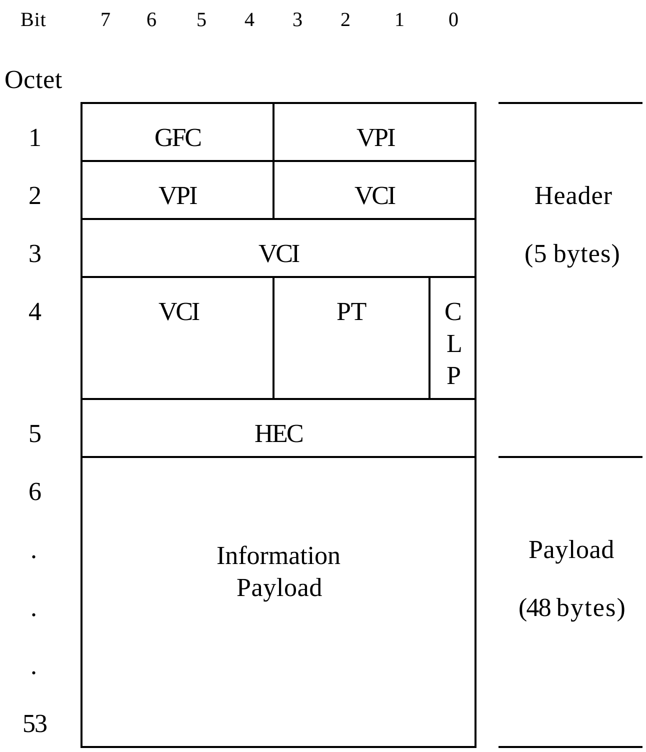
Sangoma WAN EduKit

Sample Laboratory for ATM (Asynchronous Transfer Mode)

ATM OVERVIEW

ATM is a broadband switching and multiplexing technology that uses fixed length packets called cells to transport various types of traffic. Each cell is 53 bytes in length and consists of a 5-byte header and a 48-byte payload. The cell header contains routing, payload type and priority information, as well as a HEC (Header Error Control) byte which serves to detect and/or correct errors occurring in the cell header.



GFC - Generic Flow Control (4 bits)
VPI - Virtual Path Identifier (8 bits)
VCI - Virtual Channel Identifier (16 bits)
PT - Payload Type (3 bits)
CLP - Cell Loss Priority (1 bit)
HEC - Header Error Control (8 bits)

Figure 1 - ATM cell format

ATM consists of three protocol layers: the Physical Layer (PHY Layer), the ATM Layer and the ATM Adaption Layer (AAL). The Physical Layer is responsible for handling the physical medium, for bit timing, for cell generation and reception and for passing appropriate cells to and from the ATM layer. The ATM Layer functions independently of the Physical Layer and is responsible for cell header generation and extraction, VPI/VCI translation, multiplexing and flow control. The AAL is responsible for segmentation of outgoing higher layer User Data blocks into fixed-length ATM payloads and the reassembly of incoming payloads into complete User Data blocks for passing to higher layer. In addition, the AAL performs service-dependant functions as required by the specific AAL type in use.

ATM is a connection-oriented protocol and Virtual Channels (VC) are used to define pathways between end nodes. A VC identifier has two parts; a Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI), with the virtual path containing a number of virtual channel links, all having the same endpoint. ATM supports both Permanent Virtual Connections (PVCs) and Switched Virtual Connections (SVCs). PVCs are always present at a defined interface, whereas SVCs must be set up each time a logical connection is established.

A complex ATM network requires extensive and sophisticated monitoring and failure detection capabilities. To this end, the ITU-T defined the Operations, Administration and Maintenance (OAM) functions of an ATM network, which serve to ensure the integrity and reliability of the system at all protocol levels.

ATM LAB 1 Loading and using the monitoring and testing tools for ATM

Objective

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

Background

A basic knowledge of the ATM protocol is required to make full use of the Sangoma WAN EduKit. This knowledge should include the familiarity with ATM architecture and cell formats and commonly used definitions such as CPE, AAL and OAM. Note that for ATM, the Sangoma WAN EduKit is only configured for use with PVCs (Permanent Virtual Connections) and no reference is made to SVCs (Switched Virtual Connections). In addition, AAL Type 5 is supported for carrying user data over the ATM link.

Preparation

Ensure that the Sangoma WAN EduKit is installed as per instructions.

Lab Instructions

Starting the Sangoma WAN EduKit for ATM

Click on AStart->Programs->Sangoma Tools->WAN EduKit@. Select AATM@. Two tester windows will be opened, one for the ATM Switch emulation and one for the CPE (Customer Premises Equipment) emulation. Note that these windows are titled AATM Tester B Switch@ and AATM Tester B CPE@ respectively. The ATM 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 setting the ATM configuration (at both the Phy-level and the ATM/AAL-level), sending and receiving user data and controlling the status of the PVCs. Each tester includes a status window that is used to display the details and results of commands issued by the tester to the hardware. There is a menu at the top of the tester application that allows access to various monitoring functions, protocol statistics and a line trace.

Reading the ATM PHY-Level operational statistics

From the APHY Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select AOperational Statistics@. This window displays a counter of the various types of cells received and transmitted as well as receiver synchronization statistics. Close the ACPE - PHY Operational Statistics@ window.

Reading the PVC-specific operational statistics

From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select APVC Statistics@. This window lists the PVCs that are currently configured at the CPE. Double click on the listed PVC with a VPI/VCI combination of 0/35. The operational statistics for the selected PVC will be displayed, including a count of the number of User Data blocks transferred as well as OAM statistics for that PVC. Close the ACPE - PVC statistics@ window as well as the ACPE - PVC Oper. Stats.@ window.

Reading the status of PVCs

From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select APVC Status@. This window lists the PVCs that are configured at the CPE as well as their current status (AConnected@ or ADisconnected@). User Data may be transferred on PVCs deemed to be in the AConnected@ state. Close the ACPE - VPI/VCI Status@ window.

