Sangoma WAN EduKit

Sample Laboratory for X.25

X.25 LAB 1 Loading and using the monitoring and testing tools for X.25

Objective

Provide an introduction to the usage of the Sangoma WAN EduKit.

Background

A basic knowledge of the X.25 and HDLC LAPB protocols is required to make full use of the Sangoma WAN EduKit. This knowledge should include the familiarity with commonly used definitions such as SVC, PVC, LCN and ABM as well as an understanding of the format of HDLC frames and X.25 packets. In addition, the user should be acquainted with commonly used X.25 procedures such as call setup, call clearing, restart and reset procedures.

Preparation

Ensure that Sangoma WAN EduKit is installed as per instructions.

Lab Instructions

Starting the Sangoma WAN EduKit for X.25

Click on “Start->Programs->Sangoma Tools->WAN EduKit”. Select “X.25”. Two tester windows will be opened, one for the Data Terminal Equipment (DTE) and one for the Data Circuit-Terminating Equipment (DCE) side of the network. Note that these windows are titled “X.25 Tester – DTE” and “X.25 Tester – DCE” respectively. The X.25 firmware will be downloaded to the adapter and a network connection will be established. You will notice that the testers include a number of buttons that will allow you to execute functions such as placing X.25 calls, sending and receiving Data packets and setting the X.25 configuration. Each tester includes a status window that is used to display the details and results of commands issued by the tester to the hardware.
In addition, this window indicates the occurrence of asynchronous X.25 events such as call setups, resets and restarts. There is a menu at the top of the tester application that allows access to various monitoring functions, protocol statistics and a line trace.

Monitoring asynchronous procedures using the X.25 Tester application

Using the window labeled “X.25 Tester – DTE”, click on the “Reset Call” button in the “X.25/HDLC Procedures” section. Set the LCN (Logical Channel Number) to ‘1’ and click “OK”. A Reset Request packet will be transmitted from the DTE to the DCE on LCN 1 and the DCE will respond with a Reset Confirmation packet. Examine the status window in the DCE tester (“X.25 Tester – DCE”). You will see the following:

Asynchronous X.25 packet received on LCN 1, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: RESET REQUEST/INDICATION (Responded Automatically)

This indicates that the DCE received a Reset Request packet on LCN 1 with the X.25 cause and diagnostic fields both set to 0x00. The DCE then automatically issued an appropriate response by sending a Reset Confirmation packet to the DTE. Examine the status window in the DTE tester (“X.25 Tester – DTE”). You will see the following:

Reset Request transmitted on LCN 1

Asynchronous X.25 packet received on LCN 1, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: RESET CONFIRMATION

This indicates that the DTE transmitted a Reset Request packet on LCN 1 and then received a Reset Confirmation packet in response. Note that each event displayed in the status windows includes a time stamp that assists in understanding the sequence of these transactions. For example, in the LCN resetting procedure previously described, the time stamps confirm that the DTE first transmitted the Reset Request packet, then the DCE received the Reset Request packet and transmitted the Reset Confirmation response, and then the DTE received the Reset Confirmation packet.

Reading the HDLC and X.25 configuration

Using the window labeled "X.25 Tester – DTE", click on the "Configure HDLC/X.25" button in the "Configuration" section to open an X.25 and HDLC configuration window. The HDLC configuration parameters are shown in the "HDLC Layer Configuration" section of this window. A number of buttons are listed, permitting access the various X.25 configuration parameters. Click on the "Logical Channels" button to display the current X.25 LCN configuration. Note that logical channels 1 through 3 have been configured as PVCs (Permanent Virtual Circuit) and that logical channels 4 and 5 have been configured as SVCs (Switched Virtual Circuit). This Logical Channel configuration is the default configuration at both the DTE and DCE stations in the Sangoma WAN EduKit. Click on "Cancel" to close the LCN configuration window. Click on "Cancel" to close the "X.25/HDLC Configuration" window.

Reading the HDLC link status

From the "HDLC Monitor" menu in the "X.25 Tester – DTE" window, select "Link Status". The current HDLC link status will be shown to be ABM (Asynchronous Balanced Mode), which means that the link is in the information transfer phase and that X.25 packets may be transferred over the HDLC link. Close the "HDLC Link Status" window.

Reading the HDLC operational statistics

From the "HDLC Monitor" menu, select "Operational Statistics". This window displays a counter for various types of HDLC Supervisory frames transmitted and received as well Information frame counters. Note that the X.25 protocol is carried inside HDLC I-frames. For example, reset these HDLC statistics by clicking on the "Flush" button. Using the window labeled "X.25 Tester – DTE", select "Restart" in the "X.25/HDLC Procedures" section and click "OK". A Restart Request packet will be transmitted from the DTE to the DCE and the DCE will respond with a Restart Confirmation packet. Re-examine the I-frame counters in the "Operational Statistics" window and you will see that both the transmit and receive I-frame counters have been incremented to reflect the X.25 transaction. Close this statistics window.

Listing the 'active' X.25 Logical Channels

From the "X.25 Monitor" menu, select "Active Channels". This window indicates that Logical Channels 1 through 3 are active (corresponding to the configured PVCs) and that data may be transferred on these LCNs. Note that logical channels 4 and 5 (configured as SVCs) are not 'active' as no call setup procedures have taken place on these LCNs. Close this window.

Reading the X.25 operational statistics

From the "X.25 Monitor" menu, select "Statistics". This window displays a counter for the various types of X.25 packets transmitted and received. Reset these statistics by clicking on the "Flush" button. Using the window labeled "X.25 Tester – DTE", select "Restart" in the "X.25/HDLC Procedures" section and click "OK". Examine the X.25 counters in the "X.25 Statistics" window and you will see that a Restart Request packet was transmitted and a Restart Confirmation packet was received. Close this statistics window.

Reading the X.25 history table

From the "X.25 Monitor" menu, select "History Table". This window displays a summary of asynchronous transactions that have taken place on the X.25 network. You will see a listing of the Restart and Reset procedures previously performed. Close this window.

Using the line trace

From the “Line Trace” menu, select “Open Line Trace Window” and real-time line trace data will be displayed. Note that there are two separate trace windows; one for HDLC frames and one for the encapsulated X.25 packets. Examine the “HDLC Level Trace” window. Every five seconds, an HDLC-level RR frame will be transmitted and received in accordance with the configured T4 timer. Note that this timer defines the maximum time that a DTE will allow without frames being exchanged on the HDLC link. Also, note that the “X.25 Level Trace” window is empty, as there are currently no X.25 transactions. Using the window labeled “X.25 Tester – DTE”, select “Restart” in the “X.25/HDLC Procedures” section and click “OK”. On the trace window, enable the “Stop Autoscroll” feature so as to freeze the line trace. The “X.25 Level Trace” window now shows the transmitted Restart Request and the received Restart Confirmation packets. In addition, the “HDLC Level Trace” window indicates that an I-frame (INFO) has been transmitted and received. These I-frames were used to carry the X.25 Restart Request and Restart Confirmation packets. On the trace window, disable the “Stop Autoscroll” feature so as to re-enable the line trace. The line trace may also be configured to show a hexadecimal dump of the transmitted and received data. Click on the “Show Raw Trace” button and a hexadecimal data dump will appear in the “Raw Hex Trace” window. Close the line trace window.

X.25 LAB 2 Sending and receiving Data packets

Objective

Use the Sangoma WAN EduKit to send and receive Data packets across an X.25 network. Usage of the Qualifier bit (Q-bit), Delivery Confirmation bit (D-bit) and More Data mark (M-bit) will be examined.

Background

Data packets may be transferred across an X.25 network on all Logical Channels that are currently indicated to be in the data transfer state. In addition to the actual user data, these packets may optionally set the Q-bit, D-bit and/or the M-bit depending on the requirements of the application.

- Q-bit: Is used in Data packets to differentiate between two types of information carried in the data field. For example, an application may transfer both user data and control information in Data packets. The Q-bit is then set in the control packets to differentiate these Data packets from those containing only user data. The Q-bit is found in the General Format Identifier (GFI) nibble of the Data packet.

