Testing the UMTS Iu Interface

COMPUTING TELECOM VIDEO

Protocol Testing in the 3G Wireless Network

This application note describes protocol tests for the UMTS Iu interface between the Radio Network Controller (RNC) and the Core Network (CN). It is the first in a series of documents on third-generation (3G) wireless networks. Each note addresses one of the new network interfaces and provides guidelines for equipment designers, manufacturers, operators and maintenance personnel to meet the measurement challenges with testing solutions. Examples are given in this document for testing:

- Messaging and procedures on the Radio Access Network (RANAP)
- Mobile Radio Interface Layer 3 (CC/MM/GPRS MM/GPRS SM)
- Traffic channel signaling (AAL2 layer3)
- Tunneling (GTP-U).

Due to space limitations, only brief descriptions are presented here. Complete detailed information needed to perform these and other tests can be found in the user handbooks for the K1297 and K1205 Protocol Testers and in other training materials. Please contact Tektronix sales support to obtain the most recent information.

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1. Introduction – The Iu Interface and Protocols

This document describes test applications for the Iu interface as it was defined by 3GPP at the end of 1999 (UMTS Rel. '99). Change requests have been introduced and new features have been proposed every three months since that definition was adopted, so it is possible that there will be revisions in more recent releases of the standard.

The Iu interface is defined in the 3GPP document series TS25.410-419. Iu is subdivided into two different interfaces: Iu-CS for the circuit switched domain and Iu-PS for the packet switched domain. Figures 1 and 2 show the protocol stacks for each of the Iu interfaces.

The protocols can be grouped according to their usage into:

- transport protocols for control plane
- transport protocols for user plane
- control protocols for call, session, mobility management
- protocols for user traffic

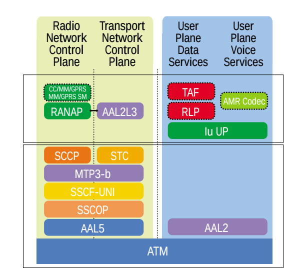


Figure 1: *Iu-CS protocol stack*

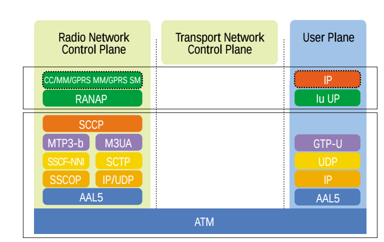


Figure 2: *Iu-PS protocol stacks*

All traffic over the Iu interface uses the Asynchronous Transfer Mode (ATM) as the physical transport technology, regardless of the data source. As a result, all data will be segmented into 53-byte ATM-cells and transported asynchronously.

1.1. Transport Protocols for the Control Plane

Transport protocols for the control plane consist of the SSCS signaling protocols (SSCOP and SSCF) as they are used in broadband networks to ensure the signaling links between network nodes with numbered datagrams. Loss of signaling messages can be detected and retransmitted. SCCP is used to setup specific connections for the different control signaling protocols, enabling both connectionless and connection-oriented communications. Iu normally uses the connection-oriented mode.

MTP3b handles the routing and traffic management function for upper layer protocols. It delivers messages to the destination point and manages the load sharing mechanism for the operation. MTP3b is responsible for routing messages within a network with one operator; SCCP routes messages beyond the board of an operator. While the connections between the RNC and Core Network nodes are shown here as point-to-point, these connections could also be incumbent networks consisting of several interim nodes.

The most logical approach for Iu-PS would be to use the IP protocol stack to transport the control signaling information. For this reason, the Internet Engineering Task Force (IETF) has proposed to replace SSCS and MTP3b with M3UA and SCTP protocols on top of UDP/IP. Since this protocol stack is still under development, there are no application tests for it in this release of the note.

1.2. Transport Protocols for the User Plane

All signaling traffic for the control plane at the Iu interface is based on AAL type 5. Signaling messages are packet data with variable lengths. However, transport protocols for the user plane use both AAL5 and AAL2 (AAL5 for packet data, AAL2 for circuit-switched transmission).

For circuit switched data, the Iu User Plane (Iu-UP) protocol is used to initialize and control the connection Rate Control, Time Alignment and Handling of Error Events in accordance with the requested QoS parameters. Circuit switched data are usually real time transmissions such as voice or video streams.

Packet data are transported using GTP-U, UDP and IP protocols in the packet switched domain of the network. In this domain, the Iu-UP protocol is in transparent mode and the GTP-U portion of the GTP protocol is responsible for the data transmission. RANAP controls the GTP-U channels – each GTP-U tunnel refers to a single mobile user identified by the tunneling ID. The QoS parameter can be assigned to the GTP-U tunnel. IP is used to address the GTP-U entity. Only four GTP messages are used to ensure data traffic.

1.3. Control Protocols for Call, Session and Mobility Management

Control protocols for circuit-switched transmission are AAL2 layer 3, mobile radio interface layer 3 (CC/MM/GPRS MM/GPRS SM). The mobile radio interface layer 3 represents the highest layer control function. It handles the communication between core network and mobile handsets and determines Handover, Location Update, Authentication and Call Handling.

RANAP carries out transmission activities based on the control decisions. For example, RANAP manages the Radio Access Bearer (RAB), which can be seen as a logical connection over the Iu interface related to a specific mobile user. RANAP initiates, modifies and releases RAB. However, the control of the real physical connection is done by AAL2 layer 3, which is used to setup, maintain and release user channels for the circuit switched domain. AAL2 layer 3 also handles the layer management function, which takes care of the transport layer itself.

1.4. Protocols for User Traffic

User traffic protocols are embedded in Codec for voice (AMR) and IP for packet data. Codec is usually not addressed in protocol testing. TAF and RLP are used to support data applications within the circuit switched domain (Fax) in order to ensure compatibility with the existing network. IP incorporates hundreds protocols used in the Internet and computer world.

2. Measurement Challenges and Solutions

2.1. Selecting the Approach – Monitoring, Simulation, Emulation, Conformance

Nearly all measurement situations can be considered in three categories with related approaches. Even though there are situations where two or more approaches could be applied to the same interface, the first steps in protocol testing should always be to determine the characteristics of the system under test and the test objectives.

→Do you have a living network that you should not, or are not, allowed to influence?

Use the non-intrusive *Monitoring* approach

→Do you have a 'dead' node or system that needs to be externally stimulated?

Use the *Simulation/Emulation* approach.

→Do you need to verify compatibility with standards or with other equipment?

Use the *Conformance* approach

2.1.1. Monitoring

Monitoring is the process of collecting data from the interface using either the K1205, a pure monitoring device, or the K1297, which can also perform simulation and emulation. The major objectives for monitoring are:

- to get an overall view of the actual performance level
- to determine a possible need for an improvement
- to discover the differences between specified/ predicted characteristics
- to improve predictions of behavior and potential problems

Interface monitoring can collect data and present results in the following way:

- data review for evaluation: The storage of measured data for subsequent review and analysis. The amount of data is normally reduced through the filtering of specified events (such as abnormal call termination), the use of statistical methods or the selection of specific conditions (tracing data at a defined address, tracing a call set-up, etc.).

2.1.2. Simulation

Simulation is the representation or imitation of a process or system by another device. In a test environment, a simulator can be used in place of a network element or a part of the network to produce desired conditions. For instance, when testing an RNC, the test equipment can simulate the Core Network behavior, keeping the RNC independent of the network. Simulators are used:

- To get information about the dependability of a network element (NE). Normal and abnormal situations are specified and simulated, and the NE's ability to cope with the simulated environment allows the operator to predict how well the NE will perform in the field. Simulations are also used for conformance testing where standardized conditions are applied to the NE.
- To substitute missing network elements or parts of a network during the development process. Simulation creates a realistic operating environment for the item under development.
- To save development and installation costs. The strong and weak points of an item can be discovered in the development process, before introducing it to an operating network.

2.1.3. Emulation

Emulation is a higher form of simulation where the behaviors of selected layers of communication protocols are simulated automatically and in conformance with standards. For instance, the simulation of the Iu RANAP is based on an emulation of the corresponding lower layers. While the lower layers are defined to act as specified, the simulated layer can be used to deliberately add faults to test an element's ability to handle them.