Using the line trace

From the ALine Trace@ menu in the AATM Tester B CPE@ window, select AOpen Line Trace@ and real-time line trace data will be displayed. There are two separate windows associated with the line trace utility, one for PHY-Level cells and one for ATM Level and AAL data. You will notice that cells are constantly being displayed in the PHY-Level window. This is due to the basic nature of ATM whereby cells are constantly being transmitted on the link, even in the absence of actual user data. Click on AShow Raw Trace@ at the top of the trace window and a hexadecimal dump of the transmitted and received cells will be displayed. Close the line trace window.

ATM LAB 2 The Basics of ATM Architecture - Physical Layer

Objective

Use the Sangoma WAN EduKit to explore the Physical Layer of the ATM protocol.

Background

As discussed above, the Physical Layer is responsible for handling the physical medium, for bit timing, for cell generation and reception and for passing appropriate cells to and from the ATM layer.

Preparation

The AATM Tester@ windows for both the CPE and the Switch should be opened.

Lab Instructions

The generation of cells at the Physical Layer

ATM cells are constantly transmitted and received by the Physical Layer, even when User Data is not being transferred across the link. This is known as Acell-rate decoupling@, where the transmission rate of ATM cells matches the payload capacity of the physical medium.

From the ALine Trace@ menu in the AATM Tester B CPE@ window, select AOpen Line Trace@ and real-time line trace data will be displayed. Examine the PHY Level trace window. You will notice that cells are constantly being received (marked ARx@) and transmitted (marked ATx@). Click the AStop AutoScroll@ feature at the APHY Level Trace@ window so as to freeze the display. All (or most) of the cells displayed have been decoded as a being of type AIdle@. These Idle Cells have been inserted into the data stream to occupy available bandwidth in the absence of user-generated cells. Close the line trace window. From the APHY Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select AOperational Statistics@. The statistic ATx underrun cell count@ in the ATx Statistics@ box is an indicator of the number of cells transmitted due to cell-rate decoupling. This counter is incrementing steadily as Idle Cells are inserted into the physical medium. Similarly, the statistic ARx Idle Cell discard count@ in the ARx Statistics@ box is incrementing steadily as Idle Cells are received. It should be noted that these cells are discarded by the Physical Layer and are not passed up to the ATM Layer - this is due to cell-rate decoupling of received cells. Two additional statistics are of interest: ATx throughput (bps)@ and ARx throughput (bps)@. These values are a theoretical calculation of the baud rate of the physical medium and are calculated by dividing the number of bits transmitted or received by the time taken for this transfer. For example, assume that in the ARx Statistics@ box the ARx Idle Cell discard count@ is 7427, the ABytes received@ (non-Idle Cell byte counter) is 23479 and the ANumber ms for Rx throughput@ is 2225186 milliseconds (2225.186 seconds). The baud rate is calculated as:

$$\text{baud rate} = \frac{\text{number of bits received}}{\text{time taken}}$$

where

number of bits received = bits in Idle Cells + bits in non Idle Cells
= (7427 X number of bytes per cell X number of bits/byte) + (23479 X number of bits per byte)
= (7427 X 53 X 8) + (23479 X 8)
= 3336880

So, baud rate = $\frac{3336880}{2225.186}$ = 1499.6 bps

The default baud rate configuration for the ATM WAN EduKit is 1,500 bps, thus confirming that cells are being received at the payload capacity of the physical medium.

Close the ACPE - PHY Operational Statistics@ window.

Discover how the receiver achieves cell delineation

The Physical Layer is responsible for delineating an incoming stream of data bits into valid cells, each of length 53 bytes. The question is: How does the receiver establish cell boundaries when there is no formal ›framing= of an ATM cell? The answer to this is found in the structure of a cell (Figure 1), where the HEC (Header Error Check) byte is at a fixed position within a 53-byte cell. When a specific error check is performed on the first four bytes in the header, the result of this check must equal the value contained in the HEC byte of the same header. It is important to note that the HEC calculation includes a coset, so that even if the first four bytes in the header are all zero, the resultant HEC value is not equal to zero.

In the hunt state, the receiver continually processes incoming bytes until it finds four bytes for which the HEC calculation matches the fifth (HEC) byte in the received data. A preliminary assumption is then made that these five header bytes plus the next received 48 bytes constitute a valid cell. The receiver then enters a pre-synchronization state, where a specified number of 53 byte cells are received and the HEC values are checked for each header within that cell. If all the HEC values are determined to be correct, then the receiver is deemed to be synchronized and the higher levels of the ATM protocol stack are notified that cell delineation has been achieved.

Examine the status window of the main AATM Tester B CPE@ window. You will see the following:

PHY_READ_EXCEPTION_CONDITION PHY - Receiver entered Hunt state.
PHY_READ_EXCEPTION_CONDITION PHY - Receiver entered Presync state.
PHY_READ_EXCEPTION_CONDITION PHY - Receiver synchronized. Rx sync...

These messages serve to report the progress of the receiver as it performed the cell delineation process on startup.

From the APHY Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select AOperational Statistics@. In the ›Rx Hunt@ box, both the ARx hunt attempt count@ and the ARx hunt achieved count@ values are set to 1, indicating a successful hunt attempt. In the ›Rx Presynchronization@ box, both the APresync attempt count@ and the APresync achieved count@ values are set to 1, indicating a successful pre-synchronization attempt. Finally, in
In the ›Rx Synchronization@ box, both the ASync attempt count@ and the ASync achieved count@ values are set to 1, indicating a successful synchronization attempt. Close the ACPE - PHY Operational Statistics@ window.

Discover how the receiver maintains cell delineation

Once the receiver is synchronized, the HEC values should be checked in all incoming cells to determine if an error has occurred and re-synchronization is required. The number of cells that may be received with an invalid HEC before receiver re-synchronization occurs is configurable and is set to 1 in the default configuration for the ATM WAN EduKit. Using the window labeled AATM Tester B Switch@, click on ADisable PHY Communications@. This will cause the ATM Switch emulation to no longer transmit valid cells, but to set the transmit line to an idle state. Examine the status window of the main AATM Tester B CPE@ window. You will see the following:

PHY_READ_EXCEPTION_CONDITION PHY - cell received with an invalid HEC.
PHY_READ_EXCEPTION_CONDITION PHY - Receiver entered Hunt state.

