QoS and QoE in 5G networks

Evolving applications and measurements

QSDG Workshop, Singapore, 19-21 August 2019

Dr. Jens Berger
Rhode & Schwarz Mobile Network Testing

Agenda

- What is 5G improving technically
- 5G deployment – first step is done
- ‘Who’ is using 5G and ‘how’ the 5G network will be used?
- New applications and use cases arising?
- How to measure QoS and QoE under 5G?
- How to score network performance?

5G technical improvements

Simply spoken: What do people expect and what are 5G promises?

- **More data-speed!** Technically it means more transport capacity.

- **More interactivity!** Technically it means very short transport latency.

- **More flexibility!** Technically addressed by ‘network slices’ serving different needs and QoS requirements.

- **New applications and use cases! (**Finally)

5G deployment – First step is done in field

- First 5G real field deployments are done!
- What does it mean in a first step?
  - **5G EN-DC → 5G non-standalone access**, covered by eMMB
  - Device is connected by LTE (4G), one or more 5G carriers are added for supporting downlink capacity
  - Requires dual coverage (4G + 5G)
  - Does only improve downlink, no uplink improvements
- **What is next?**
  - **5G standalone access (no dual coverage required, uplink improved too)**
  - **URLLC, mMTC**

Who uses 5G and how?

- Todays networks are optimized for humans using smartphones

- In 5G new **classes** of users will take advantage of the infrastructure
  - **Humans** (smartphone use case)
  - **Automotive** (connected, autonomous driving, Vehicle-to-X)
  - **Industry** 4.0 (Smart Manufacturing, private 5G networks)
  - **IoT, mMTC** (Smart City, Connected Energy,...)

Each class causes individual traffic patterns and has individual requirements to the network!

A network optimized for human users may not deliver best performance for cars or industry.

What to expect from 5G?

- Human users will be one user class amongst others
- Main popular applications will remain but evolve
- New application areas and use cases will be launched and used

- It is not a ‘switch-on’ rather a ‘phase-in’
  - Applications will use what is made available
  - There will be a transition phase

Category	Opportunity
Interactive Experience	Augmented Reality, Virtual Reality, 360 UHD
Social Networking	HD social videos, Live broadcasting, real time sharing and interaction anywhere/anytime
Wireless Home Entertainment	4K/8K Video, Cloud Edge Gaming
Connected Automotive	Autonomous Driving, Platooning, Tele Operated Driving, Collision Avoidance, Inter Vehicle communication (V2V), Vehicle to Infrastructure (V2I), Vehicle to Pedestrian (V2P)
Smart Manufacturing	Supply Chain, Product Life Cycle Management, Robotic control
Connected Energy	Energy monitoring, Supply Connections, Fault isolation
Wireless eHealth	Health/wellbeing monitoring, Remote diagnosis, Remote operation/medical robots
Connected Drones	Inspection, Security, Delivery
Smart City	Intelligent cameras, Management efficiency (bins/lights etc.), Security

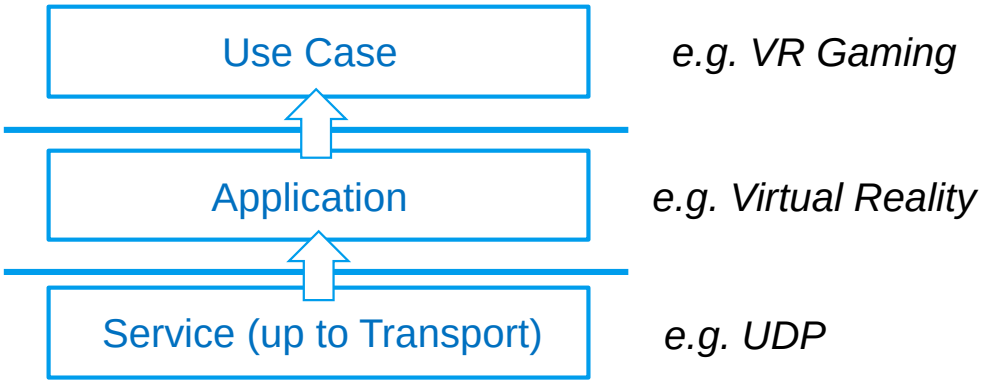
Source: HUAWEI

Short break! → …about Terminology.

