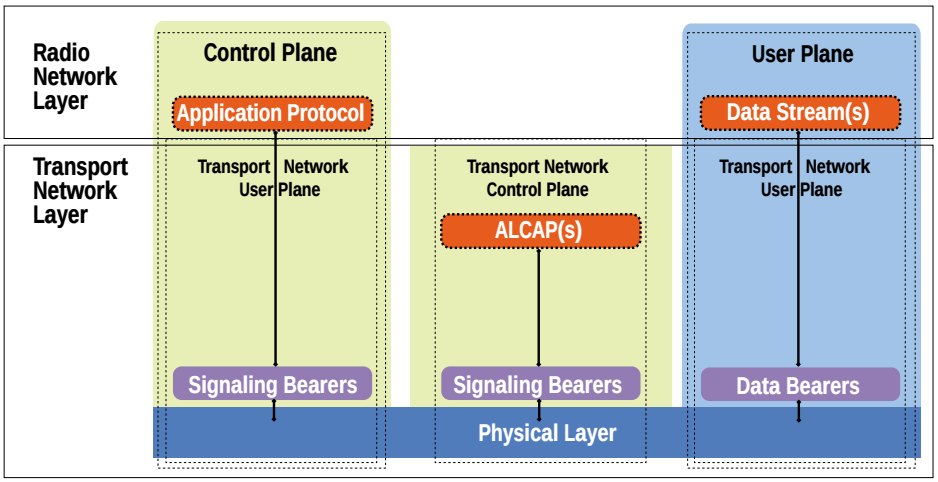
3 UMTS Interfaces

Many new protocols have been developed for the four new interfaces specified in UMTS: Uu, Iub, Iur, and Iu. This primer is organized by the protocols and shows their usage in the interfaces. That means protocols will be described individually. Only the references to the interfaces are indicated. Interface specific explanations of the protocols are however not included. Before we review the individual interface protocols, we introduce the UMTS general protocol model.



▶ ***Figure 9.*** *General Protocol Model (adopted from 3G TS 25.401 V3.1.0, p. 25)*

3.1 General Protocol Model [3G TS 25.401]

UTRAN interface consists of a set of horizontal and vertical layers (see figure 9). The UTRAN requirements are addressed in the horizontal Radio Network Layer across different types of control and user planes. Control planes are used to control a link or a connection; user planes are used to transparently transmit user data from the higher layers. Standard transmission issues, which are independent of UTRAN requirements, are applied in the horizontal Transport Network Layer.

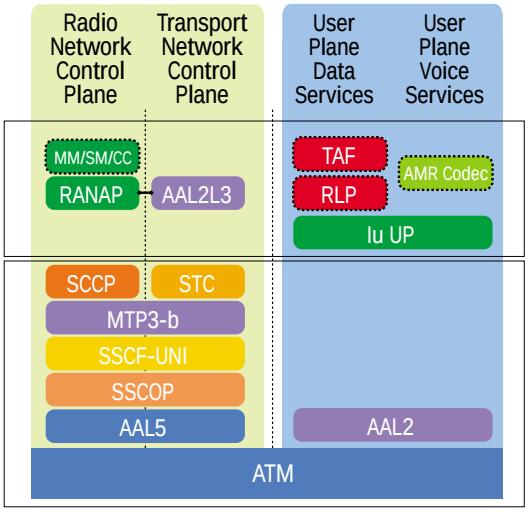
Five major protocol blocks are shown in figure 9:

- Signaling Bearers are used to transmit higher layers' signaling and control information. They are set up by O&M activities.
- Data Bearers are the frame protocols used to transport user data (data streams). The Transport Network Control Plane (ALCAP) sets them up.
- Application Protocols are used to provide UMTS specific signaling and control within UTRAN, such as to set up bearers in the Radio Network Layer.
- Data Streams contain the user data that are transparently transmitted between the network elements. User data comprises the subscriber's personal data and mobility management information that are exchanged between the peer entities MSC and UE.
- ALCAP (Access Link Control Application Part) protocol layers are provided in the Transport Network Control Plane. They react to the Radio Network Layer's demands to set up, maintain, and release data bearers. The primary objective of introducing the Transport Network Control Plane was to totally separate the selection of the Data Bearer technology from the Control Plane (where the UTRAN specific Application Protocols are located). The Transport Network Control Plane is present in the Iu-CS, Iur, and Iub interfaces. In the remaining interfaces where there is no ALCAP signaling, pre-configured Data Bearers are activated.

