

R&S®TSMx Radio Network Analyzers

HSPA measurements with all the bells and whistles

HSPA technologies in UMTS networks

not only significantly increase data

throughput in the uplink and down-

link but also complexity. This makes

achieving the targeted network quality

in these “turbo networks” even

more critical. And this is where the

R&S®TSMx radio network analyzers

(FIG 1) and the R&S®ROMES coverage

measurement software come into

their own.

The many sides to network quality

HSPA technologies for UMTS networks increase the data throughput in the downlink up to 14.4 Mbit/s and in the uplink up to 5.74 Mbit/s (see opposite page for HSPA details). However, the attainable data throughput is only one characteristic of a network – and different situations might place completely different requirements on the network. For example, while an FTP download requires the highest possible data rate, for voice over IP it is the maximum round trip time (RTT) that makes a difference.

To ensure that the targeted network quality is met, measurement systems are needed that allow the available quality of service (QoS) to be precisely viewed and analyzed, while at the same time making all relevant technical measurement values – e.g. layers 1 through 3, Internet protocol, etc. – available in a format that can be used in real-life scenarios for error analysis or optimization.

R&S®ROMES: sophisticated measurement methods for HSPA

Measurement systems must use sophisticated methods of data collection, preparation, and visualization if measurements in HSPA networks are to be meaningful. However, since the relevant measurement data can change during each transmission time interval (TTI), enormous amounts of data have to be processed. The mobile phone device drivers included in the R&S®ROMES coverage measurement software collect this data and input it into the software in blocks of 200 ms each (100 TTIs for HSDPA). This block size ensures that the generated load for the measurement system stays within limits, while also maintaining a continuous flow of measurement results on the screen for the user.

FIG 1 Essential measurement aids: the R&S®TSMx radio network analyzers.



Hybrid automatic repeat request (HARQ)

Multiple HARQ processes allow efficient use of the transmit and processing time for data packets. After a data packet has been sent for a process, the sender does not have to wait for an acknowledgement, but rather can immediately send a packet for another process. The sender does not expect a successful or failed receipt to be acknowledged for the packet until some time later.

This method also increases efficiency because it does not completely discard failed transmissions, but rather uses intelligent algorithms to combine them with additional transmissions of the same (payload) data block. This increases the likelihood of successful decoding of the packet.

Adaptive modulation and coding (AMC)

During modulation and coding of the data, high payload data throughputs are associated with less robust transmission. Therefore, the optimum parameters are continually being sought for the current transmission conditions so as to ensure secure transmission with the highest possible throughput.

HSDPA allows a choice between modulation modes (QPSK and 16QAM). Various options are also available for coding the data. Modulation and coding can be adapted per TTI, permitting a rapid response to changes in the radio field. The same applies analogously to HSUPA.

HSPA – a brief overview

HSDPA (release 5)

HSDPA was introduced with the objective of using the radio channels as efficiently as possible as well as to achieve a significant increase in data rates in the downlink as compared to UMTS. It was also intended as the first step toward reducing the round trip time (RTT).

These objectives were achieved as a result of many changes to the physical layer and the MAC layer. Parallel HARQ processes and AMC ensure both higher data throughput and a more efficient use of the RF resources. To reduce the RTT, it was necessary to move parts of the MAC layer from the radio network controller (RNC) to the 3G base station. This was the only way to achieve a transmission time interface (TTI) of 2 ms. As a result, every 2 ms the process transmits data blocks for which the transmission parameters can then be adapted to the current radio field conditions (AMC). To do this, the mobile phone must report the successful or failed receipt of a data packet to the base station every 2 ms. The base station adapts the transmission parameters using the channel quality indicator (CQI), which the mobile phone determines based on the receive quality of the pilot signal and periodically reports to the base station (every n TTI).

Three new channels were introduced to implement these requirements. In the downlink, the high speed downlink shared channel (HS-DSCH) handles the data transport. The mobile phone detects the configuration of the HS-DSCH via the high speed shared control channel (HS-SCCH). As the names of these two channels indicate, they are not reserved for a single mobile phone, but instead are used by the base station to serve multiple mobile phones in parallel. In the uplink, the high speed dedicated physical control channel (HS-DPCCH) ensures the rapid transmission of the CQI values and the acknowledgement signals for the data packets.

