

Mobile Network Testing

INDUSTRIAL RADIO DAY PERFORMANCE VERIFICATION IN TODAY'S INDUSTRY 5G NETWORKS



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Mobile Network Testing

ROHDE & SCHWARZ

Make ideas real



AGENDA

- ▶ **Industry applications and network**
- ▶ Test methods to emulate industry applications
- ▶ How do enterprise networks perform today?
(real performance measurements)
- ▶ Test solutions and summary

5G enterprise networks enable business- / mission-critical use cases with increased productivity

Manufacturing



Warehouse



Mining



Ports



Critical Infrastructure

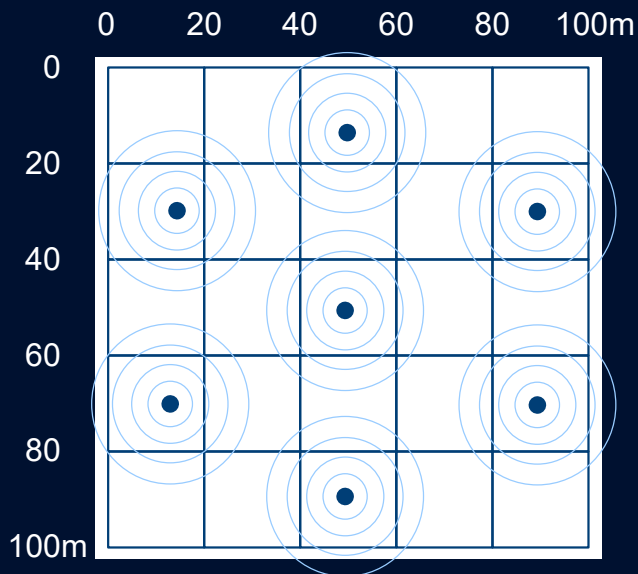


Oil / Gas



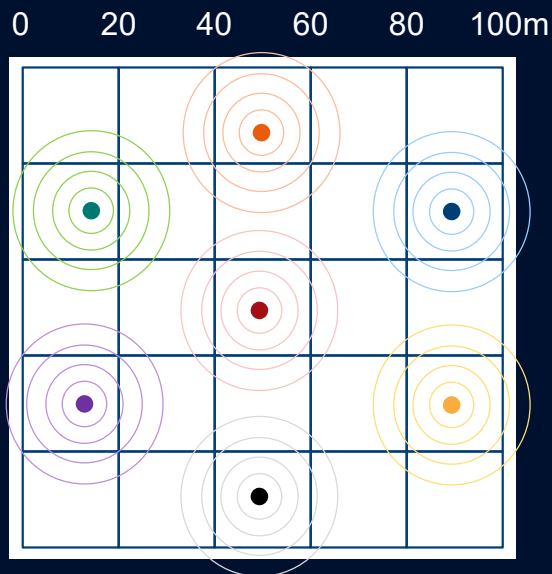
Common requirement: superior performance level (in terms of data rate and latency)

Deployment status of enterprise networks



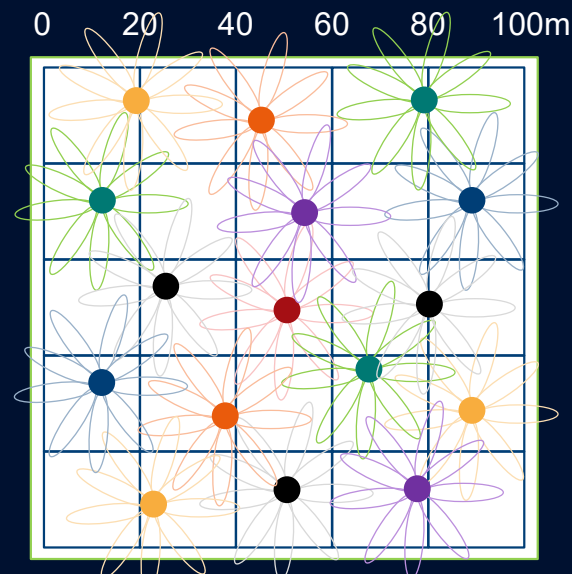
- ▶ Same PCI, same signal everywhere (omni ant.)
- ▶ Inefficient, but “Tx diversity”

At the beginning; often today



- ▶ Different PCIs, different signals
- ▶ Higher capacity, but no redundancy

Intermediate; not often seen live



- ▶ Different PCIs and beams
- ▶ Higher capacity, incl. redundancy

Optimized capacity + reliability
→ Future

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Passive and Active



Passive Measurements without subscription

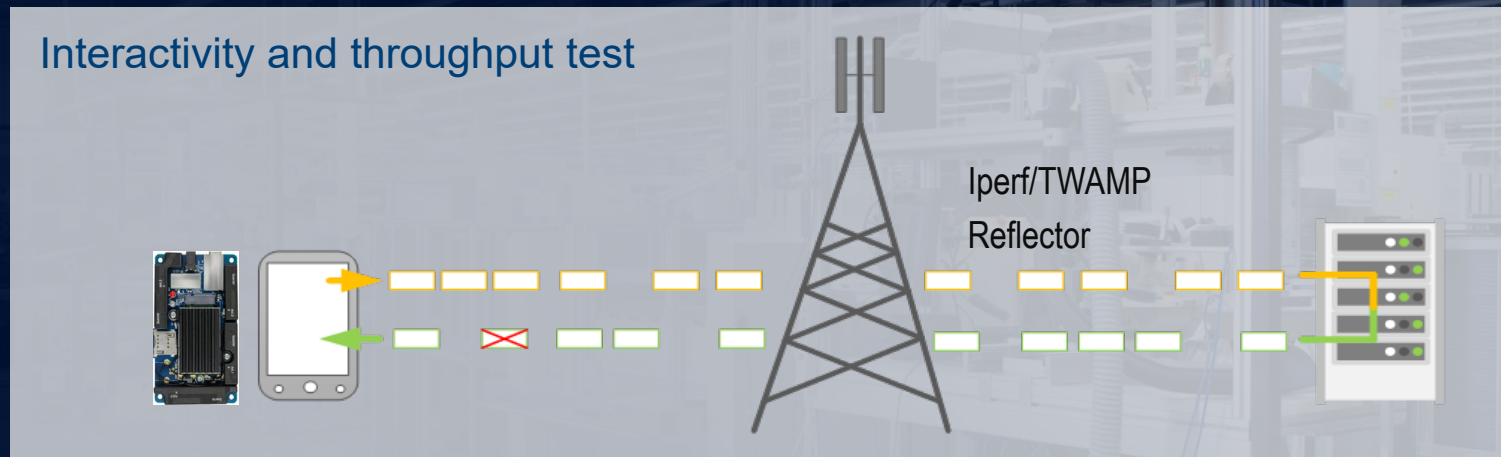
- ▶ Automatic Channel Detection
- ▶ Measurements of all DL signals on-air
- ▶ Decoding of Broadcast Channel Information
- ▶ Synchronisation
- ▶ high accuracy and speed
- ▶ Cell centric
- ▶ Beam centric
- ▶ EMF



