AHG18: Overview of 3GPP features for Extended Reality (XR) and related high quality conversational services and related implications for ultra-low latency (ULL) coding

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Introduction

- 3GPP organization work
- Lightning overview of 5G(-Advanced) RAN features
- Rather Brief overview of relevant Core Network features and QoS in Core and RAN
- XRM Features for PDU set handling and others
- Cross layer 3GPP optimization developments in each release
- Summary
- Implications for ULL and error resilient codec design and test conditions

3GPP

- Global organization developing technical specification adopted by 7 regional SDO
  - TSG -> technical specification group
  - RAN (Radio Access Network) TSG -> develop specification for Radio link (Radio Access Network)
  - SA (Service and Architecture) TSG -> Architecture of the core and develop services including codec bindings/media services
  - CT (Core & Terminal) TSG -> terminal and core related aspects
- More information: 3gpp.org

5GA introduction

- 5G Core Network and Access Network are independent by design
- 5G Core Network (5GC) can also serve non-3GPP access networks
- 5GC enables exposure of network related features and information to applications and services
- Release 18 (Feb 2024) is the inaugural release of 5G advanced
- 5G standalone usually refers to the case of-a 5G Core Network (not 5G Radio)

Radio Network and spectrum 4G LTE versus 5G NR

4G LTE (Long Term Evolution)	5G NR (new Radio)
410 MHz – 3.8 GHz	410–3800-7125MHz
5/6 GHz (LTU-U)	3.8 GHz – 7.125 GHz
No additional high frequency range	Additional high frequencies in parts of the range: 24.25-71GHz
1.4 KHz – 20 kHz sub-carrier	15 KHz to 960 kHz sub-carrier
OFDM	OFDM
QPSK, 16QAM, 64QAM, 256 QAM	QPSK, 16QAM, 64QAM, 256QAM

Lots of optimization beyond new spectrum usage!

5G QoS parameters describe the QoS characteristics
QoS = Quality of Service

Parameter	Description
Resource Type	GBR (guaranteed bit-rate), Delay Critical or NON-GBR (non guaranteed bit-rate)
Priority Level	Indicates a priority for scheduling resources amongst QoS flows
Packet Delay Budget (PDB)	Upper bound for the time that a packet may be delayed between the UE and the UPF
Packet Error Rate (PER)	Upper bound for the non-congestion related packet losses
Averaging window	The duration over which bit-rates are calculated
Maximum Data burst value	Largest amount of data that can be served in the PDB (required for QoS flows with delay critical resource type)
Guaranteed Flow Bit-rate	Bit-rate that is guaranteed to be provided for the QoS Flow
Maximum Flow Bit-rate	Highest bit rate that is allowed for the QoS Flow

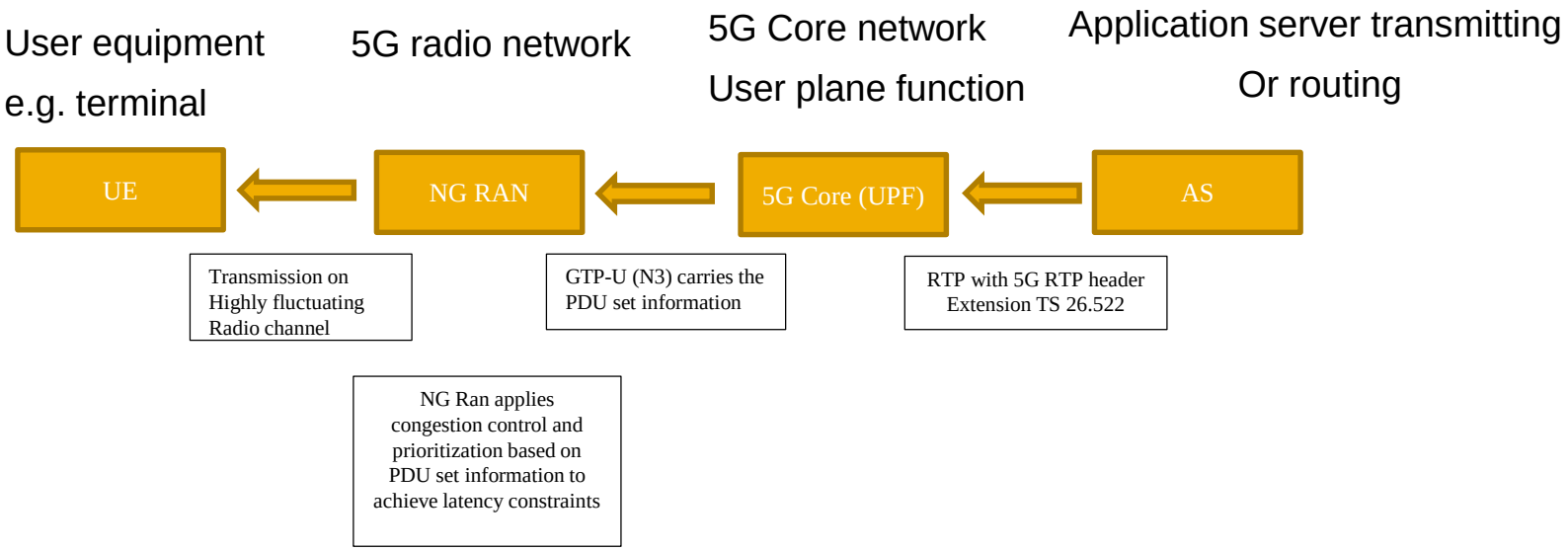
A 5QI is used to refer to a specific combination of values for these parameters

