2

Short Introduction to Network Monitoring, Troubleshooting, and Network Optimization

This chapter shall give some *practical tips* and tricks regarding network monitoring, troubleshooting, and network optimization. The emphasis is on *general ideas* that help to operate and optimize the network. It must always be kept in mind that configurations and resource planning differs from manufacturer to manufacturer and from operator to operator. Also customer-specific information must be treated as confidential and cannot be published. For this reason not every gap analysis can be drilled down as deep as possible.

2.1 Iub Monitoring

Most Node Bs are not connected directly to CRNC using an STM-1 line. As a rule the STM-1 lines from CRNC lead to one or more ATM routers that also act as interface converters. From ATM routers/interface converters often E1 lines lead to the Node B. The reason for this kind of connection is that these E1 lines already exist – so they just need to be configured to fit to UTRAN configuration needs (Figure 2.1). In a minimum configuration, two E1 lines lead to one Node B, where the second line mirrors the configuration of the first one for redundancy and loadsharing reasons. However, an E1 line has total data transmission capacity of 2 Mbps, but a single user in an UTRAN FDD cell shall already be able to set up a connection with 384 kpbs. So it is clear that for high-speed data transmission services, one or two E1 lines are not enough. For this reason Inverse Multiplex Access (IMA) was introduced.

2.1.1 IMA

IMA provides the inverse multiplexing of an ATM cell stream over up to 32 physical links (E1 lines) and to retrieve the original stream at the far end from these physical links (Figure 2.2).

UMTS Signaling Ralf Kreher and Torsten Rüdebusch
 ISBN: 0-470-01351-6.

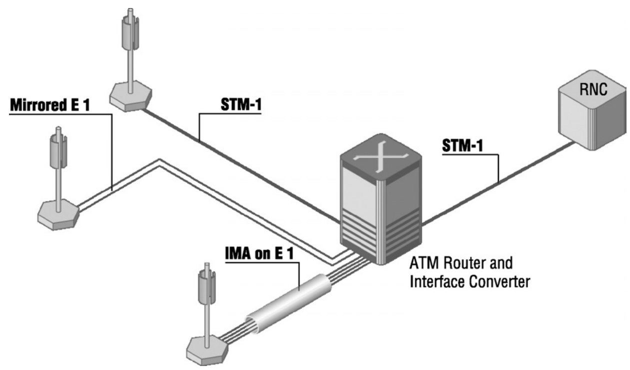


Figure 2.1 Possible transport network configurations on Iub.

The multiplexing of the ATM cell stream is performed on a cell-by-cell basis across these physical links.

The ATM inverse multiplexing technique involves inverse multiplexing and demultiplexing of ATM cells in a cyclical fashion among links grouped to form a higher bandwidth logical link whose rate is approximately the sum of the link rates. This is referred to as an IMA Group. A measurement unit like Tektronix K1297-G20 must be able to monitor all E1 lines belonging to an IMA group and to multiplex/demultiplex ATM cells in the same way as sending/receiving entities of the network.

2.1.2 Fractional ATM

Another technology that is becoming more and more important is fractional ATM. Fractional ATM allows network operators to minimize their infrastructure costs, especially during the UMTS deployment phase when the network load is low. The UMTS UTRAN and the GSM BSS share the same physical medium and exchange user and control information over this

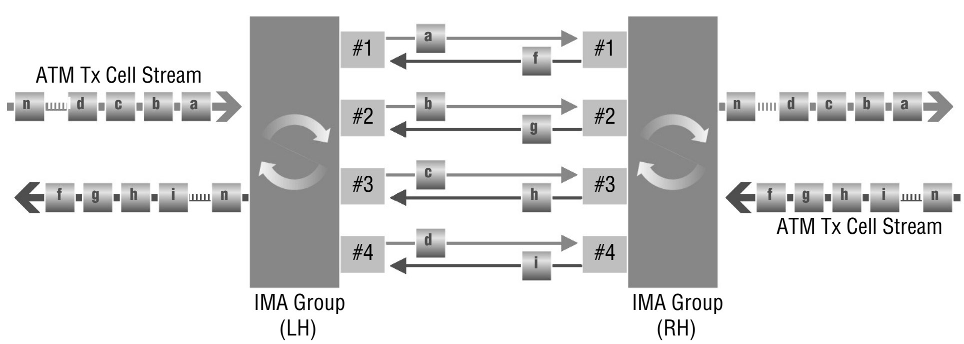


Figure 2.2 IMA: Monitoring of multiplexed ATM cells on E1 lines.

Figure 2.3 Time slot assignment for fractional ATM.

medium with the core network. The K1297-G20 time slot editor allows the assignment of an ATM fraction in any combination and is a good example to explain the fractional ATM principle. In Figure 2.3, the ATM section that forms the UMTS Iub interface is shown in dark grey. The remaining time slots can be used for GPRS Gb or GSM A interface.

2.1.3 Loadsharing and Addressing on Iub

There are several concepts for loadsharing on Iub, which means there are often several NBAP and ALCAP links between one RNC and one Node B. Loadsharing does not only increase the available transport capacity between two protocol peer entities, but it also brings redundancy to the network. In case one link crashes for any reason, there will always be alternative ways for message exchange and the connection between RNC and Node B will not be broken.

In addition, some manufacturers have divided their NBAP links into such used for common procedures and such used for dedicated procedures. A typical addressing and configuration case of a Node B with three cells is shown in Table 2.1.

The DCHs may also run in the same VPI/VCI as common transport channels. Then of course only those CID values can be used for DCH that are not occupied by common transport channels (in the example, CID 20-254 on VPI/VCI = **A/g**).

