Future directions of 5GKPI: Towards 6G

Klagenfurt, July 2024

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Workshop Introduction

Klagenfurt, 1st July 2024

Pablo Pérez & Kjell Brunnström

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5G-KPI

Mission and Goals

Mission:

- Study the relationship between the Key Performance Indicators of new communication networks (namely 5G, but extensible to others) and the QoE of the video services on top of them.

Goals:

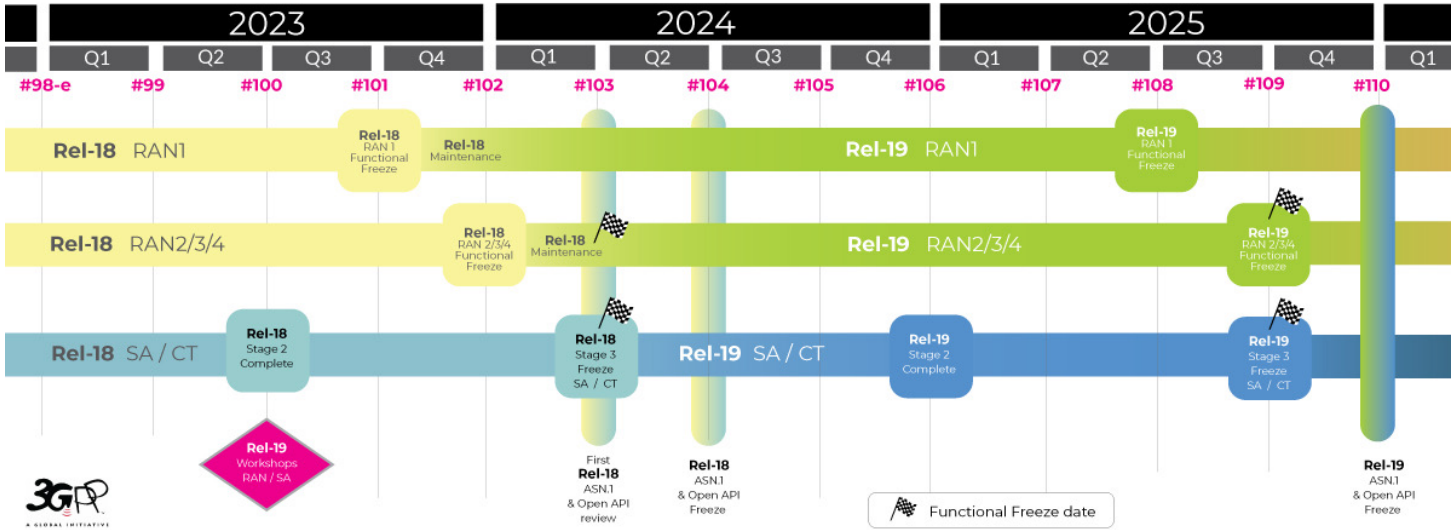
- Define **relevant use cases**, such as video for industrial applications, or mobility scenarios.
- Study global QoE aspects for **video in mobility** and industrial scenarios.
- Identify the relevant **network KPIs**(e.g. bitrate, latency, ...) and **application-level video KPI**s (e.g. picture quality, A/V sync, ...).
- Build **open datasets** for algorithm testing and training.

Group organization

- Chair: Pablo Pérez
- Vice-Chair: Kjell Brunsström

3GPP Releases

In the era of 5G-Advanced



5G ADVANCED

6G will be standardized around release 21

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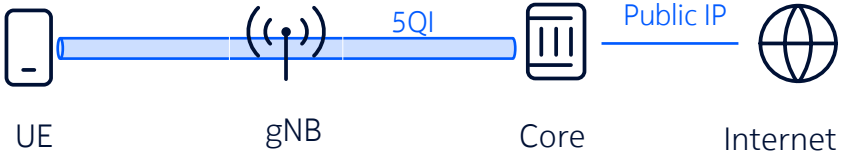
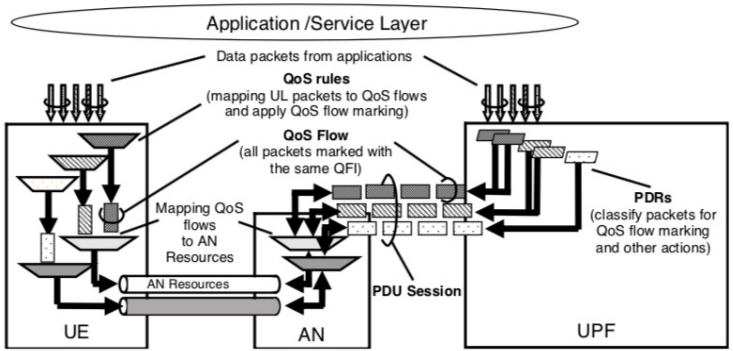
5G QoS model

