**3GPP TSG- Meeting #**

**, , - revision of S4-241472**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  |  | **CR** |  | **rev** |  | **Current version:** |  |  |
|  | | | | | | | | |
| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
|  | | | | | | | | |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network | **X** |

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | | | | | | | | | | |
| ***Title:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** |  | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** |  | | | | |  | ***Date:*** | | |  |
|  |  | | | |  | |  | | |  |
| ***Category:*** |  |  | | | | | ***Release:*** | | |  |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)  Rel-20 (Release 20)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | One of the open issues identified in the Rel-18 feasibility study 5GMS\_Pro\_Ph2 is the need for a specification that addresses interoperability considerations around content delivery protocol features and general technologies for segmented media streaming and the IP/PDU 5G System Layer. This points to the further study media plane issues to support additional functionalities, but also identifies what needs to be ported from legacy TS 26.512 to a generalised media plane technical specification. The relation to media session handling (as specified in TS 26.510) is identified in TR 26.804, but enhancements to media session handling are not the primary focus of this study. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Adds discussion and conclusions on a Media Delivery specification | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Study item objectives are not complete | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | | 1, 2, 3, 4, 5.15 (new), 6.15 (new) | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

## ===== CHANGE =====

# 1 Scope

This Technical Report identifies and evaluates a set of potential improvements and extensions, referred to as key topics. The initial set of key topics were:

- Content Preparation

- Traffic Identification

- Additional / New transport protocols

- Uplink media streaming

- Background traffic

- Content Aware Streaming

- Network Event usage

- Per-application-authorization

- Support for encrypted and high-value content

- Scalable distribution of unicast Live Services

- Network Slicing Extensions for 5G Media Streaming

- 3GPP Service Handler and URLs

- 5GMS Application Server configuration and management.

In an extension, a second set of key topics were collected as follows:

- Media Delivery Specification.

- Common Client Metadata.

- Common Server-and Network-Assisted Streaming.

- Multi-CDN and Multi-Access Media Delivery.

- Multi-Access with ATSSS.

- Modem Usage Optimized Media Streaming.

- DASH/HLS Interoperability.

- Further harmonization of RTC and Streaming for Advanced Media Delivery.

- Improved QoS support.For each of the above key topics, the following objectives are identified:

1. Document the above key topics in more detail, in particular how they relate to the 5GMS Architecture and protocols.

2. Study collaboration scenarios between the 5G System and Application Provider for each of the key topics.

3. Based on the 5GMS Architecture, develop one or more deployment architectures that address the key topics and the collaboration models.

4. Map the key topics to basic functions and develop high-level call flows.

5. Identify the issues that need to be solved.

6. Provide candidate solutions (including call flows) for each of the identified issues.

7. Coordinate work with other 3GPP groups e.g. SA2, SA3, SA5, and others as needed.

8. Coordinate work with external organizations such as DASH-IF, CTA WAVE, ISO/IEC JTC29 WG3 (MPEG Systems), or IETF, as needed.

9. Identify gaps and recommend potential normative work for stage-2 call flows and possibly stage-3.

## ===== CHANGE =====

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

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

[2] Akamai Blog, “A QUICk Introduction to HTTP/3”, April 2020, <https://www.akamai.com/blog/developers/a-quick-introduction-http3>

[3] IETF RFC 9112: "HTTP/1.1", June 2022.

[4] IETF RFC 9113: "HTTP/2", June 2022.

[5] IETF RFC 9114: "HTTP/3", June 2022.

[6] D. Bhat, A. Rizk, and M. Zink, "Not so QUIC: A Performance Study of DASH over QUIC," NOSSDAV'17: Proceedings of the 27th Workshop on Network and Operating Systems Support for Digital Audio and VideoJune 2017 Pages 13–18 https://doi.org/10.1145/3083165.3083175

[7] AWS: "Achieving Great Video Quality Without Breaking the Bank", Streaming Media June 2019, [[https://pages.awscloud.com/rs/112-TZM-766/images/GEN elemental-wp-achieving-great-video-quality-without-breaking-the-bank.pdf](https://pages.awscloud.com/rs/112-TZM-766/images/GEN%20elemental-wp-achieving-great-video-quality-without-breaking-the-bank.pdf)](https://pages.awscloud.com/rs/112-TZM-766/images/GEN%20elemental-wp-achieving-great-video-quality-without-breaking-the-bank.pdf)

[8] Netflix, "Optimized shot-based encodes: Now Streaming!", Netflix Blog, May 2018, https://netflixtechblog.com/optimized-shot-based-encodes-now-streaming-4b9464204830

[9] DASH-IF/DVB: "Report on Low-Latency Live Service with DASH", July 2017, available here: <https://dash-industry-forum.github.io/docs/Report%20on%20Low%20Latency%20DASH.pdf>

[10] DASH-IF: "IOP Guidelines v5, Low-latency Modes for DASH", available here: <https://dash-industry-forum.github.io/docs/CR-Low-Latency-Live-r8.pdf>

[11] ISO/IEC 23009-1: "Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats".

[12] IETF RFC 8673: "HTTP Random Access and Live Content".

[13] 3GPP TR 26.939: "Guidelines on the Framework for Live Uplink Streaming (FLUS)".