Table 2.1 Typical Node B configuration with three cells 1

Signaling link/channel	VPI/VCI	Allocated or reserved AAL 2 CID
NBAP Common Procedures 1	**A/a**	
NBAP Common Procedures 2	**A/b**	
NBAP Dedicated Procedures 1	**A/c**	
NBAP Dedicated Procedures 2	**A/d**	
ALCAP 1	**A/e**	
ALCAP 2	**A/f**	
RACH (1 per cell)	**A/g**	8; 12; 16
PCH (1 per cell)	**A/g**	9; 13; 17
FACH 1 (for control plane – 1 per cell)	**A/g**	10; 14; 18
FACH 2 (for user plane IP payload – 1 per cell)	**A/g**	11; 15; 19
Reserved for DCHs (AAL2 SVC)	**A/h**	8 - 254

To monitor the common transport channels RACH, FACH, and PCH, it is necessary to know not only the VPI/VCI, but also the correct transport format set, because here it is defined, e.g., how big RACH, FACH, or PCH RLC blocks are and how often they are sent (time transmission interval). Transport format set parameter values can follow 3GPP recommendations or can be defined by network operators/manufacturers!

2.1.4 Troubleshooting Iub Monitoring Scenarios

Three common problems when monitoring Iub links (without Autoconfiguration) are:

1. *There is no data monitored on common transport channels RACH, FACH, and PCH.*

   Solution: Remember that ATM lines are *unidirectional*! Ensure that measurement configuration is looking for RACH on uplink ATM line, while FACH and PCH can be found on downlink ATM line only!
2. *In case of NBAP or ALCAP only uplink or only downlink messages are captured, e.g., only ALCAP ECF, but ERQ messages are missed.*

   Solution: It may happen that loadsharing of NBAP is not organized following common and dedicated procedures, but following uplink and downlink traffic. In a similar way ALCAP uplink traffic may be sent on a different VPI/VCI than downlink traffic.

   Example:
   ALCAP_1 DL (ERQ) on VPI/VCI = **A/e** − ALCAP_1 UL (ECF) on VPI/VCI = **A/f**
   ALCAP_2 DL (ERQ) on VPI/VCI = **A/g** − ALCAP_2 UL (ECF) on VPI/VCI = **A/h**
3. *A monitoring configuration that worked some hours or days ago does not work anymore despite that no configuration parameter was changed.*

   Solution: Most likely a Node B reset procedure was performed. The Node B reset is performed in the same way as Node B setup (described in Section 3.1 of this book), but it may happen that ATM addressing parameters are assigned dynamically during the setup procedure. This means after successful restart the same links will have been established as before the reset, but especially the common transport channels will have assigned different CID values than before.

   Table 2.2 gives an example (based on previous configuration example).

Table 2.2 Typical Node B configuration with three cells 2

Channel name	VPI/VCI	CID before reset	CID after reset
RACH (1 per cell)	**A/g**	8; 12; 16	20; 24; 28
PCH (1 per cell)	**A/g**	9; 13; 17	21; 25; 29
FACH 1 (for control plane – 1 per cell)	**A/g**	10; 14; 18	22; 26; 30
FACH 2 (for user plane IP payload – 1 per cell)	**A/g**	11; 15; 19	23; 27; 31

```
TS 29.331 DCCH-UL (2002-03) (RRC_DCCH_UL)  rrcConnectionSetupComplete (= rrcConnectionSetupComplete)
uL-DCCH-Message
1 message
1.1 rrcConnectionSetupComplete
-00-----  1.1.1 rrc-TransactionIdentifier              0
1.1.2 startList
1.1.2.1 sTARTSingle
-----0--  1.1.2.1.1 cn-DomainIdentity                  cs-domain
**b20***  1.1.2.1.2 start-Value                        '00000000000000010010'B
1.1.2.2 sTARTSingle
--1-----  1.1.2.2.1 cn-DomainIdentity                  ps-domain
**b20***  1.1.2.2.2 start-Value                        '00000000000000000010'B
```

Figure 2.4 Start values for ciphering in RRC Connection Complete message.

4. *There are decoding errors in RRC messages on recently opened DCHs.*

   Solution: The frames that cannot be decoded may be ciphered. The necessary input parameters for deciphering are taken from RANAP Security Mode Control procedure, and also from RRC Connection Setup Complete message on Iub interface (contains, e.g., start values for ciphering sent from UE to each domain – see Figure 2.4).

   Hence, in case of soft handover scenarios a successful deciphering is only possible if the first Iub interface (UE in position 1) is monitored during call setup (see Figure 2.5).

An indicator of successful deciphering are proper decoded RLC Acknowledged Data PDUs in the VPI/VCI/CID that carries the DCH for DCCH after RRC Security Mode Complete message with rb-UL-CiphActivationTimeInfo was received from UE (Figure 2.6).

