INACON GmbH

V 1.000

GPRS - Troubleshooting with Wireshark

Course Duration:

- 2 days

Course Description:

- This practical course enables the participants to find throughput issues and shows how to solve them by using Wireshark on the client and/or on the network side.

Prerequisites:

- Participants should be already familiar with GPRS, UMTS and HSPA. This should stem from previous exposure to design, troubleshooting or operations jobs in GPRS/UMTS/HSPA telecommunication networks.

Course Target:

- After the course the participant is able to use Wireshark efficiently for drop and throughput analysis. We teach the students how to set filters, add more columns for better fault analysis and how to export logs for further post-processing e.g. in Excel.

Some of your Questions that will be answered:

- How can a technician find out if the UE, NodeB, RNC, Core or the Internet are responsible for low throughput? Many times this requires TCP-tracing on the client, Gb/Iu-ps and on Gn/Gi-interface.
- What performance indicators can be seen in a TCP throughput graph?
- Why can't the End-to-End RTT not go below a minimum value but increases when the TCP-Window Size increases? A too high Window Size fixes delay issues caused by the network but slows down the TCP-retransmissions and demands higher buffers in core and radio access network.
- Why TCP Selective ACK's are counterproductive for TCP-Data frames but would be good for TCP-ACK ↔ out of sequence delivery of TCP-ACK's would be beneficial for the throughput if supported?
- Why Core Network can throttle the throughput down due to out-of-sequence delivery?

Who should attend this Course:

- The course is mainly targeted for Operators and UE-vendors which need to identify network problems leading to bad throughput and drops.

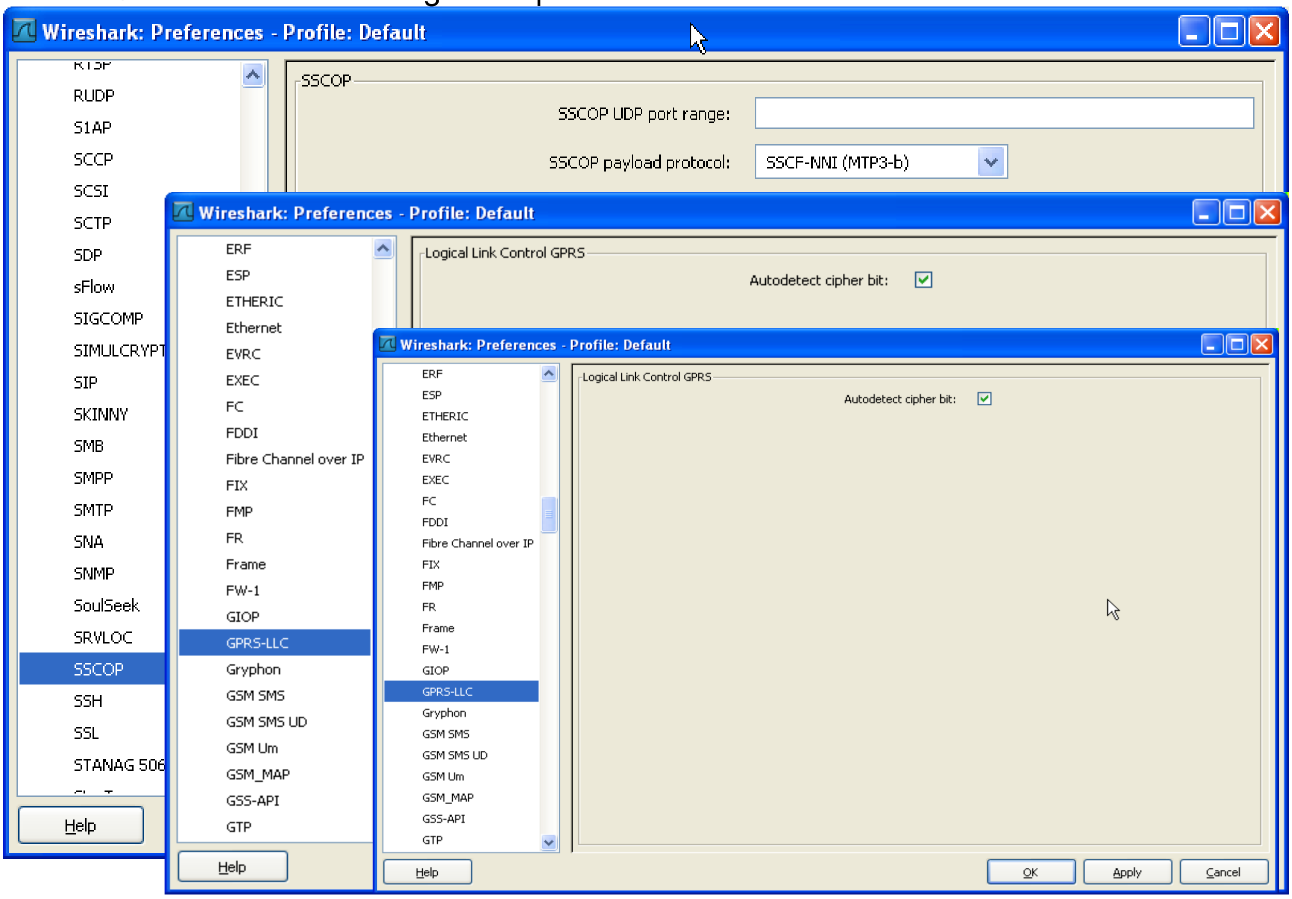
Table of Content:

How to use Wireshark in Mobile Networks

- **Wireshark Menu Bar**

  ⇒ Preferences for Gb, Iu-ps, Iu-cs, Iub, S1, Gn/Gp/Gi interfaces

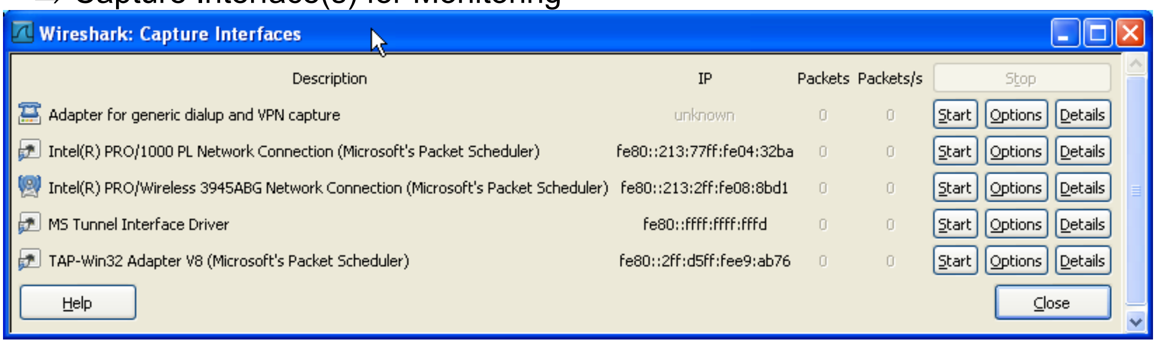
  ⇒ Verification of Settings of important Telecom Protocol's



  Frame Relay, BSSGP, GPRS-LLC; RANAP, NBAP, SSCOP, RRC-UMTS, RRC-LTE, S1-AP, S1-MME, TCP (e.g. relative TCP-packet numbering)

