

LTE - 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/lu-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.

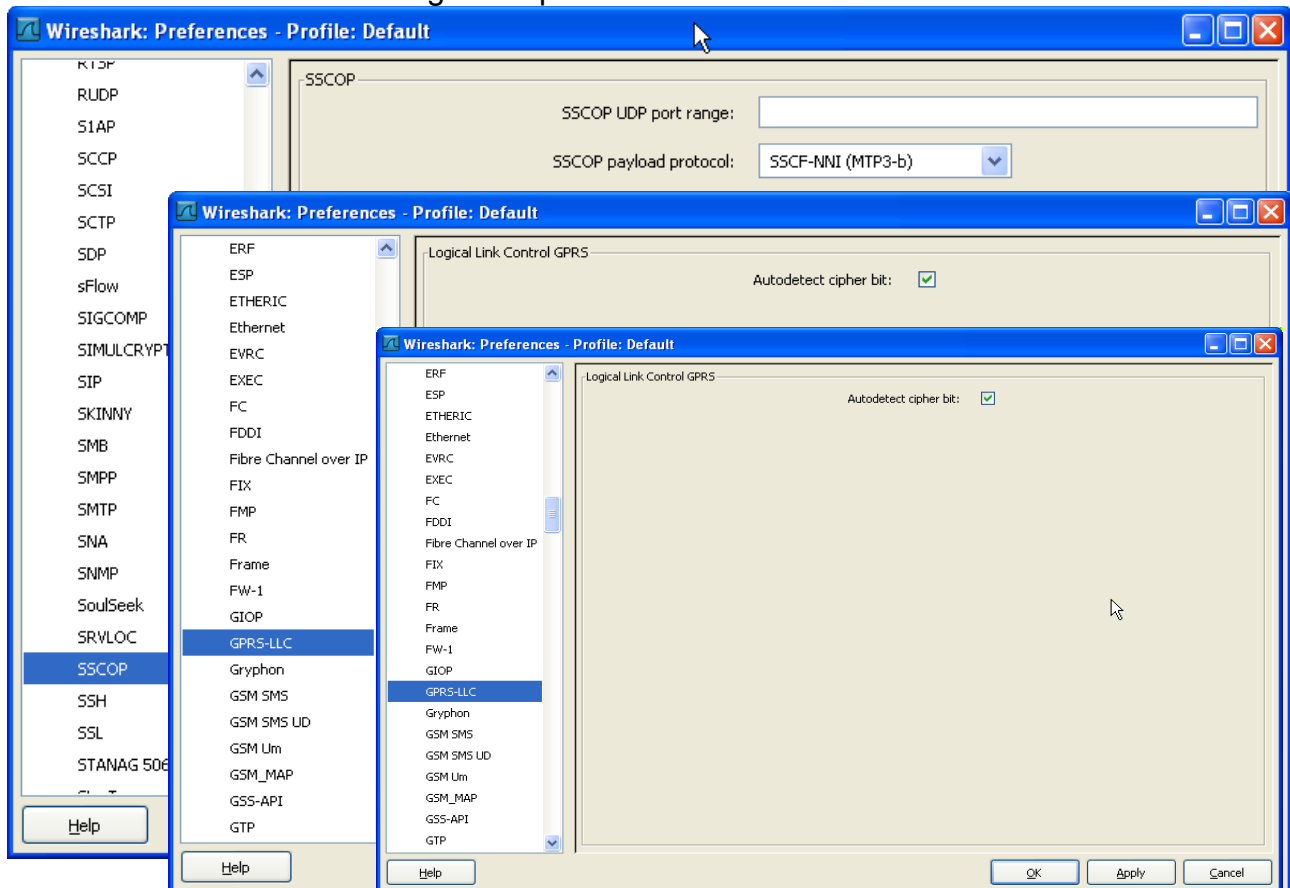
Table of Content:

How to use Wireshark in Mobile Networks

- **Wireshark Menu Bar**

⇒ Preferences for Gb, lu-ps, lu-cs, lub, S1, Gn/Gp/Gi interfaces

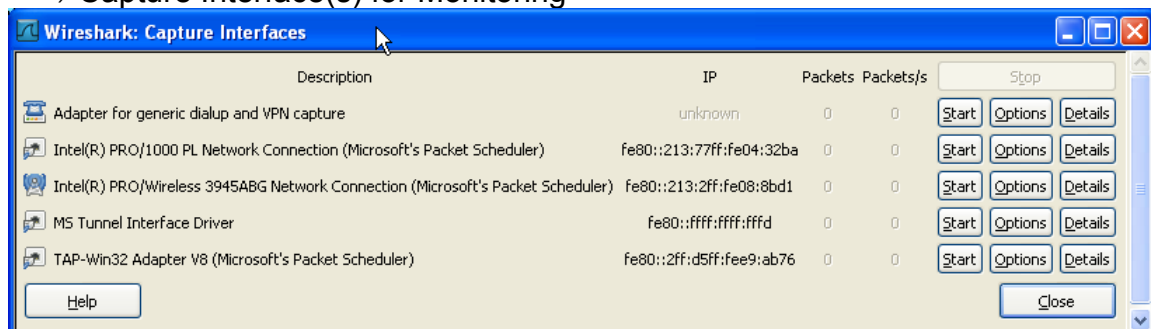
⇒ Verification of Settings of important Telecom Protocol's



Frame Relay, BSSGP, GPRS-LLC; RANAP, NBAP, SSCTP, 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