[14] 3GPP TS 26.238: "Uplink Streaming".

[15] 3GPP TS 26.501: "5G Media Streaming (5GMS); General description and architecture".

[16] 3GPP TS 26.512: "5G Media Streaming (5GMS); Protocols".

[17] ISO/IEC 13818-1:2019: "Information technology — Generic coding of moving pictures and associated audio information — Part 1: Systems".

[18] SCTE 35 2020: "Digital Program Insertion Cueing Message", <https://www.scte.org/pdf-redirect/?url=https://scte-cms-resource-storage.s3.amazonaws.com/SCTE-35-2020_notice-1609861286512.pdf>

[19] ISO/IEC 23000-19: "Information technology — Multimedia application format (MPEG-A) —Part 19: Common media application format (CMAF) for segmented media".

[20] ISO/IEC 23009-1:2019/DAMD1: "Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 1: Media presentation description and segment formats — Amendment 1: CMAF support, events processing model and other extensions".

[21] VSF TR-06-01:2020, "RIST Simple Profile", https://vsf.tv/download/technical\_recommendations/VSF\_TR-06-1\_2020\_06\_25.pdf

[22] VSF TR-06-02: "RIST Main Profile", <https://www.videoservicesforum.org/download/technical_recommendations/VSF_TR-06-2_2020_03_24.pdf>

[23] 3GPP TS 23.501: "System architecture for the 5G System (5GS)".

[24] 3GPP TS 23.502: "Procedures for the 5G System (5GS)".

[25] 3GPP TS 29.517: "5G System; Application Function Event Exposure Service; Stage 3".

[26] 3GPP TS 29.244: "Interface between the Control Plane and the User Plane nodes; Stage 3".

[27] IETF RFC 6733: "Diameter Base Protocol".

[28] 3GPP TS 29.514: "5G System; Policy and Charging Control over Rx reference point; Stage 3".

[29] IETF RFC 7657: "Differentiated Services (Diffserv) and Real-Time Communication", November 1995.

[30] IETF RFC 3168: "The Addition of Explicit Congestion Notification (ECN) to IP", September 2001.

[31] IETF RFC 9204: "QPACK: Field Compression for HTTP/3", June 2022.

[32] IETF RFC 9000: "QUIC: A UDP-Based Multiplexed and Secure Transport", May 2021.

[33] IETF RFC 9001: "Using TLS to Secure QUIC", May 2021.

[34] IETF, RFC 9002: "QUIC Loss Detection and Congestion Control", May 2021.

[35] IETF RFC 5681: "TCP Congestion Control".

[36] M. Kuehlewind and B. Trammell, draft-ietf-quic-manageability-11, "Manageability of the QUIC Transport Protocol", Work in Progress, Internet-Draft, 30 June 2021.

[37] N. Cardwell et. al. "BBR Updates: Internal Deployment, Code, Draft Plans", 9 March 2021, https://datatracker.ietf.org/meeting/110/materials/slides-110-iccrg-bbr-updates-00.pdf

[38] ETSI TS 103 799: "Publicly Available Specification (PAS); DASH-IF Content Protection Information Exchange Format".

[39] ISO/IEC JTC1/SC29/WG11/N19062 23090‑8 FDIS: "MPEG-I: Network-based Media Processing — Network-Based Media Processing Specification".

[40] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".[41] 3GPP TS 23.503: "Policy and charging control framework for the 5G System (5GS); Stage 2".

[42] 3GPP TS 29.514: "5G System; Policy Authorization Service; Stage 3".

[43] 3GPP TS 29.522: "5G System; Network Exposure Function Northbound APIs; Stage 3".

[44] 3GPP TS 29.122: "T8 reference point for Northbound APIs".

[45] 3GPP TS 29.512: "5G System; Session Management Policy Control Service; Stage 3".

[46] 3GPP TS 26.803: "5G Media Streaming (5GMS); Architecture extensions".

[47] 3GPP TS 23.558: "Architecture for enabling Edge Applications (EA)".

[48] 3GPP TS 23.288: "Architecture enhancements for 5G System (5GS) to support network data analytics services".

[49] Tdoc S4-210723: "Generic architecture for data collection and reporting", submission from BBC, Dolby Laboratories Inc., LM Ericsson and Qualcomm Incorporated to SA4#114-e, May 19-28, 2021.

[50] Tdoc S2-2103267: "Extension of Naf\_EventExposure for observed service experience data collection from UEs", CR from InterDigital to SA2#144e, Apr 12-16, 2021.

[51] 3GPP TS 26.114: "IP Multimedia Subsystem (IMS); Multimedia telephony; Media handling and interaction".

[52] Tdoc S2-2104496: "Extension of Naf\_EventExposure for observed service experience data collection from UEs", CR from Qualcomm Incorporated to SA2#145e, May 17-28, 2021.

[53] 3GPP TS 26.118: "Virtual Reality (VR) profiles for streaming applications".

[54] 3GPP TS 26.346: "Multimedia Broadcast/Multicast Service (MBMS); Protocols and codecs".

[55] 3GPP TS 29.554: "Background Data Transfer Policy Control Service; Stage 3".