HSUPA (release 6)

All improvements that HSDPA provides in the downlink are to be provided by HSUPA in the uplink. It therefore makes sense to use similar methods. As a result, efficient data transmission is provided by means of HARQ processes here as well, and the TTI was reduced to 10 ms or 2 ms, respectively. To achieve the rapid response times required, a part of the MAC layer had to be moved to the base station.

While the factor that limits throughput for HSDPA is the CQI of the radio field as determined by the mobile phone, in the uplink it is the maximum transmit power that the base station can allot to a mobile phone. Although the maximum transmit power that can be allotted is limited by the maximum transmit power of each mobile phone, the base station must in general limit the transmit power for a given mobile phone so that it does not overpower the other phones. The base station regulates the transmit power using grants it assigns to the mobile phones. The serving cell can set this power to a defined initial value by assigning an absolute grant. Moreover, any base station that is disrupted by a transmitting mobile phone can use a relative grant to stepwise reduce in the phone's allotted transmit power.

The objective was achieved by introducing five new channels. The E-DCH dedicated physical data channel (E-DPDCH) and the E-DCH dedicated physical control channel (E-DPCCH) together serve to transmit the data in the uplink. The data is sent to the base station via the E-DPDCH and the format via the E-DPCCH. In the downlink, the E-DCH absolute grant channel (E-AGCH) and the E-DCH relative grant channel (E-RGCH) regulate the permitted transmit power. Finally, the acknowledgements from the base station to the mobile phone needed for the HARQ processes are forwarded via the E-DCH hybrid ARQ indicator channel (E-HICH).

► Aggregated values are usually more useful than a number of individual raw measurement values in gaining an overview of the network status. This is why, during the measurements, the R&S®ROMES mobile phone drivers prepare additional statistics and analyses from the raw data provided by the phone. All measured values can be viewed and analyzed as standard R&S®ROMES signals shown as 2D chart, alphanumeric view, or route track view, and then linked with other signals from R&S®ROMES for further analysis.

If a problem area is identified, R&S®ROMES has special views where it can provide full access to all available measured values for a TTI to allow detailed analysis.

Views in R&S®ROMES: clear and detailed

HSUPA/HSDPA: How good is the data transmission right now?

The HSUPA view (FIG 2) and the HSDPA view (FIG 3) provide an initial impression of the quality of the current data transmission. Both views include a bargraph using colors to indicate the success of the transmission. Green bars show successfully transmitted packets or TTIs, and red bars represent faulty packet or TTI transmissions. Yellow bars indicate TTIs in which no data transmission took place (discontinuous transmission, DTX).

The y-axis in the HSUPA view represents the number of bits transmitted by the mobile phone (transport block size, TBS) and defined for each TTI based on the permissible transmit power. This allows the relationship between the block size and the transmission success to be read immediately.

In the HSDPA view, the bar size represents the CQI. This value, which the mobile phone calculates from the pilot

signal of the base station, reflects the required data rate.

Decode statistic views: How large are the transmission blocks?

The software generates statistics for both transmission directions describing the transmission quality of the HARQ processes. A distinction is made between (data) blocks and (data) sub-blocks. Blocks that have to be resent are called sub-blocks. Here is an example of a transmission process:

In a first transmission attempt, a block is sent within a TTI. If the receiver can decode the contents, the transmission is ended successfully (the number of blocks and sub-blocks is equal in this case, i.e. it is 1). If the transmission fails – because the receiver cannot decode the data – a sub-block error (SBLE) results and the transmission must be repeated. To initiate this, the receiver sends an error message (NACK – not acknowledged) to the

sender, which then reattempts the transmission. If the receiver is able to decode this second sub-block, one sub-block error and one sub-block success will be counted, resulting in a sub-block error rate (SBLER) of 50%. The (data) block itself was transmitted successfully, however, so the resulting block error rate (BLER) is 0%. A block error is present if the sender exceeds the maximum permissible number of send attempts for a block. When this happens, the sender reports this block to the higher layers as not transmitted.