- There is use of terms as ‘service’, ‘application’, ‘use case’ and more.
- Services are usually used for technical, primary services, e.g. telephony service, mobile data service
  - *There is also a term ‘messaging service’ applied to OTT messengers.*
  - *There will be for sure no ‘AR/VR service’…*
- Let’s agree for now:

(it is not fully correct and not applicable for all cases)

(there are ‘grey zones’ between)

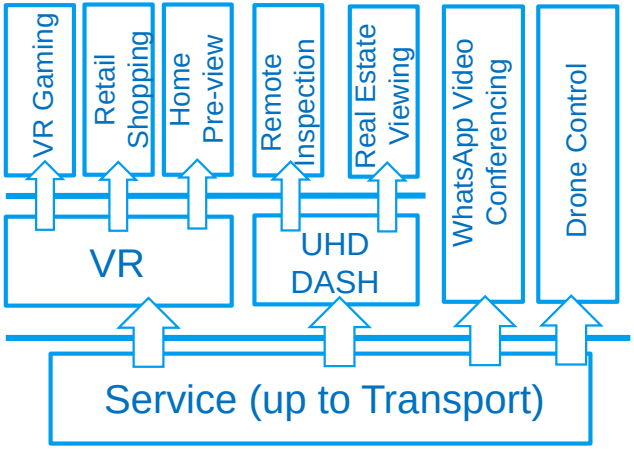


Short break! → …about Terminology.

- There is use of terms as ‘service’, ‘application’, ‘use case’ and more.
- Services are usually used for technical primary services, e.g. telephony service, mobile data service
  - *There is also a term ‘messaging service’ applied to OTT messengers.*
  - *There will be for sure no ‘AR service’…*
- Let’s agree for now:

(it is not fully correct and not applicable for all cases)

(there are ‘grey zones’ between)



…break is over: 5G!

Let’s start simple: How telephony will evolve in 5G?

- **3GPP Telephony** (telephony as primary service)
  - QoE makes no significant difference to 4G VoLTE
    - Very short call setup time, EVS 24.4 high quality coding
  - Accessibility and sustainability will further increase
  - Video Telephony may increase but strong competition by OTT

- **OTT Telephony**
  - Today (4G) OTT telephony applications are still behind VoLTE
    - Lower accessibility and sustainability (more failed and dropped calls)
    - Voice quality is lower due to time-warping and packet loss (unreliable channels), not by coding
  - Significant improvement in 5G (more reliable channels, short latency)

OTT services will become fully equivalent or even superior to VoLTE (because of wider functionality)

Data applications in in 5G, the vast majority

- **Existing applications and use cases**

  → Today's use cases will remain popular
  (HTTP-Browsing, Video streaming, OTT Messaging,…)

- **Evolving applications and use cases** (based on existing use cases)
  - 4K/8K video, HDR → Similar to today's video streaming, 'just' more bandwidth
  - 360° video, Virtual Reality → Similar to today's video streaming, 'just' more bandwidth
    → Rendering will move from device to core (in interaction with device)
  - Live broadcasting, video upstream → Similar to today's approach, more bandwidth, more reliable
  - Real time gaming → Similar to today's approach, more bandwidth, shorter latency, more reliable
    → Rendering will move from device to core (in interaction with device)

- **New applications and use cases**
  - Augmented reality and AR gaming, remote control, VR retail shopping,…
  - Highly adaptive to network conditions by ML and AI techniques

Data services: Use cases and applications

- There will NOT be totally independent implementations of applications (e.g. AR, live broadcasting,…) for individual services and use cases
- Individual use cases will use same underlying libraries and techniques and may lead to similar data patterns in the network
- Differences will be in the objectives and the requirements in performance

