3.5 Iu, Iur, Iub: The Physical Layers [3G TS 25.411]

The physical layer defines the access to the transmission media, the physical and electrical properties and how to activate and de-activate a connection. It offers to the higher layer physical service access points to support the transmission of a uniform bit stream. A huge set of physical layer solutions is allowed in UTRAN, including: ETSI STM-1 (155 Mbps), STM-4 (622 Mbps); SONET STS-3c (155 Mbps), STS-12c (622 Mbps); ITU STS-1 (51 Mbps), STM-0 (51 Mbps); E1 (2 Mbps), E2 (8 Mbps), E3 (34 Mbps), T1 (1.5 Mbps), T3 (45 Mbps); J1 (1.5 Mbps), J2 (6.3 Mbps).

With the above protocol layers, the interfaces Iu, Iur, and Iur are fully described. There is only the air interface left for a more detailed analysis:

3.6 The air interface Uu [3G TS 25.301]

The air interface solution is usually a major cause for dispute when specifying a new radio access network. Figure Uu shows the realization of the lower parts of the protocol stack in the UE. As can be seen, a physical layer, data link layer, and network layer (the part for the radio resource control (RRC)) have been specified.

The physical layer is responsible for the transmission of data over the air interface. The FDD and TDD W-CDMA solutions have been specified in UMTS Rel. '99.

The data link layer contains four sub-layers:

- Medium Access Control (MAC) [3G TS 25.321]

  The MAC layer is located on top of the physical layer. Logical channels are used for communication with the higher layers. A set of logical channels is defined to transmit each specific type of information. Therefore, a logical channel determines the kind of information it uses.

  The exchange of information with the physical layer is realized with transport channels. They describe how data is to be transmitted over the air interface and with what characteristics.

  The MAC layer is responsible for more than mapping the logical channels into the physical ones. It is also used for priority handling of UEs and the data flows of a UE, traffic monitoring, ciphering, multiplexing, and more.

- Radio Link Control (RLC) [3G TS 25.322] is responsible for acknowledged or unacknowledged data transfer, establishment of RLC connections, transparent data transfer, QoS settings, unrecoverable error notification, ciphering, etc. There is one RLC connection per Radio Bearer.

The two remaining layer 2 protocols are used only in the user plane:

- Packet Data Convergence Protocol (PDCP) [3G TS 25.323] is responsible for the transmission and reception of Radio Network Layer PDUs. Within UMTS several different network layer protocols are supported to transparently transmit protocols. At the moment IPv4 and IPv6 are supported, but UMTS must be open to other protocols without forcing the modification of UTRAN protocols. This transparent transmission is one task of PDCP; another is to increase channel efficiency (by protocol header compression, for example).
- Broadcast/Multicast Control (BMC) [3G TS 25.324] offers broadcast/multicast services in the user plane. For instance, it stores SMS CB messages and transmits them to the UE.

4 UMTS and UTRAN Measurement Objectives

As noted in the preceding section, four new interfaces have been introduced with UMTS/UTRAN. With the new interfaces came a huge set of protocol layers for mobile communication networks. Dealing with these new protocols presents a demanding challenge to manufacturers, operators, and measurement equipment suppliers.

4.1 Measurement Approaches

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 disturb?
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.

4.1.1 Monitoring [see also CCITT 880 and GSM Rec. 12.04]

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 main reason for operators and manufacturers to collect data is to retrieve the necessary information for decision making in relation to a specified objective. The item under investigation can be an individual network element, parts of the PLMN or even the whole PLMN. The major objectives for monitoring data collections 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 its actual performance
- to improve predictions of behavior and potential problems.

Interface monitoring can collect data and present results in two ways:

measurement result collection: Use of cumulative counters to capture the number of occurrences of an event and/or discrete event registers to capture and trace specified results such as overload situations and failures.

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.).

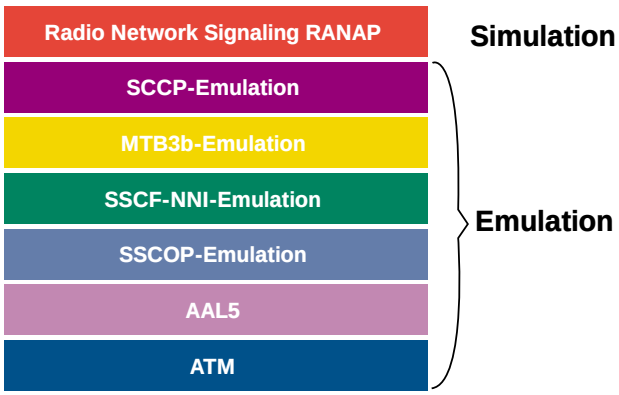
4.1.2 Simulation

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.

