Application Paper:
Monitoring HSUPA Connections with NSA 1.6

Tektronix

About This Document

Tektronix Network and Service Analyzer (NSA) software version 1.6 contains a couple of specific counters, measurement and KPI equations released to deal with the analysis of packet-switched services using High Speed Uplink Packet Access (HSUPA) technology. This application paper describes which HSUPA analysis capabilities are available with NSA 1.6. Furthermore, it will describe how data for analysis is gathered and computed, how measurement results can be displayed in tables and diagrams and how analysis results can be evaluated to troubleshoot and optimize the network.

The paper covers the following topics:

- HSUPA Introduction
- Supported Scenarios in NSA
- How to Find an HSUPA Call in NSA

Monitoring HSUPA Connections with NSA 1.6

HSUPA Introduction

After HSDPA has been introduced for high speed data transmission on the downlink in Release 5 there was a need to introduce a similar enhancement for uplink data transport. As a result enhanced uplink data transfer for FDD radio mode was introduced in Release 6. A basic description of the new service is found in 3GPP 25.309. The term high speed uplink packet access (HSUPA) is used to have a complementary abbreviation to high speed downlink packet access (HSDPA) although the underlying technologies are completely different. In case of combined uplink/downlink high speed packet access the abbreviation HSPA is generally applied.

The most obvious difference between HSDPA and HSUPA technology is that on the downlink the data is transported on a common channel, the high speed downlink shared channel (HS-DSCH). High speed uplink data transfer is realized using an enhanced dedicated transport channel (E-DCH). The reason why a dedicated channel is required is that the network needs to control the uplink transmission power of the UE.

A shared channel used for uplink data transfer (like the HS-DSCH is used on the downlink) would not allow to reach the high data transmission rates of the E-DCH, because common channels cannot be power controlled. This is the reason why the E-DCH has been defined and it is also the reason why there is a power control mechanism in HSUPA, but no power control in HSDPA. What both high speed packet access technologies have in common is hybrid ARQ (HARQ) error correction on the radio interface, shorter TTI than on Rel. 99 DCH and code bundling. To reach its maximum radio interface bit rate of 5.76 Mbps a single E-DCH uses two codes with spreading factor 4 plus two codes with spreading factor 2. However, it is not expected that this maximum configuration will be implemented in first HSUPA-capable mobile phones.

For TDD networks including TD-SCDMA the HSUPA standards have not been finished yet.

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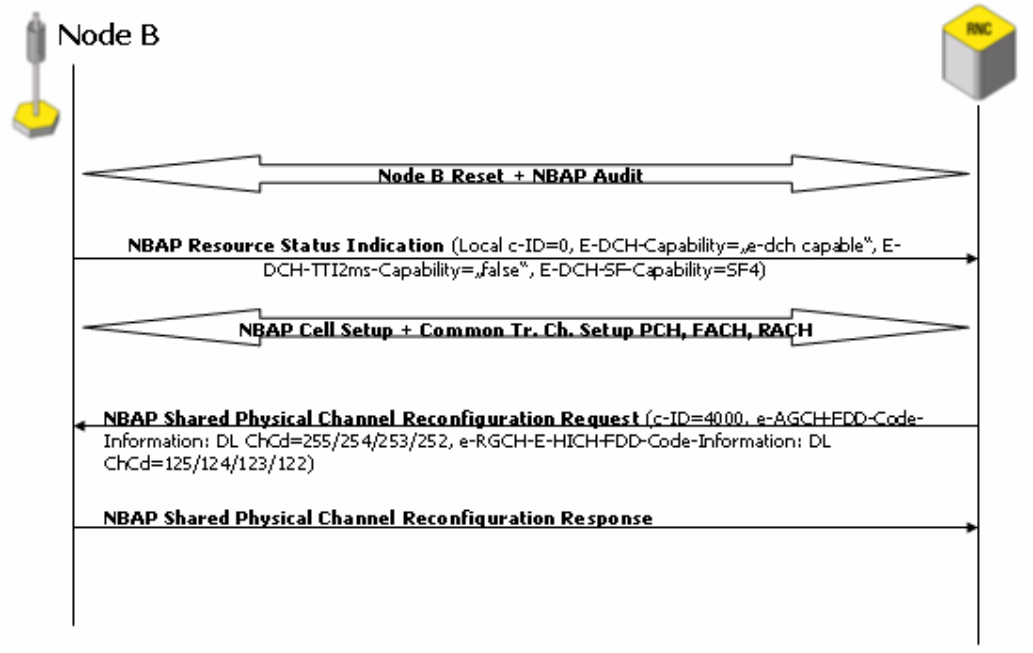
HSUPA Cell Setup

To use HSUPA it is a prerequisite that the UE as well as the cell are HSUPA-capable. To enable the cell to support HSUPA it is necessary to establish new common physical channels. These channels are the E-DCH absolute grant channel (E-AGCH), the E-DCH relative grant channel (E-RGCH) and the E-DCH HARQ indicator channel (E-HICH). These common physical channels are set up in quite the same manner as described for establishment of common HSDPA channels before.

After the RNC audited the Node B, for each local cell ID that supports HSUPA a NBAP Resource Status Indication message is sent to the RNC. It indicates the local cell ID and its E-DCH capability. Further its capability to support the 2ms TTI and the smallest spreading factor to be used for E-DCH are signalled to the controlling RNC. In the example shown in the following figure the 2ms TTI is not supported and the cell can only handle uplink spreading codes with SF 4.



HSUPA cell setup

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After the cell setup and establishment of the common transport channels RACH, FACH and PCH, the shared channels that are required for HSUPA are configured. The appropriate NBAP Shared Physical Channel Reconfiguration Request message contains the cell identity, because this message is sent to each E-DCH-capable cell in the Node B. The most important channel parameters are the downlink channelisation codes for the E-DCH absolute grant channel (E-AGCH) that transmits power control information to the UE.

The E-AGCH delivers five bits to the UE that represent the so-called absolute grant value, indicating the exact power level the E-DPDCH shall use in relation to the E-DPCCH sent by the same UE. The E-DPCCH fulfils the same function for E-DPDCH data transmission as the DPCCH does for DPDCH transmission. It carries a transport format combination indicator used on the E-DPDCH (E-TFCI), a sequence number for HARQ retransmissions sent on E-DPDCH and the happy bit that indicates if the UE is satisfied with the provided bit rate for UL data transmission or if higher power shall be allocated to allow a higher bit rate. If the UE is happy or not depends on the backlog in the uplink RLC data transmission buffer.