Simplified





- Each data connection has a **QoS profile (5QI)**:
  - Priority Level
  - Packet Delay Budget
  - Packet Error Rate
  - Guaranteed Bit Rate (some profiles)
- 5G-network-wide (UE to Core)
- **Enforced by the network**

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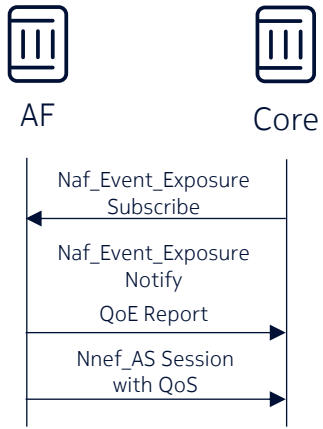
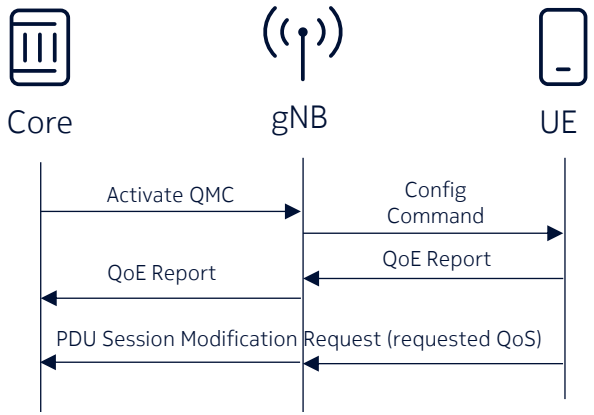
QoE Measurements and Requested QoS

3GPP specifies methods for QoE measurements collection from the AF and the UE.

Requests for specific QoS handling and segregation of service data flows can be done from the AF and the UE.





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QoE Metrics

Quality DASH [26.247]
- List of Representation Switch Events
- Average Throughput
- Initial Playout Delay
- Buffer Level
- Play List
- MPD Information
- Playout Delay for Media Start-up
- Device information

VR [26.118]
- Based on DASH QoE (all metrics apply to VR also)
- Comparable quality viewport switching latency
- Rendered viewports
- VR device information

MTSI [26.114]
- Corruption Duration
- Successive loss of RTP packets
- Frame rate
- Jitter duration
- Sync loss duration
- RTT
- Average codec rate
- Codec information
- Call setup time

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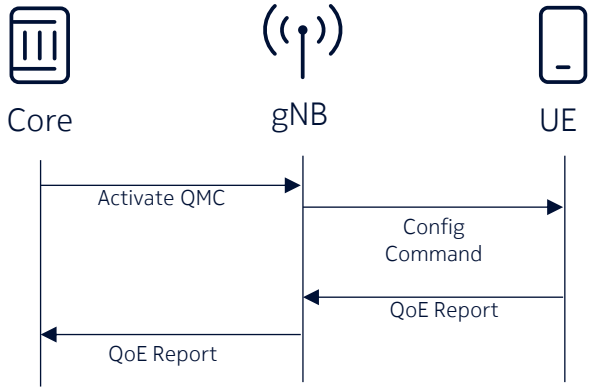
QoE Measurement Collection (QMC) framework

- TS 28.405 (SA5) defines QoE Measurement Collection control:
  - **Management based** activation (from Network Management to RAN)
  - **Signalling based** activation (through Core Network to RAN) (supported as per TS 38.300)
- RAN visible QoE (RVQoE): QoE Measurements are sent "in clear" from the UE to gNB:
  - Buffer Level
  - Playout Delay for Media Startup
- **Not widely used**. In practice, QoE measurement is basically done at pilot deployments / network dimensioning.