The CPE has received a cell with an invalid HEC (due to the idle line condition) and has re-entered the hunt state. From the APHY Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select AOperational Statistics@. The statistic ARx Bad HEC count@ in the ARx Statistics@ is set to A1@, confirming the discussion above. Close the ACPE - PHY Operational Statistics@ window. Using the window labeled AATM Tester B Switch@, click on AEnable PHY Communications@ so that the ATM Switch emulation once again transmits valid cells. Examine the status window of the main AATM Tester B CPE@ window. You will see the following:

PHY_READ_EXCEPTION_CONDITION PHY - Receiver entered Presync state.

After a short while, you will see:
PHY_READ_EXCEPTION_CONDITION PHY - Receiver synchronized. Rx sync...

The receiver is once again synchronized on a cell boundary and transfer of User Data may resume.

Types of cells used for cell-rate decoupling

From the ALine Trace@ menu in the AATM Tester B CPE@ window, select AOpen Line Trace@ and real-time line trace data will be displayed. Examine the PHY Level trace window. The default configuration for the ATM WAN EduKit is to transmit Idle Cells when performing cell-rate decoupling and you will notice that vast majority of cells being received (marked ARx@) and transmitted (marked ATx@) have been decoded as a being of type AIdle@. However, Idle Cells are not the only type of cells that are used for cell-rate decoupling - the selection is dependant on the specific installation and the selected hardware vendor. For example, Unassigned cells may also be used for cell-rate decoupling. Using the window labeled AATM Tester B CPE@, click on ASet PHY Configuration@. Change the ACLP@ value in the ATx rate adaption cell format@ section from default value of A1" to A0" and click on AOK@ to save the configuration. Re-examine the CPE line trace. The cells being transmitted (marked ATx@) have been decoded as a being of type AUnassigned@, indicating that the cell being used for cell-rate decoupling in the transmit direction is an Unassigned Cell. Continue monitoring the line trace until the receiver is synchronized and incoming cells (marked ARx@) are displayed. Note that these incoming cells are decoded as a being of type AIdle@, indicating that the cell being used for cell-rate decoupling in the receive direction is still an Idle Cell. Using the window labeled AATM Tester - CPE@, click on ASet PHY Configuration@. Change the ACLP@ value in the ATx rate adaption cell format@ section back to A1@ and click on AOK@ to save the configuration. Monitor the line trace to see that an Idle Cell is now once again used for cell-rate decoupling in both the receive and transmit directions. Close the line trace window.

ATM LAB 3 The Basics of ATM Architecture - AAL (ATM Adaption Layer)

Objective

Use the Sangoma WAN EduKit to explore the ATM Adaption Layer of the ATM protocol.

Background

As discussed above, the AAL is responsible for segmentation of outgoing higher layer User Data blocks into fixed-length ATM payloads and the reassembly of incoming payloads into complete User Data blocks for passing to a higher layer. Specifically, AAL Type 5 data formats will be examined and discussed.

For transmission of AAL Type 5 data, the User Layer passes information blocks of length 0 to 65,535 bytes to the Convergence Sublayer of the AAL engine that in turn generates a Protocol Data Unit (PDU). This PDU consists of a payload and a trailer as shown in Figure 2 below.

	Payload		Trailer			
	User Information	Pad	UU	CPI	Length	CRC
Octets	0-65,535	0-47	1	1	2	4

Figure 2 - AAL Type 5 Convergence Sublayer PDU

The payload portion of the PDU consists of the actual User Information plus pad characters (generally 6A hexadecimal) required to align the PDU on a 48-byte boundary. The PDU trailer is eight bytes in length and consists of four fields:

a) The UU (User-to-User) field which contains information to be transferred transparently between AAL5 users.
b) The CPI (Common Part Indicator) field which is serves to align the PDU trailer on a 64-bit boundary.
c) The Length field which indicates the length of the actual payload. This parameter is most important for the reassembling of multiple cells into a single block of User Data by the receiver.
d) A CRC (Cyclic Redundancy Check) that is issued to detect any bit errors in the AAL5 PDU.

Preparation

The AATM Tester@ windows for both the CPE and the Switch should be opened.

Lab Instructions

The formatting of AAL5 PDUs - no PDU segmentation

From the ALine Trace@ menu in the AATM Tester B CPE@ window, select AOpen Line Trace@ and real-time line trace data will be displayed. Uncheck the AShow OAM (F5) cells@ option in the AATM/AAL Level Trace@ window and click the AFlush Trace Window@ button to clear the trace data. In the AATM Tester - CPE@ window, select ASend User Data@ and click ASend@ so as to transmit three bytes of User Information - 0x01, 0x02, 0x03. Close the ACPE - Send User Data@ window. Examine the AATM/AAL Level Trace@ in the previously opened CPE line trace and you will see that a single User Data cell has been transmitted. Examine the complete Apayload@ field by using the horizontal scroll bar. The AAL Type 5 PDU is made up as follows:

a) The PDU payload field which consists of the actual three bytes of User Information (0x01, 0x02, 0x03) followed by 37 pad characters (0x6A).

b) The AAL Type 5 trailer as described in Figure 2 above.

It is important to note that as shown in Figure 1, the length of the Information Payload in an ATM cell is 48 bytes. This implies that if the length of the User Information to be transmitted in an AAL 5 PDU is less than or equal to 40 bytes, then both the PDU payload and the 8-byte AAL Type 5 trailer will be transmitted in a single ATM cell.

In the AATM/AAL Level Trace@ window and click the AFlush Trace Window@ button to clear the AAL trace data. In the AATM Tester - CPE@ window, select ASend User Data@ and modify the ALength@ field in the ASend Many User Data blocks@ area so that 40 bytes of user data will be transmitted. Click on the AStart= button so as to transmit the User Information and close the ACPE - Send User Data@ window. Examine the AATM/AAL Level Trace@ in the previously opened CPE line trace and you will see that a single User Data cell has been transmitted. Note that the Apayload@does not contain any pad characters (0x6A), as the complete PDU payload field has been filled with the 40 bytes of actual user data.

