

Why operations support systems (OSS) are not the answer to all? Enhanced network performance evaluation with mobile probes

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Why operations support systems (OSS) are not the answer to all?

Mobile Network Operator



Do I get all the answers from my OSS?

OSS

Provides valuable information about the network and triggers capacity enhancements, but vendor-specific models mostly work on

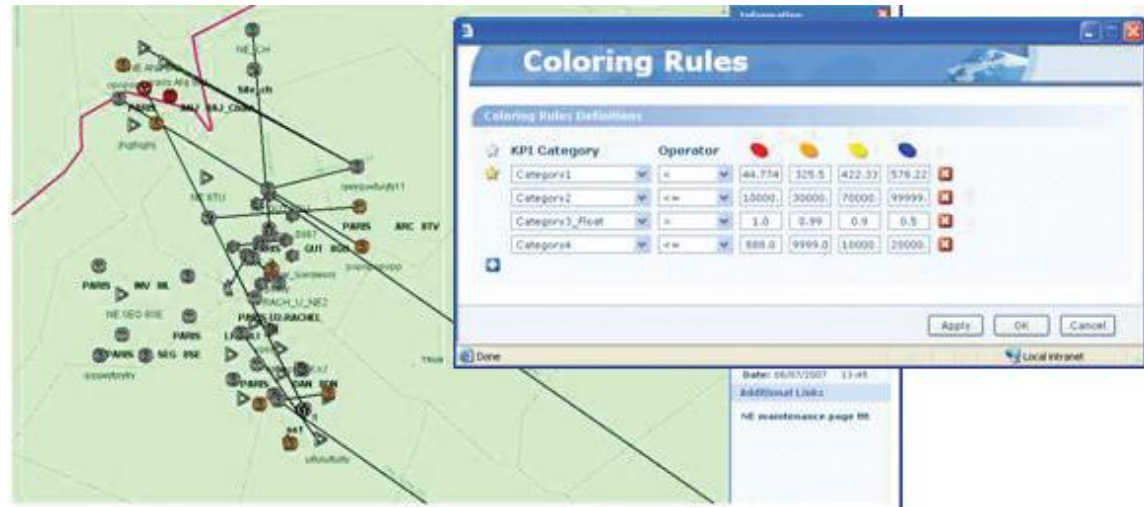
- cell load (%),
- medium- to long-term network/cell KPI and
- medium- to long-term fault statistics

Mobile Network Testing (MNT) in addition provides the end user view (user perceived capacity):

- Free capacity is measured at certain locations instead of % free cell resources (OSS counters)
- It is not “either MNT or OSS/SON” → it is “MNT and OSS/SON”!
(MNT to provide validation of vendor specific OSS models and simulation performance)

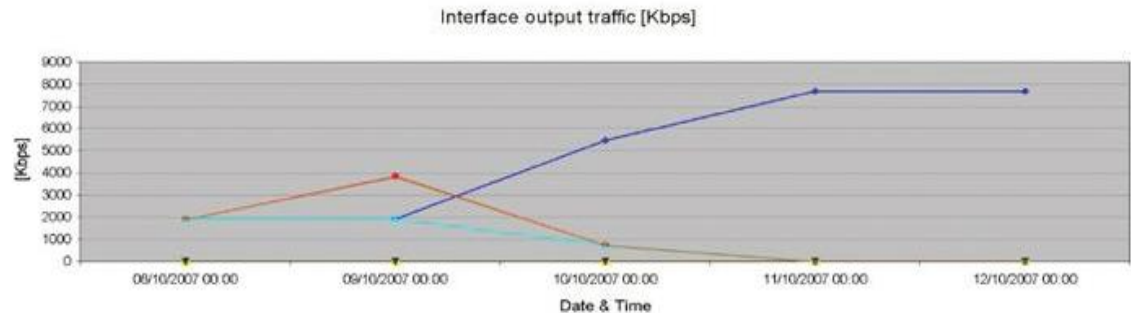
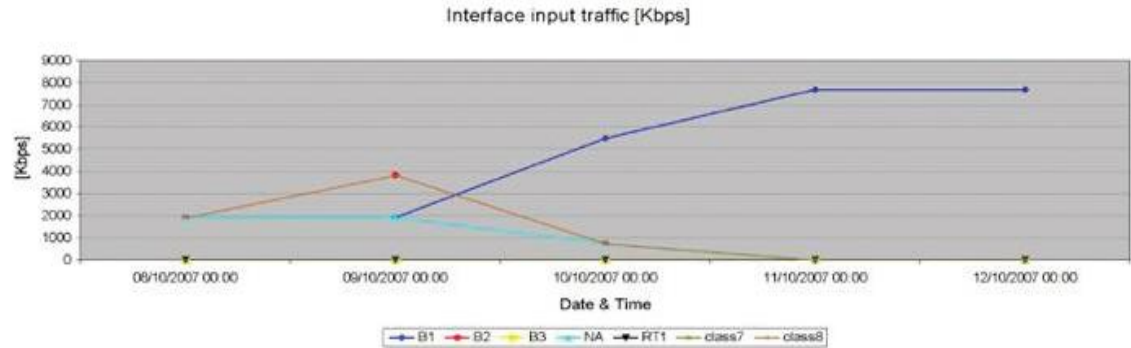
OSS performance management sample

- Simple performance mapping
- KPI generation with modded source database
- Integrated tool for thinning out data – *Lossy*
- A significant **gap** between meas time (not real-time)



OSS traffic report sample

- Typical OSS Traffic report ->
- OSS provides triggers for capacity enhancements (network view)
- True network performance perceived by end users before capacity enhancement
- Network Performance should be measured in a reliable way from users' perspective



Reasons for using probes in addition to OSS

OSS:

- Non active testing
- Not controllable and not reproducible
- No detailed radio information
- Limited location precision (except for geo-location solutions)
- No visibility in coverage gaps
- No voice/video quality representing user perspective
- No real time KPIs (generally 15 minutes or more)
- Large solutions, hence large budget approvals required
- 3rd party OSS requires integration in Mobile Operators eco-system and processes
- (+) larger scope and end to end view (including core network)



Enhanced KPI evaluation and deep analysis solution



QualiPoc - Product Family Overview

Optimization

QualiPoc Android THE PREMIER HANDHELD TROUBLESHOOTER

QualiPoc Android is a multi-functional smartphone-based tool for voice, video and data service quality troubleshooting and RF optimization. As the premier handheld troubleshooter, QualiPoc Android set a new industry standard for smartphone-based Mobile Network Testing.



Benchmarking

QualiPoc Freerider THE ULTIMATE PORTABLE BENCHMARKER

The compact, lightweight, and well-designed backpack provides extensive functionalities to test voice, data, video, and messaging to assess quality of service (QoS) and quality of experience (QoE) from a real end-user perspective, including the complete information about the physical RF environment.



Service Quality Monitoring

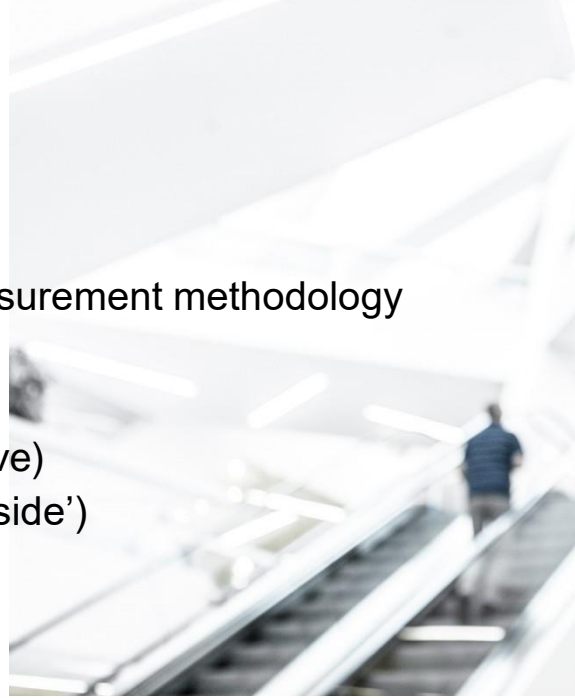
QualiPoc Android Probe NON-STOP SERVICE QUALITY MONITORING

QualiPoc Probe is a versatile, smartphone-based mobile network probe for unattended network-wide non-stop service quality monitoring and optimization. It is remotely controlled and delivers in real-time a continuous stream of KPIs and insight into network quality just as the customer perceives it.



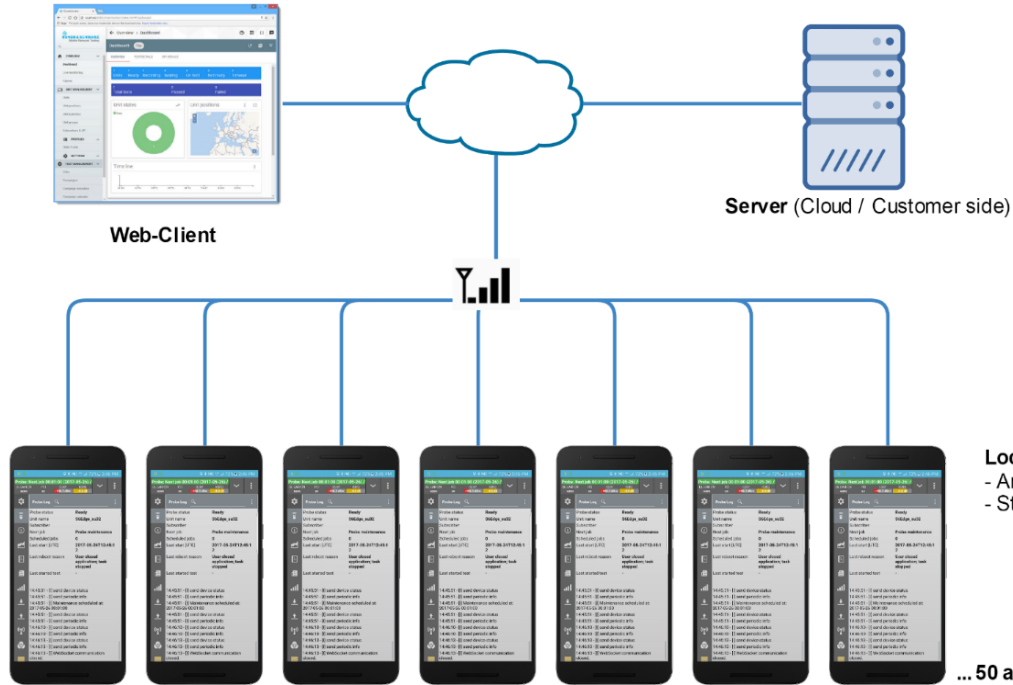
Probe subsystem

- User view KPI
- Patented 'Network Performance Test' measurement methodology
- Network Utilization Trend Analysis
- Weighted Network Performance Score
- Forecasting and Capacity Management (live)
- Long-term monitoring with live load ('user side')
- IP Trace + SIP/RTP Handling
- Layer 3 view
- PCAP export
- Send/Receive/Compare