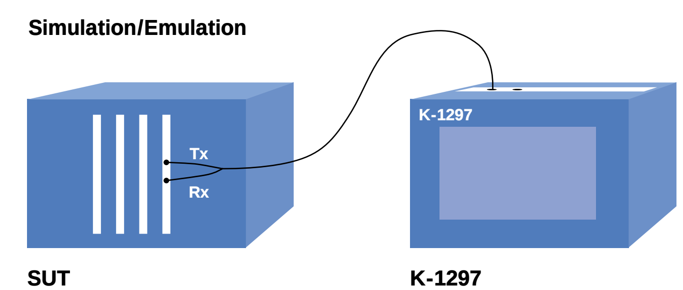
2.1.4. Conformance Testing

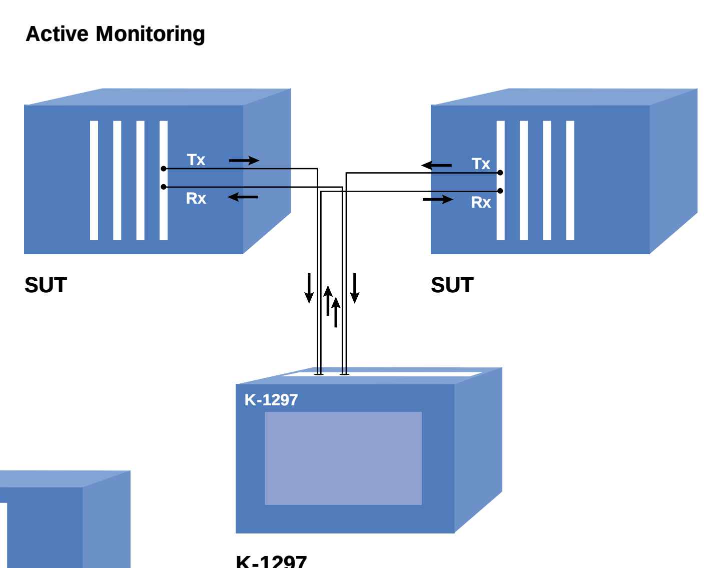
Standards allow different manufacturers to develop systems which can interoperate and exchange and handle information. A system or an implementation is declared conformant when its capabilities and external behavior meet those defined in the referenced standards. Conformance testing is the verification process that determines whether a system or an implementation is conformant. While specific conformance tests are defined in UMTS for the air interface (see 3G TS 34.xxx), conformance tests of the remaining UTRAN interfaces are still dependent upon mutual agreement between manufacturers, operators, and measurement suppliers.

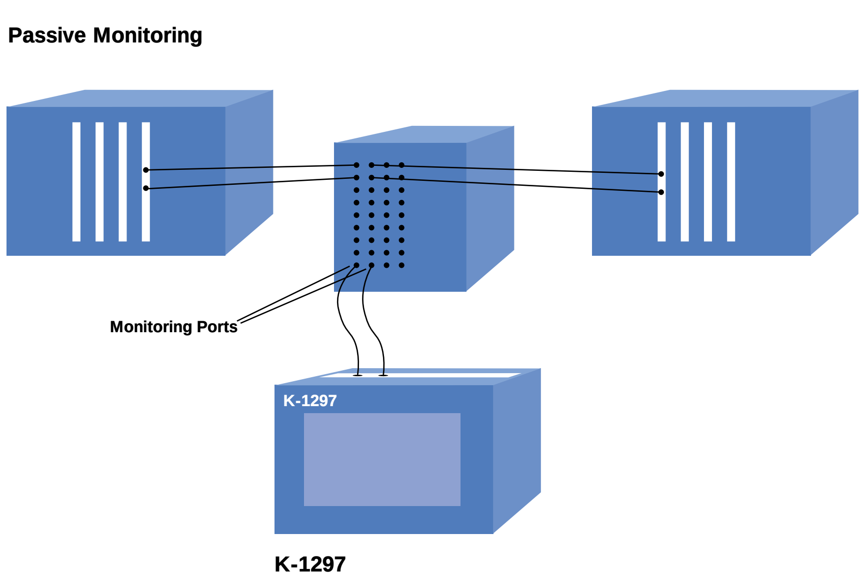
Note: For *Monitoring* applications, you may proceed to capturing and analyzing data after you have completed the hardware portion of the tester configuration (Step 2.2.2).

2.2. Configuring the Test Equipment

Figure 3 shows two diagrams that illustrate how to connect the K1297 with the system under test (SUT).





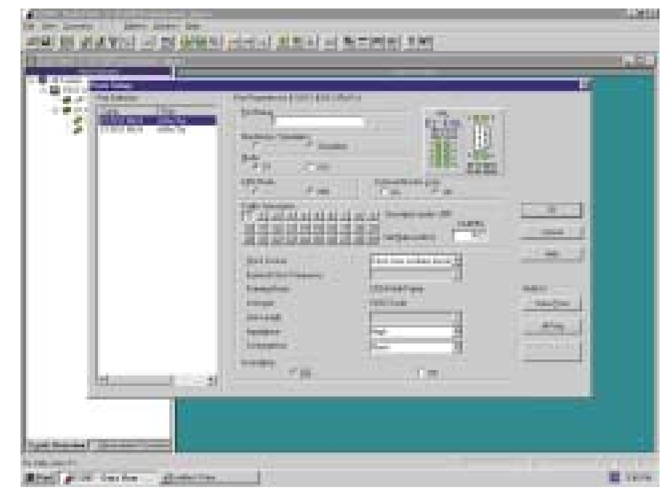


▶ ***Figure 3:*** *Connecting the K1297 with the system under test (SUT).*

2.2.1. Hardware Connection Issues

Securing the proper cables is often a major issue for connecting to the SUT. There are many different connectors and cables that it is nearly impossible to predict what you will need in advance. To be on the safe side, you should assume that none of the standard cables delivered with the test equipment is the proper one and check to see that you have the necessary adapters to suit each SUT. Adapters for STM1 optical interfaces are provided with the K1297 to overcome the problem for those connections.

Another issue is the mode of operation (single- or multi-mode). Even though the K1297 interface boards can handle both modes, the receiver of the system under test could be overpowered if it were operated in multi-mode. Power reduction should be inserted to ensure a stable multi-mode connection.



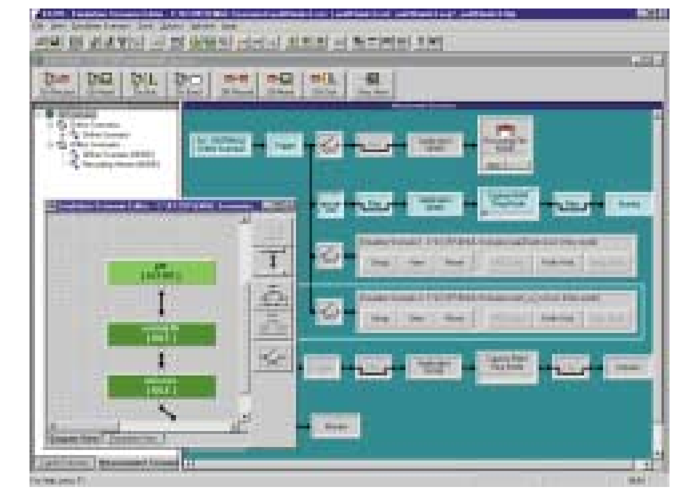
▶ ***Figure 4:*** *Dialog box for physical interface*

▶ ***Figure 5:*** *LDS settings for the ATM link*

2.2.2. Setting the Operating Parameters

Once the equipment is physically connected, parameters for the fiber or electrical connections must be set to conform to the SUT. Figure 4 shows an example of the parameter windows where values and options are selected. To view this window, select "Cards Overview" in the main dialog box of the K1297. Detailed descriptions of the parameters are included in the user manual.

The most important settings are the "VPI," *virtual path id*, and "VCI," *virtual channel id*, which are used to address the connections for



▶ ***Figure 6:*** *Simulation pipeline and Emulations Scenario Editor*

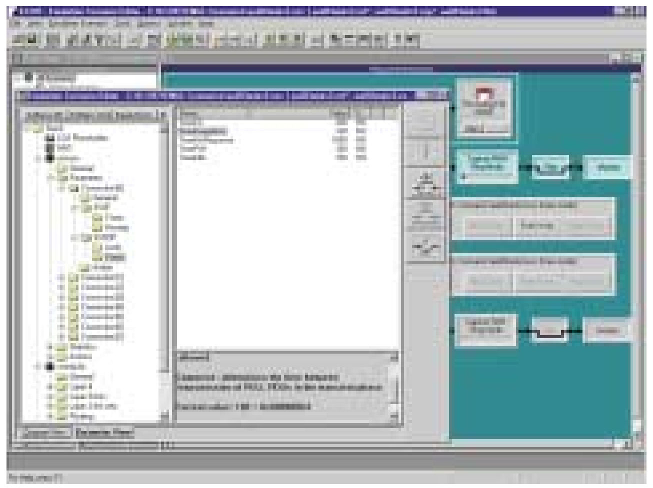
the digital data. Thousands of virtual connections can exist in a single ATM physical connection, so it is critical to know the VPI/VCI in order to configure the correct logical links between the test instrument and the lower layer. Figure 5 shows the window for configuring the VPI and VCI. This window also allows the assignment of a protocol stack to each of the logical links. The "*Browse*" function enables the selection of predefined protocol stacks for this purpose.