[56] 3GPP TS 28.530: "Management and orchestration; Concepts, use cases and requirements".

[57] 3GPP TS 28.531: "Management and orchestration; Provisioning".

[58] 3GPP TS 28.532: "Management and orchestration; Generic management services".

[59] 3GPP TS 28.533: "Management and orchestration; Architecture framework".

[60] 3GPP TS 28.540: "Management and orchestration; 5G Network Resource Model (NRM); Stage 1".

[61] 3GPP TS 28.541: "Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3".

[62] 3GPP TS 28.542: "Management and orchestration of networks and network slicing; 5G Core Network (5GC) Network Resource Model (NRM); Stage 1".

[63] 3GPP TS 28.543: "Management and orchestration of networks and network slicing; 5G Core Network (5GC) Network Resource Model (NRM); Stage 2 and stage 3".

[64] 3GPP TS 28.545: "Management and orchestration; Fault Supervision (FS)".

[65] 3GPP TS 28.546: "Management and orchestration of networks and network slicing; Fault Supervision (FS); Stage 2 and stage 3".

[66] 3GPP TS 28.552: "Management and orchestration; 5G performance measurements".

[67] 3GPP TS 28.554: "Management and orchestration; 5G end to end Key Performance Indicators (KPI)".

[68] 3GPP TS 23.434: " Service Enabler Architecture Layer for Verticals (SEAL); Functional architecture and information flows ".

[69] 3GPP TS 23.700‑99: " Study in Network slice capability exposure for application layer enablement (NSCALE)".

[70] 3GPP TS 29.520: " 5G System; Network Data Analytics Services; Stage 3".

[71] 3GPP TR 23.700-40: "Study on enhancement of network slicing; Phase 2".

[72] 3GPP TS 26.531: “Data Collection and Reporting; General Description and Architecture”.

[73] 3GPP TR 26.802: "Multicast Architecture Enhancement for 5G Media Streaming".

[74] IETF RFC 822: "STANDARD FOR THE FORMAT OF ARPA INTERNET TEXT MESSAGES", August 13, 1982.

[75] IETF RFC 1521: "MIME (Multipurpose Internet Mail Extensions)", September 1993.

[76] IETF RFC 2474: "Definition of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers".

[77] IETF RFC 2475: "An Architecture for Differentiated Services".

[78] IETF RFC 3246: "An Expedited Forwarding PHB (Per-Hop Behavior)".

[79] IETF RFC 2597: "Assured Forwarding PHB Group".

[80] S. Hurst, draft-hurst-quic-rtp-tunnelling: "QRT: QUIC RTP Tunnelling", Internet-Draft, Work in Progress.

[81] J. Ott and M. Engelbart, draft-engelbart-rtp-over-quic: "RTP over QUIC", Internet-Draft, Work in Progress.

[82] SRT Alliance, “Secure Reliable Transport (SRT) Protocol”, https://github.com/Haivision/srt

[83] M.P. Sharabayko and M.A. Sharabayko, draft-sharabayko-srt-over-quic-00 ,“Tunnelling SRT over QUIC”, Internet-Draft, Work in Progress, 28 July 2021.

[84] Robin Marx, Luca Niccolini, Marten Seemann, Lucas Pardue, draft-ietf-quic-qlog-main-schema-09, "Main logging schema for qlog", Internet-Draft, Work in Progress, 8 July 2024.

[85] Robin Marx, Luca Niccolini, Marten Seemann, Lucas Pardue, draft-ietf-quic-qlog-h3-events-08, "HTTP/3 and QPACK event definitions for qlog", Internet-Draft, Work in Progress, 8 July 2024.

[86] Robin Marx, Luca Niccolini, Marten Seemann, Lucas Pardue, draft-ietf-quic-qlog-quic-events-08, "QUIC event definitions for qlog", Internet-Draft, Work in Progress, 8 July 2024.

[87] Roger Pantos and William May, Jr., "HTTP Live Streaming", RFC 8216, August 2017.

[88] 3GPP TR 26.925: "Typical traffic characteristics of media services on 3GPP networks".

[89] 3GPP TR 26.917: "Multimedia Broadcast Multicast Services (MBMS) and Packet-switchedStreaming Service (PSS) enhancements to support television services".

[90] "DASH-IF WebRTC-based Streaming", https://dashif.org/news/webrtc/

[91] IETF RFC 6749: "The OAuth 2.0 Authorization Framework".

[92] IETF RFC 6750: "The OAuth 2.0 Authorization Framework: Bearer Token Usage".

[93] 3GPP TS 33.501: "Security architecture and procedures for 5G System".

[94] 3GPP TS 26.531: "Data Collection and Reporting; General Description and Architecture".

[95] 3GPP TS 26.532: "Data Collection and Reporting; Protocols and Formats".

[96] 3GPP TS 26.511: "5G Media Streaming (5GMS); Profiles, codecs and formats".

[97] ETSI TS 103 770: "Digital Video Broadcasting (DVB); Service Discovery and Programme Metadata for DVB-I".

[98] Android Developer Documentation: "Handling Android App Links",  
<https://developer.android.com/training/app-links>

[99] 3GPP TS 26.347: "Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL".

