

# Agilent Technologies

## Testing GPRS Signaling

Product Note



## **Introduction**

General Packet Radio Services (GPRS), is a new technology for GSM networks that will allow GPRS-compatible handsets to transfer data at much higher rates than the current 9.6 or 14.4 kb/s available to GSM handsets. GPRS has been designed to enhance existing GSM networks to provide end-to-end transport of packet based IP data. This technology will effectively make mobile internet access a reality and is seen by many as a stepping stone between 2<sup>nd</sup> Generation (2G) and 3<sup>rd</sup> Generation (3G) networks.

This product note briefly introduces some of the concepts of GPRS technology and how current GSM networks have been updated to provide GPRS. It will then describe how the Agilent Technologies J37908A Opt. 12, GSM/GPRS Signaling Advisor can be used to help test and troubleshoot the installation and maintenance of your GSM/GPRS network.

## **What Does GPRS Do?**

GPRS gives mobile subscribers access to their e-mail, corporate LANs, and even the internet using their mobile telephones. In time GPRS will support access speeds up to 171.2 kb/s, surpassing ISDN access rates. It is well suited to internet access because it gives access to high data rates for short periods at reasonable cost with users billed for the amount of data transferred rather than how long they remain connected.

As GPRS service becomes more popular, new applications will appear to take advantage of the new capabilities available. One such example is highly accurate location-based services that could allow you to search for restaurants within a 1 km radius from your location and even allow you to download a map to help you get there.

## **How Does GPRS Work?**

A GSM network equipped with GPRS can be thought of as a hybrid between circuit-switched technology and packet-switched technology.

Existing GSM network elements utilize circuit-switched technology to transfer information (speech or data) between users. When a call is made a circuit is reserved for the exclusive use of that user, even if all of the available bandwidth is not required, effectively tying up network resources for the duration of the call.

New GPRS network elements use packet-switched technology to transfer data. Packet-switched networks allocate bandwidth in a dynamic way, when required, to transfer data to/from terminal equipment that makes much more efficient use of the available resources. The network elements even have their own IP addresses in the same way current IP routers and servers have. GPRS can also offer asymmetrical transfer rates where the downlink to the mobile has greater bandwidth than the uplink.



The existing GSM network elements and the new GPRS network elements are shown above. The new GPRS network elements each perform a specific function and can be summarized as follows:

**Gateway GPRS Support Node (GGSN)**

Its function is similar to that of the GSM Gateway Mobile Switching Center (GMSC) in that it provides a gateway between the GPRS network and the public PDN or other GPRS networks. It provides authentication and location management functions as well as firewall functions. It also connects to the Home Location Register (HLR) by means of the Gc interface. Another important function is that it counts the number of packets it transmits to give accurate billing.

**Serving GPRS Support Node (SGSN)**

Its function is similar to that of the GSM Mobile Switching Center/ Visitor Location Register (MSC/VLR) in that it controls all aspects of the connection between the network and MS by providing Session Management (SM) and GPRS Mobility Management (GMM) functions such as handovers, paging, attach/detach etc. It also connects to the HLR via the Gr interface, but more importantly it connects to the MSC/VLR via the Gs interface using the Base Station Sub-system Application Part (BSSAP+) protocol. The SGSN also counts the number of packets it routes, again, to provide accurate billing.

**Packet Control Unit (PCU)**

Its functions include... converting the packet data into a format that can be transferred over the air interface; radio resource management; and Quality of Service (QoS) measurements such as throughput, delay, reliability, and priority.

There are also new physical interfaces that connect the GGSN and SGSN to each other and to the existing network elements.

**Gb Interface**

Is a 2.048 Mb/s E1 or 1.553 Mb/s T1 frame relay link that connects the SGSN to the PCU is usually located in the Base Station Sub-system (BSS).

**Gn and Gp Interfaces**

Connect GGSNs and SGSNs to each other. They are IP-based interfaces and most current implementations use Ethernet backbones at 100 base TX rates. European Telecommunications Standards Institute (ETSI) has not specified a particular physical connection for these interfaces so they could use Asynchronous Transfer Mode (ATM) and even optical physical connections if required.

**Gc, Gd, Gf, Gr and Gs Interfaces:**

Are all 2.048 Mb/s E1 interfaces, or 1.553 Mb/s that carry SS7 based protocols.

There are two protocol planes used in GPRS:

- The transmission plane consists of layered protocols that provide user information transfer along with control procedures such as flow control and error correction.
- The signaling plane consists of protocols that support and control the transmission plane functions and is responsible for controlling all aspects of user mobility, network resource allocation, network access connections and provision of supplementary services.

Let us now look at the new signaling and transmission protocols that are of interest to us and can help to troubleshoot and maintain the GPRS network.

If we look at figure 2 we can see that the main job of the network elements and protocols is to transport the Application and IP/X.25 data transparently between the core network and the MS. All of the layers play their part in accomplishing this. We can see some familiar datacom protocols such as IP, UDP, TCP, MAC, SNDCP, LLC, frame relay; and some new ones added specifically for GPRS such as GTP, BSSGP and RLC. Each protocol is given a short description of what it does.