- *Example AR/VR used in many different areas*

Application	Area	Example Use Cases
AR/VR	Communications & Social	AR/VR Immersive Calling
		User generated AR/VR Content
		Stream my Life in 360
	Gaming & Entertainment	Outdoor Augmented Gaming
		Immersive sporting / music arenas
	Sports & fitness	Augmented/Virtual Stats & maps
		Augmented exercise/personnel trainer
	Retail & e-commerce	AR/VR Retail shopping
		Real Estate viewings/ Home preview
		Product Finder/In store navigation
	Industrial	Assisted maintenance
		Remote Support
	Health & Wellness	Remote patient care
		Assisted Surgery/ Post Op rehab

There will be
*not **the** AR use case and*
*not **the** AR QoE model*

Source: HUAWEI

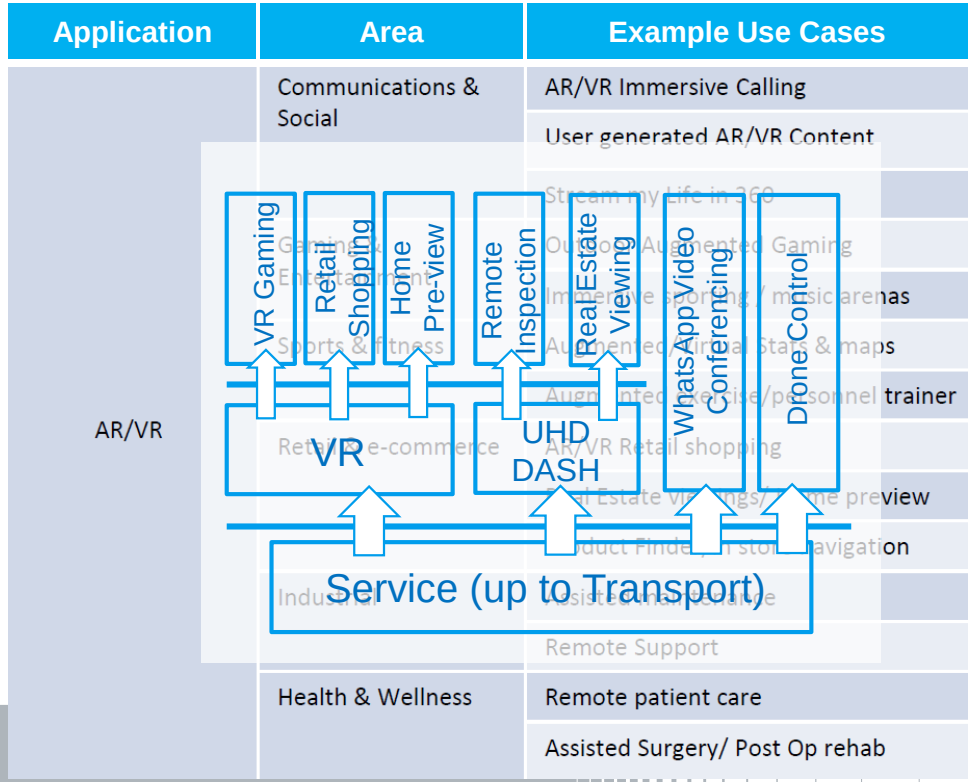
Data services: Use cases and applications

- There will NOT be totally independent implementations of applications (e.g. AR, live broadcasting,…) for individual services and use cases
- Individual use cases will use same underlying libraries and techniques and may lead to similar data patterns in the network
- Differences will be in the objectives and the requirements in performance

- *Example AR/VR used in many different areas*

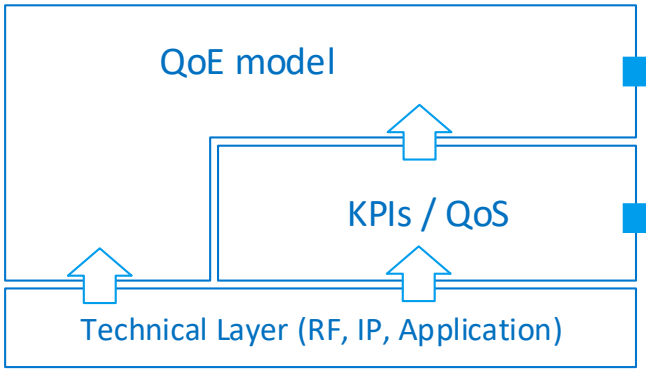
*There will be not **the** AR use case and not **the** AR QoE model*

Source: HUAWEI



How to measure QoS and QoE in 5G?