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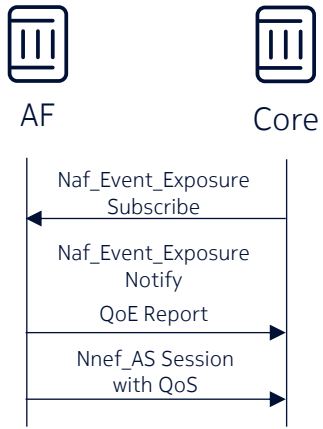
Event Exposure Service by Applications

- Data collection is done through event exposures including [TS 29.517]:



AF application events exposed by AF:

- Service Experience information for an application:
  - MOS with upper and lower values of the rating score
  - Time window
  - IP traffic filter
- UE mobility information;
- …

UE application events exposed via Data Collection AF:

- Media Streaming QoE metrics;
  - 3GP-DASH QoE Report [26.247]
  - virtual reality media the report [26.118]
- Media Streaming Consumption reports;
- …

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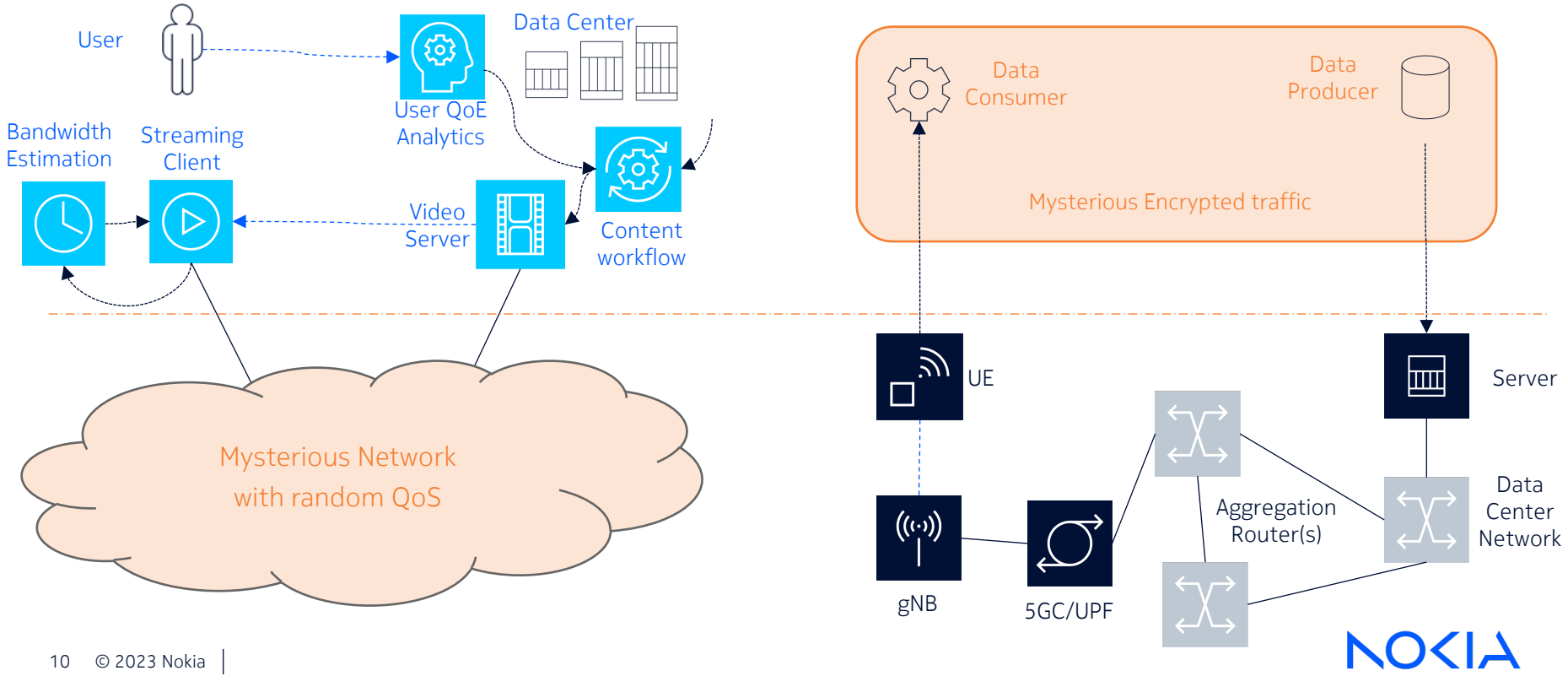
Information mismatch