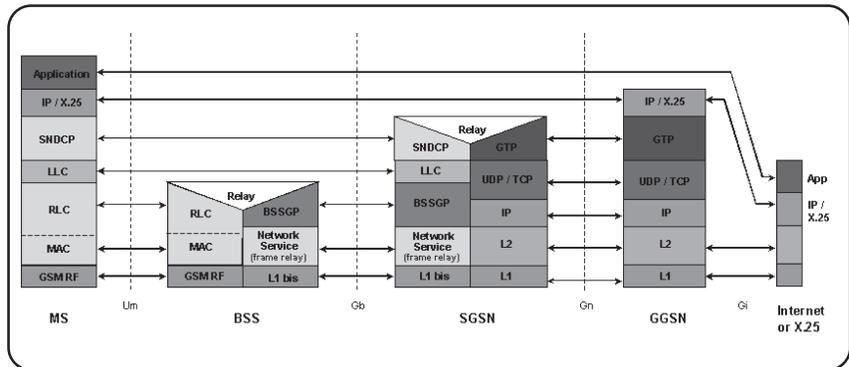


Figure 2. GPRS transmission plane protocols.

**Application**

This is the user data that is being transferred, and it could be HTML, graphics, e-mail or user data.

**IP/X.25**

This is the IP or X.25 information exchanged between the MS and the originating point in the network. For example, the IP address of the web site and MS would be contained here.

**GPRS Tunneling Protocol (GTP)**

As its name suggests, GTP tunnels data, charging details and signaling information between the GPRS Support Nodes (GSNs) in the GPRS backbone network.

**Sub Network Dependent Convergence Protocol (SNDCP)**

Provides multiplexing and data buffering between the MS and SGSN. It also provides data compression and segmentation/re-assembly services to the data carried within it.

**Logical Link Control (LLC)**

Provides a reliable connection between the MS and the SGSN. It provides acknowledged/unacknowledged operation, prioritizes data based on QoS parameters, and ciphering of the higher layer data. LLC operates above the RLC layer so that GPRS can be provided on different radio systems.

**Base Station Subsystem GPRS Protocol (BSSGP)**

Conveys routing and QoS information between the LLC and Network Service (NS) layers. It also allows a number of MSs to share a Gb interface timeslot, passes radio information between the BSS and SGSN, and carries signaling to the MS.

**User Datagram Protocol (UDP)**

Carries Protocol Data Units (PDUs) over the GPRS backbone that require a less reliable connection. Signaling information is usually carried by UDP.

**Transmission Control Protocol (TCP)**

Carries PDUs over the GPRS backbone that require a reliable connection. User data is usually carried by TCP.

**Radio Link Control (RLC)**

Provides a reliable radio link between the MS and BSS. It also performs segmentation/re-assembly to allow packets to be transmitted on the air interface (mm). It also controls the coding schemes used depending on the speed of connection required.

**Medium Access Control (MAC)**

Controls multiple MSs that share a common resource on the GPRS air interface. It does this by informing an MS when it can transmit its data to avoid collision with other MSs sharing the same timeslot.

**Network Service (NS)**

Transports BSSGP PDUs between the BSS and SGSN. It is currently based on frame relay.

Now let us look at the signaling plane in figure 3.

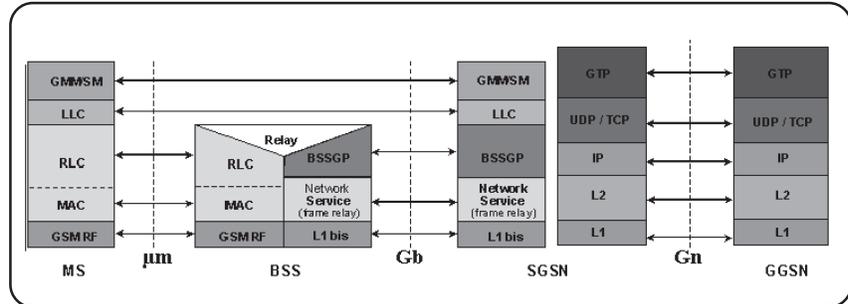


Figure 3. Signaling plane.

We can see that many of the transmission plane protocols are also used in the signaling plane. The additions are GMM and SM.

**GPRS Mobility Management (GMM)**

Is used to control the mobility of the MS within a network and is involved with location updates, handovers, paging, authentication, and attach/detach procedures.

**Session Management (SM)**

Is used to set up and clear down GPRS sessions.

There are also new and modified SS7 based protocols and they are shown in figure 4 below.

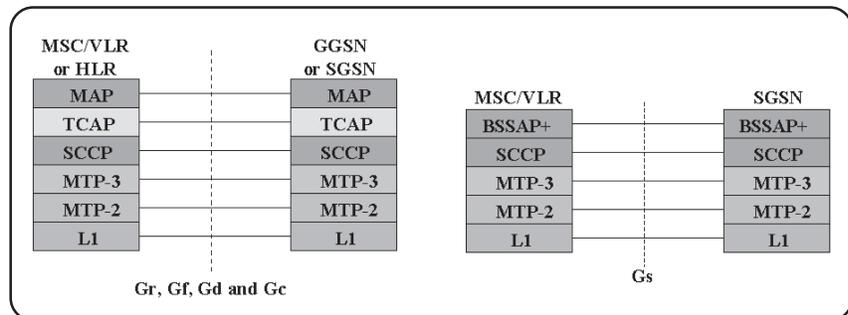


Figure 4. GPRS SS7 protocols.