- KPIs and QoS parameters are independent from radio and access technology, but the acceptance thresholds have to be adjusted to new services.
- QoE is not directly depending of radio technology, but the expectation will increase with higher performance. Increasing expectation changes QoE but it happens for all technologies then.



QoE is based on Experience, experience on Expectation

Objectives and thresholds based on technical needs for applications

Expectation will change with new and evolving applications over time

Applications will become much more adaptive to network conditions than today by ML and AI techniques!

How to measure QoS and QoE in 5G?

- QoE considers a user's expectation, QoS is more rational based on technical measurements

- Existing applications and uses cases (e.g. Web-Browsing, Video Streaming) are used in 5G too
  - KPIs and QoS parameters are the same as for 4G and below, they are widely independent from radio technology
  - Quality usually reads as 'quality of media presentation', e.g. Speech-MOS or Video-MOS
  - QoE models stay for a while too. Along with increasing expectation, QoE models have to be re-adjusted

- Evolving and new services (e.g. 4K Video, Virtual Reality, Real-time Broadcasting, Real-time Gaming)
  - Many existing KPIs and QoS parameters and concepts can be used (access time, failure ratio,…),
  - New KPIs and QoS parameters are required for e.g. response times, seamless connectivity and similar
  - New QoE parameters for quality (e.g. 4K Video, 360° Video) are required
  - Quality will go beyond today's 'media presentation' concept and will include e.g. 'interactivity'

What drives subscriber's QoE and satisfaction in general?

The R&S QoE concept considers three different dimensions
and can be adjusted to almost each application and/or use case

- Accessibility and sustainability
  - Do I have access to the 'service' at all and is it 'technically' kept?
  - (Do I stop waiting because of too long waiting times?)
  - (Do I stop because of bad quality or limited functionality?)
- Waiting time for 'action' (task being started and/or completed)
  - How long the access takes (e.g. Call Setup Time, Video Access Time)
- How is the quality / experience during active use
  - How is 'quality' (e.g. video quality)
  - How is interaction, 'fluentness', response time,…

QoE of a use case or application

What drives subscriber's QoE and satisfaction in general?

The R&S QoE concept considers three different dimensions
and can be adjusted to almost each application and/or use case

Counted as 'soft drop'?

- Accessibility and sustainability
  - Do I have access to the 'service' at all ... is it 'technically' kept?
  - (Do I stop waiting because of too long waiting times?)
  - (Do I stop because of bad quality / limited functionality?)
- Waiting time for 'action' (task being started and/or completed)
  - How long the access takes (e.g. Call Setup Time, Video Access Time)
- How is the quality / experience during active use
  - How is 'quality' (e.g. video quality)
  - How is interaction, 'fluentness', response time,…

I stop, if waiting is too long.

I stop, if quality is too low.

