QoS/QoE NETWORK PERFORMANCE TESTING IN 5G/6G

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Rohde & Schwarz mobile network testing

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Make ideas real

ACTIVE TESTING MOBILE NETWORKS – APPLICATION LAYER

▶ **2G/3G (GSM/UMTS)** era → *Test calls, FTP/HTTP up-/download, SMS, Ping*
  – Rather constant network setups after optimization
  – Except cell load: rather constant behavior in performance, congestion in telephony

▶ **4G (LTE/LTE+)** era → *…, + apps, video, social media, VoIP, messengers,… speed tests*
  – Inter-Technology handovers, dynamic resource mgmt. (CA) within rather constant setups
  – Still time-constant networks, congestion in data transfer due to load

▶ **5G / 6G** era → *…, + interactive / real-time services, new 'players'*
  – Highly dynamic network adjustment changing in time, per location, based on 'targets' (e.g. performance, power saving). AI used for local, temporary automated optimization
  – Achieving constant very short data latencies is a main challenge

EXPANSION OF MOBILE NETWORKS AND USE CASES

Cellular ('mobile') networks

$$$

Human use cases
- Telephony, messaging
- Web browsing
- Video streaming

Non-human use cases (IoT)
- Power meter
- Recycling
- Transport

Mission critical communication
(authorities, civil protection, defense, first responders,,...)
- Telephony / Video call
- Data up- / download
- Video upstream (body cam, drone)
- Positioning

Business critical communication
- Real-time factory control, production
- Logistics and transport
- Securing air corridors (drone transport)
- …

SOS

Offload

dedicated Infrastructure

Non-critical

Business critical

Verticals

Emergeny eCall,…

Mission critical

Non-critical

Consumer "Traditional"

Smartphone	IoT Devices	"Modem"	IoT Devices
			Smartphones

MC Smartphone

Country / area wide mobility is important

Wider mobility is less important

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EXPANSION OF MOBILE NETWORKS AND USE CASES

Cellular ('mobile') networks

Public networks	Private networks
	Slice (dedicated resources)	Independent ('dedicated infrastructure')

Verticals

Non-critical

Business critical

Emergeny eCall,…

Non-critical

Mission critical

Consumer "Traditional"

Smartphone — IoT Devices — "Modem" — IoT Devices

MC Smartphone — Smartphones

…as today
(Telephony, streaming, retrieving web-content, file upload, video conferencing,…)

Human + Non-human use
- **Telephony / Push-to talk**
- **Modem devices (cam, drone)**
- Typical protocols and traffic patterns
- Video upstream
- Position tracking

Non-human use cases
- **Non-smartphone devices**
- **Different traffic and load patterns**

→ there are the usual suspects:
  → eMBB
  → mMTC
  → URLLC

…as today

Real-time interactive services
(Gaming, VR/XR applications, smart home, remote control,…

Real-time interactive services

... OF MOBILE NETWORKS AND USE CASES

Spectrum clearing

Acceptance

Network audit
Performance evaluation

Benchmarking

Monitoring

Cellular ('mobile') networks

... networks

Private networks

Slice
(dedicated resources)

Independent ('dedicated infrastructure')

...critical

Business critical

Verticals

Non-critical

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Consumer "Traditional"

Smartphone

IoT Devices

"Modem"

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Real-time
interactive
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Real-time interactive services
(Gaming, VR/XR applications,
smart home, remote control,…)

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EXPANSION OF MOBILE NETWORKS AND USE CASES

Cellular ('mobile') networks

Public networks		Private networks	
Spectrum clearing	Spectrum clearing	**Spectrum clearing**	**Spectrum clearing**
Acceptance	Acceptance	**Acceptance**	Acceptance
Network audit Performance evaluation	**Network audit** Performance evaluation	**Network audit** Performance evaluation	Network audit Performance evaluation
Benchmarking			
Monitoring	**Monitoring**		IoT Devices Smartphones

Regulators

IoT Devices

"Modem"

...as today
(Telephony, streaming, retrieving web-content, file upload, video conferencing,…)

Non-human use cases
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...as today

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Real-time interactive services

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CONSEQUENCES FOR TESTING NETWORK PERFORMANCE

QoS

► QoS / technical KPIs to test?