The hardware configuration is now completed, and *Monitoring* applications can be started.

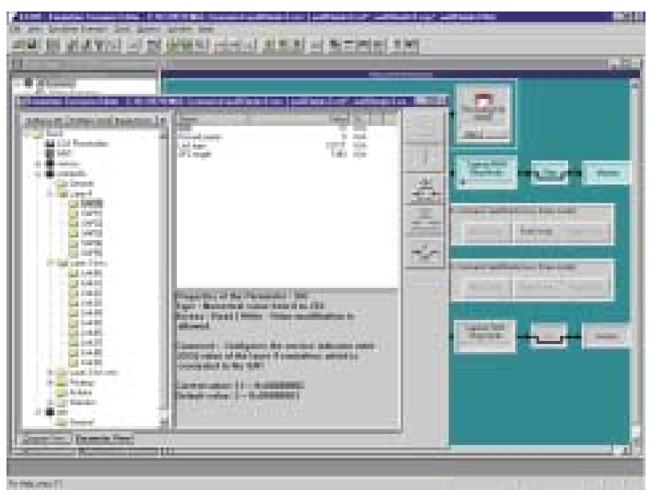
2.2.3. Defining Protocol Stacks

For *Simulation/Emulation* applications, the first step is to create a simulation pipeline. A protocol emulation stack can be defined for each of the pipelines using the "*Emulation Scenario Editor*" (Figure 6). The emulation protocols are stacked together by logically connecting the upper-layer and lower-layer service access points to represent the protocol instances for each communication connection.

"*Logical Data Source*" (LDS) represents the configured physical links which can be connected to the upper layer protocols. In the example shown in Figure 6 two protocol emulations are selected and connected, NNISSCS and NNIMTP3b. NNISSCS emulates the



▶ ***Figure 7:*** *Parameters of the SSCP emulation*

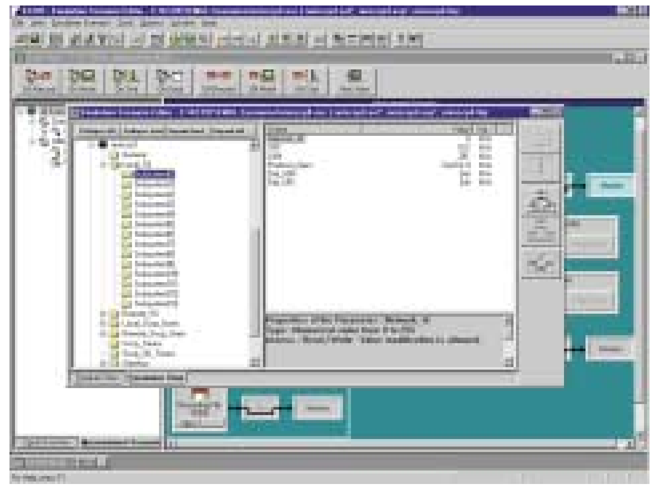


▶ ***Figure 8:*** *Parameters of the MTP3b*

Service Specific Convergence Sublayer for the Network-Node-Interface, while NNIMTP3b is the broadband MTP layer 3. These emulations contain the AAL2 layer 3 protocol information.

2.2.4. Defining Emulation Parameters

Parameters for configuring the protocol emulations are listed in the "Parameter View" for each protocol. Most protocol test functions are delivered with pre-configured emulation (Figure 9).



▶ ***Figure 9:*** *Parameters of the SSCOP emulation*

Timers need to be defined for SSCS (SSCOP/SSCF) in order to specify the quality of the SSCOP service that is provided to the upper layers. For example, the timer for keeping the connection alive addresses a critical issue when configuring SSCS for Proving.

Defining routing information, such as DPC, OPC and link set, configures MTP3b and provides the signaling information to destinations in the network. SIO values are needed to forward the messages to the upper service access points (SAPs), so an SIO value must be defined for each SAP depending on the expected upper layer protocols (Figure 8). A destination point code (DPC) must be named for each of the MTP3b links. The length of the DPC and OPC is defined with 14 bits, except in North America where 24 bits are defined.

Signaling Connection Control Part (SCCP) ensures the connection for signaling protocol, especially for messages accessing the database beyond the board of an operator (for global title translation). SCCP emulation provides both connection-oriented and connectionless services and operates on a database of subsystems and users.

Before SCCP can be put into operation, parameters for supported subsystems and users must be defined. In order to test RANAP, for example, we need to set the subsystem number (SSN) to 142 (Figure 7). Once these protocols are configured for use, Mobile Network control protocols can be put on top of this protocol stack

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and tested.

Detailed descriptions of each of the emulations can be found in the directory c:\K1297\hlp. Please refer to these files to configure the emulations completely and accurately.

2.3. Testing AAL2 layer 3

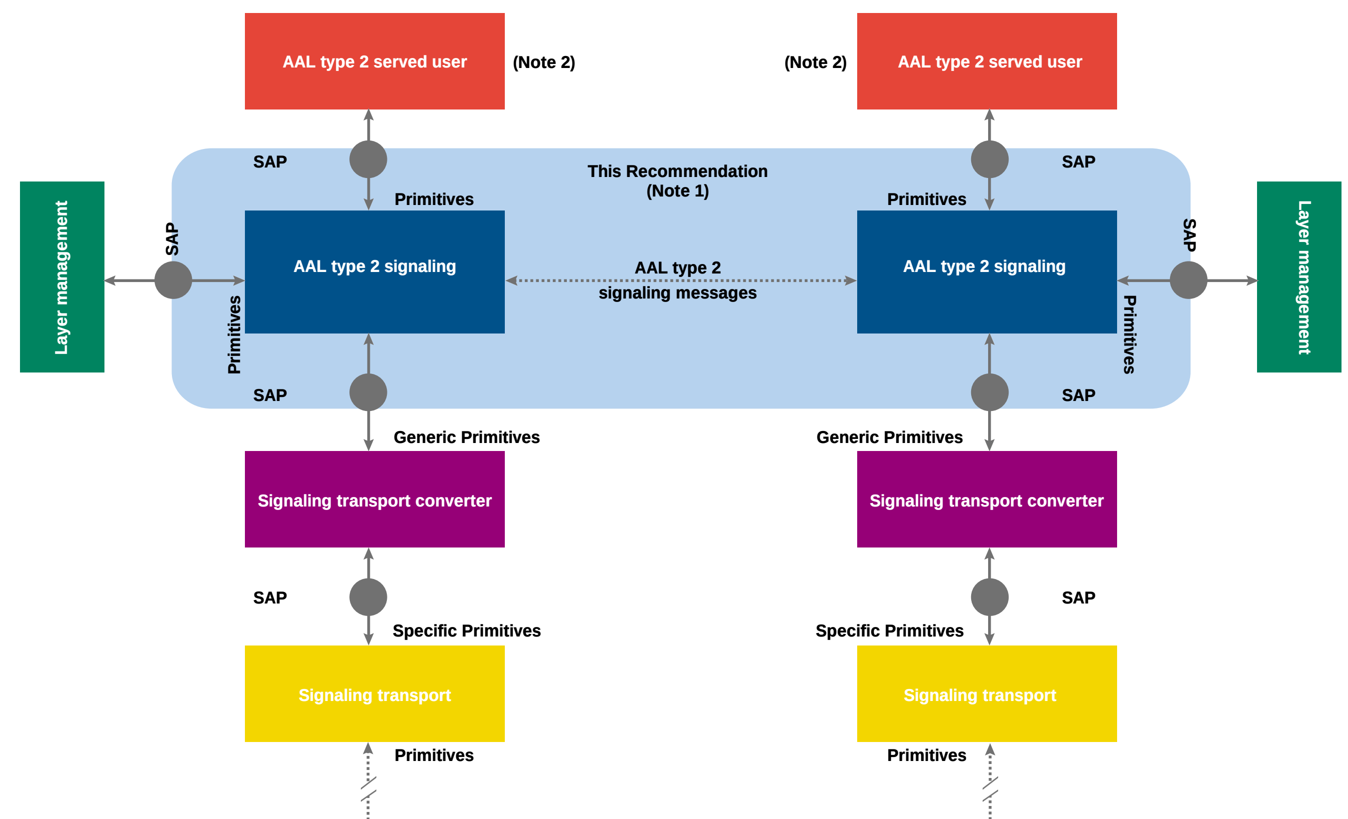
This section describes guidelines for AAL2 layer 3 *Simulation/Emulation*. This protocol layer is responsible for signaling traffic channels on behalf of users such as RANAP. Figure 11 shows the logical structure of AAL2 layer 3 protocol.