In the unsuccessful case the Iub interface that is used for call establishment is not monitored. Hence, RRC Connection Setup Complete message is not monitored and start values necessary for deciphering cannot be extracted by measurement software. If UE moves later into position

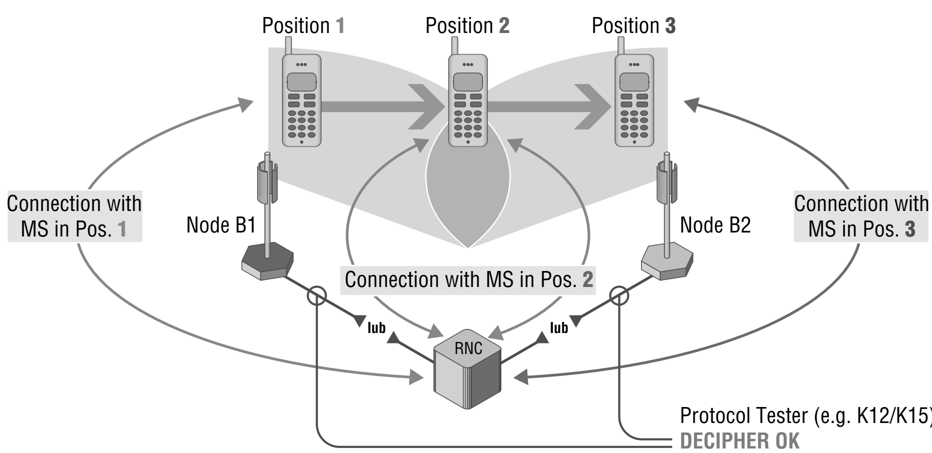


Figure 2.5 Iub deciphering.

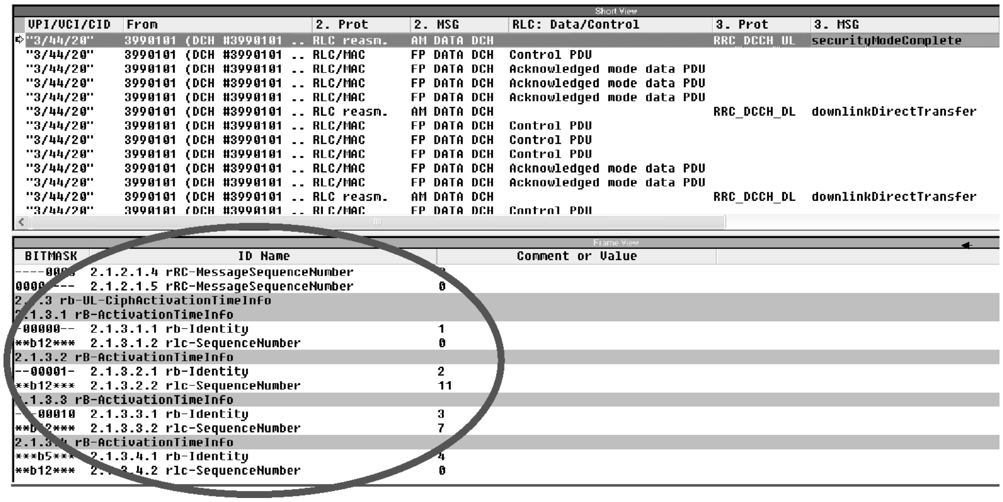


Figure 2.6 Correct decode of RLC Acknowledged Data PDU.

2 it is impossible to decipher the current connection, because correct start values are missed. This case is shown in Figure 2.7.

An indicator that the deciphering is not executed successfully is RLC Acknowledged Data PDUs, which show invalid length field information (Figure 2.8). This is because the length info of RLC frames is also ciphered and so the value is changed and becomes incorrect.

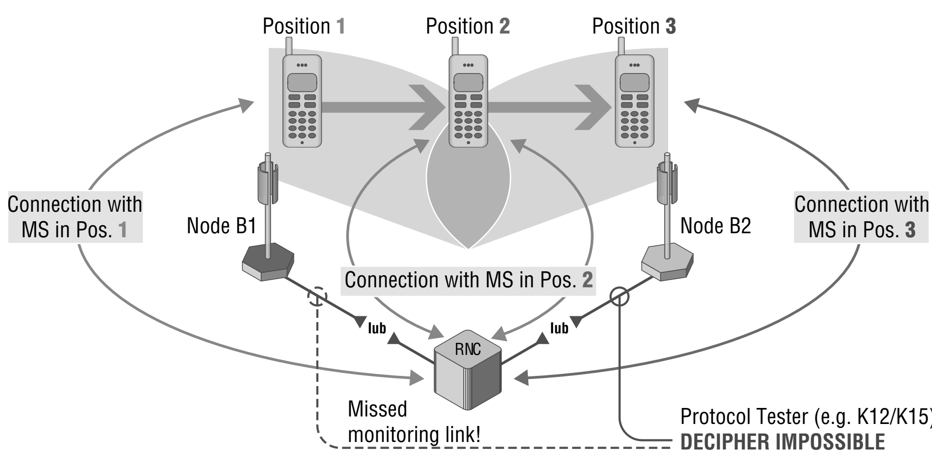
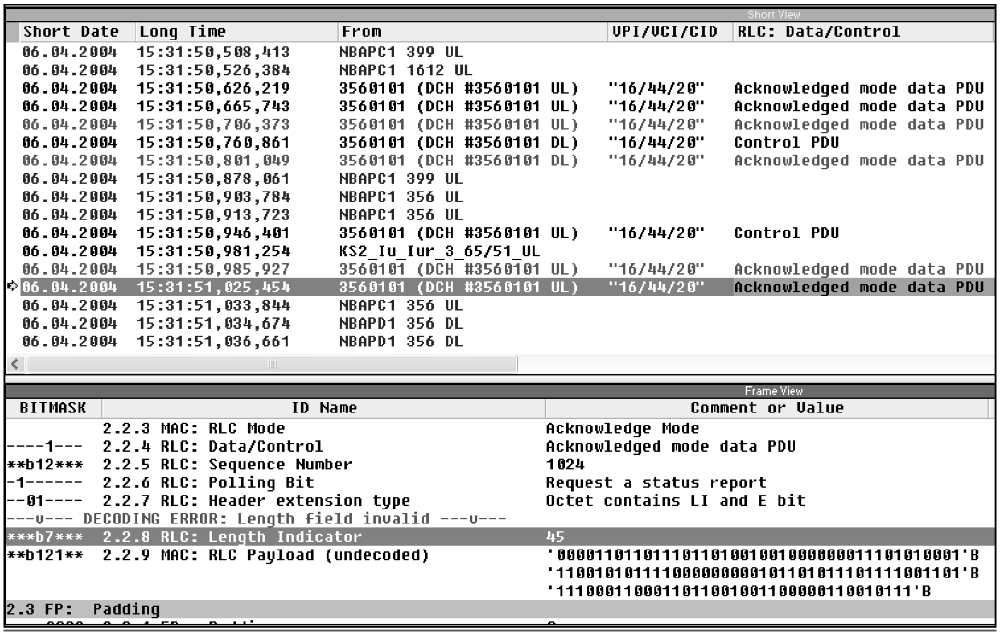


Figure 2.7 Iub deciphering problem.