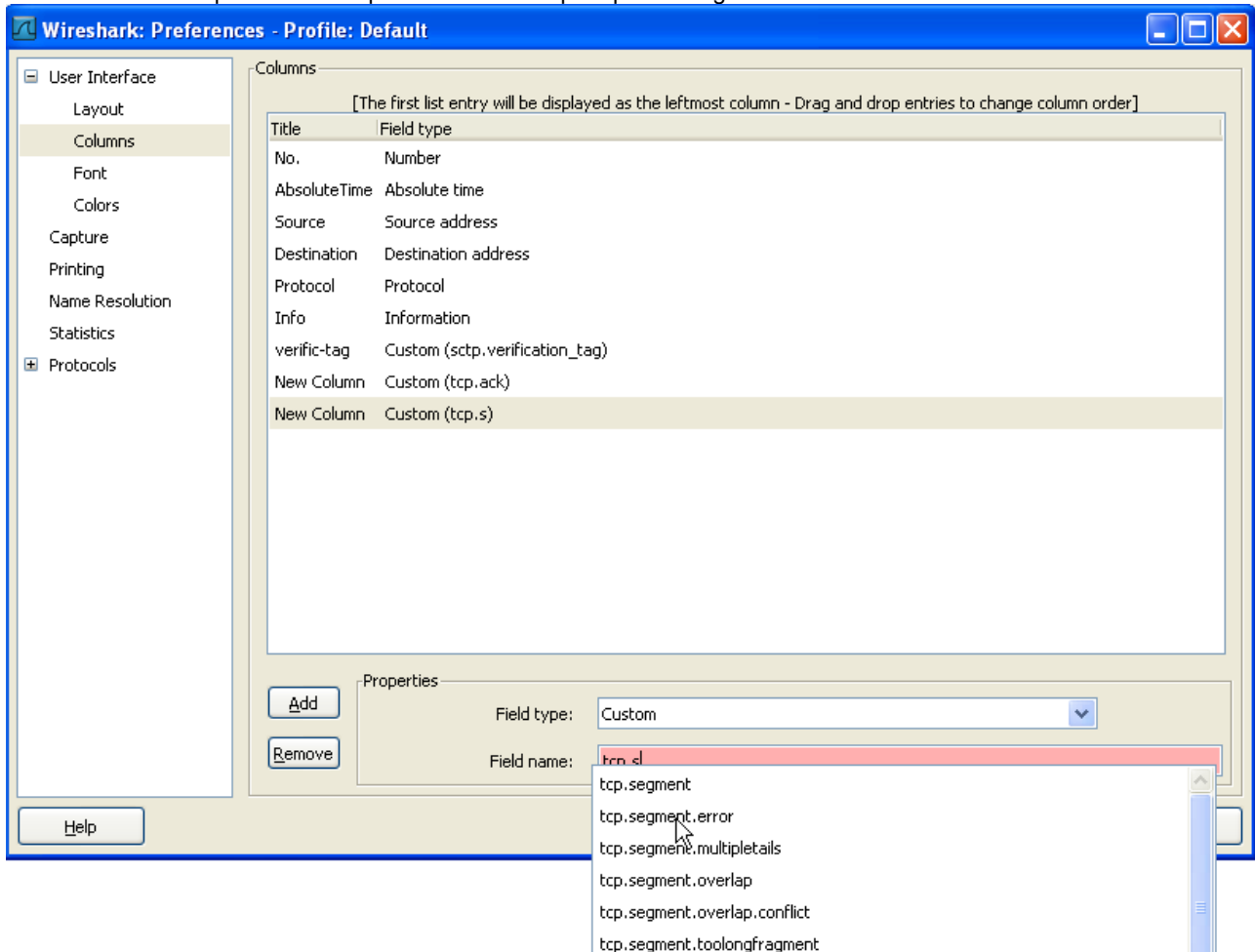


⇒ Wireshark Preference Settings

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

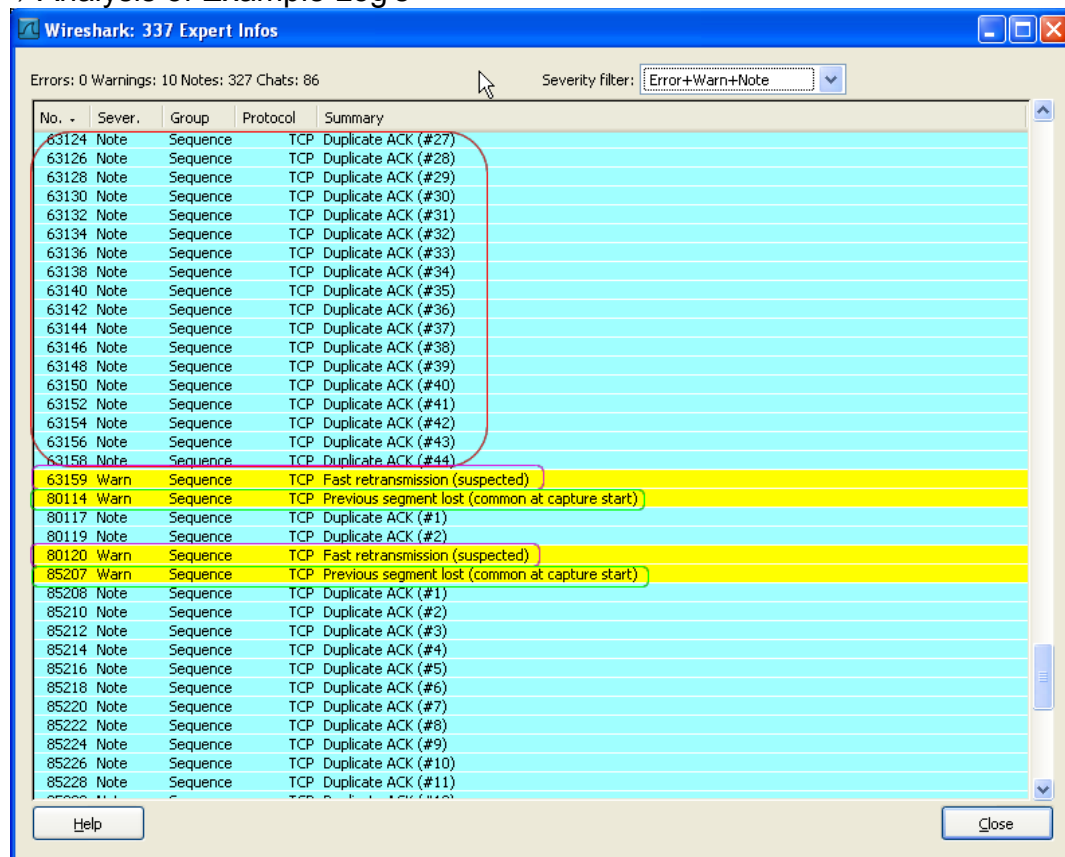
⇒ Pro's and Con's of Selective Acknowledgments