Content & Application Providers vs. Communication Service Providers



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Information mismatch

Different research communities

QoE in IEEE Tr. on Multimedia

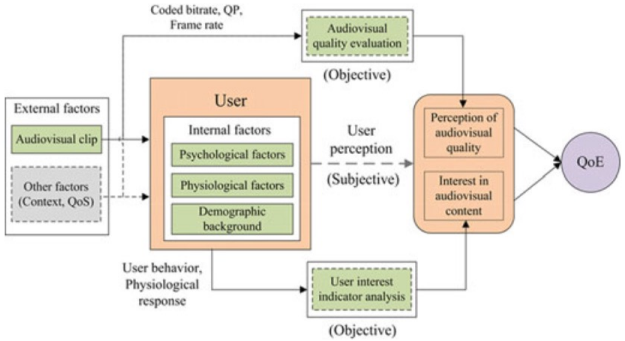
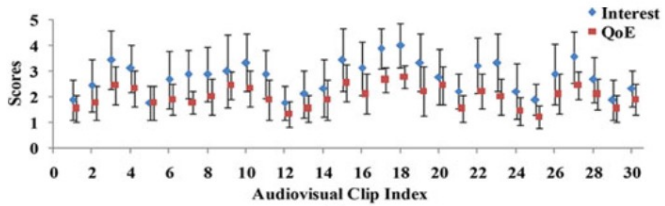


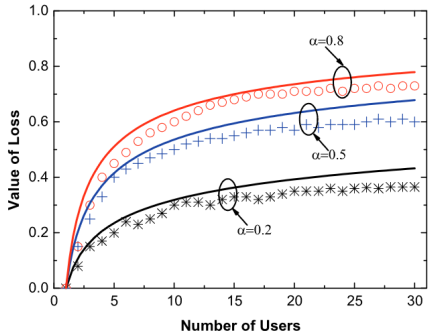
Fig. 2. QoE assessment framework for audiovisual services.



QoE in IEEE Tr. on Wireless Communications

Assumption 1: There exists some positive constants $A, a > 0$, $\forall n \in [1, N]$, enabling $\mathcal{M}$ to satisfy:

1) $Q_n(R_n; \theta_n) \leq A$ for any $\mathcal{Q} \in \mathcal{M}$;
2) $Q_n(R_n; \theta_n)$ is a strictly no-decreasing function on R_n, and differentiable on θ for any $\mathcal{Q} \in \mathcal{M}$;
3) $|Q_n(R_n; \theta_{n,1}) - Q_n(R_n; \theta_{n,2})| \leq a \|\theta_{n,1} - \theta_{n,2}\|_\infty$ for any two parameters $\theta_{n,1}, \theta_{n,2} \in \theta$.



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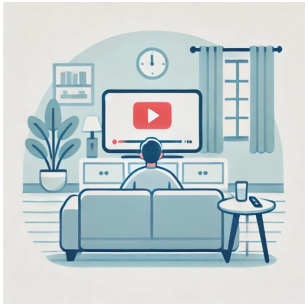
A diversity of use cases

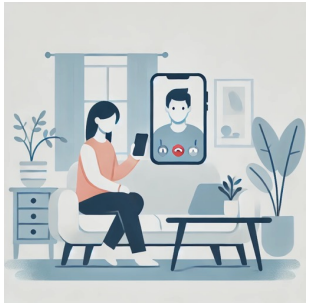
Each one has its own QoE parametrization – but the network cannot distinguish!

