforming channel (therefore concentric)	
			001_2	Non-conforming channel: concentric	
			010_2	Non-conforming channel: sectored	
			011_2	Non-conforming channel: super-sectored	
			100_2	Non-conforming channel: eccentric	
			101_2	Reserved	
			etc.	etc.	
			111_2	Reserved	
BS link imbalance (see note 4)	4	C		See "BS link imbalance" information element definition	
BS transmit power relative to main carrier (see note 4)	5	C		See "BS transmit power relative to main carrier" information element definition	
Napping status (see note 4)	2	C	00_2	Napping is not permitted on the allocated channel	The new repetitive reception process is now conditional on the future augmentation flag; conventional napping is not permitted.
			01_2	Napping information is included	
			10_2	MS may use current napping information on the allocated channel	
			11_2	Reserved	
Napping information (see note 10)	11	C		See "napping information" information element definition	Not present if napping status element not set to 01_2.
Reserved (see note 4)	4	C		Reserved, value shall be set to 0000_2	
Conditional element A flag (see note 4)	1	C	0	Conditional element A not present	
			1	Conditional element A present	
Conditional element A (see note 11)	16	C		See table 21.91	
Conditional element B flag (see notes 4 and 13)	1	C	0	Conditional element B not present	
			1	Conditional element B present	
Conditional element B (see notes 12 and 14)	16	C		Reserved	
Further augmentation flag (see note 4)	1	C	0	No further augmentation of channel allocation	
			1	Further augmentation of channel allocation	Further augmentation used to provide independent uplink and repetitive reception information.
Repetitive reception information present (see note 16)	1	C	0	Repetitive reception information not present	
			1	Repetitive reception information present	
Repetitive reception information (see note 16)	14	C		Present if 'Reception information present' set	This element used to indicate reception waking times (previously referred to as 'extended napping pattern').
Independent UL information present (see note 16)	1	C	0	Independent UL information not present	
			1	Independent UL information present	
Independent UL information (see note 16)	24	C		Present if 'Independent UL information present' is set	New element to contain uplink channel information.
Reserved (see note 16)	16	C	0	Reserved for future use and shall be set to zero in the present document.	Further extension; element size may be determined differently in future standards activity.
Enhanced augmentation flag (see note 16)	1	C	0		
			1	Reserved for further extension, MS receiving this shall discard the PDU See note 15	

Information element	Length	Type	Value	Remark	Usage
NOTE 1: If an MS that does not support augmented channel allocations receives a channel allocation with the up/downlink assigned element set to 002, it shall discard the channel allocation and any TM-SDU carried in the MAC-RESOURCE or MAC-END PDU that contained the channel allocation. NOTE 2: This element shall be present only in the case of extended carrier numbering i.e. extended carrier numbering flag set to 1. NOTE 3: This element shall be present only in the case that no monitoring pattern is assigned i.e. monitoring pattern element set to 002. NOTE 4: This element shall be present only for an augmented channel allocation i.e. up/downlink assigned element set to 002. NOTE 5: If the MS receives a channel allocation with the up/downlink assigned for augmented channel allocation element set to 002, it shall discard the channel allocation and any TM-SDU carried in the MAC-RESOURCE or MAC-END PDU that contained the channel allocation. NOTE 6: This element shall be set to 0002 when allocating a π/4-DQPSK channel or a D8PSK channel. NOTE 7: This element shall be present only for an augmented channel allocation allocating a QAM channel i.e. up/downlink assigned element set to 002 and modulation mode of allocated channel element set to 0102. NOTE 8: If the MS does not understand the value of this element, it shall regard the value as indicating the maximum QAM modulation level supported by that MS. NOTE 9: This element shall be present only for an augmented channel allocation not allocating a QAM channel i.e. up/downlink assigned element set to 002 and modulation mode of allocated channel element not set to 0102. NOTE 10: This element shall be present only for an augmented channel allocation with napping information included i.e. up/downlink assigned element set to 002 and napping status element set to 012. NOTE 11: This element shall be present only for an augmented channel allocation with the Conditional element A flag indicating that the Conditional element A is present i.e. up/downlink assigned element set to 002 and Conditional element A flag set to 1. NOTE 12: This element shall be present only for an augmented channel allocation with the Conditional element B flag indicating that the Conditional element B is present i.e. up/downlink assigned element set to 002 and Conditional element B flag set to 1. NOTE 13: The Conditional element B flag shall be set to 0 in the present document. NOTE 14: Conditional element B shall not be included in the present document. However, if the MS receives a channel allocation with the Conditional element B flag set to 1, it shall assume that a 16-bit element is included following the Conditional element B flag. NOTE 15: The enhanced augmentation flag shall be set to 0 in the present document. If the MS receives a channel allocation with the enhanced augmentation flag set to 1, it shall discard the channel allocation and any TM-SDU carried in the MAC-RESOURCE or MAC-END PDU that contained the channel allocation. NOTE 16: This element shall be present only when further augmentation is applied, i.e. when 'Further augmentation' = 1.					