- D-bit: In normal X.25 data transfer pragmatics, Data packets are only acknowledged by the receiving station according to the configured (or negotiated) X.25 window parameter. By setting the D-bit to 1 in a transmitted Data packet, the station indicates that an immediate end-to-end acknowledgement of the transmitted Data packet is required. The D-bit is found in the General Format Identifier nibble of the Data packet.

- M-bit: Is used to indicate a sequence of more than one Data packet. For example, if an application is performing a file transfer, the M-bit may be set in every transmitted Data packet except the last one. It is important to note that the M-bit should only be set in full Data packets, where the number of data bytes transmitted is equal to the configured (or negotiated) X.25 packet size.

Preparation

The Sangoma WAN EduKit for both the DTE and the DCE should be active.

Lab Instructions

Displaying received X.25 Data packets

Incoming X.25 Data packets will be displayed in the status window of the "X.25 Tester – DTE" and "X.25 Tester – DCE" application programs.

Sending X.25 Data packets on a specified Logical Channel

Using the window labeled "X.25 Tester – DTE", click on the "Send" button in the "Send/Receive Data" section to open a Data packet transmission window. You will notice that the tester has been preconfigured to send the hexadecimal data 0x01 0x02 0x03 by default. Also, the Q-bit, D-bit and M-bit options are not selected. Set the "LCN" field to '1' so as to transmit data on Logical Channel 1. Click "OK", and the Data packet will be transmitted. Examine the status window of the "X.25 Tester – DCE". You will see the following:

Data packet received on LCN 1, Q:0, D:0, M:0 (length: 3)
Data: 01 02 03

This indicates that 3 bytes of data were received on LCN 1. Note that the Q, D and M-bits were all set to 0 in the Data packet.

Sending X.25 Data packets with the Q-bit set
Using the window labeled "X.25 Tester – DTE", click on the "Send" button in the "Send/Receive Data" section to open a Data packet transmission window. Set the "LCN" field to '1' and enable the Q-bit option. Click "OK" to transmit the Data packet. Examine the status window of the "X.25 Tester – DCE". You will see the following:

Data packet received on LCN 1, Q:1, D:0, M:0 (length: 3)
Data: 01 02 03

This indicates that 3 bytes of data were once again received on LCN 1. Note that the Q-bit is set to 1, correctly indicating the reception of a Data packet on LCN 1 with the Q-bit set.

D-bit usage in X.25 Data packets
Using the window labeled "X.25 Tester – DTE", click on the "Configure HDLC/X.25" button in the "Configuration" section to open an X.25 and HDLC configuration window. Click on the "Packet & Window Size" button. Note that the "Default packet window" is set to 2. The packet window defines the number of Data packets authorized to cross the interface before these transmitted packets are acknowledged by the receiving station. So, a packet window of 2 implies that the transmitting station may only transmit 2 Data packets before receiving an acknowledgement from the remote station. Press "Cancel" to close the "Packet & Window Size" window. Press "Cancel" to close the "X.25/HDLC Configuration" window. From the "Line Trace" menu in the "X.25 Tester – DTE" window, select "Open Line Trace Window" and real-time line trace data will be displayed. Note that the "X.25 Level" trace window is empty, as there are currently no X.25 transactions. Using the window labeled "X.25 Tester – DTE", click on the "Send Many" button in the "Send/Receive Data" section to open a Data packet transmission window. Set the "LCN" to '1', the "# to send" to '10' and the "Size (bytes)" to '10'. Click "OK" and 10 Data packets each of length 10 bytes will be transmitted on LCN 1. Re-examine the "X.25 Level" trace window. You will see a sequence of two Data packets transmitted (TX) and then an RR packet received (RX) to acknowledge the two transmitted Data packets. This trace confirms the packet window setting of 2 and the relevant discussion above. Now, using the window labeled "X.25 Tester – DTE", click on the "Send" button in the "Send/Receive Data" section to open a Data packet transmission window. Set the "LCN" field to '1' and enable the D-bit option. Click "OK" to transmit the Data packet. Repeat this transmission procedure 3 times, taking care to set the D-bit before each transmission. Re-examine the "X.25 Level" trace window. You will now see a sequence of a single Data packet transmitted (with the D-bit set) and then an RR packet received (RX) to acknowledge the transmitted Data packet. This is because by setting the D-bit to 1 in a transmitted Data packet, the station indicates that an immediate end-to-end acknowledgment of that transmitted Data packet is required. Close the line trace window.

M-bit usage in X.25 Data packets
Using the window labeled "X.25 Tester – DTE", click on the "Configure HDLC/X.25" button in the "Configuration" section to open an X.25 and HDLC configuration window. Click on the "Packet & Window Size" button. Note that the "Default packet size in bytes" is set to 128 bytes. This implies that the M-bit should only be set in Data packets where the length of the data being transmitted is equal to 128 bytes. Press "Cancel" to close the "Packet & Window Size" window. Press "Cancel" to close the "X.25/HDLC Configuration" window. Using the window labeled "X.25 Tester – DTE", click on the "Send" button in the "Send/Receive Data" section to open a Data packet transmission window. Set the "LCN" field to '1' and enable the M-bit option. Click "OK" to transmit the Data packet. Examine the status windows of both the DTE and DCE testers. You will see that there has been an X.25 asynchronous transaction, with a Reset Request packet being sent by the DCE. This transaction was the result of a procedural error in that a partially full Data packet was transmitted with the M-bit set. It is important to note that the X.25 protocol includes an extensive list of diagnostic codes to indicate the reason for the asynchronous transaction. Examine the "X.25 Tester – DTE". You will see the following:

Asynchronous X.25 packet received on LCN 1, Q:0, D:0, M:0, Cause:0x05, Diag: 0xA5
Async. packet type: RESET REQUEST/INDICATION (Responded Automatically)

The diagnostic code of 0xA5 is defined in the X.25 ISO 8208 standard as "invalid partially full Data packet". By examining this diagnostic code, the application will be made aware of the reason for the procedural error and necessary adjustments can be made to the configuration and/or application to remedy this error. Using the window labeled "X.25 Tester – DTE", click on the "Send Many" button in the "Send/Receive Data" section to open a "Multiple Send" Data packet transmission window. Set the "LCN" field to '1' so as to transmit data on Logical Channel 1. Set the "# to send" to '1' and the "Size (bytes)" to '128'. Enable the M-bit option and click "OK" to transmit the Data packet. Examine the status window of the "X.25 Tester – DCE". You will see that a Data packet of length 128 bytes has been received with the M-bit set (“M:1”). There are no procedural errors, as the M-bit is being set in a Data packet of length 128 bytes, which matches the configured default packet size.

X.25 LAB 3 Virtual Call setup and clearing

Objective

Use the Sangoma WAN EduKit to demonstrate X.25 call setup and clearing procedures.

Background

Virtual calls may be setup and cleared on Logical Channels configured to be Switched Virtual Circuits (SVCs). SVCs are very much like telephone calls; a connection is established, data may be transferred and then the connection is released. Each DTE on the network is given a unique DTE address that can be used much like a telephone number. To establish a connection on an SVC, the calling DTE sends a Call Request packet, which includes the address of the remote DTE to be contacted.
The destination DTE decides whether or not to accept the call (the Call Request packet includes the sender's DTE address, as well as other information that the called DTE can use to decide whether or not to accept the call). A call is accepted by issuing a Call Accepted packet, or cleared by issuing a Clear Request packet. Once the originating DTE receives the Call Accepted packet, the virtual circuit is established and data transfer may take place. When either DTE wishes to terminate the call, a Clear Request packet is sent to the remote DTE, which responds with a Clear Confirmation packet.

Preparation

The Sangoma WAN EduKit for both the DTE and the DCE should be active.