The standard GSM Mobile Application Part (MAP) has been modified to incorporate the Routing Area (RA) updating procedure, and the new BSSAP+ protocol which controls the GPRS air interface. Both the transmission and signaling planes have to operate in conjunction with each other to ensure smooth and seamless operation to subscribers.

## **How Does a Subscriber Surf the Web?**

As mentioned earlier, a GPRS mobile is always connected to the network when it is switched on and receiving a signal. When the mobile is switched on it attaches itself to the network, and part of the attach procedure is authentication of the mobile and subscriber.

When a user wants to initiate a session they will select the connect option on their mobile and it will connect to their Internet Service Provider (ISP) initiating a PDP Context session. When the session has been initiated the mobile can begin to transfer data, and the subscriber is billed for the amount of data transferred, not how long the session lasts.

## **Testing GPRS**

As GPRS uses two protocol planes (transmission and signaling), both have to be tested. The SS7 and datacom interfaces have to be tested to ensure that correct functionality and acceptable QoS are experienced by subscribers.

Typical testing would include functional tests to ensure that MSs are successfully attaching to the network, that they can initiate PDP context sessions, and that mobility and security functions are all operating correctly.

Also, as resources are shared between voice and data, the effect of capacity restrictions must also be monitored to determine the effect they have on the QoS for both voice and data sessions. Typical QoS measures could be minimum, average and peak throughput; minimum, average and peak error rates; number of unsuccessful sessions/hour and latency of the network.

Much of this testing can be done using test calls – with a protocol analyzer monitoring the appropriate interfaces. It is therefore important to be able, as far as possible, to monitor the SS7 and datacom interfaces simultaneously. It is preferable to use a single instrument to view how efficient data transfer is across the transmission plane, and how control messages (being transferred across the signaling plane) affect the transmission plane.

Listed below are the tools that a protocol analyzer has to help troubleshoot your GPRS network.

### **GSM Call and GPRS Session Trace applications**

These allow you to view the signaling that flows between a single MS, or group of MSs, and the network. This makes pinpointing potential problems with attach procedures, PDP context sessions, handovers, and authentication procedures much quicker. Without call or session trace it would be almost impossible to pick out the useful data to troubleshoot an individual subscriber's problem from the massive amounts of data being transferred.

**Statistical Analysis**

This allows you to monitor the performance of your network by presenting data such as network usage and utilization, the number of successful/unsuccessful sessions, average session times, reject cause counts, and the number of packets transferred by the uplink and downlink. The statistical analysis can be run over a period to help analyze trends and highlight differences between quiet and peak times.

**Protocol Decodes**

These allow you to decode the signaling data to help you determine why certain problems occur. The signaling contains much of the information required to successfully find network problems. The protocol decodes provide you with a way of decoding the complex signaling messages into text for analysis and comparison with the specifications.

When a single instrument is used, tools such as call/session trace, statistical analysis and protocol decodes become significantly more effective for troubleshooting your GPRS service – which means you can roll out the GPRS service sooner and keep it efficient once installed.

## Testing GPRS Using Signaling Advisor

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### Hardware and Software Configuration

The Agilent Technologies Signaling Advisor (with the right software options enabled and hardware installed) can test on both the datacom and SS7 interfaces.

For a Signaling Advisor to be fully equipped to monitor GPRS, the following options and hardware are required:

Product No	Description	Qty
37908A Opt. 012	GSM/GPRS Signaling Advisor software (Includes GPRS SS7 protocols)	1
37908A Opt. 043	GPRS decodes (Includes Gb decodes, statistics and session trace)	1
37907A	Signaling Advisor mainframe	1
E7571A or E7573A	E1 interface for balanced (120 W) connections. E1 interface for unbalanced (75 W) connections.	1
E7578A	Fast Ethernet undercradle (includes Ethernet and GTP decodes and statistics)	1

Either the T1 interface E7571A, E7572A or E7573A is capable of monitoring 2.048 Mb/s , 1.553 Mb/s frame relay links used for the Gb interface.

Older Signaling Advisors may need upgraded to the latest version of software. The earliest version to support GPRS is NA.1.12.36. To discover which version your instrument is equipped with, click on “Help” then “About” in any Signaling Advisor screen. If the version you have is earlier than NA.1.12.36 then please contact your local Agilent representative to obtain an upgrade.

## Configuring Signaling Advisor to monitor Gb and SS7

Configuring Signaling Advisor is very quick and simple. Where you need to monitor the SS7 interfaces, simply connect the physical interfaces and run the automatic configuration tool. It will detect which timeslots are carrying signaling and it will also assign the correct protocol stack. For details on how to automatically configure the Signaling Advisor please consult the instrument's on-line help screens.