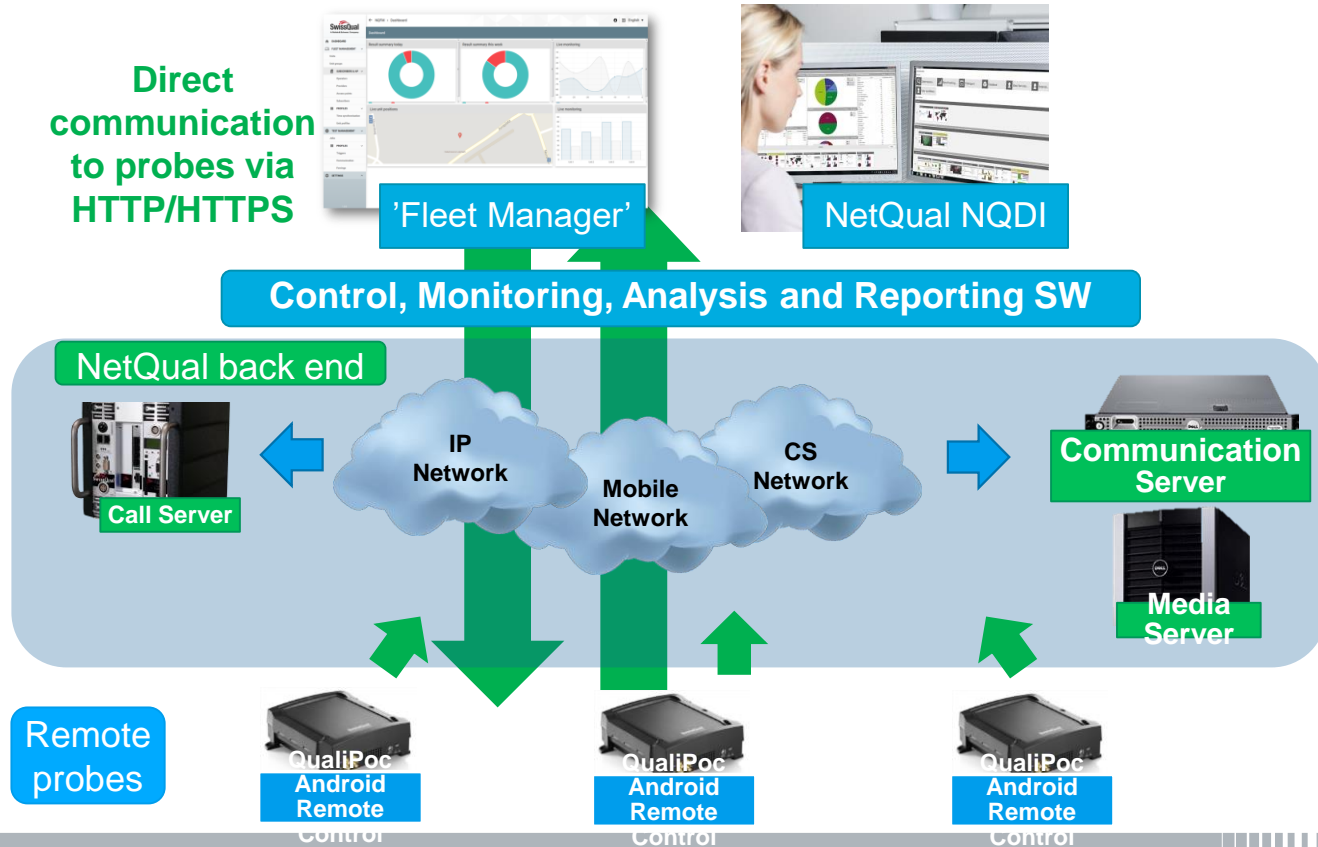
QualiPoc Remote Probe with SmartMonitor

Remote Controlled Shell (RCS) with Power Control

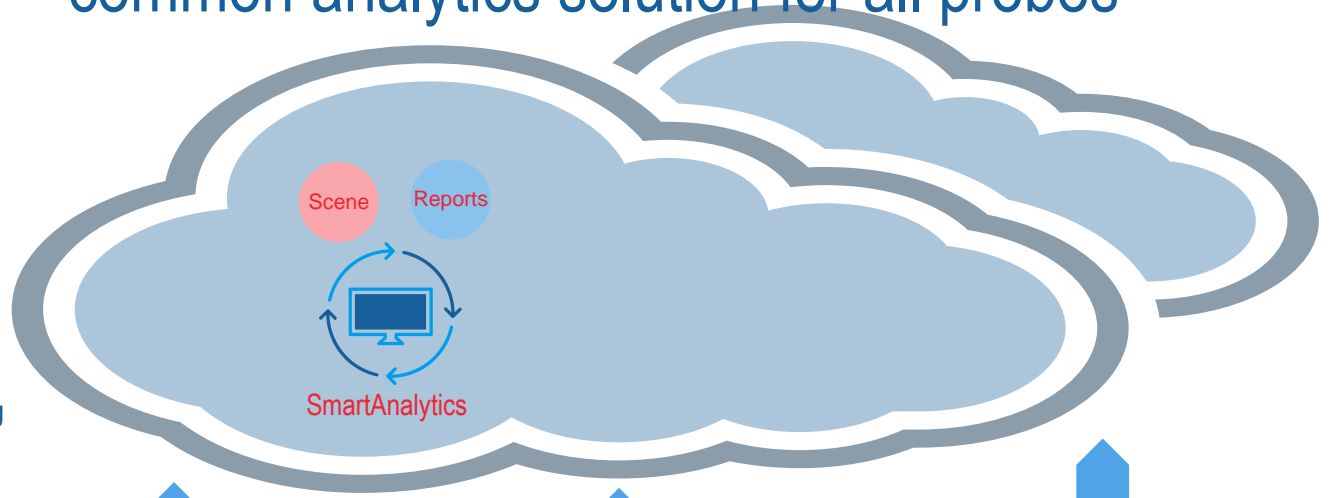


Location-Provider:
- Android Internal GPS
- Static Location

QualiPoc Remote Control



SmartAnalytics – common analytics solution for all probes



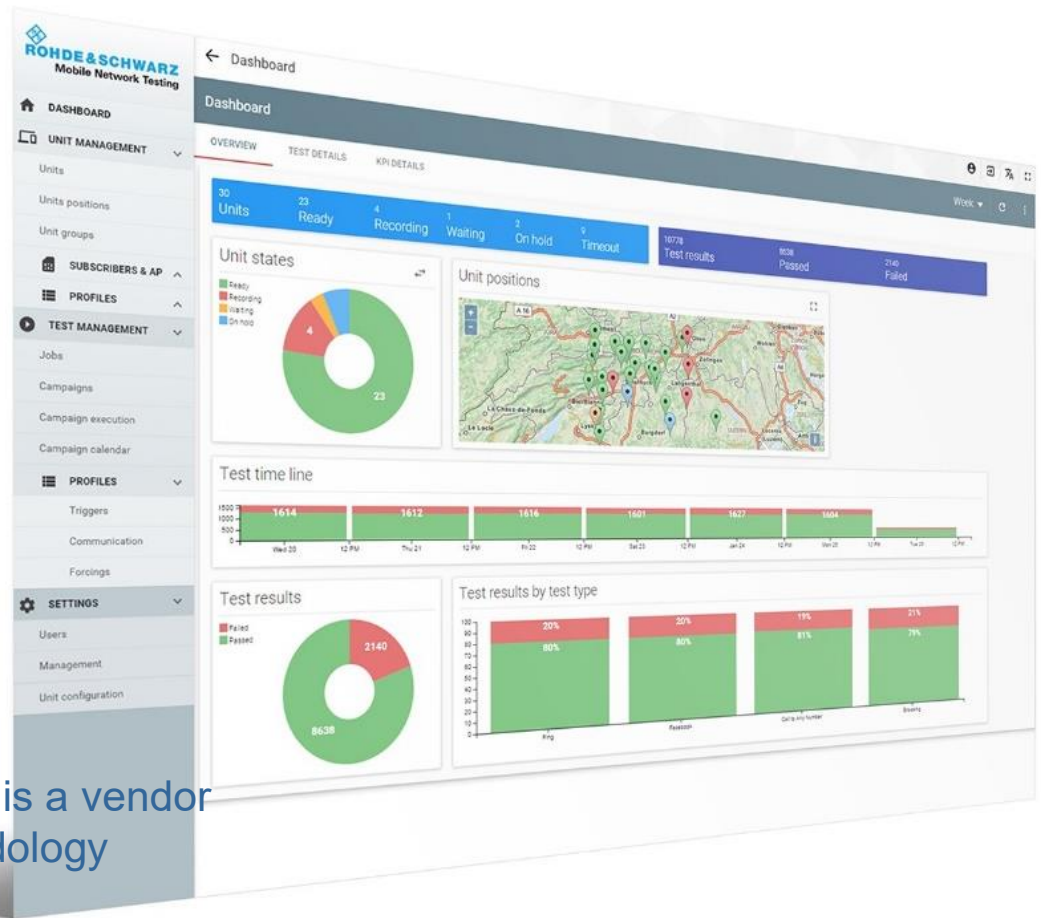
Probes



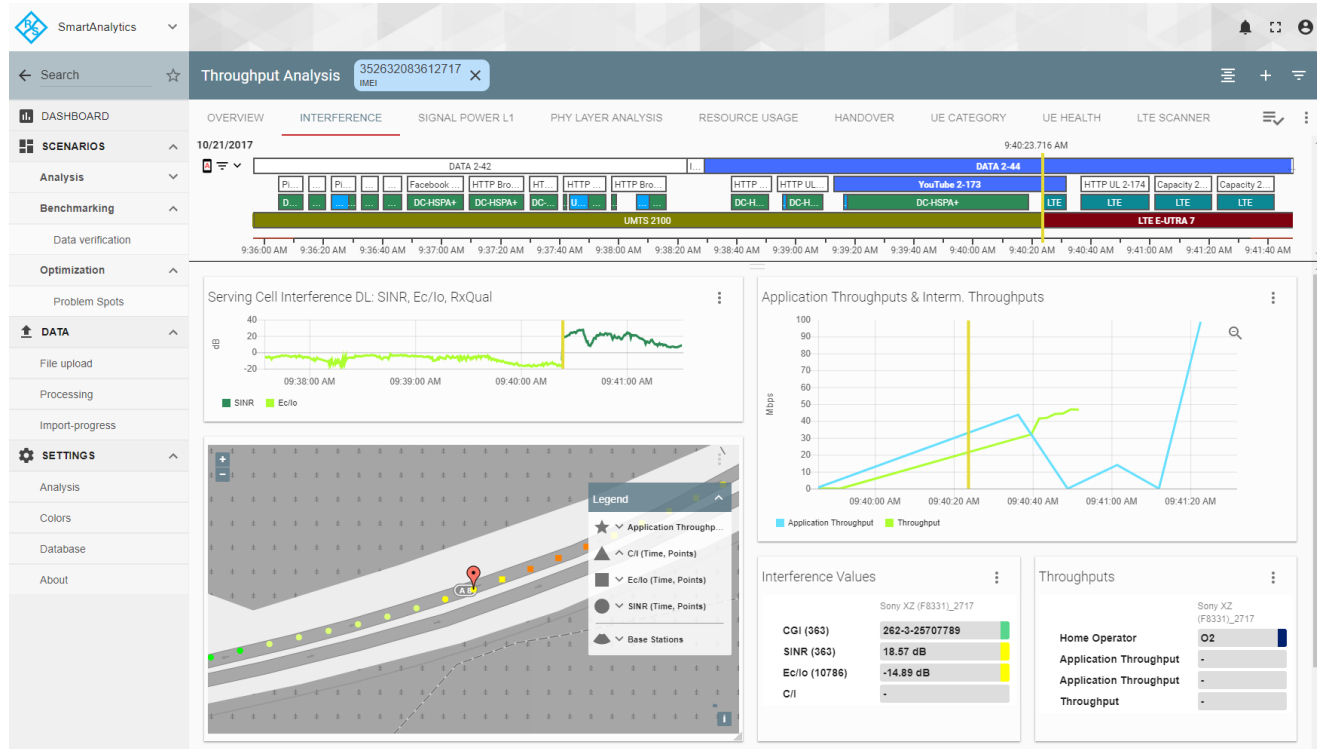
SmartAnalytics

- SmartAnalytics provides visibility of the principle factors influencing network performance and quality of experience