4.1.3 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.



▶ ***Figure 16.*** *Iu RANAP Simulation*

4.1.4 Conformance Testing [ETSI ETR 021]

Standards allow different manufacturers to develop systems that 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.

4.2 Test Procedures

Several different test configurations are supported in the Tektronix K1297:

1. The Simulation/Emulation of the CN and the UTRAN or RNC. Figure 17 demonstrates how the manufacturer's development and system integration process can be supported by simulation/emulation. The device under test's environment can be simulated under both normal and abnormal conditions, and the dependability of its response can be measured. When the K1297 is the "peer entity" to the CN, it can simulate and emulate the UTRAN (including the UE) and/or the RNC alone.

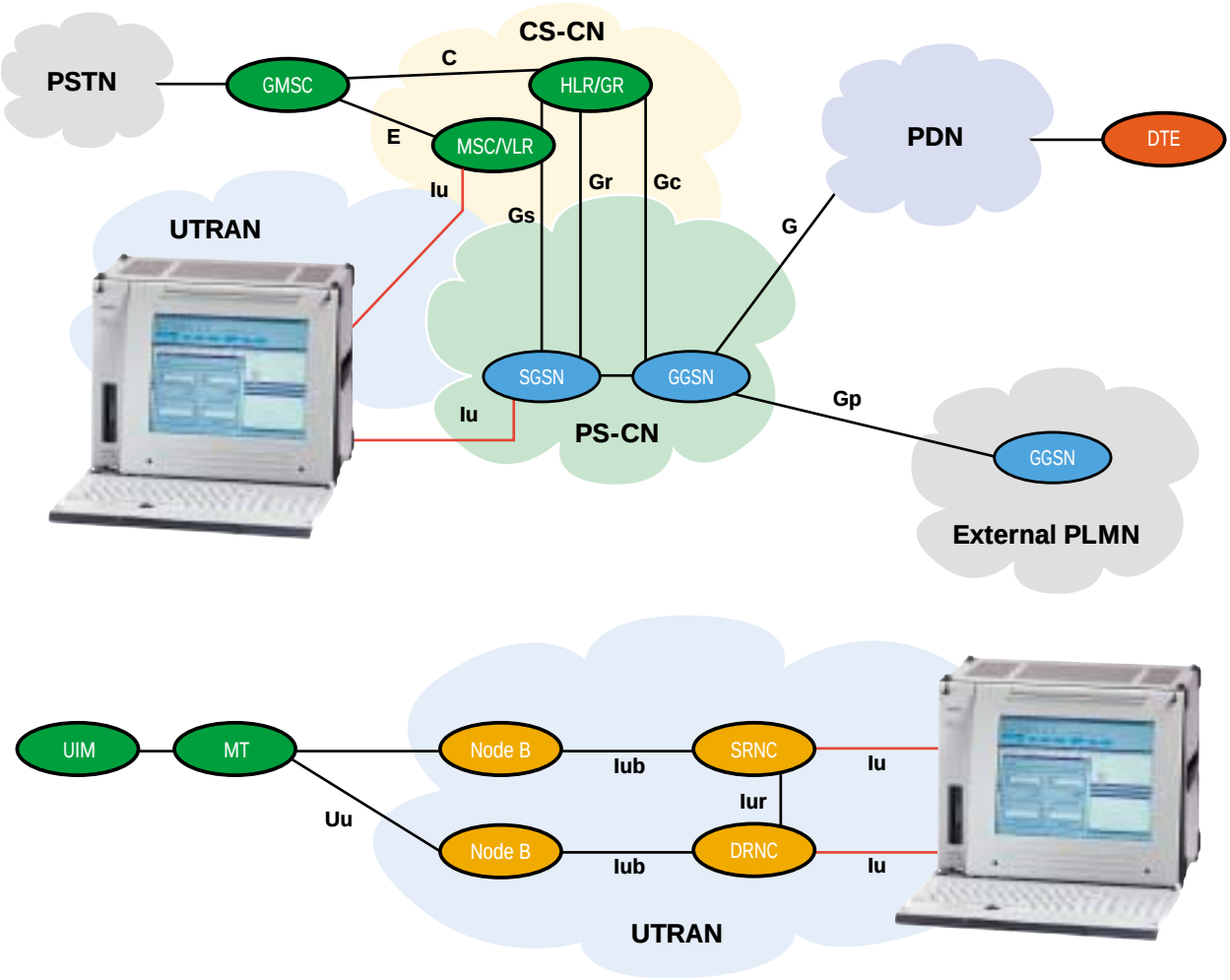
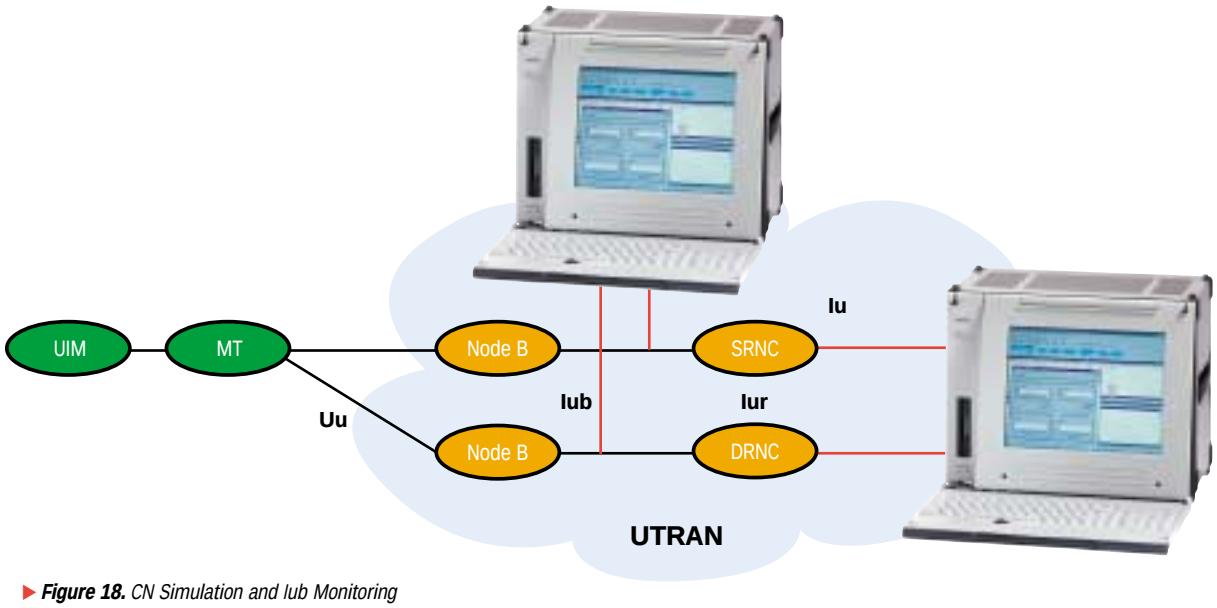