NOTE: The 'maximum uplink QAM modulation level' element in the main channel allocation element can continue to specify the maximum uplink QAM modulation level for any other data sent by the MS on the channel. As the 'Specified uplink QAM modulation level' has moved to the slot grant, it will always be present and associated with resource grants for the speech call. It is unlikely that the BS will specify a higher modulation level for speech than it allows for data, as the maximum rate is intended to indicate base station capability.

A.3 Independent uplink information element

The new Independent uplink information element could take the form shown in Table A.2, where this element specifies an offset from the expected centre frequency of the UL associated with the DL (i.e. offset from the UL defined by DL + duplex spacing).

Table A.2: Possible independent uplink information element

Information element	Length	Type	Value	Remark
Offset direction	1	M	0_2	Lower frequency than UL
			1_2	Higher frequency than UL
Minor offset	2	M	00_2	No offset
			01_2	6,25 kHz
			10_2	12,5 kHz
			11_2	18,75 kHz
Major offset	12	M		Number of 25 kHz increments
Bandwidth of allocated channel	3	M	000_2	25 kHz
			001_2	50 kHz
			010_2	100 kHz
			011_2	150 kHz
			100_2	Reserved
			etc.	etc.
			111_2	Reserved
Timeslot assigned	4	M	0000_2	Reserved
			00012	Timeslot number 4
			0010_2	Timeslot bit map
			etc.	etc.
			1110_2	Timeslot bit map
			1111_2	All four timeslots
Reserved	3	M		

NOTE 1: Minor offset follows the offset direction requirements used in other elements.

NOTE 2: The frequency from which the offset is counted will be defined in future standardization activity.

A.4 Slot granting

A possible revision to the current multiple slot granting element to permit a repetitive slot grant suitable for streaming media is shown in Table A.3. The table is based on 'Table 21.97: Multiple slot granting information element contents' from ETSI TS 100 392-2 [i.1], version 3.7.1.

Red text indicates new or redefined element values within the multiple slot grant element.

Table A.3: Possible revision of slot granting information element

Information element	Length	Type	Value	Remark
Number of slot granting sets (see note 1)	3	M	000_2	Repetitive grant
			001_2	1 slot granting set
			etc.	etc.
			111_2	7 slot granting sets
Basic slot granting element (see note 3 and note 5)	8	C		See basic slot granting information element definition
Implicit repeat count (see note 3 and note 5)	4	C	0000_2	No implicit repetition of basic slot granting element
			0001_2	1 implicit repetition of basic slot granting element
			etc.	etc.
			1010_2	10 implicit repetitions of basic slot granting element
			1011_2	Reserved (see note 4)
			1100_2	Reserved (see note 4)
			1101_2	Reserved (see note 4)
			1110_2	Reserved (see note 4)
			1111_2	Reserved (see note 4)
Slot grant extension (see note 6 and note 7)	1	C	0_2	No slot grant extension
			1_2	Reserved for future use

Information element	Length	Type	Value	Remark
Uplink for slot grant (see note 7)	1	C	0_2	Slot grant on current uplink
			1_2	Slot grant on independent uplink
Initial grant delay (see note 7 and note 8)	5	C	00000_2	First granted slot is in same timeslot as this grant
			00001_2	First granted slot is in next timeslot following grant
			00010_2	First granted slot is in second timeslot following grant
			etc.	etc.
			11110_2	First granted slot is in 30th timeslot following grant
			11111_2	Reserved
Transmission slot length (see note 7)	3	C	000_2	First sub slot
			001_2	Second sub slot
			010_2	1 slot wide
			011_2	2 slots wide
			100_2	3 slots wide
			101_2	4 slots wide
			110_2	Reserved
			111_2	Reserved
Slot repetition interval (see note 7)	5	C	00000_2	Every slot
			00001_2	Delay 1 slot between transmission opportunities
			00010_2	Delay 2 slots between transmission opportunities
			etc.	
			00111_2	Delay 7 slots between transmission opportunities
			01000_2	Reserved
			etc.	
			11111_2	Reserved
Maximum Grant length (see notes 7 and 9)	8	C	00000_2	Reserved
			00000001_2	One grant of transmission of transmission slot length
			00000010_2	Two grants of transmission of transmission slot length
			etc.	etc.
			11111110_2	254 grants of transmission of transmission slot length
			11111111_2	Reserved. See Notes below table.
Ignore 18th frame (see note 7)	1	C	0	Do not include slots in the 18th frame in the counting pattern
			1	Include slots in the 18th frame in the counting pattern
Information transmission in CLCH allowed (see note 7)	1	C	0	Information transmission is not allowed in CLCH
			1	Information transmission is allowed in CLCH
Specified uplink QAM modulation level (see note 7)	3	C	000_2	4-QAM
			001_2	16-QAM
			010_2	64-QAM r=1/2
			011_2	64-QAM r=2/3
			100_2	Reserved
				etc.
			111_2	Reserved