The spread is also calculated to show how many attempts were necessary to successfully transmit of a block. Because the block size affects the level of protection for the data to be transmitted, R&S®ROMES breaks down the statistics accordingly. This means that the user can clearly see the relationship between block size and transmission probability (FIGS 4 and 5). ►

R&S®TSMx radio network analyzers from Rohde & Schwarz

Third-generation mobile radio networks require measurement methods that identify potential problem spots and offer solutions in the easiest way possible. The R&S®TSMx radio network analyzers from Rohde & Schwarz meet exactly these needs, because in combination with the R&S®ROMES software they offer sophisticated algorithms for neighborhood analysis. They are an indispensable aid in all cycles of a mobile radio network and deliver measurement results much faster and more precisely than test mobile phones. Their broadband RF frontend and the simple and modular option concept offer utmost flexibility for network operators, service providers, regulatory authorities, and hardware manufacturers.

Abbreviations

AMC	Adaptive modulation and coding
BLER	Block error rate
CQI	Channel quality indicator
DTX	Discontinuous transmission
HARQ	Hybrid automatic repeat request
HSDPA	High speed downlink packet access
HSPA	High speed packet access
HSUPA	High speed uplink packet access
NACK	Not acknowledged
RNC	Radio network controller
RTT	Round trip time
SBLE	Sub-block error
SBLER	Sub-block error rate
TBS	Transport block size
TTI	Transmission time interval

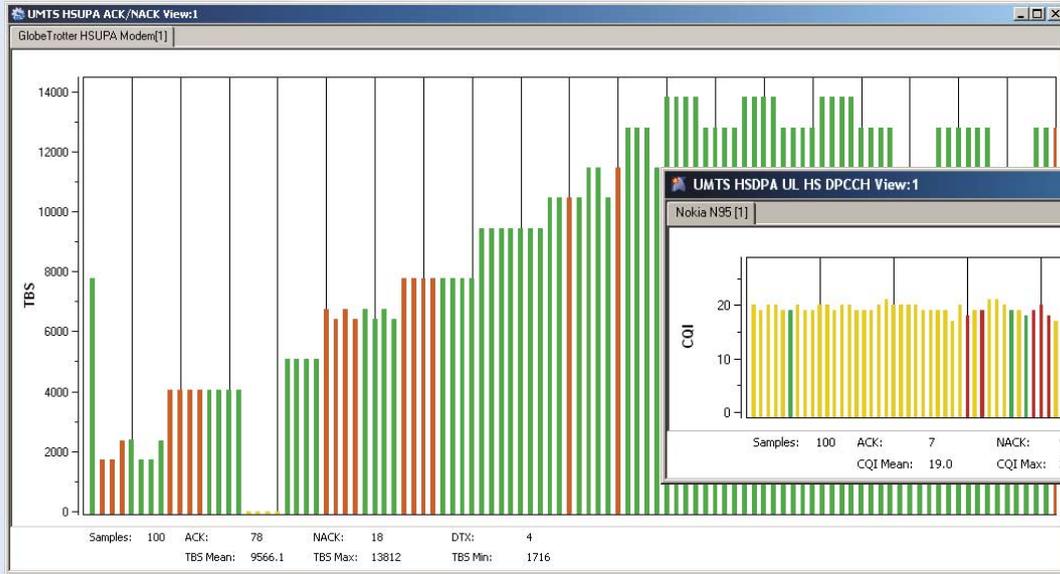


FIG 2 This example clearly shows the stepwise increase in the serving grant, resulting in a higher transport block size (see also FIG 8).

FIG 3 In this example, it is immediately obvious that the large number of TTIs without data is the cause of the low throughput.