- The network performance score allows network operators to identify strategic areas for investment

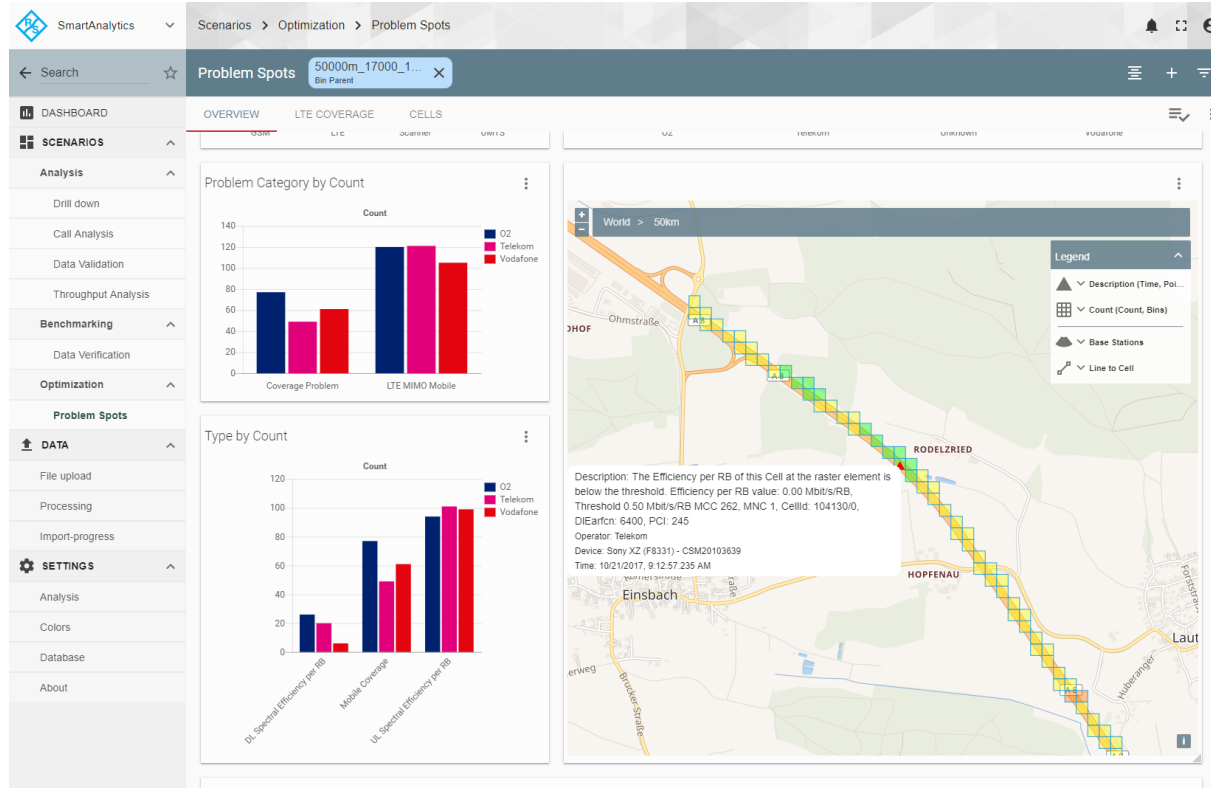
“The Network Performance Score is a vendor independent and objective methodology across the whole network”



Throughput Analysis



Problem Spots



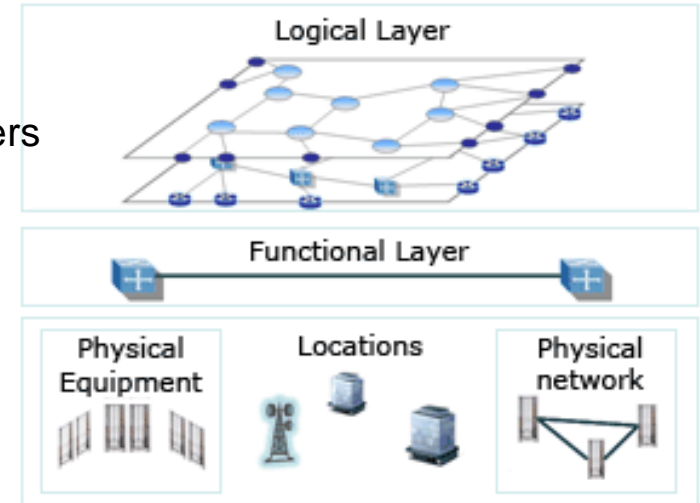
The Network - What's in there?

Thousands of thousands of different types of physical resources

- Infrastructure: Cables, fibre, copper, RF
- Wireless equipment: antennas, satellites, routers
- Switches/equipment: SDH/SONET, DWDM, routers, repeaters

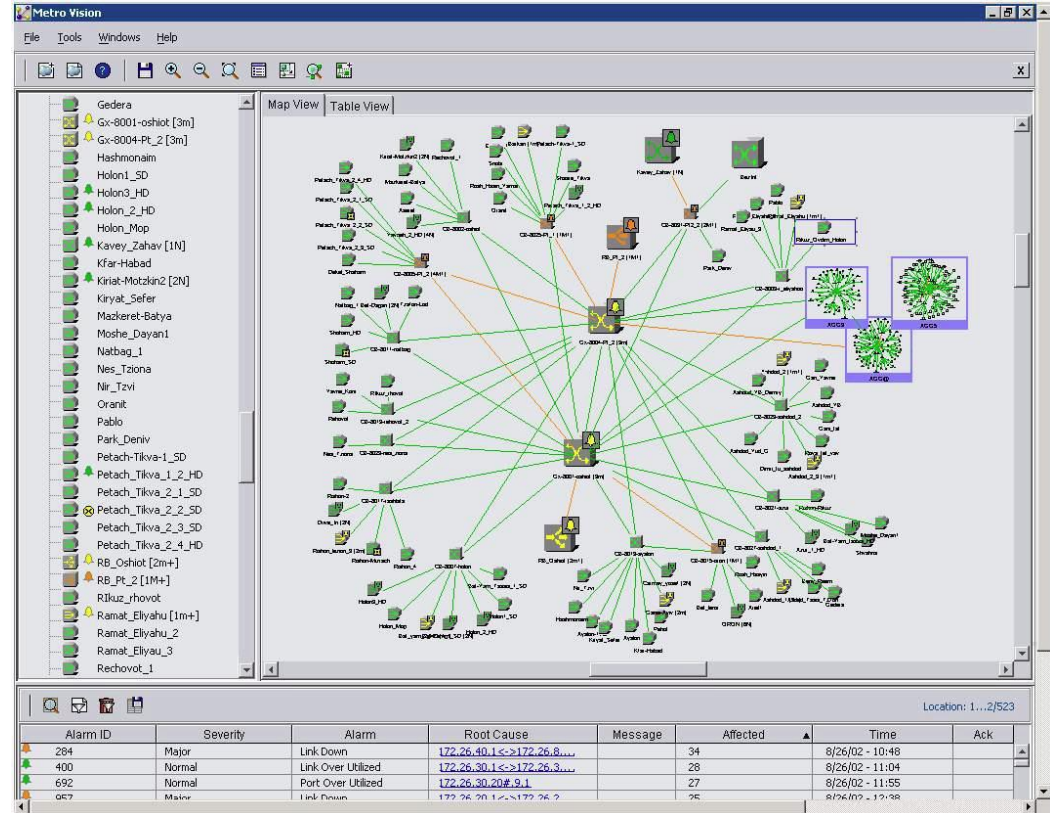
Logical resources:

- IP addresses, phone numbers, IP application (VLAN's)
- Multiple vendors
- Logical routers / VNFs



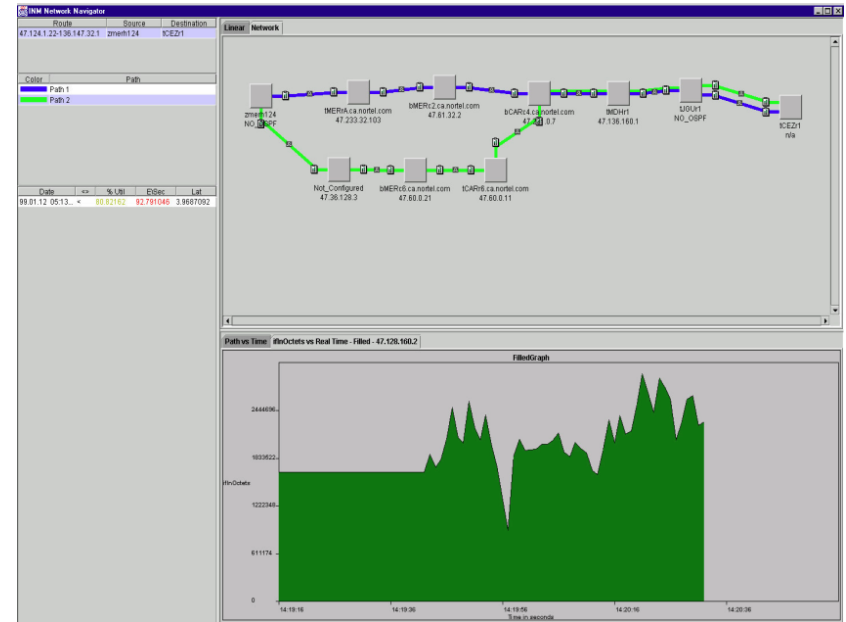
OSS: provider side samples

- Alarms/Alerts
- Fault management
- Fault correction (auto/manual)
- Network display
- Configuration management
- User accounting
- Performance management



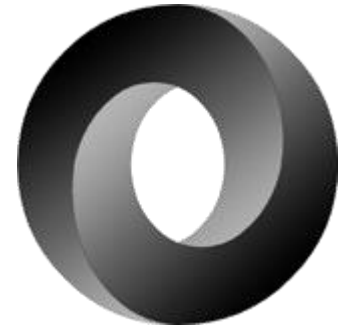
Performance Management sample

- Performance Monitoring – sample various metrics
 - Traffic distribution
 - Percentage of packet types
 - Distribution of packet sizes
 - Delay distribution
 - Collisions, CRC errors, Dropped packets
 - Channel Utilization
- Performance Management Control
 - Alarm Thresholds
 - Traffic control
- Performance Analysis
 - Record statistics & network trends.
 - Effect of traffic load
 - Define a stable network



Advanced Alarming interface

R&S Probes to OSS via JSON



- Advanced Alarming interface supporting JSON to URL
- Advanced alarming interface on SmartMonitor is the JSON to URL
- SmartMonitor will forward received alarms from probes in JSON format
- JSON (JavaScript Object Notation) is a very convenient and light-weight format for exchanging data between applications or systems.
- All network infrastructure vendors offer their own OSS monitoring system to customers. But those monitoring systems do not see the real end user perspective.
- Therefore QualiPoc Android Probes and SmartMonitor will deliver this missing view and information to those systems. OSS monitoring systems offer an interface for 3rd party tools to provide information and the format used is JSON



Measurements to characterize „Network Performance“?

Performance target	To be measured
Capacity	Remaining data throughput at given location
Coverage	Minimum connectivity

Do's

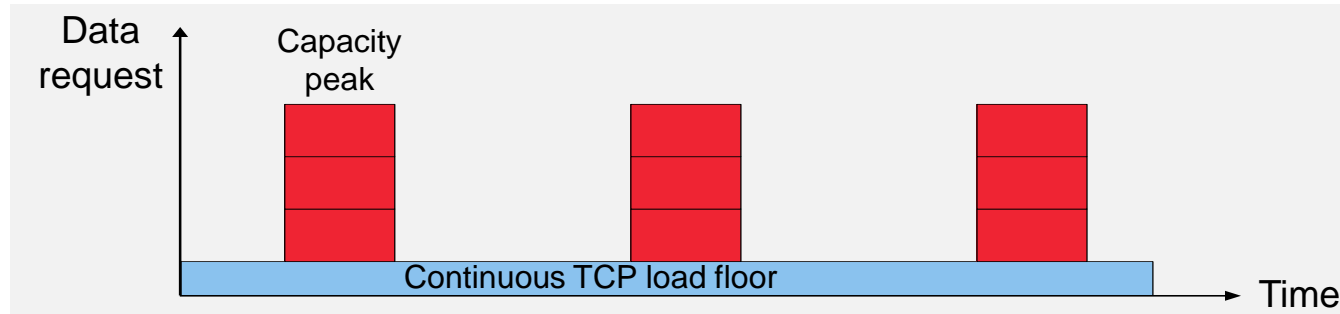
- Reliable and reproducible measurements
- Real world: use smartphones' internal antennas
- Real world: Use TCP as data protocol
- Simple test case but full configurability
- Should work for all RATs without preconditions

Don'ts

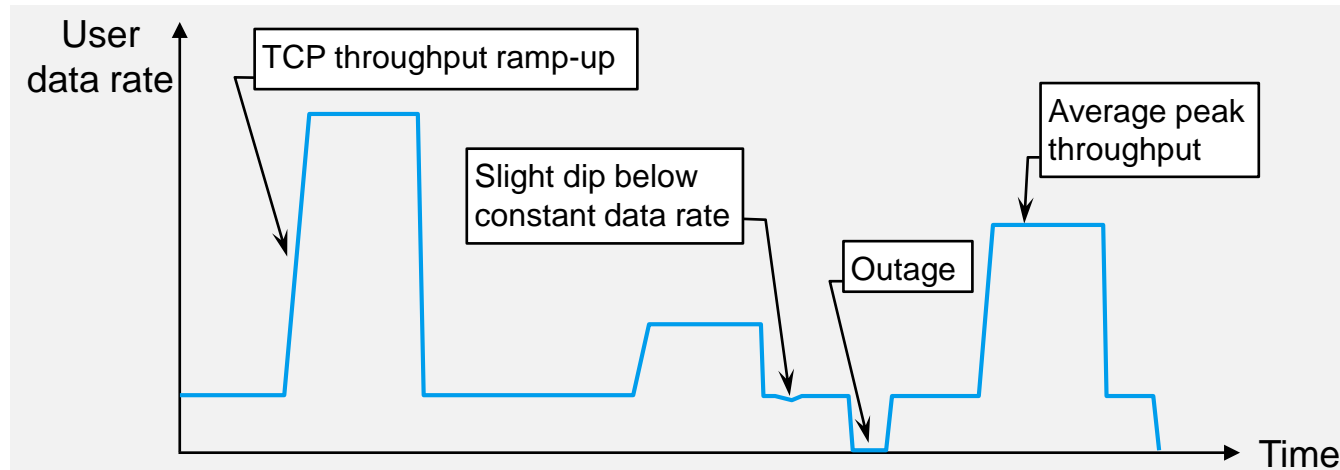
- Load the network extensively (intrusiveness)
- Overheat the test equipment / smartphone (heat significantly affects the UE performance)
- No 'bottlenecks' outside the Mobile Network (e.g. 3rd party providers, servers, UE etc.)