   ► Real-time, interactive services need KPIs based on short-term evaluation

   ► Statistics must reflect more than 'averages'
   e.g. median instead of average for asymmetric distributed measurement values,
   percentile values consideration of peaks and undercuts

      …don't use Ping, it does not create a load profile

► QoS measurements under realistic load conditions

   ► Real services or applications
   e.g. phone call, download a web page, streaming a video

   ► Generic tests creating realistic load
   e.g. realistic transfer rates as in ITU-T G.1051
   Note: 'ping' is not stimulating realistic network traffic

ITUPublications
Recommendations

International Telecommunication Union
Standardization Sector

Recommendation

ITU-T G.1051 (03/2023)

SERIES G: Transmission systems and media, digital
systems and networks

Multimedia Quality of Service and performance – Generic
and user-related aspects

**Latency measurement and interactivity
scoring under real application data traffic
patterns**

CONSEQUENCES FOR TESTING NETWORK PERFORMANCE

Best practice:
ITU-T P.863 'POLQA' for voice
ITU-T J.343.1 for video

QoE

▶ Simplified: What are aspects of 'experience' of a s

    ▶ **Success** of a service or application (complet

    ▶ **Time to** … (Call setup, video start, web cont

    ▶ **Quality of presentation** (speech/video quali

▶ Many underlying QoS parameters

    ▶ DNS resolution

    ▶ Throughput, IP-Capacity

    ▶ Latency, latency variation

    ▶ Loss, discontinuous transmission

QoE

=

end-to-end

→ How to apply in real field?

EXPANSION OF MOBILE NETWORKS AND USE CASES

EVALUATION OF NETWORK PERFORMANCE

▶ Often 'network performance' is used equivalent to 'data speed' or 'bitrate'

▶ Network performance is more, it should consider all dimensions of network use

    ▶ *What are use cases or services and how important are they?*

    ▶ *How to derive a QoE performance per service?*

▶ A network is not a single point, it is deployed region- or country-wide

    ▶ *How to aggregate performance measures across a region or a country?*

▶ A network is not homogenous, not geographically and not technology-wise.