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



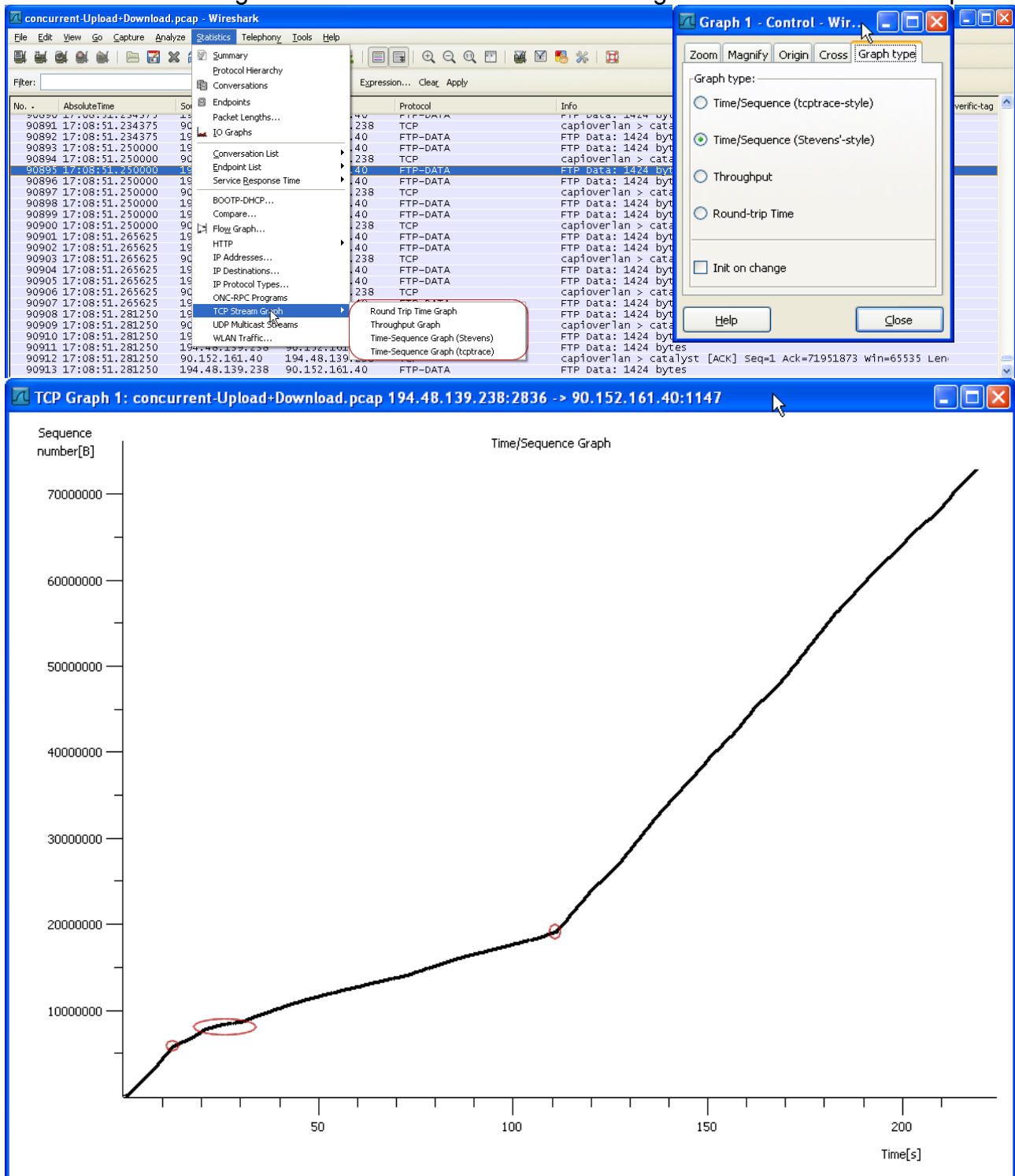
No.	Sever.	Group	Protocol	Summary
63124	Note	Sequence	TCP	Duplicate ACK (#27)
63126	Note	Sequence	TCP	Duplicate ACK (#28)
63128	Note	Sequence	TCP	Duplicate ACK (#29)
63130	Note	Sequence	TCP	Duplicate ACK (#30)
63132	Note	Sequence	TCP	Duplicate ACK (#31)
63134	Note	Sequence	TCP	Duplicate ACK (#32)
63136	Note	Sequence	TCP	Duplicate ACK (#33)
63138	Note	Sequence	TCP	Duplicate ACK (#34)
63140	Note	Sequence	TCP	Duplicate ACK (#35)
63142	Note	Sequence	TCP	Duplicate ACK (#36)
63144	Note	Sequence	TCP	Duplicate ACK (#37)
63146	Note	Sequence	TCP	Duplicate ACK (#38)
63148	Note	Sequence	TCP	Duplicate ACK (#39)
63150	Note	Sequence	TCP	Duplicate ACK (#40)
63152	Note	Sequence	TCP	Duplicate ACK (#41)
63154	Note	Sequence	TCP	Duplicate ACK (#42)
63156	Note	Sequence	TCP	Duplicate ACK (#43)
63158	Note	Sequence	TCP	Duplicate ACK (#44)
63159	Warn	Sequence	TCP	Fast retransmission (suspected)
80114	Warn	Sequence	TCP	Previous segment lost (common at capture start)
80117	Note	Sequence	TCP	Duplicate ACK (#1)
80119	Note	Sequence	TCP	Duplicate ACK (#2)
80120	Warn	Sequence	TCP	Fast retransmission (suspected)
85207	Warn	Sequence	TCP	Previous segment lost (common at capture start)
85208	Note	Sequence	TCP	Duplicate ACK (#1)
85210	Note	Sequence	TCP	Duplicate ACK (#2)
85212	Note	Sequence	TCP	Duplicate ACK (#3)
85214	Note	Sequence	TCP	Duplicate ACK (#4)
85216	Note	Sequence	TCP	Duplicate ACK (#5)
85218	Note	Sequence	TCP	Duplicate ACK (#6)
85220	Note	Sequence	TCP	Duplicate ACK (#7)
85222	Note	Sequence	TCP	Duplicate ACK (#8)
85224	Note	Sequence	TCP	Duplicate ACK (#9)
85226	Note	Sequence	TCP	Duplicate ACK (#10)
85228	Note	Sequence	TCP	Duplicate ACK (#11)