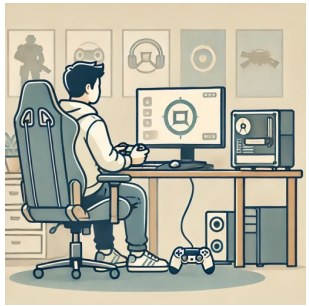
TODAY



Streaming

Video Call



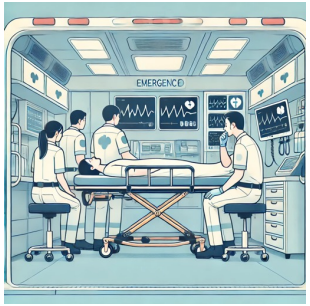


Online Gaming

TOMORROW

XR TeleMeeting

Remote Driving



First-Responder Support

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Status

Towards 6G

- **Identified missing points**:
  - No clear path QoE Measures —> QoE
  - Improve QoE manageability in the network (A “6G QoE model”)
  - Poor interpretation of QoE metrics (e.g. MOS) when used by network design
  - No working solution for information exchange between application and network

- **Contour conditions**:
  - No plan in 3GPP to significantly enhance QMC list of measures. AR/MR can reuse existing measures.
  - For parametric models, 3GPP will probably rely on ITU-T SG12 Recommendations.
  - QoE analysis + network optimization is typically a one-shot project activity →limited interest for standardized QoE models.
  - No direct Liaison Statment path from VQEG to 3GPP or ITU-T.
  - Risk of developing a model which is not used further on

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Recap: Towards 6G

North Star: Develop QoE-QoS models And/OR develop framework to manage QoE in 5G/6G

Current status: missing visibility

- Operators are missing visibility on content quality
- CAP lacks visibility on N/W health, bandwidth, congestion

Use cases: today and future

- Today: streaming + video calls
- Future: XR, tele-operation…

What can VQEG do?

1. Identify relevant QoE-QoS activities (ITU-T, VQEG, NGMM, TIP, IETF, 3GPP…)

2. Organize colaboration between operators – content providers - vendors

3. Develop FMK to define metrics and requirements: Define concepts & QoE models

4. Develop FMK for continuous QoE monitor / management Insights for network optimization, feedback loop

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In summary

Target of the workshop

1. ”Be on the same page”: describe the current status from different perspectives: content vs network, industry vs academia, standardization bodies.

2. Identify the key areas to address: how the gap between different parts could be closed.

3. Discuss how VQEG could help.

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Agenda

Presenter	Title
Pablo Pérez & Kjell Brunnström	Introduction
Michele Zorzi	QoE and QoS in 6G
Tobias Hoßfeld & Pablo Pérez	QoE Management and Parametric Models
Kjell Brunnström & Gunilla Berndtsson	Current status of standardization & industry
Break	
Francois Blouin	Perspectives from Content and Application Providers (CAPs)
Emir Halepovic	Perspectives from Communication Services Providers (CSPs)
Narciso García (moderator) Francois Blouin, Enrico Masala, Christian Timmerer *(and you!)*	Panel-guided discussion: What are the needs and the possibilities for QoE management in 6G?
Pablo Pérez & Kjell Brunnström	Conclusions. Future directions of 5GKPI

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Conclusions
Future directions of 5GKPI project

Klagenfurt, 1st July 2024

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VQEG 5GKPI

Potential areas for action (1/2)

- Create a **common language**
  - Currently use case requirements are defined in terms of QoS metrics.
  - From a telecommunication perspective, QoE is a measure of the quality of the data which are transmitted
    - Example of LiDAR Point Clouds → QoE is a machine-oriented metric, not a human-oriented mesaure.
    - Trade-off between QoS and QoE → reinforcement learning

- Agree on the right approach to **modeling** QoS-QoE relationship
  - Which information is needed in each part.
  - Appropriate **testing methodology** and user **modeling**
  - Which is the connection between QoS → Application KQIs → Actual QoE / User experience
  - Which information **cannot** be shared (privacy, business, etc).
  - Which are the right **context** factors to take into account
  - Have a correct definition on the **metrics**

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VQEG 5GKPI

Potential areas for action (2/2)

- Define **requirements / protocols for applicability**
  - How to exchange information between parties
  - Actionable QoE:
    - Real time (resource reservation, react to problems)
    - Post-session: analytics, network dimensioning

- Provide **implementation** and/or validation
  - Open source implementations
  - Data sets
  - Tests

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VQEG 5GKPI

Next steps

- Create/update working group → Who is interested?