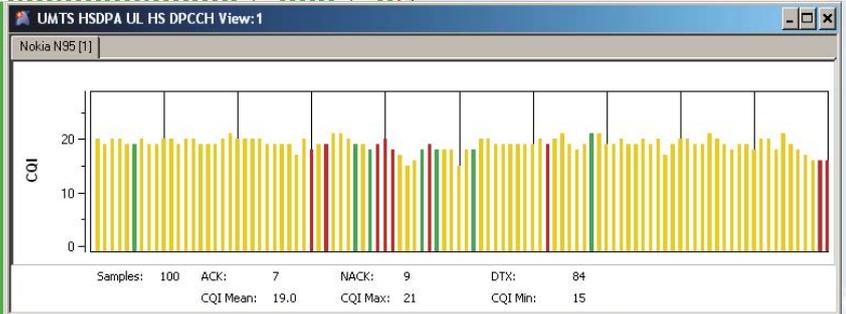


FIG 4 In this example, many different transport blocks of varying sizes are used for transmission. It can be seen that an increase in size also increases the probability of sub-block errors.

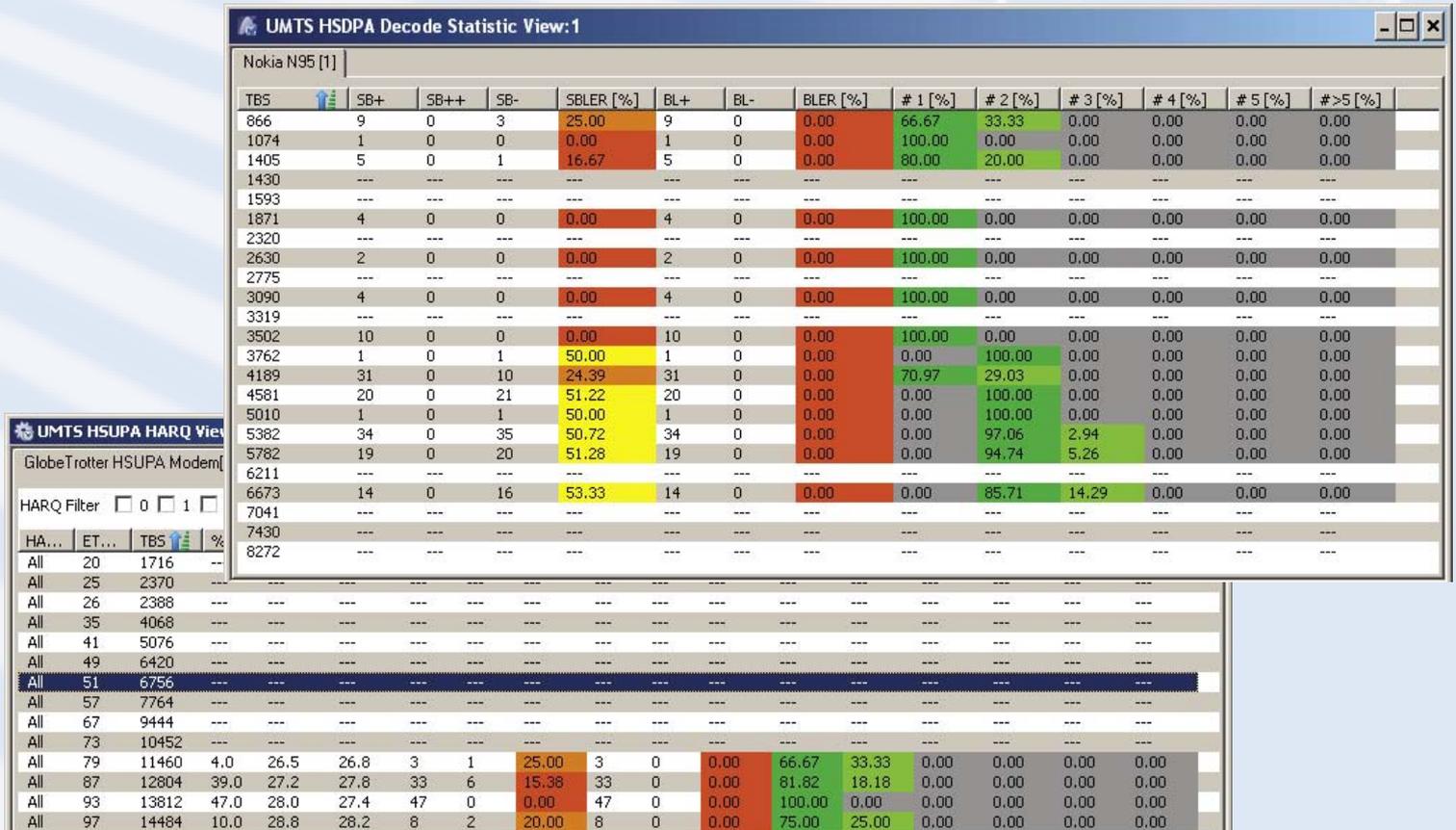


FIG 5 This view shows that mostly large transport block sizes are being used, which frequently require a second transmission.

► Performance views – throughput

Both views show the change over time for the most important HSPA parameters. The HSDPA view (FIG 6) includes sections for the transmission parameters required by the mobile phone and those set by the network, as well as the delta between the two. It also shows the data throughput in both the MAC layer and the RLC layer.

The HSUPA view (FIG 7) displays the success rates and the throughput of the data transmission. The software shows the corresponding values both in combination as well as listed out for the individual base stations involved in the transmission. The payload limit section also shows the factors limiting the throughput. This method of combining the success rates and the payload limit makes efficient analysis possible in those cases where the data rates are low.

Progress views – packet tracking in R&S®ROMES

These views (FIGs 8 and 9) allow easy tracking of the transmission parameter control over time. For each TTI, the software displays the corresponding parameters in the form of colored squares. This type of display makes it possible to evaluate the status of the data transmission at a glance. Analysis of HARQ processes is thus easy with the HSDPA view. The HSUPA view, however, permits a rapid analysis of how the serving grant is regulated in the serving and non-serving cells.

The data quality analyzer handles data traffic

The test data traffic is generated with the R&S®ROMES data quality analyzer option. This option is continually being improved to reflect new technologies. It now allows, for example, adaptation of the buffers in use, which ensures optimum throughput. Even next-generation HSPA data cards that register in the operating system exclusively as network cards can be used.

The IP tracer makes it all crystal clear