Lab Instructions

Issuing an X.25 Call Request packet (basic)

Using the window labeled “X.25 Tester – DTE”, click on the “Place Call” button in the “X.25/HDLC Procedures” section. In the “Data” entry section of the “Place Call Transaction Data” window, enter:

‘-d123’

Click “OK”. Examine the “X.25 Tester – DCE” status window. You will see the following, indicating that the DCE received a Call Request packet from the DTE:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL REQUEST/INCOMING CALL
Data: -d123 –f430202420707

There are four separate fields associated with a Call Request packet that are of interest:

- The Called DTE Address – this field is analogous to a telephone number and contains the unique DTE address allocated to the remote device. In the Sangoma X.25 code this field is preceded by a ‘-d’ symbol (**d**estination address), for example, ‘-d123’. The Called DTE Address field must be included in any outgoing Call Request packet.

- The Calling DTE Address – this field contains the unique DTE address allocated to the calling device. In the Sangoma X.25 code this field is preceded by a ‘-s’ symbol (**s**ource address), for example, ‘-s567’. The Calling DTE Address field is generally added to a Call Request packet by the X.25 network.

- The facilities field – this field is optional and is used to request and negotiate special features and configuration options for this Virtual Circuit. Facilities include flow control parameter negotiation, user group definitions and reverse charging, to name a few. In the Sangoma X.25 code this field is preceded by an ‘-f’ symbol (**f**acilities), for example, ‘-f0101’.

- The user data field – this field is optional and its function is to allow the inclusion of specific user data (such as passwords, protocol identifiers, etc) in the Call Request packet. In the Sangoma X.25 code this field is preceded by a '-u' symbol (**u**ser data), for example, '-u1a2b'.

Issuing an X.25 Call Request packet, using the Called DTE Address, Calling DTE Address, Facilities and User Data fields

Using the window labeled "X.25 Tester – DTE", select "Restart" in the "X.25/HDLC Procedures" section and click "OK". A Restart Request packet will be issued – this serves to clear any calls pending or calls previously accepted on all SVCs. Using the window labeled "X.25 Tester – DTE", click on the "Place Call" button in the "X.25/HDLC Procedures" section. In the "Data" entry section of the "Place Call Transaction Data" window, enter:

'-d123 –s567 –f0101 –u1a2b'

Click "OK". Examine the "X.25 Tester – DCE" status window. You will see the following, indicating that the DCE received a Call Request packet from the DTE:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL REQUEST/INCOMING CALL
Data: -d123 –s567 –f0101430202420707 –u1A2B

The Call Request arguments displayed at the DCE reflect those entered in the "Place Call Transaction Data" window at the DTE, with one difference: the Sangoma X.25 code has automatically inserted additional facilities ("430202420707") into the packet. These facilities are used for packet and window size negotiation.

Call Request packets and Logical Channel allocation

Note that the Call Request packet was issued by the DTE on LCN 5. In a previous laboratory exercise, it was seen that logical channels 4 and 5 have been configured as SVCs. The X.25 specification states that for station configured as a DTE, outgoing Call Request packets are issued on the highest available SVC. Using the window labeled "X.25 Tester – DTE", select "Restart" in the "X.25/HDLC Procedures" section and click "OK". Using the window labeled "X.25 Tester – DTE", click on the "Place Call" button in the "X.25/HDLC Procedures" section. In the "Data" entry section of the "Place Call Transaction Data" window, enter:

'-d123'

Click "OK". A Call Request will be issued on LCN 5. Immediately place another call by again clicking on the "Place Call" button and entering

'-d123'

as the call data. Verify in status windows of both the DTE and DCE testers that the first Call Request packet was issued on LCN 5 and the second Call Request packet was issued on LCN 4.

Timeout pragmatics used in call setup procedures

Observe the status windows of both the DTE and DCE testers for approximately 60 seconds. You will see that a call clearing transaction occurs on LCNs 4 and 5. This is due to a timeout in the call setup procedures. If a station transmits a Call Request packet on a particular LCN, then the remote station has a finite time (defined by X.25 as the T11 or T21 timer) to respond to the call by either accepting or clearing it. In this demonstration environment, the DTE has its T21 timer set to 60 seconds, after which a Clear Request packet is issued on the LCN.

Accepting an X.25 call

From the "X.25 Monitor" menu in the "X.25 Tester – DTE" window, select "Active Channels". This window indicates that logical channels 1 through 3 are active (corresponding to the configured PVCs). Note that logical channels 4 and 5 (configured as SVCs) are not 'active' as no successful call setup procedures have taken place on these LCNs. Using the window labeled "X.25 Tester – DTE", click on the "Place Call" button in the "X.25/HDLC Procedures" section. In the "Data" entry section of the "Place Call Transaction Data" window, enter:

'-d123'

Click "OK". A Call Request will be issued on LCN 5. Using the window labeled "X.25 Tester – DCE", click on the "Accept Call" button in the "X.25/HDLC Procedures" section. Set the "LCN" to '5' and click "OK". A Call Accepted packet will be transmitted by the DCE. Examine the status windows for the DTE tester. You should see the following:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL ACCEPTED/CONNECTED

Re-examine the “Active Channels” window. You should see that LCN 5 has been added to the list of active channels and Data packets may now be transferred on this LCN.

Clearing an X.25 call

Using the window labeled “X.25 Tester – DTE”, click on the “Clear Call” button in the “X.25/HDLC Procedures” section. Set the “LCN” to ‘5’ and click “OK”. A Clear Request packet will be transmitted by the DTE. Examine the status windows for the DTE and DCE testers to confirm that the call clearing procedure has indeed taken place on LCN 5. In addition, re-examine the “Active Channels” window. LCN 5 has now been deleted from the list of active channels. Close the “Active Channels” window.

X.25 LAB 4 X.25 facilities and flow control negotiation

Objective

Use the Sangoma WAN EduKit to demonstrate the use of X.25 facilities. In particular, the Flow Control Parameter Negotiation facility is examined in detail.

Background

When setting up virtual calls, an optional facilities field may used to request and negotiate special features and configuration options for this Virtual Circuit. Facilities include flow control parameter negotiation, user group definitions and reverse charging, to name a few. In the Sangoma X.25 code this field is preceded by a '-f' (**f**acilities) symbol when placing a call. For example, '-f0101' is a facility used to request reverse charging.

Preparation

The Sangoma WAN EduKit for both the DTE and the DCE should be active.

Lab Instructions

Understanding some of the Facilities used in an X.25 Call Request packet, with special reference to the Flow Control Parameter Negotiation Facility

Using the window labeled "X.25 Tester – DTE", click on the "Place Call" button in the "X.25/HDLC Procedures" section. In the "Data" entry section of the "Place Call Transaction Data" window, enter:

'-d123 –f0101'

Click "OK". Examine the "X.25 Tester – DCE" status window. You will see the following, indicating that the DCE received a Call Request packet from the DTE:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL REQUEST/INCOMING CALL
Data: -d123 –f0101430202420707

Note the received facilities field of "0101430202420707". There are actually three different facilities included within this facilities field:

- "0101" – Reverse Charging requested. The first "01" byte indicates the type of facility (Reverse Charging or Fast Select) requested and the second "01" byte qualifies the facility to indicate that Reverse Charging has been requested and that Fast Select has not been requested.

- "430202" - Flow Control Parameter Negotiation facility and is used to negotiate the window size for the LCN. Note that this facility was not included by the user in the "Place Call Transaction Data" window. Instead, the Sangoma X.25 code has automatically inserted this additional facility so as to correctly negotiate the window size on call setup. The "43" indicates that the window size is being negotiated. The "0202" indicates the actual window size for each direction of data transmission. In this case, the window size is 2 for both directions.

- "420707" - Flow Control Parameter Negotiation facility and is used to negotiate the packet size for the LCN. Note that this facility was not included by the user in the "Place Call Transaction Data" window. Instead, the Sangoma X.25 code has automatically inserted this additional facility so as to correctly negotiate the packet size on call setup. The "42" indicates that the packet size is being negotiated. The "0707" indicates the actual packet size for each direction of data transmission as follows:

Value	Packet Size
“04”	16
“05”	32
“06”	64
“07”	128
“08”	256
“09”	512
“0A”	1024
“0B”	2048
“0C”	4096

According to this table, the packet size being negotiated is 128 bytes for both directions of data transmission.