Active measurements with subscription

- ▶ Performance
 - ▶ Latency
 - ▶ Throughput Downlink / Uplink
 - ▶ Network availability
- ▶ Trouble shooting
- ▶ Signalling verification
- ▶ Interactivity with variation of traffic patterns

Latency and Throughput Downlink / Uplink



- ▶ **TWAMP: Two-Way Active Measurement Protocol** – specified by IETF (RFC 5357)
(Traffic can be emulated; TWAMP defined for latency SLA verifications)
Based on TWAMP, definition of test scenarios (Interactivity score)
- ▶ **iperf3**: Throughput uplink/downlink single stream or multiple streams (UDP/TCP)

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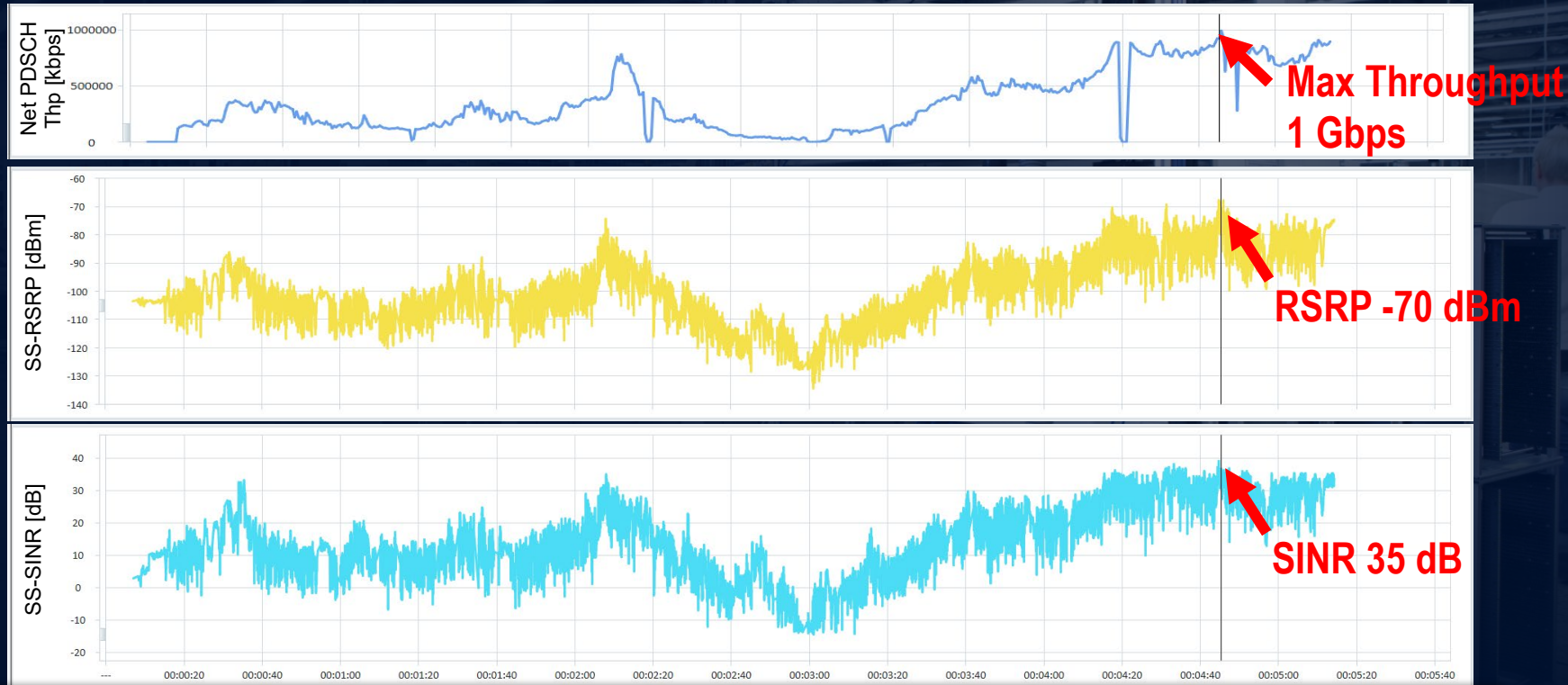
Case 1: How are these networks performing today