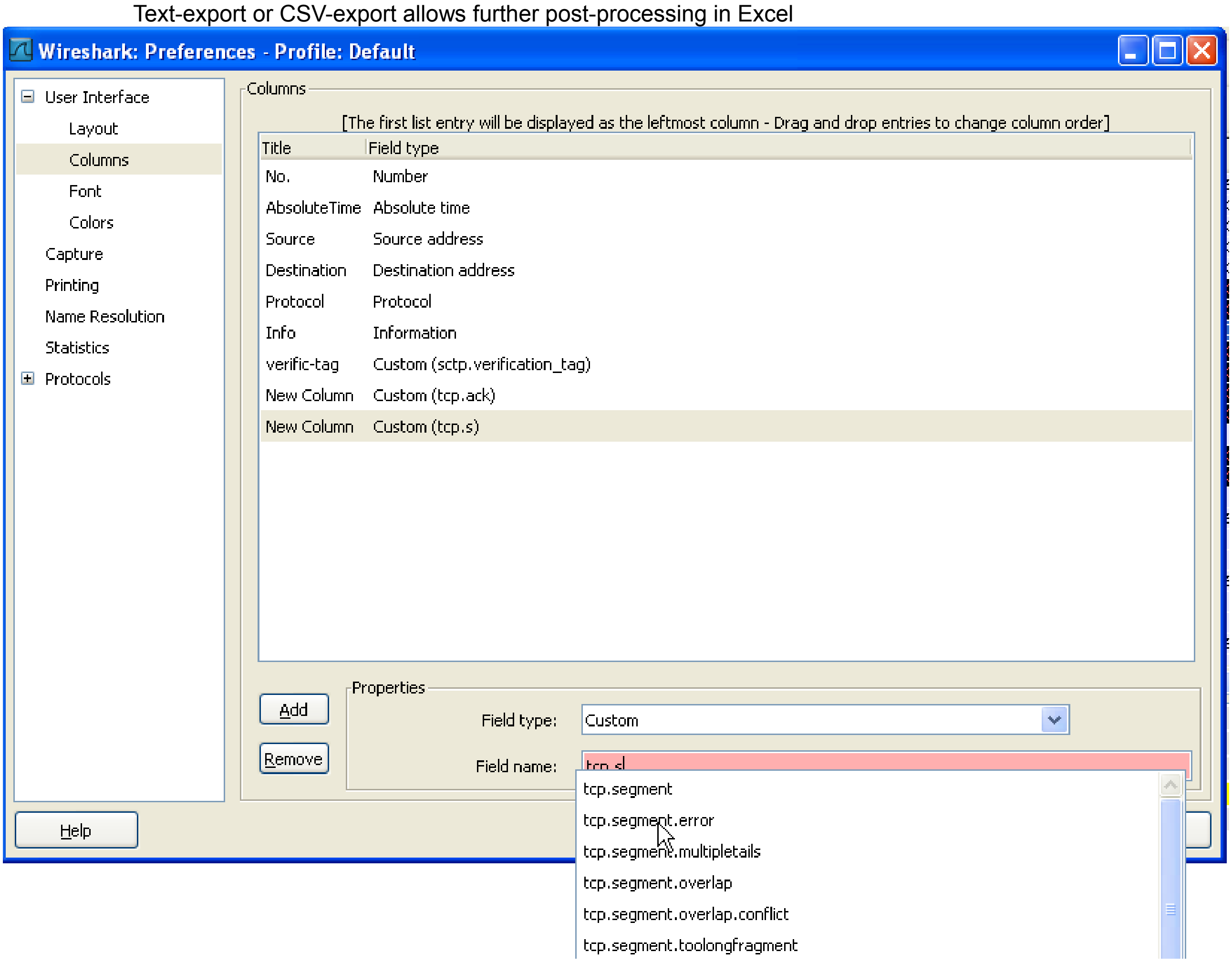
- **Start Tracing IP-connection (Network Interface Card's)**

  ⇒ Capture Interface(s) for Monitoring



⇒ Wireshark Preference Settings
Timestamp options, Colorizing two different IP (e.g. FTP) Connections in same Logfile

⇒ Adding customized Column's for enhanced analysis
Text-export or CSV-export allows further post-processing in Excel



⇒ Export of Logfiles as Textfile, CSV-file, PCAP-file

- **Reviewing important TCP/IP Fundamentals**

⇒ Overview of IP, TCP and UDP header

⇒ TCP Slow Start and Congestion Avoidance

⇒ TCP Connection Establishment & Release
3-way handshake, Receive Window Size of Client is critical, Reset a Connection

⇒ Overview of important TCP-Parameters
Window Size, Round Trip Time, Maximum Segment Size, Maximum Transfer Unit, Socket Parameter

⇒ Bandwidth Delay Product: Throughput = Window Size / RTT
Specifics of a Wireless System like GPRS, UMTS or LTE:
- Throughput should be preferably limited by the UE's Capability's
- The E-t-E-RTT cannot fall below a minimum value but increases easily
- Window Size of TCP-client (e.g. laptop) should be set to a certain value matching the RTT of the system

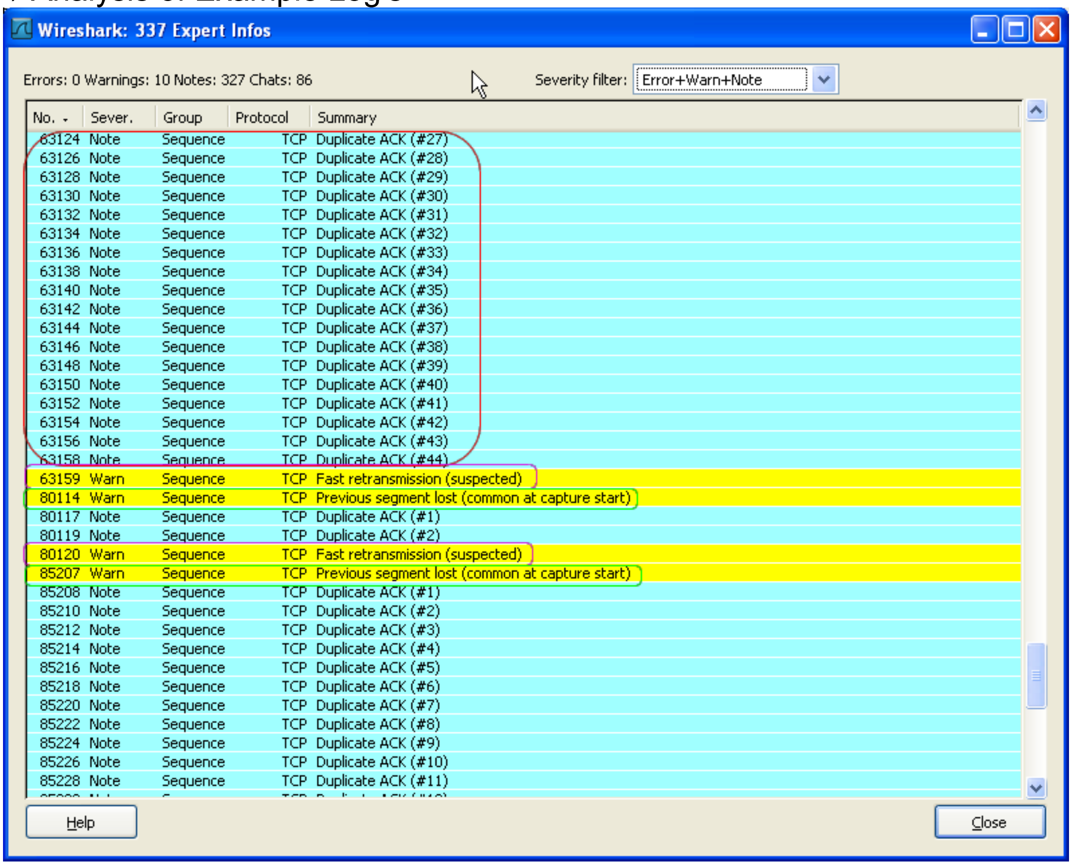
⇒ Concurrent Download and Upload leads to lower throughput
Upload throttles down the download due to Windows-PPP issue (no prioritization of TCP-ACK's), Linux computer are able to prioritize the sending of TCP-ACK's before TCP-data are sent