Short View

Short Date	Long Time	From	VPI/VCI/CID	RLC: Data/Control
06.04.2004	15:31:50,508,413	NBAPC1 399 UL		
06.04.2004	15:31:50,526,384	NBAPC1 1612 UL		
06.04.2004	15:31:50,626,219	3560101 (DCH #3560101 UL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:50,665,743	3560101 (DCH #3560101 UL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:50,706,373	3560101 (DCH #3560101 UL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:50,760,861	3560101 (DCH #3560101 DL)	"16/44/20"	Control PDU
06.04.2004	15:31:50,801,049	3560101 (DCH #3560101 DL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:50,878,061	NBAPC1 399 UL		
06.04.2004	15:31:50,903,784	NBAPC1 356 UL		
06.04.2004	15:31:50,913,723	NBAPC1 356 UL		
06.04.2004	15:31:50,946,401	3560101 (DCH #3560101 UL)	"16/44/20"	Control PDU
06.04.2004	15:31:50,981,254	KS2_Iu_Iur_3_65/51_UL		
06.04.2004	15:31:50,985,927	3560101 (DCH #3560101 UL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:51,025,454	3560101 (DCH #3560101 UL)	"16/44/20"	Acknowledged mode data PDU
06.04.2004	15:31:51,033,844	NBAPC1 356 UL		
06.04.2004	15:31:51,034,674	NBAPD1 356 DL		
06.04.2004	15:31:51,036,661	NBAPD1 356 DL		

Frame View

BITMASK	ID Name	Comment or Value
	2.2.3 MAC: RLC Mode	Acknowledge Mode
----1---	2.2.4 RLC: Data/Control	Acknowledged mode data PDU
b12*	2.2.5 RLC: Sequence Number	1024
-1------	2.2.6 RLC: Polling Bit	Request a status report
--01----	2.2.7 RLC: Header extension type	Octet contains LI and E bit
---v--- DECODING ERROR: Length field invalid ---v---		
b7	2.2.8 RLC: Length Indicator	45
b121	2.2.9 MAC: RLC Payload (undecoded)	'0000110110111011010010010000000011101010001'B '110010101111000000000101101011101111001101'B '111000110001101100100110000011001011'B
2.3 FP: Padding		

Figure 2.8 Iub deciphering protocol trace.

2.2 Iu Monitoring

In the context of this chapter, the term "Iu monitoring" includes monitoring of IuCS, IuPS, and Iur interfaces. Looking forward to Release 5 features also Iurg interface between UTRAN RNC and GERAN BSC can be included, because information exchange on Iurg will be done using a set of RNSAP (Release 5) messages.

Also on Iu interfaces loadsharing is used for capacity and redundancy reasons. However, it may also be possible that data from several interfaces is exchanged using the same link.

Figure 2.9 shows a possible configuration scenario.

Between RNCs and core network elements there are transit exchanges (TEX 1 and TEX 2). These transit exchanges must be seen as multifunctional switches. They have an all-in-one functionality and work simultaneously as ATM router, SS#7 Signaling Transfer Point and interface/protocol converter. If CS core network domain is structured as described in Release 4 specifications, the transit exchanges may also include the Media Gateway (MGW) function.

There are 4 STM-1 fiber lines (4 fibers uplink, 4 fibers downlink) that lead from each RNC to two different transit exchanges (TEX 1 and TEX 2). In the transit exchange the VPI/VCI from the RNC (e.g., VPI/VCI = B/b) is terminated and higher layer messages like SCCP/RANAP are routed depending on Destination Point Code (DPC) of MTP Routing Label (MTP RL).

In other words, all messages on IuCS, IuPS, and Iur interfaces belonging to a single RNC are transported on the 4 STM-1 with two different VPI/VCI values between the RNC and a TEX and there is no distinguished STM-1 line for any interface like IuCS, IuPS, or Iur. The

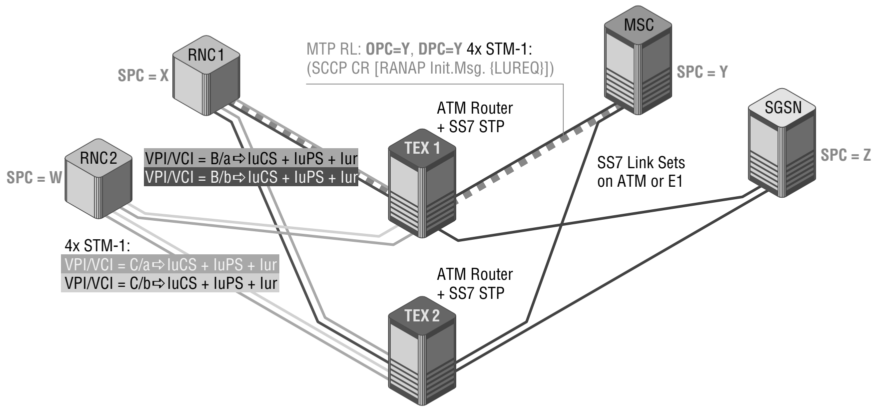


Figure 2.9 Configuration of transport network for IuCS, IuPS, and Iur.