NOTE 1: The "number of slot granting sets" element indicates the number of slot granting sets that follow in the PDU. Each slot granting set comprises two information elements i.e. "basic slot granting element" and "implicit repeat count". The information elements in each repeated set shall be in the order specified. For example, if the "number of slot granting sets" element is set to 010_2, it is followed by: first basic slot granting element, implicit repeat count for first basic slot granting element, second basic slot granting element, implicit repeat count for second basic slot granting element.

NOTE 2: Void

NOTE 3: Shall be repeated as a set as indicated by the "number of slot granting sets" element.

NOTE 4: Reserved for future use. An MS receiving one of these values from a BS shall discard this slot granting set and any subsequent slot granting sets within the same "multiple slot granting" element.

NOTE 5: Element present if "number of slot granting sets" $\neq 000_2$

NOTE 6: If the MS receives a value of 1 in the "slot grant extension" element, it shall discard the "multiple slot granting" element and the remainder of the MAC-RESOURCE or MAC-END PDU that contains this "multiple slot granting" element.

NOTE 7: Element present if "number of slot granting sets" = 000_2

NOTE 8: Initial grant delay shall count all slots in frames 1-18

NOTE 9: Each single granted transmission opportunity may be up to 4 slots long, according to the value of the "Transmission slot length" element.

NOTE 1: As part of a further standardization activity, a greater number of values may be reserved for future definition, allowing a lower number of defined granted slots (or sets of adjacent slots). The proposed linear relationship between number of granted slot sets shown in this table could be replaced by a look up table for some or all values, which could allow the length of this element to be reduced.

NOTE 2: With the values in table A.3, one 24 bit slot grant can grant 254 slots (or sets of adjacent slots). With a 2:1 TDMA effective pattern (e.g. 4-QAM 25 kHz), this grants about 8 seconds of speech. With an 8:1 TDMA this grants about 30 seconds of speech.

In a future standardization activity, it could be useful to define further repetition intervals (shown reserved in table A.3) with values that progress in a non linear manner, for example to provide solutions suitable for telemetry or other lower bit rate applications. Values could be defined for 12, 24, 48 slots (or other convenient values).

Where there is no 'Independent uplink element', each of the parameters 'Initial grant delay', 'Transmission slot length', 'Slot repetition interval' and 'Maximum grant length' will count slots within the width of the allocated channel only. If 'Ignore 18th frame' is set, then slots within the allocated channel bandwidth on the 18th frame will not be counted. The slot repetition interval will be counted from the first full slot after the last transmission opportunity to the last full slot before the next transmission opportunity (inclusively) within the allocated channel bandwidth.

EXAMPLE: If three slots are allocated to a channel, and the MS is allocated a transmission pattern of a second half slot every two TDMA frames, the slot length will indicate 'Second half slot' and the 'Slot repetition interval' indicates 5 slots. The 'Initial grant delay' only counts the integer number of slots between the slot in which the channel allocation is sent, and the slot in which the initial second half slot is expected to be sent.

If there is an 'Independent uplink' element in the PDU, the slots allocated to the channel will be counted for the 'Transmission slot length', 'Slot repetition interval' and 'Maximum grant length' (except that use of the 18th frame slots are be dependent on the 'Ignore 18th frame' element). The 'Initial grant delay' element will need to count all slots including all in the 18th frame (and for this count will not take the 'Ignore 18th frame' element into account), and the count will include the timeslot in which the channel allocation was carried, and every slot up to and including the last timeslot before that in which the MS is to transmit. This is because there could be ambiguity in which slots are valid for counting within the delay period if the channel width of the primary channel and independent uplink channels are different, or if there is a difference on the use of the 18th frame between uplink and downlink allocations. An 'Initial grant delay' value of zero will cause the MS to make its first transmission in the timeslot in which the channel allocation is received.

NOTE 3: The BS can still multiplex different MSs on the independent uplink by assigning different sets of parameters to each MS.