⇒ Impact of Duplicate ACK's & Fast Retransmissions on Subscriber Throughput

⇒ Pro's and Con's of Selective Acknowledgments
Issue of lower layer retransmissions while Selective ACK's invoke TCP-Retransmissions resulting in “double” resp. unnecessary retransmissions, Advantage when UTRAN or PCU do not stall the forwarding of TCP-ACK's to the TCP-Server and thus allow out-of-sequence delivery of TCP-ACK's if they hang in retransmissions due to RLC-AM
A TCP aware UTRAN or PCU would be beneficial for the throughput if TCP-ACK's are handled preferred

- **Quick Logfile Analysis using “Expert Info”**

⇒ Analysis of Example Log's

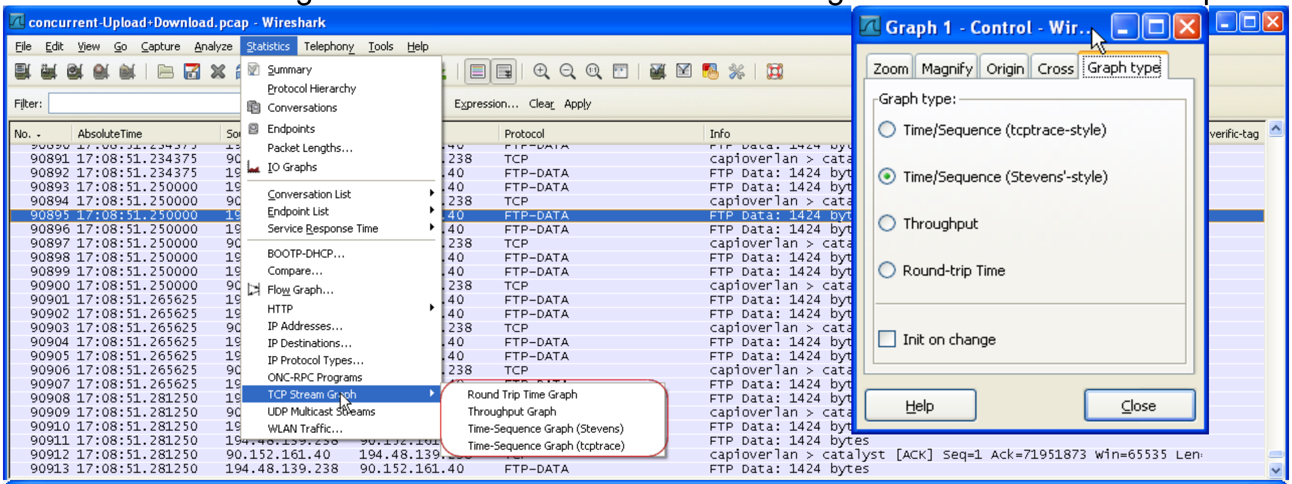


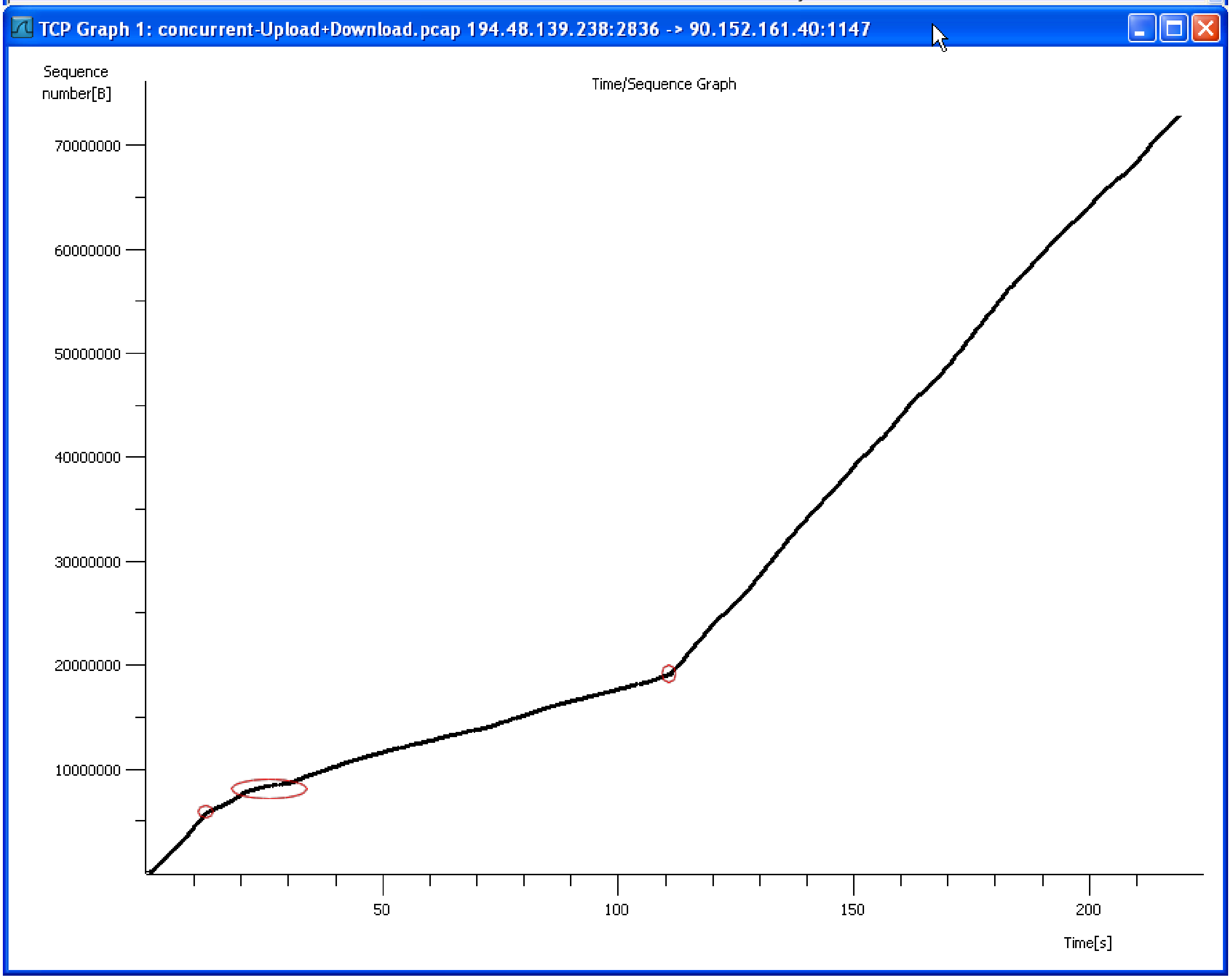
For every new TCP/IP Packet the Client sends a Duplicate ACK pointing out that a certain older TCP/IP-packet is still missing. All the newer incoming TCP/IP-packets have to be buffered until the very missing/dropped TCP/IP Packet is re-transmitted by the Server and properly received by the Client.