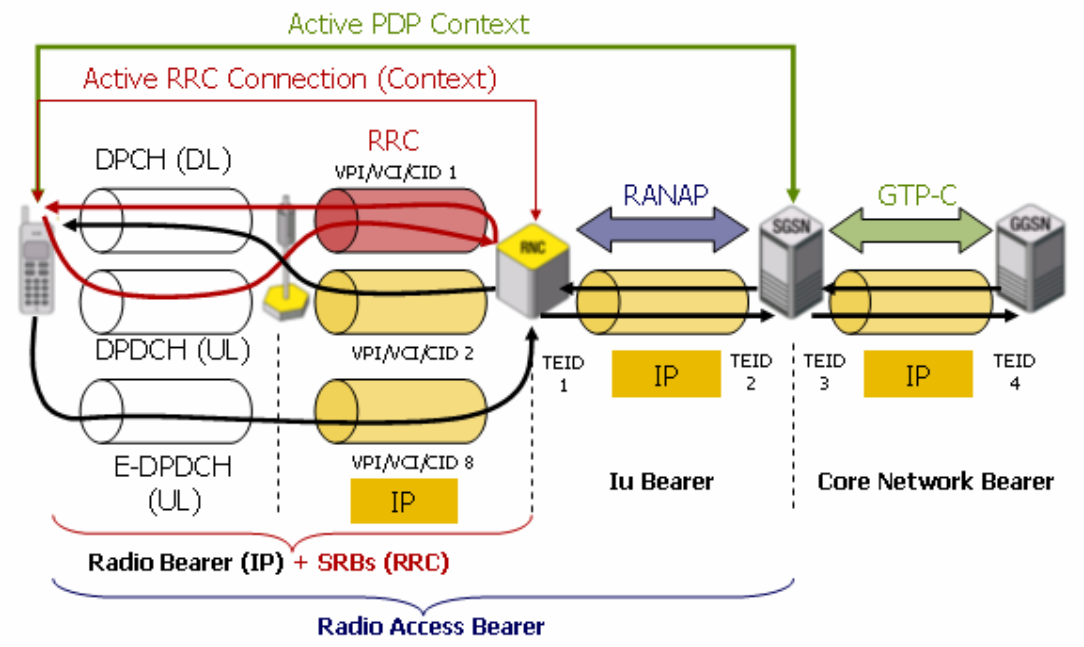
The E-RGCH is the E-DCH relative grant channel that is responsible for transmitting single step up/down commands to control the power the UE is allowed to use for transmission of E-DPDCH. As discussed before this will result in increase/decrease of the uplink bit rate.

Finally, the E-HICH is the E-DCH hybrid ARQ indicator channel used to transmit positive and negative acknowledgments for uplink packet transmission. The frame structure of the E-RGCH and the E-HICH is identical. Thus, a combined information element name is used in NBAP.

NOTE. *On NSA, all messages are completely decoded with NBAP Rel. 6 protocol stacks. You must ensure that the correct release version and vendor are set in the NSA Probe Configuration.*

HSUPA Call Scenarios

If a PS connection uses HSUPA it does not need to use HSDPA simultaneously. Although it is unlikely it might be possible that a HSUPA cell is not HSDPA-capable. And what may happen more often is that in a specific call scenario high speed downlink data rates are not required. One may think about a file upload scenario where on the downlink only some TCP acknowledgement frames need to be transmitted. This kind of data can be transmitted on a DPCH using a high spreading factor. The channel mapping situation in such a scenario is shown in the following figure.



HSUPA call scenario with downlink payload transported on Rel. 99 DCH

As one can see the signalling radio bearers are also transmitted using the Rel. 99 dedicated channels while the E-DCH uses the enhanced dedicated physical data channel (E-DPDCH) for uplink transmission. In this scenario the E-DCH carries only IP payload, but it is not limited to this transport function in general. The VPI/VCI/CID 8 is the Iub physical transport bearer that carries a MAC-d-flow of the E-DCH. In case that multiple PS RABs requiring different QoS are running in parallel (e.g. after establishment of a secondary PDP context) additional MAC-d-flows are set up that all are mapped onto the same E-DCH/E-DPDCH. If E-DCH is used in parallel with DCH the maximum uplink bit rate of the Rel. 99 dedicated channel is limited to 64 kbps by 3GPP definition.

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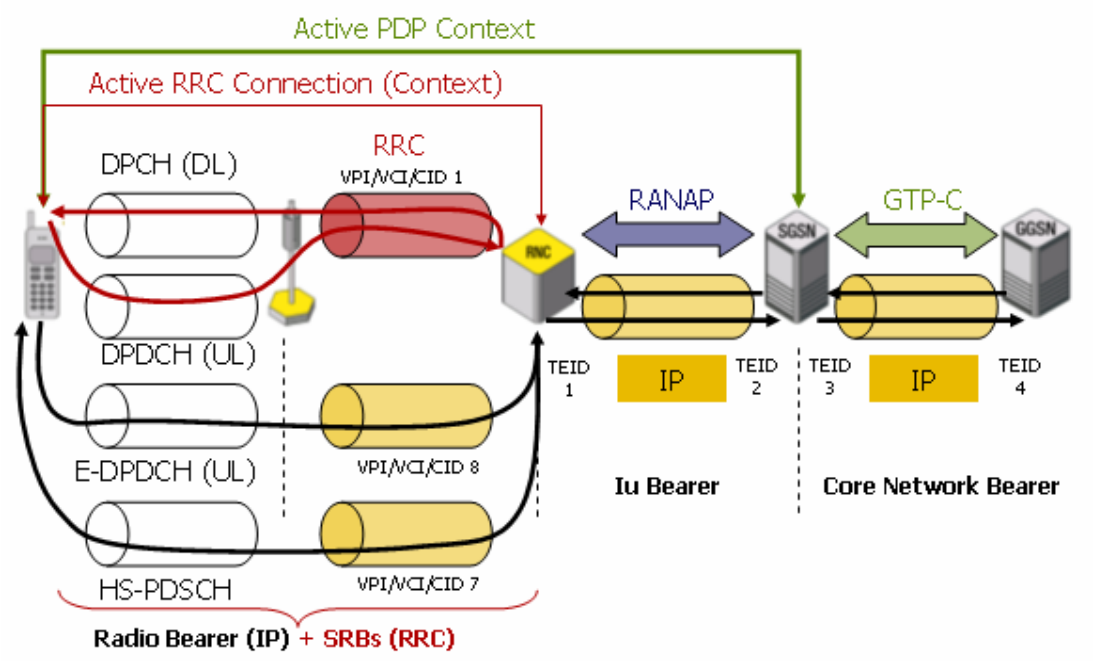
The following figure shows a call scenario in which uplink IP payload is transmitted using the E-DCH while downlink IP packets are sent on the HS-DSCH.