    ▶ *How to consider a wide variation of local performances*

    ▶ *How to stay technology-agnostic?*

EVALUATION OF NETWORK PERFORMANCE
TYPICAL USE CLASSES IN PUBLIC NETWORKS

Performance evaluation must cover **all aspects of network use**

P2P direct
real-time connection

Telephony
Remote Meeting

Continuous transfer
of media, real-time

Streaming media
Online gaming
VR Applications

Up- or download files

Messaging
Browsing
Social media
File transfer

Network performance
on low layer

Data speed
Latency

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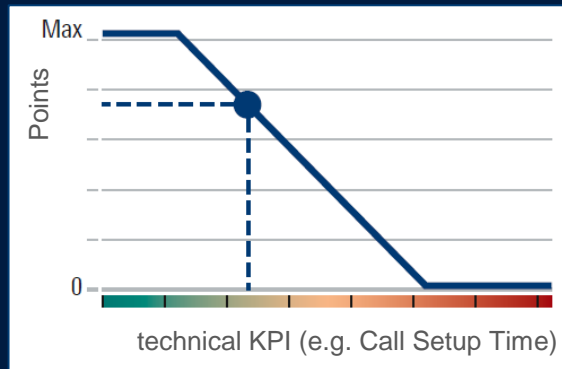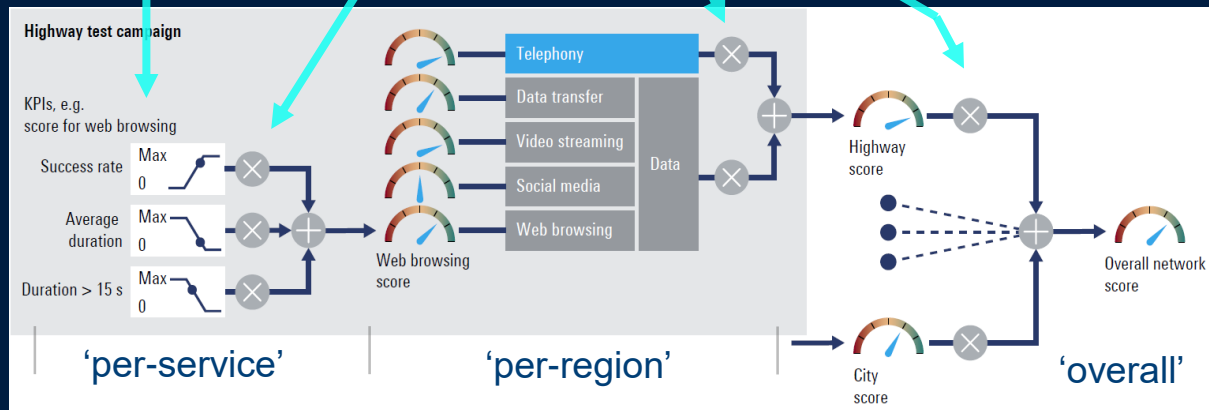File transfer

Network performance
on low layer

Data speed
Latency
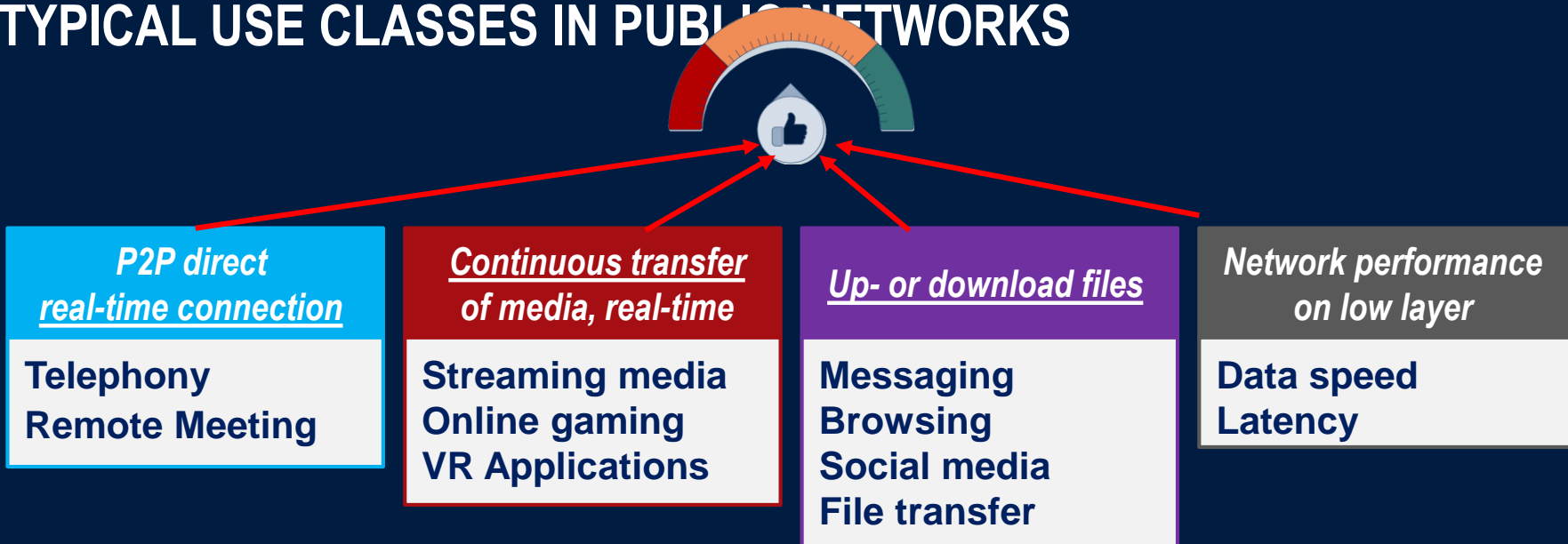
NETWORK PERFORMANCE SCORE
IN PRINCIPLE: AN AGGREGATION MODEL

Each technical KPI is transformed to a **perceptual** point scale. This makes the KPIs directly comparable (same scale).