The formatting of AAL5 PDUs - PDU segmentation required

In the AATM/AAL Level Trace@ window and click the AFlush Trace Window@ button to clear the AAL trace data. In the AATM Tester - CPE@ window, select ASend User Data@ and modify the ALength@ field in the ASend Many User Data blocks@ area so that 41 bytes of user data will be transmitted. Click on the AStart= button so as to transmit the User Information and close the ACPE - Send User Data@ window. Examine the AATM/AAL Level Trace@ in the previously opened CPE line trace and you will now see that a two User Data cells have been transmitted. The combination of the 41 bytes of user data plus the 8-byte AAL Type 5 trailer (49 bytes) is greater than the 48-byte Information Payload area of a single ATM cell; hence two User Data cells are transmitted. Examine the first User Data cell. The PDU payload field consists of the actual 41 bytes of User Information (0x01, 0x02, 0x03 ... 0x28) followed by 7 pad characters (0x6A) to make up the 48-byte ATM cell payload. Examine the second User Data cell. The PDU payload field consists 40 pad characters (0x6A) followed by the AAL Type 5 trailer, which defines the actual length of the User Information, in this case 41 bytes. The obvious question arising from this AAL segmentation logic is how does the receiver ›know=:

a) Which incoming User Data cells should be reassembled into a single User Information field and

b) Which incoming User Data cell contains the AAL Type 5 trailer so that parameters such as the actual length of the User Information may be read?

The answer lies in the 3-bit PT (Payload Type) field shown in Figure 1 (ATM cell format). The low bit of this field defines the SDU (Service Data Unit) type; if it is set to 1, then this is the last User Data cell in a segmented block and contains the AAL Type 5 trailer that is used for User Information reassembly. Re-examine the AATM/AAL Level Trace@ and you will see that the ›PT= field in the first outgoing User Data cell is set to ›0x0' and that of the second outgoing User Data cell is set to ›0x1', indicating that this is the last User Data cell in the segmented block.

In the AATM/AAL Level Trace@ window and click the AFlush Trace Window@ button to clear the AAL trace data. In the AATM Tester - CPE@ window, select ASend User Data@ and modify the ALength@ field in the ASend Many User Data blocks@ area so that 200 bytes of user data will be transmitted. Click on the AStart= button so as to transmit the User Information and close the ACPE - Send User Data@ window. Examine the AATM/AAL Level Trace@ in the previously opened CPE line trace and you will now see that a five User Data cells have been transmitted, the first four with the PT= field set to ›0x0' and the last with the PT= field set to ›0x1', designating this the last User Data cell in the segmented block. It is important to note that only the last User Data cell in a segmented block and contains the AAL Type 5 trailer; all other cells in this segmented block contain only user data or pad characters.

Close the line trace window. In the AATM Tester - CPE@ window, select ASend User Data@ and set the ANumber of User Data blocks to send@ to 50. Click on the AStart= button so as to transmit the User Information. Examine the status window of the main AATM Tester B Switch@ window and you will see that user data is being received. Note that this user data is extracted from received and reassembled AAL Type 5 cells and reflects the actual User Information transmitted at the CPE. Close the ACPE - Send User Data@ window.

ATM LAB 4 Virtual Channels

Objective

Discover how Virtual Channels are identified and used.

Background

ATM is a connection-oriented protocol and Virtual Channels (VC) are used to define pathways between end nodes. A VC identifier has two parts; a Virtual Path Identifier (VPI) and Virtual Channel Identifier (VCI), with the virtual path containing a number of virtual channel links, all having the same endpoint. The VPI and VCI values are included in the header of ATM cells as shown in Figure 1.

ATM supports both Permanent Virtual Connections (PVCs) and Switched Virtual Connections (SVCs). PVCs are always present at a defined interface, whereas SVCs must be set up each time a logical connection is established. Note that for ATM, the Sangoma WAN EduKit is only configured for use with PVCs and no further reference will be made to SVCs.

Preparation

The AATM Tester@ windows for both the CPE and the Switch should be opened.

Lab Instructions

Adding PVCs

From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B CPE@ window, select APVC Status@. This window lists the PVCs that are configured at the CPE as well as their current status (AConnected@ or ADisconnected@). On startup, the Sangoma WAN EduKit is configured to include a single PVC with a VPI of 0 and a VCI of 35 and this PVC is shown to currently be in the AConnected@ state. In the AATM Tester - CPE@ window, select AAdd Virtual Channel@ to open the window that allows you to add and configure Virtual Channels. Set the ›VPI= field to ›5' and the VCI field to ›55' and click AOK@. In the AATM Tester - CPE@ window, select AConnect/Disconnect PVC@, highlight the VC identified by VPI 5/VCI 55 and click AConnect PVC@. Close the ACPE - Connect/Disconnect PVC@ window. Examine the previously opened ACPE - VPI/VCI Status@ window and you will see that two PVCs are now listed: VPI 0/VCI 35 and VPI 5/VCI 55, with the latter VC being shown as ADisconnected@. In the AATM Tester - Switch@ window, select AAdd Virtual Channel@ to open the window that allows you to add and configure Virtual Channels. Set the ›VPI= field to ›5' and the VCI field to ›55' and click AOK@. In the AATM Tester - Switch@ window, select AConnect/Disconnect PVC@, highlight the VC identified by VPI 5/VCI 55 and click AConnect PVC@. Close the ASwitch - Connect/Disconnect PVC@ window. Re-examine the previously opened ACPE - VPI/VCI Status@ window and you will see that the status of the PVC identified by VPI 5/VCI 55 will now be shown (or will shortly be shown) as AConnected@. Close the ACPE - VPI/VCI Status@ window.

Sending and receiving User Information on different PVCs

User Information may be transferred on all PVCs deemed to be in the AConnected@ state. In the AATM Tester - CPE@ window, select ASend User Data@ and click ASend@ so as to transmit three bytes of User Information - 0x01, 0x02, 0x03. Note that this window defines the current VC on which the User Information is to be transmitted as being identified by VPI 0/VCI 35. Examine the status window of the main AATM Tester B Switch@ window and you will see that user data has been received on the Virtual Channel VPI 0/VCI 35. In the ACPE - Send User Data@ window, modify the AVPI= field to >5' and the VCI field to >55' and click ASend@ so as to transmit User Information. Close the ACPE- Send User Data@ window. Examine the status window of the main AATM Tester B Switch@ window and you will see that user data has now been received on the Virtual Channel VPI 5/VCI 55.