Call Accepted/Connected packets and Flow Control Parameter Negotiation

Using the window labeled “X.25 Tester – DTE”, select “Restart” in the “X.25/HDLC Procedures” section and click “OK”. A Restart Request packet will be issued – this serves to clear any calls pending or previously accepted on all SVCs. Using the window labeled “X.25 Tester – DTE”, click on the “Place Call” button in the “X.25/HDLC Procedures” section. In the “Data” entry section of the “Place Call Transaction Data” window, enter:

‘-d123’

Click “OK”. A Call Request packet will be issued on LCN 5. Using the window labeled “X.25 Tester – DCE”, click on the “Accept Call” button in the “X.25/HDLC Procedures” section. Set the “LCN” to ‘5’ and click “OK”. A Call Accepted packet will be transmitted by the DCE. Examine the status windows for the DTE tester. You should see the following:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL ACCEPTED/CONNECTED
Data: –f430202420707

Note that the Call Accepted packet included the “430202420707” Flow Control Parameter Negotiation facilities so as to complete the packet and window size negotiations. From the “X.25 Monitor” menu in the “X.25 Tester – DTE” window, select “Active Channels”. This window indicates that logical channels 1 through 3 are active (corresponding to the configured PVCs) as well as logical channel 5, which is the SVC on which the call setup procedures have just taken place. Select LCN 5 in this list and click on the “Show Config” button. The current configuration for LCN 5 indicates that the negotiated window size is 2 and the packet size is 128 for both directions of data transmission. This corresponds to the facilities in the Call Request and Call Accepted packets. Close the “Current Configuration for LCN 5” window.

Negotiating the X.25 window and packet size

Using the window labeled “X.25 Tester – DTE”, click on the “Place Call” button in the “X.25/HDLC Procedures” section. In the “Data” entry section of the “Place Call Transaction Data” window, enter

‘-d123 –f430101420606’

Click “OK”. A Call Request will be issued on LCN 4. Using the window labeled “X.25 Tester – DCE”, click on the “Accept Call” button in the “X.25/HDLC Procedures” section. Set the “LCN” to ‘4’ and click “OK”. A Call Accepted packet will be transmitted by the DCE. Examine the status windows for the DTE tester. You should see the following:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL ACCEPTED/CONNECTED
Data: –f430101420606

Once again, examine the “Active LCNs” window. This window now indicates that logical channel 4 has become active, corresponding to the successful call setup procedure. Select LCN 4 in this list and click on the “Show Config” button. The current configuration for LCN 4 indicates that the window size is 1 and the packet size is 64 for both directions of data transmission. This corresponds to the Flow Control Parameter Negotiation facilities “430101420606” used in the call setup procedure for LCN 4. Close the “Current Configuration for LCN 4” window and then close the “Active LCNs” window.

Comparing the X.25 window sizes negotiated on Switched Virtual Circuits

From the “Line Trace” menu in the “X.25 Tester – DTE” window, select “Open Line Trace Window”. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘5’, the “# to send” to ‘10’ and the “Size (bytes)” to ‘10’. Click “OK” and the 10 Data packets each of length 10 bytes will be transmitted on LCN 5. Examine the “X.25 Level” trace window. You will see a sequence of two Data packets transmitted (TX) by the DTE and then an RR packet received (RX) from the DCE to acknowledge the two transmitted Data packets. This trace confirms the packet window setting of 2 for LCN 5 as negotiated in the call setup procedures. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘4’, the “# to send” to ‘10’ and the “Size (bytes)” to ‘10’. Click “OK” and the 10 Data packets each of length 10 bytes will be transmitted on LCN 4. Examine the “X.25 Level” trace window. You will see a sequence of one Data packet transmitted (TX) by the DTE and then an RR packet received (RX) from the DCE to acknowledge the transmitted Data packet. This trace confirms the packet window setting of 1 for LCN 4 as configured in the call setup procedures. Close the line trace window.

Checking the X.25 packet size (64 bytes) negotiated on LCN 4

Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘4’, the “# to send” to ‘1’ and the “Size (bytes)” to ‘128’. Click “OK” so as to transmit the Data packet. Examine the status window in the “X.25 Tester – DTE” application. You will the following message being repeatedly displayed:

Data length exceeds permitted maximum

This message indicates that the Sangoma X.25 code will not transmit a Data packet of length 128 bytes on LCN 4, as the maximum packet size of this LCN was negotiated to be 64 bytes. Click on the “Stop Send” button in the DTE tester. Once again, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘4’, the “# to send” to ‘1’ and the “Size (bytes)” to ‘64’. Click “OK” so as to transmit the Data packet. Examine the status window in the “X.25 Tester – DCE” application and you will see that the transmitted Data packet was received. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘4, the “# to send” to ‘1’ and the “Size (bytes)” to ‘63’. Enable the M-bit option and click “OK” so as to transmit the Data packet. Examine the status windows of both the DTE and DCE testers. You will see that there has been an X.25 asynchronous transaction, with a Reset Request packet being sent by the DCE. This transaction was the result of a procedural error in that a partially full Data packet was transmitted with the M-bit set. Once again, open a “Send Many” Data packet transmission window. Set the “LCN” field to ‘4’, the “# to send” to ‘1’ and the “Size (bytes)” to ‘64’. Enable the M-bit option and click “OK” so as to transmit the Data packet. Examine the status window in the “X.25 Tester – DCE” application and you will see that the transmitted Data packet was received with the M-bit set. This exercise confirms that the packet size was set to 64 bytes for LCN 4 during the call setup procedures.

Checking the X.25 packet size (128 bytes) negotiated on LCN 5

Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘5’, the “# to send” to ‘1’ and the “Size (bytes)” to ‘127’. Enable the M-bit option and click “OK” so as to transmit the Data packet. Examine the status windows of both the DTE and DCE testers. You will see that there has been an X.25 asynchronous transaction, with a Reset Request packet being sent by the DCE. This transaction was the result of a procedural error in that a partially full Data packet was transmitted with the M-bit set. Once again, open a “Send Many” Data packet transmission window. Set the “LCN” field to ‘5’, the “# to send” to ‘1’and the “Size (bytes)” to ‘128’. Enable the M-bit option and click “OK” so as to transmit the Data packet. Examine the status window in the “X.25 Tester – DCE” application and you will see that the transmitted Data packet was received by the DCE with the M-bit set. This exercise confirms that the packet size was set to 128 bytes for LCN 5 during the call setup procedures. Using the window labeled “X.25 Tester – DTE”, select “Restart” in the “X.25/HDLC Procedures” section and click “OK”. A Restart Request packet will be issued – this serves to clear the calls previously set up on Logical Channels 4 and 5.

X.25 LAB 5 X.25 and HDLC configuration

Objective

Demonstrate commonly used X.25 and HDLC LAPB configuration parameters and exhibit the importance of these parameters in maintaining an X.25 link.

Background

Configuration parameters of importance used when configuring an X.25 network include the following:

- HDLC LAPB-level parameters such as the station configuration (DTE or DCE), the frame window size and various timers and counters such as T1, T4 and N2.
- X.25 parameters such as the Logical Channel configuration, packet and window sizes and various timers and counters such as T10, T11, R10 and R11.

The user should combine this laboratory with reference material that describes the configuration parameters listed above.

Preparation

The Sangoma WAN EduKit for both the DTE and the DCE should be active.

Lab Instructions

Setting the station configuration (DTE/DCE) parameter

From the “HDLC Monitor” menu in the “X.25 Tester – DTE” window, select “Link Status”. The “Station configuration” will be shown as DTE and the “Link status” will be shown to be ABM (Asynchronous Balanced Mode), which means that the HDLC link is in the information transfer phase and that X.25 packets may be transferred over this link. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. In the “HDLC Layer Configuration” section, select “DCE” as the station configuration. Click “OK” to set the configuration. Re-examine the “HDLC Link Status” window. The “Station configuration” will be now shown as DCE and the “Link status” will be shown to be “DISCONNECTED” (as opposed to ABM). The reason that the HDLC link is disconnected is that both ends of the link have been configured as DCE. This causes an address conflict in the actual HDLC frames and the link setup will fail. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. In the “HDLC Layer Configuration” section, select “DTE” as the station configuration and click “OK” to set the configuration. Re-examine the “HDLC Link Status” window. The “Link status” will once again be shown to be ABM as the configuration has now been corrected with one station being DTE and the other being DCE. Close the “HDLC Link Status” window.