example in the picture shows the way of a Location Update Request message (LUREQ) that is embedded in an SCCP Connection Request (SCCP CR)/RANAP Initial Message and sent from RNC 1 to the MSC. This message is sent on STM-1 line with VPI/VCI = B/b to TEX 1 and is then routed based on DPC = Y to the MSC – no matter whether the transport network between TEX 1 and MSC is ATM as well or just a set of SS7 links on E1 line(s). Whether the LUREQ message is sent on VPI/VCI = B/a or B/b is decided by loadsharing function of RNC 1, which also does not depend on any interface characteristics.

2.2.1 Troubleshooting Iu Monitoring

Usually it is not difficult to find the ATM links on Iu interfaces. The only problem when using a protocol tester for message analysis is to use the correct decoder when the links are monitored on the STM-1 between RNC and TEX 1/2.

For those readers who are not familiar with protocol testers it should be mentioned that in a protocol tester the decoder layers are arranged in quite the same way as the layers of the protocol stack on the monitored link.

The problem on the combined Iu link (with IuCS, IuPS, and Iur) is that there must be a dynamical decision on which messages are RANAP and which messages are RNSAP. Both RANAP and RNSAP are users of SCCP identified by different Subsystem Numbers (RANAP: SSN = 142; RNSAP: SSN = 143). But subsystem numbers are only exchanged during SCCP connection setup using the SCCP Connection Request (CR) and SCCP Connection Confirmed (CC) messages. SCCP DT1 messages used to transport NAS PDUs do not have an SSN in header, but protocol tester decoder layers need to decide for every single DT1 message to which higher layer decoder the DT1 contents shall be send.

A typical decoder problem looks like the example shown in Figure 2.10.

In the Iu signaling scenarios it was already explained that there is a single SCCP Class 2 connection for each RANAP or RNSAP transaction. Different SCCP Class 2 connections are distinguished on behalf of their source local reference and destination local reference numbers (SLR/DLR). So it is necessary to have SLR/DLR context-related protocol decoder

Short View

3. Prot	3. MSG	Procedure Code	4. Prot	4. MSG	5. Prot	5. MSG
RL	RL	id-radioLinkSetup	SCCP	CR	RNSAP370	initiatingMessage
RL	RL		SCCP	CC		
RL	RL		SCCP	DT1		
RL	RL		SCCP	DT1		
RL	RL	id-RelocationResourceAll	SCCP	DT1	RANAP err	initiatingMessage
RL	RL	8	SCCP	DT1	RANAP err	initiatingMessage
RL	RL	id-LocationReport	SCCP	DT1	RANAP err	initiatingMessage
RL	RL	8	SCCP	DT1	RANAP err	successfulOutcome
RL	RL	id-CommonID	SCCP	DT1	RANAP err	initiatingMessage
RL	RL	15	SCCP	DT1	RANAP err	successfulOutcome
RL	RL		SCCP	RLSD		
RL	RL		SCCP	RLC		

Figure 2.10 RNSAP decoding errors in DT1 messages on combined Iu link.

as implemented in Tektronix K12/K15 protocol testers to ensure correct decoding of all RANAP/RNSAP messages on the combined link (Figure 2.11). Here the SLR/DLR combination of the active SCCP connection is stored in relation to the higher layer decoder indicated by subsystem number. Using this intelligent feature the decoding errors on Iur disappear.

Another problem that might appear is that single RNSAP messages on Iur interface, especially RNSAP Radio Link Setup messages, are not shown in protocol tester monitor window. This happens because of SCCP segmentation (described in Iur handover scenarios). Figure 2.12 shows a message flow example with RNSAP frames successfully reassembled by protocol tester.

2.3 Network Optimization and Network Troubleshooting

Especially in Europe, UMTS network deployment after successful field trials and service launches entered a new critical stage: the phase of network optimization and network troubleshooting. Despite the fact that users can already use 3G services, there are still many problems in the networks, and the quality of services does not always meet expectations. The objective of network optimization is to evaluate and improve the quality of services. Network troubleshooting means to detect problems, and then find and eliminate the root causes of these problems. The fewer problems one finds, the higher quality of services can be guaranteed.

Short View

3. Prot	3. MSG	Procedure Code	4. Prot	4. MSG	5. Prot	5. MSG
RL	RL		SCCP	CR		
RL	RL		SCCP	CC		
RL	RL	id-radioLinkSetup	SCCP	DT1	RNSAP370	initiatingMessage
RL	RL		SCCP	DT1		
RL	RL		SCCP	DT1		
RL	RL	id-downlinkPowerControl	SCCP	DT1	RNSAP370	initiatingMessage
RL	RL	id-dedicatedMeasurementI	SCCP	DT1	RNSAP370	initiatingMessage
RL	RL	id-dedicatedMeasurementI	SCCP	DT1	RNSAP370	successfulOutcome
RL	RL	id-radioLinkRestoration	SCCP	DT1	RNSAP370	initiatingMessage
RL	RL	id-radioLinkDeletion	SCCP	DT1	RNSAP370	initiatingMessage
RL	RL	id-radioLinkDeletion	SCCP	DT1	RNSAP370	successfulOutcome
RL	RL		SCCP	RLSD		
RL	RL		SCCP	RLC		

Figure 2.11 Correct decoding of RNSAP messages on combined Iu link.