Throughput in relation to data settings



Case 1: How are these networks performing today

Throughput in relation radio condition

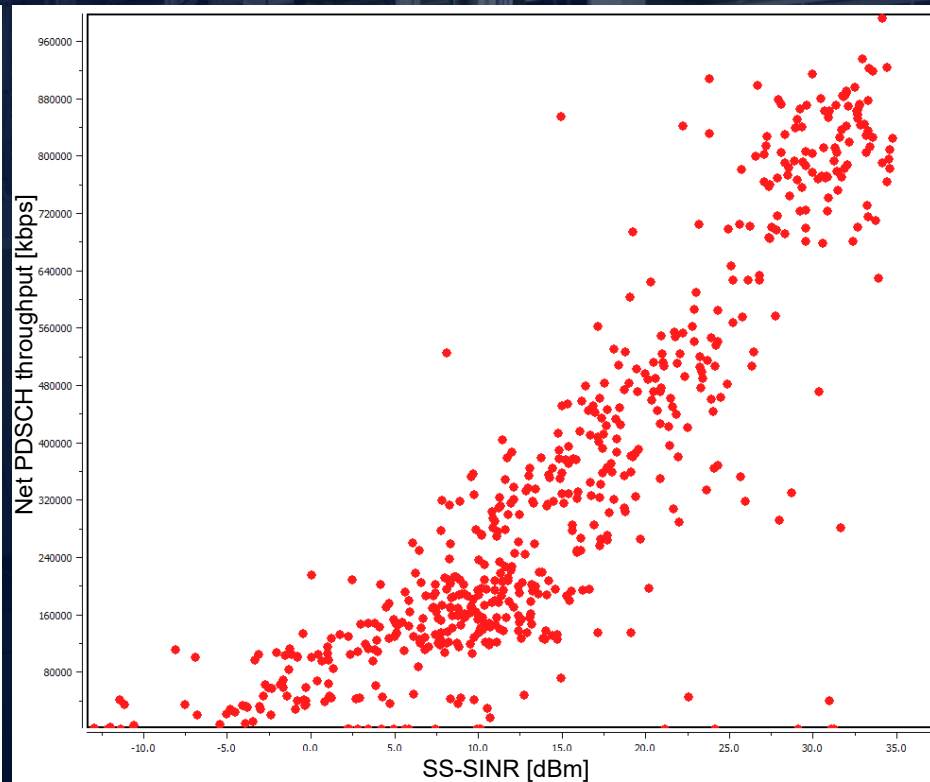
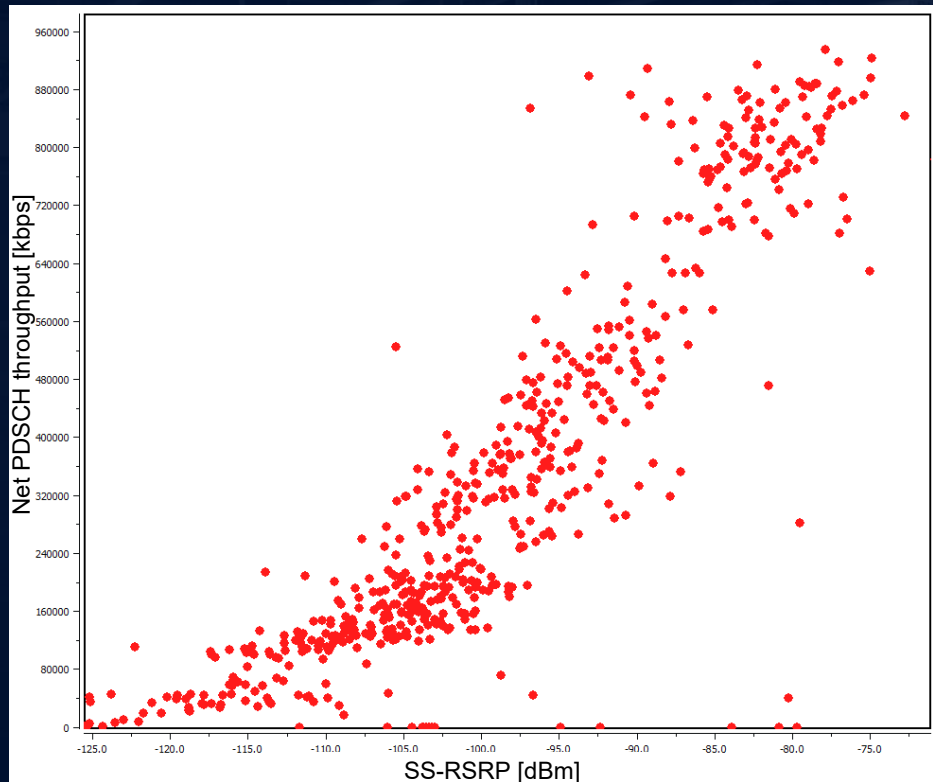


► Data throughput offered by 5G is given



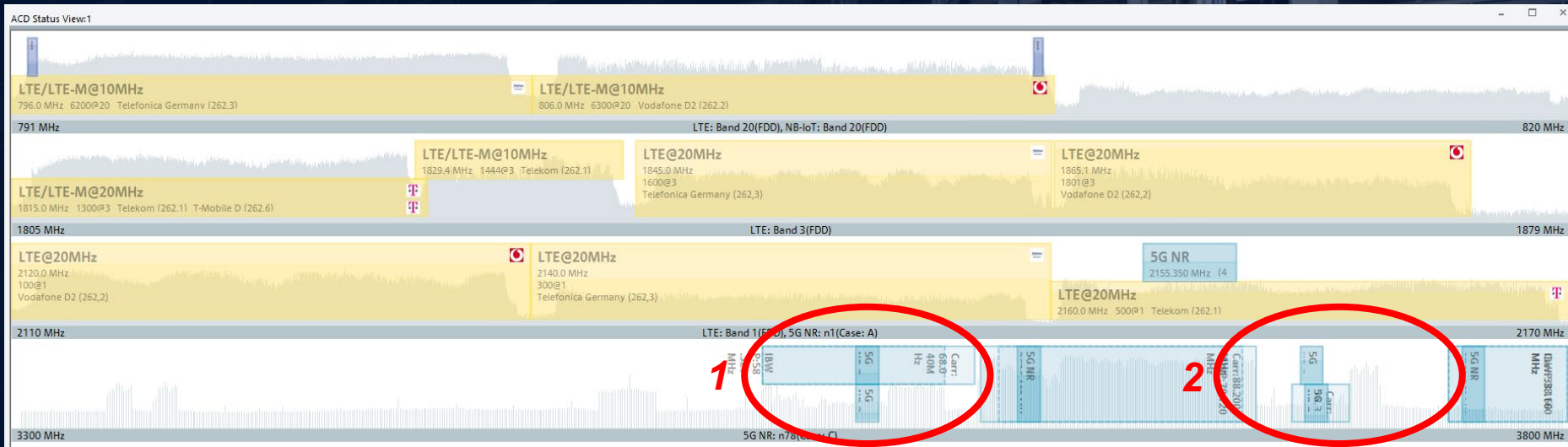
Case 1: How are these networks performing today