HSUPA call scenario with downlink payload transported on HS-DSCH

VPI/VCI/CID 8 is again the Iub physical transport bearer for the E-DCH MAC-d-flow while VPI/VCI/CID 7 carries the MAC-d-flow that is multiplexed onto the HS-DSCH.

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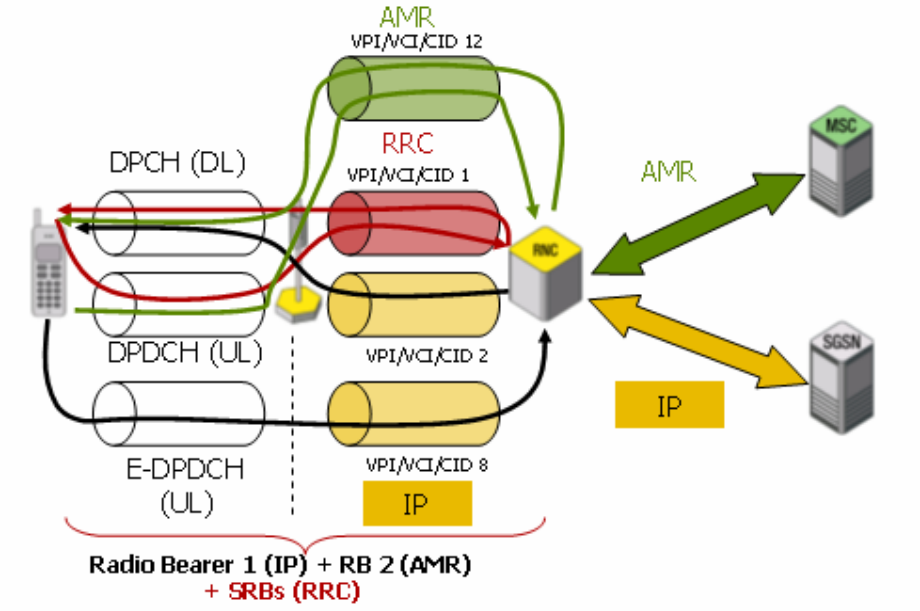
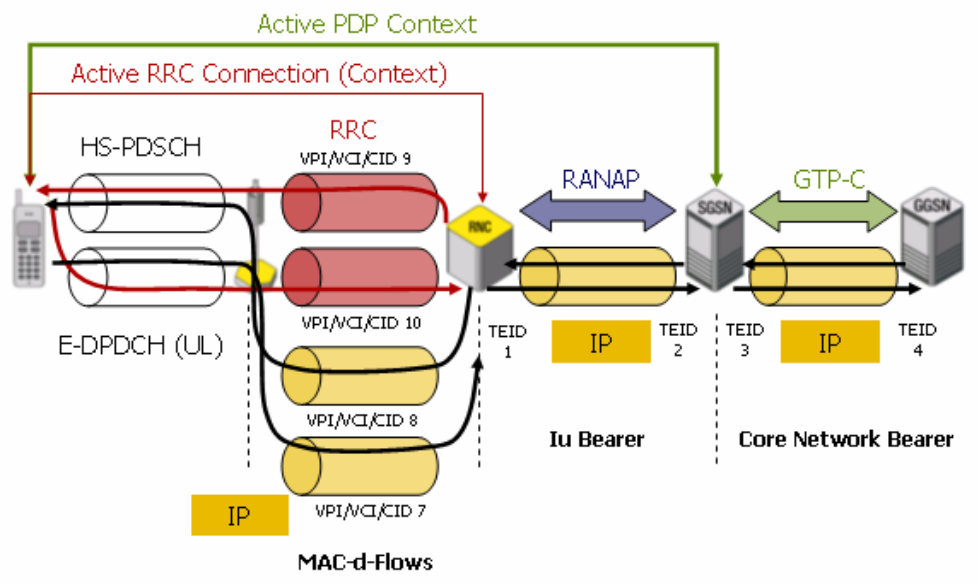
If an AMR voice call is active together with a PS connection that uses E-DCH the speech radio bearers have to be mapped onto Rel. 99 dedicated channels. Neither the HS-DSCH nor the E-DCH are designed to transport AMR packets.



HSUPA multi-service call, PS data plus AMR voice

However, it is an intention of 3GPP to use the high speed transport channels for voice over IP (VoIP). In this scenario – a typical configuration is shown in the following figure – two important prerequisites must be available. First it must be possible to use RLC unacknowledged mode (UM) for IP data transmission. This was generally defined by 3GPP in Release 6 standards to enable the high speed channels to be used for transmission of real-time services.

The second prerequisite is that UE as well as cell support the fractional dedicated physical channel (F-DPCH).



HSPA call using F-DPCH for power control

This channel is not shown in the figure above, but runs in parallel to the HS-PDSCH(s). The frame structure of the F-DPCH is derived from the frame structure of the PDCH that carries data and downlink control information on Rel. 99 radio interface. However, the data fields, pilot bits and transport format combination indicator bits of the PDCH are not transmitted anymore. Instead the free fields are stuffed with transmitter power commands of multiple UEs. For this reason the channel is now seen as a fractional one. Since the data fields of the DPCH are not available anymore the signalling radio bearers need to be mapped onto the HS-DSCH and the E-DCH. On the Iub interface this channel mapping scheme results in setup of four different MAC-d-flows, each transported by a VPI/VCI/CID. There is one MAC-d-flow for RRC signalling send in downlink direction and one MAC-d-flow for RRC in uplink. The other two carry IP payload in uplink and downlink respectively.