The Access Link Control Application Part (ALCAP) consists of three parts: Layer Management, AAL type 2 Signaling, and Signaling Transport Converter (STC). STC converts the AAL2 layer3 messages or primitives into specific primitives according to the signaling transport in use, as defined in Q.2150.1 and Q.2150.2. This can be the MTP3b for the Iu and Iur interfaces, or the SSCS for the Iub interface.

Depending on test objectives, the K1297 provides either *Simulation or Emulation* for AAL2 layer 3. The following sections provide guidelines for each approach.

2.3.1. Simulation of AAL2 layer 3

The K1297 provides a "*Message Building System*" to compose correct and incorrect messages and a "*Message Sequence Chart*" to describe test sequences graphically. A predefined configuration set for AAL2 layer 3 *Simulation* can be loaded by selecting "*c:\k1297\umtsaal2l3.s.*" This configuration is designed to provide an environment for back-to-back testing.



▶ ***Figure 10:*** *Protocol structure of AAL2 layer 3*

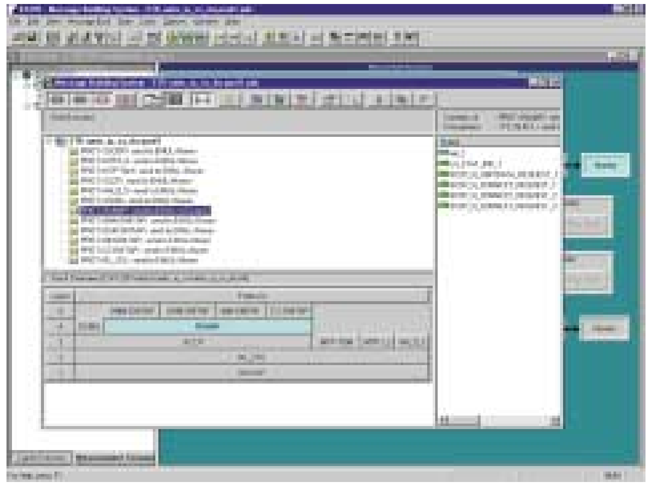


Figure 11: *Protocols in STK-umts_iu_cs-pool1.pdc*

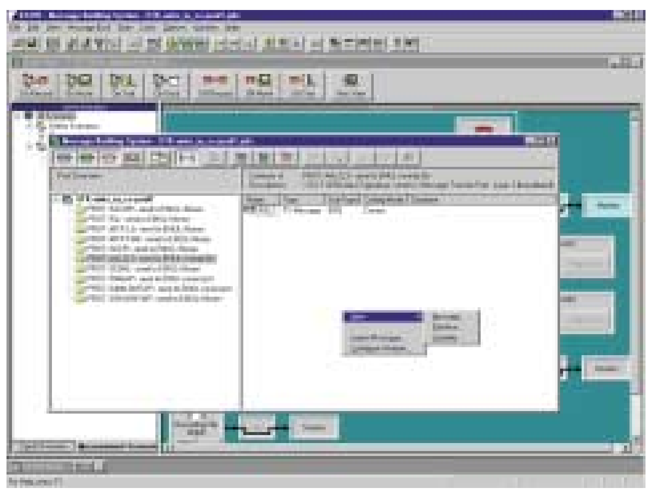


Figure 12: *Messages and primitives*

You can either open an existing message pool or create a new one. During the creation of a new message pool one appropriate protocol stack must be selected and linked with the pool. Figure 11 illustrates the protocols created in a message pool labeled "*STK-umts_iu_cs-pool1.pdc*".

In order to create new messages and new primitives, the underlying emulation must be connected to the protocol by defining the property of the protocol (Figure 12).

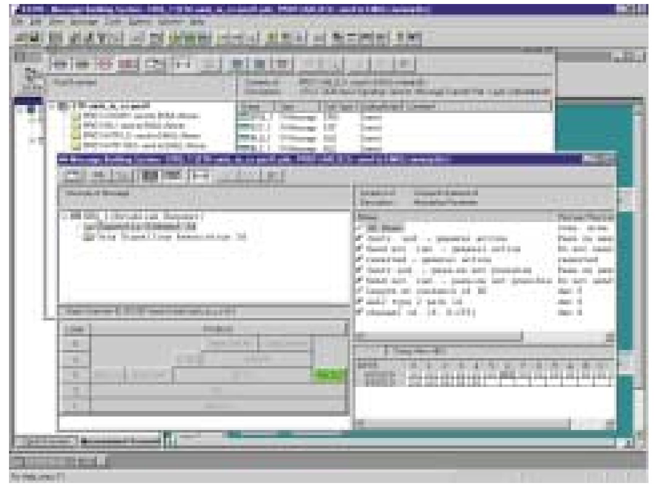


Figure 13: *Parameter definition for an ESTABLISH REQUEST message*

When the previous steps are completed, messages for AAL2 layer 3 services for protocols, such as RANAP, and for layer management can be created and modified. Figure 13 displays the window for parameter definition of an *ESTABLISH REQUEST* message.

Messages for served users are:

- Establish Request
- Establish Confirm
- Release Request
- Release Confirm

Messages for layer management are:

- Block Request
- Block Confirm
- Unblock Request
- Unblock Confirm
- Reset Request
- Reset Confirm
- Confusion

Once the necessary messages are defined, primitives to the lower layer protocol should be created for each of the receiving and transmission messages.

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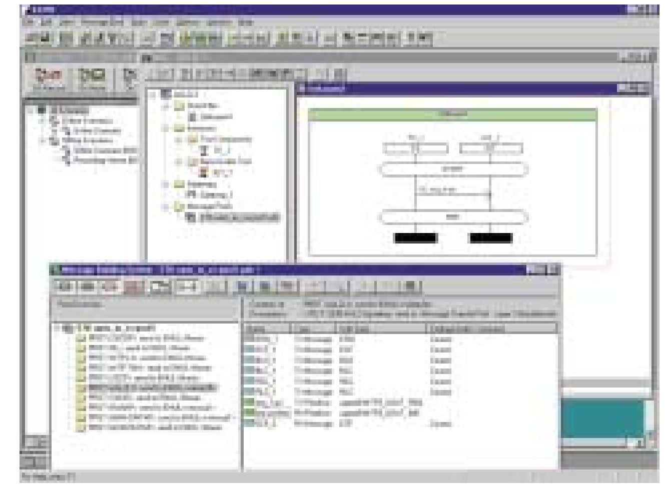

Figure 14: *Message Sequence Chart*

Now, we are ready to develop test scenarios with the K1297 "*Message Sequence Chart*" (MSC). An MSC can be created as shown in Figure 14. TC represents the test tool (in this case, the K1297) and IUT means implementation under test. The first message shown in Figure 14 is the *Establish Request* message enclosed in an *MTP3_UserData_Req* primitive.

A Forth language script is provided with the AAL2 layer 3 Software Product. This script is loaded when the system configuration "*umtsaal2l3.s*" is opened. The script includes messages that can be sent very easily. In this example the IUT only contains the MTP emulation without user (AAL2 layer 3). Therefore, after the program sends one of the messages, the MTP emulation of the opposite side responds with UPU message (Figure 15).

In addition to the Forth programming environment, which allows the development of *Simulation* test sequences, the K1297 provides the C-API interface for the programming of test scripts for AAL2 layer 3.

2.3.2. Emulation of AAL2 layer 3

The *Emulation* of AAL2 layer 3 is set up to act and react automatically to either Layer Management or protocols. For example, RANAP procedures such as RAB Assignment Request, Iu-Release Complete and Iu Bearer Reconfiguration will trigger AAL2 layer 3 emulations for setting up or releasing an AAL2 connection.