In the AATM Tester - CPE@ window, select ADelete Virtual Channel@ to open the window that allows you to delete Virtual Channels. Double click on the VC identified by VPI 5/VCI 55 to delete that VC and close the ACPE - Delete PVC@ window. In the AATM Tester - Switch@ window, select ADelete Virtual Channel@. Double click on the VC identified by VPI 5/VCI 55 to delete that VC and close the ASwitch - Delete PVC@ window.

ATM LAB 5 Operations, Administration and Maintenance (OAM) functions and the PVC status

Objective

The Sangoma WAN EduKit is used to demonstrate the mechanics employed by an ATM network in determining the state and availability of PVCs.

Background

ATM networks are typically characterized by a number of switches that may be connected with multiple possible routes to carry traffic generated by nodes or customer premises equipment. The Operations, Administration and Maintenance (OAM) functions of the network provide the monitoring and the defect/failure detection capabilities required by both the network managers and the ATM equipment to ensure the integrity and reliability of the system. The OAM functions operate on five levels within the Physical and ATM protocol layers so as to provide the extensive performance and fault management functions required by a sophisticated ATM network. One of the most important OAM layers is referred to as the AF5 end-to-end layer@, which provides an indication of possible user data interruption between ATM end points.

In the absence of user data, OAM Fault Management procedures employ an optional Akeep alive@ function by transmitting and receiving Continuity Check (CC) cells between end points in the ATM network. The absence of reception of both user data and timely CC OAM cells would indicate a transmission defect in the data path and link failure notifications may be issued. The Continuity Check process is controlled by OAM Activation/Deactivation procedures that determine the direction of transmission of the CC cells. It is important to note that F5 Continuity Check cells are transmitted on the same Virtual Channel as user data, thereby determining the status and ensuring end-to-end maintenance of that specific Virtual Channel.

In addition to the Continuity Check Akeep alive@ function, OAM includes a loopback capability that may be used for connectivity verification. An end point on an ATM network may issue an OAM Loopback cell and request that the receiving station loop that cell back, providing an explicit indication that loopback has occurred at the requested destination.

Preparation

The AATM Tester@ windows for both the CPE and the Switch should be opened.

Lab Instructions

The transmission and reception of OAM Continuity Check cells

From the ALine Trace@ menu in the AATM Tester B Switch@ window, select AOpen Line Trace@ and real-time line trace data will be displayed. When the AATM/AAL Level Trace@ window is full of trace data, enable the AStop AutoScroll@ feature on the line trace so as to freeze the display. The cells captured are shown as having a ACell Type@ of AOAM@, an AOAM Type@ of AFault Mgmt@ and an AOAM Funcn Type@ of AContinuity Check@. Notice that these Continuity Check cells are both being transmitted (ATx@) and received (ARx@) on the Virtual Channel identified by VPI 0/VCI 35. In addition, by computing the difference between the time stamps (1/100th second) allocated to the transmitted cells, you can see that these CC cells are being transmitted at intervals of approximately 500 1/100th seconds (5 seconds). Disable the AStop AutoScroll@ feature on the line trace so that OAM cells are once again displayed.

OAM Continuity Check cells and the PVC status

In the AATM Tester - CPE@ window, select AAdd Virtual Channel@ to open the window that allows you to add and configure Virtual Channels. There are three configuration parameters listed that are relevant to the Continuity Check procedures:

a) AOAM Continuity Check transmit timer@ - this defines the time interval between transmitted CC cells and is set to 500 1/100th seconds (5 seconds), corresponding to the time stamps seen in the line trace.

b) AOAM Continuity Check receive timer@ - this defines that maximum permitted time interval between received CC cells before a Areceive Continuity Check timeout condition@ is declared. This timer is set by default to 550 1/100th seconds (5.5 seconds).

c) AOAM Continuity Check receive disconnection counter@ - this defines the number of consecutive Areceive Continuity Check timeout conditions@ permitted before the Virtual Channel is declared as being disconnected.

Click ACancel@ to close the AATM add VPI/VCI@ window.

From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B Switch@ window, select APVC Status@. The Virtual Channel identified by VPI 0/VCI 35 is shown as being AConnected@. From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B Switch@ window, select APVC Statistics@. Double click on the listed PVC with a VPI/VCI combination of 0/35 and then click on AFlush@ to reset the displayed statistics. In the AATM Tester - CPE@ window, select AConnect/Disconnect PVC@. Highlight the Virtual Channel identified by VPI 0/VCI 35 and click on ADisconnect PVC@. This will halt the transmission of Continuity Check cells at the CPE on the Virtual Channel VPI 0/VCI 35. Close the ACPE - Connect/Disconnect PVC@ window. Re-examine the previously opened ASwitch - VPI/VCI Status@ window. The status of the Virtual Channel identified by VPI 0/VCI 35 has changed (or will shortly change to) ADisconnected@ as OAM Continuity Check cells are no longer being received. Re-examine the previously opened ASwitch - PVC Statistics@ window. The AOAM Continuity Check receive timeout counter@ statistic is incremented every 5.5 seconds as set in AOAM Continuity Check receive timer@ configuration parameter discussed above. Close the ASwitch - VPI/VCI Status@ window and the ASwitch - PVC Statistics@ window.