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

No.	Time	Source	Destination	Protocol	Info
1210	22:32:17.186267			BSSGP	FLOW-CONTROL-MS-ACK, TLLI 0xea0616b7
1211	22:32:18.185461			BSSGP	FLOW-CONTROL-MS, TLLI 0xea0616b7
1212	22:32:18.186217			BSSGP	FLOW-CONTROL-MS-ACK, TLLI 0xea0616b7
1549	22:40:06.414616			BSSGP	FLUSH-LL, TLLI 0xea0616b7, BVCI 10114, BVCI 10024
1553	22:40:06.458431			BSSGP	FLUSH-LL-ACK, TLLI 0xea0616b7, BVCI 10024
1564	22:40:15.611828			BSSGP	FLUSH-LL, TLLI 0xea0616b7, BVCI 10024, BVCI 10114
1565	22:40:15.636330			BSSGP	FLUSH-LL-ACK, TLLI 0xea0616b7, BVCI 10114
1584	22:40:40.670185			BSSGP	LLC-DISCARDED, TLLI 0xea0616b7, BVCI 10114
1595	22:40:57.334380			BSSGP	LLC-DISCARDED, TLLI 0xea0616b7, BVCI 10114
1598	22:41:02.809708			BSSGP	FLUSH-LL, TLLI 0xea0616b7, BVCI 10114, BVCI 10024
1599	22:41:02.834067			BSSGP	FLUSH-LL-ACK, TLLI 0xea0616b7
1614	22:41:06.389792			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 2(DTAP) (SM) Deactivate PDP Context Request
1615	22:41:06.400933			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 2(DTAP) (SM) Deactivate PDP Context Accept
1616	22:41:08.930453			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 3(DTAP) (GMM) Detach Request
1617	22:41:09.355029			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 3(DTAP) (GMM) Detach Accept
1618	22:41:26.290869			BSSGP	RADIO-STATUS, TLLI 0xea0616b7
1619	22:41:26.328763			BSSGP	LLC-DISCARDED, TLLI 0xea0616b7, BVCI 10024
1620	22:41:37.791334			GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 0(DTAP) (GMM) Attach Request
1621	22:41:37.794178			GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 0(DTAP) (GMM) Identity Request
1622	22:41:38.190083			GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 1(DTAP) (GMM) Identity Response
1623	22:41:38.194078			GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 37(DTAP) (GMM) Authentication and cipherin
1624	22:41:38.790532			GPRS-LLC	SAPI: LLGMM, UI, protected, non-ciphered information, N(U) = 2(DTAP) (GMM) Authentication and cipherin
1625	22:41:38.792987			GPRS-LLC	SAPI: LLGMM, U, XID
1626	22:41:39.049977			GPRS-LLC	SAPI: LLGMM, U, XID
1627	22:41:40.515569			BSSGP	RA-CAPABILITY, TLLI 0xaa0616b7
1628	22:41:40.517049			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 0(DTAP) (GMM) Attach Accept
1629	22:41:40.770537			GPRS-LLC	SAPI: LLGMM, UI, protected, ciphered information, N(U) = 0(DTAP) (GMM) Attach Complete
1630	22:42:02.031222			PPP IPCP	Configuration Request
1631	22:42:02.102834			PPP IPCP	Configuration Nak
1632	22:42:02.650877			GPRS-LLC	SAPI: LL3, U, XID
1633	22:42:02.651843			GPRS-LLC	SAPI: LL3, U, XID
1727	22:43:56.212554			BSSGP	LLC-DISCARDED, TLLI 0xc323d752, BVCI 10114
1728	22:43:56.214396			BSSGP	RADIO-STATUS, TLLI 0xc323d752
1729	22:43:56.230538			BSSGP	LLC-DISCARDED, TLLI 0xc323d752, BVCI 10114
1730	22:44:03.037428			BSSGP	PAGING-PS, IMSI 8520028794, (P)TMSI 0xc323d752

⇒ GPRS Connection Hang-up with Drop

No.	Time	Source	Destination	Protocol	Info
4215	22:43:04.141437			192.192.1 TCP	LibbDevMgmt_A > Ethernet/IP-2 [SYN] Seq=0 Win=4096 Len=0 MSS=1360 WS=0 TSV=11986515 TSER=0
4216	22:43:05.813514			192.192.1 TCP	EtherNet/IP-2 > LibbDevMgmt_A [SYN, ACK] Seq=0 Ack=1 Win=2000 Len=0 MSS=16384
4217	22:43:05.845246			192.192.1 TCP	LibbDevMgmt_A > Ethernet/IP-2 [ACK] Seq=1 Ack=1 Win=4096 Len=0
4218	22:43:05.848001			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4219	22:43:06.592950			192.192.1 ENIP	[TCP Acked lost segment] List Services (Rsp), Communications
4220	22:43:06.623831			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4221	22:43:07.173714			192.192.1 ENIP	[TCP Acked lost segment] Register Session (Rsp), Session: 0xc3CE09C
4222	22:43:07.206703			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4223	22:43:08.098272			192.192.1 CIP	[TCP Acked lost segment] success
4224	22:43:08.143968			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4225	22:43:08.844689			192.192.1 CIP	[TCP Acked lost segment] success
4226	22:43:08.847563			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4227	22:43:16.298010			192.192.1 TCP	[TCP Keep-Alive] LibbDevMgmt_A > Ethernet/IP-2 [ACK] Seq=378 Ack=389 Win=4096 Len=0
4228	22:43:17.360894			91.1 89.14 L2TP	Control Message - Hello (tunnel id=50610, session id=0)
4229	22:43:18.359214			91.1 89.14 L2TP	Control Message - Hello (tunnel id=50610, session id=0)
4230	22:43:18.732318			192.192.1 TCP	[TCP Keep-Alive ACK] Ethernet/IP-2 > LibbDevMgmt_A [ACK] Seq=389 Ack=379 Win=2000 Len=0
4231	22:43:18.734832			89.1 91.11 L2TP	Control Message - Hello (tunnel id=6, session id=0)
4232	22:43:18.791958			89.1 91.11 L2TP	Control Message - ZLB (tunnel id=6, session id=0)
4233	22:43:18.832081			89.1 91.11 L2TP	Control Message - ZLB (tunnel id=6, session id=0)
4234	22:43:18.832984			89.1 91.11 L2TP	Control Message - ZLB (tunnel id=6, session id=0)
4235	22:43:26.298164			192.192.1 TCP	[TCP Keep-Alive] LibbDevMgmt_A > Ethernet/IP-2 [ACK] Seq=378 Ack=389 Win=4096 Len=0
4236	22:43:26.694636			192.192.1 CIP	Kick Timer
4237	22:43:33.298813			192.192.1 CIP	[TCP Retransmission] Kick Timer
4238	22:43:36.690159			91.1 89.14 PPP VJ	VJ compressed TCP (direction unknown)
4239	22:43:47.304046			192.192.1 CIP	[TCP Retransmission] Kick Timer
4240	22:43:56.212554			BSSGP	LLC-DISCARDED, TLLI 0xc323d752, BVCI 10114
4241	22:43:56.214396			BSSGP	RADIO-STATUS, TLLI 0xc323d752
4242	22:43:56.230538			BSSGP	LLC-DISCARDED, TLLI 0xc323d752, BVCI 10114
4243	22:44:03.037428			BSSGP	PAGING-PS, IMSI 8520028794, (P)TMSI 0xc323d752