Throughput in relation radio condition



Case Exhibition: Overview Network situation

Sharing the same frequencies – Automatic Channel Detection

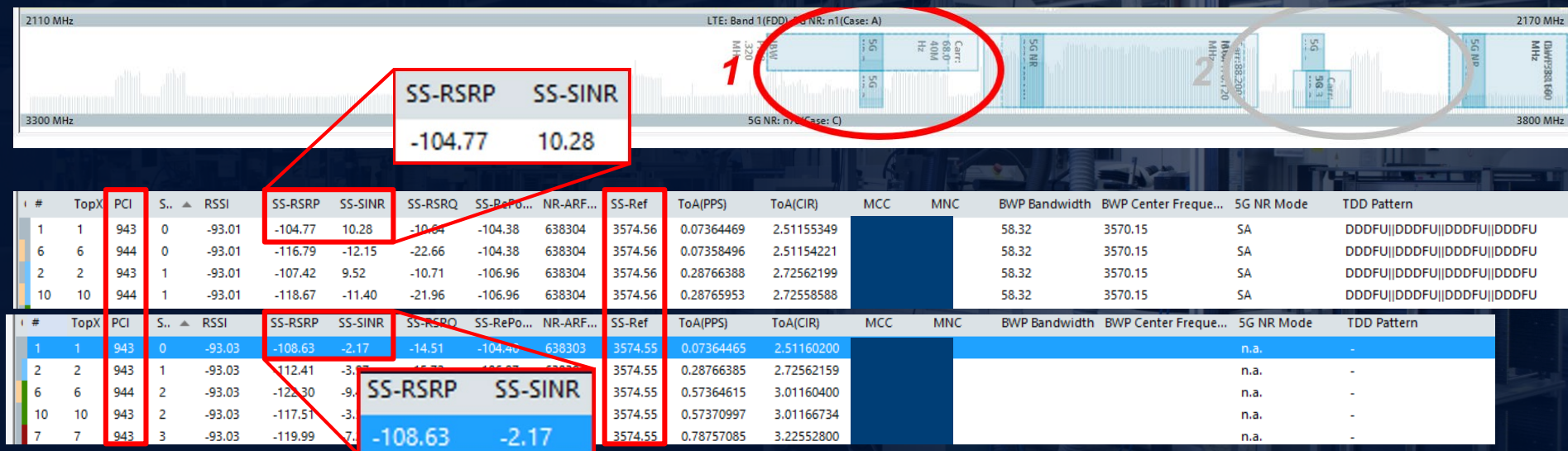


- 1) Multiple cells overlap in operator spectrum around 3.5 GHz
- 2) Multiple cells overlap in dedicated spectrum around 3.7GHz (private spectrum)

► Let's do drill-down

Case 2: Overview Network situation

Sharing the same frequencies – drill-down 1



- Problems and measurements:
 - PCIs: same or very similar
 - SS-Ref. frequencies slightly different
 - Second network has bad signal quality (SINR)

- Analysis of purely passive measurements:
- Misconfiguration of cells (same PCI)?
 - Check frequency stability?

► **Advantage of scanner**

Case 2: Overview Network situation

Sharing the same frequencies – drill-down 2

Expected SINR ~ +25 dB

SS-RSRP SS-SINR
-77.57 14.41

List																			
#	Top	PCI	S..	▲	RSSI	SS-RSRP	SS-SINR	SS-RSRQ	SS-RePo...	NR-ARF...	SS-Ref	ToA(PPS)	ToA(CIR)	MCC	MNC	BWP Bandwidth	BWP Center F...	5G NR ...	TDD Pattern
1	1	390	0		-68.40	-77.57	14.41	-10.31	-77.42	647808	3717.12	0.07212810	2.51008549					n.a.	-
5	5	361	0		-68.40	-92.03	-14.45	-24.85	-77.42	647808	3717.12	0.07239748	2.51034490					n.a.	-
3	3	390	1		-68.40	-79.27	17.96	-10.31	-79.20	647808	3717.12	0.28611730	2.72413909					n.a.	-
8	8	361	1		-68.40	-98.57	-19.31	-29.61	-79.20	647808	3717.12	0.28672588	2.72468258					n.a.	-

List																			
#	Top	PCI	S..	▲	RSSI	SS-RSRP	SS-SINR	SS-RSRQ	SS-RePo...	NR-ARF...	SS-Ref	ToA(PPS)	ToA(CIR)	MCC	MNC	BWP Bandwidth	BWP Center F...	5G NR ...	TDD Pattern
1	1	2	0		-84.62	-113.12	-2.32	-15.14	-108.79	647904	3718.56	4.67522709	7.11315302	999	99	18.36	3719.82	5A	DDDFU DDFUU DDDFU DDFUU DDDFU DDFUU

2) Measurements:

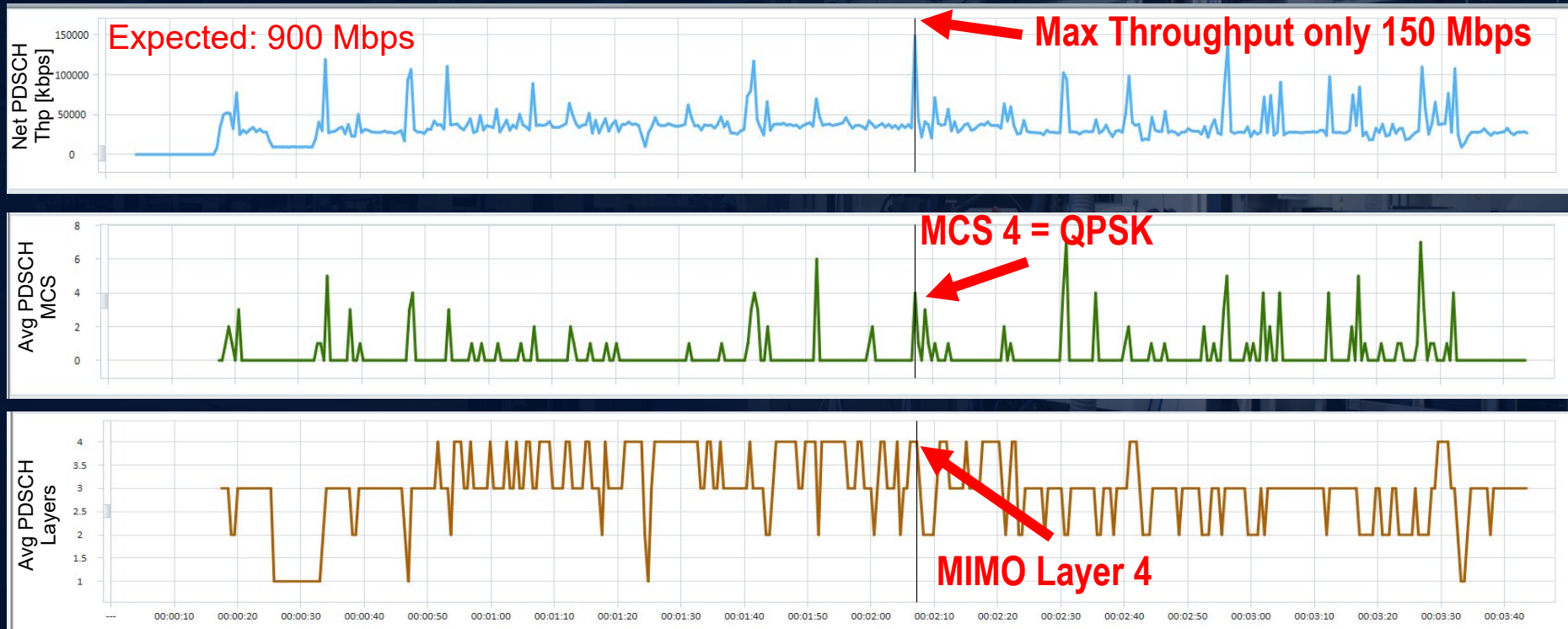
- Different networks overlap (different PCIs)
- Much higher SINR expected
- Networks not synchronized (4.6ms difference)