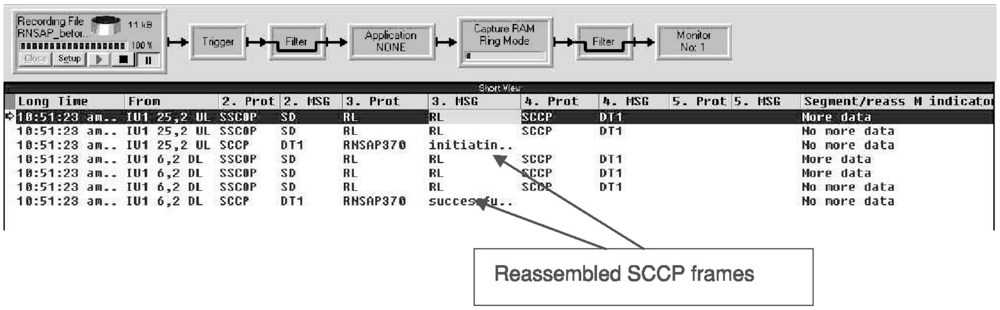


Figure 2.12 Segmented and reassembled RNSAP messages an Iur interface.

To evaluate problems (find out which problems appear and how often they appear in a network), special indicators are defined that are based on measurement results. These indicators are called key performance indicators (KPI).

In general, nowadays, the term KPI has become more and more a marketing phrase, “because it sounds good.” The result is that not everybody using the term KPI really means a KPI following the correct definition. Often this abbreviation is used to cover a wide field of measurement results that includes, e.g., counters of protocol events as described in 3GPP 42.403 as well as various measurement settings and measurement reports extracted directly from signaling messages or measurements derived from analysis of data streams.

A real KPI is mostly a mathematical formula used to define a metrics ratio that describes network quality and behavior for network optimization purposes. Comparison of KPI values shall point out in a simple and understandable way whether actions that have been made to improve network and service quality have been successful or not.

All other measurements are input for KPI formulas and it is possible that also additional data is added coming, e.g., from equipment manufacturers and network operators, as shown in Figure 2.13.

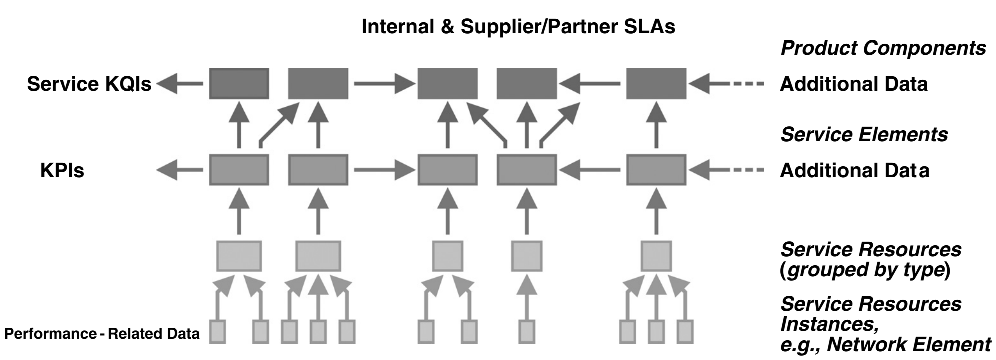


Figure 2.13 KPI as key element of KQI.

A good example of performance-related data are event counters used to count protocol messages that indicate successful or unsuccessful procedures.

A simple KPI defined based on such counters could be a success or failure rate.

Example:

Counter 1 = Σ of all GPRS Attach Request messages captured within a defined time period
Counter 2 = Σ of all GPRS Attach Reject messages captured within a defined time period

KPI: GPRS Attach Failure Ratio [in %] = $\frac{\text{Counter2}}{\text{Counter1}} \times 100$

There is a long list of similar success and failure ratios that are relatively easy to be defined using performance measurement definitions found in 3GPP 32.403. All these values are useful because they give a first overview of network quality and behavior and they may also be helpful to identify possible problems in defined areas of the network. However, simple counters and simple ratio formulas are often not enough.

For instance, if the already defined GRPS Attach Failure Ratio is calculated per SGSN, it can be used to indicate whether there is an extremely high rate of rejected GPRS Attach Requests in a defined SGSN area. However, such a high Attach Failure Ratio does not need to indicate a network problem by itself. Always a further analysis is necessary to find the root cause of network behavior. Based on the root cause analysis it can be determined whether there are problems or not. This procedure is also called drill-down analysis.

In case of rejected GPRS attach, the first step of analysis will always be to check the reject cause value of the Attach Reject message. A value that is often seen here is the cause "network failure." From 3GPP 24.008 (Mobility Management, Call Control, Session Management) it is known that the cause value "network failure" is used "if the MSC or SGSN cannot service an MS generated request because of PLMN failures, e.g. problems in MAP."

A problem in MAP may be caused by transmission problems on Gr interface between SGSN and HLR. The address of a subscriber's HLR is derived from IMSI as explained in Section 4.4 and the best way to analyze the procedure is to follow up the MAP signaling on Gr interface after GRPS Attach Request arrives at SGSN.

On Gr it can be seen whether there is a response from HLR or not and how long does it take until the response is received.

Common reasons why GPRS attach attempts are rejected with cause "network failure" are

- expiry of timers while waiting for answer from HLR, because of too much delay on signaling route between SGSN and HLR
- abortion of MAP transactions because of problems with different software versions (application contexts) in SGSN and HLR (see Section 4.4.2)
- invalid IMSI (e.g., if a service provider does not exist anymore, but its USIM cards are still out in the field)
- routing of MAP messages from foreign SGSN to home HLR of subscriber impossible, because there is no roaming contract between foreign and home network operators

The first two reasons indicate network problems that shall be solved to improve the general quality of network service. The latter two reasons show a correct behavior of the network that prevents misusage of network resources by unauthorized subscribers.