Network Performance Test – definition and typical result



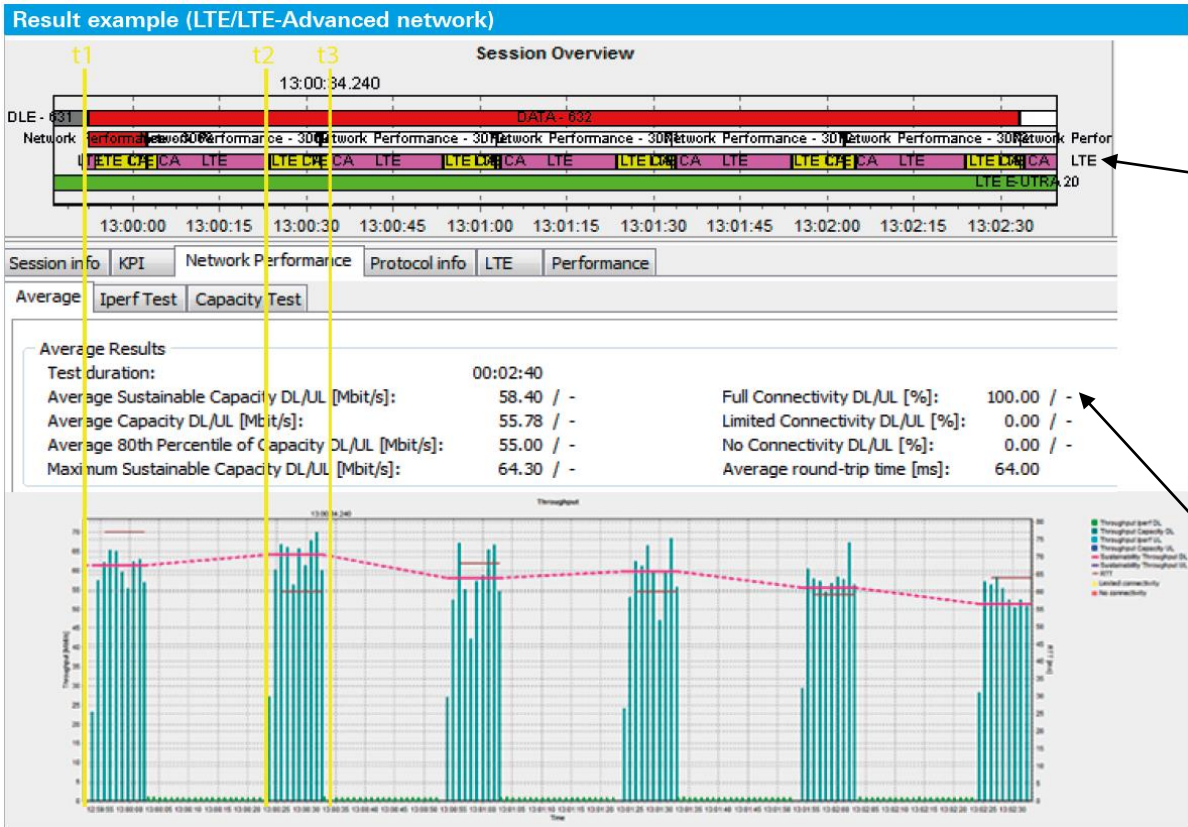
- R&S methodic
- All times configurable
- Capacity peaks = one or more parallel TCP connections



Example of user experienced data rate depending on

- Network load
- Technology
- Channel (fading,...)

Network Performance Test – Result example LTE-A

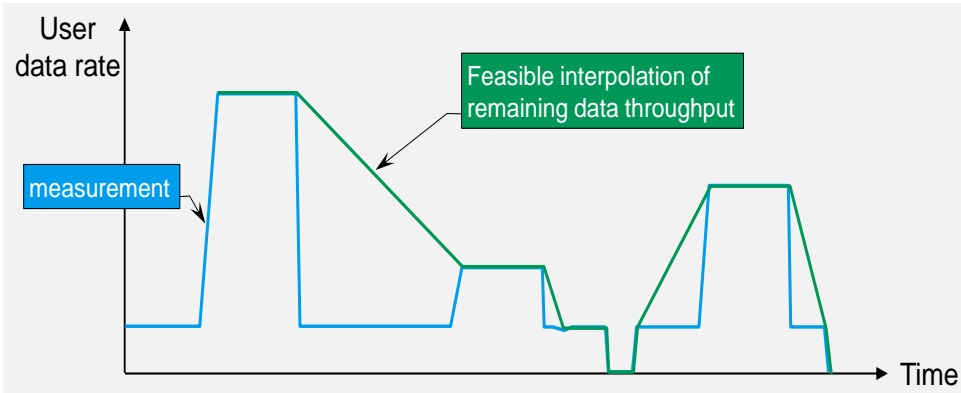


Exp: LTE-Advanced Network:

- NPT Capacity peaks even triggered the BS to switch on the 2nd component carrier (LTE CA – yellow area) – see t1 and t2
- Shortly after the capacity peak the 2nd carrier has been switched off again – see t3
- TCP load floor at 1Mbps shows 100% full connectivity
- Results also available on map

➔ True view of your network

Network Performance Test – Evaluation



Evaluation:

- + Acceptable interpolation of the remaining network capacity
 - Approximation of long term Capacity Test
- + Detection of coverage holes and limited connectivity
- + Defined / configurable intrusiveness independent of network technology (EDGE, HSPA, LTE, CA)
- + No temperature or power consumption issues for testing smartphone
- + Lower costs for SIM/data in testing competitors' networks (benchmarking)

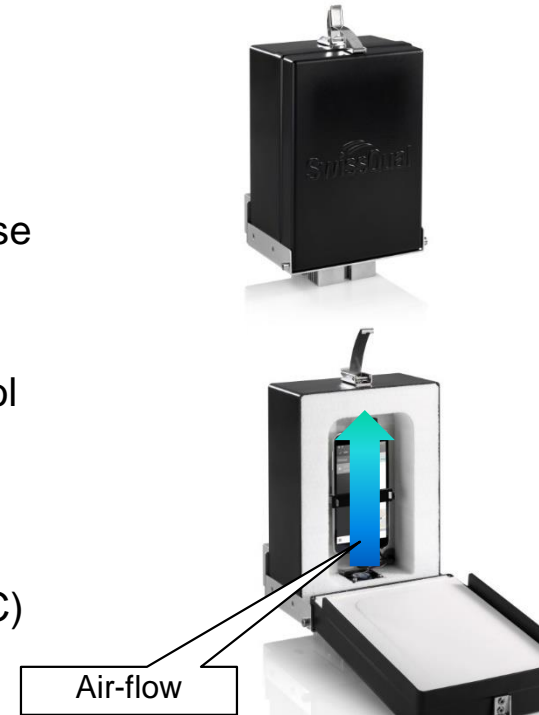
Measuring true network performance

with minimum impact on the network load and on the test UE (avoid heating etc.)



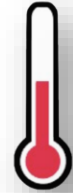
Test Device Containment Module (TCM)

- Robust casing to protect the device
 - Hinged top, single latch to release top
 - Easily **replaceable** device for **future upgrades**
 - Position of the device is **upright** as in a normal daily use case
- Unique **self-healing** functions
 - Automatically reboot the test device (as in the ASM)
- Active **thermal conditioning** for a superior temperature control
 - Thermal isolating foam
 - No air-exchange to ambient
 - Internal active circular airflow for active **heating/cooling**
 - **Stable** and **optimal temperature** inside the module (23-24C)
 - External temperature ranges (+45C to -40C)



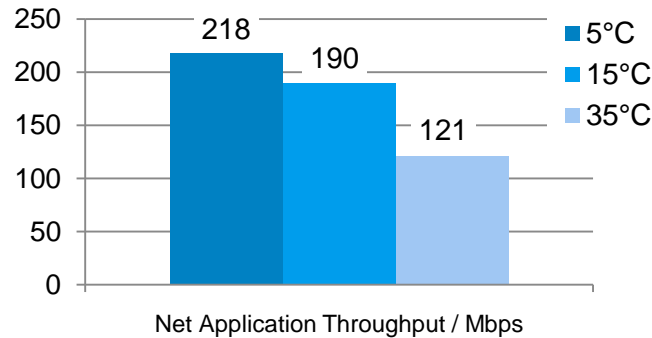
Influence of temperature on performance

Testing throughput on Android Smartphone



- Testing latest Android Smartphone in a controlled (lab) environment
 - Different Temperatures applied in a controlled, RF-shielded climate chamber
 - Simulated Network (using **R&S® CMW500**)
 - 2 aggregated carriers (Band 7, Band 3) with **Max throughput = 127.552 Mbps** per carrier

■ Results:



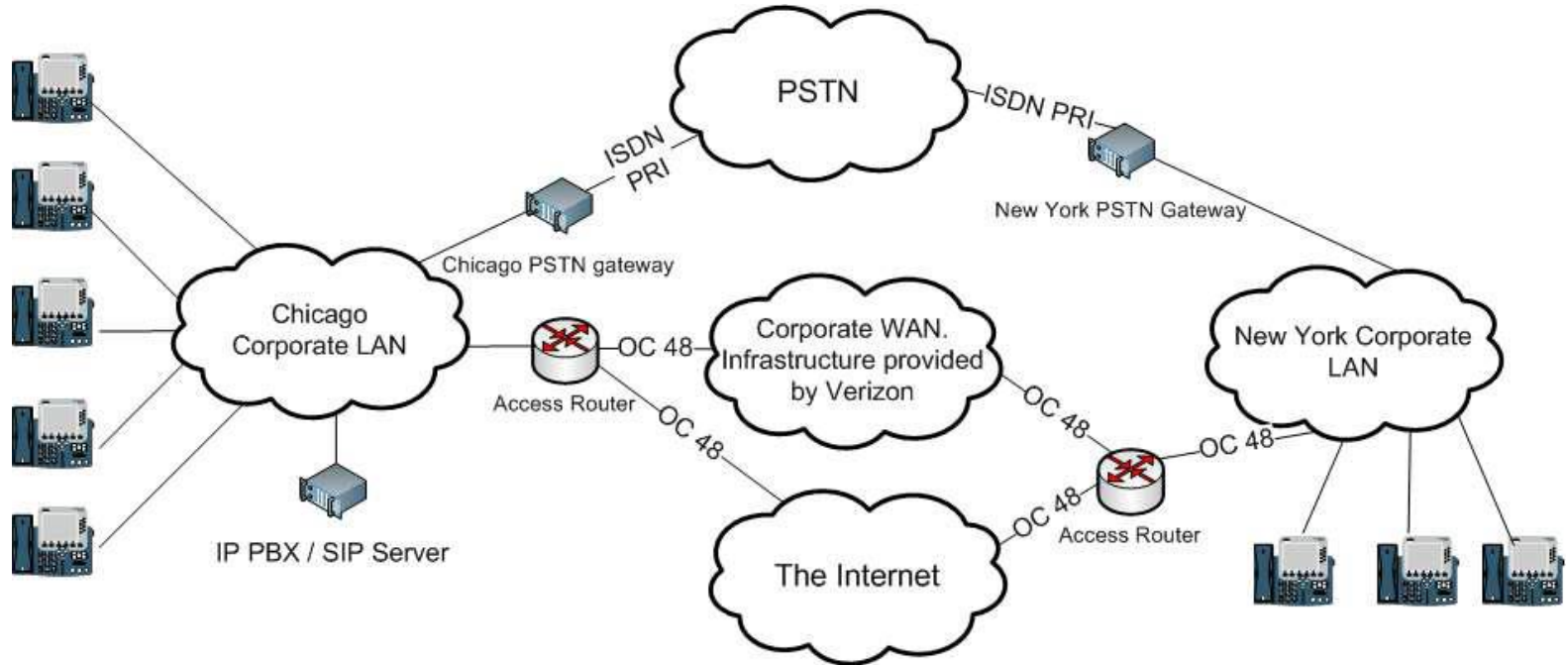
■ Conclusions

- **Stable temperature conditions** needed for **maximum results comparability**



Enterprise VoIP deployment

- Shared bandwidth usage across the WAN



IP trace and Layer 3 decoder

- "IP trace" monitor displays header information from HTTP, FTP, TCP, DNS and ICMP packages
- QualiPoc updates the monitor in real time.