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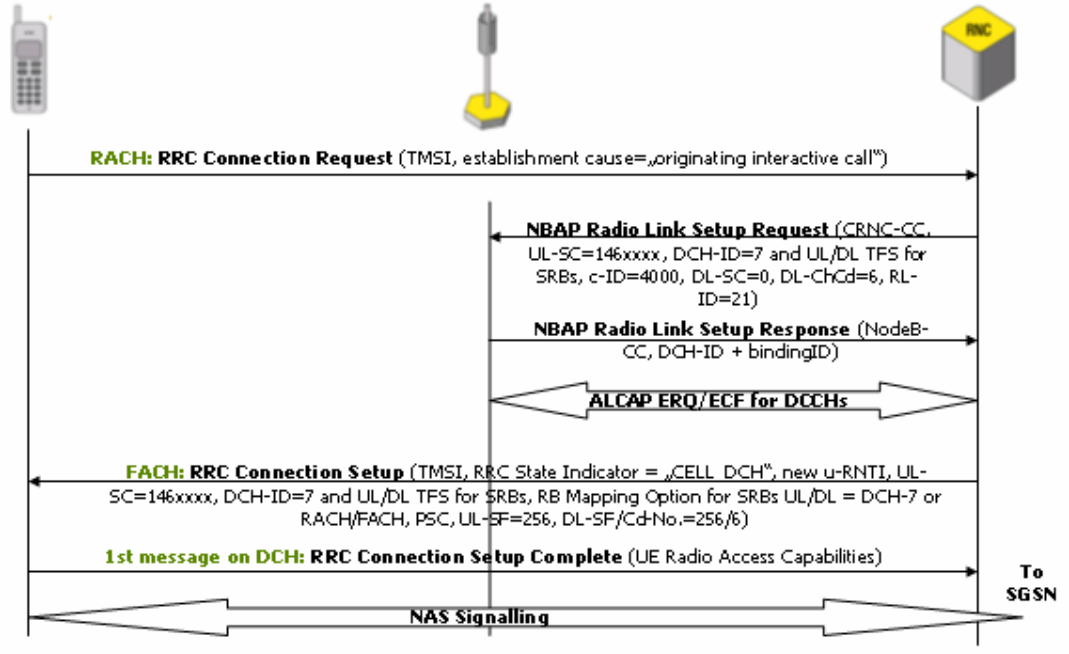
HSUPA Basic Call Setup

This section describes the establishment of a HSUPA call. Again, as in case of HSDPA, it must be highlighted that a stand-alone HSUPA does not exist. Rather the usage of the E-DCH is a channel mapping option for uplink data transfer of PS calls as the usage of RACH for the same purpose is another one. E-DCH and RACH are on a par, so to say. It only depends on required bit rate which channel is used.



HSUPA basic call setup 1/3

For setup of RRC connections, no E-DCH is required as shown in the figure above.

Triggered by RAB Assignment Request received by the SRNC on IuPS the NBAP Synchronized Radio Link Reconfiguration Preparation Request message is sent to prepare the setup of the radio bearer (see the following figure). Here now an E-DCH MAC-d-flow is established with a e-TTI of 10 ms, because the 2 ms TTI is not supported by the cell (see cell setup before).

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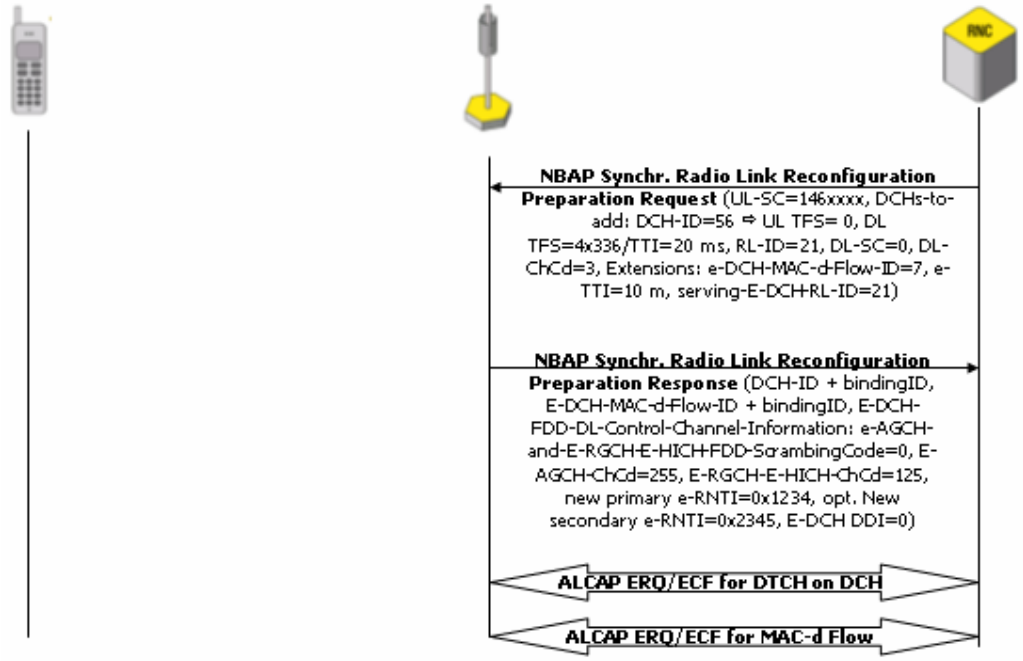
The serving E-DCH radio link ID in the NBAP reconfiguration message has the same value as the radio link ID for Rel. 99 DCHs. This means that cell with c-ID = 4000 is going to become the serving E-DCH cell.



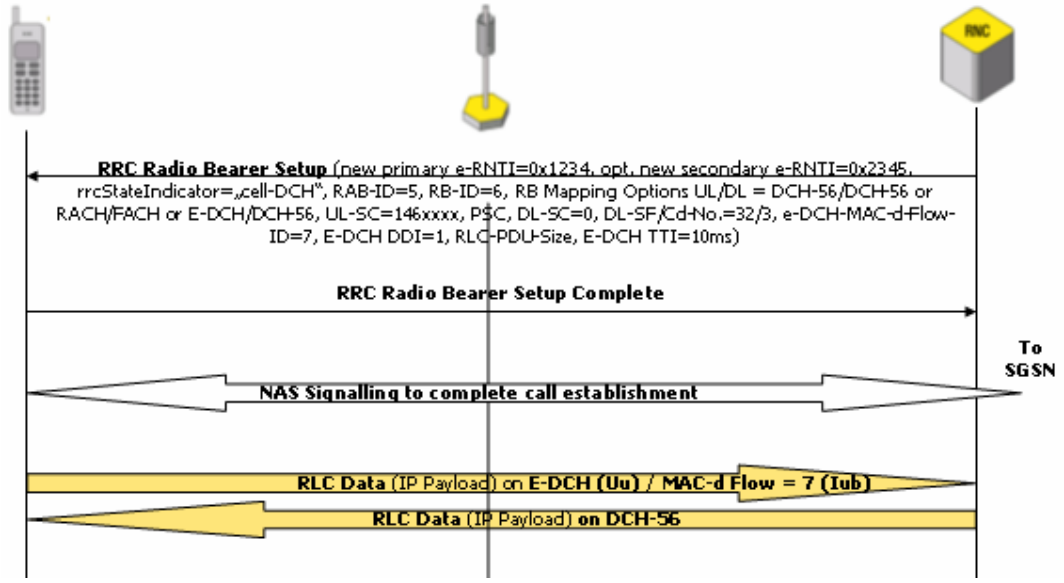
HSUPA basic call setup 2/3

In the NBAP Synchronized Radio Link Reconfiguration Preparation Response the codes of the downlink control channels related to E-DCH are transmitted to RNC. In addition a primary e-RTNI and optionally a secondary e-RNTI is found. It must be highlighted that the e-RNTIs are assigned by the Node B in difference to all other RNTIs that are assigned by RNC. The reason for this behaviour is that the packet scheduler for uplink data transfer is now located in the Node B, but the Node B cannot directly communicate with the UE. Hence, the Node B sends all relevant parameters for packet scheduling to the RNC that on its part sends the assigned e-RNTIs to the UE using the RRC protocol.