This example shows how difficult it is to distinguish between "good cases" (no problem) and "bad cases" (problem) in case of a single reject cause value. In general, four main features can be identified as main requirements of good KPI analysis:

- Intelligent multi-interface call filtering
- Provision of useful event counters
- Flexible presentation of measurement results from different points of view (sometimes called dimensions), e.g., show first Attach Rejects messages by cause values and then show IMSI of rejected subscribers related to one single cause value (to find out if they are roaming subscribers or not)
- Latency measurement to calculate time differences, e.g., between request and response messages

Another example that demonstrates these needs is shown in Figure 2.14.

The call flow diagram in the figure shows that MSC rejects a location update request belonging to a combined Location/Routing Area Update procedure, because RNC is obviously not able to execute Security Mode functions required by CS core network domain within an acceptable time frame. Once again the reject cause value in this case is "network failure," but this time the root cause of the problem is not in core network. A classical location update failure rate would show the problem related to MSC only, but using multi-interface call trace

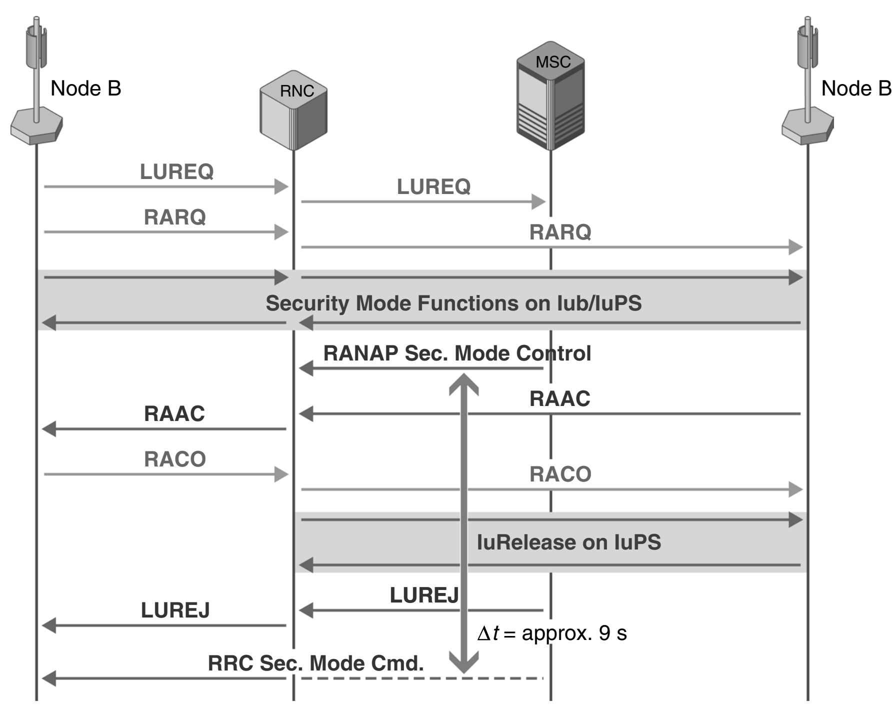


Figure 2.14 Drill-down analysis of rejected Location Update procedure.

function and call-related latency measurement it becomes possible to identify the RNC as the problem child of the network in this case.

In addition to root cause analysis, latency measurement is also useful to calculate call setup times as well as delivery times for short messages and data frames. Further important network performance parameters are throughput (data transmission rate on single interfaces or for single applications, e.g., file transfer).

Quality of services on radio interface can be determined on behalf of so-called radio link performance indicators to which belong the following:

- *BLER*: This is long-time average block error rate calculated from transport blocks. A transport block is considered to be erroneous if a CRC error is indicated by appropriate information element of Framing Protocol for uplink data. Unfortunately there is not good downlink BLER report specified yet that could be sent by user equipment. Only RRC measurement report with event-ID *e5a* indicates that downlink BLER exceeded a defined threshold.
- *BER*: Bit error rate (BER) can either be measured as Transport Channel BER or Physical Channel BER. Reports are sent by Node B to RNC for uplink data. The uplink BER is encoded in Framing Protocol Quality Estimate value.
- *SIR Error*: This shows the gap between the assigned SIR target and measured SIR. Analysis of SIR error per connection shows how good the SRNC is able to adjust uplink transmission power of UE, which means accuracy of Open Loop Power Control.
- *Transmitted Code Power*: This is the power allocated per connection. Based on this measurement, DL load of any user per connection can be estimated. The purpose of this procedure in RNC is to avoid the blockage of all available DL power resources by single UEs.

  In order to establish the radio link with the defined bit rate, the appropriate transmission power is also needed: the higher the required bit rate, the higher the output power per connection. Admission controller and packet scheduler should allow UE to use as much power as needed to reach the Node B at a predefined quality level. The allowed UE transmitted power should be on as low a level as possible, to save the short radio resources.

  Quality level per connection is defined in the planning phase and should be kept constant as long as customer satisfaction is ensured.
- *RTWP*: Received Total Wideband Power (RTWP) reflects the total noise level within the UMTS frequency band of one single cell. Call admission control and packet scheduler functions in RNC may use RTWP for calculation of necessary dedicated resources (load-based admission control function). A high RTWP level indicates increasing interferences in cell. To prevent excessive cell breathing, RNC may reconfigure all existing radio bearers used in this cell. As a result, short-time peaks of intra-cell handover rate KPIs can be measured.