OAM Activation/Deactivation Procedures for Continuity Check Pragmatics

Examine the previously opened ASwitch - Line Trace@ window and enable the AStop AutoScroll@ feature on the line trace so as to freeze the display. Notice that Fault Management Continuity Check cells are now only being transmitted by the Switch (labeled ATx@) on the Virtual Channel identified by VPI 0/VCI 35 and are no longer being issued by the CPE. This is due to the fact that you have previously issued a ADisconnect PVC@ command on that VC at the CPE and no further CC cells will be transmitted. In addition, OAM Activation/Deactivation cells are now being transferred. The Switch is transmitting cells shown as having a ACell Type@ of AOAM@, an AOAM Type@ of AAct/Deact@ and an AOAM Funcn Type@ of AContinuity Check@. The payload of this OAM cell is decoded as AAct Req, B->A (To Activator)@. This indicates that the Switch is requesting (via an Activation Request) that the CPE should resume the transmission of Continuity Check cells so that the Switch may once again see the Virtual Channel as being connected. The CPE is responding to each received Activation Request with a cell shown as having a ACell Type@ of AOAM@, an AOAM Type@ of AAct/Deact@ and an AOAM Funcn Type@ of AContinuity Check@. The payload of this OAM cell is decoded as AAct/Deact Req Denied, B->A (To Activator)@. This indicates that the CPE is denying this Activation Request and Continuity Check cells will not be issued by the CPE.

Disable the AStop AutoScroll@ feature on the line trace so that OAM cells are once again displayed. In the AATM Tester - CPE@ window, select AConnect/Disconnect PVC@. Highlight the Virtual Channel identified by VPI 0/VCI 35 and click on AConnect PVC@. Close the ACPE - Connect/Disconnect PVC@ window. Re-examine the previously opened

ASwitch - Line Trace@ window and enable the AStop AutoScroll@ feature on the line trace so as to freeze the display. Using the scroll bar, you will see that the CPE has now   responded to an Activation Request transmitted by the Switch with a cell shown as having a ACell Type@ of AOAM@, an AOAM Type@ of AAct/Deact@ and an AOAM Funcn Type@ of AContinuity Check@. The payload of this OAM cell is decoded as AAct/Deact Req Confirmed, B->A (To Activator)@. This indicates that the CPE is confirming the Activation Request and Continuity Check cells will once again be issued by the CPE. From the AATM/AAL Level Status/Statistics@ menu in the AATM Tester B Switch@ window, select APVC Status@. The Virtual Channel identified by VPI 0/VCI 35 is shown as being AConnected@. Close the ASwitch - VPI/VCI Status@ window.

The transmission and reception of OAM Loopback cells

Disable the AStop AutoScroll@ feature on the line trace so that OAM cells are once again displayed. In the AATM Tester - CPE@ window, select ASend OAM Loopback Cell@. Double click on the listed PVC with a VPI/VCI combination of 0/35 and an OAM Loopback cell will be issued. Close the ACPE - send a Loopback cell@ window. Enable the AStop AutoScroll@ feature on the previously opened AATM/AAL Level Trace@ line trace window so as to freeze the display. Using the vertical scroll bar, you will find a transaction where the Switch has received a cell shown as having a ACell Type@ of AOAM@, an AOAM Type@ of AFault Mgmt@ and an AOAM Funcn Type@ of ALoopback@. The Switch in turn has issued an OAM Loopback response to this cell. This represents a typical end-to-end OAM Loopback transaction, where the receiving station is requested to respond to a received Loopback cell. Close the ASwitch - Line Trace@ window.

ATM LAB 6 ATM Cell Formats

Objective

Use the line trace utility included in the Sangoma WAN EduKit to examine the format of ATM cells.

Background

An ATM cell is 53 bytes in length and consists of a 5-byte header and a 48-byte payload as shown in Figure 1. The various fields within this header contain routing, payload type and priority information, as well as a HEC (Header Error Control) byte which detects and/or corrects errors occurring in the header. Some commonly used ATM header fields are shown in Table 1 below.

Cell Type	**VPI**	**VCI**	**PT**	**CLP**
Idle	0x000	0x0000	0x0	0x1
VC end-to-end OAM (F5)	Any	Any (other than 0x0000)	0x5	0x0 or 0x1
ATM user data	Any	Any (other than 0x0000)	0x0 (no congestion, SDU type 0) 0x1 (no congestion, SDU type 1) 0x2 (congestion, SDU type 0) 0x3 (congestion, SDU type 1)	0x0 or 0x1

Table 1. Commonly used ATM header fields.

Once the ATM cell header has been used to identify the payload type, then further interpretation of the actual payload may be necessary. For example, if an F5 OAM cell is found, then the 48-byte payload area of the cell includes OAM-specific fields that determine the OAM cell type, the OAM function type and function-specific fields. In addition, a 10-bit CRC (Cyclic Redundancy Check) value is included so as to detect any bit errors in the OAM cell. The format of an OAM Cell is shown in Figure 3 below.

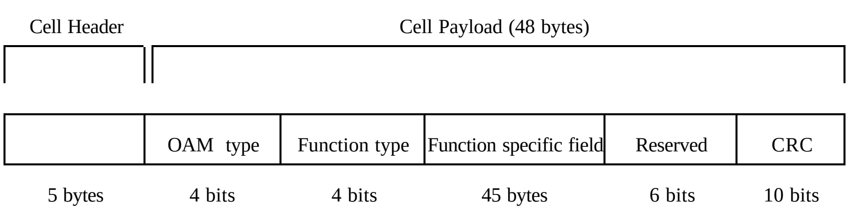


Figure 3 - OAM cell format

As discussed in the exercise AOperations, Administration and Maintenance (OAM) functions and the PVC status@, an OAM cell definition allows a number of different operations, administration and maintenance functions to be performed. Table 2 below lists selected OAM cell types and their associated formats.

OAM Type	**Coding (binary)**	**Function Type**	**Coding (binary)**	**Application**
Fault Management	0001	Continuity Check	0100	Connection integrity check
		Loopback	1000	Route tracing/fault location
Activation/Deactivation	1000	Control of OAM signals	0001	Activation/ Deactivation of Continuity Check

Table 2. OAM cell types and functions.

Preparation

The AATM Tester@ windows for both the CPE and the Switch should be opened.

Lab Instructions

The ATM cell header

From the ALine Trace@ menu in the AATM Tester B CPE@ window, select AOpen Line Trace@. Click on the AShow Raw Trace@ button and real-time line trace data will be displayed in hexadecimal format. When the APHY Level Trace@ window is full of trace data, enable the AStop AutoScroll@ feature on the line trace so as to freeze the display. Most of the cells displayed are of the following format:

00 00 00 01 52 6A 6A 6A 6A 6A 6A 6A 6A ....