Usage of the HDLC LAPB T1 timer and N2 counter

Using the window labeled “X.25 Tester – DCE”, click on the “Disable X.25 Data Receiver” button in the “Send/Receive Data” section. This serves to disable the X.25 Data packet receiver function in the tester application, so that all incoming Data packets remain on the adapter and HDLC flow control logic comes into play. From the “Line Trace” menu in the “X.25 Tester – DTE” window, select “Open Line Trace Window”. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘1’, the “# to send” to ‘18’ and the “Size (bytes)” to ‘10’. Click “OK” and the 18 Data packets each of length 10 bytes will be transmitted on LCN 1. Examine the “HDLC Level” trace window. You will see a sequence similar to that shown below:

TX	**4**	**28203**	**01**	**RR**	**0**	**1**
RX	**4**	**28273**	**01**	**RNR**	**0**	**1**
TX	**4**	**29203**	**01**	**RR**	**0**	**1**

RX	**4**	**29273**	**01**	**RNR**	**0**	**1**
TX	**4**	**30203**	**01**	**RR**	**0**	**1**
RX	**4**	**30273**	**01**	**RNR**	**0**	**1**
TX	**4**	**31203**	**01**	**SABM**		**1**
RX	**4**	**31273**	**01**	**UA**		**1**

In the HDLC trace shown above, a number of I-frames (carrying X.25 Data packets) have been transmitted from the DTE to the DCE. The receive buffers at the DCE have become full and so the DCE issues an RNR (Receive Not Ready) response to each RR (Receive Ready) poll transmitted by the DTE. After the DTE receives a number of RNR responses, the DTE resets the HDLC link by issuing a SABM (Set Asynchronous Balanced Mode) frame. Enable the “Stop Autoscroll” option in the trace window so as to freeze the trace data. Notice that the time between polls issued by the DTE (TX) is 1 second. This interval is specified by a timer T1, which defines the maximum amount of time that the transmitter should wait for an acknowledgement before initiating a recovery procedure. Use the scroll bar at the side of the “HDLC Level” trace window to count the number of RNR frames received by the DTE between the issuing of SABM frames. Verify that there are 10 RNR frames received between the link resetting procedures. This counter is specified by a parameter N2, which is the maximum number of times that the LAPB station attempts to transmit the same frame without receiving a satisfactory response. In this particular case, the DTE ‘expects’ the response from the DCE to indicate that the DCE has buffered the incoming I-frames. Instead, the DCE indicates that its receive buffers are full – this is an ‘unsatisfactory’ response. After N2 retransmissions of the same frame, the link is reset. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Examine the “T1 (period timer)” and the “N2 (max re-transmit)” parameters in the “HDLC Layer Configuration” section and confirm that these values are set to 1 and 10 respectively. Click on the “Cancel” button to close the configuration window. In the line trace window, disable the “Stop Autoscroll” option so that trace data is once again displayed. Using the window labeled “X.25 Tester – DCE”, click on the “Enable X.25 Data Receiver” button in the “Send/Receive Data” section, once again allowing the DCE to accept and buffer incoming HDLC I-frames and X.25 Data packets. Re-examine the line HDLC-level trace to confirm that the DCE is no longer responding with RNR frames to RR polls issued by the DTE, but is now responding with RR frames. Close the line trace window.

X.25 Logical Channel configuration

When configuring an X.25 link, it is essential that the Logical Channel configurations match at both the DTE and DCE end of the network. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Click on the “Logical Channels” button to display the current LCN configuration. Note that logical channels 1 through 3 have been configured as PVCs (Permanent Virtual Circuit) and that logical channels 4 and 5 have been configured as SVCs (Switched Virtual Circuit). This Logical Channel configuration is the default configuration at both the DTE and DCE stations in the Sangoma WAN EduKit. Modify this configuration by setting the “Highest PVC” to ‘5’, the “Lowest SVC (2-way)” to ‘6’ and the “Highest SVC (2-way)” to ‘7’. Click “OK” to save the LCN setting and then click “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration. From the “X.25 Monitor” menu in the “X.25 Tester – DTE” window, select “Active Channels”. This window indicates that logical channels 1 through 5 are active (corresponding to the configured PVCs) and therefore Data packets should be able to be transferred on these LCNs. Close the “Active Channels” window. Using the window labeled “X.25 Tester – DTE”, click on the “Send” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” field to ‘5’ so as to transmit data on Logical Channel 5. Click “OK”, and the Data packet will be transmitted. Examine the status window of the “X.25 Tester – DCE”. You will see the following:

Protocol Violation on LCN 5, Q:0, D:0, M:0, Cause: 0x13, Diag 0x14
Transmitted Packet Type: CLEAR REQUEST/INDICATION

Clearly, the reception of this Data packet at the DCE generated a protocol error, as LCN 5 is configured as a Switched Virtual Circuit at the DCE. As far as the DCE is concerned, no call setup procedures have occurred on this SVC, and so the transfer of Data packets constitutes a protocol violation. Using the window labeled “X.25 Tester – DTE”, click on the “Place Call” button in the “X.25/HDLC Procedures” section. In the “Data” entry section of the “Place Call Transaction Data” window, enter

‘-d123’

Click “OK”. Examine the “X.25 Tester – DCE” status window. You will see the following:

Protocol Violation on LCN 7, Q:0, D:0, M:0, Cause: 0x00, Diag 0x24
Transmitted Packet Type: DIAGNOSTIC
Data: 24 10 07 13

The Logical Channel configuration at the DCE only includes LCNs 1 to 5, so the reception of a Call Request packet on LCN 7 constitutes a protocol violation. This error is indicated by the transmission of a Diagnostic packet from the DCE to the DTE. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Click on the “Logical Channels” button and modify this configuration by setting the “Highest PVC” to ‘3’, the “Lowest SVC (2-way)” to ‘4’ and the “Highest SVC (2-way)” to ‘5’ as per the original configuration. Click “OK” to save the LCN setting and then click “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration.

X.25 packet window configuration

Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘1’, the “# to send” to ‘10’ and the “Size (bytes)” to ‘10’. Click “OK” and the 10 Data packets each of length 10 bytes will be transmitted on LCN 1. The 10 Data packets will be received by the DCE and will be displayed in the status window of the “X.25 Tester – DCE” application. Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Then click on the “Packet & Window Size” button and change the “Default packet window” from ‘2’ to ‘1’. Click “OK” to save the window setting and then click “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a Data packet transmission window. Set the “LCN” to ‘1’, the “# to send” to ‘10’ and the “Size (bytes)” to ‘10’. Click “OK” to start the transmission of the Data packets. Note that now only one Data packet is transmitted by the DTE and received at the DCE. You will see the following message constantly being displayed in the status window of the “X.25 Tester – DTE” application:

Packet window closed or no transmit buffers available

What has happened is as follows: A packet window of two implies that a transmitting station may only have two unacknowledged Data packets outstanding on a selected Logical Channel at any one time. It also implies that a receiving station should acknowledge the receipt of the incoming data after buffering two Data packets. In the first data transfer test performed, the packet window sizes were set to 2 at both the DTE and the DCE stations and all 10 Data packets were correctly transmitted and received. However, in the second test, the packet window was set to 1 at the DTE, implying that this station may only have one unacknowledged Data packet outstanding at any one time. So, after transmitting the first Data packet, the DTE was awaiting an acknowledgement from the DCE. Of course, the DCE was still configured with a packet window of 2 so as to provide an acknowledgement of the receipt of the incoming data after buffering two Data packets. Clearly, this resulted in a ‘stand off’ situation, with the DTE waiting for an acknowledgement before transmitting another Data packet and the DCE waiting for the second Data packet before issuing an acknowledgement. This indicates the extreme importance of the correct configuration of the window size parameter on an X.25 network. Using the window labeled “X.25 Tester – DTE” click on the “Stop Send” button to halt data transmission. Click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Then click on “Packet & Window Size” and change the “Default packet window” from ‘1’ back to ‘2’.