[100] ETSI TS 103 769: "Digital Video Broadcasting (DVB); Adaptive media streaming over IP multicast".

[101] 3GPP TS 23.247: "Architectural enhancements for 5G multicast-broadcast services".

[102] 3GPP TS 29.558: "Enabling Edge Applications; Application Programming Interface (API) specification; Stage 3".

[103] IETF RFC 2045: "Multipurpose Internet Mail Extensions Part One: Format of Internet Message Bodies".

[104] IETF RFC 3986: "Uniform Resource Identifier (URI): Generic Syntax", January 2005.

[105] Consumer Technology Association Specification CTA‑5004: "Web Application Video Ecosystem – Common Media Client Data", September 2020.

[106] 3GPP TS 26.531: "Data Collection and Reporting; General Description and Architecture".

[107] 3GPP TS 26.532: "Data Collection and Reporting; Protocols and Formats".

[108] 3GPP TS 26.510: "Media delivery: Interactions and APIs for provisioning and media session handling (Release 18)".

[109] 3GPP TS 26.247: "Transparent end-to-end Packet-switched Streaming Service (PSS); Progressive Download and Dynamic Adaptive Streaming over HTTP (3GP-DASH)".

[110] 3GPP TS 29.591: "Network Exposure Function Southbound Services; Stage 3 (Release 18)".

[111] ETSI TS 103 998: "DASH-IF: Content steering for DASH".

[112] Draft Text of ISO/IEC FDIS 23009-9: "Information technology - Dynamic adaptive streaming over HTTP (DASH) – Part 9: Redundant Encoding and Packaging for segmented live media (REaP)", ISO/IEC JTC 1/SC 29/WG 3 NO 1165, Jan. 26, 2024. [Online]. Available: https://www.mpeg.org/standards/MPEG-DASH/9/

[113] Emma Roth, "A popular open-source content delivery network went down for hours", The Verge, Apr. 12, 2024. [Online]. Available: https://www.theverge.com/2024/4/12/24128276/open-source-unpkg-cdn-down (accessed May 9, 2024).

[114] Sebastian Moss, "Cloudflare recovers from service outage after power failure at core North American data center", Data Center Dynamics, Nov. 3, 2023. [Online]. Available: https://www.datacenterdynamics.com/en/news/cloudflare-recovers-from-service-outage-after-power-failure-at-core-north-american-data-center/ (accessed May 9, 2024).

[115] Brian Barrett, "How an Obscure Company Took Down Big Chunks of the Internet", Wired, Jun. 8, 2021. [Online]. Available: https://www.wired.com/story/fastly-cdn-internet-outages-2021/ (accessed May 9, 2024).

[116] Josh Fomon, "CDN Provider Akamai Takes Down Popular Internet Services During Outage", Ookla, Jul. 22, 2021. [Online]. Available: https://www.ookla.com/articles/akamai-outage-july-22-2021 (accessed May 9, 2024).

[117] Charlotte Trueman, "Cloudflare outage brings hundreds of sites, services temporarily offline", Computer World, Jun. 21, 2022. [Online]. Available: https://www.computerworld.com/article/1627967/cloudflare-outage-brings-hundreds-of-sites-services-temporarily-offline.html (accessed May 9, 2024).

[118] Jim Salter, "The Internet broke today: Facebook, Verizon, and more see major outages", Ars Technica, Jul. 3, 2019. [Online]. Available: https://arstechnica.com/information-technology/2019/07/facebook-cloudflare-microsoft-and-twitter-suffer-outages/ (accessed May 9, 2024).

[119] Marc Hoppner, "A content owner, a CDN and a player walk into a bar", (Jan. 6, 2023). Accessed: May 9, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=S9EdoQFOQ9I&list  
=PLkyaYNWEKcOf98lZxnCcL6y7ZIVU3oSYO&index=12

[120] Guillaume du Pantavice, "Improving streaming experience with Bayesian optimization, from AB to AZ test", (Dec. 25, 2021). Accessed: May 9, 2024. [Online Video]. Available: https://www.youtube.com/  
watch?v=t4nRrLygVwo&list=PLkyaYNWEKcOfD1GYFxFbZXDP03XM-cZPg&index=19

[121] E. Ghabashneh and S. Rao, "Exploring the interplay between CDN caching and video streaming performance", IEEE INFOCOM 2020 – IEEE Conference on Computer Communications, Toronto, ON, Canada, 2020, pp. 516-525.

[122] K. Vermeulen, L. Salamatian, S. H. Kim, M. Calder, and E. Katz-Bassett, "The central problem with distributed content: common CDN deployments centralize traffic in a risky way", In Proceedings of the 22nd ACM Workshop on Hot Topics in Networks (HotNets ’23). Association for Computing Machinery, New York, NY, USA, 70-78.

[123] A. Bentaleb, R. Farahani, F. Tashtarian, C. Timmerer, H. Hellwagner, and R. Zimmermann, "Which CDN to Download From? A Client and Server Strategies", (Jan. 6, 2024). Accessed: May 9, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=xCZmCnWgQRE

[124] Will Law, "Content steering with MPEG DASH", (May 4, 2023). Accessed: May 9, 2024. [Online Video]. Available: https://www.youtube.com/watch?v=o9Pa5y-Usxw

[125] W. Law and Y. Reznik, "DASH content steering at scale", Media Web Symposium (MWS’23), June 2023.