Connecting to a Gb interface is also quick and simple, although the automatic configuration does not support frame relay. Go to the link view screen from the configuration utility and select the relevant line termination options and choose how much of the 2.048 Mb/s, 1.553 Mb/s capacity is to be allocated for frame relay. Figure 5 below shows a typical frame relay configuration.

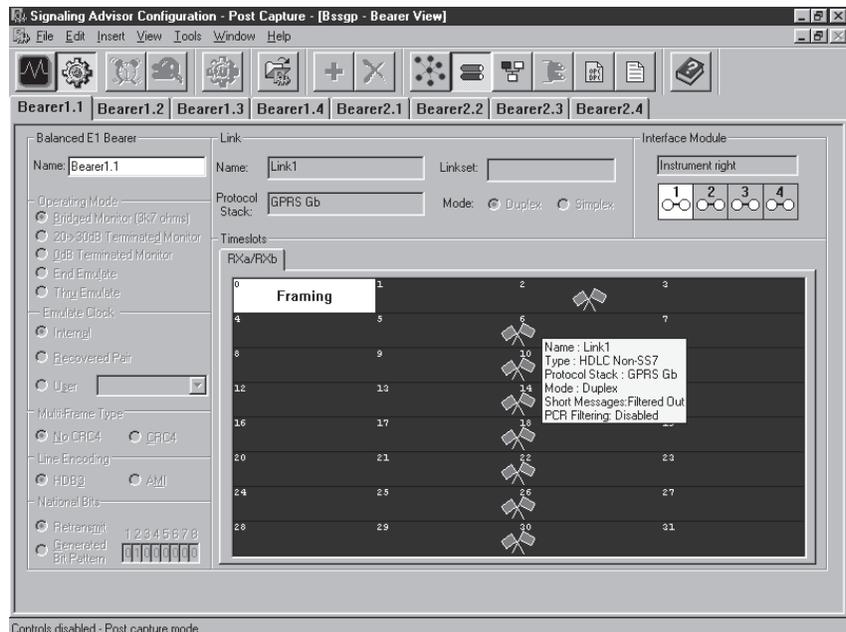


Figure 5. Typical frame relay configuration

## Monitoring Gb and SS7 Interfaces

Once configured you can start monitoring the connected interfaces simultaneously. If you have connected to a Gb and a SS7 link, both decodes will be shown in the monitor window.

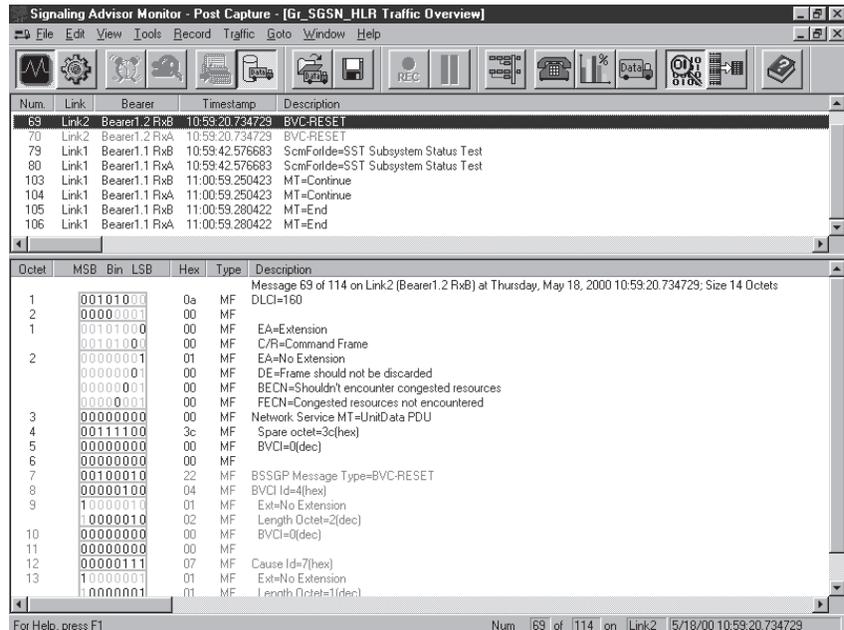


Figure 6. SS7 and Gb traffic.

Figure 6 shows a screen that contains both SS7 and Gb traffic. The top part is showing a single line summary of each packet or message captured on all of the configured interfaces. The bottom half of the screen shows the highlighted message in the summary view decoded to text. Each relevant octet (byte) or bit within an octet is given a description to help troubleshoot errors in the protocol.

Any captured message that has an error or does not conform to the specification can be highlighted in red in the summary view. If a highlighted message is decoded then the octet(s) that contain errored bits are also highlighted in red to aid quick troubleshooting.

Decoding of signaling messages is a very effective method of fault finding because they contain all of the data you need to find out what's happening.

For example, if a subscriber is experiencing problems, such as being unable to connect to their Internet Service Provider (ISP) they will complain to their GSM operator. The fault could be in many places, such as the MS itself, the subscription information contained in the HLR, a transmission fault, or a fault in the internet outside the GSM operator's network. Without access to the signaling messages it would be very difficult to pinpoint where the fault is. If you can't find the cause of a problem then you can't fix it.