⇒ 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	Station	Protocol	Info
1	06:22:50.171284		GPRS-LLC SAPI:	LLGMM, UI, protected, non-ciphered information, N(U) = 36(DTAP) (GMM) Authentication and Ciphering Request
2	06:22:51.642174		GPRS-LLC SAPI:	LLGMM, UI, protected, non-ciphered information, N(U) = 2(DTAP) (GMM) Authentication and Ciphering Request
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	06:22:01.197192		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:	LLGMM, 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 Request

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	D	E	F	G	H	I	J	K	L	M	N	O	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 delivery 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	SourceDestination	Protocol	Info
3004	09:24:23.082919	19	GTP <TCP>	cedros_fds > https [ACK] Seq=347065 Ack=475873 win=65535 Len=0
3005	09:24:23.082976	19	GTP <SSL>	Continuation Data
3006	09:24:23.247496	19	GTP <TCP>	https > cedros_fds [ACK] Seq=475873 Ack=347177 win=17088 Len=0
3007	09:24:34.132321	19	GTP <SSL>	Continuation Data
3008	09:24:34.248705	19	GTP <TCP>	https > cedros_fds [ACK] Seq=475873 Ack=347321 win=17088 Len=0
3009	09:24:34.725697	19	GTP <SSL>	[TCP Retransmission] Continuation Data
3010	09:24:34.727455	19	GTP <TCP>	[TCP Dup ACK 3008#1] https > cedros_fds [ACK] Seq=475873 Ack=347321 win=17088 Len=0
3011	09:24:39.204262	19	GTP <SSL>	Continuation Data
3012	09:24:39.207509	19	GTP <SSL>	Continuation Data
3013	09:24:39.645679	19	GTP <TCP>	cedros_fds > https [ACK] Seq=347473 Ack=476025 win=65383 Len=0
3014	09:24:43.835735	29	RANAP	id-DirectTransfer (DTAP) (SM) Deactivate PDP Context Request
3015	09:24:43.842919	29	RANAP	id-DirectTransfer (DTAP) (SM) Deactivate PDP Context Accept
3016	09:24:43.843214	29	RANAP	id-RAB-Assignment
3017	09:24:44.394152	29	RANAP	id-RAB-Assignment
3018	09:24:44.397069	29	RANAP	id-IU-Release
3019	09:24:45.128596	29	RANAP	id-IU-Release
3020	09:41:50.339526	29	RANAP	id-InitialUE-Message (DTAP) (GMM) Attach Request
3021	09:41:50.343914	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Req
3022	09:41:50.507849	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Resp
3023	09:41:50.510824	29	RANAP	id-SecurityModeControl
3024	09:41:50.639993	29	RANAP	id-SecurityModeControl
3025	09:41:50.642435	29	RANAP	id-CommonID
3026	09:41:50.644077	29	RANAP	id-IU-Release
3027	09:41:51.257584	29	RANAP	id-IU-Release
3028	09:42:07.034840	29	RANAP	id-InitialUE-Message (DTAP) (GMM) Attach Request
3029	09:42:07.039909	29	RANAP	id-DirectTransfer (DTAP) (GMM) Identity Request
3030	09:42:07.135008	29	RANAP	id-DirectTransfer (DTAP) (GMM) Identity Response
3031	09:42:07.378579	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Req
3032	09:42:07.544042	29	RANAP	id-DirectTransfer (DTAP) (GMM) Authentication and Ciphering Resp
3033	09:42:07.547268	29	RANAP	id-SecurityModeControl
3034	09:42:07.665201	29	RANAP	id-SecurityModeControl
3035	09:42:07.670210	29	RANAP	id-CommonID
3036	09:42:09.096292	29	RANAP	id-DirectTransfer (DTAP) (GMM) Attach Accept
3037	09:42:09.214338	29	RANAP	id-DirectTransfer (DTAP) (GMM) Attach Complete
3038	09:42:09.217849	29	RANAP	id-IU-Release
3039	09:42:09.817343	29	RANAP	id-IU-Release
3040	09:44:38.254675	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)