[126] ETSI TS 103 973: "Coded multisource media format (CMMF) for content distribution and delivery".

[127] IETF RFC 6330: "RaptorQ forward error correction scheme for object delivery", August 2011.

[128] IETF RFC 5110: "Reed-Solomon forward error correction (FEC) schemes", April 2009.

[129] ETSI TS 103 285: "Digital Video Broadcasting (DVB); MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks".

[130] ISO/IEC 26090-8:2020: "Information technology – Coded representation of immersive media, Part 8: Network based media processing".

[131] IETF RFC 5052: "Forward Error Correction (FEC) Building Block", August 2007.

[132] IETF RFC 5053: "Raptor Forward Error Correction Scheme for Object Delivery", October 2007.

[133] IETF RFC 6726: "FLUTE - File Delivery over Unidirectional Transport," November 2012.

[134] IETF RFC 8684: "TCP Extensions for Multipath Operation with Multiple Addresses", March 2022.

[135]

[136] Q. De Coninck, O. Bonaventure, C. Huitema, M. Kuehlewind, draft-ietf-quic-multipath-10, "Multipath Extension for QUIC", July 2024.

[137] IETF RFC 6897: "Multipath TCP (MPTCP) Application Interface Considerations", March 2013

[138] IETF Draft: "Multipath Extension for QUIC", draft-ietf-quic-multipath-10, July 2024

[139] Media Source Extension, W3C Working Draft 01, April 2024,  
<https://www.w3.org/TR/media-source-2/>

[140] Movie labs: "Specification for Enchanced Content Protection", available at: <https://movielabs.com/ngvideo/MovieLabs_ECP_v1.4.pdf>.

[141] W3C: "Encrypted Media Extensions", available at: https://www.w3.org/TR/encrypted-media-2/

[142] Akamai: "Welcome to Adaptive Media Delivery", in *Adaptive Media Delivery Implementation Guide*, available at: <https://learn.akamai.com/en-us/webhelp/adaptive-media-delivery/adaptive-media-delivery-implementation-guide/GUID-3F89E64C-415D-452D-9541-BB650CD783B9.html>

[143] ETSI TS 103 799: "Content Protection Information Exchange Format (CPIX)".

[144] DASH-IF: "Interoperability Points; Part6-v5.0.0: Content protection and security".

[145] ETSI TS 104 002: "DASH-IF Forensic A/B Watermarking".

[146] DASH Industry Forum: "DASH-IF Live Media Ingest Protocol v1.2", February 2024,  
<https://dashif-documents.azurewebsites.net/Ingest/master/DASH-IF-Ingest.pdf>

[147] Consumer Technology Association CTA-5005-A: "Web Application Video Ecosystem – DASH-HLS Interoperability Specification",  
<https://shop.cta.tech/products/web-application-video-ecosystem-dash-hls-interoperability-specification-cta-5005-a>

[148] ISO/IEC 23001-7: "Information technology — MPEG systems technologies Part 7: Common encryption in ISO base media file format files".

[149] IETF RFC 9330:"Low Latency, Low Loss, Scalable Throughput (L4S) Internet Service: Architecture".

[150] IETF RFC 9331: "Explicit Congestion Notification (ECN) Protocol for Very Low Queuing Delay (L4S)".

[151] IETF RFC 9332: "Dual-Queue Coupled Active Queue Management (AQM) for Low Latency, Low Loss, and Scalable Throughput (L4S)".

[152] 3GPP TS 38.300: "NR; NR and NG-RAN Overall Description".

[153] 3GPP TS 26.522: "5G Real-time Media Transport Protocol Configurations".

[154] Apple Developer Documentation, nw\_ip\_metadata\_get\_ecn\_flag(\_:) | Apple Developer Documentation

[155] IETF RFC 3168: "The Addition of Explicit Congestion Notification (ECN) to IP".

[156] 3GPP TS 29.122: "T8 reference point for Northbound APIs".

[108] 3GPP TS 26.510: "Media delivery; interactions and APIs for provisioning and media session handling".

[149] Chaudhary, Sapna, Mukulika Maity, Sandip Chakraborty, and Naval Shukla. "A dataset for analyzing streaming media performance over HTTP/3 browsers." *Advances in Neural Information Processing Systems* 36 (2024)

[150] Chaudhary, Sapna, et al. "Managing Connections by QUIC-TCP Racing: A First Look of Streaming Media Performance Over Popular HTTP/3 Browsers." *IEEE Transactions on Network and Service Management* (2024).

[151] Kazuho Oku, Lucas Pardue Robin Marx, Luca Niccolini, Marten Seemann, draft-kazuho-httpbis-http3-on-streams-00, "HTTP/3 on Streams", Expired Internet-Draft, 19 August 2024.

[154] Chellappa, Sindhu, and Radim Bartos. "Is QUIC Quicker with HTTP/3? An Empirical Analysis of Quality of Experience with DASH Video Streaming." *2022 IEEE International Conference on Advanced Networks and Telecommunications Systems (ANTS)*. IEEE, 2022.