3.2 Application Protocols

Application Protocols are layer 3 protocols that are defined to perform UTRAN specific signaling and control. A complete UTRAN and UE control plane protocol architecture is illustrated in figure 11. UTRAN specific control protocols exist in each of the four interfaces.

Iu: Radio Access Network Application Part (RANAP) [3G TS 25.413]



▶ ***Figure 10.*** *Iu-CS Protocol Stack*

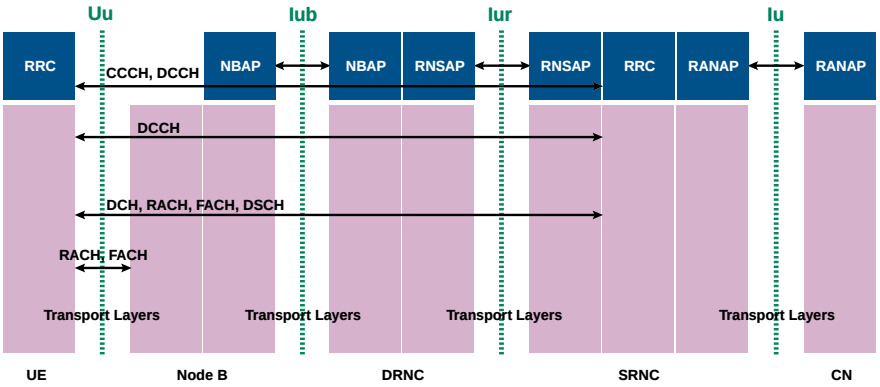


Figure 11. *Control Plane Protocols: adopted from 3G TS 25.931 V3.3.0, p. 8 (note: only the RRC, NBAP, RNSAP and RANAP shall be portrayed in a final version).*

This protocol layer provides UTRAN specific signaling and control over the Iu-interface. The following is a subset of the RANAP functions:

- Overall Radio Access Bearer (RAB) Management, which includes the RABs' setup, maintenance, and release
- Management of Iu connections
- Transport of Non-Access Stratum (NAS) information between the UE and the CN. For example, NAS contains the mobility management signaling and broadcast information.
- Exchanging UE location information between the RNC and CN
- Paging requests from the CN to the UE
- Overload and general error situation handling

Iur: Radio Network Sublayer Application Part (RNSAP) [3G TS 25.423]

UTRAN specific signaling and control over this interface contains:

- management of radio links, physical links and common transport channel resources
- paging
- affecting an SRNC relocation
- measurements of dedicated resources

Iub: Node B Application Part (NBAP) [3G TS 25.433]

UTRAN specific signaling and control in the Iub-interface includes:

- management of common channels, common resources, and radio links
- configuration management, such as cell configuration management
- measurement handling and control
- synchronization (TDD)
- reporting of error situations

Uu: Radio Resource Control (RRC) [3G TS 25.331]

This layer handles the control plane signaling over the Uu interface between the UE and the UTRAN (see also figure 15). Some of the functions offered by the RRC are:[1]

- Broadcasting information
- Management of connections between the UE and the UTRAN, which include their establishment, maintenance, and release.
- Management of the Radio Bearers, which include their establishment, maintenance, release, and the corresponding connection mobility.

[1] The RRCs also perform local inter-layer control services, which are not discussed in this document

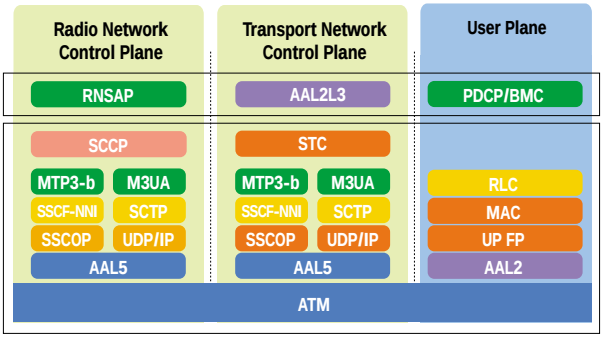
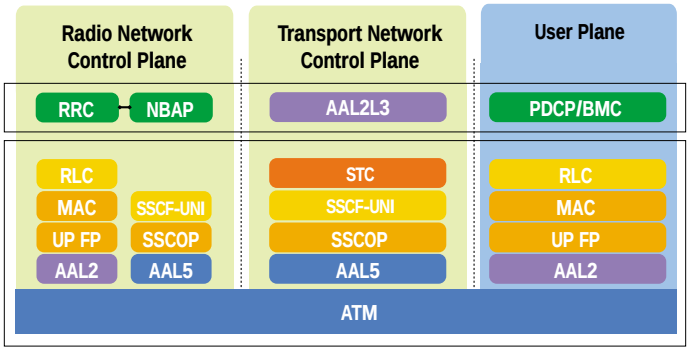