How event counters and performance parameters depend on each other is still pretty unknown. Hence, one of the main challenges of UMTS network optimization is to define so-called co-related KPIs that link protocol events with QoS parameters. The general difficulty is to define useful KPIs on one hand and to give a correct interpretation of measured KPIs on the other hand. Indeed, a high level of expertise is necessary to work on this task and just to list all possible known problems would exceed the contents of this book.

However, finally another nice example shall be given that shows how protocol analysis can be used to optimize the network.

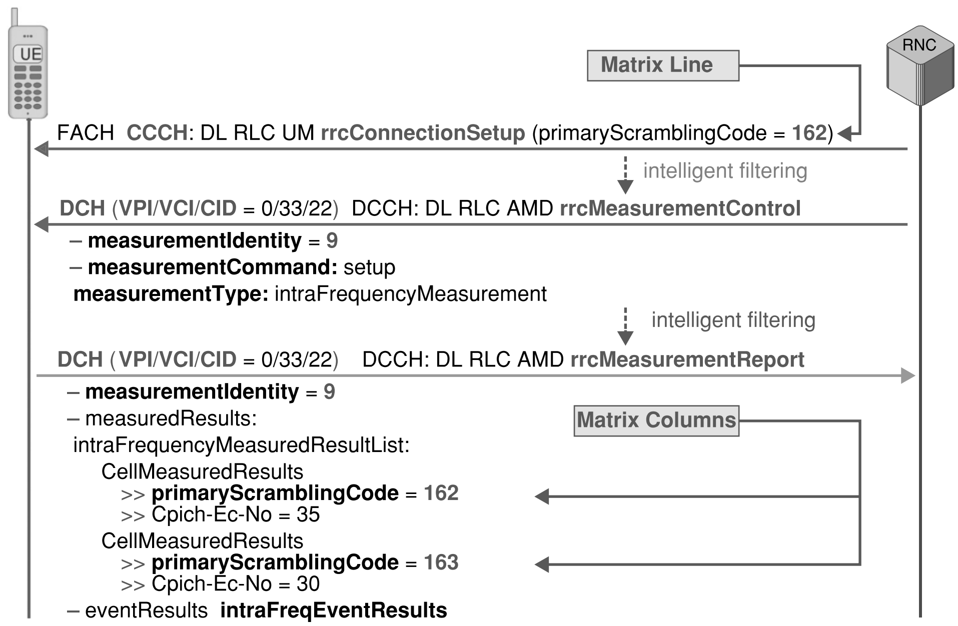


Figure 2.15 RRC messages used to calculate cell neighbor matrix.

As the reader will learn in Chapter 3, softer and soft handovers play an important role to guarantee a stable radio link quality. The prerequisite to perform handovers is that cells overlap, but overlapping shall only happen in border areas. If one UMTS cell overlaps another one too much, the interference level of the overlapped cells will rise, which is indicated by increased RTWP level and this will in turn lower the QoS of radio links. However, if overlapping areas are too small there is a quite big risk that UE can lose contact with network, which leads to a dropped call.

At any time of radio network planning and optimization there is the question of how much neighbor cells overlap and whether the expected overlapping factor is reached or not. The tool that helps radio network planners to optimize their settings is called “cell overlapping matrix” or “cell neighbor matrix.”

Using intelligent call filter functions and statistic functions this matrix can easily be calculated based on data found in different RRC messages.

As shown in Figure 2.15, primary scrambling code included in RRC Connection Setup message helps to identify the cell in which a UE is located during call setup. Then, after call setup, this UE will send RRC Measurement Report messages to SRNC (see Section 3.7). Those RRC Measurement Reports include measured signal strength of primary CPICH of all cells the UE is able to measure on radio interface: the cell in which the call was set up as well as neighbor cells of this cell. All cells are identified by their primary scrambling codes and now these primary scrambling codes are used to name columns and lines of cell neighbor matrix.

The cell in which the call was originally set up and where the measurement reports come from is used to define a line of the matrix, e.g., SC = 9 in the first line of Figure 2.16. Neighbor cell primary scrambling codes are found in the column names of the matrix.

	cell neighbor matrix						
SC	220	380	444	355	345	152	84
9	214	202	106	92	90	36	32
	24.0991 %	22.747747 %	11.936937 %	10.36036 %	10.135135 %	4.054054 %	3.6036036 %
SC	220	177	150	113			
18	2	2	2	2			
	25.0 %	25.0 %	25.0 %	25.0 %			
SC	417	414	220				
37	4	4	4				
	33.333336 %	33.333336 %	33.333336 %				
SC	220	355	380	72	444	479	152
60	602	92	66	32	28	22	16
	65.72052 %	10.043668 %	7.2052402 %	3.49345 %	3.0567684 %	2.4017467 %	1.746725 %
SC	220	479	380	355	444	345	60
72	10	6	6	6	4	4	4
	20.833332 %	12.5 %	12.5 %	12.5 %	8.333334 %	8.333334 %	8.333334 %
SC	380	220	355	444	9	417	399
84	12	8	6	4	4	2	2
	28.57143 %	19.047619 %	14.285715 %	9.523809 %	9.523809 %	4.7619047 %	4.7619047 %

Figure 2.16 Cell neighbor matrix calculated by analysis tool.

The final cell neighbor matrix (Figure 2.16) shows how often a single neighbor cell was reported by an UE with an active radio link in the cell that stands in front of a matrix line. If the cell was reported in 2 out of 10 total measurement reports the overlapping factor is 20%. The figure shows neighbor cells for cells with primary scrambling codes (SC) = 9, 18, 37, 60, 72, and 84.