5QIs and standardized QoS characteristics

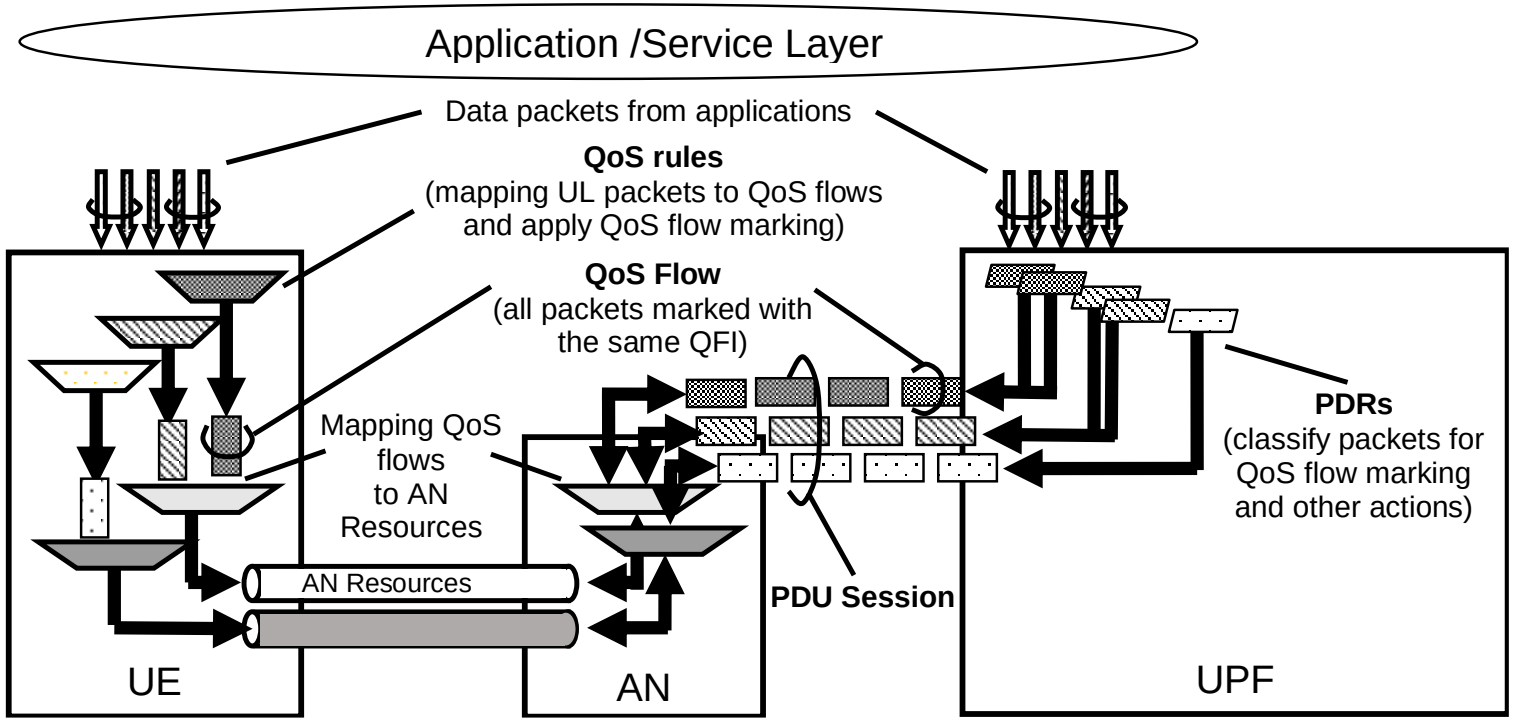
5QI Value	Resource Type	Default Priority Level	Packet Delay Budget (NOTE 3)	Packet Error Rate	Default Maximum Data Burst Volume (NOTE 2)	Default Averaging Window	Example Services
1	GBR	20	100 ms (NOTE 11, NOTE 13)	10^{-2}	N/A	2000 ms	**Conversational Voice**
2	(NOTE 1)	40	150 ms (NOTE 11, NOTE 13)	10^{-3}	N/A	2000 ms	**Conversational Video (Live Streaming)**
3		30	50 ms (NOTE 11, NOTE 13)	10^{-3}	N/A	2000 ms	**Real Time Gaming, V2X messages (see TS 23.287 [121]). Electricity distribution – medium voltage, Process automation monitoring**
4		**50**	**300 ms (NOTE 11, NOTE 13)**	**10^{-6}**	**N/A**	**2000 ms**	**Non-Conversational Video (Buffered Streaming)**