No. -	AbsoluteTime	SourceDestination	Protocol	Info	verific-tag
5	11:43:06.426985	10.4	10.4	SLAP	id-UEContextReleaseRequest
6	11:43:06.447475	10.4	10.4	SLAP	id-ErrorIndication
9	11:43:11.638798	10.4	10.4	PPP IPCP	Configuration Request
10	11:43:11.695362	10.4	10.4	SLAP/NAS-EPS	id-InitialContextSetup Attach accept Activate default EPS bearer context request
13	11:43:14.047007	10.4	10.4	PPP IPCP	Configuration Request
15	11:43:17.716353	10.4	10.4	SLAP/NAS-EPS	id-InitialContextSetup Attach accept Activate default EPS bearer context request
16	11:43:17.720582	10.4	10.4	SLAP	id-InitialContextSetup
17	11:43:17.783683	10.4	10.4	SLAP	id-InitialContextSetup
19	11:43:17.783687	10.4	10.4	SLAP	id-UEContextReleaseRequest
21	11:43:17.913452	10.4	10.4	SLAP	id-UEContextRelease
22	11:43:17.917159	10.4	10.4	SLAP	id-UEContextRelease
43	11:43:29.638375	10.4	10.4	PPP IPCP	Configuration Request

UEContextReleaseRequest	<ul style="list-style-type: none"> protocolIEs: 3 items <ul style="list-style-type: none"> Item 0: id-MME-UE-SIAP-ID <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: id-MME-UE-SIAP-ID (0) criticality: reject (0) value <ul style="list-style-type: none"> MME-UE-SIAP-ID: 680 Item 1: id-ENB-UE-SIAP-ID <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: id-ENB-UE-SIAP-ID (8) criticality: reject (0) value <ul style="list-style-type: none"> ENB-UE-SIAP-ID: 18 Item 2: id-Cause <ul style="list-style-type: none"> ProtocolIE-Field <ul style="list-style-type: none"> id: id-Cause (2) criticality: ignore (1) value <ul style="list-style-type: none"> 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	D	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?

No.	AbsoluteTime	Destination	Protocol	Info	MME-id	eNB-id
1636	12:10:00.382163	11C	SIAP/NAS-EP	id-InitialUEMessage		
1637	12:10:00.398769	11C	SIAP/NAS-EP	id-downlinkNASTransport Service reject	4294967295	64
1638	12:10:00.582855	11C	SCTP	SACK		64
1639	12:10:00.597100	11C	SCTP	SACK		
1640	12:10:00.784708	11C	SCTP	HEARTBEAT		
1641	12:10:00.784725	11C	SCTP	HEARTBEAT		
1642	12:10:00.784824	11C	SCTP	HEARTBEAT_ACK		
1643	12:10:00.784840	11C	SCTP	HEARTBEAT_ACK		
1644	12:10:00.981878	11C	SIAP	id-InitialContextSetup	691	63
1645	12:10:00.982519	11C	SIAP	id-UEContextReleaseRequest	691	63
1646	12:10:00.982599	11C	SCTP	SACK		
1647	12:10:01.004961	11C	SIAP	id-UEContextRelease		
1648	12:10:01.008280	11C	SIAP	id-UEContextRelease	691	63
1649	12:10:01.201133	11C	SCTP	SACK		
1650	12:10:01.210224	11C	SCTP	SACK		
1651	12:10:05.861061	11C	SIAP	id-UEContextReleaseRequest	4294967295	64
1652	12:10:05.878366	11C	SIAP	id-ErrorIndication		
1653	12:10:06.063726	11C	SCTP	SACK		
1654	12:10:06.077299	11C	SCTP	SACK		
1655	12:10:11.065701	11C	PPP IPCP	Configuration Request		65
1656	12:10:11.123911	11C	SIAP/NAS-EP	id-InitialContextSetup Attach accept Activate default	691	65
1657	12:10:11.267130	11C	SCTP	SACK		
1658	12:10:11.321480	11C	SCTP	SACK		
1659	12:10:11.397488	11C	SCTP	HEARTBEAT		
1660	12:10:11.397503	11C	SCTP	HEARTBEAT		
1661	12:10:11.397587	11C	SCTP	HEARTBEAT_ACK		
1662	12:10:11.397602	11C	SCTP	HEARTBEAT_ACK		
1663	12:10:12.912056	11C	SIAP	id-InitialContextSetup	691	65
1664	12:10:12.946437	11C	SIAP	id-UEContextRelease		
1665	12:10:12.949928	11C	SIAP	id-UEContextRelease	691	65

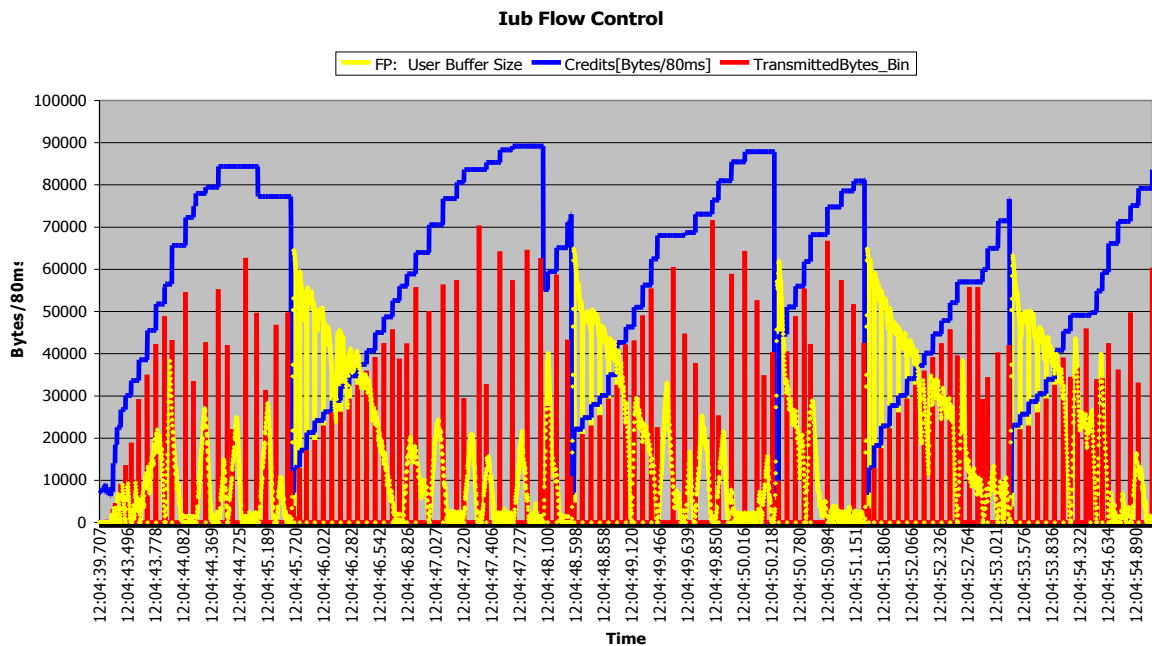
SCTP does not distinguish the Signaling for different Users/UE's between eNodeB and MME. Thus S1AP in eNodeB assigns upon connection establishment (e.g. with ATTACH REQUEST) a unique number called eNB-UE-S1AP-ID. In response the MME allocates his unique number MME-UE-S1AP-ID and mirrors back the number 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