⇒ Issues with Buffer Size in Client and Network Nodes are discussed

- **IO-Graph in Wireshark (for quick throughput analysis)**
- **Detailed Throughput and RTT Analysis**

⇒ Determining Slow Start and Retransmission using various TCP Stream Graph's

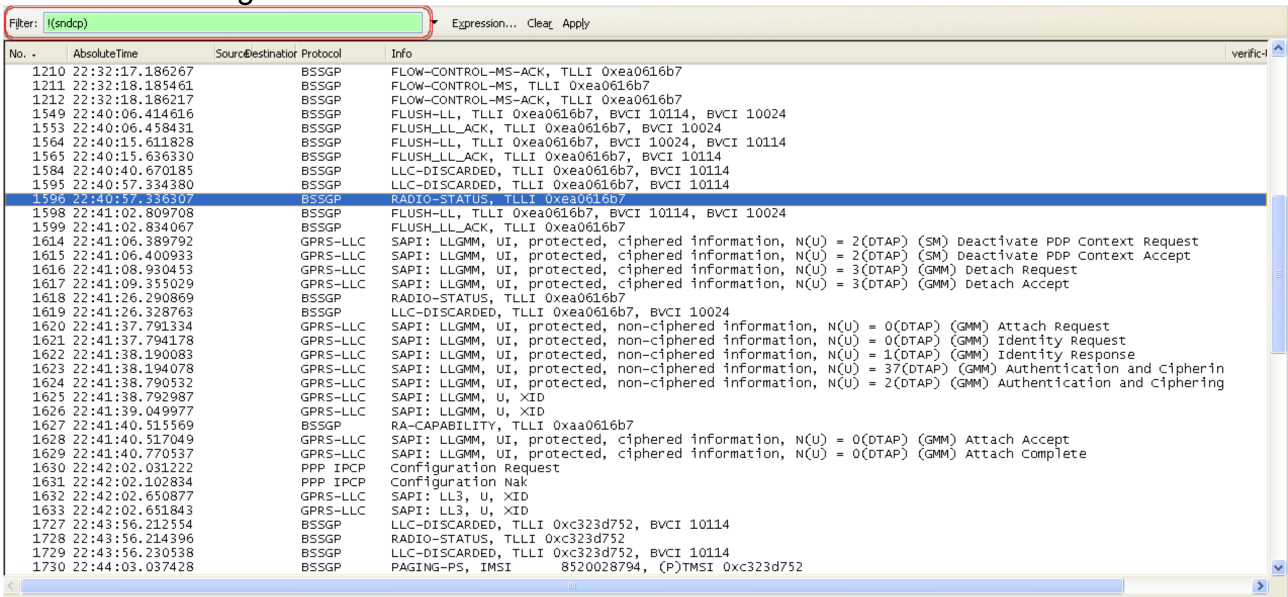




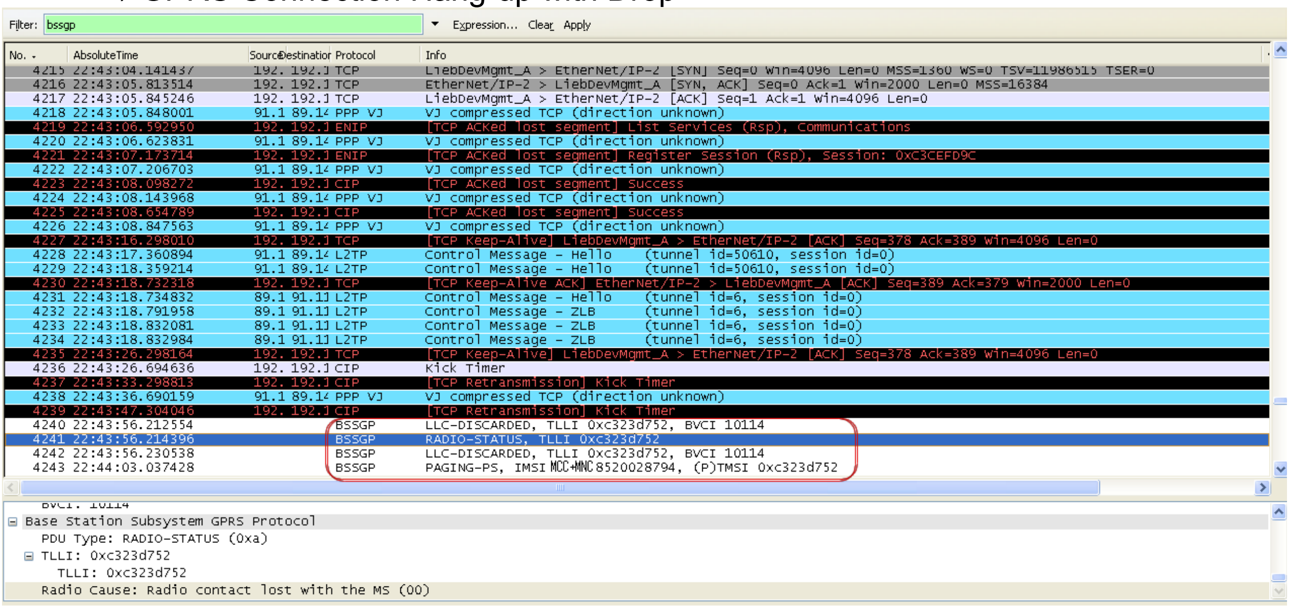
Troubleshooting of RAN and Core Errors

- **Failure & Drops in GPRS/EGPRS**

⇒ Filtering in Wireshark



⇒ GPRS Connection Hang-up with Drop



⇒ Low Throughput in EGPRS

EGPRS Throughput per cell/BVCI, faulty GPRS Dial-up software (dashboard issue with LCP protocol)

⇒ GPRS Suspend after 3G→2G HO but no Suspend ACK

⇒ Attach Accept but no Attach Complete from UE

Ciphering Key mismatch between UE and SGSN

No.	Time	Protocol	Info
1	06:22:50.171284	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 36(DTAP) (GMM) Authentication and Ciphering
2	06:22:51.642174	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 2(DTAP) (GMM) Authentication and Ciphering R
3	06:22:51.644418	GPRS-LLC	SAPI: LLGMM, U, XID
4	06:22:53.101582	GPRS-LLC	SAPI: LLGMM, U, XID
5	06:22:54.183777	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 0(DTAP) (GMM) Routing Area Update Accept
6	06:23:01.197192	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 37(DTAP) (GMM) Routing Area Update Accept
7	06:23:05.160053	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 0(DTAP) (GMM) Routing Area Update Request
8	06:23:05.162071	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 74(DTAP) (GMM) Routing Area Update Accept
9	06:23:12.176788	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 111(DTAP) (GMM) Routing Area Update Accept
10	06:23:19.186958	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 148(DTAP) (GMM) Routing Area Update Accept
11	06:23:20.081543	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 1(DTAP) (GMM) Routing Area Update Request
12	06:23:20.083054	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 185(DTAP) (GMM) Routing Area Update Accept
13	06:23:27.096936	GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 222(DTAP) (GMM) Routing Area Update Accept
14	06:23:28.876349	GPRS-LLC	SAPI: LLGMM, U, Unknown/invalid code:0
15	06:23:28.876969	BSSGP	FLUSH-LL, TLLI 0xa2a4ef67, BVCI 9200, BVCI 56303
16	06:23:28.877609	GPRS-LLC	SAPI: LLGMM, U, Unknown/invalid code:0
17	06:23:34.107749	GPRS-LLC	SAPI: LL11, U, XID
18	06:23:35.135044	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 2(DTAP) (GMM) Routing Area Update Request
19	06:23:35.139250	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 223(DTAP) (GMM) Routing Area Update Reject
20	06:23:37.694933	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 3(DTAP) (GMM) Attach Request
21	06:23:37.703967	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 0(DTAP) (GMM) Identity Request
22	06:23:38.774932	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 4(DTAP) (GMM) Identity Response
23	06:23:38.777965	GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 37(DTAP) (GMM) Authentication and Ciphering

Failure and Drops in UMTS

- **Core Network causes Duplicate ACK's and Fast Retransmissions**

⇒ Out of Sequence Delivery of TCP-Packets on Gn/Gp- or Gi-interface

UE sends Duplicates ACK's in uplink; UTRAN assures In-Sequence Delivery through RLC-AM and HARQ;