Figure 12. *Iur Protocol Stack*



▶ ***Figure 13.*** *Iub Protocol Stack*

- Ciphering control
- Outer loop power control
- Message integrity protection
- Timing advance in the TDD mode
- UE measurement report evaluation
- Paging and notifying

Two modes of operation are defined for the UE – the idle mode and the dedicated mode. In the idle mode the peer entity of the UE's RRC is at the Node B, while in the dedicated mode it is at the SRNC. The dedicated mode is shown in figure 11.

Higher-layer protocols to perform signaling and control tasks are found on top of the RRC. The MM and CC are defined in the existing GSM specifications. Even though MM and CC occur between the UE and the CN and are therefore not part of UTRAN specific signaling (see figure UU), they demand basic support from the transfer service which is offered by Duplication Avoidance (see 3G TS 23.110). This layer is responsible for in-sequence transfer and priority handling of messages. It belongs to UTRAN, even though its peer entities are located in the UE and CN.

3.3 Transport Network Layer specific layer 3 signaling and control protocols.

Two types of layer 3 signaling protocols are found in the Transport Network Layer:

- Iu, Iur: Signaling Connection Control Part (SCCP) [ITU-T Q.711 - Q.716] provides connectionless and connection-oriented services. On a connection-oriented link it separates each mobile unit and is responsible for the establishment of a connection-oriented link for each and every one of them.
- Iu-CS, Iur, Iub: Access Link Control Application Part (ALCAP) [ITU-T Q.2630.1, Q.2150.1, and Q.2150.2]. Layer 3 signaling is needed to set up the bearers to transmit data via the User Plane. This function is the responsibility of the ALCAP, which is applied to dynamically establish, maintain, release, and control AAL2 connections. ALCAP also has the ability to link the connection control to another higher layer control protocol. This, and additional capabilities were specified in ITU-T Q.2630.1. Because of the protocol layer specified in Q.2630.1, a converter is needed to correspond with underlying sub-layers of the protocol stack. These converters are called (generically) Signaling Transport Converter (STC). Two converters are defined and applied in UTRAN:
  - Iu-CS, Iur: AAL2 STC on Broadband MTP (MTP3b) [Q.2150.1]
  - Iub: AAL2 STC on SSCOP [Q.2150.2]

3.4 Transport Network Layer specific "transmission" technologies.

Now that we have a circuit switched and packet switched domain in the CN and a growing market for packet switched network solutions, a new radio access network must be open to both types of traffic in the long run. That network must also transmit the layer 3 signaling and control information. ATM was selected as the layer 2 technology, but higher layer protocols used in the Transport Network Layer demonstrate the UMTS openness to a pure IP solution.

Iu, Iur, Iub: Asynchronous Transfer Mode (ATM) [ITU-T I.3610]
Broadband communication will play an important role with UMTS. Not only voice, but also multimedia applications such as video conferencing, exploring the Internet and document sharing are anticipated. We need a data link technology that can handle both circuit-switched and packet-switched traffic as well as isochronous and asynchronous traffic. In UMTS (Release '99), ATM was selected to perform this task.

An ATM network is composed of ATM nodes and links. The user data is organized and transmitted in each link with a stream of ATM cells. ATM Adaptation Layers (AAL) are defined to enable different types of services with corresponding traffic behavior. Two of these are applied in UTRAN:

- Iu-CS, Iur, Iub: ATM Adaptation Layer 2 (AAL2) [ITU-T I.363.2] With AAL2, isochronous connections with variable bit rate and minimal delay in a connection-oriented mode are supported. This layer was designed to provide real time service with variable data rates, such as voice and video.
- Iu-PS, Iur, Iub: ATM Adaptation Layer 5 (AAL5) [ITU-T I.363.5] With AAL5, isochronous connection with CBR, VBR, UBR, and ABR in a connection-oriented mode are supported. This layer is used for IP and signaling. In UTRAN, AAL5 is used to carry the packet switched user traffic in the Iu-PS-interface and the signaling and control data throughout.