Recording (Swisscom / WCDMA)

UARFCN 10613 PSC 498 ASI RSCP 101.5 dBm ASI EoTo -9.5 dB

IP

ICMP echo request
192.168.3.143 > 82.220.1.20
UL - 09:17:36.801

ICMP echo reply
82.220.1.20 > 192.168.3.143
DL - 09:17:36.839

ICMP echo request
192.168.3.143 > 82.220.1.20
UL - 09:17:37.897

ICMP echo reply
82.220.1.20 > 192.168.3.143
DL - 09:17:37.944

ICMP echo request
192.168.3.143 > 82.220.1.20
UL - 09:17:38.707

ICMP echo reply
82.220.1.20 > 192.168.3.143
DL - 09:17:38.755

ICMP echo request
192.168.3.143 > 82.220.1.20
UL - 09:17:39.806

ICMP echo reply
82.220.1.20 > 192.168.3.143
DL - 09:17:39.855

Frame: timestamp = 2015-03-04 09:17:54.96
Frame: wire length = 100 bytes
Frame: captured length = 100 bytes
Frame:
SLL: ***** SLL - "Linux Cooked Capture" - offset=0 (0)
SLL: packetType = 4
SLL: haType = 1
SLL: haLength = 6
SLL: address = 90:18:7c:fa:7f:39
SLL: type = 0x800 (2048)
Ip: ***** Ip4 - "ip version 4" - offset=16 (0x10) length=20
Ip: version = 4
Ip: hlen = 5 [5 * 4 = 20 bytes, No Ip Options]
Ip: difserv = 0x0 (0)
Ip: 0000 00.. = [0] code point: not set
Ip:0. = [0] ECN bit: not set
Ip:0 = [0] ECE bit: not set
Ip: length = 84
Ip: id = 0x0 (0)
Ip: flags = 0x2 (2)
Ip: 0.. = [0] reserved
Ip: .1. = [1] DF: do not fragment: set
Ip: ..0 = [0] MF: more fragments: not set
Ip: offset = 0
Ip: ttl = 64 [time to live]
Ip: type = 1 [next: Internet Control Message]
Ip: checksum = 0x2282 (8834) [correct]
Ip: source = 192.168.3.143
Ip: destination = 82.220.1.20
Ip:
Icmp: ***** Icmp offset=36 (0x24) length=8
Icmp:

Idle (Swisscom / WCDMA)

UARFCN 10613 PSC 498 ASI RSCP 101.5 dBm ASI EoTo -9.5 dB

IP

DNS Standard query response CNAME clients.l.google.com; A 193.134.255.99; A 193.134.255.119; A 193.134.255.114; A 193.134.255.113; A 193.134.255.88; A 193.134.255.98; A 193.134.255.89; A 193.134.255.104; A 193.134.255.108; A 193.134.255.94; A 193.134.255.84; A 193.134.255.118; A 193.134.255.103; A 193.134.255.93; A 193.134.255.109; A 193.134.255.123
195.186.1.162 > 192.168.3.143
DL - 09:12:23.448

TCP 49854 > 80 [SYN] Seq=1064259604 Ack=0 Win=14600
192.168.3.143 > 193.134.255.99
UL - 09:12:23.450

TCP 80 > 49854 [SYN; ACK] Seq=1178958715 Ack=1064259605 Win=28960
193.134.255.99 > 192.168.3.143
DL - 09:12:23.489

HTTP GET /generate_204 HTTP/1.1
192.168.3.143 > 193.134.255.99
UL - 09:12:23.490

HTTP HTTP/1.1 204 No Content
193.134.255.99 > 192.168.3.143
DL - 09:12:23.534

TCP 80 > 59346 [FIN; ACK] Seq=2651309990 Ack=1614611349 Win=65
77.95.70.166 > 192.168.3.143

Idle (Swisscom / WCDMA)

UARFCN 10613 PSC 498 ASI RSCP 101.5 dBm ASI EoTo -9.5 dB

IP response

DNS Standard query response CNAME mobile-gtalk.l.google.com; A 64.233.166.188
195.186.1.162 > 192.168.3.143
DL - 09:12:21.376

DNS Standard query response CNAME clients.l.google.com; AAAA
2A00:1450:400A:0804:0000:0000:1003
195.186.1.162 > 192.168.3.143
DL - 09:12:23.405

DNS Standard query response CNAME clients.l.google.com; A 193.134.255.99; A 193.134.255.119; A 193.134.255.114; A 193.134.255.113; A 193.134.255.88; A 193.134.255.98; A 193.134.255.89; A 193.134.255.104; A 193.134.255.108; A 193.134.255.94; A 193.134.255.84; A 193.134.255.118; A 193.134.255.103; A 193.134.255.93; A 193.134.255.109; A 193.134.255.123
195.186.1.162 > 192.168.3.143
DL - 09:12:23.448

Real-time TCP statistics

Custom monitor:

- TCP frames
- TCP bytes"
- TCP frames lost
- TCP frame "out of order"
- TCP window full

The left screenshot shows the 'SERVICE TEST (5)' configuration screen. A red box highlights the following selected tests:

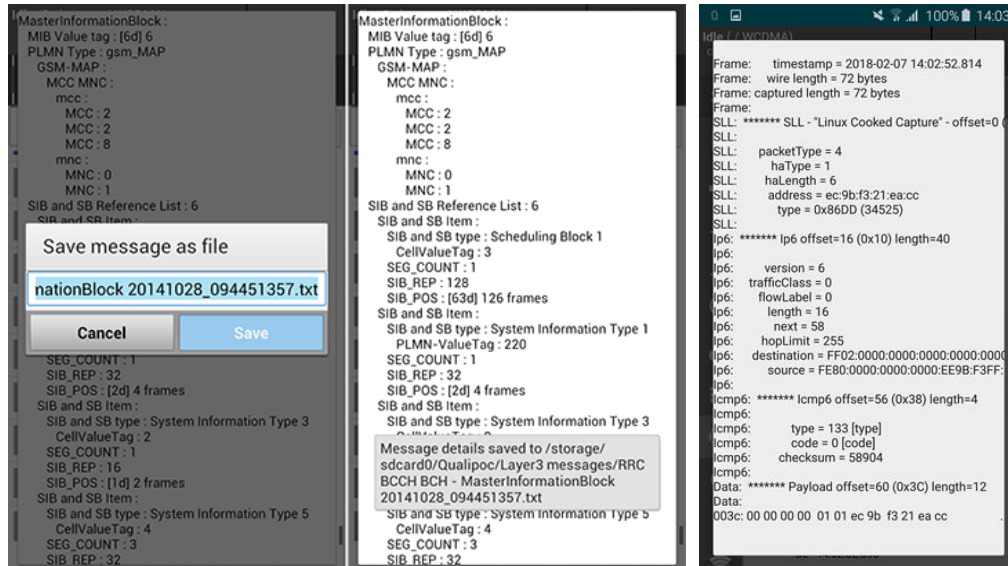
- Test TCP frames (Last test TCP frames count)
- Test TCP bytes (Last test TCP bytes count)
- Test TCP frames lost (Last test TCP frames lost)
- Test TCP frames OoO (Last test TCP frames out of order)
- Test TCP window full (Last test TCP window full event count)

The right screenshot shows the 'TCP Stats' results screen. A red arrow points from the selected tests to the following statistics:

Test	Count
Test TCP window full	0
Test TCP frames OoO	307
Test TCP frames lost	226
Test TCP bytes	8660992
Test TCP frames	11964

Advanced Analysis Settings

- "Log captured IP packet": advanced packet details in the IP Monitor
- **Saving signaling messages**



QualiPoc Android - Supported Test Cases

Test cases

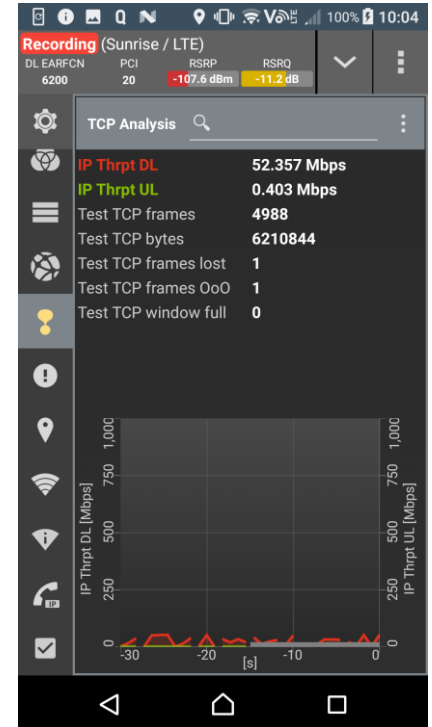
- **Video Streaming** on **YouTube, Netflix, DirecTVnow** and **Facebook Watch** incl. Video-MOS
- App service tests:
 - **Dropbox** (File up and download)
 - **Facebook** (Send post and picture, like post, delete post)
 - **Ookla Speed Test** (Latency, UL and DL throughput)
 - **Line** (Instant messaging)
 - **Line** (VoIP incl. audio MOS using POLQA)
 - **WhatsApp** (Instant messaging)
 - **WhatsApp** (VoIP incl. audio MOS using POLQA)
 - **FCC Speed** app (UDP Latency and Packet Loss / Speed test (GET and POST HTTP)
 - **Instagram** (Send pictures and videos, post text and comments)
- **Generic Video Test** allows to test **any video streaming** or **live TV** service incl. video quality
- **Video Telephony** including **audio** and **video quality**