The motivation to have two e-RNTIs is to address a group of UEs by using the primary e-RNTI. Whenever data arrives at eth UE RLC buffer it can be transmitted quickly without the relatively long delay that is necessary to get a unique e-RNTI assigned by the network. In other words: the UE can start to transmit data on E-DCH after channel type switching procedures faster by using a default uplink transmission power value that is broadcasted using the primary e-RNTI. Later the dedicated e-RNTI is assigned to the connection. This is the secondary e-RNTI that is used to control a particular active UE.

Another parameter found in the NBAP reconfiguration procedure is the E-DCH data description indicator (DDI). The DDI becomes important if data packets of different MAC-d-flows are mapped onto the same E-DCH. The DDI is the identifier of a logical channel related to a radio bearer that is transmitted on E-DCH radio interface on MAC-e layer. MAC-e is only transmitted on radio interface (Uu) and cannot be monitored on Iub.

Following ALCAP establishment procedures are used to set up Iub physical transport bearers for the DCH that carries IP packets of DTCH in downlink direction and for the MAC-d-flow that serves the E-DCH.



HSUPA basic call setup 3/3

The above figure shows the RRC Radio Bearer Setup procedure that is executed to enable IP data transport for the RAB that is identified by RAB-ID=5. The radio bearer ID is RB-ID=6. This radio bearer may either use RACH/FACH, DCH/DCH or E-DCH/DCH for data transport. E-RNTI and E-DCH MAC-d-flow ID signal that the E-DCH shall be used for uplink data transmission.

Once the radio bearer setup procedure is successfully complete remaining NAS signalling to complete PDP context activation (if required) is exchanged between UE and SGSN. Then payload transport starts. The RLC PDUs that carry IP packets can be monitored on the VPI/VIC/CID assigned to MAC-d-flow number 7 and DCH 56.

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Supported Scenarios in NSA

New test: All HSUPA call scenarios described in the previous chapters will be supported by NSA. This includes call scenarios in which the UL signaling radio bearers (SRB) are transmitted using the E-DCH. In addition softer and intra-RNC soft handover scenarios are supported.

Messages belonging to the HSUPA cell setup do not belong to a specific call and hence, cannot be correlated by a call trace application. One can find these messages that are individually signaled between each HSUPA capable cell and its controlling RNC in the RF5 file of the NSA session.

Not supported are call scenarios with inter-RNC soft HO of E-DCH (via Iur) and the fractional DPCH (F-DPCH) call scenario.

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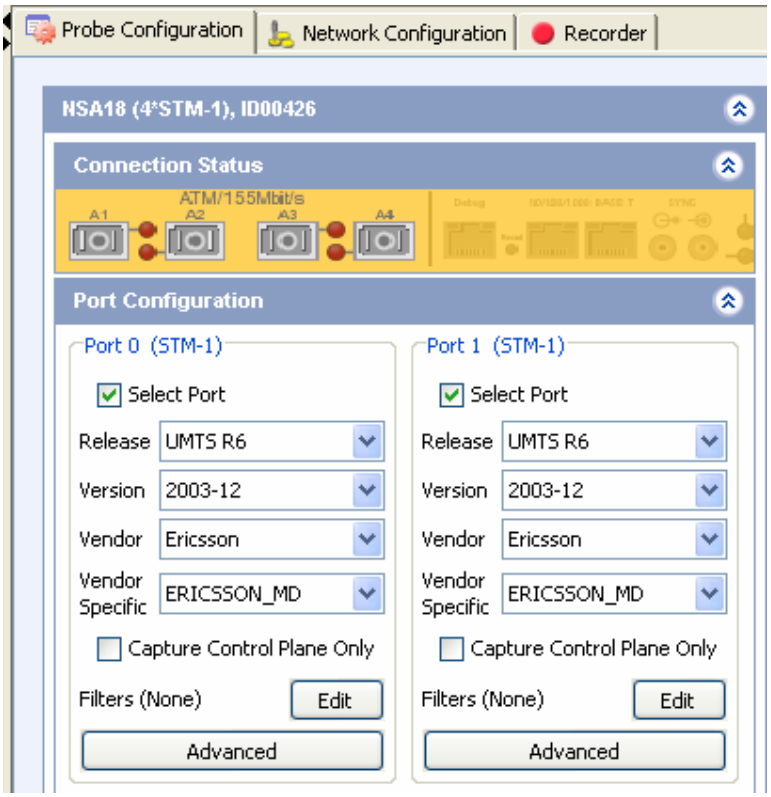
How Can I find an HSUPA Call in NSA

Tektronix NSA software auto-detects all VPI/VCI/CID established to serve a PS connection that used HSUPA and assigns the necessary protocol stacks to decode signaling and user plane information properly.

The only prerequisite for this function is that probe configuration parameters for Release, version and vendor have been set correctly before a session is captured or rerun.