X.25 packet size configuration

Examine the settings in the “X.25 Packet Configuration” window. Note that the “Default packet size in bytes” is set to ‘128’. This means that that:

a) The maximum packet size for all PVCs is 128 bytes

b) The default maximum packet size for all SVCs is 128 bytes,
unless this packet size is renegotiated during call setup.

Click “OK” to exit the “X.25 Packet Configuration” window and then click “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a “Multiple Send” Data packet transmission window. Set the “LCN” field to ‘1’ so as to transmit data on Logical Channel 1. Set the “# to send” to ‘1’ and the “Size (bytes)” to ‘128’. Enable the M-bit option and click “OK” to transmit the Data packet. Examine the status window of the “X.25 Tester – DCE”. You will see that a Data packet of length 128 bytes has been received with the M-bit set (“M:1”). Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Then click on “Packet & Window Size” button and change the “Default packet size in bytes” from ‘128’ to ‘64’. Click “OK” to save the packet size setting and then click “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration. Using the window labeled “X.25 Tester – DTE”, click on the “Send Many” button in the “Send/Receive Data” section to open a “Multiple Send” Data packet transmission window. Set the “LCN” field to ‘1’ so as to transmit data on Logical Channel 1. Set the “# to send” to ‘1’ and the “Size (bytes)” to ‘64’. Enable the M-bit option and click “OK” to transmit the Data packet. Examine the “X.25 Tester – DTE” status window. You will see the following:

Asynchronous X.25 packet received on LCN 1, Q:0, D:0, M:0, Cause:0x05, Diag: 0xA5
Async. packet type: RESET REQUEST/INDICATION (Responded Automatically)
A procedural error has occurred, as the X.25 protocol states that the M-bit should only be set in full Data packets, where the number of data bytes transmitted is equal to the configured (or negotiated) maximum X.25 packet size. Of course, due to the X.25 configuration error, the DTE considers a full Data packet to be of length 64 bytes, while the DCE considers a full Data packet to be of length 128 bytes. In this case, the DCE has transmitted a Reset Request packet to notify the DTE of the error. Note that a diagnostic code of 0xA5 is included in this Reset Request packet so as to notify the DTE of the reason for the procedural error (the code 0xA5 is defined in the X.25 ISO 8208 standard as “invalid partially full Data packet”). Using the window labeled “X.25 Tester – DTE”, click on “Configure HDLC/X.25” to open an X.25 and HDLC configuration window. Then click on “Packet & Window Size” button and change the “Default packet size in bytes” from ‘64’ to the original setting of ‘128’. Click “OK” to save the packet size setting.

X.25 timers
In the “X.25/HDLC Configuration” window, click on the “Timeouts & Counters” button. The timers and counters listed are important to the operation of an X.25 link and should be understood. For example, the timer listed as “T11/T21 (Call Request/Inc)” defines the maximum number of seconds that a Call Request/Incoming Call packet may exist on a Logical Channel before another packet is issued to change the state of that LCN. Click “OK” to exit the “Timeout Values and Retransmission Counts” window and then click on “OK” in the “X.25/HDLC Configuration” window to set the X.25 configuration. Using the window labeled “X.25 Tester – DTE”, click on the “Place Call” button in the “X.25/HDLC Procedures” section. In the “Data” entry section of the “Place Call Transaction Data” window, enter

‘-d123’

Click “OK”. Examine the “X.25 Tester – DCE” status window and you will see that a Call Request packet was received on LCN 5. Wait for 60 seconds (the configured T11/T21 timer) and you will see the following:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x05, Diag: 0x31
Async. packet type: CLEAR REQUEST/INDICATION (Responded Automatically)

The DTE did not receive an appropriate response (such as a Call Accepted or Clear Request packet) to the issued Call Request packet within the configured T11/T21 timeout period. The X.25 protocol dictates that the pending call setup procedures should be ‘abandoned’ by the transmission of a Clear Request packet so as free up the selected Logical Channel.

X.25 LAB 6 HDLC frame and X.25 packet formats

Objective

To use the line trace utility included in the Sangoma WAN EduKit to examine the format of HDLC LAPB frames and X.25 packets.

Background

According to the OSI Reference Model, X.25 encompasses the lower three layers of this OSI model; the physical, data link and network layers. The data link level is provided by HDLC LAPB and the X.25 Packet Layer Protocol (network layer) runs above (and is encapsulated within) the HDLC LAPB protocol. In this laboratory we will use the line trace utility to examine both LAPB frames and X.25 packets and match the trace data with the specified frame/packet structure. It is recommended that this exercise be performed in conjunction with formal documentation describing the format of HDLC LAPB frames and X.25 packets. In addition, the user should be familiar with commonly used definitions such as N(R) (LAPB Receive Sequence Number), N(S) (LAPB Send Sequence Number), P(R) (Packet Level Receive Sequence Number), P(S) (Packet Level Send Sequence Number) and P/F-bit (Poll/Final bit).

Note that all byte references will assume bit 0 to be the low order bit and bit 7 to be the high order bit. By default, all numbering is in decimal, and hexadecimal values are prefixed by “0x”.

The table below shows the basic (modulo 8) format of an HDLC LAPB frame according to the ISO 7776 specification (single link operation). Note that the opening and closing HDLC flag characters have been omitted, as they are not shown in the line trace.

Offset (Dec)	Value (Hex)	Definitions
0	0x01 or 0x03	Address field – For frames transmitted by a DTE, commands use the address 0x01 and responses use the address 0x03. For frames transmitted by a DCE, commands use the address 0x03 and responses use the address 0x01.
1	Various (see Table 2)	Control field – defines the type of frame and includes the poll/final bit. In addition, specific frame types contain send and receive sequence numbers.
		For a frame shown in the line trace to be of length 4 bytes, the next two bytes (offsets 2, 3) are CRC bytes. Otherwise, the byte at offset 2 is the first byte of an Information field associated with this frame.
2 to N (if applicable)	Various	CRC bytes or Information field – for a Control field defining an Information frame, this Information field contains the actual X.25 packet.

Table 1 - Basic Format of an HDLC LAPB frame

The table below shows the types of Control fields used in HDLC LAPB frames, as well as the format of each Control field.

Control Field Type	**Command and Response Usage (C/R)**	**Bit Structure** **7 6 5 4 3 2 1 0**	**Control Field (Hex)**
I (Information)	C and R	N(R) | P | N(S) | 0	0x??
RR (Receive Ready)	C and R	N(R) | P/F | 0 0 0 1	0x?1
RNR (Receive Not Ready)	C and R	N(R) | P/F | 0 1 0 1	0x?5
REJ (Reject)	C and R	N(R) | P/F | 1 0 0 1	0x?9
SABM (Set Asynchronous Balanced Mode)	C	0 0 1 | P | 1 1 1 1	0x2F or 0x3F
DISC (Disconnect)	C	0 1 0 | P | 0 0 1 1	0x43 or 0x53
UA (Unnumbered Acknowledgement)	R	0 1 1 | F | 0 0 1 1	0x63 or 0x73
DM (Disconnected Mode)	R	0 0 0 | F | 1 1 1 1	0x0F or 0x1F
FRMR (Frame Reject)	R	1 0 0 | F | 0 1 1 1	0x87 or 0x97

Table 2 – HDLC Control Field Types and Formats

The table below shows the structure of an X.25 packet encapsulated within an HDLC Information frame (I-frame). Note that the opening and closing HDLC flag characters and the CRC bytes have been omitted from this table.