The tools built into the Signaling Advisor give you the capability to pinpoint fault locations and by decoding the signaling messages to analyze the data you can quickly find where the fault is being generated and even what the cause is. You can then take steps to rectify the problem and use the Signaling Advisor to verify that the action you've taken has rectified the problem.

## Fault Analysis Using Signaling Advisor

The main tools used in fault analysis are call/session trace and triggers and filters.

The call/session trace utility gives you the ability to view the signaling messages that relate to a single subscriber, a group of subscribers, or even just the unsuccessful sessions.

By entering search criteria you can quickly zoom into the signaling messages that you are interested in from the many thousand sent every second.

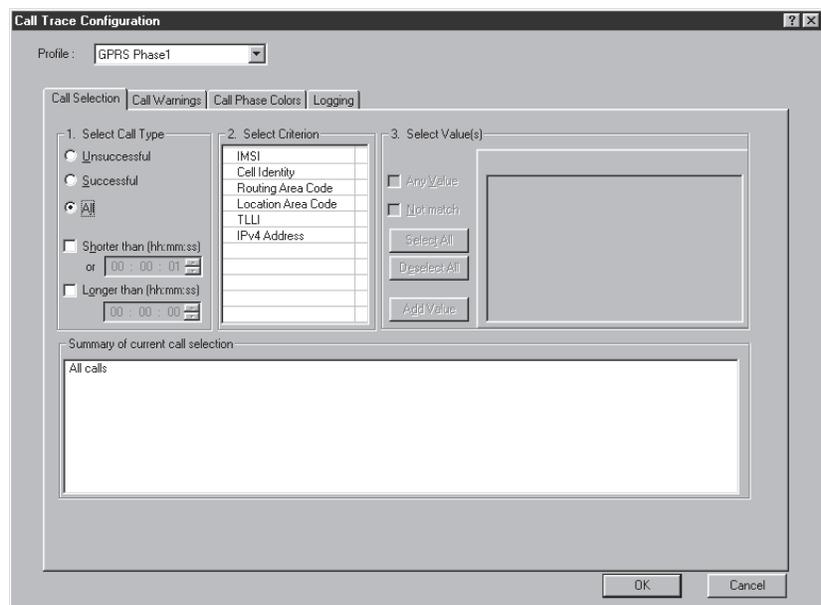


Figure 7. Gb session trace configuration screen

The search criteria required to pinpoint problems can be to trace all unsuccessful sessions to/from a certain International Mobile Subscriber Identity (IMSI) or group of IMSIs. More than one criterion can be chosen.

For example you can choose to trace all unsuccessful calls to/from a certain IMSI. The criteria in each pane are logically AND'd together and multiple values entered in pane 3 are logically OR'd with each other.

Once the criteria have been selected you can then perform the session trace either on data captured from the links in real-time mode or data captured earlier in post-capture mode.

Multiple session traces can be running simultaneously if required.

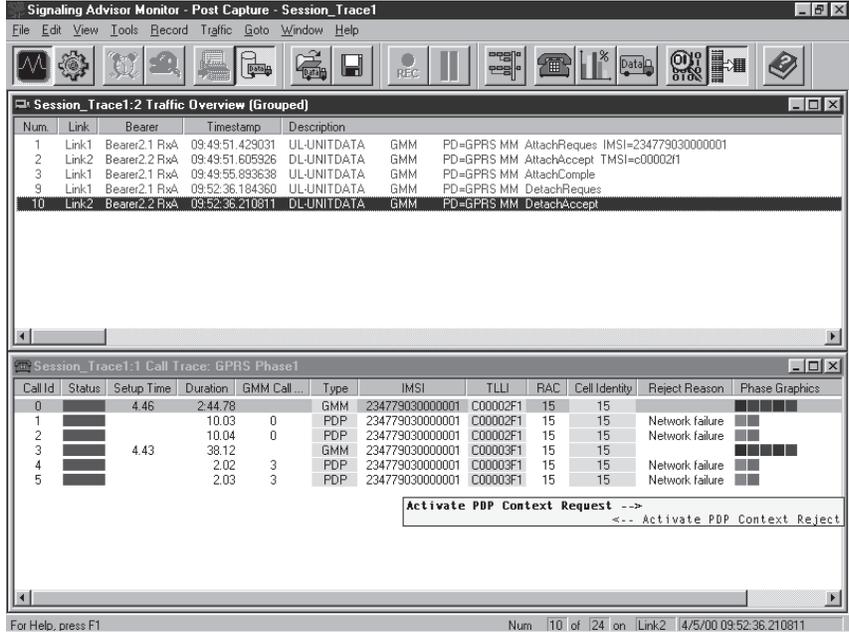


Figure 8. Typical session trace screen

In the example above, using captured data, the bottom part is the session trace view which shows a single line for each session encountered. The single line displays information such as duration, IMSI, reject reason and the phase graphics. The phase graphics help you see the state of each session if there are a large number shown on the screen.

Where the last graphic of a sequence line is red, this indicates a failure has been encountered. In the screen above, the PDP Context Requests all failed. The reason for the reject is also displayed.