QoE of a use case or application

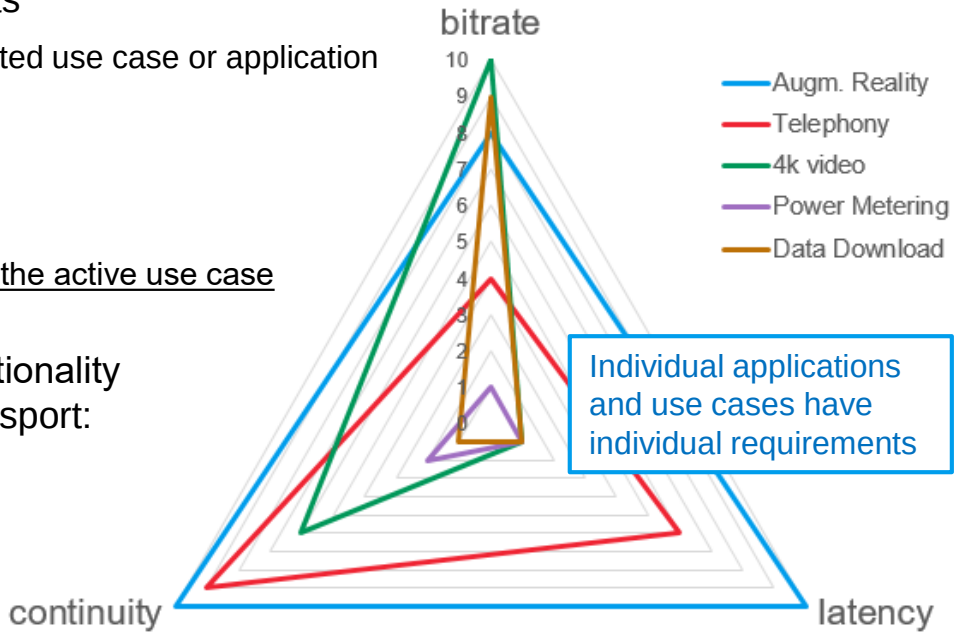
How to measure QoS and QoE of 5G applications und use cases?

- The number of applications and related use cases will increase by sizes in 5G
- There are always ‘common’ QoS/QoE indicators as
  - Availability, accessibility and sustainability of the requested use case or application
  - Waiting time to use the offered functionality
  - → Availability will increase to ‘always available’,
  - → Waiting time will become shorter and shorter
  - → Focus will move towards ‘quality’, means experience of the active use case

- The quality and experience of the use case’s functionality as such is determined by three dimensions of transport:
  - **Transport capacity** (‘bitrate’)
  - **Transport duration** (’latency’)
  - **Transport continuity** (‘seamless’ transport’)

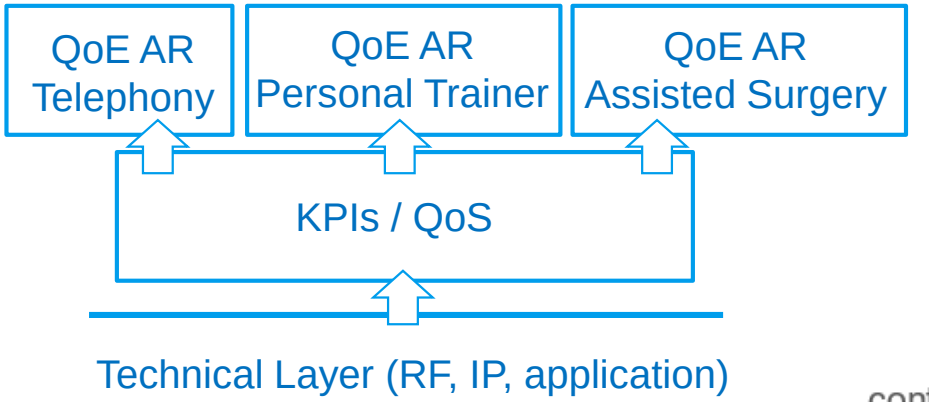
How to measure QoS and QoE of 5G applications and use cases?