The IP tracer rounds out the software functionality. This tool can be used to record and analyze the entire IP data traffic (optionally without payload) on a specific data link. Combining the IP data traffic with the layer 3 messages from the mobile phone creates the layer 3 view as a powerful tool for analyzing all protocols involved.

Unparalleled interworking

Of course, all described modules can be operated in parallel with other R&S®ROMES modules, including the UMTS PN scanner or the GSM network scanner. As a result, just one drive test is needed to prepare a quality of service report, identify problem spots, and at the same time collect all conceivable measurement values for optimization.

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More information on the radio network analyzers and the R&S®ROMES coverage measurement software at www.rohde-schwarz.com (search term: TSM or Romes)

REFERENCES

R&S®TSMx Radio Network Analyzers – Radio network analyzers for all tasks and any budget. News from Rohde & Schwarz (2007) No. 192, pp 5–8

FIG 6

The upper graph shows the throughput desired by the mobile phone based on the radio field conditions. The remaining graphs show the throughput assigned by the network, as well as the delta between the two.

FIG 7

A typical start of transmission. First comes the "buffer" as the limiting element because it still has to be filled by the application (e.g. by the FTP client). But shortly after that the serving grant limits the maximum data throughput.

FIG 8

The green squares in the second line (RGCH) very nicely show the stepwise increase of the serving grant in every fourth TTI (see also FIG 2).

FIG 9

The progress of the HARQ process is clearly displayed. The red square in the third line shows a faulty transmission in HARQ process 3 (first column). HARQ process 3 is continued in column 7. The new transmission indicator (line 4) shows that this is a retransmission that fails again (line 3). Finally, the green square in column 13 and line 3 shows a successful data transmission. New (payload) data can now be transmitted. The green square in column 19 shows the new transmission indicator set in the next TTI of process 3.