[155] Zhang, X., Jin, S., He, Y., Hassan, A., Mao, Z. M., Qian, F., & Zhang, Z. L. (2024, May). QUIC is not Quick Enough over Fast Internet. In *Proceedings of the ACM on Web Conference 2024* (pp. 2713-2722).

[156] Herbots, Joris, et al. "Cross that boundary: Investigating the feasibility of cross-layer information sharing for enhancing ABR decision logic over QUIC." *Proceedings of the 33rd Workshop on Network and Operating System Support for Digital Audio and Video*. 2023.

[157] Belson, D. and Pardue L.: "Examining HTTP/3 usage one year on", June 2023  
<https://blog.cloudflare.com/http3-usage-one-year-on>

[158] IETF RFC 5321: “Simple Mail Transfer Protocol”, October 2008.

[159] HTTP Archive: State of the Web, https://httparchive.org/reports/state-of-the-web#h3

[160] W3C Working Draft: "WebTransport", May 2024, <https://www.w3.org/TR/webtransport>

[161] A. Frindell, E. Kinnear, V. Vasiliev: "WebTransport over HTTP/3", Work In Progress, Internet Draft, draft-ietf-webtrans-http3, <https://datatracker.ietf.org/doc/html/draft-ietf-webtrans-http3/>

[162] IETF RFC 9297: "HTTP Datagrams and the Capsule Protocol", August 2022.

[163] IETF RFC 9221: "An Unreliable Datagram Extension to QUIC", March 2022.

[164] IETF RFC 9218: "Extensible Prioritization Scheme for HTTP", June 2022.

[165] ISO/IEC 23009-6: "Information technology — Dynamic adaptive streaming over HTTP (DASH) — Part 6: DASH with server push and WebSockets".

[166] L. Curly, K. Pugin, S. Nandakumar, V. Vasiliev, I. Swett: "Media over QUIC Transport", Work In Progress, Internet Draft, draft-ietf-moq-transport, https://datatracker.ietf.org/doc/draft-ietf-moq-transport/07/

[167] S. Nandakumar, W. Law, M. Zanaty: "Common Catalog Format for moq-transport", Work In Progress, Internet Draft, draft-ietf-moq-catalogformat, https://datatracker.ietf.org/doc/draft-ietf-moq-catalogformat/01/

[168] Zhang, X., Jin, S., He, Y., Hassan, A., Mao, Z. M., Qian, F., & Zhang, Z. L., "QUIC is not Quick Enough over Fast Internet", in *Proceedings of the ACM on Web Conference 2024* (pp. 2713–2722), May 2024.

[169] Nguyen, M., Nys, P., Pham, S., Silhavy, D., Arbanowski, S., & Steglich, S., "Toward WebTransport Support in HTTP Adaptive Streaming", in *Tenth International Conference on Communications and Electronics 2024* (ICCE) (pp. 96–101), IEEE, July 2024.

[170] Roberto Ramos-Chavez, Espen Braastad, Jamie Fletcher, and Arjen Wagenaar. 2024. Standards based OTT A/B Watermarking at Scale. In Proceedings of the 3rd Mile-High Video Conference (MHV '24). Association for Computing Machinery, New York, NY, USA, 94. <https://doi.org/10.1145/3638036.3640251>

[171] 3GPP TS 26.506: "5g Real-time Media Communication Architecture (Stage 2)".

[172] Media Source Extension, W3C Editor's Draft 26, October 2023,  
<https://jyavenard.github.io/media-source/media-source-respec.html#dfn-endstreaming>

[173] 5G-MAG Report: "Uplink media delivery: Architectures & Features", available in https://www.5g-mag.com/post/uplink-media-delivery-architectures-features