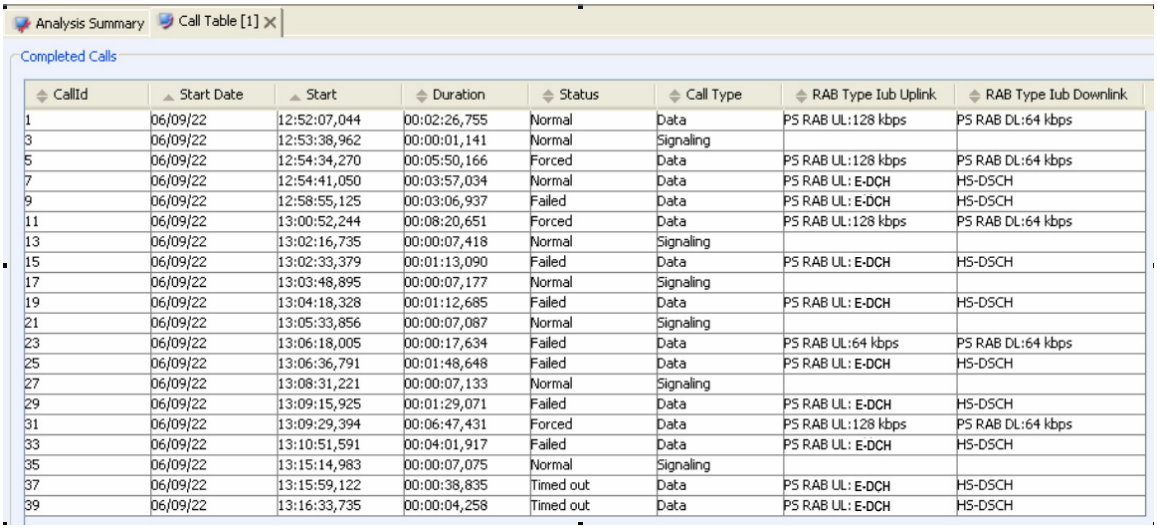


NSA Probe Configuration

Monitoring HSUPA Connections with NSA 1.6

Once the above settings have been made and data recording/analysis starts the multi-interface call trace application, NSA automatically detect s all calls that use HSUPA.

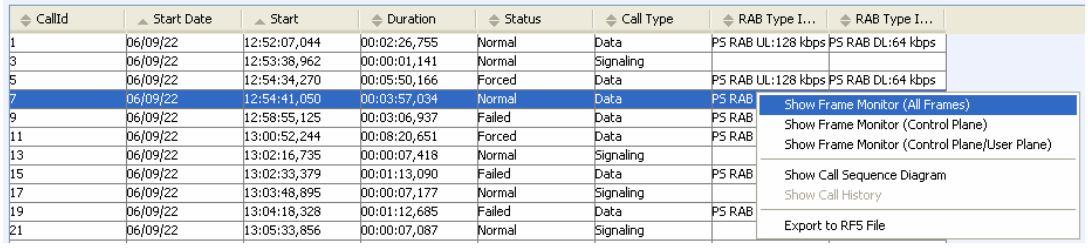
To detect HSUPA activity, is to take a look at the the RAB Type Iub UL column of the call table. This column indicates if an E-DCH was used during a radio connection. The RAB Type used on Iub and Uu is dynamically reconfigured during an active radio connection. The RAB Type Iub UL column shows only the last RAB Type used for the radio bearer (user plane traffic).



CallId	Start Date	Start	Duration	Status	Call Type	RAB Type Iub Uplink	RAB Type Iub Downlink
1	06/09/22	12:52:07,044	00:02:26,755	Normal	Data	PS RAB UL:128 kbps	PS RAB DL:64 kbps
3	06/09/22	12:53:38,962	00:00:01,141	Normal	Signaling		
5	06/09/22	12:54:34,270	00:05:50,166	Forced	Data	PS RAB UL:128 kbps	PS RAB DL:64 kbps
7	06/09/22	12:54:41,050	00:03:57,034	Normal	Data	PS RAB UL: E-DCH	HS-DSCH
9	06/09/22	12:58:55,125	00:03:06,937	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
11	06/09/22	13:00:52,244	00:08:20,651	Forced	Data	PS RAB UL:128 kbps	PS RAB DL:64 kbps
13	06/09/22	13:02:16,735	00:00:07,418	Normal	Signaling		
15	06/09/22	13:02:33,379	00:01:13,090	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
17	06/09/22	13:03:48,895	00:00:07,177	Normal	Signaling		
19	06/09/22	13:04:18,328	00:01:12,685	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
21	06/09/22	13:05:33,856	00:00:07,087	Normal	Signaling		
23	06/09/22	13:06:18,005	00:00:17,634	Failed	Data	PS RAB UL:64 kbps	PS RAB DL:64 kbps
25	06/09/22	13:06:36,791	00:01:48,648	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
27	06/09/22	13:08:31,221	00:00:07,133	Normal	Signaling		
29	06/09/22	13:09:15,925	00:01:29,071	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
31	06/09/22	13:09:29,394	00:06:47,431	Forced	Data	PS RAB UL:128 kbps	PS RAB DL:64 kbps
33	06/09/22	13:10:51,591	00:04:01,917	Failed	Data	PS RAB UL: E-DCH	HS-DSCH
35	06/09/22	13:15:14,983	00:00:07,075	Normal	Signaling		
37	06/09/22	13:15:59,122	00:00:38,835	Timed out	Data	PS RAB UL: E-DCH	HS-DSCH
39	06/09/22	13:16:33,735	00:00:04,258	Timed out	Data	PS RAB UL: E-DCH	HS-DSCH

NSA Call Table

Once you have found an HSUPA call in call table you can click the right mouse button to open the following context menu.



Select one option from this context menu for further analysis using the Frame Monitor.

Monitoring HSUPA Connections with NSA 1.6

Filtering HSUPA Activity in the Frame Monitor

You can easily isolate HSUPA activity in the Frame Monitor window by using the Filters feature accessible through the context-menu item **View Filter->Display Filter Setup** or the shortcut key 'F'.

We recall some key concepts about HSUPA before proceeding:

- To support HSUPA (High Speed Uplink Packet Access) a new kind of transport channel has been defined by 3GPP in the TS 25322 recommendation: the E-DCH (enhanced dedicated channel).
- The E-DCH exists in the UL direction only.
- Both DCCH (dedicated control Ch) and DTCH (dedicated traffic Ch) can be mapped onto E-DCH TrCh.