A ToolTip is also available to show each message type encountered in the sequence.

The information shown in the session trace view can be changed by right clicking anywhere in that view to bring up a dialog box. You can then choose to display or hide information such as TLLI, IPv4 address, IMSI and other parameters. You can also re-configure the session trace provided that capture has stopped.

The upper part of the screen shows a summary view of the individual signaling messages. By double clicking on a session of interest in the session trace view then the upper part will change to show only the signaling messages for that session.

For example, figure 9 below shows how the screen would look if we selected the last session from the previous diagram.

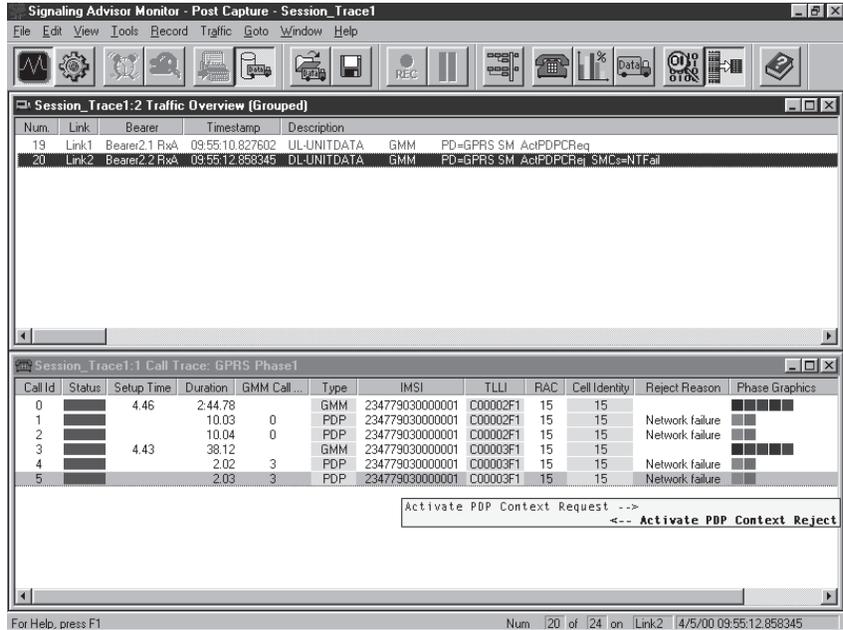


Figure 9. Typical session trace screen (continued).

The summary of each signaling message is shown and can now be decoded to text if required.

Therefore, using the call/session trace tool is an extremely effective method of viewing the data that you need to solve problems quickly and efficiently.

In addition to the call/session trace application, the Signaling Advisor also has extensive triggering and filtering capabilities to help reduce the amount of data captured, or to begin/end capture on certain events. There are two types of filter available: Logging filters that limit what is saved to the logging buffer, and view filters that limit the data displayed on the screen.

Triggers and filters can be used in conjunction with each other or with applications such as statistics and call/session traces.

The triggers and logging filters are configured from the measurement setup screen and the view filters can be configured from either measurement setup or monitor screens.

## Statistical Analysis of Gb Interface

Statistical analysis can give you an insight into how your network is operating and, if it is ran over a whole day, can give you a comparison between busy periods and quiet periods.

One of the issues that GPRS may face is that subscribers sign a contract which guarantees them a minimum data rate and QoS. The subscribers have no way of testing whether or not they are getting the guaranteed rate or not, and if they perceive that their service is slow they may well complain to the operator.

The Signaling Advisor's graphical statistic application is unique because it can take in the results from a session trace and produce statistics for only those results. This means that a single subscriber's service can be very easily investigated.

One measure for determining data throughput experienced by subscribers is to count the number of packets and octets transferred over the uplink and downlink to a specific mobile.

Figure 10 shows the data transferred over the air interface as seen from the Gb interface.

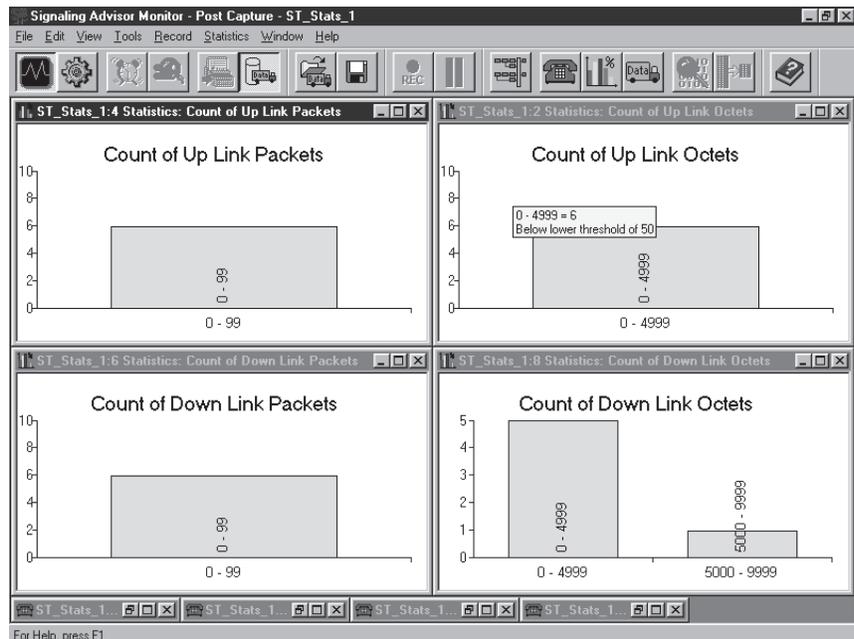


Figure 10.