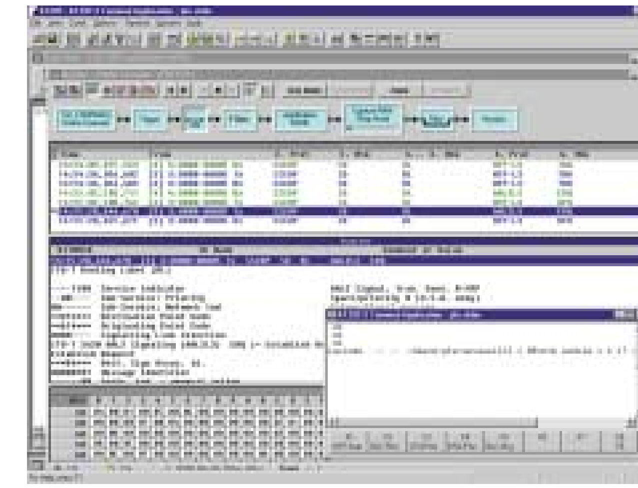

Figure 15: *An example of Simulation of AAL2 layer 3*

This emulation will be described in greater detail in the next release of this application note.

2.4. Testing RANAP

RANAP is much more complex than AAL2 layer 3 and therefore requires more sophisticated testing. Supported RANAP messages and elementary procedures are shown in the following tables.

Elementary Procedure	Initiating Message	Successful Outcome Response Message	Unsuccessful Outcome Response Message
Iu Release	Iu Release Command	Iu Release Complete	
Relocation Preparation	Relocation Required	Relocation Command	Relocation Preparation Failure
Relocation Resource Allocation	Relocation Request	Relocation Request Acknowledge	Relocation Failure
Relocation Cancel	Relocation Cancel	Relocation Cancel Acknowledge	
SRNS Context Transfer	SRNS Context Request	SRNS Context Response	
Security Mode Control	Security Mode Command	Security Mode Complete	Security Mode Reject
Data Volume Report	Data Volume Report Request	Data Volume Report	
CN Information Broadcast	CN Information Broadcast Request	CN Information Broadcast Confirm	CN Information Broadcast Reject
Reset	Reset	Reset Acknowledge	
Reset Resource	Rest Resource	Reset Resource Acknowledge	

Elementary Procedure	Message
RAB Release Request	RAB Release Request
Iu Release Request	Iu Release Request
Relocation Detect	Relocation Detect
Relocation Complete	Relocation Complete
SRNS Data Forwarding Initiation	SRNS Data Forward Command
SRNS Context Forwarding from Source RNC to CN	Forward SRNS Context
Paging	Paging
Common ID	Common ID
CN Invoke Trace	CN Invoke Trace
CN Deactivate Trace	CN Deactivate Trace
Location Reporting Control	Location Reporting Control
Location Report	Location Report
Initial UE Message	Initial UE Message
Direct Transfer	Direct Transfer
Overload Control	Overload
Error Indication	Error Indication

Elementary Procedure	Initiating Message	Response Message
RAB Assignment	RAB Assignment Request	RAB Assignment Response x N (N>=1)

To keep messages as short as possible, RANAP uses the ASN.1 packed encoding rules. A byte board is used to separate the message and information elements.

Mobility Management, Call Control, GPRS Mobility Management and GPRS Session Management are provided on top of the RANAP.

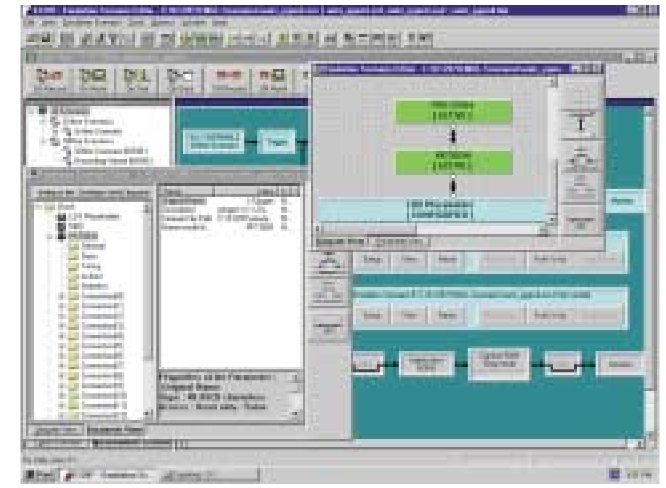

Figure 16: *Packet Generation*

2.5. Testing of the GTP-U Protocol

GPRS Tunneling Protocol for User Plane (GTP-U) consists of four messages:

- Echo Request
- Echo Response
- Version Not Supported
- T-PDU

Echo-Messages check the availability of a link. T-PDU's carry user data between GTP-U Tunnel Endpoints.

The K1297 supports two GTP-U test objectives – you can test the GTP-U protocol elements themselves or test the data services that GTP-U provides. For the first purpose, GTP-U MBS and MSC can be used to simulate the protocol by inserting correct or incorrect messages and timers. These tests follow the same test sequences as the other protocols (see Section 2.3, above).

The software tools "*Packet Generator*" and "*Comparator*" are provided to test the GTP-U data services. A predefined configuration (*C:\K1297\config\umts_pgen.s*) loads this software for the user (Figure 16). In addition to the message pool and the necessary protocol stack,

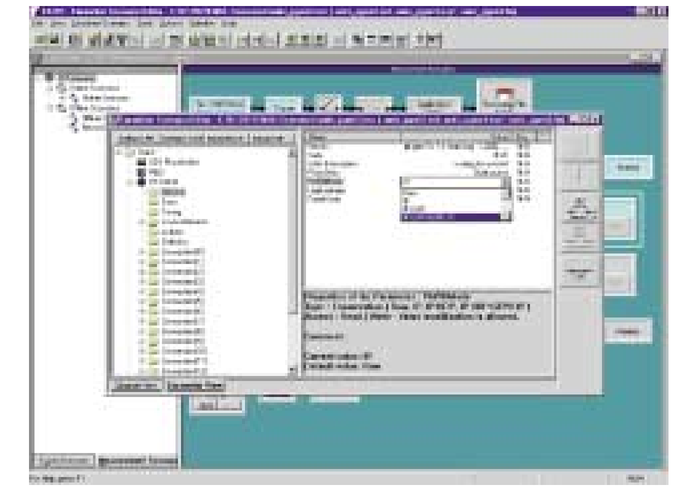

Figure 17: *Protocol stacks and parameter views*

two Forth programs, *UMTSPGEN.4th* and *UMTSPCOM.4th*, are included for both the transmission and receiving sides.

UMTSPGEN sets the necessary header information for the different protocol layers such as IP, UDP and GTP-U. For a switch to accept the generated packet, the header information must be set in accordance with the switch settings. Some parameters are defined by other signaling protocols in RANAP such as TEID (Tunneling Endpoint ID).

The *Packet Generator* is an emulation with extended features like an application supporting the following protocols: GTP-U (TS 29.060), UDP (RFC 769), IP (RFC 791, 1483, 2225). Data packets can be generated for each of these protocol layers. Figure 17 shows protocol stacks and

Figure 18: *Result of Packet Generation*

corresponding parameter views. *PKTGEN* can be configured and run for up to 16 data links by using the configuration tool within the "*Parameter View*." In the example, Forth scripts are used to configure and to start packet generation for a single data link.

UMTSCOMP receives the data, collects statistical information and calculates delays. Figure 18 shows the results of a typical test.

3. Conclusion

The K1297 Protocol Tester is a powerful tool for the design, development and deployment of new 3G networks. The K1297 is a comprehensive solution, adding simulation and emulation capabilities and an enhanced graphical user interface to the extensive monitoring functions of its predecessor, the K1205. The K1297 is compact and configurable to help you meet a variety of measurement challenges with ease, including:

- protocol functional tests
- node simulations, where the entire protocol stack is emulated/simulated, including the user plane.
- node tests, where all messages belonging to a message group can be collected.