Offset (Dec)	**Value (Hex)**	**Definitions**
0	0x01 or 0x03	LAPB frame: Address field
1	An I-frame as defined in Table 2 above. Note that I-frames may be differentiated from all other HDLC frames, as they have the low bit (bit 0) of the Control Field set to 0.	LAPB frame: Control field for an I-frame, and includes the poll bit and the send and receive sequence numbers.
2	Various	X.25 packet: High four bits - used for the General Format Identifier (GFI) Field as follows: Bit 7 – Qualifier bit (Q-bit) Bit 6 – Delivery Confirmation bit (D-bit) Bits 5, 4 – Modulo bits, and are set to 0 and 1 respectively in the Sangoma WAN EduKit to indicate modulo 8 support. X.25 packet: Low four bits – make up the high four bits of the Logical Channel Identifier.
3	Various	X.25 packet: The low eight bits of the Logical Channel Identifier.
4	Various (see Table 4)	X.25 packet: Packet Type Identifier - defines the type of packet. In addition, specific packet types contain send and receive sequence numbers and the More Data bit (M-bit).
5 to N (if applicable)	Various	X.25 packet: The Data/Cause/Diagnostic field associated with the specific X.25 packets type.

Table 3 - Format of an X.25 packet encapsulated within an HDLC I-frame.

The table below shows the various Packet Type Identifiers used in X.25 packets, as well as the format of each Packet Type Identifier.

Packet Type Identifier (PTI)	**Bit Structure** **7 6 5 4 3 2 1 0**	**PTI (Hex)**
Data	P(R) | M | P(S) | 0	0x??
RR (Receive Ready)	P(R) | 0 0 0 0 1	0x?1
RNR (Receive Not Ready)	P(R) | 0 0 1 0 1	0x?5
REJ (Reject)	P(R) | 0 1 0 0 1	0x?9
Call Request/Incoming Call	0 0 0 0 1 0 1 1	0x0B
Call Accept/Call Connect	0 0 0 0 1 1 1 1	0x0F
Clear Request/Clear Indication	0 0 0 1 0 0 1 1	0x13
Clear Confirmation	0 0 0 1 0 1 1 1	0x17
Reset Request/Reset Indication	0 0 0 1 1 0 1 1	0x1B
Reset Confirmation	0 0 0 1 1 1 1 1	0x1F
Restart Request/Restart Indication	1 1 1 1 1 0 1 1	0xFB
Restart Confirmation	1 1 1 1 1 1 1 1	0xFF
Diagnostic	1 1 1 1 0 0 0 1	0xF1
Interrupt	0 0 1 0 0 0 1 1	0x23
Interrupt Confirmation	0 0 1 0 0 1 1 1	0x27

Table 4 – X.25 Packet Type Identifiers and Formats

The table below shows the structure of an X.25 Call Request or Call Accepted packet encapsulated within an HDLC Information frame (I-frame). Note that the opening and closing HDLC flag characters and the CRC bytes have been omitted from this table.

Offset (Dec)	Value (Hex)	Definitions
0	0x01 or 0x03	LAPB frame: Address field
1	An I-frame as defined in Table 2 above.	LAPB frame: Control field for an I-frame, and includes the poll bit and the send and receive sequence numbers.
2	Various	X.25 packet: High four bits - used for the General Format Identifier (GFI) Field as follows: Bit 7 – Set to 0 (Q-bit) Bit 6 – Delivery Confirmation bit (D-bit) Bits 5, 4 – Modulo bits, and are set to 0 and 1 respectively in the Sangoma WAN EduKit to indicate modulo 8 support. X.25 packet: Low four bits – make up the high four bits of the Logical Channel Identifier.
3	Various	X.25 packet: The low eight bits of the Logical Channel Identifier.
4	0x0B – Call Request/Incoming Call 0x0F – Call Accepted/Call Connected	X.25 packet: Packet Type Identifier
5	Various	X.25 packet: High four bits – indicate the Calling DTE Address length. X.25 packet: Low four bits – indicate the Called DTE Address length
6 to N	Various	X.25 packet: Called DTE Address
	Various	X.25 packet: Calling DTE Address
	Various	X.25 packet: Facility Length
	Various	X.25 packet: Facilities
	Various	X.25 packet: User Data

Table 5 - Format of an X.25 Call Request or Call Accepted packet encapsulated within an HDLC I-frame.

Preparation

The Sangoma WAN EduKit for both the DTE and the DCE should be active.

Lab Instructions

Examination of a line trace that includes an HDLC link setup and an X.25 restart transaction

From the “Line Trace” menu in the “X.25 Tester – DTE” window, select “Open Line Trace Window” and real-time line trace data will be displayed. Click on the “Show Raw Trace” option so as to display a hexadecimal dump of the transmitted and received LAPB frames. Using the window labeled “X.25 Tester – DTE”, select “HDLC” in the “X.25/HDLC Procedures” section to open an HDLC function window. Click on the “Link Setup” button. The HDLC link will be re-initialized and a restart procedure will occur at the X.25 packet level. Let the line trace run for about 30 seconds and then enable the “Stop Autoscroll” feature in the trace window, so as to freeze the trace display. Using the scroll bar at the side of the line trace window look for a transaction similar to the trace below. Note - when looking for this transaction, you should disregard the time stamp and the ‘Transaction Label’ listed below.

Transaction Label

TX 4 11254 01 3F FF FF #1
RX 4 11323 01 73 83 57 #2
TX 9 11354 01 00 10 00 FB 00 00 FF FF #3

RX	**4**	**11463**	**01 21 14 26**	**#4**
RX	**7**	**11497**	**03 20 10 00 FF 05 D7**	**#5**
TX	**4**	**11544**	**03 21 FF FF**	**#6**
TX	**4**	**16514**	**01 31 FF FF**	**#7**
RX	**4**	**16578**	**01 31 95 36**	**#8**

The logic (and the frame/packet interpretation) for this transaction is as follows:

Transaction #1 (TX 01 3F FF FF): When the "Link Setup" was performed according to the instructions above, the HDLC link was re-initialized by the transmission of a SABM frame by the DTE. According to Table 1, the first byte (offset 0) in the frame (0x01) is the HDLC Address and the second byte (offset 1) in the frame (0x3F) is the Control Field. According to Table 2, a Control Field of 0x3F corresponds to a SABM frame with the Poll-bit (P-bit) set. Also, note that according to Table 1, the HDLC Address could be either 0x01 or 0x03. However, a SABM is a command frame, and a command frame issued by a DTE is given the HDLC Address 0x01. The bytes at offset 2 and 3 are the two CRC bytes in the frame. Note that in the "TX" (outgoing) frames, the CRC bytes are always set to a dummy value of "0xFF 0xFF", as the actual value of the CRC is calculated on transmission by the communications hardware and is not made available to the line trace.

Transaction #2 (RX 01 73 83 57): The byte at offset 1 in this frame is 0x73, which according to Table 2, corresponds to a UA frame with the Final-bit (F-bit) set. This UA response to the transmitted SABM frame indicates that the link is now in the ABM (Asynchronous Balanced Mode) and that information transfer may take place on the link. Note the HDLC Address (0x01) used in this frame. According to Table 2, a UA is a response frame, and a response frame issued by a DCE is given the HDLC Address 0x01. The bytes at offset 2 and 3 are the two CRC bytes in the frame. Unlike the CRC bytes in outgoing frames, the CRC bytes listed for incoming frames are the actual CRC bytes received.

Transaction #3 (TX 01 00 10 00 FB 00 00 FF FF): The byte at offset 1 in this frame is 0x00, which according to Table 2, corresponds to an I-frame with the N(R) and N(S) values set to zero and the P-bit reset. Note the N(R) and N(S) counters. These are the HDLC–level receive and send sequence numbers and have values from 0 to 7. They are used to ensure that frames are delivered in sequence and are reset to 0 by the link setup procedure described above (SABM/UA). HDLC I-frames are used to carry X.25 packets in their payload area, which begins at offset 2 in the frame. The byte at offset 2 in this frame is 0x10. According to Table 3, the four high bits of this byte represent the X.25 GFI (General Formal Identifier) the four low bits of this byte represent the four high bits of the Logical Channel Identifier. Examining this byte more closely, we see that bits 5 and 4 are set to 0 and 1 respectively, indicating X.25 modulo 8 support. The byte at offset 3 in this frame is 0x00. According to Table 3, this byte represents the low eight bits of the Logical Channel Identifier. Combining the all the bits making up the Logical Channel Identifier, we see that this packet was transmitted on LCN 0. The byte at offset 4 is set to 0xFB, which according to Table 4, indicates a Restart Request packet. This corresponds correctly to the interaction between the HDLC and X.25 layers; if the HDLC link is re-initialized and enters the ABM, the X.25 packet layer should be restarted.
Transaction #4 (RX 01 21 14 26): The byte at offset 1 in this frame is 0x21, which according to Table 2, corresponds to an RR frame with the N(R) count set to 1 and the F-bit set to 0. This frame was transmitted by the DCE to acknowledge the reception of the I-frame previously transmitted by the DTE (Transaction #3). In essence, this RR means the following to the DTE: The I-frame previously transmitted with the N(S) count set to 0 has been received and buffered by the remote station and the remote station is ready to receive an I-frame with the N(S) count set to 1.