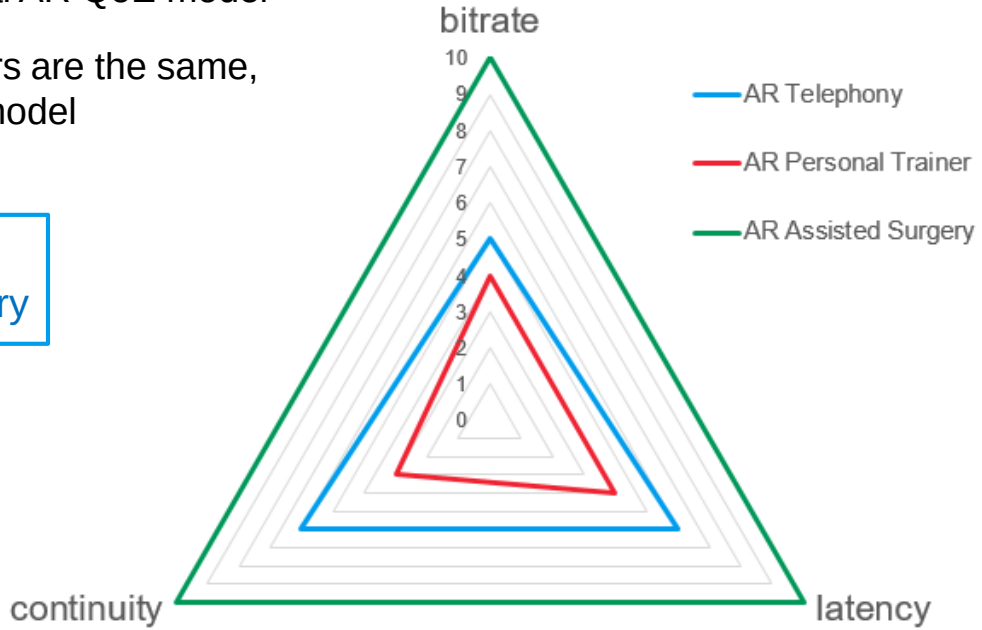
- The number of applications and related use cases will increase by sizes in 5G
- There are always ‘common’ QoS/QoE indicators as
  - Availability, accessibility and sustainability of the requested use case or application
  - Waiting time to use the offered functionality
  - → Availability will increase to ‘always available’,
  - → Waiting time will become shorter and shorter
  - → <u>Focus will move towards ‘quality’, means experience of the active use case</u>
- The quality and experience of the use case’s functionality as such is determined by three dimensions of transport:
  - **Transport capacity** (‘bitrate’)
  - **Transport duration** (’latency’)
  - **Transport continuity** (‘seamless’ transport’)



Application Augmented Reality as example

- There are tons of use cases using Augmented Reality
- QoE depends on the use case, there is no general AR QoE model
- But: The underlying KPIs and technical parameters are the same, differences are how they are weighted in a QoE model





Summary

- Most of today's popular applications and use cases will continue under 5G, KPIs and QoS will further apply
  - 'Service' accessibility and sustainability will increase to 'always available'
  - 'Waiting' time will be very short
    - → Focus will move more and more to quality in a given, running (active) use case
    - → Existing QoE models have to be re-adjusted (mid-term)
- Evolving and new applications and use cases will require new QoE models
- Increased bitrate and related KPIs are not sufficient anymore

→ Interactivity and continuity of transport become crucial for real-time applications under 5G

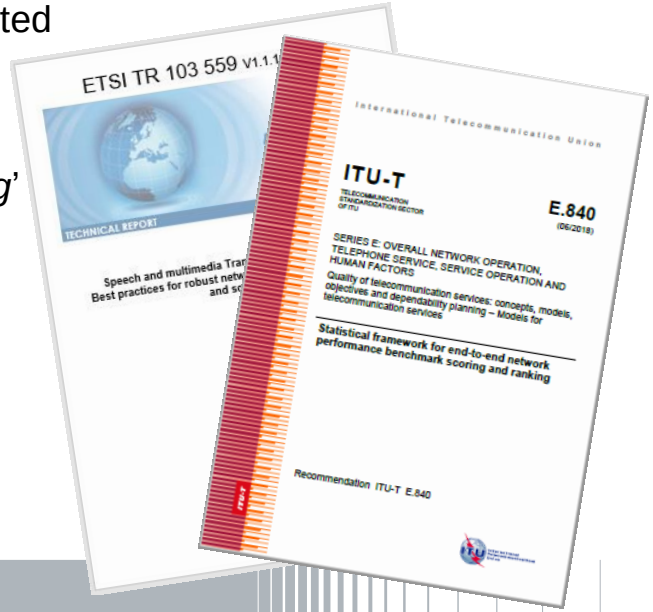
→ KPIs and QoS parameters for interactivity and continuity have to be developed and accepted

→ New applications will be highly adaptive to network conditions by ML / AI and optimize QoE over time

How to score a general network's performance? …ready for 5G?