Analysis of purely passive measurements:

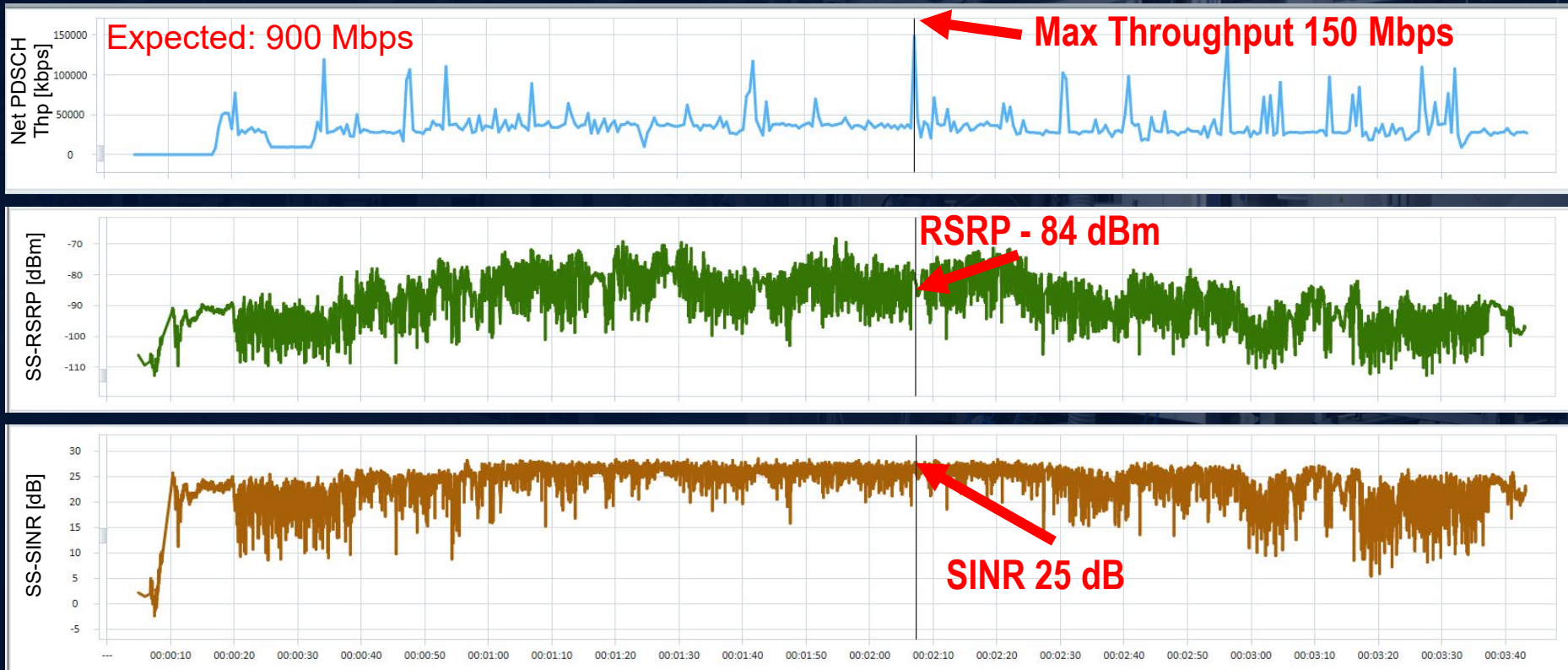
- Upper network interfered
- Lower network seems to be the interference source

► Advantage of scanner

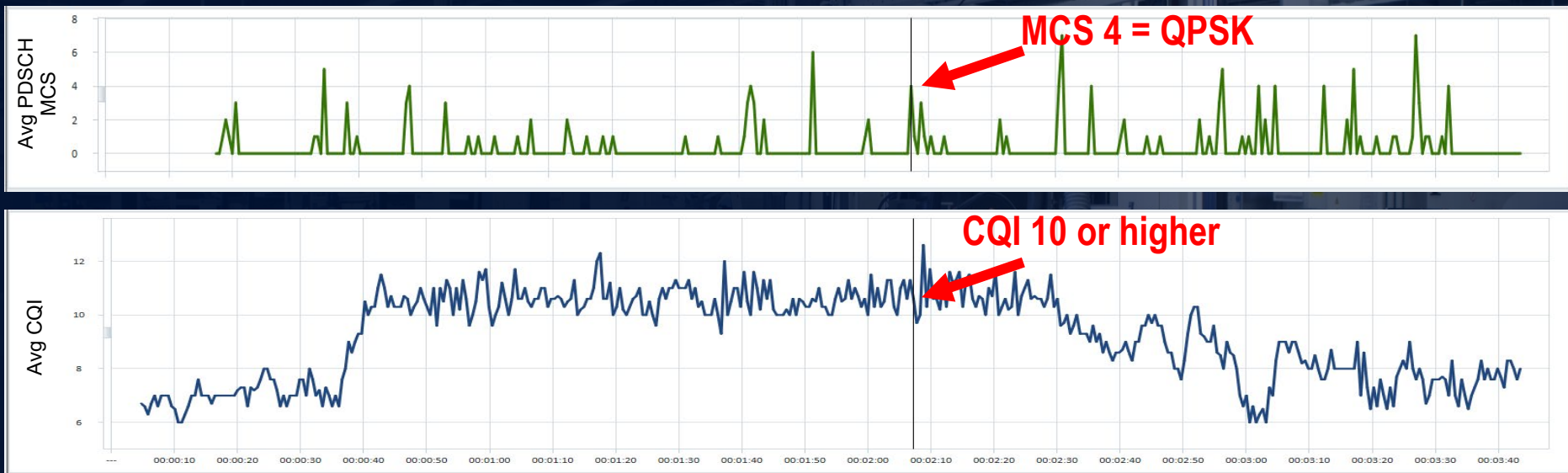
Case 3: Drill down into throughput problems