## ===== CHANGE =====

## 3.3 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].

AAAA Authentication, Authorization, Accounting, and Auditing

ABR Adaptive Bitrate

ACK ACKnowledgment

ACM Association for Computing Machinery

ALPN Application-Layer Protocol Negotiation

AMF Access and Mobility Management Function

ANBR Access Network Bitrate Recommendation

ANTS Advanced Network Technologies Symposium

API Application Programming Interface

AQM Active Queue Management

ARPA Advanced Research Projects Agency

ARQ Automatic Repeat reQuest

ASP Application Service Provider

ATSSS Access Traffic Steering, Switching, and Splitting

AUS AUthentication Server

AVC Advanced Video Coding

AWS Amazon Web Services

BBC British Broadcasting Corporation

BBR Bottleneck Bandwidth and Round-trip propagation time

BDT Background Data Transfer

BMFF Base Media File Format

BMSC Broadcast/Multicast Service Center

CAE Content-Aware Encoding

CBR Constant Bitrate

CCF Call Control Function

CDF Cumulative Distribution Function

CDN Content Delivery Network

CDP Content Delivery Protocol

CERN European Organization for Nuclear Research

CIRR Carrier-Independent Routing Registry

CMAF Common Media Application Format

CMAS Commercial Mobile Alert System

CMCD Common Media Client Data

CMMF Coded Multisource Media Format

CMSD Content Media Server Data

CNAME Canonical Name

CPI Content Protection Information

CPIX Content Protection Information Exchange

CPT Content Preparation Template

CRUD Create, Read, Update, Delete

CTA Consumer Technology Association

CWR Congestion Window Reduced

DANE DASH-Aware Network Element

DASH Dynamic Adaptive Streaming over HTTP

DCSM Data Collection and Storage Management

DGRAM Datagram

DNS Domain Name System

DRM Digital Rights Management

DSCP Differentiated Services Code Point

DTT Digital Terrestrial Television

DVB Digital Video Broadcasting

DVR Digital Video Recorder

EAS Edge Application Server

ECE Explicit Congestion Notification

ECN Explicit Congestion Notification

ECP Enhanced Content Protection

ECT Explicit Congestion Notification-Capable Transport

EDGE Enhanced Data rates for GSM Evolution

EDL Enhanced Data Link

EEC Edge-Enabled Client

EEL End-to-End Latency

EES Edge Enabler Server

EFDT Enhanced File Delivery Table

EME Encrypted Media Extensions

ENP Enhanced Network Performance

EPS Evolved Packet System

EPT Enhanced Packet Transport

EVEX EVent EXposure

EXT Extension

FALSE False

FAR Forward Action Rule

FDIS Final Draft International Standard

FDT File Delivery Table

FEC Forward Error Correction

FHD Full High Definition

FLUS Framework for Live Uplink Streaming

FLUTE File Delivery over Unidirectional Transport

FOR For

FORMAT Format

FQDN Fully Qualified Domain Name

GBR Guaranteed Bit Rate

GRO Generic Receive Offload

GSO Geostationary Orbit

GTP GPRS Tunneling Protocol

GUID Globally Unique Identifier

HDR High Dynamic Range

HEVC High Efficiency Video Coding

HLS HTTP Live Streaming

HPACK Header Compression for HTTP/2

HTTP Hypertext Transfer Protocol

HTTPS Hypertext Transfer Protocol Secure

IANA Internet Assigned Numbers Authority

ICCE International Conference on Consumer Electronics

IEC International Electrotechnical Commission

IEEE Institute of Electrical and Electronics Engineers

IETF Internet Engineering Task Force

IMS IP Multimedia Subsystem

INFOCOM International Conference on Computer Communications

IOP Interoperability Points

IPC Inter-Process Communication

IPTV Internet Protocol Television

ISO International Organization for Standardization

JSON JavaScript Object Notation

JTC Joint Technical Committee

KID Key Identifier

KPI Key Performance Indicator

LPT Low-Power Transceiver

LSD Low-Speed Data

LTE Long-Term Evolution

MABR Multicast Adaptive Bitrate

MANO Management and Orchestration

MAR Multi-Access Rule

MAX Maximum

MBMS Multimedia Broadcast Multicast Service

MBS Multicast Broadcast Service

MBSF Multicast Broadcast Service Function

MBSTF Multicast Broadcast Service Transport Function

MHV Mile-High Video

MIME Multipurpose Internet Mail Extensions

MNO Mobile Network Operator

MOQ Media over QUIC

MPD Media Presentation Description

MPEG Moving Picture Experts Group

MPQUIC Multipath QUIC

MPTCP Multipath TCP

MQTT Message Queuing Telemetry Transport

MSE Media Source Extensions

MSH Media Session Handler

MTSI Multimedia Telephony Service for IMS

NAT Network Address Translation

NBMP Network-Based Media Processing

NEF Network Exposure Function

NFV Network Functions Virtualization

NRF Network Repository Function

NRM Network Resource Model

NSACF Network Slice Admission Control Function

NSCALE Network Slice Capability Exposure

NSSAI Network Slice Selection Assistance Information

NWDAF Network Data Analytics Function

OAM Operations, Administration, and Maintenance

OMA Open Mobile Alliance

OTI Object Transmission Information

OTT Over-The-Top

PAS Publicly Available Specification

PCC Policy and Charging Control

PCF Policy Control Function

PDF Portable Document Format

PDR Packet Detection Rule

PDU Protocol Data Unit

PFCP Packet Forwarding Control Protocol

PFD Packet Flow Description

PFDF Packet Flow Description Function

PFS Packet Flow Set

PHB Per-Hop Behavior

PING Packet Internet Groper

PLMN Public Land Mobile Network

PSA Public Service Announcement

PSDB Packet Set Delay Budget

PSER Packet Set Error Rate

PSIHI Packet Set Integrated Information

PSNR Peak Signal-to-Noise Ratio

PSS Packet-Switched Streaming

QER Quality of Experience Rule

QFI QoS Flow Identifier

QLOG QUIC Logging

QPACK QUIC Header Compression