Each KPI is weighted according to its importance and further combined and aggregated with other KPIs.
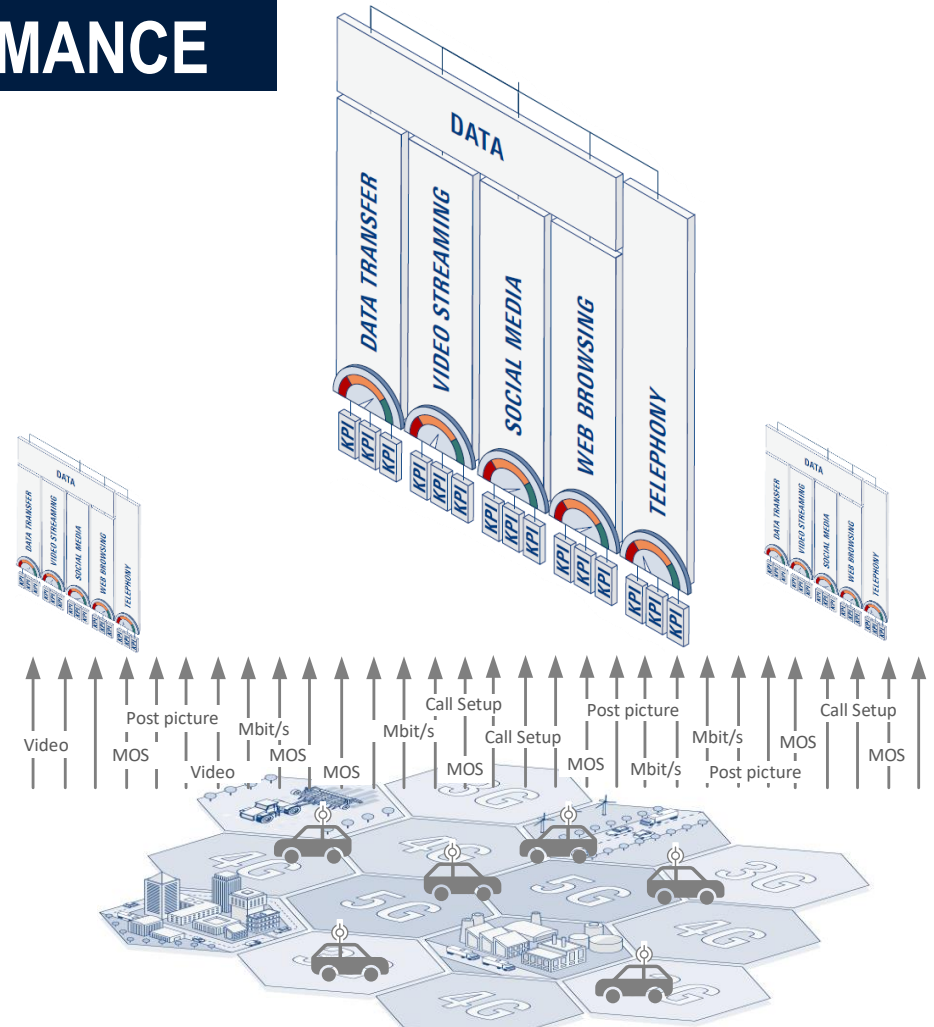

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SCORING NETWORK PERFORMANCE

Integrated score per 'service'