The K1297 features programming flexibility and a common platform for all protocol testing applications. All bundles include:

- Monitoring
- Protocol simulation
- Emulation
- Sample scripts for message sequences, message pools and predefined emulation stacks
- Simulation Base software with Emulation Scenario Editor (ESE), Message Sequence Chart (MSC), Message Building System (MBS), PFE-Forth based interpreted scripting language

To address the new ATM features in the UMTS, K1297/ATM Software includes:

- Monitor and simulation software for UNI (Q.2931 CS2.1, ATMF UNI3.1, ATMF UNI4.0)
- Monitor and simulation software for NNI (Q.2761 - Q.2764 CS2.1, B-ICI 2.1)
- Monitor and emulation software for 8xSSCOP
- TTCN Compiler for Conformance Test Suites
- Executable Test Suites (SSCOP(SSCF), Q.2931, UNI3.1, Q.2763, MTPL3b)
- Support for AAL 3/4, AAL 5, STM 4, STM 1 optical/electrical/TP, E3/DS3, E1/DS1, ATM 25.6 interfaces.

The following software packages are available:

- UMTS Monitor SW (G20) for Iu-PS user plane interface; incl.: GTP-U (TS29.060) and IP as well as underlying protocols UDP/IP and IP over ATM; English documentation; Required basic package >=V1.0 (7KK1220-0SCxx) and ATM-HW
- UMTS Test SW (G20) for Iu control-plane; incl.: Emulations of SSCOP, MTP3B, SCCP emulation and simulation of AAL2L3(Q.2630.1, Q.2150.2), RANAP(TS25.413) and Mobile Radio Layer 3 (TS24.008); English documentation; Required basic package >= V1.0 (7KK1220-0SCxx) and ATM-HW
- UMTS Test SW (G20) for Iu-PS user plane; incl.: simulation of GTP-U (TS29.060) and emulation of IP packet generator and comparator; English documentation; Requirements (7KK1220-0SCxx) >= V1.0 and ATM-HW

For additional information please also access our web site at www.tektronix.com/commtest.

This first release of the application note presents guidelines for the test engineer who is interested in solutions for the UMTS Iu interface as it was defined by 3GPP in 1999. Updates and solutions for the new Iub and Iur interfaces will follow in the near future. This document is also available at our web site (www.tektronix.com), along with updates and related documents.

Tektronix is committed to the most advanced test solutions for mobile networks. As mobile networks continue to evolve through GPRS, UMTS and cdma2000, we will keep you in the forefront with the latest testing products and methods.

We welcome your comments and suggestions for improving these documents and your ideas for developing other tools to help you meet the measurement challenges of new wireless systems.

4. Appendix I

4.1 Recommended Documents and Standards:

3G TS 23.110	UMTS Access Stratum Services and Functions
3G TS 25.301	Radio Interface Protocol Architecture
3G TS 25.321	Medium Access Control (MAC) Protocol Specification
3G TS 25.322	Radio Link Control (RLC) Protocol Specification
3G TS 25.323	Packet Data Convergence Protocol (PDCP) protocol
3G TS 25.324	Radio Interface for Broadcast/Multicast Services
3G TS 25.331	Radio Resource Control (RRC) Protocol Specification
3G TS 25.401	UTRAN Overall Description
3G TS 25.410	UTRAN Iu Interface: General Aspects and Principles
3G TS 25.411	UTRAN Iu interface Layer 1
3G TS 25.413	UTRAN Iu Interface: RANAP Signaling
3G TS 25.420	UTRAN Iur Interface: General Aspects and Principles
3G TS 25.423	UTRAN Iur interface RNSAP Signaling
3G TS 25.430	UTRAN Iub Interface: General Aspects and Principles
3G TS 25.433	UTRAN Iub interface NBAP Signaling
3G TS 29.060	3rd Generation Partnership Project; Technical Specification Group Core Network; General Packet Radio Service (GPRS); GPRS Tunneling Protocol (GTP) across the Gn and Gp Interface
ETSI ETR 021	Advanced Testing Methods (ATM); Tutorial on protocol conformance testing (Especially OSI standards and profiles) (ETR/ATM-1002)
ETSI GSM 12.04	Digital cellular telecommunication system (Phase 2); Performance data measurements
IETF M3UA	G. Sidebottom et al, "SS7 MTP3-User Adaptation Layer (M3UA draft-ietf-sigtran-m3ua-02.txt (Work In Progress), IETF, 10 March 2000
IETF SCTP	R. Stewart et al, "Simple Control Transmission Protocol," draft-ieft-sigtran-sctp-v0.txt (Work In Progress), IETF, September 1999
IETF RFC 791	Internet Protocol
IETF RFC 768	User Datagram Protocol
IETF RFC 1483	Multi Protocol Encapsulation over ATM Adaptation Layer 5
IETF RFC 2225	Classical IP and ARP over ATM
IETF RFC 2460	"Internet Protocol, Version 6 (IPv6) Specification."
ITU-T I.361	B-ISDN ATM layer specification.
ITU-T I.363.2	B-ISDN ATM Adaptation Layer Type 2
ITU-T I.363.5	B-ISDN ATM Adaptation Layer Type 5
ITU-T Q.711	Functional description of the Signaling connection control part
ITU-T Q.712	Definition and function of Signaling connection control part messages
ITU-T Q.713	Signaling connection control part formats and codes
ITU-T Q.714	Signaling connection control part procedures
ITU-T Q.715	Signaling connection control part user guide
ITU-T Q.716	Signaling Connection Control Part (SCCP) performance
ITU-T Q.2100	B-ISDN Signaling ATM Adaptation Layer (SAAL) - overview description.
ITU-T Q.2110	B-ISDN ATM Adaptation Layer - Service Specific Connection Oriented Protocol (SSCOP).
ITU-T Q.2130	B-ISDN Signaling ATM Adaptation Layer - Service Specific Coordination Function for Support of Signaling at the User Network Interface (SSCF at UNI)
ITU-T Q.2140	B-ISDN ATM adaptation layer - Service Specific Co-ordination Function for Signaling at the Network Node Interface (SSCF AT NNI).
ITU-T Q.2150.1	AAL type 2 Signaling Transport Converter on Broadband MTP
ITU-T Q.2150.2	AAL Type 2 Signaling Transport Converter on SSCOP (Draft)
ITU-T Q.2210	Message transfer part level 3 functions and messages using the services of ITU-T Recommendation Q.2140.
ITU-T Q.2630.1	AAL type 2 Signaling Protocol (Capability Set 1)