As the statistics use data from session trace, the measurement can be very easily changed to be one for a single subscriber to a group of subscribers or even how much data is transferred by a whole cell. The Signaling Advisor is the only product to give you this level of flexibility.

The statistics also include other QoS measures such as a count of the number of successful/unsuccessful sessions monitored, the PDP context activation time, a count of PDP context reject causes, and many other useful measurements.

Statistical analysis is an effective method for viewing trends and general health of your GPRS network. It is especially effective when combined with the call/session trace application and the triggering and filtering capabilities of the Signaling Advisor.

## **Testing GPRS Ethernet Interfaces**

The main connection between the SGSNs and GGSNs is currently based on Ethernet technology with 100 base Tx data rates.

To connect to this interface the Signaling Advisor utilizes the Fast Ethernet undercradle and the Agilent Advisor software application from the Agilent Advisor. By combining the Signaling Advisor and the Agilent Advisor applications in a single instrument Agilent Technologies has provided an effective and flexible tool to help you test your GPRS service. However, since they are two separate applications Agilent does not guarantee that both will operate error free under all conditions when run simultaneously.

These Agilent Advisor capabilities allow you to decode the GTP protocol that is used to transfer data between SGSNs and GGSNs in addition to the in-built Ethernet test applications such as on-line statistics.

Double clicking on the icon on the Windows® desktop starts the Agilent Advisor application. Configuration of the hardware is simple and both the line speed and line mode can be detected by the Auto-Negotiation application.

Once configured, monitoring the GTP protocol is started by clicking on data display and start icons. The screen shows a single line summary and a detailed view of the captured data. If required a hex view of the data is also available.

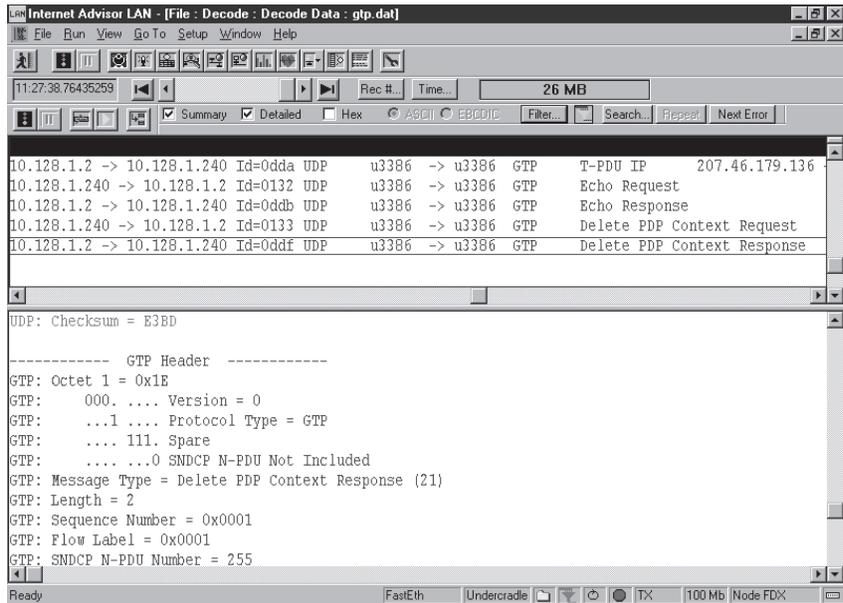


Figure 11. Typical Internet Advisor GTP data view

The data can be filtered by protocol such as IP or HTTP and by the IP addresses of either the terminal equipment or network elements. You can also search the file for specific messages using the built-in search filters.

Figure12 shows an IP filter in the process of being defined.

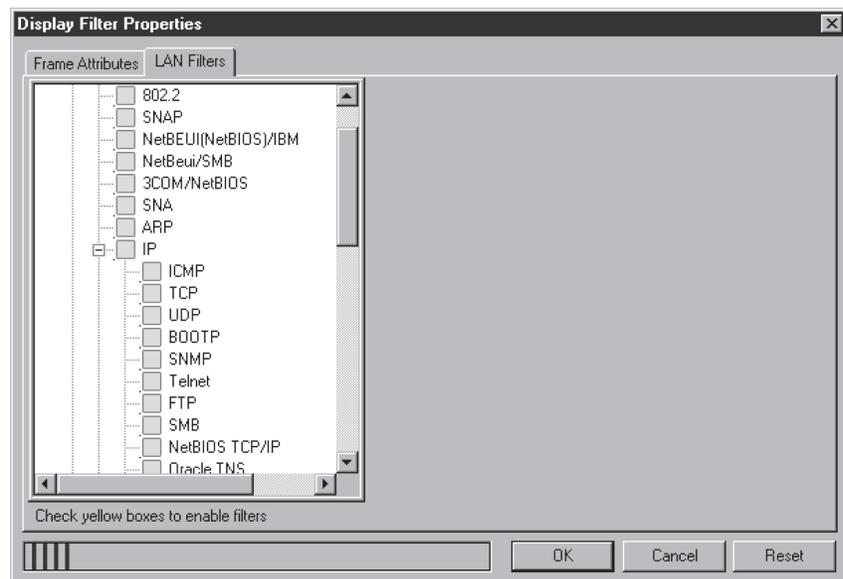


Figure 12.