All technical KPIs 'as usual' are measured, accessible and reported

You will not loose any detail!
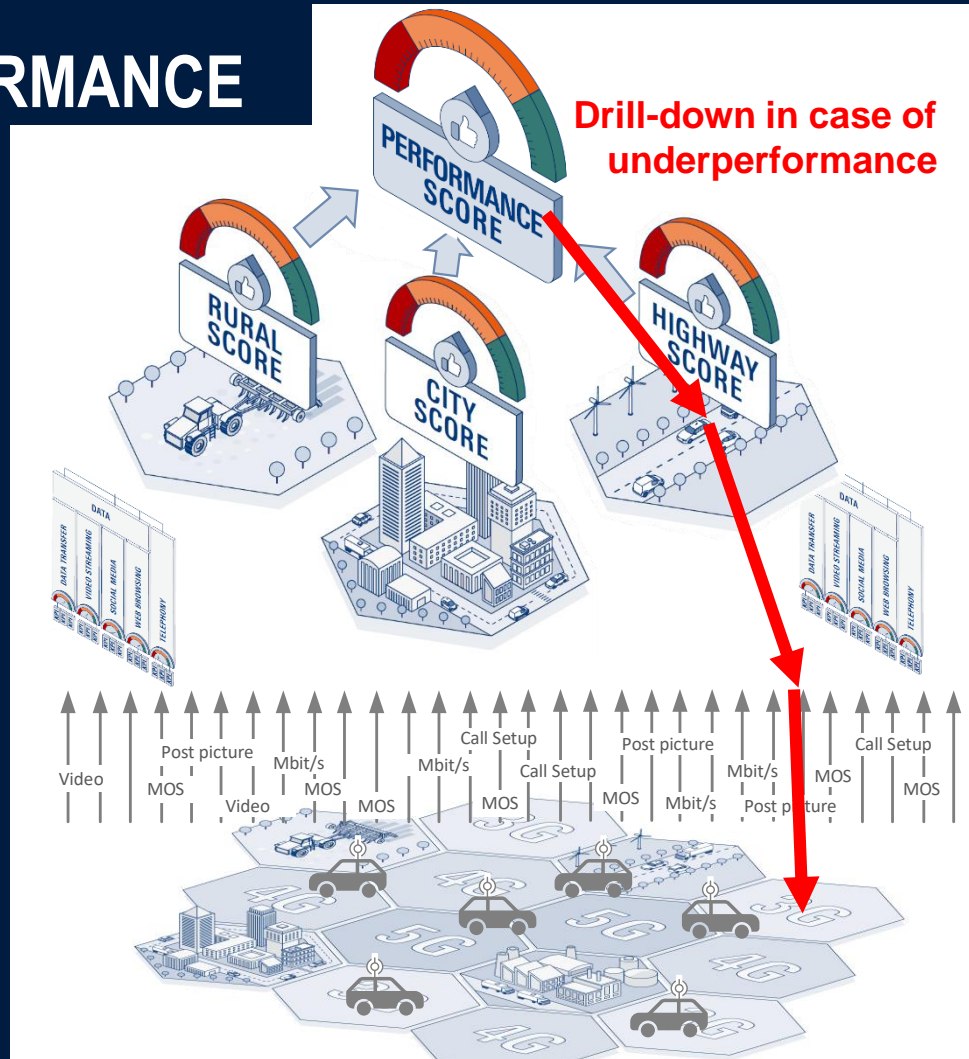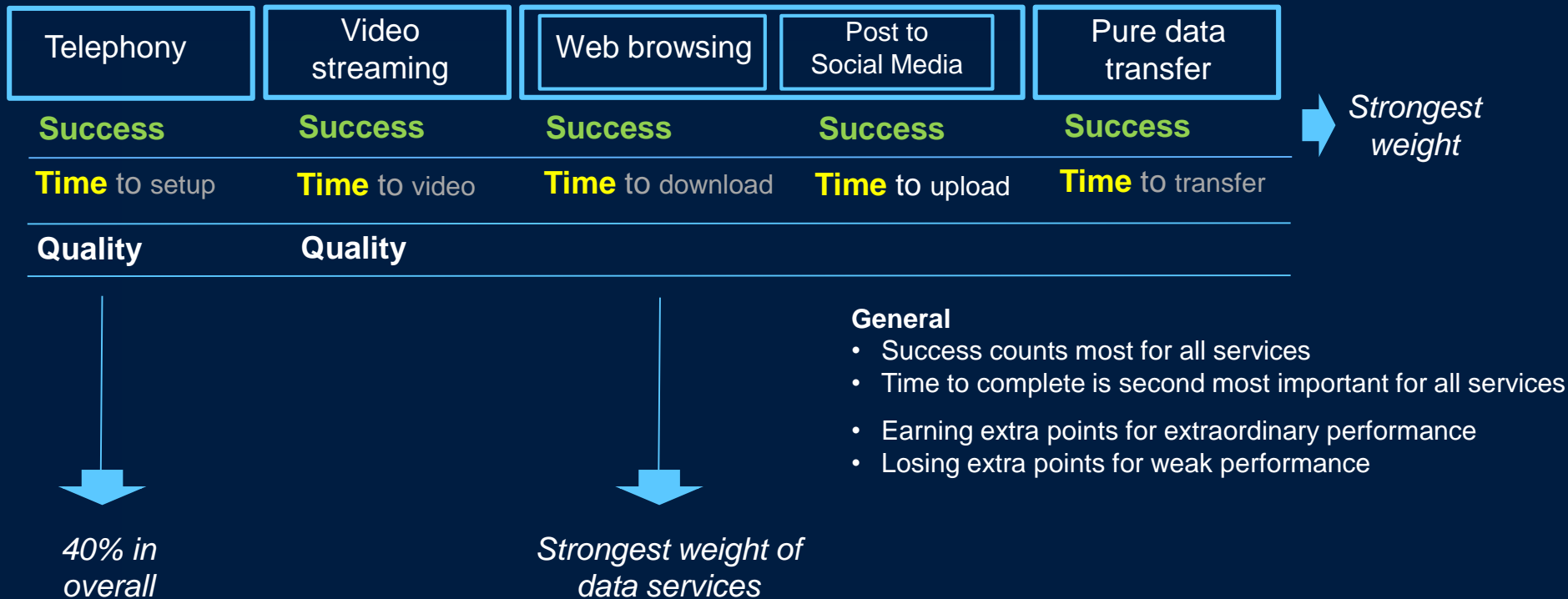
SCORING NETWORK PERFORMANCE