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Layer 3 View:1 RH500Q-GLTY

Time

00:00:09 AT-CTUN=0

00:00:09 SG NR MIB(Down)

00:00:09 BCCH BCH Message(Down)

00:00:14 AT-CTUN=1

00:00:14 SG NR MIB(Down)

00:00:14 BCCH BCH Message(Down)

00:00:14 systemInformationBlockType1(Down)

00:00:14 systemInformation(Down)

00:00:14 - sib3

00:00:14 - sib5

00:00:14 - sib4

00:00:15 SG NR MIB(Down)

00:00:15 BCCH BCH Message(Down)

00:00:15 systemInformationBlockType1(Down)

00:00:15 Mm5gMsgDeRegistrationRequest(Up)

00:00:15 rcSetupRequest(Up)

00:00:15 -SG NR RRC Connectivity RRC Setup Attempt

00:00:15 SG NR RACH: Success (1)(Up)

00:00:15 rcSetupComplete(Up)

00:00:15 securityModeCommand(Down)

00:00:15 dlnasInformationTransfer(Down)

00:00:15 Mm5gMsgRegistrationAccept(Down)

00:00:15 Mm5gMsgRegistrationComplete(Up)

00:00:15 ulInformationTransfer(Up)

00:00:15 Sm5gPduSessionEstablishmentRequest(Up)

00:00:15 Mm5gMsgUlnasTransport(Up)

00:00:15 ulInformationTransfer(Up)

00:00:15 rcReconfiguration(Down)

00:00:15 - radioBearerConfig

00:00:15 - measConfig

00:00:15 - masterCellGroup

00:00:15 - dedicatedNAS_MessageList

00:00:15 Mm5gMsgDlnasTransport(Down)

00:00:15 Sm5gPduSessionEstablishmentAccept(Down)

00:00:15 rcReconfiguration(Down)

00:00:15 - masterCellGroup

00:00:16 rcReconfigurationComplete(Up)

00:00:16 rcRelease(Down)

00:03:34

Layer 3 View:1 RH500Q-GLTY

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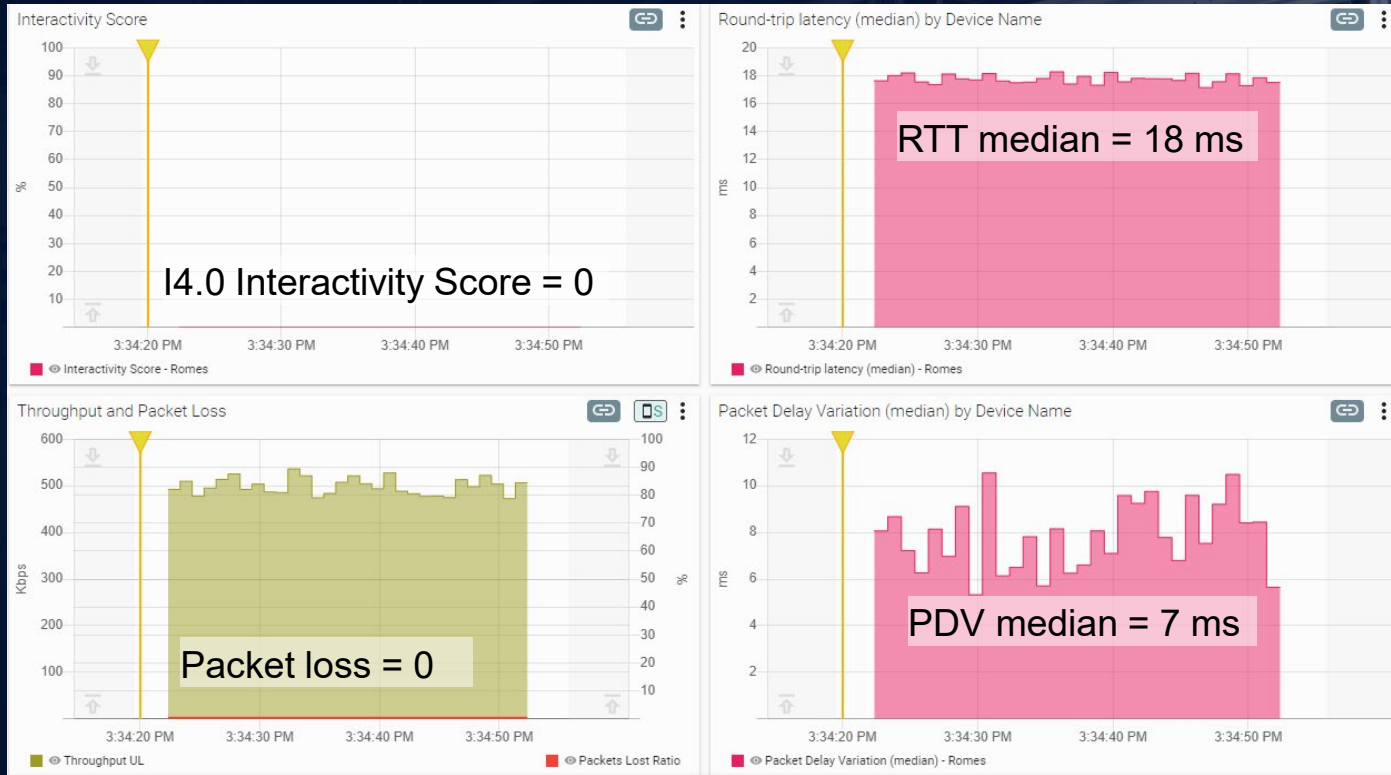
00:00:16 rcRelease(Down)

00:03:34

< 38.214 - Table 5.2.2.1-3: 4-bit CQI Table 2 >

CQI index	modulation	code rate x 1024	efficiency
0	out of range		
1	QPSK	78	0.1523
2	QPSK	193	0.3770
3	QPSK	449	0.8770
4	16QAM	378	1.4766
5	16QAM	490	1.9141
6	16QAM	616	2.4063
7	64QAM	466	2.7305
8	64QAM	567	3.3223
9	64QAM	666	3.9023
10	64QAM	772	4.5234
11	64QAM	873	5.1152
12	256QAM	711	5.5547
13	256QAM	797	6.2266
14	256QAM	885	6.9141
15	256QAM	948	7.4063