QualiPoc Android

Real-time TCP analysis

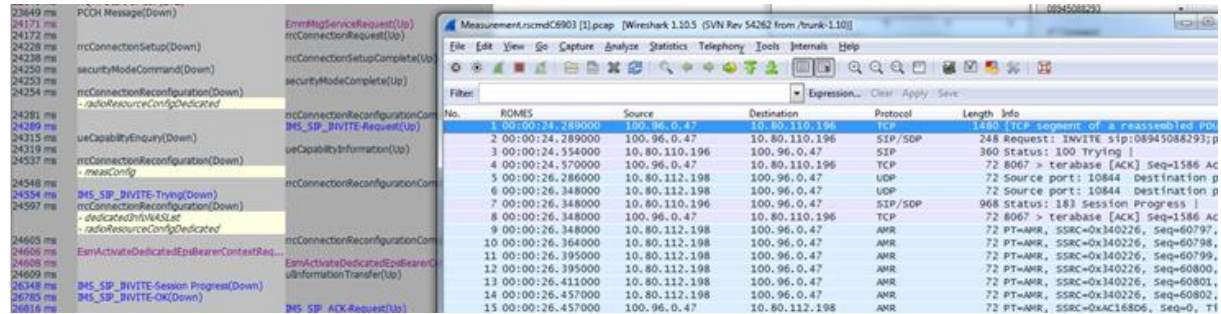
- QualiPoc Android offers
 - a real time analysis of the TCP stream during measurements
 - provides a TCP statistics for each executed test.
- TCP statistics and analysis are done always on data tests even without the need for recording a PCAP file.
- The statistics include all data traffic from the smartphone during the test time and might include some traffic not originated on QualiPoc



SIP: Message views comparison

Layer 3 SIP/IP messages

- ROMES4 software / Wireshark / QualiPoc



IP tracer results

Time	Source	Destination	Down	Up
409509 ms	10.129.196.192	213.199.161.251	2186 > 443 [ACK] Seq=1266 Ack=5397 Win=1606...	
409509 ms	10.129.196.192	213.199.161.251	2186 > 443 [FIN, ACK] Seq=1266 Ack=5397 Win=...	
409509 ms	213.199.161.251	10.129.196.192		Application Data
409510 ms	213.199.161.251	10.129.196.192		443 > 2184 [FIN, ACK] Seq=5396 Ack=1266 ...
409510 ms	10.129.196.192	213.199.161.251	2184 > 443 [ACK] Seq=1266 Ack=5397 Win=1606...	
409510 ms	10.129.196.192	213.199.161.251	2184 > 443 [FIN, ACK] Seq=1266 Ack=5397 Win=...	
409510 ms	213.199.161.251	10.129.196.192		443 > 2185 [ACK] Seq=5397 Ack=1267 Win=...
409510 ms	213.199.161.251	10.129.196.192		443 > 2186 [ACK] Seq=5397 Ack=1267 Win=...
409511 ms	213.199.161.251	10.129.196.192		443 > 2184 [ACK] Seq=5397 Ack=1267 Win=...
409874 ms			radioBearerReconfiguration (Down)	
410440 ms				measurementReport (Up)
410524 ms	10.129.196.192	217.6.164.162	GET /scs/d4s/3/i/l/tbxr_o_14x16.gif HTTP/1.1	
410526 ms	10.129.196.192	217.6.164.162	GET /scs/d4s/3/i/l/tbxr_o_1x16.gif HTTP/1.1	
410526 ms	10.129.196.192	217.6.164.162	GET /scs/d4s/3/i/l/tbxr_or_27x16.gif HTTP/1.1	
410526 ms	10.129.196.192	217.6.164.162	GET /scs/d4s/3/i/l/tbxr_l_14x1.gif HTTP/1.1	
410652 ms				radioBearerReconfigurationComplete (Up)
410962 ms	10.129.196.192	1.2.3.4	2143 > 80 [RST, ACK] Seq=354 Ack=2878 Win=0 ...	
410963 ms	217.6.164.162	10.129.196.192		HTTP/1.0 200 OK (GIF89a)
410963 ms	217.6.164.162	10.129.196.192		HTTP/1.0 200 OK (GIF89a)
410963 ms	10.129.196.192	217.6.164.162	2146 > 80 [RST, ACK] Seq=6951 Ack=22497 Win=...	
410964 ms	10.129.196.192	217.6.164.162	2145 > 80 [RST, ACK] Seq=6373 Ack=31296 Win=...	
410964 ms	10.129.196.192	217.6.164.162	2147 > 80 [RST, ACK] Seq=12110 Ack=40961 Wi...	
410964 ms	10.129.196.192	217.6.164.162	2148 > 80 [RST, ACK] Seq=11113 Ack=55527 Wi...	

IP Tracer TCP Checksum layer 3 view

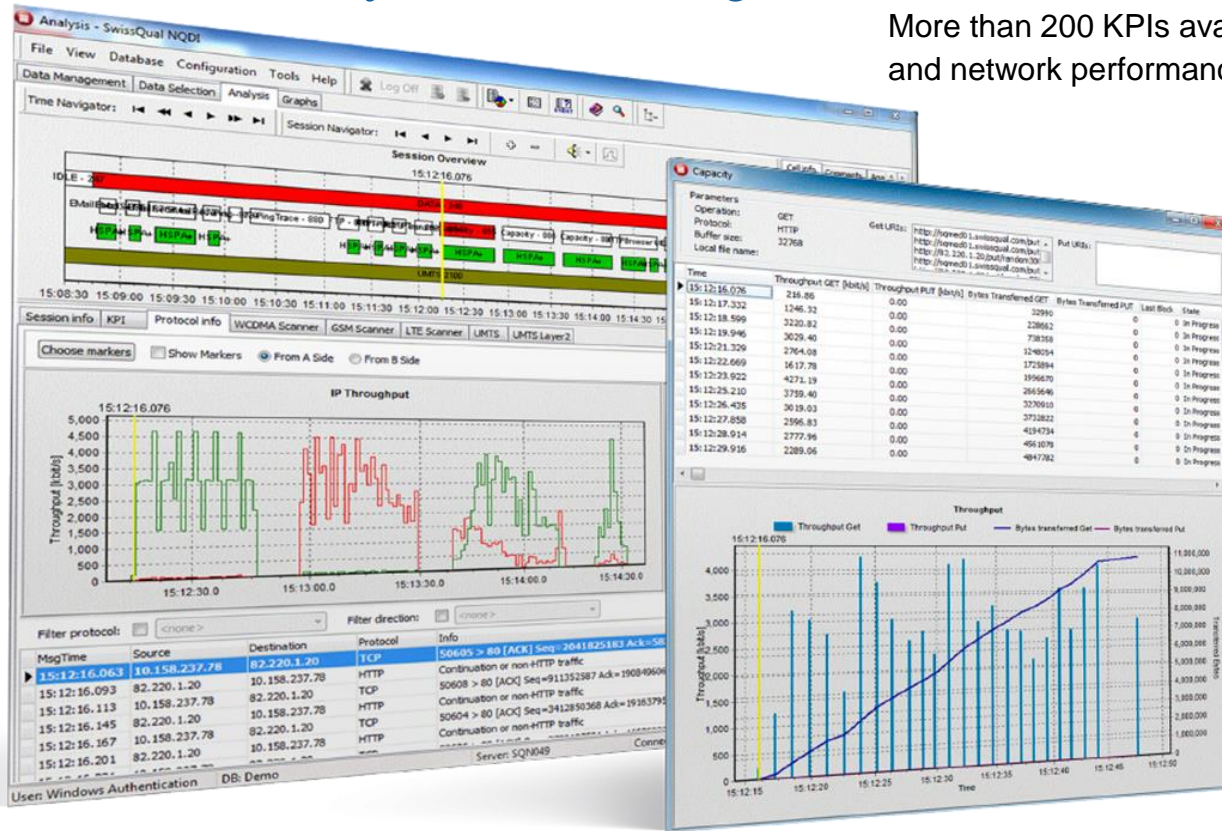
TCP Statistics

TCP Statistics	
Test Id:	3 (17179869187)
Frame count:	1361
TCP bytes:	1169536
Frames lost:	5
Frames out of order:	13
Window full events:	0
Packet loss [%]:	0.4
Packets out of order [%]:	1