## Summary

GPRS adds a new level of complexity to existing GSM networks and opens up the prospect of a large number of new value added applications that were unable to be supported only a short time ago. This added complexity has made the difficult task of maintaining existing services and rolling out new ones even more challenging.

However, with the right tools it is possible to successfully test this new technology and help provide superior quality to your subscribers.

The GSM/GPRS Signaling Advisor is the tool that provides you with the capability to test your GPRS implementation from the Gb interface all the way to the GGSN using a single instrument. It provides an effective set of applications such as a unique session trace and unique real-time graphical statistics that can be connected to the output of triggers/filters and session trace.

These capabilities make the Signaling Advisor the most effective GPRS test tool currently available to you today.

## GPRS Glossary

### GPRS Terms and Abbreviations

mm	Air interface
ACK	Acknowledge
APN	Access Point Name
ATM	Asynchronous Transfer Mode
AuC	Authentication Center
BSS	Base Station Sub-System
BSSGP	Base Station Sub-System GPRS Protocol
BTS	Base Transceiver Station
BVC	BSSGP Virtual Connection
BVCI	BSSGP Virtual Connection Identifier
DHCP	Dynamic Host Configuration Protocol
DISC	Disconnect
DNS	Domain Name Server
DRX	Discontinuous Reception
EDGE	Enhanced Data Rates for GSM Evolution
EIR	Equipment Identity Register
ETSI	European Telecommunications Standards Institute
FCS	Frame Check Sequence
FRBS	Frame Relay Bearer Service
FTP	File Transfer Protocol
Gb	BSS (PCU) to SGSN connection
GGSN	Gateway GPRS Support Node
Gi	External reference point for connecting via TCP/IP or X.25
GMM	GPRS Mobility Management
GMSC	Gateway Mobile Switching Center
GMSK	Gaussian Minimum Shift Keying
Gn	GSN backbone network
Gp	PLMN to PLMN connection
GPRS	General Packet Radio Service
Gr	SGSN to HLR connection
Gs	SGSN to MSC/VLR connection
GSM	Global System for Mobile Communications
GSN	GPRS Support Node
GTP	GPRS Tunneling Protocol
HLR	Home Location Register
HTML	Hyper Text Markup Language
HTTP	Hyper Text Transfer Protocol
IANA	Internet Assigned Number Authority
IETF	Internet Engineering Task Force
IMEI	International Mobile Equipment Identity
IMSI	International mobile Subscriber Identity
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
ISP	Internet Service Provider
ITR	Information Transfer Rate
LA	Location Area
LAC	Location Area Code
LAI	Location Area Identity
LAN	Local Area Network

LLC	Logical Link Control
MAC	Medium Access Control
MAP	Mobile Application Part
MM	Mobility Management
MS	Mobile Station
MSC	Mobile Switching Center
NS	Network Service
NSAPI	Network Service Access Point Identifier
OSI	Open System Interconnection
PCU	Packet Control Unit
PDN	Packet Data Network
PDP	Packet Data Protocol
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
PSTN	Public Switched Telephone Network
P-TMSI	Packet Temporary Mobile Subscriber Identity
PVC	Permanent Virtual Circuit
QoS	Quality of Service
RA	Routing Area
RAC	Routing Area Code
RAI	Routing Area Identity
RF	Radio Frequency
RLC	Radio Link Control
SAPI	Service Access Point Identifier
SGSN	Serving GPRS Support Node
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
SNDCP	Sub-Network Dependent Convergence Protocol
TCP	Transmission Control Protocol
TE	Terminal Equipment
TID	Tunnel Identifier
TLLI	Temporary Logical Link Identifier
TMSI	Temporary Mobile Subscriber Identity
TS	Time Slot
UDP	User Datagram Protocol
UNI	User Network Interface
VLR	Visitors Location Register
WAP	Wireless Application Protocol
WML	Wireless Markup Language
WWW	World Wide Web

**Notes** \_\_\_\_\_

## **Agilent Technologies' Test and Measurement Support, Services, and Assistance**

Agilent Technologies aims to maximize the value you receive, while minimizing your risk and problems. We strive to ensure that you get the test and measurement capabilities you paid for and obtain the support you need. Our extensive support resources and services can help you choose the right Agilent products for your applications and apply them successfully. Every instrument and system we sell has a global warranty. Support is available for at least five years beyond the production life of the product. Two concepts underlie Agilent's overall support policy: "Our Promise" and "Your Advantage."

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Printed in U.S.A. May 20, 2002



5988-0304EN

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