Figure 17. *Development process supported by Network Element Simulation/Emulation*



▶ ***Figure 18.*** *CN Simulation and Iub Monitoring*

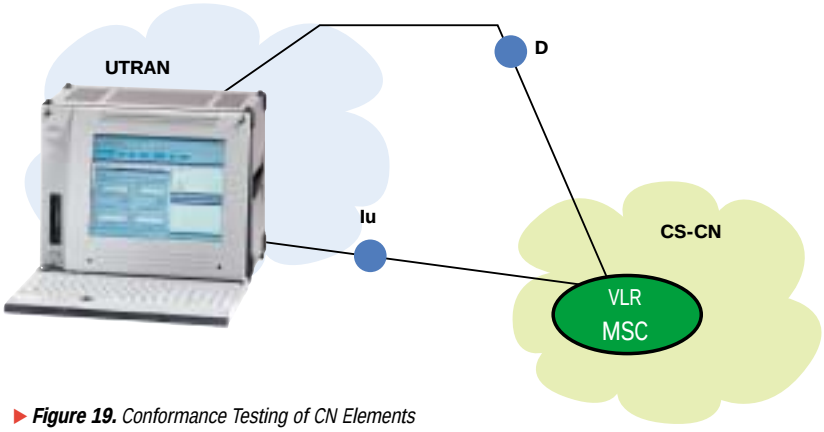
2. Active and passive monitoring are primary measurement tools. Monitoring for all UMTS interfaces will be supported. The manufacturer but and the operator can evaluate network element performance. Statistical data can be retrieved that give the operator additional information about the load and type of traffic, such as BHCA's. A CN-simulation and Iub-interface monitoring application are shown in figure 18.
3. Conformance testing will be offered to verify an item's conformant behavior. As standards are agreed upon, conformance test suites will be made available in software upgrades for the K1297. The conformance testing of CN elements can be seen In Figure TS3 - the K1297 simulates the HLR to guarantee that the network elements under test only get approved data.

5 Conclusion:

This second release of the UMTS Primer presents information for the test engineer who is interested in solutions for the new world of 3G mobile networks. Updates will follow in the near future, as the standards continue to evolve. This document is also available at our web site (www.tektronix.com/commtest), along with updates and related documents (including a series of Application Notes on the testing of UMTS interfaces).

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.



▶ ***Figure 19.*** *Conformance Testing of CN Elements*