	A	B	C	F	G	H	K	L	M	P	Q	R
1	Gi @ GGSN2			Gn @ GGSN2			Gn @ SGSN11			Iu @ SGSN11		
2	TCP-SN	TCP-ACK	DELTA SN	TCP-SN	TCP-ACK	DELTA SN	TCP-SN	TCP-ACK	DELTA SN	TCP-SN	TCP-ACK	DELTA SN
37	3556828330	3556829754	0	3556828330	3556829754	0	3556828330	3556829754	0	3556828330	3556829754	0
38	3556829754	3556831178	0	3556829754	3556831178	0	3556829754	3556831178	0	3556829754	3556831178	0
39	3556831178	3556832602	0	3556831178	3556832602	0	3556831178	3556832602	0	3556831178	3556832602	0
40	3556832602	3556834026	0	3556832602	3556834026	0	3556832602	3556834026	0	3556832602	3556834026	0
41	3556834026	3556835450	0	3556834026	3556835450	0	3556834026	3556835450	0	3556834026	3556835450	0
42	3556835450	3556836874	0	3556835450	3556836874	0	3556835450	3556836874	0	3556835450	3556836874	0
43	3556836874	3556838298	0	3556836874	3556838298	0	3556836874	3556838298	0	3556836874	3556838298	0
44	3556838298	3556839722	0	3556838298	3556839722	0	3556838298	3556839722	0	3556838298	3556839722	0
45	3556839722	3556841146	0	3556839722	3556841146	0	3556839722	3556841146	0	3556839722	3556841146	0
46	3556841146	3556842570	0	3556841146	3556842570	0	3556841146	3556842570	0	3556841146	3556842570	0
47	3556842570	3556843994	0	3556842570	3556843994	0	3556842570	3556843994	0	3556842570	3556843994	0
48	3556843994	3556845418	0	3556843994	3556845418	0	3556843994	3556845418	0	3556843994	3556845418	0
49	3556845418	3556846842	0	3556845418	3556846842	0	3556845418	3556846842	0	3556845418	3556846842	0
50	3556846842	3556848266	0	3556846842	3556848266	0	3556846842	3556848266	0	3556846842	3556848266	0
51	3556848266	3556849690	0	3556848266	3556849690	0	3556848266	3556849690	0	3556848266	3556849690	0
52	3556849690	3556851114	0	3556849690	3556851114	0	3556849690	3556851114	0	3556849690	3556851114	0
53	3556851114	3556852538	0	3556851114	3556852538	0	3556852538	3556853962	1424	3556852538	3556853962	1424
54	3556852538	3556853962	0	3556852538	3556853962	0	3556853962	3556855386	0	3556853962	3556855386	0
55	3556853962	3556855386	0	3556853962	3556855386	0	3556851114	3556852538	-4272	3556851114	3556852538	-4272
56	3556855386	3556856810	0	3556855386	3556856810	0	3556855386	3556856810	2848	3556855386	3556856810	2848
57	3556856810	3556858234	0	3556856810	3556858234	0	3556856810	3556858234	0	3556856810	3556858234	0

⇒ GGSN discards sometimes IP-packets

Delta-measurement between Gi (incoming) and Gn (outgoing) of IP-Packets; Internet Server may stick with Congestion Avoidance only after TCP-Retransmission due to packet loss

⇒ RLC-AM In-Sequence and Out-of-Sequence Delivery Configuration

For Rel. 99 bearers, RLC-AM out-of-sequence delivery is counter-productive as it causes Duplicate ACK's. Bearers mapped on Rel. 5/6 HS-DSCH or Rel. 6 E-DCH provide almost in-sequence deliver due to HARQ underneath unless during HSPA Serving Cell Changes and if RLC-AM is configured for out-of-sequence delivery!

⇒ SRNC can delay TCP/IP packets mapped on HS-DSCH unnecessary

Iub HS-DSCH Frame Protocol (user plane) trace required to compare with Iu-ps user plane timing

⇒ Modem/Data-card hangs-up (UE software bug)

One or more TCP Retransmissions for same TCP-Packet but no ACK from TCP-client, then UE performs sudden GPRS ATTACH due to Switch-off-on, PDP Context Activation and “normal” download resumes

No.	AbsoluteTime	Source	Destinat	Protocol	Info
3004	09:24:23.082919	9	19	GTP <TCP>	cedros_fds > https [ACK] Seq=347065 Ack=475873 Win=65535 Len=0
3005	09:24:23.082976	9	19	GTP <SSL>	Continuation Data
3006	09:24:23.247496	1	90	GTP <TCP>	https > cedros_fds [ACK] Seq=475873 Ack=347177 Win=17088 Len=0
3007	09:24:34.132321	9	19	GTP <SSL>	Continuation Data
3008	09:24:34.248705	1	90	GTP <TCP>	https > cedros_fds [ACK] Seq=475873 Ack=347321 Win=17088 Len=0
3009	09:24:34.725697	9	19	GTP <SSL>	[TCP Retransmission] Continuation Data
3010	09:24:34.727455	1	90	GTP <TCP>	[TCP Dup ACK 3008#1] https > cedros_fds [ACK] Seq=475873 Ack=347321 Win=17088 Len=0
3011	09:24:39.204262	9	19	GTP <SSL>	Continuation Data
3012	09:24:39.207509	1	90	GTP <SSL>	Continuation Data
3013	09:24:39.645679	9	19	GTP <TCP>	cedros_fds > https [ACK] Seq=347473 Ack=476025 Win=65383 Len=0
3014	09:24:43.835735	2	29	RANAP	id-DirectTransfer (DTAP) (SM) Deactivate PDP Context Request
3015	09:24:43.842919	2	29	RANAP	id-DirectTransfer (DTAP) (SM) Deactivate PDP Context Accept
3016	09:24:43.843214	2	29	RANAP	id-RAB-Assignment
3017	09:24:44.394152	2	29	RANAP	id-RAB-Assignment
3018	09:24:44.397069	2	29	RANAP	id-Iu-Release
3019	09:24:45.128596	2	29	RANAP	id-Iu-Release
3020	09:41:50.339526	2	29	RANAP	id-InitialUE-Message (DTAP) (GMM) Attach Request
3021	09:41:50.343914	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Req
3022	09:41:50.507849	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Resp
3023	09:41:50.510824	2	29	RANAP	id-SecurityModeControl
3024	09:41:50.639993	2	29	RANAP	id-SecurityModeControl
3025	09:41:50.642435	2	29	RANAP	id-CommonID
3026	09:41:50.644077	2	29	RANAP	id-Iu-Release
3027	09:41:51.257584	2	29	RANAP	id-Iu-Release
3028	09:42:07.034840	2	29	RANAP	id-InitialUE-Message (DTAP) (GMM) Attach Request
3029	09:42:07.039909	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Identity Request
3030	09:42:07.135008	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Identity Response
3031	09:42:07.378579	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Req
3032	09:42:07.544042	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Resp
3033	09:42:07.547268	2	29	RANAP	id-SecurityModeControl
3034	09:42:07.665201	2	29	RANAP	id-SecurityModeControl
3035	09:42:07.670210	2	29	RANAP	id-CommonID
3036	09:42:09.096292	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Attach Accept
3037	09:42:09.214338	2	29	RANAP	id-DirectTransfer (DTAP) (GMM) Attach Complete
3038	09:42:09.217849	2	29	RANAP	id-Iu-Release
3039	09:42:09.817343	2	29	RANAP	id-Iu-Release
3040	09:44:38.254675	2	29	RANAP	id-InitialUE-Message (DTAP) (GMM) Service Request

Failure and Drops in LTE

- **S1-MME Signaling Issues**

⇒ UE lost in E-UTRAN (uplink drop)