Transaction #5 (RX 03 20 10 00 FF 05 D7): The byte at offset 1 in this frame is 0x20, which according to Table 2, corresponds to an I-frame with the N(R) count set to 1 and the N(S) count set to 0. As per transaction # 3, this HDLC I-frames is used to carry an X.25 packet in the payload area. Also, as per transaction #3, the bytes at offset 2 and 3 in this frame are 0x10 and 0x00 respectively, indicating that this packet was transmitted on LCN 0. The byte at offset 4 in this packet is set to 0xFF. According to Table 4, this is a Restart Confirmation packet, which was transmitted by the DCE in response to the Restart Request packet previously transmitted by the DTE.

Transaction #6 (TX 03 21 FF FF): The byte at offset 1 in this frame is 0x21, which according to Table 2, corresponds to an RR frame with the N(R) count set to 1 and the F-bit set to 0. This frame was transmitted by the DTE to acknowledge the reception of the I-frame previously transmitted by the CPE (Transaction #5).

Transaction #7 (TX 01 31 FF FF): The byte at offset 1 in this frame is 0x31, which according to Table 2, corresponds to an RR frame with the N(R) count set to 1 and the P-bit set to 1. Note that the time between this transaction and transaction #6 is about 5 seconds as this RR was transmitted by the DTE in accordance with the configured T4 timer. This frame has the HDLC Address set to 0x01 (command address for a DTE) and the P-bit set to 1, indication that a response is required from the DCE.

Transaction #8 (RX   01 31 95 36): This frame is the RR response to the frame transmitted by the DTE in transaction #7. Note that this frame has the HDLC Address set to 0x01 (response address for a DCE) and the F-bit set to 1, indicating that this frame is the response to the frame previously transmitted by the DTE with the P-bit set.

Decoding an X.25 Call Request packet

Disable the "Stop Autoscroll" feature in the trace window, so as to once again activate the trace display. Using the window labeled "X.25 Tester – DTE", select "HDLC" in the "X.25/HDLC Procedures" section to open an HDLC function window. Click on the "Link Setup" button. The HDLC link will be re-initialized and a restart procedure will occur at the X.25 packet level. Using the window labeled "X.25 Tester – DTE", click on the "Place Call" button in the "X.25/HDLC Procedures" section. In the "Data" entry section of the "Place Call Transaction Data" window, enter:

'-d1234 –u5678'

Click "OK". Examine the "X.25 Tester – DCE" status window. You will see the following, indicating that the DCE received a Call Request packet from the DTE:

Asynchronous X.25 packet received on LCN 5, Q:0, D:0, M:0, Cause:0x00, Diag: 0x00
Async. packet type: CALL REQUEST/INCOMING CALL
Data: -d1234 –f430202420707 –u5678

Using the window labeled "X.25 Tester – DCE", click on the "Accept Call" button in the "X.25/HDLC Procedures" section. Set the "LCN" to 5 and click "OK". A Call Accepted packet will be transmitted by the DCE. In the line trace window of the "X.25 Monitor – DTE", enable the "Stop Autoscroll" feature in the trace window, so as to freeze the trace display. Using the scroll bar at the side of the line trace window look for a transaction similar to the trace below. Note - when looking for this transaction, you should disregard the time stamp.

TX   19   1926   01 22 10 05 0B 04 12 34 06 43 02 02 42 07 07 56 78 FF FF

The byte at offset 1 in this frame is 0x22, which according to Table 2, corresponds to an I-frame with the N(R) count set to 1 and the N(S) count set to 1. The bytes at offset 2 and 3 in this frame are 0x10 and 0x05 respectively, indicating that this packet was transmitted on LCN 5. The byte at offset 4 in this packet is set to 0x0B, which, according to Table 4, is a Call Request packet. The byte at offset 5 is set to 0x04, which, according to Table 5, defines the calling DTE address length as zero and the called DTE address length as four. Note that data in call setup packets is transmitted as packed binary coded decimal, so a called DTE address length equal to four implies that four nibbles (two bytes) of address data are present. The bytes at offsets 6 and 7 define the called DTE address length as '1234' as used in the arguments entered when placing the call. The byte at offset 8 in this frame is 0x06, which defines the length of the facilities field. The bytes at offsets 9 to 14 define the actual facilities included in the Call Request packet ('430202420707') and the bytes at offsets 15 and 16 reflect the user data ('5678') provided.

Decoding an X.25 Call Accepted packet

Using the scroll bar at the side of the line trace window look for a transaction similar to the trace below.

RX   15   9989   03 42 10 05 0F 00 06 43 02 02 42 07 07 FC 1C

One again, the byte at offset 1 defines this as an HDLC I-frame. The bytes at offset 2 and 3 in this frame are 0x10 and 0x05 respectively, indicating that this packet was transmitted on LCN 5. The byte at offset 4 in this packet is set to 0x0F, which, according to Table 4, is a Call Accepted packet. The byte at offset 5 is set to 0x00, which, according to Table 5, defines both the calling and the called DTE address lengths as zero. The byte at offset 6 in this frame is 0x06, which defines the length of the facilities field. The bytes at offsets 7 to 12 define the actual facilities included in the Call Accepted packet ('430202420707') and the bytes at offsets 13 and 14 are the HDLC CRC bytes.

Decoding an X.25 Data packet

Disable the "Stop Autoscroll" feature in the trace window, so as to once again activate the trace display. Using the window labeled "X.25 Tester – DTE", click on the "Send" button in the "Send/Receive Data" section to open a Data packet transmission window. You will notice that the tester has been preconfigured to send the hexadecimal data 0x01 0x02 0x03 by default. Set the "LCN" field to '1' so as to transmit data on Logical Channel 1. Enable the Q-bit option and click "OK" to transmit the Data packet. In the line trace window of the “X.25 Monitor – DTE”, enable the “Stop Autoscroll” feature in the trace window, so as to freeze the trace display. Using the scroll bar at the side of the line trace window look for a transaction similar to the trace below. Note - when looking for this transaction, you should disregard the time stamp.

TX 10 14716 01 44 90 01 00 01 02 03 FF FF

The byte at offset 1 in this frame is 0x44, which according to Table 2, corresponds to an I-frame with the N(R) count set to 2 and the N(S) count set to 2. The byte at offset 2 in this frame is 0x90. According to Table 3, the four high bits of this byte represent the X.25 GFI (General Formal Identifier) the four low bits of this byte represent the four high bits of the Logical Channel Identifier. Examining this byte more closely, we see that bits 5 and 4 are set to 0 and 1 respectively, indicating X.25 modulo 8 support. Also, bit 7 is set which, according to Table 3, indicates that the Q-bit was set in the outgoing Data packet. Combining the all the bits making up the Logical Channel Identifier (from the bytes at offsets 2 and 3), we see that this packet was transmitted on LCN 1. The Packet Type Identifier (0x00) is found at offset 4 (see Table 3). According to Table 4, the packet is a Data packet with both the P(R) and P(S) counts set to 0, and the M-bit reset. The bytes at offsets 5 to 7 reflect the actual data in the packet (0x01 0x02 0x03) and the bytes at offsets 8 and 9 are the HDLC CRC bytes. Close the line trace monitor. Using the window labeled “X.25 Tester – DTE”, select “Restart” in the “X.25/HDLC Procedures” section and click “OK” to issue the Restart Request packet.