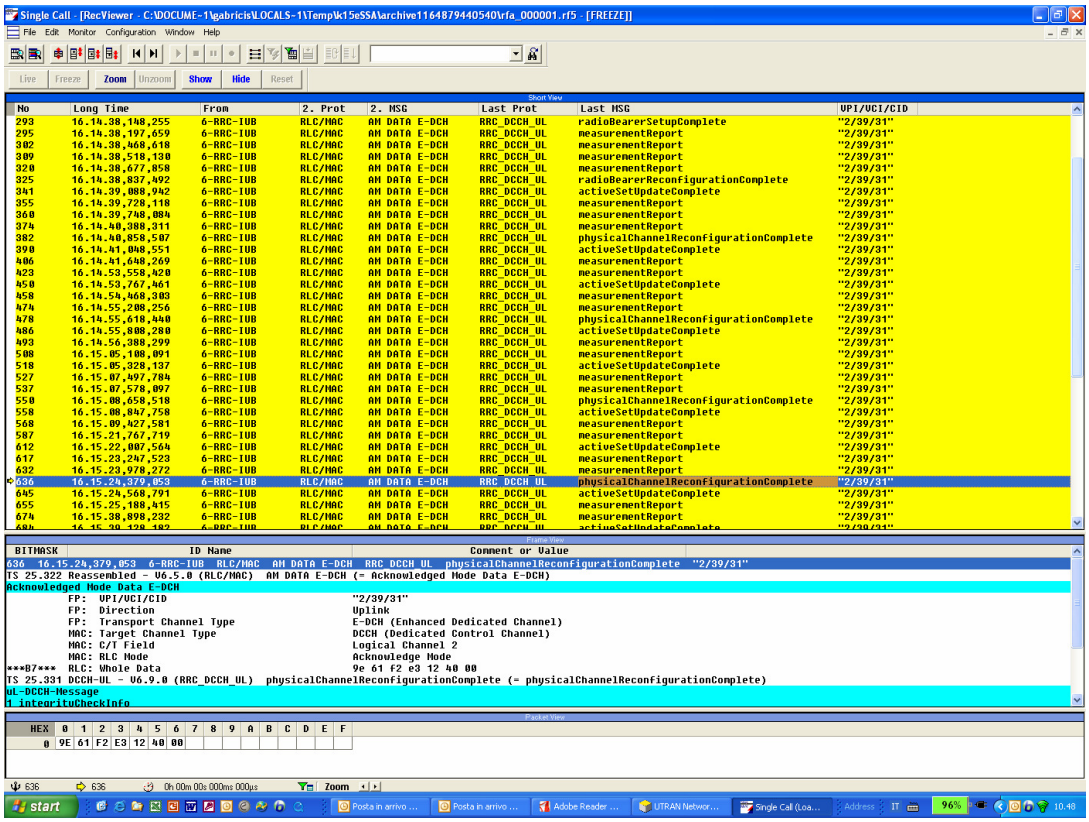
Filtering DCCH mapped on E-DCH

To filter a DCCH mapped on E-DCH, proceed as follows:

- Open the Filter dialog and click the Protocols tab
- On the Protocols Stacks sub pane, select "umts_rrc_(*release; vendor; version*).
  Fields *release; vendor; version* depend on the particular implementation you are monitoring.
- On the Protocols pane, select RLC/MAC.
- On the Messages of RLC/MAC pane check AM DATA E-DCH
- Click OK to confirm to activate the filter.

Monitoring HSUPA Connections with NSA 1.6

This allows you to filter the reassembled RRC messages on the Control Channel, which messages are shown in yellow color by default:



To display also the frames that once reassembled will build a given message, reopen the Filter and check in the Protocols pane FP DATA E-DCH.

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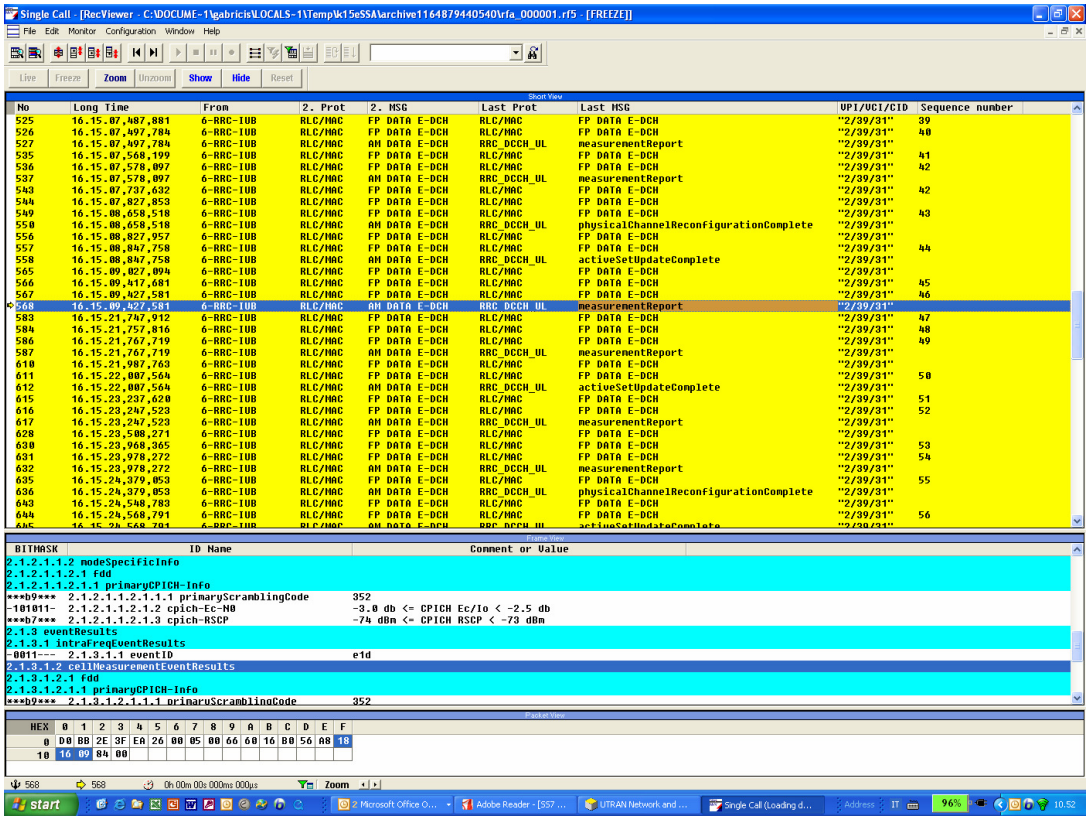
The Figure below shows the result of the operation:



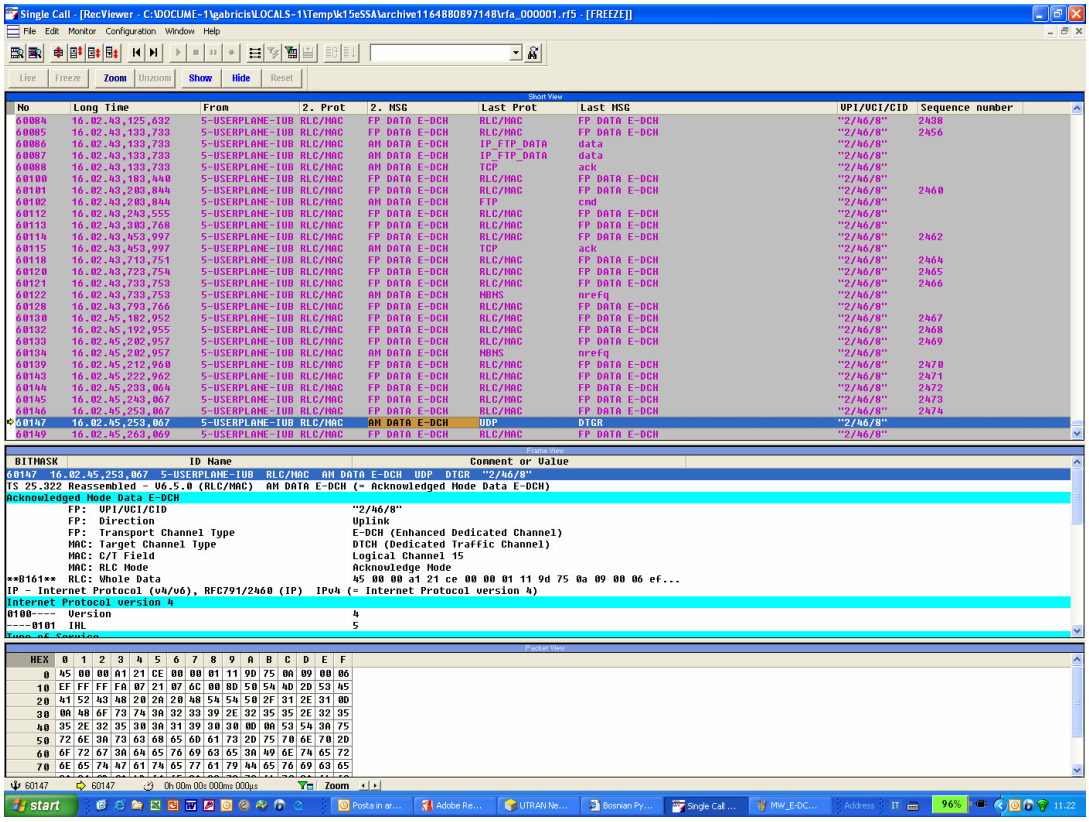
As well, you can add or delete from the display other messages related to E-DCH by checking or un-checking them in the Messages of [RLC/MAC] pane.

Monitoring HSUPA Connections with NSA 1.6

Filtering DTCH mapped to E-DCH

As before explained open the Filter dialog and click the Protocols tab. In order to filter user plane traffic, proceed as follows:

- On the Protocols Stacks sub pane select umts_user_plane_(*release, vendor, version*).
  As outlined in the previous example *release vendor and version* depend on the configuration of the Protocols Stacks as assigned by NSA during the session capture.
- On the Protocols sub pane select RLC/MAC
- On the Messages of [RLC/MAC] sub pane check AM DATA E-DCH
- If you want to display also the indivudual FP frames before reassembly check also the FP DATA E-DCH checkbox.



The example above shows the initiation of an FTP session with E-DCH in use. Also in this case additional messages of RLC/MAC layer can be added deleted to/from the view.

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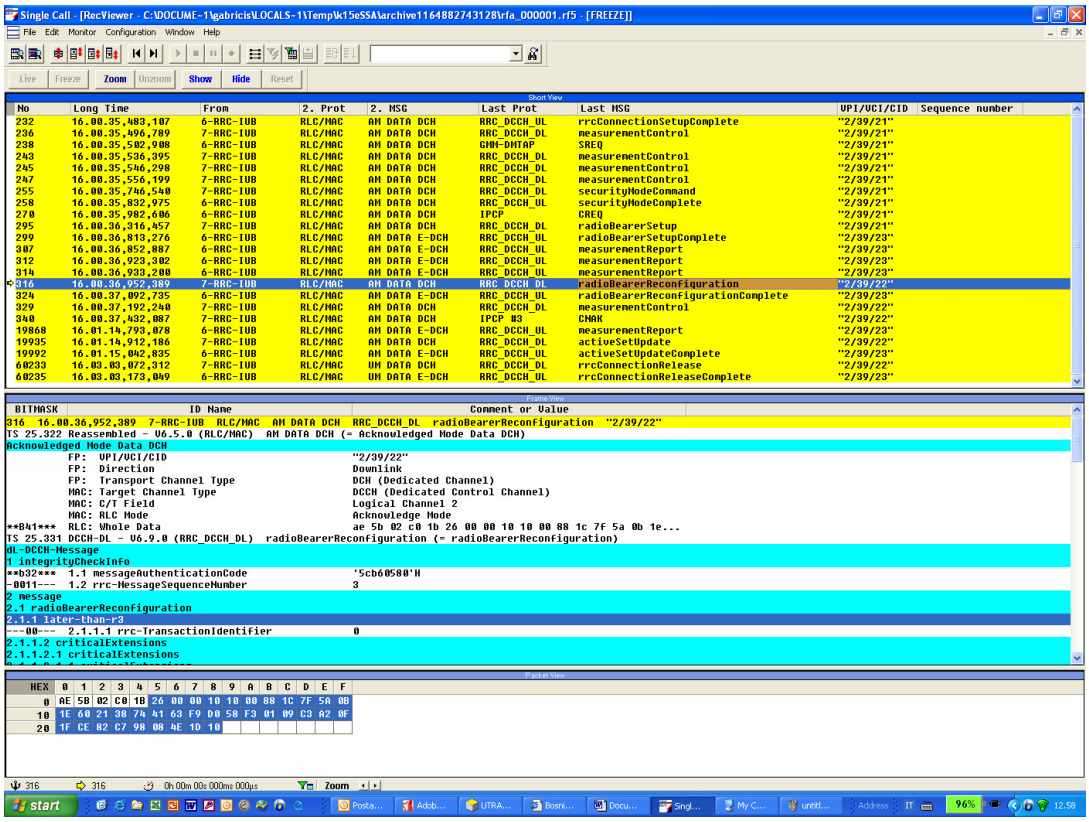
Filtering on Particular Messages

E-DCH is a dedicated control channel. The filtering of particular messages of interest proceeds as in the case of DCCH mapped on DCH:

- Check in the Protocols sub pane RRC_DCCH_UL
- Check in the Messages of [RRC_DCCH_UL] sub pane the messages of interest.
- Add other messages of interest, e.g. whole DCH channel
- Click OK to confirm the settings and activate the filtered view.

The following figure shows signaling activity for DCH and E-DCH on same view.



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