Filter: s1ap   Expression... Clear Apply

No.	AbsoluteTime	Source	Destination	Protocol	Info	verific-tag
5	11:43:06.426985	10.4	10.4	S1AP	id-UEContextReleaseRequest	0xb91d397d
6	11:43:06.447475	10.4	10.4	S1AP	id-ErrorIndication	0xfd371a51
9	11:43:11.638798	10.4	10.4	PPP IPCP	Configuration Request	0xb91d397d
10	11:43:11.695362	10.4	10.4	S1AP/NAS-EPS	id-InitialContextSetup Attach accept Activate default EPS bearer context request	0xfd371a51
13	11:43:14.047007	10.4	10.4	PPP IPCP	Configuration Request	0xb91d397d
15	11:43:17.716353	10.4	10.4	S1AP/NAS-EPS	id-InitialContextSetup Attach accept Activate default EPS bearer context request	0xfd371a51
16	11:43:17.720582	10.4	10.4	S1AP	id-InitialContextSetup	0xb91d397d
17	11:43:17.783683	10.4	10.4	S1AP	id-InitialContextSetup	0xb91d397d
19	11:43:17.785347	10.4	10.4	S1AP	id-UEContextReleaseRequest	0xb91d397d
21	11:43:17.913452	10.4	10.4	S1AP	id-UEContextRelease	0xfd371a51
22	11:43:17.917159	10.4	10.4	S1AP	id-UEContextRelease	0xb91d397d
43	11:43:29.638375	10.4	10.4	PPP IPCP	Configuration Request	0xb91d397d

```
UEContextReleaseRequest
  protocolIEs: 3 items
    Item 0: id-MME-UE-S1AP-ID
      ProtocolIE-Field
        id: id-MME-UE-S1AP-ID (0)
        criticality: reject (0)
        value
          MME-UE-S1AP-ID: 680
    Item 1: id-eNB-UE-S1AP-ID
      ProtocolIE-Field
        id: id-eNB-UE-S1AP-ID (8)
        criticality: reject (0)
        value
          ENB-UE-S1AP-ID: 18
    Item 2: id-Cause
      ProtocolIE-Field
        id: id-Cause (2)
        criticality: ignore (1)
        value
          Cause: radioNetwork (0)
            radioNetwork: radio-connection-with-ue-lost (21)
```

⇒ UE drops due to downlink out-of-sync

RRC Re-establishment Procedure Scenario

⇒ Tracking Area Update after failed RRC Re-establishment

Network Paging in case of downlink Data Delivery, As long as the TCP Timers in UE/Client are not fired, TCP triggers the Connection Establishment with E-UTRAN again (same in GPRS and UMTS), UE keeps its IP-address after drop or being in Idle Mode until Detach or “Deactivate PDP Context”

- **X2AP Signaling Issues**

⇒ Handover Signaling

Meaning of snStatusTransfer, Why are there duplicate X2AP messages visible?

	A	B	C	D	E	F	G	H	I
1	No.	Time	S	De	Protocol	Info			
391	390	56:06.8	10.4	10.4	X2AP	id-handoverPreparation			
392	391	56:06.8	10.4	10.4	X2AP	id-handoverPreparation			
393	392	56:06.8	10.4	10.4	X2AP	id-handoverPreparation RRCConnectionReconfiguration			
394	393	56:06.8	10.4	10.4	X2AP	id-handoverPreparation RRCConnectionReconfiguration			
395	394	56:06.8	10.4	10.4	X2AP	id-snStatusTransfer			
396	395	56:06.8	10.4	10.4	X2AP	id-snStatusTransfer			
406	405	56:07.0	10.4	10.4	X2AP	id-uEContextRelease			
407	406	56:07.0	10.4	10.4	X2AP	id-uEContextRelease			
627	626	56:38.5	10.4	10.4	X2AP	id-handoverPreparation			
628	627	56:38.5	10.4	10.4	X2AP	id-handoverPreparation			
629	628	56:38.5	10.4	10.4	X2AP	id-handoverPreparation RRCConnectionReconfiguration			
630	629	56:38.5	10.4	10.4	X2AP	id-handoverPreparation RRCConnectionReconfiguration			
631	630	56:38.5	10.4	10.4	X2AP	id-snStatusTransfer			
632	631	56:38.5	10.4	10.4	X2AP	id-snStatusTransfer			
642	641	56:38.7	10.4	10.4	X2AP	id-uEContextRelease			
643	642	56:38.7	10.4	10.4	X2AP	id-uEContextRelease			

⇒ How to trace the complete signaling of a single UE on S1-MME?

Filter: s1ap || x2ap   Expression... Clear Apply

No.	AbsoluteTime	Source	Destinat	Protocol	Info	MME-id	eNB-id
1636	12:10:00.382163	1	1C	S1AP/NAS-EP	id-initialUEMessage		64
1637	12:10:00.398769	1	1C	S1AP/NAS-EP	id-downlinkNASTransport Service reject	4294967295	64
1638	12:10:00.582855	1	1C	SCTP	SACK		
1639	12:10:00.597100	1	1C	SCTP	SACK		
1640	12:10:00.784708	1	1C	SCTP	HEARTBEAT		
1641	12:10:00.784725	1	1C	SCTP	HEARTBEAT		
1642	12:10:00.784824	1	1C	SCTP	HEARTBEAT_ACK		
1643	12:10:00.784840	1	1C	SCTP	HEARTBEAT_ACK		
1644	12:10:00.981878	1	1C	S1AP	id-InitialContextSetup	691	63
1645	12:10:00.982519	1	1C	S1AP	id-UEContextReleaseRequest	691	63
1646	12:10:00.982599	1	1C	SCTP	SACK		
1647	12:10:01.004961	1	1C	S1AP	id-UEContextRelease		
1648	12:10:01.008280	1	1C	S1AP	id-UEContextRelease	691	63
1649	12:10:01.201133	1	1C	SCTP	SACK		
1650	12:10:01.210224	1	1C	SCTP	SACK		
1651	12:10:05.861061	1	1C	S1AP	id-UEContextReleaseRequest	4294967295	64
1652	12:10:05.878366	1	1C	S1AP	id-ErrorIndication		
1653	12:10:06.063726	1	1C	SCTP	SACK		
1654	12:10:06.077299	1	1C	SCTP	SACK		
1655	12:10:11.065701	1	1C	PPP IPCP	Configuration Request		65
1656	12:10:11.123911	1	1C	S1AP/NAS-EP	id-InitialContextSetup Attach accept Activate default	691	65
1657	12:10:11.267130	1	1C	SCTP	SACK		
1658	12:10:11.321480	1	1C	SCTP	SACK		
1659	12:10:11.397488	1	1C	SCTP	HEARTBEAT		
1660	12:10:11.397503	1	1C	SCTP	HEARTBEAT		
1661	12:10:11.397587	1	1C	SCTP	HEARTBEAT_ACK		
1662	12:10:11.397602	1	1C	SCTP	HEARTBEAT_ACK		
1663	12:10:12.912056	1	1C	S1AP	id-InitialContextSetup	691	65
1664	12:10:12.946437	1	1C	S1AP	id-UEContextRelease		
1665	12:10:12.949928	1	1C	S1AP	id-UEContextRelease	691	65