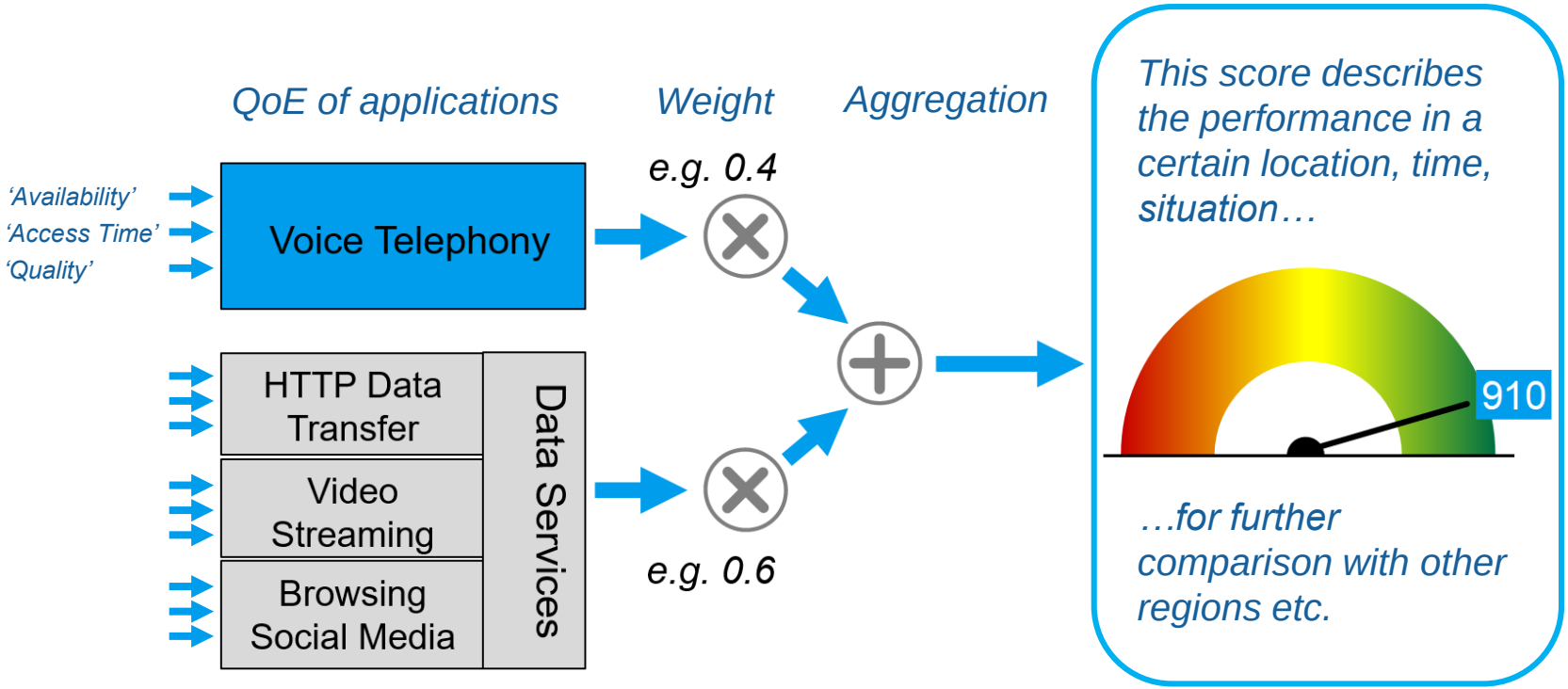
- Performance scoring considers different typical applications and use cases
- Performance is based on QoE (today for human users)
- Regional or other morphological categories can be applied and weighted

- ETSI TR 103 559 (brand new: ratified 07/2019)
  '*Best practices for robust network QoS benchmark testing and scoring*'
- ITU E.840 (06/2018)
  '*Statistical framework for end-to-end network-performance benchmark scoring and ranking*'