Integrated score 'overall'

Integrated score per 'region'

Integrated score per 'service'

All technical KPIs 'as usual' are measured, accessible and reported

You will not loose any detail!

Drill-down in case of underperformance

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NETWORK PERFORMANCE SCORE
SIMPLE CONSTRUCTION PRINCIPLE

Telephony	Video streaming	Web browsing	Post to Social Media	Pure data transfer
Success	**Success**	**Success**	**Success**	**Success**
Time to setup	**Time** to video	**Time** to download	**Time** to upload	**Time** to transfer
Quality	**Quality**			

Strongest weight

General
- Success counts most for all services
- Time to complete is second most important for all services

- Earning extra points for extraordinary performance
- Losing extra points for weak performance

40% in overall

Strongest weight of data services

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ETSI TR 103 559
ROBUST SCORING NETWORK PERFO

► TR 103 559 describes the methodology, the KP
  guidance for scoring network's end-to-en

► TR 103 559 methodology is techn

► Referenced in ITU-T E.804.1

► Scoring is based on standardize

  ► Telephony: ETSI T

  ► Speech Quality: ITU-T P.

  ► Video/YouTube: ETSI TR

  ► Video Quality: ITU-T J.343

  ► Data Transfer: ETSI TS 102

  ► Browsing: ETSI TS 102 2   SI TR
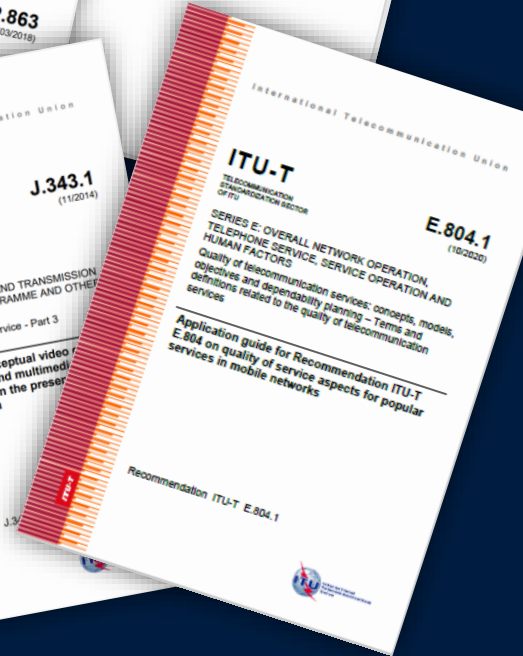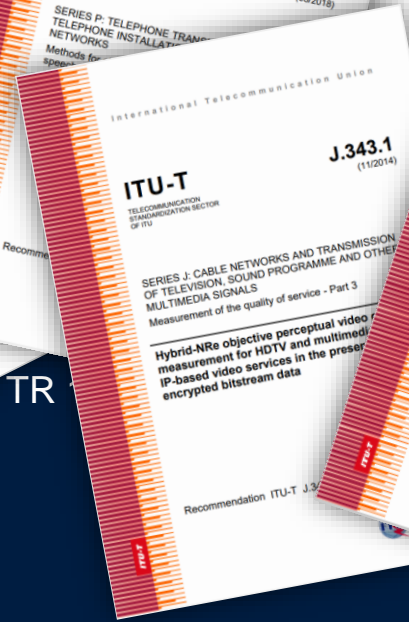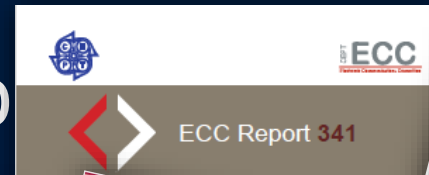
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▶ Scoring is

    ▶ Teleph

    ▶ Speech quality:

    ▶ Video/YouTube: ETSI TR 1

    ▶ Video Quality: ITU-T J.343.

    ▶ Data Transfer: ETSI TS 102

    ▶ Browsing: ETSI TS 102 23

▶ Obtaining the KPIs according to standard

▶ Aggregating to Performance Score

▶ Statistical Evaluation

EXPECTED MAJOR TRENDS TO BE CONSIDERED FOR 5G/6G

► Telephony / conferencing
- Stays a relevant service, transition to **VoNR** requires field testing
- **OTT VoIP** telephony services become equivalent in use and quality
- Telephony extends towards **interactive and audio-visual** experience

► Media / Web content delivery
- Streaming stays very relevant, transition to **interactive use cases**
- **VR/XR apps** and **cloud gaming** require very short interaction times
- Social Media become more **interactive**

► 5G beyond smartphones
- eMBB, mMTC, URLLC, **real-time** control
- Office applications via hotspot, **connected cars**, smart home
- **Private 5G networks**

SOME SELECTED DOCUMENTATION OUTSIDE ITU-T

► ETSI TR 103 559: Network performance scoring
(Methodology, KPIs, gives guidance for scoring network's <u>end-to-end performance)</u>

► ETSI TR 101 578: Testing mobile video streaming

► ETSI TR 103 733: Testing Browsing / Web Content Delivery

► ETSI TR 103 702: QoS Aspects for 5G

► …more to come 2023/24 (OTT VoIP testing, cloud gaming,…

► CEPT / ECC Report 341: …performance aspects for 5G

► ETSI TS 102 250-2: Reflected in ITU-T E.804, focus on newer technologies: ITU-T E.804.1

THANK YOU!

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