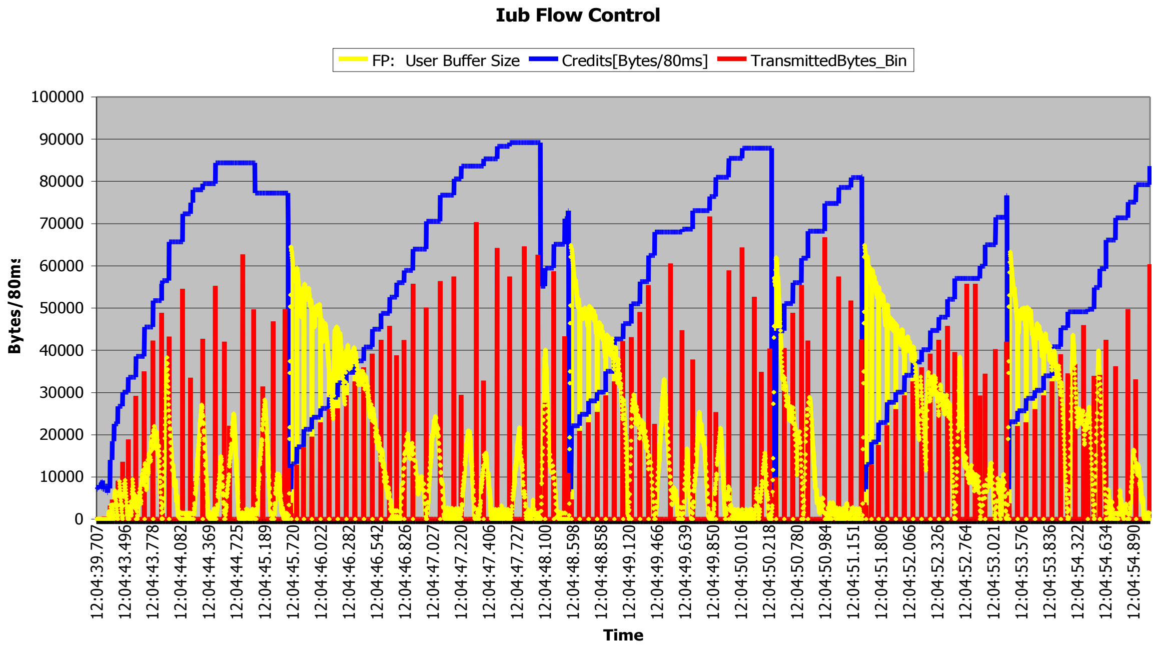
SCTP does not distinguish the Signaling for different Users/UE's between eNodeB and MME. Thus S1AP in eNodeB assigns upon connection establishment (e.g. with ATTACH REQUEST) a unique number called eNB-UE-S1AP-ID. In response the MME allocates his unique number MME-UE-S1AP-ID and mirrors back the number which eNodeB has assigned for the call. Thus from that moment on the UE/User is uniquely identified by two numbers and eNodeB refers to the MME-ID when sending some S1AP-message to the MME where as the MME refers to eNB-ID when sending some message for the specific UE to eNodeB.

⇒ How to identify the User Plane Connection (S1-U) of eNB ↔ SGW for a certain UE?

Low Throughput Troubleshooting in HSPA Networks

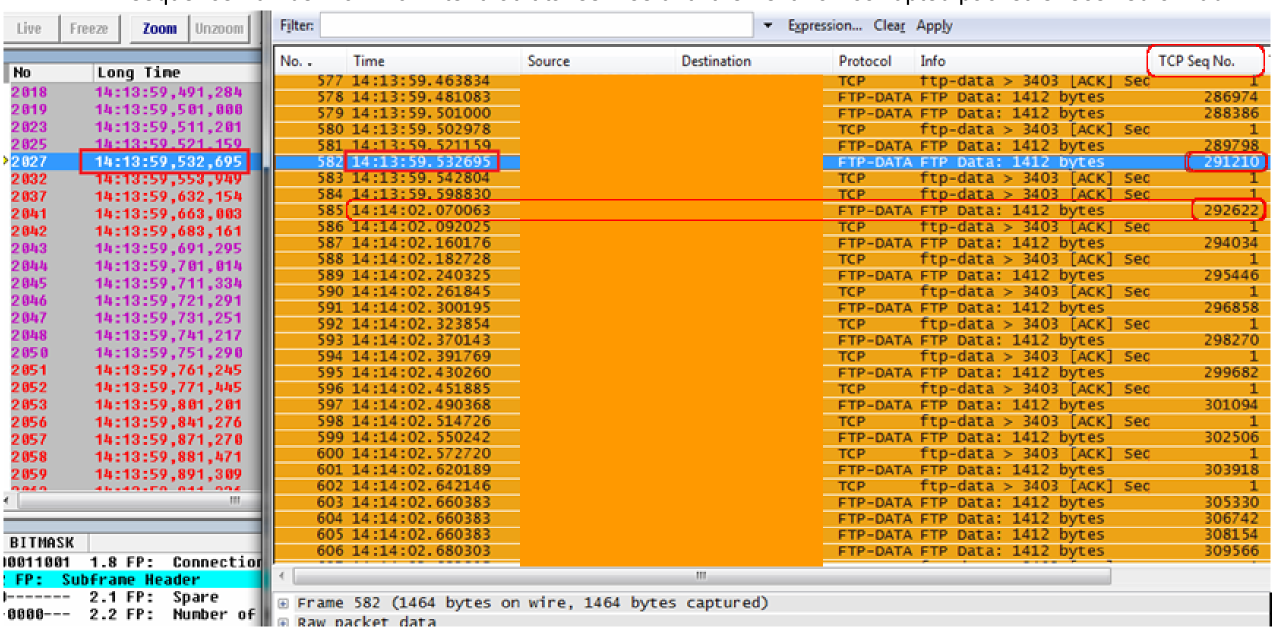
- **Iub Flow Control Issues**

  ⇒ Bad HS-DSCH Flow Control



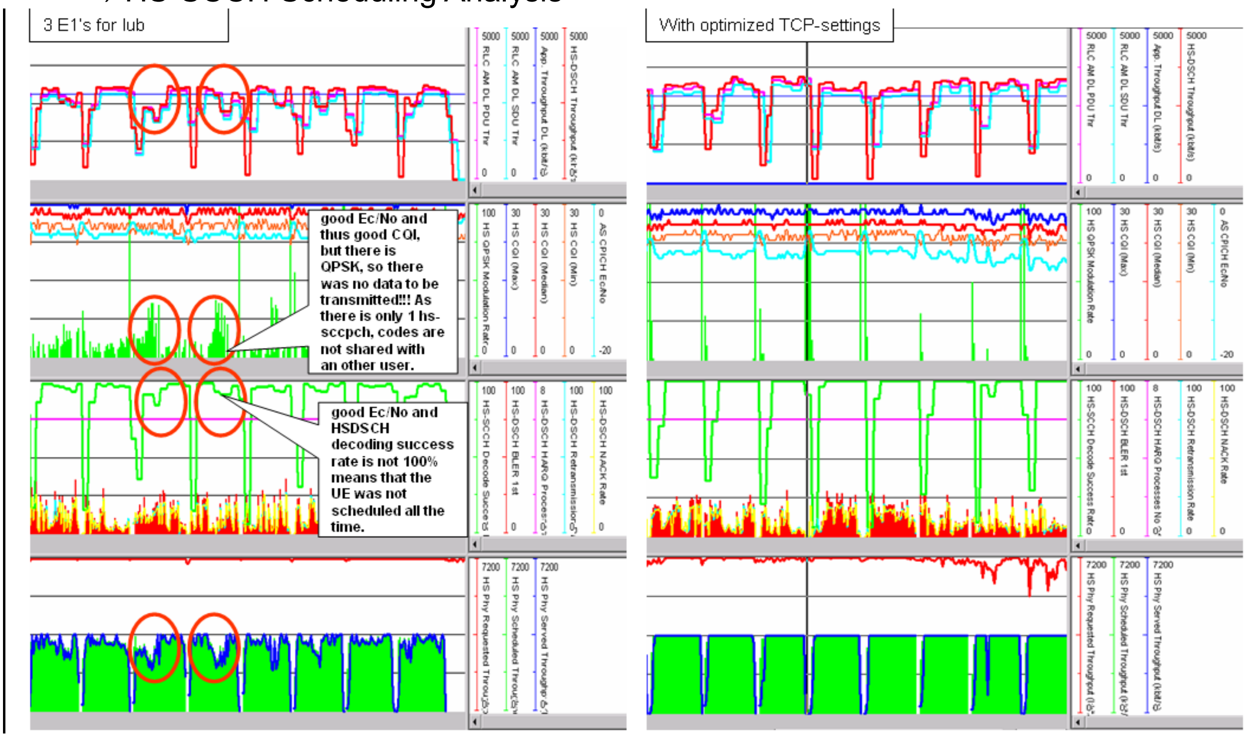
  ⇒ E-DCH FP throttles uplink Throughput