According to Figure 1, this cell has the following header fields:

Header Parameter	Value
GFC/VPI	0x000
VCI	0x0000
PT	0x0
CLP	0x1
HEC	0x52

Referring to Table 1 above, these cells are identified as Idle Cells and are used for cell-rate decoupling.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. Uncheck the AShow Idle cells@ option so that all cells with the exception of Idle Cells are displayed. All the cells being displayed are of the format:

00 00 02 3A D9 14 6A 6A 6A 6A 6A 6A 6A ....

According to Figure 1, this cell has the following header fields:

Header Parameter	Value
GFC/VPI	0x000
VCI	0x0023
PT	0x5
CLP	0x0
HEC	0xD9

According to Table 1 above, the PT value of 0x05 in this cell identifies this as a VC end-to-end OAM (F5) cell. Note that VPI field in this cell is 0 and the VCI is 23 hexadecimal (35 decimal) which corresponds to that of the default Virtual Channel configured by the WAN EduKit on start-up. As discussed in the exercise AOperations, Administration and Maintenance (OAM) functions and the PVC status@, F5 Continuity Check cells are transmitted on the same Virtual Channel as user data, thereby determining the status and ensuring end-to-end maintenance of that specific Virtual Channel.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. In the AATM Tester - Switch@ window, select ASend User Data@. Click on the AStart: button so as to transmit an AAL5 User Information block of length 100 bytes on the Virtual Channel identified by VPI 0/VCI 35. Close the ASwitch - Send User Data@ window. Enable the AStop AutoScroll@ feature in the previously opened CPE APHY Level Trace@ window so as to freeze the display. Use the vertical scroll bar to find three incoming (ARx@) cells of the following format:

00 00 02 30 EF 00 01 02 03 04 05 06 07 08 ....
00 00 02 30 EF 30 31 32 33 34 35 36 37 38 ....
00 00 02 32 E1 60 61 62 63 6A 6A 6A 6A ....

According to Figure 1, the first two cells have the following header fields:

Header Parameter	Value
GFC/VPI	0x000
VCI	0x0023
PT	0x0
CLP	0x0
HEC	0xEF

According to Figure 1, this third cell has the following header fields:

Header Parameter	Value
GFC/VPI	0x000
VCI	0x0023
PT	0x1
CLP	0x0
HEC	0xE1

The VPI field in these cells are 0 and the VCI field are set to 23 hexadecimal (35 decimal) which corresponds to the Virtual Channel VPI 0/VCI 35 on which the User Data was transmitted. According to Table 1 above, PT values of 0x0 and 0x1 identifies these cells as ATM User Data cells with a Ano congestion@ indicator. Note that the first two cells have the PT field set to 0x0 and the last cell has this field set to 0x1. As discussed in the exercise AThe formatting of AAL5 PDUs - PDU segmentation required@, the low bit of the PT field defines the SDU (Service Data Unit) type; if it is set to 1, then this is the last User Data cell in a segmented block and contains the AAL Type 5 trailer that is used for User Information reassembly.

The format of the Operations, Administration and Maintenance (OAM) cell

Disable the AStop AutoScroll@ feature in the CPE APHY Level Trace@ window so that cells are once again displayed. All the cells being shown are of the format:

00 00 02 3A D9 14 6A 6A 6A 6A 6A 6A 6A....

which are identified by the ATM cell header as VC end-to-end OAM (F5) cells as discussed above. Enable the AStop AutoScroll@ feature on the line trace so as to freeze the display and examine the comp lete payload by using the horizontal scroll bar. The cell payload consists of the following:

14 6A 6A 6A 6A 6A 6A 6A…6A 6A 03 87

Referring to Figure 3 (OAM cell format) above, the cell payload includes the following OAM fields:

OAM Field	Value
OAM type	0x1 (0001 binary)
Function type	0x4 (0100 binary)
Function specific fields	0x6A 0x6A 0x6A...
CRC	0x387

According to Table 2 (OAM cell types and functions) above, an OAM type of 0001 binary corresponds to a Fault Management cell and Function type of 0100 binary corresponds to a Continuity Check cell.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. In the AATM Tester - Switch@ window, select ASend OAM Loopback Cell@. Double click on the listed PVC with a VPI/VCI combination of 0/35 and an OAM Loopback cell will be issued. Close the ASwitch - send a Loopback cell@ window. Enable the AStop AutoScroll@ feature in the previously opened CPE APHY Level Trace@ window so as to freeze the display. Use the vertical scroll bar to find the following incoming (ARx@) cell:

00 00 02 3A D9 18 01 00 00 00 ....

Similarly to the Continuity Check cell discussed above, this cell is identified by the ATM cell header as a VC end-to-end OAM (F5) cell. The cell payload consists of the following:

18 01 00 00 ...

Referring to Figure 3 (OAM cell format) above, the cell payload includes the following OAM fields:

OAM Field	Value
OAM type	0x1 (0001 binary)
Function type	0x8 (1000 binary)

According to Table 2 (OAM cell types and functions) above, an OAM type of 0001 binary corresponds to a Fault Management cell and Function type of 1000 binary corresponds to a Loopback cell, confirming the transmission of the Loopback cell by the Switch. Note that the next transaction displayed in the line trace indicates an outgoing cell (ATx@) with contents:

00 00 02 3A D9 18 00 00 00 00 ....

This cell is the OAM Loopback response cell that has been transmitted by the CPE in accordance with OAM loopback requirements so as to verify end-to-end connectivity.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. In the AATM Tester - Switch@ window, select ADelete Virtual Channel@ to open the window that allows you to delete Virtual Channels. Double click on the VC identified by VPI 0/VCI 35 to delete that VC and close the ASwitch - Delete PVC@ window. In the ACPE - Line Trace@ window click the AFlush Trace Window@ button to clear the trace data. When the APHY Level Trace@ window is full of trace data, enable the AStop AutoScroll@ feature on the line trace so as to freeze the display. Use the vertical scroll bar to find an outgoing (ATx@) cell of the following format:

00 00 02 3A D9 81 05 ....