Case 4: I4.0 process control with industry module as frontend

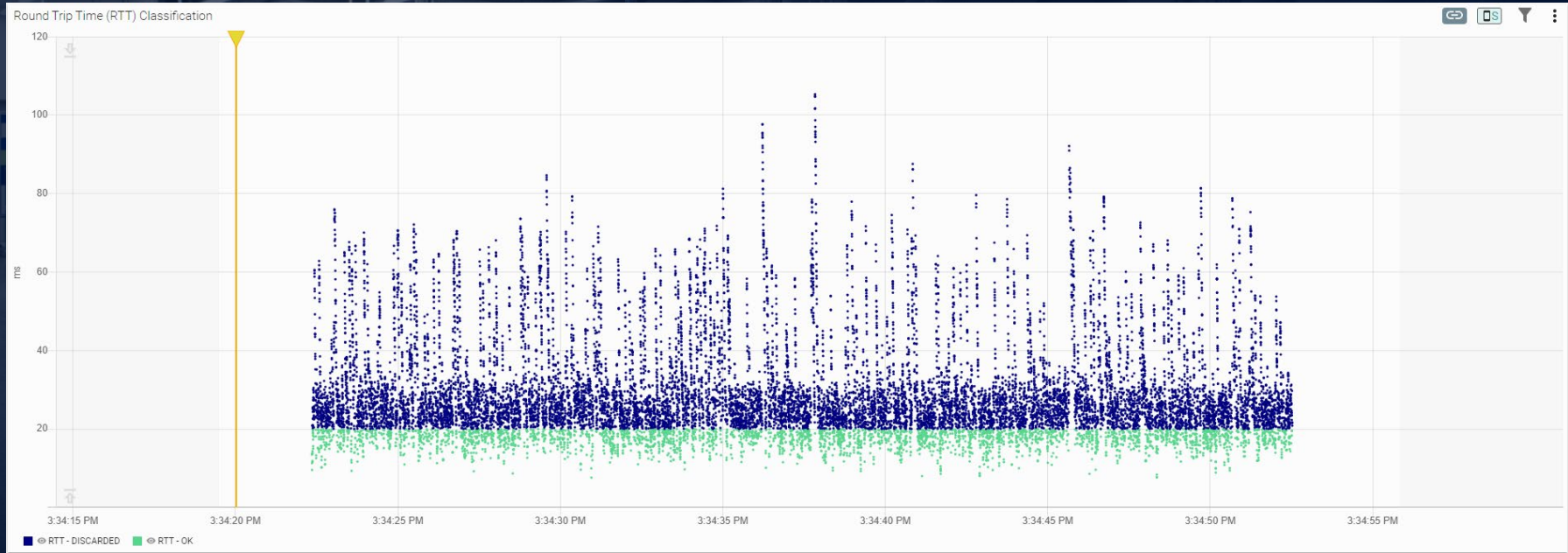


Target RTT = 20 ms
PER: $2 * 10^{-4}$

▶ Let's do drill-down

Case 4: Roundtrip Time per packet

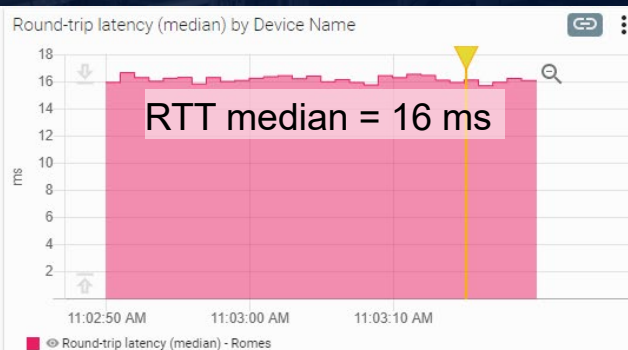
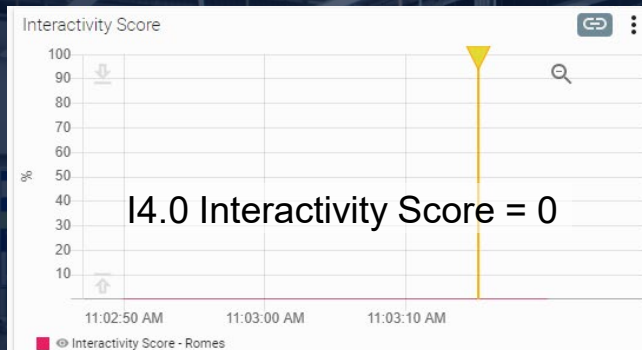
$RTT_{\min} = 7.6 \text{ ms}$; $RTT_{\text{avg}} = 17.7 \text{ ms}$; $RTT_{\max} = 105.3 \text{ ms}$



► 80% of packets are too late (discarded) – causing „Interactivity Score = 0“

Case 5: I4.0 process control with industry module as frontend

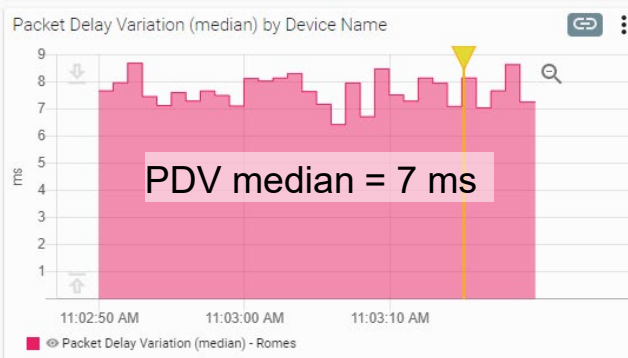
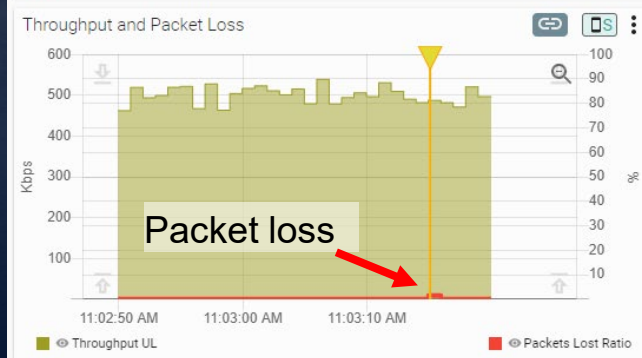
Slightly better RTT results