In order to carry signaling and control data, the AAL5 has to be "enhanced." Here, UTRAN offers both a "classical" ATM solution and an IP-based approach:

- Signaling AAL and MTP3b

  To make Signaling AAL (SAAL) available in place of the AAL5 sub-layer SSCS, the SSCOP, which provides a reliable data transfer service, and the SSCF, which acts as coordination unit, are defined:

- Iu, Iur, Iub: Service Specific Connection Orientated Protocol (SSCOP) [ITU-T Q.2110]

  The SSCOP is located on top of the AAL layer. It is a common connection-oriented protocol which provides a reliable data transfer between peer entities. Its capabilities include the transfer of higher layer data with sequence integrity, flow control, connection maintenance in case of a longer data transfer break, error correction by protocol control information, error correction by retransmission, error reporting to layer management, status report, and more.

Two versions of the Service Specific Coordination Function (SSCF) are defined: one for signaling at the User-to-Network Interface (UNI), and one for signaling at the Network-Node Interface (NNI):

- Iub: Service Specific Coordination Function for Support of Signaling at the User-Network Interface (SSCF-UNI) [ITU-T Q.2130]

  The SSCF-UNI receives layer 3 signaling and maps it to the SSCOP, and visa versa. The SSCF-UNI performs coordination between the higher and lower layers. Within UTRAN, it is applied in Iub with the NBAP and ALCAP on top of the SSCF-UNI.

- Iu, Iur: Service Specific Coordination Function at the Network Node Interface (SSCF-NNI) [ITU-T Q.2140]

  The SSCF-NNI receives the SS7 signaling of a layer 3 and maps it to the SSCOP, and visa versa. The SSCF-NNI performs coordination between the higher and the lower layers. Within UTRAN, MTP3b has the higher layer 3, which requires service from the SSCOP-NNI.

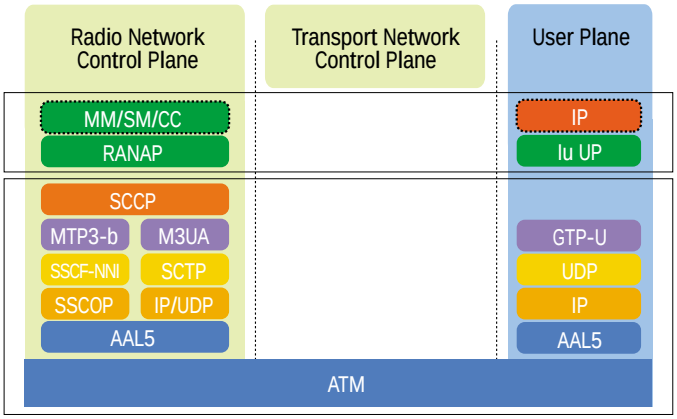


Figure 14. *Iu-PS Protocol Stack*

Originally the SS7 protocol layer, SCCP relies on the services offered by MTP, so the layer 3 part of the MTP must face the SCCP layer:

- Iu, Iur: Message Transfer Part Level 3 (MTP3b) [ITU-T Q.2210]

  Signaling links must be controlled in level 3 for: message routing, discrimination and distribution (for point-to-point link only), signaling link management, load sharing, etc. The specific functions and messages for these are defined by the MTP3b, which requires the SSCF-NNI to provide its service.

The layer 3 signaling and control data can also be handled by an enhanced IP-protocol stack using a tunneling function (see figure 12). Tunneling is also applied for packet switched user data over the Iu-PS-interface (see figure 14).

- IP over ATM:
  - Iu-PS, Iur: Internet Protocol (IP) [IETF RFC 791, 2460, 1483, 2225], User Datagram Protocol (UDP) [IETF RFC 768] The

Internet Protocol can be encapsulated and then transmitted via an ATM connection, a process which is described in the RFC 1483 and RFC 2225. Both IPv4 and IPv6 are supported. IP is actually a layer 3 protocol. UDP is applied on top of the unreliable layer 4 protocol. The objective is to open this signaling link to future "pure IP" network solutions.