Testing the UMTS Iu Interface
Appendix I

4.2. Glossary

1G	First Generation
2G	Second Generation
3G	Third Generation
3GPP	Third Generation Partnership Project (of ETSI)
8PSK	Eight phase Shift Keying
AAL	ATM Adaptation Layer
AAL2	ATM Adaptation Layer Type 2
AAL5	ATM Adaptation Layer Type 5
AC	Authentication Center
ALCAP	Access Link Control Application Part
AMPS	Advanced Mobile Phone Service
AMR	Adaptive Multi-Rate (speech codec)
ANSI T1	Standards Committee T1 Telecommunication of the American National Standards Institute
ARIB/TTC	Association of Radio Industries and Business/Telecommunication Technology Committee
ASN.1	Abstract Syntax Notation One
ATM	Asynchronous Transfer Mode
AuC	Authentication Center
BEC	Backward Error Correction
BMC	Broadcast/Multicast Control
BSC	Base Station Controller
BSS	Base Station Subsystem
BTS	Base Transceiver Station
CAMEL	Customized Application for Mobile Enhanced Logic
CAP	CAMEL Application Part
CATT	China Academy of Telecommunication Technology
CBR	Constant Bit Rate (data stream)
CC	Call Control
CCITT	Comité Consultatif International Téléphonique et Telecommunication
CCS7	Common Control Signaling System No 7
CDMA	Code Division Multiple Access
CDMA2000	3rd generation Code Division Multiple Access
CC	Call Management protocols
CN	Core Network
CRNC	Controlling RNC (Radio Network Controller)
CS	Circuit Switched
CS-CN	Circuit Switched Core Network
CSE	CAMEL Service Environment
CT	Conformance Test
D-AMPS	Digital AMPS
DCH	Dedicated Channel
DECT	Digital Enhanced Cordless Telephone
DL	Downlink
DPC	Destination Point Code
DRNC	Drift Radio Network Controller
DRNS	Drift Radio Network Subsystem
DTE	Data Terminal Equipment
EDGE	Enhanced Data Rates for GSM Evolution
EFR	Enhanced Full Rate (speech codec)
EIR	Equipment Identity Register
ESE	Emulation Scenario Editor
ETSI	European Telecommunication Standards Institute
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FEC	Forward Error Correction
FER	Frame Error Rate
GGSN	Gateway GPRS Support Node
GMM	GPRS Mobility Management (protocols)
GMSC	Gateway MSC
GMSK	Gaussian Minimum Shift Keying
GPRS	General Packet Radio Service
GSM	Global System for Mobile Communication
GSM-R	GSM Railway
gsmSCF	GSM Service Control Function
gsmSSF	GSM Service Switching Function
GTP	GPRS Tunneling Protocol
GTP-C	GTP Control
GTP-U	GTP User
HLR	Home Location Register
HO/HoV	Handover
HSCSD	High Speed Circuit Switched Data
ICO	Intermediate Circular Orbits
IETF	Internet Engineering Task Force
IMEI	International Mobile Equipment Identification
IMT-2000	International Mobile Telecommunications 2000
IMUN	International Mobile User Number
IN	Intelligent Network
IP	Internet Protocol
IPv4	IP version 4
IPv6	IP version 6
IS-95	Interim Standard ´95
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
ISUP	ISDN User Part
ITU	International Telecommunication Union
Iu	UTRAN interface between RNC and CN
Iub	UTRAN interface between Node B and RNC
Iu-CS	UTRAN interface between RNC and the circuit switched domain of the CN
Iu-PS	UTRAN interface between RNC and the packet switched domain of the CN
Iur	UTRAN interface between two RNCs
IUT	Implementation Under Test
IWF	Interworking Function
kbps	kilobits per second
LLC Relay	Logical Link Control - Relay
M3UA	MTP3 User Adaptation
MAC	Medium Access Control
MAP	Mobile Application Part
Mbps	Megabits per second
MBS	Message Building System
MC	Multi-Carrier
MC-CDMA	Multi-Carrier CDMA
MCE	Multi-protocol Encapsulation
ME	Mobile Equipment
MM	Mobility Management (protocols)
MSC	Mobile Services Switching Center, Message Sequence Chart
MSS	Mobile Satellite System
MT	Mobile Telephone
MTP	Message Transfer Part
MTP3b	Message Transfer Part level 3 (broadband) for Q.2140
NAS	Non Access Stratum
NBAP	Node B Application Protocol
NE	Network Elements
NMT	Nordic Mobile Telephone
NNI	Network-Node Interface
Node B	UMTS Base Station
NRT	Non-Real Time
NSS	Network Switching Subsystem
O&M	Operation and Maintenance
OSA	Open Service Architecture
OSS	Operation Subsystem
PDC	Personal Digital Communication
PDCP	Packet Data Convergence Protocol
PDH	Plesiochronous Digital Hierarchy
PDN	Packet Data Network
PDU	Protocol Data Unit
PLMN	Public Land Mobile Network
PMR	Private Mobile Radio
PS	Packet Switched
PS-CN	Public Switched Core Network
PSTN	Public Switched Telephone Network

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QoS	Quality of Service (ATM network channels)
QPSK	Quadrature Phase Shift Keying (or, Quaternary Phase Shift Keying)
RAB	Radio Access Bearer
RAN	Radio Access Network
RANAP	Radio Access Network Application Part
RLC	Radio Link Control
RLP	Radio Link Protocol
RNC	Radio Network Controller
RNS	Radio Network Subsystem
RNSAP	Radio Network Subsystem Application Part
RNTI	Radio Network Temporary Identity
RR	Radio Resource
RRC	Radio Resource Control
RRM	Radio Resource Management
RTT	Radio Transmission Technology
SAAL	Signaling ATM Adaptation Layer
SCCP	Signaling Connection Control Part
SCTP	Simple Control Transmission Protocol
SDH	Synchronous Digital Hierarchy
SDO	Standard Development Organization
SGSN	Serving GPRS Support Node
SIM	Subscriber Identity Module
SM	Session Management protocols
SRNC	Serving Radio Network Controller
SRNS	Serving Radio Network Subsystem
SS7	= CCS7 (Common Control Signaling System No. 7)
SSCF	Service Specific Coordination Function
SSCOP	Service Specific Connection Oriented Protocol
SSF	Service Switching Function
STC	Signaling Transport Converter
STM1	Synchronous Transport Module - level 1
SUT	System Under Test
SW	Software
TACS	Total Access Communication System
TAF	Terminal Adaptation Functions
TC	Transcoder
TD-CDMA	Time Division-Code Division Multiple Access
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TD-SCDMA	Time Division - Synchronous CDMA
TEID	Tunneling Endpoint ID
TETRA	TErrestrial Trunked Radio Access
TIA	Telecommunications Industry Association
TN-CP	Transport Network-Control Plane
TPC	Transmission Power Control
TRAU	Transcoder and Rate Adaptation Unit
TS	Technical Specification
TTA	Telecommunications Technology Association
U MSC	U MSC Mobile Switching Center (the integration of the MSC and the SGSN in one physical entity (UMTS+MSC = UMSC)
U MSC-CS	U MSC Circuit Switched
U MSC-PS	U MSC Packed Switched
U SSD	Unstructured Supplementary Service Data
UDP	User Datagram Protocol
UE	User Equipment
UICC	UMTS IC Card
UL	Uplink
Um	GSM Air Interface
UMTS	Universal Mobile Telecommunication System
UNI	User-Network Interface
UP	User Plane
USIM	UMTS Subscriber Identity Module
UTRA	UMTS Terrestrial Radio Access
UTRAN	UMTS Terrestrial Radio Access Network
Uu	UMTS Air interface
UWC-136	Universal Wireless Communication
VBR	Variable Bit Rate (data stream)
VHE	Virtual Home Environment
VLR	Visitor Location Register
VMSC	Visited MSC
WCDMA	Wide band Code Division Multiple Access
WLL	Wireless Local Loop

5. Appendix II – Introduction to UMTS

UMTS – Entering the Third Generation of Mobile Networks

The Universal Mobile Telecommunication System (UMTS) is one of the most significant advances in the evolution of telecommunications into the 3rd Generation of Mobile Networks. UMTS allows many more applications to be introduced to a worldwide base of users and provides a vital link between today's multiple GSM systems and the ultimate single worldwide standard for all mobile telecommunications (IMT-2000). The new network also addresses the growing demand of mobile and Internet applications for new capacity in the overcrowded mobile communications sky. UMTS increases transmission speed to 2 Megabits/s per mobile user and establishes a global roaming standard.

Standardization

UMTS is being developed by 3GPP (Third Generation Partnership Project), a joint venture of several Standards Development Organizations - ETSI (Europe), ARIB/TTC (Japan), ANSI T1 (USA), TTA (South Korea) and CWTS (China). To reach global acceptance, 3GPP is introducing UMTS in Phases and Annual Releases. The first release (UMTS Rel. '99), introduced in December of 1999, defines enhancements and transitions for existing GSM networks.

The Public Land Mobile Network (PLMN) described in UMTS Rel. ´99 incorporates three major categories of network elements:

- GSM Phase 1/2 core network elements: MSC,VLR, HLR, AC and EIR
- GSM Phase 2+ enhancements: GPRS (SGSN and GGSN) and CAMEL (CSE)
- UMTS specific modifications and enhancements, particularly UTRAN

The GSM Phase 1/2 PLMN consists of 3 subsystems: the Base Station Subsystem (BSS), the Network Switching Subsystem (NSS) and the Operation Subsystem (OSS). The BSS consists of the Base Station Controller (BSC), Base Transceiver Station (BTS) and Transcoding & Rate Adaptation Unit (TRAU). The NSS consists of Mobile Services switching Center (MSC), Visitor Location Register (VLR), Home Location Register (HLR), Equipment Identity Register (EIR) and the Authentication Center (AC). The MSC provides functions such as switching, signaling, Paging, and Inter-MSC Handover. The OSS consists of Operation & Maintenance Centers (OMC), which are used for remote and centralized Operation, Administration and Maintenance tasks.

UMTS (Rel. '99) incorporates enhanced GSM Phase 2+ Core Networks as a platform, creating an entirely new network and protocol architecture with GPRS (General Packet Radio Services) and CAMEL (Customized Applications for Mobile network Enhanced Logic). The new networks will be installed as islands within the GSM Phase 1/2 landscape, enabling network operators to enjoy the improved cost efficiency of UMTS while protecting their 2G investments and reducing the risks of implementation.