Similarly to the Continuity Check and Loopback cells discussed above, this cell is identified by the ATM cell header as a VC end-to-end OAM (F5) cell. The cell payload consists of the following:

81 05 ...

Referring to Figure 3 (OAM cell format) above, the cell payload includes the following OAM fields:

OAM Field	Value
OAM type	0x8 (1000 binary)
Function type	0x1 (0001 binary)

According to Table 2 (OAM cell types and functions) above, an OAM type of 1000 binary corresponds to an Activation/Deactivation cell and Function type of 0001 binary corresponds to a Continuity Check Activation/Deactivation, indicating that the CPE is attempting to activate OAM Continuity Check pragmatics after the deletion of the Virtual Channel at the Switch.

Figure 3 also includes provision for a 45-byte AFunction Specific field@ as part of an OAM cell format. This field is used to provide additional data required for the specific OAM function. In the case of the Continuity Check Activation/Deactivation cell, this Function Specific field is as shown below:

Message ID	Direction of Action	Correlation Tag	PM block size (A-B)	PM block size (B- A)	Unused
6 bits	2 bits	8 bits	4 bits	4 bits	42 bytes

Table 3 below list function specific fields for the Continuity Check Activation/Deactivation OAM cell.

Field	**Options**	**Coding (binary)**
Message ID	Activation Request	000001
	Activation Confirmed	000010
	Activation request denied	000011
	Deactivate	000101
	Deactivation Confirmed	000110
	Deactivation request denied	000111
Direction of Action	Default	00
	B to A	01
	A to B	10
	Two-way	11

Table 3. Function specific fields for the Continuity Check Activation/Deactivation OAM cell

Referring back to the cell under discussion with a payload of :

81 05 ...

Figure 3 decodes the Message ID/Direction of Action byte of 0x05 (00000101 binary) as follows:

Field	**Value**
Message ID	000001
Direction of Action	01

According to Table 3 (Function specific fields for the Continuity Check Activation/Deactivation OAM cell) above, a Message ID of 000001 binary corresponds to an Activation Request and a Direction of Action of 01 binary corresponds to B to A.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. In the AATM Tester - Switch@ window, select AAdd Virtual Channel@ to open the window that allows you to add Virtual Channels. Set the ›VPI= field to ›0' and the VCI field to ›35' and click AOK@. In the AATM Tester - Switch@ window, select AConnect/Disconnect PVC@, highlight the VC identified by VPI 0/VCI 35 and click AConnect PVC@. Close the ASwitch - Connect/Disconnect PVC@ window. Enable the AStop AutoScroll@ feature in the previously opened CPE APHY Level Trace@ window so as to freeze the display. Use the vertical scroll bar to find the following transaction:

Tx 00 00 02 3A D9 81 05 ....
Rx 00 00 02 3A D9 81 09 ....

The outgoing cell (ATx@) is the Continuity Check Activation/Deactivation OAM cell as discussed above. The incoming cell (ARx@) cell is an OAM cell with a payload of:

81 09 ...

Figure 3 decodes the Message ID/Direction of Action byte of 0x09 (00001001 binary) as follows:

Field	Value
Message ID	000010
Direction of Action	01

According to Table 3 (Function specific fields for the Continuity Check Activation/Deactivation OAM cell) above, a Message ID of 000010 binary corresponds to an Activation Confirmed response and a Direction of Action of 01 binary corresponds to B to A. The VC identified by VPI 0/VCI 35 has been added and connected at the Switch an OAM Continuity Check procedures are resumed between the two end-to-end devices.

The format of AAL Type 5 Protocol Data Units (PDUs)

The previous exercise ***The ATM cell header*** in this laboratory has shown us how to identify ATM User Data by examining the VPI, VCI and PT fields within an ATM cell header. We will now examine the cell payload contents so as to be able to identify the various field within the AAL5 PDU trailer. As discussed in AATM LAB 3 - The Basics of ATM Architecture - AAL@, the AAL is responsible for segmentation of outgoing higher layer User Information blocks into fixed-length ATM payloads and the reassembly of incoming payloads into complete User Information blocks for passing to a higher layer. In addition, Figure 2 - AAL Type 5 Convergence Sublayer PDU, detailed the format of the eight-byte AAL5 PDU trailer.

Disable the AStop AutoScroll@ feature on the APHY Level Trace@ window so that cells are once again displayed. In the AATM Tester - Switch@ window, select ASend User Data@. Click on the AStart: button so as to transmit an AAL5 User Information block of length 100 bytes on the Virtual Channel identified by VPI 0/VCI 35. Close the ASwitch - Send User Data@ window. Enable the AStop AutoScroll@ feature in the previously opened CPE APHY Level Trace@ window so as to freeze the display. Use the vertical scroll bar to find three incoming (ARx@) cells of the following format:

00 00 02 30 EF 00 01 02 03 04 05 06 07 08 ....
00 00 02 30 EF 30 31 32 33 34 35 36 37 38 ....
00 00 02 32 E1 60 61 62 63 6A 6A 6A 6A ....

As discussed in the exercise ***The ATM cell header*** in this laboratory, these are the incoming ATM User Data cells, with the first two cells having the PT field set to 0x0 and the last cell having this field set to 0x1. As discussed in the exercise AThe formatting of AAL5 PDUs - PDU segmentation required@, the low bit of the PT field defines the SDU (Service Data Unit) type; if it is set to 1, then this is the last User Data cell in a segmented block and contains the AAL Type 5 trailer that is used for User Information reassembly. Use the horizontal scroll bar to examine the cell

00 00 02 32 E1 60 61 62 63 6A 6A 6A 6A ....

The last eight bytes in this cell are:

00 00 00 64 C9 4E 5A A3

Matching these bytes to the eight-byte AAL5 PDU trailer shown in Figure 2 (AAL Type 5 Convergence Sublayer PDU), we have the following:

Field	Value
UU	0x00
CPI	0x00
Length	0x0064
CRC	0xC94E5AA3

The length field is shown as 0x64 (100 decimal), correctly corresponding to the block of length 100 bytes transmitted by the Switch.

Close the ACPE-Line Trace@ window.