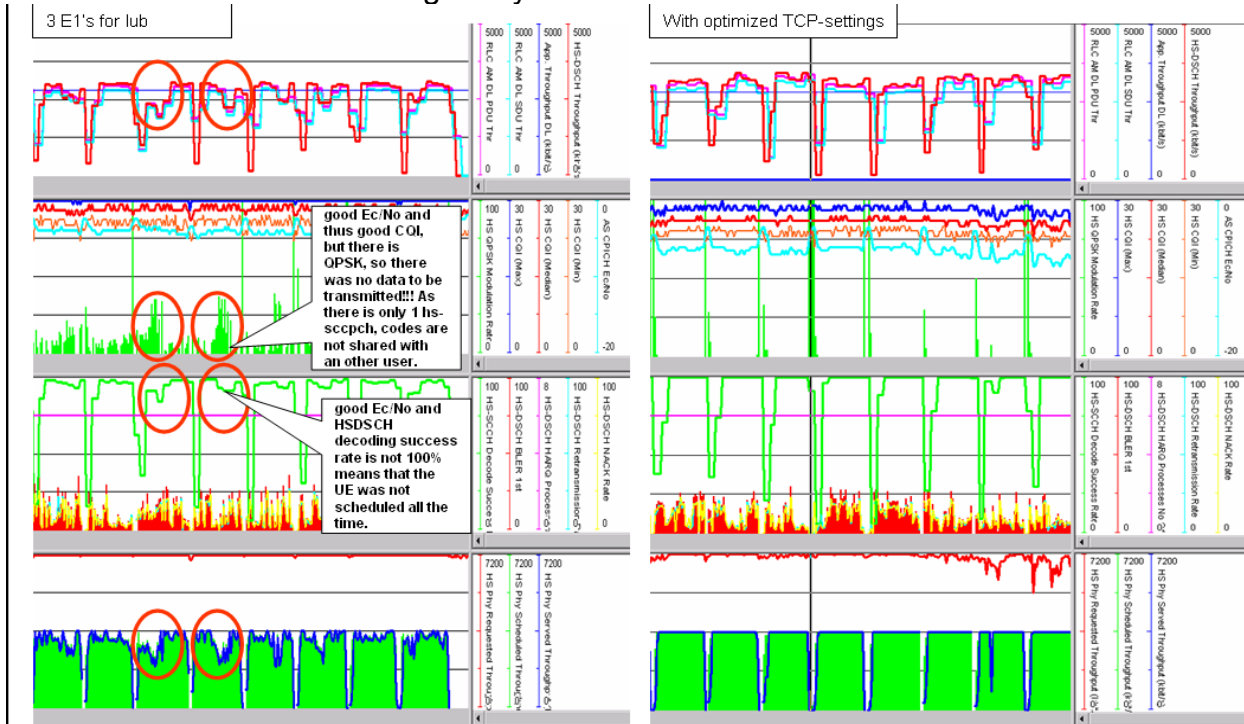
⇒ E-DCH FP throttles uplink Throughput

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:

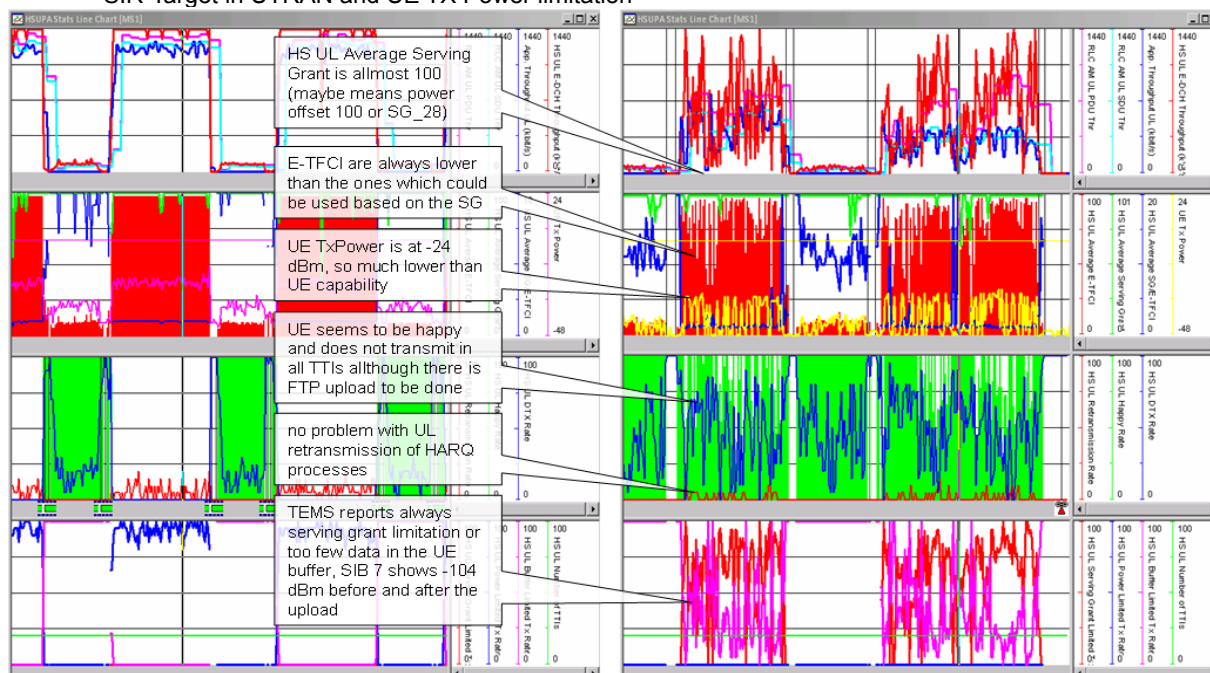
No.	Time	Source	Destination	Protocol	Info	TCP Seq No.
577	14:13:59.463834			TCP	ftp-data > 3403 [ACK] Seq	1
578	14:13:59.481083			FTP-DATA	FTP Data: 1412 bytes	286974
579	14:13:59.501000			FTP-DATA	FTP Data: 1412 bytes	288386
580	14:13:59.502978			TCP	ftp-data > 3403 [ACK] Seq	1
581	14:13:59.521159			FTP-DATA	FTP Data: 1412 bytes	289798
582	14:13:59.532695			FTP-DATA	FTP Data: 1412 bytes	291210
583	14:13:59.542804			TCP	ftp-data > 3403 [ACK] Seq	1
584	14:13:59.598830			TCP	ftp-data > 3403 [ACK] Seq	1
585	14:14:02.070063			FTP-DATA	FTP Data: 1412 bytes	292622
586	14:14:02.092025			TCP	ftp-data > 3403 [ACK] Seq	1
587	14:14:02.160176			FTP-DATA	FTP Data: 1412 bytes	294034
588	14:14:02.182728			TCP	ftp-data > 3403 [ACK] Seq	1
589	14:14:02.240325			FTP-DATA	FTP Data: 1412 bytes	295446
590	14:14:02.261845			TCP	ftp-data > 3403 [ACK] Seq	1
591	14:14:02.300195			FTP-DATA	FTP Data: 1412 bytes	296858
592	14:14:02.323854			TCP	ftp-data > 3403 [ACK] Seq	1
593	14:14:02.370143			FTP-DATA	FTP Data: 1412 bytes	298270
594	14:14:02.391769			TCP	ftp-data > 3403 [ACK] Seq	1
595	14:14:02.430260			FTP-DATA	FTP Data: 1412 bytes	299682
596	14:14:02.451885			TCP	ftp-data > 3403 [ACK] Seq	1
597	14:14:02.490368			FTP-DATA	FTP Data: 1412 bytes	301094
598	14:14:02.514726			TCP	ftp-data > 3403 [ACK] Seq	1
599	14:14:02.550242			FTP-DATA	FTP Data: 1412 bytes	302506
600	14:14:02.572720			TCP	ftp-data > 3403 [ACK] Seq	1
601	14:14:02.620189			FTP-DATA	FTP Data: 1412 bytes	303918
602	14:14:02.642146			TCP	ftp-data > 3403 [ACK] Seq	1
603	14:14:02.660383			FTP-DATA	FTP Data: 1412 bytes	305330
604	14:14:02.660383			FTP-DATA	FTP Data: 1412 bytes	306742
605	14:14:02.660383			FTP-DATA	FTP Data: 1412 bytes	308154
606	14:14:02.680303			FTP-DATA	FTP Data: 1412 bytes	309566

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

⇒ HS-SCCH Scheduling Analysis

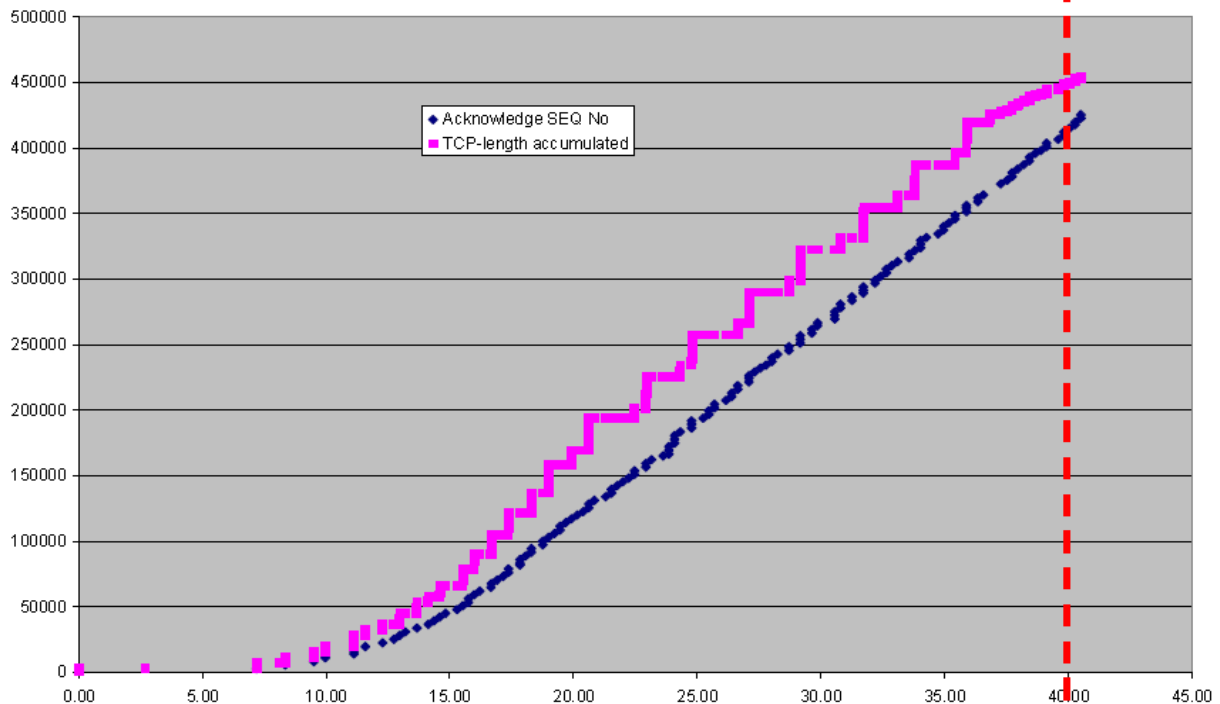


⇒ Serving Grant Monitoring for low HSUPA Throughput SIR-Target in UTRAN and UE TX Power limitation



⇒ 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