- Work on white paper (or equivalent)
  - Common language
  - Right approach to QoE modeling (asking the right questions)
  - (Discuss before writing! → This is a research activity on its own)

- Contribute to SDO
- Develop/test specific models (what use cases?)
- Create data sets

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Appendix: Panel Discussion

Supporting Slides

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Chaired by Narciso García

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Improving QoE Management

- Need to consider the various factors that influence QoE
  - **User** expectation, **context** influence factors, **app** requirements, **network** performance
- Difficult to assess the impact of each factor on the overall QoE
  - Models exist (e.g., parametric models) to compute an estimate of the QoE value
- **QoE** perception is highly **individual** and depends on expectation
  - Especially when considering content quality
  - User expectations could be used as **input** to the network for better QoE management
- VQEG: Focus more on modeling **QoE as perceived by individual**/classes of users, with different expectations, instead of one-size-fits-all QoE value

Enrico Masala, Politecnico di Torino University, Turin, Italy

VQEG 5G-KPI session

Christian Timmerer, Professor at AAU, Director at CD Lab ATHENA, Chief Innovation Officer at Bitmovin
Klagenfurt, Austria

July 1, 2024

Introduction / Motivation

Video streaming is dominating today's Internet traffic

- 2024*: **68% (fixed)** and **64% (mobile)**
  - Video on-demand: 54% / 57% – Live: 14% / 7%
  - Main applications: YouTube, Netflix (>10%), Tik Tok, Amazon Prime, Disney+ (<10%)

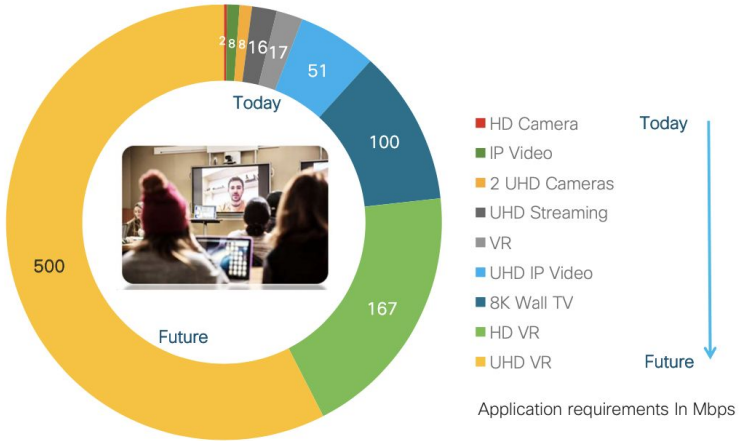
- Video and other applications continue to be of enormous demand in today's home, but there will be **significant bandwidth demands** with the application requirements of the future**

Top Content Categories by Downstream Volume – Fixed

	Downstream Volume		
	Content Category	% DS Vol	Sub. Volume
1	On-Demand Streaming	54%	7.9 GB
2	Live Streaming	14%	2.0 GB
3	File Delivery	13%	2.0 GB
4	Browsing	3%	441 MB
5	Game Play	3%	398 MB
6	Video Call	2%	300 MB
7	Messaging	0.6%	81 MB
8	Voice Call	0.5%	74 MB
9	Machine to Machine	0.01%	2 MB
10	AR/VR	0.00%	18 KB
11	Other	10%	1.4 GB

Top Content Categories by Downstream Volume – Mobile

	Downstream Volume		
	Content Category	% DS Vol	Sub. Volume
1	On-Demand Streaming	57%	900 MB
2	File Delivery	11%	173 MB
3	Live Streaming	7%	107 MB
4	Game Play	5%	75 MB
5	Video Call	5%	73 MB
6	Browsing	2%	38 MB
7	Messaging	2%	29 MB
8	Voice Call	1%	19 MB
9	Machine to Machine	0.00%	68 KB
10	AR/VR	0.00%	1 KB
11	Other	10%	160 MB



Sources:
* Sandvine Global Internet Phenomena (January 2024).
** Cisco Annual Internet Report (2018–2023) White Paper (March 2020)