Further notes on the use of this element are given in clause 7.4.

A.5 Repetitive reception

The Repetitive reception element is a possible new element which could be optionally contained in the Channel allocation element in order to indicate the first slot(s) and periodicity of reception slots for reception of a streamed media call. The possible format of this information element is shown in Table A.4.

Table A.4: Possible repetitive reception information element

Information element	Length	Type	Value	Remark
First reception slot	6	M	000000_2	Current timeslot
			000001_2	Next timeslot
			000011_2	Two timeslots' time
			etc.	etc.
			111110_2	30 timeslots' time
			111111_2	Reserved
Reception slot length	3	M	000_2	1 slot wide
			001_2	2 slots wide
			010_2	3 slots wide
			011_2	4 slots wide
			100_2	Reserved
			etc.	etc.
			111_2	Reserved
Slot repetition interval	4	M	0000_2	Every slot
			0001_2	Delay 1 slot between reception opportunities
			0010_2	Delay 2 slots between reception opportunities
			etc.	
			0111_2	Delay 7 slots between reception opportunities
			1110_2	Reserved
			etc.	
			1111_2	Reserved
Ignore 18th frame	1	M	0	Do not include slots in the 18th frame in the counting pattern
			1	Include slots in the 18th frame in the counting pattern
Reserved	2	M		

A.6 MAC traffic format

The possible new MAC PDUs to carry native traffic are described in this clause. PDUs will be required for both downlink and uplink. The contents of a possible MAC SDU which contains the traffic are also described here.

A.6.1 Downlink

A possible MAC downlink PDU format for carrying speech and other streamed media is as follows. A PDU could carry one or more frame of speech or other media information, or U-plane stolen information. Table A.5 shows the possible format of this PDU.

Table A.5: Possible downlink MAC PDU structure to carry speech or other information

Information element	Length	Type	Value	Remark
MAC PDU type	2	M	11_2	Supplementary MAC PDU
Supplementary MAC PDU subtype	1	M	1	Additional PDU beyond MAC-D-BLCK
Additional supplementary MAC PDU subtype	1	M	0	0 =speech frame PDU 1= reserved for further PDU types
PDU length	5	M		Length, given according to a lookup table See notes 1 and 2
First frame + slot number	5	C		Conditional on certain (to be defined) values of PDU length See note 3
Encryption mode	2	M	00_2	Not encrypted See note 4
			01_2	See ETSI EN 300 392-7 [i.2] See note 4
			10_2	See ETSI EN 300 392-7 [i.2] See note 4
			11_2	See ETSI EN 300 392-7 [i.2] See note 4
Address/Usage marker	6	M		The address distinguishes calls within a timeslot., provides confirmation that the MS is receiving the correct call, and can be aligned with Usage Marker in CMCE
TM-SDU-Q	varies	C		

NOTE 1: As the PDU has a length element, fill bits are not used.

NOTE 2: The length can be according to a lookup table, which might allow a reduced number of bits in this element. The actual number of bits required is for further standardization activity.

NOTE 3: The First frame + slot number is indicated to provide a simple numbering system plus an indication whether the enclosed ACELP packet is the first or second of a pair, to enable frame stealing in a connected phase modulation air interface. The value shown as 5 bits (4 bits for frame+slot numbering plus 1 bit for half slot numbering) is subject to further standardization. With the MAC PDU header contents postulated here, and with multiples of 138 bit traffic contents, there are still 11 bits spare within a downlink frame in the most critical case (six traffic frames contained in a 50 kHz channel using 16QAM which has a total of 861 available bits), hence the size of this numbering scheme could be increased.

NOTE 4: The need for an encryption mode element is for further study. As the information contained in the PDU is related to a channel allocation, the mode could be taken from the channel allocation (as performed for circuit mode speech calls). If this approach was chosen, then this element might not be needed.

A.6.2 Uplink

The possible MAC uplink PDU format for carrying speech and other streamed media is as follows. Each speech frame, stolen channel or other information type is contained in a single PDU. Table A.6 shows the possible format of this PDU.

Table A.6: Possible uplink MAC PDU structure to carry speech or other information

Information element	Length	Type	Value	Remark
MAC PDU type	2	M	11_2	Supplementary MAC PDU
Supplementary MAC PDU subtype	1	M	1	Additional PDU, beyond MAC-U-BLCK
Additional supplementary MAC PDU subtype	1	M	0	0 =speech frame PDU 1= reserved for further PDU types
Encrypted flag	1	M	0	Not encrypted see note 1
			1	Encrypted see note 1
Address/Usage marker	6	M		Allows a check against the granted call
PDU length	4	M		Length, given according to a lookup table see notes 2 and 3
First frame + slot number	5	C		Conditional on certain (to be defined) values of PDU length see note 4
TM-SDU-Q	varies	C		

NOTE 1: The encryption state could follow the channel allocation element, and therefore this bit may not be needed.