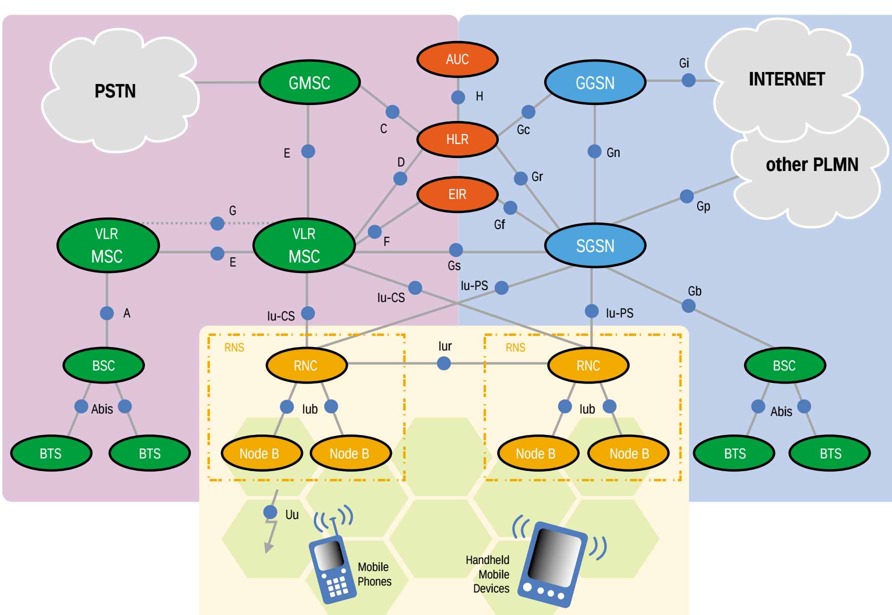

Figure 1: *Overview of a UMTS network*

The most significant change in Rel. '99 is the new UMTS Terrestrial Radio Access Network (UTRAN) that includes the UMTS Terrestrial Radio Access (UTRA), a W-CDMA radio interface for land based communications. UTRA supports Time Division Duplex (TDD) and Frequency Division Duplex (FDD).

The TDD mode is optimized for public Micro & Pico cells and unlicensed cordless applications. The FDD mode is optimized for wide area coverage, i.e. public Macro & Micro cells. Both modes offer flexible and dynamic data rates up to 2 Mbit/s.

Another newly defined UTRA mode - Multi Carrier (MC) - is expected to establish compatibility between UMTS and cdma2000.

Implementation - New Network Elements and Interfaces

UMTS standardization and development is moving very quickly, but several steps must be taken before we can enjoy global mobility at the remarkable new speeds. New network elements are being developed and adopted, while existing network nodes are being extensively modified. All of these developments require the creation and integration of new software and hardware modules that will then be manufactured, deployed, commissioned and operated.

The UMTS standard can be seen as an extension of existing networks. Two new network elements are introduced in UTRAN, Radio Network Controller (RNC) and Node B. UTRAN is subdivided into single Radio Network Systems (RNS), where each RNS is controlled by a Radio Network Controller (RNC). The RNC is connected to a set of Node B elements, each of which can serve one or several cells.

Existing network elements, such as MSC, SGSN and HLR, can be extended to adopt the UMTS requirement, but RNC, Node B and the handsets must be completely new designs. RNC will become the replacement for BSC and Node B fulfills nearly the same functionality as a BTS. GSM and GPRS networks will be extended and new services will be integrated into an overall network that contains both existing interfaces such as A, Gb, Abis and new interfaces that include Iu, Iub and Iur.

UMTS defines four new open interfaces:

- Uu: User Equipment(UE) to Node B (UTRA, the UMTS W-CDMA air interface)
- Iu: RNC to GSM Phase 2+ Core Network interface (MSC/VLR or SGSN)
  - Iu-CS for circuit switched data
  - Iu-PS for packet switched data.
- Iub: RNC to Node B interface
- Iur: RNC to RNC interface; not comparable to any interface in GSM

The Iu, Iub and Iur interfaces are based on ATM transmission principles.

The Radio Network Controller (RNC) enables autonomous Radio Resource Management by UTRAN. It performs the same functions as the GSM Base Station Controller (BSC), providing central control for the Radio Network System (RNS) elements (RNC and Node Bs).

The RNC handles protocol exchanges between Iu, Iur, and Iub interfaces and is responsible for centralized Operation & Maintenance for the total RNS with access to the Operation SubSystem (OSS). Because the interfaces are ATM-based, the RNC switches ATM cells between them. The user's circuit-switched and packet switched data coming from Iu-CS and Iu-PS interfaces are multiplexed together for multimedia transmission via Iur, Iub, and Uu interfaces to and from the User Equipment (UE).

The RNC uses the Iur to autonomously handle 100% of the Radio Resource Management (RRM), eliminating that burden from the Core Network. Serving control functions such as Admission, RRC connection to the UE, Congestion and Handover/Macro Diversity are managed entirely by a single Serving RNC (SRNC). If another RNC is involved in the active connection through an Inter-RNC Soft Handover, it is declared a Drift RNC (DRNC). The DRNC is only responsible for the allocation of Code resources. The term Controlling RNC (CRNC) is used to define the RNC that controls Node Bs.

Node B is the physical unit for radio transmission/reception with one or more cells. A single Node B can support both FDD and TDD modes, and it can be co-located with GSM BTS to reduce implementation costs. Node B connects with the UE via the W-CDMA Uu radio interface and with the RNC via the Iub ATM based interface. Node B is the ATM termination point.

The main task of Node B is the conversion of data to/from the Uu radio interface. It measures the quality and strength of the connection and determines the Frame Error Rate (FER), transmitting these data to the RNC as a Measurement Report for Handover and Macro Diversity Combining.The Node B is also responsible for the FDD Softer Handover. This Micro Diversity combining is carried out independently, eliminating the need for additional transmission capacity in the Iub.

The Node B also participates in Power Control as it enables the UE to adjust its power using DL TPC commands via the Inner Loop Power Control on the basis of UL Transmit Power Control TPC information. The predefined values for Inner Loop Power Control are achieved from the RNC via Outer Loop Power Control.

New Technology - New Testing Challenges

From the technology standpoint, testing UMTS interfaces presents a new set of challenges. UMTS networks are based on the integration of ATM, IP and Mobile Network technologies. ATM brings "unlimited" bandwidth and QoS limits, IP brings "unlimited" coverage, and Mobile Network brings "unlimited" mobility. In addition, UMTS will use CDMA as the air interface technology, introducing different signaling procedures and different control signal levels than those found in GSM and GPRS networks.

Almost every ATM transmission speed from two Megabits/s up to STM4 (622 Megabits/s) is defined for UMTS. Moreover, ATM has been designed to support these speeds at specified quality of service (QoS) levels for traffic with guaranteed delays, losses and error rates. Constant bit rate (CBR) and variable bit rate (VBR) data streams are assigned to VPI/VCI virtual channels to achieve the required bandwidth. It is possible for a single connection to occupy the entire physical bandwidth of a virtual channel, or even require hundreds or thousands of virtual channels with smaller bandwidths.

ATM Adaptive Layers AAL2 and AAL5 protocols are the assembly and reassembly mechanisms used within UMTS networks. AAL5 is primarily used for packet data connections and signaling traffic, while AAL2 with its sub-channels is used for voice and real time applications. Another issue for testing is that AAL2 and AAL5 connections can occur simultaneously in the same physical link.

While ATM provides virtual channels with QoS using either AAL2 or AAL5 protocols; IP distributes almost all applications over the network using hundreds of different application protocols. From the testing point of view, IP (at least IPv4) doesn't care about bandwidth or transmission quality. IP routes the carried information to each destination independently, regardless of where it is in the world. The challenges of testing IP are the large amount of data and the variety of application protocols that it carries.

The UMTS enabled network is being grown from islands within the GSM landscape to full coverage during the next 10 years. Therefore, cross network services must be managed by signaling protocols along with the UMTS specific services. For example, signaling must handle UMTS originated and GSM terminated calls without interrupts. Protocol interactions across the networks and inter-system handover are challenging tasks in the testing of mobility and call control.

During the life cycle of UMTS, one of the most important aspects is quality management. Protocol Testers such as the K1297 help to shorten the development time, increase product quality and maintain the UMTS network. These instruments are essential partners for manufacturers and operators who are phasing into 3G mobile networks.

The K1297 Protocol Tester always refers to standardized UMTS interfaces. It treats the System Under Test (SUT), whether a single network node or a sub-network, as if it were a black box. In both "*Monitoring*" and "*Simulation & Emulation*" modes, the tester compares the digital data streams that appear at the interfaces with those defined in the standard.

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