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Common Media Client Data (CMCD)

CMCD is an open specification by CTA WAVE

- **Media player – CDN**
  Standardized protocol for exchanging information between the client and the CDN; bridging gap between client-side QoE metrics and server-side QoS data – better troubleshooting, optimization, and dynamic delivery adjustments by CDNs
- **CMCD: players send key-value pairs of data to CDNs**
  Encoded bitrate, buffer length, buffer starvation, content ID, object duration, deadline, measured throughput, next object request, next range request, object type, playback rate, requested maximum throughput, streaming format, session ID, stream type, startup, top bitrate
- **Benefits of CMCD**
  Troubleshooting errors and finding root causes faster
  Combine playback sessions and CDN logs with common session & content identifiers
  Improve the quality of experience and reduce rebuffering by enabling pre-fetching
  Integration with (Bitmovin's) analytics
- **GitHub**: https://github.com/cta-wave/common-media-client-data

Common Media Server Data (CMSD)

CMSD is an open specification by CTA WAVE

- **Media servers (origin and intermediate) towards media players**
  Standardized protocol to communicate data with each media object response towards media players (incl. any intermediary) to improve the efficiency and performance of distribution + QoE
- **CMSD: servers send key-value pairs (dynamic/static) of data towards players**
  Availability time, duress, encoded bitrate, estimated throughput, held time, intermediary identifier, max suggested bitrate, next object response, next range response, object duration, object type, response delay, round trip time, startup, stream type, streaming format, version
- **Benefits of CMSD**
  Let players make better informed decisions, better telemetry/service, reduce waste
  Lowering latency and slaying start-up buffering
  Facilitate in-network optimizations (edge computing)
- **GitHub**: https://github.com/cta-wave/common-media-server-data

VQEG 5G-KPI session

- **What are the main needs to improve content vs network integration in terms of QoE management?**
  Interoperable communication among participants
- **In theory, there are models, interfaces, etc. Why is it not working yet? What is missing?**
  CMCD/CMSD is considered/implemented by multiple vendors (e.g., Bitmovin) and CDNs (e.g., Akamai)
- **What can VQEG do about it?**
  Study usage of CMCD/CMSD in the context of quality (VQEG)

Some references

Abdelhak Bentaleb, May Lim, Mehmet N. Akcay, Ali C. Begen, and Roger Zimmermann. 2021. Common media client data (CMCD): initial findings. In Proceedings of the 31st ACM Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV '21). Association for Computing Machinery, New York, NY, USA, 25–33. https://doi.org/10.1145/3458306.3461444

Stefan Pham, Will Law, Ali C. Begen, Daniel Silhavy, Bertrand Berthelot, Stefan Arbanowski, and Stephan Steglich. 2023. Common Media Server Data (CMSD) – Update on Implementations and Validation of Key Use Cases. In Proceedings of the 2nd Mile-High Video Conference (MHV '23). Association for Computing Machinery, New York, NY, USA, 137–138. https://doi.org/10.1145/3588444.3591031

Abdelhak Bentaleb, May Lim, Mehmet N. Akcay, Ali C. Begen, and Roger Zimmermann. 2021. Common media client data (CMCD): initial findings. In Proceedings of the 31st ACM Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV '21). Association for Computing Machinery, New York, NY, USA, 25–33. https://doi.org/10.1145/3458306.3461444

Stefan Pham, Will Law, Ali C. Begen, Daniel Silhavy, Bertrand Berthelot, Stefan Arbanowski, and Stephan Steglich. 2023. Common Media Server Data (CMSD) – Update on Implementations and Validation of Key Use Cases. In Proceedings of the 2nd Mile-High Video Conference (MHV '23). Association for Computing Machinery, New York, NY, USA, 137–138. https://doi.org/10.1145/3588444.3591031

M. Nguyen, B. Taraghi, A. Bentaleb, R. Zimmermann and C. Timmerer, "CADLAD: Device-aware Bitrate Ladder Construction for HTTP Adaptive Streaming," 2022 18th International Conference on Network and Service Management (CNSM), Thessaloniki, Greece, 2022, pp. 198-204, doi: 10.23919/CNSM55787.2022.9964669.


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