  Example for a bunch of corrupted E-DCH frames. The last correct received packet on Iub is having sequence number 291210. After that it takes 2.5s until the next non-corrupted packet is received on Iub:



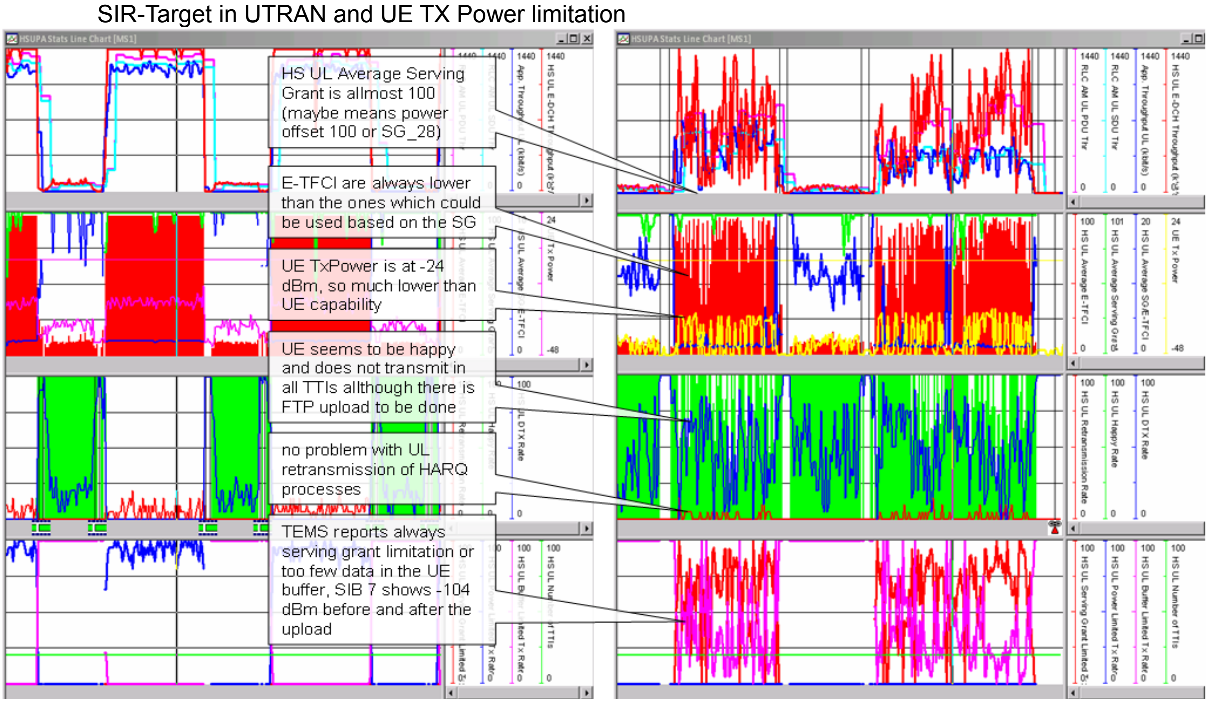
- **Combined Trace Analysis of Air-interface (Uu) and Wireshark**

⇒ HS-SCCH Scheduling Analysis



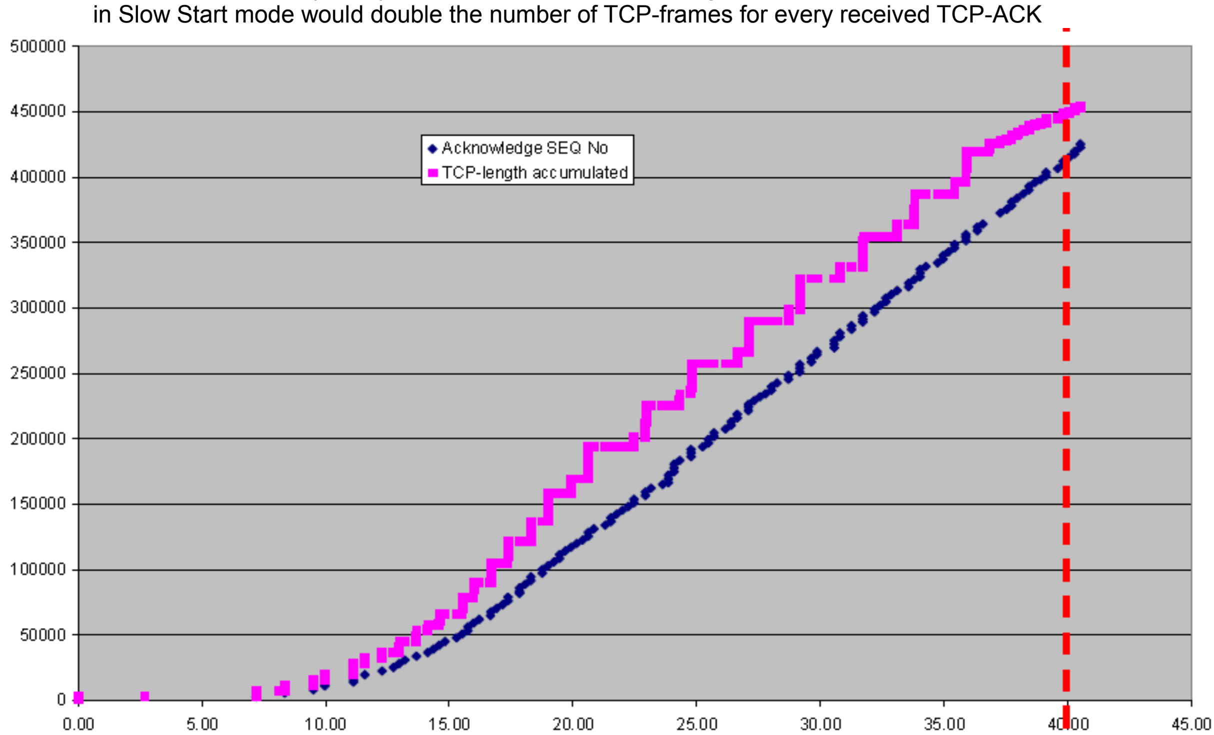
⇒ Serving Grant Monitoring for low HSUPA Throughput

SIR-Target in UTRAN and UE TX Power limitation



⇒ TCP/IP ACK counting on Client Laptop

(typically a Windows PC ack's only every 2nd TCP-frame) – downlink packets arrive too slow although Client-PC ack's nicely every 2nd TCP-frame ↔ self-clocking principle of the TCP-connection. A TCP-Server in Slow Start mode would double the number of TCP-frames for every received TCP-ACK



⇒ High uplink BLER (RTT) throttles HS-DSCH Throughput

As the downlink HARQ of HS-DSCH (and also uplink HARQ of E-DCH) is usually very robust, throughput issues only occur due to too high TCP-RTT (high E-to-E delays) or TCP-Packet out-of-sequence delivery caused by Core or due to lossy Core Network (GGSN, SGSN, Router) or lossy Iub/Iu-ps (e.g. too aggressive ATM overbooking), provided that the CQI reporting of UE is good and that sufficient E1-links on Iub are available and that more than 1 HS-SCCH is configured in the cell and just one UE is using HSDPA