Example 5QI, for the full list see TS 23.501 clause 5.7.4

High Volume and Low Latency Transmission at RAN

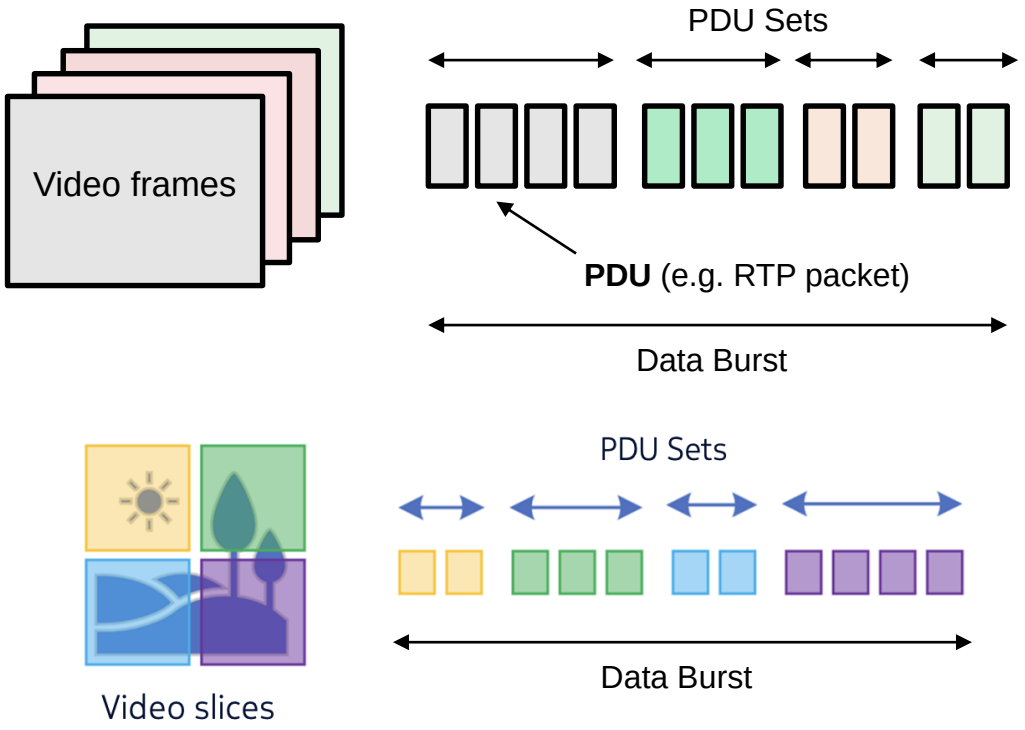


Using different QoS Flows using PDRs and QoS rules in User plane

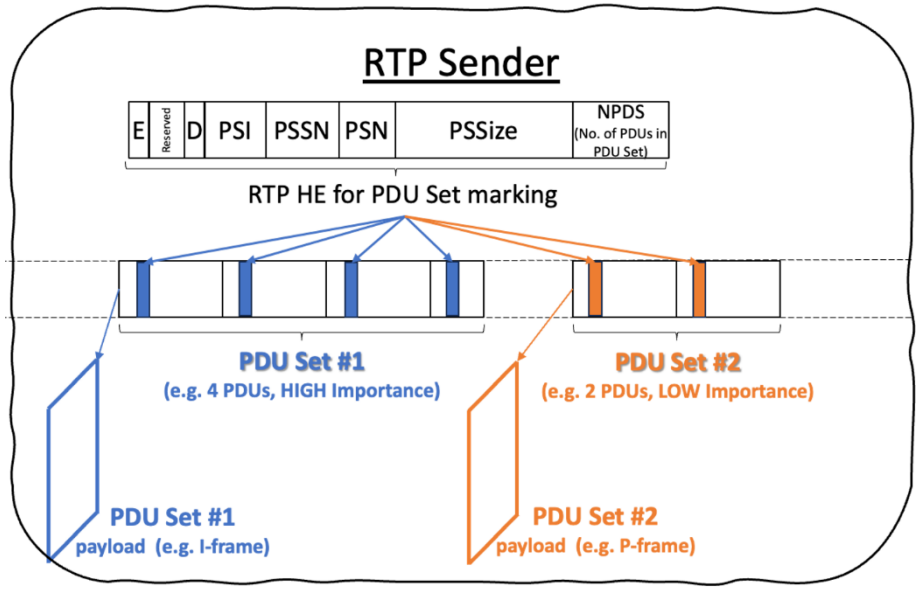


Source: TS 23.501 clause 5.7.1

PDU Set Handling (set of protocol data units that are related)



PDU Set differentiation



Release 17 (~2020-2021)

- **RAN1 WG** led a study on XR (Extended Reality) evaluations for New Radio NR (5G Radio network). The study focuses on the evaluation of 5G New Radio (NR) capability to support emerging XR and cloud gaming services from different angles, including capacity, mobility, power saving and coverage consideration in [1] RP-210460. The considered services include the following:
  - VR1: "Viewport dependent streaming"
  - VR2: "Split Rendering: Viewport rendering with Time Warp in device"
  - AR1: "XR Distributed Computing"
  - AR2: "XR Conversational"
  - CG: Cloud Gaming.
- Besides, RAN1 also evaluated the transmission differentiation based on frame type as an optional evaluation scenario with the assumption the awareness of frame semantics in the network side as described in the report [2] RP-212047. The output of the study item is in [3] TR 38.838.
- In this period, SA WG4 led the study work, "Traffic Models and Quality Evaluation Methods for Media and XR Services in 5G Systems (FS_XRTraffic)", which studied the traffic characteristics and evaluation methodologies for use cases like viewport dependent streaming, Split rendering, Cloud gaming, etc. with support of RAN1 study resulting in technical report [4].
- SA2 WG led the work on " 5G System Enhancement for Advanced Interactive Services (5G_AIS)" in Release 17 with the main target to specify the Key performance indicator values for the interactive XR/Cloud gaming services, including the required latency, reliability and data rates for both uplink sensor/pose data and downlink pre-rendered/rendered audio/visual data [5].

[1] RP-210460 Revised SID on XR Evaluations for NR https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_91e/Docs/RP-210460.zip

[3] TR 38.838 Study on XR (Extended Reality) evaluations for NR

[4] TR 26.926: Traffic Models and Quality Evaluation Methods for Media and XR Services in 5G Systems

[5] 5G System Enhancement for Advanced Interactive Services: https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_84/Docs/SP-190564.zip

Release 18 (~2022-2023)