QRT QUIC RTP Tunneling

QUIC Quick UDP Internet Connections

RAN Radio Access Network

RAPTORQ RaptorQ Forward Error Correction

RCVBUF Receive Buffer

RFC Request for Comments

RIST Reliable Internet Stream Transport

RLC Radio Link Control

ROM Receive-Only Mode

RSFEC Reed-Solomon Forward Error Correction

RTC Real-Time Communication

RTCP Real-Time Control Protocol

RTMP Real-Time Messaging Protocol

RTP Real-Time Protocol

RTT Round-Trip Time

SAND Server and Network Assisted DASH

SAP Service Access Point

SBI Service-Based Interface

SCONEPRO Secure Communication of Network Properties

SCTE Society of Cable Telecommunications Engineers

SDAP Service Data Adaptation Protocol

SDF Service Data Flow

SEAL Service Enabler Architecture Layer

SEI Supplemental Enhancement Information

SIB System Information Block

SIM Subscriber Identity Module

SLA Service Level Agreement

SMF Session Management Function

SMS Short Message Service

SMTP Simple Mail Transfer Protocol

SRT Secure Reliable Transport

SRV Service

SSD Seek Start-up Delay

SST Slice Selection Type

STS Secure Token Service

SVC Scalable Video Coding

SVTA Streaming Video Technology Alliance

SYN Synchronize

TBD To Be Determined

TCP Transmission Control Protocol

TEE Trusted Execution Environment

TEID Tunnel Endpoint Identifier

TLS Transport Layer Security

TMGI Temporary Mobile Group Identity

TOI Transmission Object Identifier

TSG Technical Specification Group

TSI Transport Stream Identifier

TYP Type

TZM Time Zone Management

UDP User Datagram Protocol

UDR Unified Data Repository

UHD Ultra-High Definition

UMTS Universal Mobile Telecommunications System

UPF User Plane Function

URI Uniform Resource Identifier

URL Uniform Resource Locator

URN Uniform Resource Name

URR Usage Reporting Rule

USIM Universal Subscriber Identity Module

UTC Coordinated Universal Time

UUID Universally Unique Identifier

VBR Variable Bitrate

VSF Video Services Forum

WAVE Web Application Video Environment

WDD Workflow Description Document

XML Extensible Markup Language

XXX To Be Determined

ZSM Zero-touch network and Service Management

## ===== CHANGE =====

# 4 5G Media Streaming

The 5G Media Streaming architecture is defined in TS 26.501 [15].

Protocols and APIs are specified in TS 26.512 [16], with reference to the generalized Media Session Handling to TS 26.510 [108].

Profiles, codecs and formats are provided in TS 26.511 [96].

## ===== CHANGE =====

## 5.15 Media Delivery Specification

### 5.15.1 Description

The primary focus of the update to TS 26.512 [16] is addressing the of segmented media objects in the media plane, i.e. at reference points M2, M3, M4, M7, M11 and M12 of the Media Delivery architecture as shown in Figure 5.15.1-1.



Figure 5.15.1-1 Media Delivery Architecture as defined in TS 26.501 [15] with emphasis for protocol specification (M2, M3, M4, M7, M11 and M12) to be developed.

The specification is expected to address interoperability considerations around content delivery protocol features and general technologies for segmented media streaming and the IP/PDU 5G System Layer. It was discussed whether a new specification is needed or updates to TS 26.512 [16] are sufficient.

M12 is not in scope for this Technical Report and the expected new specification, the focus is on Media AS from/to UE.

Key aspects of such a specification should include common protocols on M2 and M4, as well as common APIs and reference points on M3, M7 and M11. In addition, consistent extensions to such protocols need to be reviewed, for example custom HTTP headers, query parameters, etc.

### 5.15.2 Considered Text in Specification

The following outline is considered for a new specification addressing the media plane.

1 Overview and Assumptions

1.1 General Assumptions and Protocol Stack for M2 and M4: IPv4 or IPv6 and HTTP according to RFC 9110

- HTTP/1.1, TLS (optional), TCP, IP – parallel requests, RFC 9112

- HTTP/2, TLS, TCP, IP – one TCP connection, RFC 9113

- HTTP/3, QUIC (+TLS), UDP, IP – one QUIC connection, RFC 9114

- HTTP Methods

- HTTP Headers

1.2 General Assumptions for M7 and M11

- Existence of a reference API in Media Access function

1.3 General Assumptions for M3

- Existence of a reference API in Media AS

1.4 Features

- What are features?

- Configurable UE and Media AS functionalities.

- Features may be mandatory or optional, but are typically optional

- Features are fully specified and normative

- How can the features be configured?

- What are the requirements for each feature?

- Overview of features and mapping to reference points

2 Media Delivery Features

- For each feature

- Overview

- Procedures (if not in stage-2, possibly referenced)

- Requirements for each function and reference point

- Configuration on AS through M3, Impact on M2 and M4, client APIs M7 and M11.

- Implementation Guidelines

### 5.15.3 Conclusions

Based on the discussion in this clause, it is recommended to

- update TS 26.512 for addressing extensions to media segment-based delivery

- adopt a documentation following the structure in clause 5.15.2.

## ===== CHANGE =====

## 6.15 Media Delivery Specification

The primary focus of the update to TS 26.512 [16] is addressing the of segmented media objects in the media plane, i.e. at reference points M2, M3, M4, M7, M11 and M12 of the Media Delivery architecture as shown in Figure 5.15.1-1.

Based on the discussion in clause 5.15 and the conclusion in 5.15.3, it is recommended to

- update TS 26.512 for addressing extensions to media segment-based delivery

- adopt a documentation following the structure in clause 5.15.2.