In order to tunnel SCCP or ALCAP signaling information, two protocols are applied:

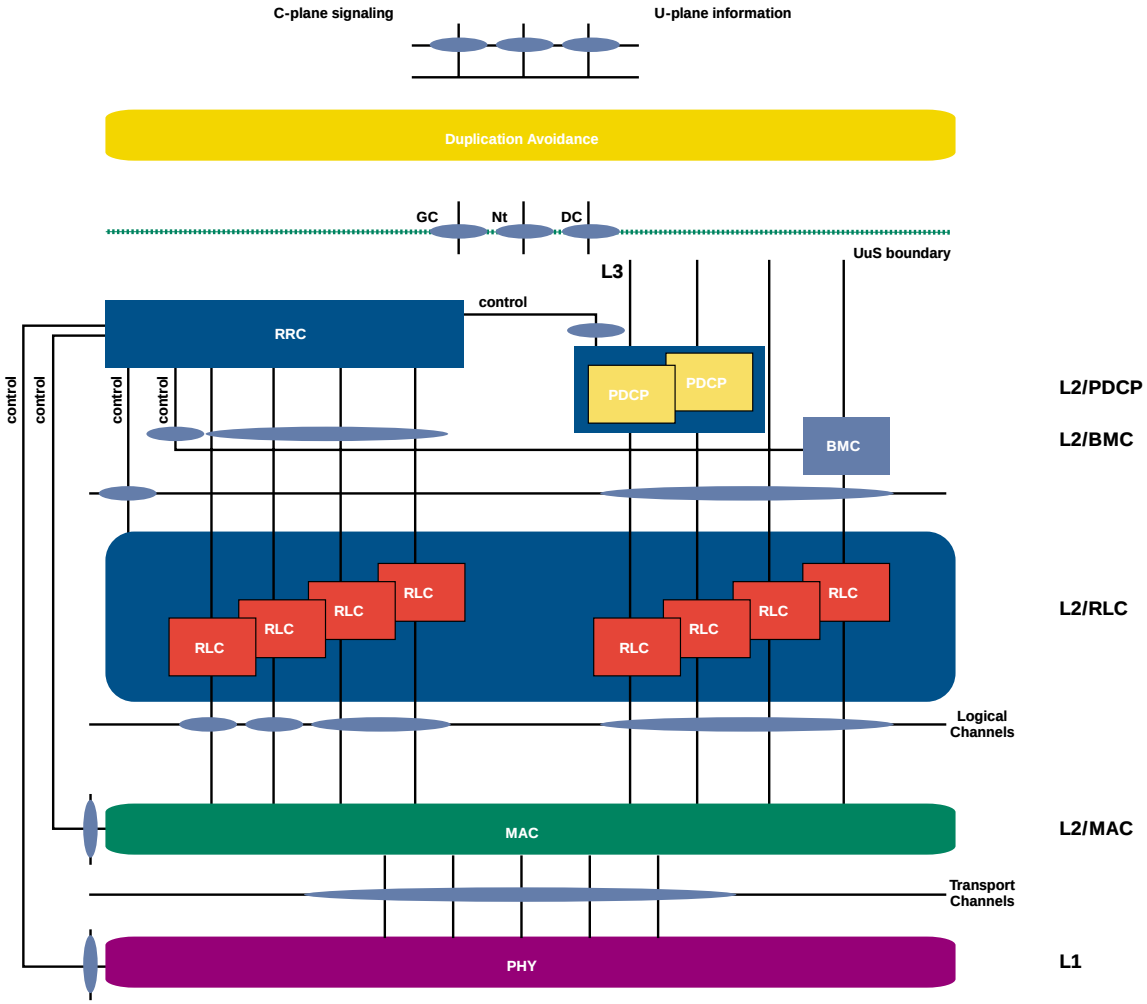
- Iu-PS, Iur: Simple Control Transmission Protocol (SCTP) [IETF draft-ieft-sigtran-sctp-v0.txt]

  This protocol layer allows the transmission of signaling protocols over IP networks. Its tasks are comparable with MTP3b. On Iu-CS, SS7 signaling must be tunneled between the CN and the RNC. This is planned to be done with the Iu-PS, Iur: SS7 MTP3-User Adaptation Layer (M3UA) [IETF draft-ietf-sigtran-m3ua-02.txt]

The tunneling of packet switched user data is done with the:

- Iu-PS: GPRS Tunneling Protocol (GTP) [3G TS 29.060]

  The GTP provides signaling (GTP-C) and data transfer (GTP-U) procedures. Only the latter is applied in the Iu-PS interface, since the control function is handled by the RANAP protocol. The GTP-U is used to tunnel user data between the SGSN and the RNC.



▶ ***Figure 15.*** *Uu Interface Protocol Structure (adopted from 3G TS 25.301 V3.3.0, p. 11)*

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.