Type	Source	Destination	Down	Up
TCP	31.224.92.100	80.246.32.125		49868 > 3190 Len=20 Request: STOR upload/100k.bin
TCP	31.224.92.100	80.246.32.125		49870 > 3190 Len=40
TCP	31.224.92.100	80.246.32.125		49870 > 3190 Len=20
TCP	31.224.92.100	80.246.32.125		49870 > 3190 Len=1480 measurementReport (Up)
UL DCOH (RRC)	31.224.92.100	80.246.32.125		
TCP	80.246.32.125	31.224.92.100	3190 > 49870 Len=20	49870 > 3190 Len=740
TCP	31.224.92.100	80.246.32.125		49870 > 3190 Len=20
TCP	31.224.92.100	80.246.32.125		49868 > 21 Len=20
TCP	31.224.92.100	80.246.32.125		49868 > 21 Len=20 uplinkDirectTransfer (Up)
UL DCOH (RRC)				DEACTIVATE PDP CONTEXT ACC...
GMM				downlinkDirectTransfer (Down)
DL DCOH (RRC)				measurementReport (Up)
DL DCOH (RRC)				radioBearerRelease (Down)
UL DCOH (RRC)				measurementReport (Up)
UL DCOH (RRC)				radioBearerReleaseComplete (Up)
DL DCOH (RRC)				rrcConnectionRelease (Down)
DL DCOH (RRC)				rrcConnectionReleaseComplete (Up)
DL DCOH (RRC)				rrcConnectionReleaseComplete (Up)
DL DCOH (RRC)				rrcConnectionReleaseComplete (Up)
DL BCOH BOH (RRC)				System Information Block 19 (Down)
DL BCOH BOH (RRC)				Master Information Block (Down)
DL BCOH BOH (RRC)				System Information Block 7 (Down)
DL BCOH BOH (RRC)				System Information Block 2 (Down)
DL BCOH BOH (RRC)				System Information Scheduling Bl...
DL BCOH BOH (RRC)				Master Information Block (Down)
DL BCOH BOH (RRC)				System Information Block 7 (Down)
DL BCOH BOH (RRC)				System Information Block 1 (Down)
DL BCOH BOH (RRC)				System Information Block 2 (Down)
DL BCOH BOH (RRC)				System Information Block 3 (Down)
DL BCOH BOH (RRC)				System Information Block 19 (Down)
DL BCOH BOH (RRC)				Master Information Block (Down)
DL BCOH BOH (RRC)				System Information Block 7 (Down)
UL DCOH (RRC)				rrcConnectionRequest (Up)
DL DCOH (RRC)				rrcConnectionSetup (Down)
UL DCOH (RRC)				rrcConnectionSetupComplete (Up)
GMM				SERVICE REQUEST (Up)
UL DCOH (RRC)				initialDirectTransfer (Up)
DL DCOH (RRC)				measurementControl (Down)
DL DCOH (RRC)				measurementControl (Down)
DL DCOH (RRC)				securityModeCommand (Down)
UL DCOH (RRC)				securityModeComplete (Up)
GMM				ACTIVATE PDP CONTEXT REQ...
DL DCOH (RRC)				uplinkDirectTransfer (Up)
UL DCOH (RRC)				radioBearerSetup (Down)
DL DCOH (RRC)				radioBearerSetupComplete (Up)
DL DCOH (RRC)				measurementControl (Down)
DL DCOH (RRC)				measurementControl (Down)
GMM				ACTIVATE PDP CONTEXT ACCEPT...
DL DCOH (RRC)				downlinkDirectTransfer (Down)
UL DCOH (RRC)				measurementReport (Up)
DL DCOH (RRC)				radioBearerReconfiguration (Down)

NQDI – Network Quality Data Investigator

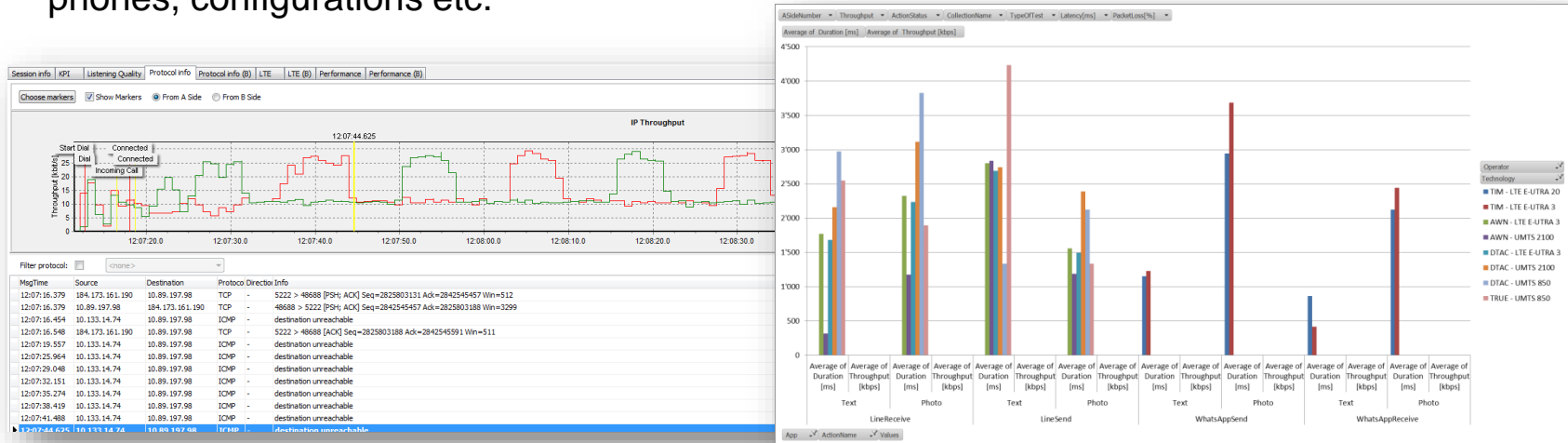
More than 200 KPIs available for service and network performance reporting and trending



NQDI – Features

■ Skype VoIP and Messaging

Same as for WhatsApp or Line we support Skype measurements. NQDI analyzes the results congruent to the other tests. With this the Network but also the different Apps providing the service can be compared against each other in different networks and/or network conditions, phones, configurations etc.



LIST OF REFERENCES

- Success of Digital Services Hinges on BSS/OSS, InterComms Magazine
- Win at digital transformation: How to adopt agile BSS/OSS, TM Forum global industry association
- ECMA-404 The JSON Data Interchange Standard
- YANG Logical Network Elements, IETF Tools
- Network Inventory Model, MCH information & communication solutions
- Next Generation Telecom OSS, Network, Amdocs
- Others



Thank you

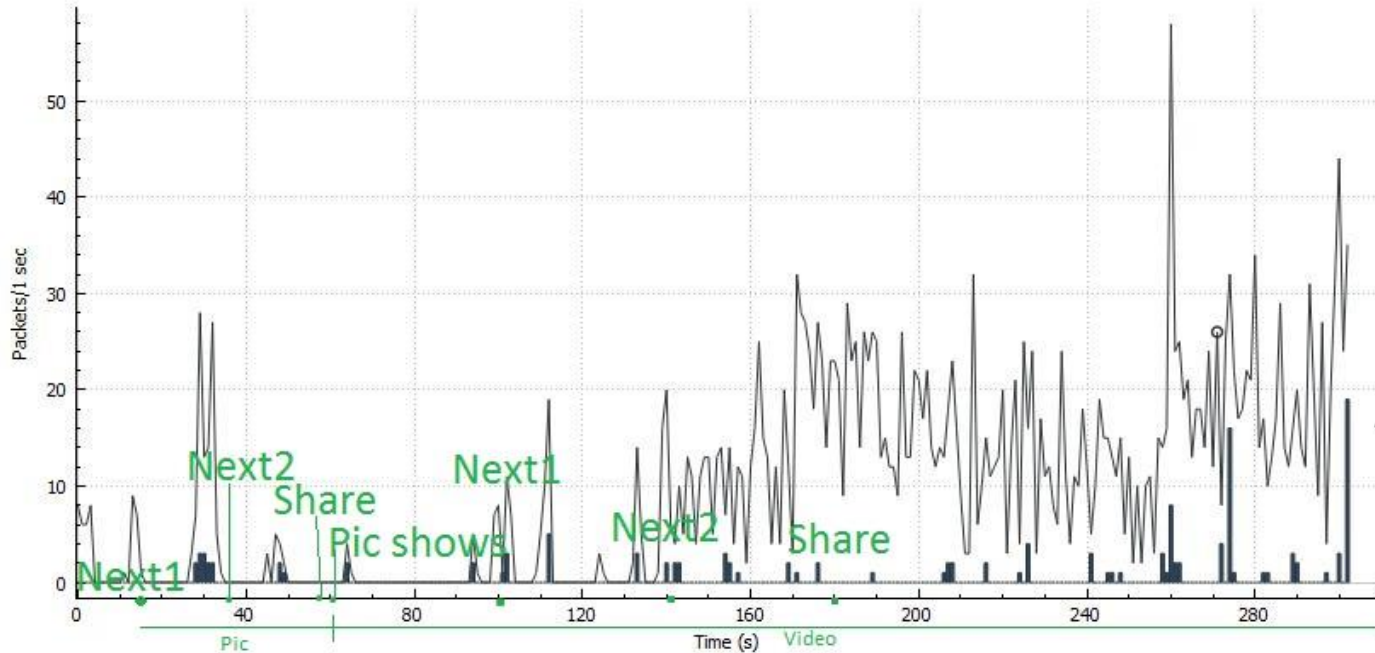


Backup slides



Pcap: packet capture and analysis

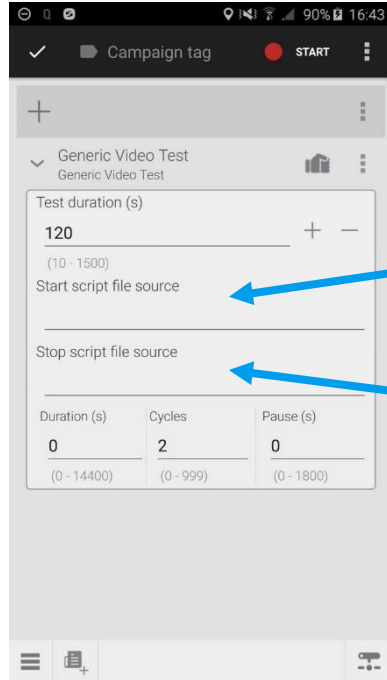
Wireshark IO Graphs: 2017-03-02-11-25-19-0000-8872-8047-0004-S0101



QualiPoc Android

Generic Video Streaming test

- Define start- and stop- scripts, so no manual interaction is needed!



Start script:

```
echo Script started [0]
pm clear com.google.android.youtube[0]
am start -n com.google.android.youtube/.UrlActivity -a android.intent.action.VIEW \[0]
-d "https://www.youtube.com/watch?v=1La4QzGeaaQ"[0]
echo Script was executed[0]
```

Stop script:

```
echo Script started [0]
am force-stop com.google.android.y[0]
echo Script was executed
```

Test more efficient

Test more sensitive

Increase flexibility

QualiPoc Android

Application Service Tests

App service tests supported on QualiPoc:

- **FCC speed test:** This speed test app includes UDP Latency and Packet Loss as well as speed test (GET and POST HTTP)
- **Instagram:** Supported actions Send pictures and videos, post text and comments. Measured KPIs: Time taken to deliver a picture (post), Time taken to deliver a video (post), Time taken to deliver a post comment/text, Time taken to measure successful delivery of the post comment.