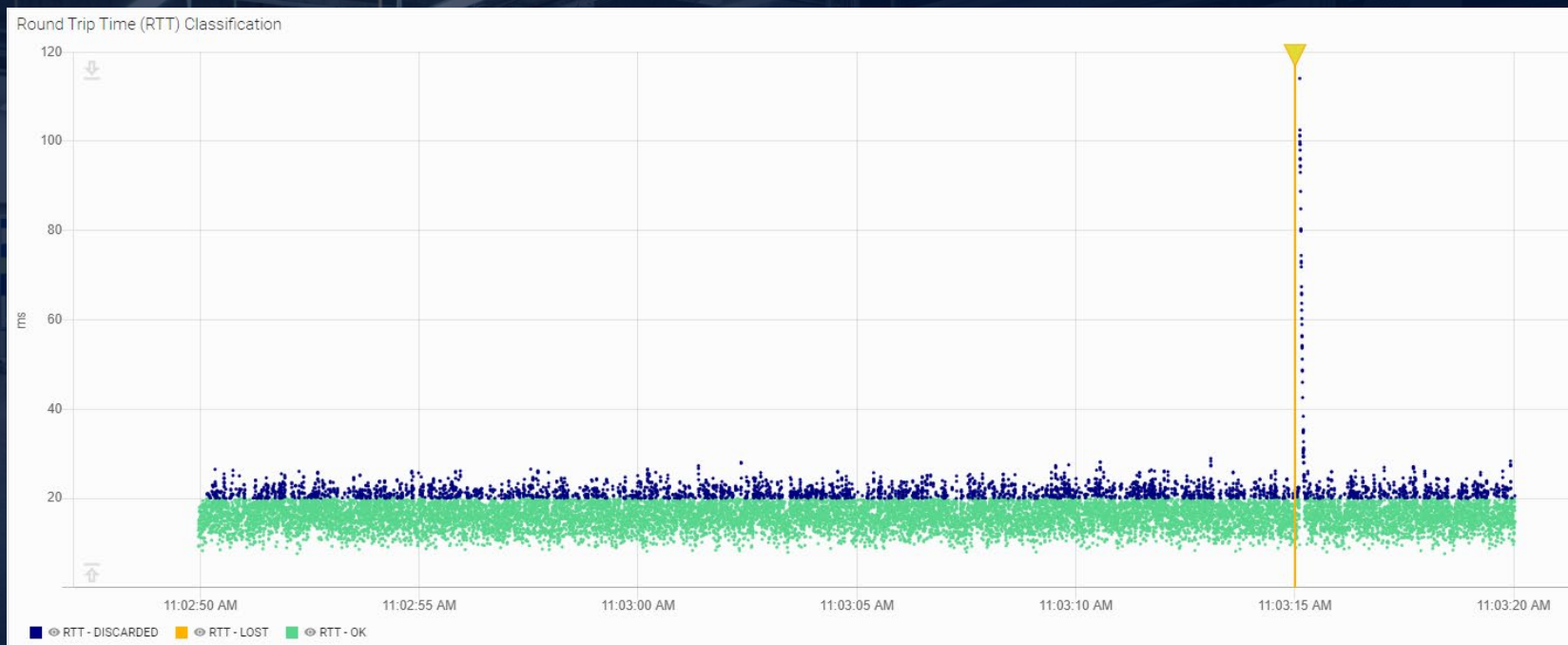
Target RTT = 20 ms

PER: $2 \cdot 10^{-4}$

Still Interact. Score = 0 ?



Case 5: Roundtrip Time per packet



- ▶ More RTT samples below 20 ms
- ▶ One significant outlier (where also packet loss happens) → drill-down next level!

Case 5: multi-cell network

Time	Layer	Message Info
11:03:15.102 AM	5G NR-RRC	DCCH-MeasurementReport
11:03:15.119 AM	5G NR-RRC	DCCH-RRCReconfiguration
11:03:15.164 AM	5G NR-RRC	DCCH-RRCReconfigurationComplete
11:03:15.197 AM	5G NR-RRC	BCCH-SCH-SIB1
11:03:15.715 AM	5G NR-RRC	BCCH-SCH-SystemInformation

SS-RSRP by Carrier Index



SS-SINR by Carrier Index



- ▶ **RRC Reconfiguration: 5G NR cell change**
- ▶ **Cell change causes packet loss and impacts RTT**

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(real performance measurements)
- ▶ **Test solutions and summary**

Private Network testing solutions for all user groups

► Deployment, site acceptance, initial performance

R&S@5G STS



QualiPoc Android SW

Easy GUI
passive + active

- Fast to operate

► Performance tuning, troubleshooting

R&S@5G STS

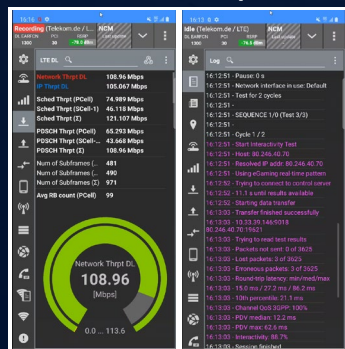


R&S@ROMES4 SW

Advanced GUI
passive + active

- Deep dive
- Engineering
- TTI resolution

► Network operation (e.g. factory IT)

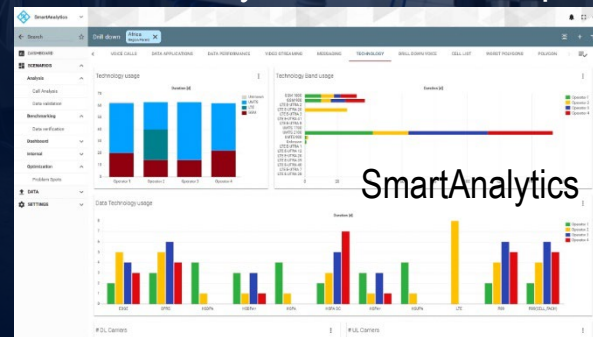


QualiPoc Android
(smartphone based)

Easy GUI
Active tests

- Functional testing
- Performance test

► Data analytics, drill down, quality monitoring



Web-based GUI
Database

- Multiple objects
- campaigns
- Trend analysis



Rohde & Schwarz

Verification in today's industry 5G networks

Summary

www.rohde-schwarz.com/mnt/private-networks

www.rohde-schwarz.com/mnt-5G

5G provides all means for business-critical use cases (URLLC, network slicing,...)

Potential interruptions in production / logistics / processes due to too long latencies and lost packets compromise productivity gains

Data throughput is already well underway (outlook to more busy networks and multi-cell / multi-beam approach)

Latency is an area for optimization (URLLC features are often not yet implemented; networks are more tuned for high data rate, but not for minimized latency)

Passive and active network testing solutions available for all enterprise user groups in deployment, site acceptance, performance tuning, troubleshooting and operation

► **Rohde & Schwarz is your One-Stop-Shop
for verifying 5G enterprise network performance**