- In Release 18, standardizations on "architecture enhancement for XR and media services" and "XR (eXtended Reality) enhancements for NR" are led by SA TSG [6] SP-220705 and RAN TSG [7] RP-220285 separately. Several features are specified to support of real-time low latency media communications from the network perspective.
- On one hand, the network can get aware of the media semantics for better scheduling, including:
  - The network can get aware of the video bitstream semantics and provide the corresponding handling to guarantee the quality of service, e.g. fulfilling the delay/reliability requirements and scheduling enhancements can be achieved in the case of network congestion.
  - The network can get aware of an end packet of a data burst and further sends UE to sleep for power saving with the traffic periodicity and jitter into account.
  - In order to make sure the network can identify groups of correlated packets corresponding to a frame or slide the PDU Set feature was developed enabling exposure of this information to the 3GPP network (both RAN and core). 3GPP SA also led a work item "Real-time Transport Protocol Configurations (5G_RTP)", defining an RTP binding in TS 26.522 to assist the 5G network to detect and identify the packets of a video in terms of importance (also importance of the correlated group of packets is considered) being regarded as a PDU Set [8] for conversation services using RTP such as the IP media Telephony service.
- On the other hand, the network further exposes the network status information to the media application side, The Low Latency, Low Loss, and Scalable
  - Throughput (L4S) mechanism is further introduced to expose the congestion status of the link between UE and the RAN for the application layer adjustment, e.g. rate adaptation.
- Besides, the QoS monitoring for the network transmission latency (i.e. UL and/or DL latency), congestion status, etc. can also be exposed to the application layer for awareness of the network status.

[6] SP-220705: SID update on Study on architecture enhancement for XR and media services https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_96_Budapest_2022_06/Docs/SP-220705.zip

[7] RP-220285 Study on XR Enhancements for NR https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_95e/Docs/RP-220285.zip

[8] 5G RTP TS 26.522 5G Real-time Media Transport Protocol Configurations https://www.3gpp.org/ftp/Specs/archive/26_series/26.522/26522-j00.zip

Release 19 (~2024-2025)

- As a follow up, the work items on network enhancement for XR service are further provided in SA2 and RAN2/3 as following:
  - Extended Reality and Media service (XRM) Phase 2 led by SA2 in SP-241385 [9]
  - XR (eXtended Reality) for NR Phase 3 led by RAN2/3 in RP-250107 [10].
  - For PDU Set identification (i.e. identification of an application unit, video frame/slice) in case of the end-to-end encryption scenarios, three options are developed to assist the 5G network to identify the packets belonging to the same video frame/slice.
  - The available data rate that the RAN can support currently is further exposed to the application side for its consideration.
- Besides, dynamic changing traffic characteristics, like data burst size, time to next burst, are provided by the sender via the RTP header extension defined by "5G Real-time Transport Protocol Configurations, Phase 2 (5G_RTP_Ph2)"[8]. The 5G network further considers these dynamic changing traffic characteristics for better radio resource scheduling and power saving.

[9] SP-241385 Revised WID on Extended Reality and Media service (XRM) Phase 2
https://www.3gpp.org/ftp/tsg_sa/TSG_SA/TSGS_105_Melbourne_2024-09/Docs/SP-241385.zip

[10] RP-250107 Revised WID: XR (eXtended Reality) for NR Phase 3

Conclusion/Summary

- 3GPP network provides video services conversational up to XR
- Real time is important and using RTP, and consequentially potential packet losses
- 3GPP 5G network provides different levels of QoS (5QI)
- Packets may be dropped in PDU Sets together to limit the impact of congestion at the RAN, especially in low latency high volume cases this may happen
- Different PDU Sets can be assigned different priority values (PSI)
- Broad project in 3GPP involving all TSG (RAN, SA, CT) and several working groups (SA2,SA4,RAN1,RAN2,CT4)
- Some additional public information available from Nokia colleagues on 3GPP XR featuers
  - https://www.nokia.com/blog/enhancing-xr-application-awareness-for-optimized-user-experience/
  - https://ieeexplore.ieee.org/document/11008742
  - https://ieeexplore.ieee.org/document/10622463

Implications/proposal

1) For ULL video coding it would be good if error resilience design could take into account the PDU set feature and specifically cover the case of PDU Set discards as can happen in 3GPP Network. This would imply that error resilience feature not only exist for packets but also for resilience to losses of "groups" of correlated packets (i.e. PDU Sets).

2) For ULL coding and error resilient video coding, it would be good if the more granular error resilience information could also be included (i.e. range from 1-15) to be consistent with the 3GPP design. In this case the loss of a PSI 1 packet would have a worse impact compared to a value 15 packet and ideally this would follow the corresponding perceptual degradation.

Huawei Technologies can provide further technical input after discussion and agreement in principle.

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