NOTE 2: As the PDU has a length element, fill bits are not used.

NOTE 3: The length can be according to a lookup table, which allows a more efficient use of bits in this element. The actual number of bits required is for further standardization activity.

NOTE 4: The First frame + slot number is indicated to provide a simple 4 bit numbering system plus an indication whether the enclosed ACELP packet is the first or second of a pair, to enable frame stealing in a connected phase modulation air interface. The value shown as 5 bits (4 bits for frame+slot numbering plus 1 bit for half slot numbering) is subject to further standardization. With the MAC PDU header contents postulated here, and with multiples of 138 bit traffic contents, there are 5 bits spare within an uplink frame in the most critical case (two traffic frames contained in a half slot transmission in a 50 kHz channel using 16QAM, which has a total of 301 available bits), hence the size of this numbering scheme could be increased.

A.6.3 TM SDU-Q

Within each MAC PDU, there will be a TM SDU for QAM channels, indicated in the present document as a TM SDU-Q. The TM SDU-Q can contain a number of traffic frames which would consist of ACELP speech frames or stolen frames in a first release of a standard where speech was implemented on QAM channels, but could have further contents relating to other media in future releases.

Table A.7 summarizes the TM-SDU-Q and the traffic contents are shown in following tables.

Table A.7: Possible format of TM-SDU-Q

Information element	Length	Type	Value	Remark
Traffic frames	Var			1-15 frames. The number of frames would be specified by the length field in the MAC header

There does not need to be a composite TM SDU-Q header. The number of frames of information, and the type of information can be determined from the MAC PDU header's length field. If media types other than speech, or different codec types, are supported in later releases of the standard, the length field lookup table can contain entries where the lengths appropriate to one or multiple frames of such media are indicated.

In the case of encapsulation of speech traffic in the current ACELP codec, each traffic frame can have a fixed length (138 bits) which includes a one bit header, where this one bit header indicates whether the remainder of the frame is ACELP audio, or a stolen frame.

Table A.8 below shows the structure of the traffic frame for an ACELP speech frame.

Table A.8: ACELP traffic frame

Information element	Length	Type	Value	Remark
Traffic frame type	1	M	0 or 1	Traffic (speech) or stolen
Traffic frame contents	137	M		The traffic frame could contain speech or U-plane signalling information.

The ACELP speech frame is a single 137 bit element, as shown in Table A.9.

Table A.9: Traffic frame contents for ACELP

Information element	Length	Type	Value	Remark
ACELP	137	M		

Where contents are a U-plane stolen frame, the contents are the stolen frame information as sent over a phase modulation air interface, plus some supplemental information. This will allow the stolen frame length to match the ACELP frame length, reducing the number of length options and easing PDU parsing. The traffic frame structure for stolen information is shown in Table A.10.

Table A.10: Traffic frame contents for U-plane signalling

Information element	Length	Type	Value	Remark
Supplementary or stolen slot	1	M	0 or 1	0 indicates that the data replaces the speech frame that would have followed. 1 indicates that the data is sent additionally, and is sent together with the following speech frame. See note 1
First/second half slot	1	M		Indicates whether the slot is a first or second half slot. Second half slot is not valid if the preceding half slot was not stolen, where compatibility with a phase modulation air interface is needed. See note 2
Slot data	121	M		Length as contents today.
Frame number included	1	M		See note 3
First frame number	5	C		Present if 'Frame number included' = 'included' See note 3
Reserved	5	C		Present if 'Frame number included' = 'not included' See note 3
Reserved	8	M		Reserved for future information, and used to pad the traffic frame to 137 bits.

NOTE 1: A C-plane/U-plane stolen flag is not needed, as a separate MAC DATA PDU can be used to carry signalling information. If 'additional data' is sent, it does not replace an ACELP traffic frame. See clause 7.6 for more information.

NOTE 2: It is for further study whether the presence of stolen slots could be signalled in the MAC header length information, therefore not needing this element here; however placing the element in the traffic frame does mean that capacity for this element could only be used where it is needed, and in an overall element which has sufficient capacity.

NOTE 3: It is for further study whether frame numbering information can optionally be included here, but this may be unnecessary if the appropriate frame numbering is carried in the MAC PDU. However by sending it with stolen frames, it may be possible to avoid sending it in some cases in the MAC PDU header, thus saving capacity in those cases.

History

Document history		
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