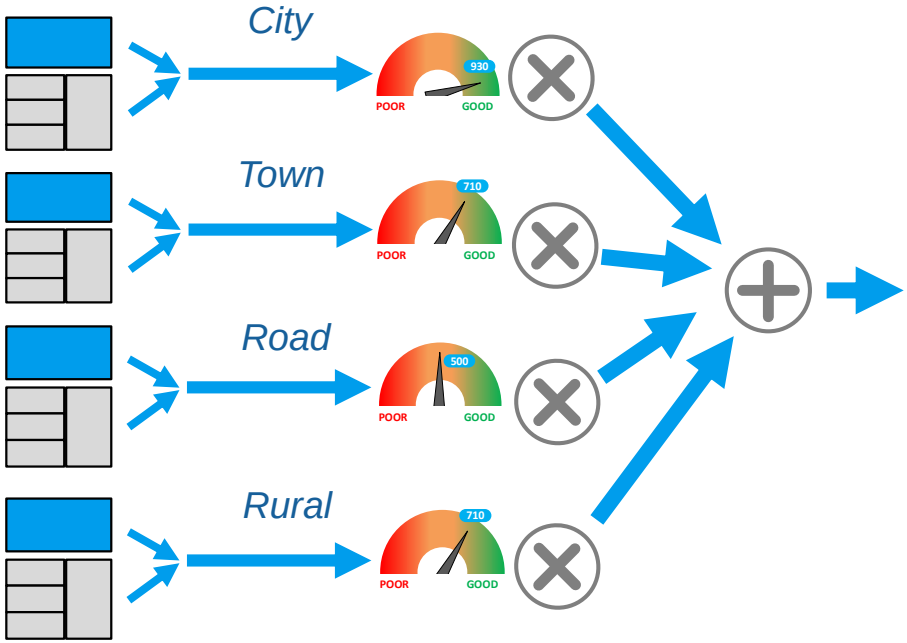
How to score a general network's performance?

Principle: An aggregation model

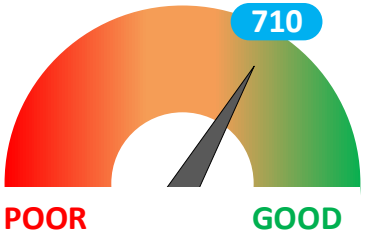


How to score a general network's performance

Principle: An aggregation model



This score describes the performance 'country-wide…'



…for further comparison with competitors or other markets etc.

Network performance scoring under 5G requirements

- Many of today's applications remain or will 'only' evolve
- New applications will become more real-time and more interactive

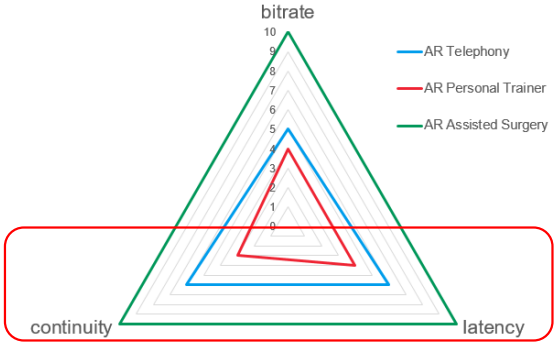
- The principle of an aggregation model can be kept
- The change will be on lower layers

  - Today: Performance based on simple up-/download functionalities (browsing, video streaming, posting)
  - **5G: Real-time functionality and interactivity (no established measures in scoring methods)**
    Consideration of typical applications and use cases based on AR/VR, remote control,…

  - Today: Scoring models 'performance as by humans'
  - **5G: Multiple models scoring 'performance as by Automotive', '…as by Remote Factoring', …**

Network performance scoring under 5G requirements

- Many of today's applications remain or will 'only' evolve
- New applications will become more real-time and more interactive



- You may remember:
  - The quality and experience of the use case's functionality as such is determined by three dimensions of transport:
    - **Transport capacity** ('bitrate')
    - **Transport duration** ('latency')
    - **Transport continuity** ('seamless' transport')

This is key for real-time interaction

Thank you!

…and keep being real and interactive

ROHDE&SCHWARZ
Mobile Network Testing