S-72.3340 OPTICAL NETWORKS

SDH LABORATORY EXERCISE

INSTRUCTIONS

HELSINKI UNIVERSITY OF TECHNOLOGY

Spring 2007

1. BACKGROUND

1.1 General information about the laboratory exercises

The SDH laboratory exercises are part of the course S-72.3340 Optical Networks. The exercises in the student laboratory room E306 at Otakaari 5A. The goal of this exercise is to provide the students with greater knowledge on SDH technology and gain a practical insight on the configuration of SDH nodes in order to create a digital communications network. Time spent on the exercises in the laboratory is restricted to 3 hours, therefore it would help if you do some background reading before attending the lab session.

1.2 Group

The experiments performed in pairs under the supervision of the course assistant or lecturer.

1.3 Preliminary knowledge

The SDH material presented in the handouts for the S-72.3340 course would be sufficient to some extent. However, an even greater understanding of the experiments would be gained by reading the accompanying SDH tutorial. You are expected to be familiar with the following:

- The STM-N frame structure and its overheads.
- How a 2 Mb/s (El) signal is mapped into STM-1 and STM-4 frames.
- Protection mechanisms in SDH rings.
- Structure and functions of digital cross connects.
- The meaning of different alarms.

1.4 Laboratory regulations and etiquette

- The components you will be handling (fibers, connectors etc.) are rather delicate; please handle them with care when connecting the SDH nodes.

- If you are unsure about something always ask for guidance from the course assistant or any of the laboratory staff.

- Keep things such as drinks or snacks away from the equipment as any accidental spillages and so forth could cause unnecessary damage.

- Before leaving the laboratory, you should also do a quick check of all the areas you worked in to insure you do not inadvertently leave things out of place.

1.5 Evaluation of exercise

The exercise is evaluated with grades pass or fail. Furthermore, the laboratory exercise counts towards 20% of the final grade of the course.

1.6 Equipment used in the experiments

The experimental setup is depicted in Figure 1 and the main equipment of the experiment described briefly below.

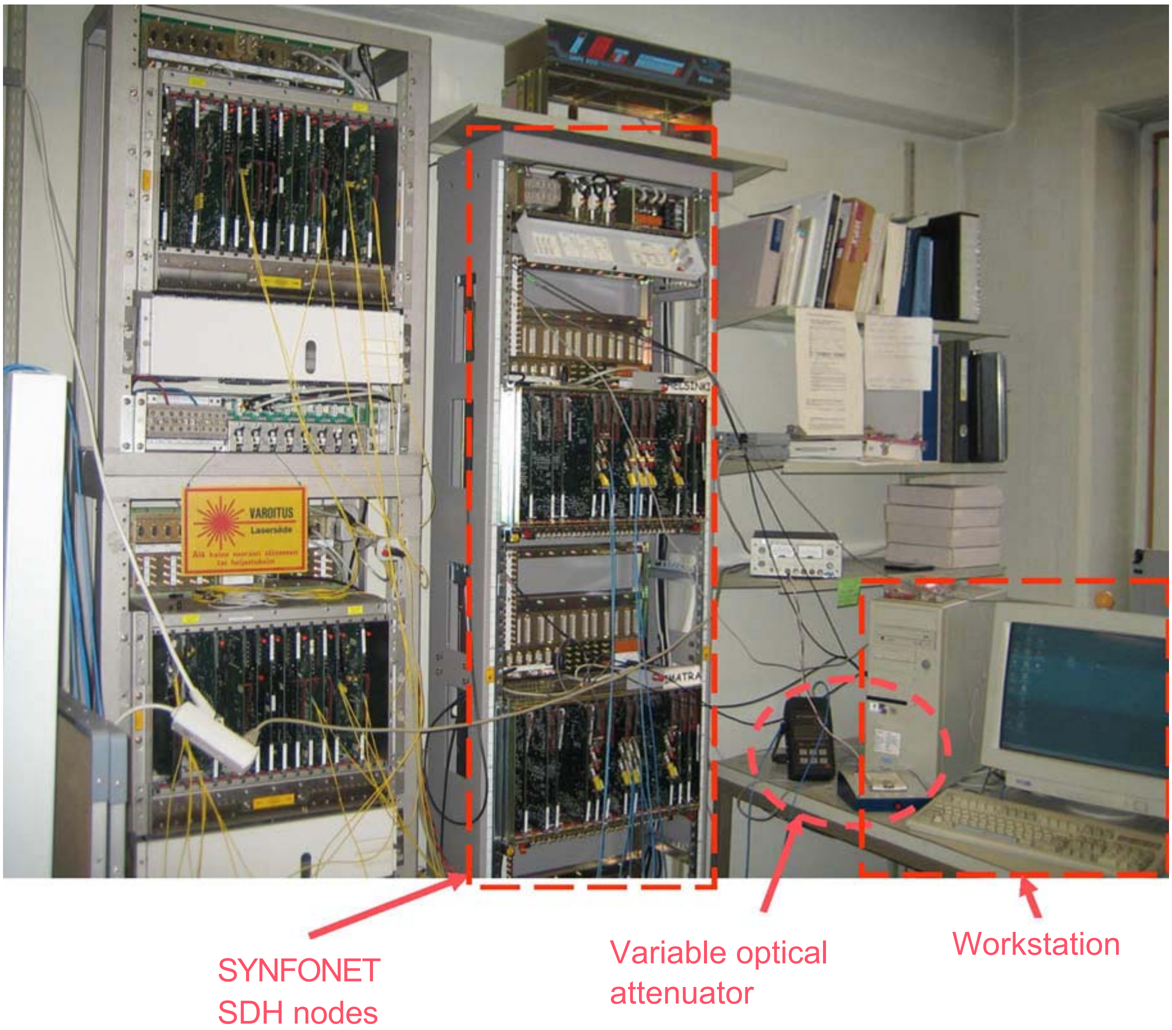

Figure 1 The SDH laboratory experimental setup.

a. SDH Nodes

The three SDH nodes to be used in the experiments are Nokia SYNFONET digital cross connect nodes. The three nodes occupy individual subracks that are mounted in a common 600 mm wide ETSI-standardized rack (see Figure 1) and each has the following features:

- Optical interfaces: STM-1 (155.520 Mb/s) short haul 1300 nm and STM-4 (622.080 Mb/s) short haul 1300 nm.

- Electrical interfaces: El (2.048 Mb/s), E3 (34 Mb/s) and STM-1 E or E4 (140 Mb/s).

- System Switch (SSW) plug-in unit (line cards) for cross-connection and add/drop of 16xAU-4 signals at VC-4, VC-3, VC-2 or VC-12 levels.
- TSW plug-in unit for adapting lower order VCs to higher order VCs.
- 2MT plug-in unit for mapping 2 Mb/s or 31x64 kbit/s signal to VC-12 (via C-12 container).
- 2MTA interface plug-in unit for mapping 2 Mb/s or 31x64 kbit/s signal to VC-12. Afterwards it maps the VC-12 and possible VC-3 signals into VC-4 and adds AU-4 pointers.
- Control Unit (CU) plug-in unit for node management, management communications and synchronization functions.
- Service Unit (SU) plug-in unit providing auxiliary interfaces and support the service telephone option.

b. Variable optical attenuator

An electrically controlled 3M variable optical attenuator shown in Figure 1.

c. Workstation

The SYNFONET Node Managers for controlling and monitoring the nodes are on a Pentium 90 MHz workstation (see Figure 1). The workstation is communicates with the gateway SDH node using a Q3 management communication protocol over an Ethernet LAN connection. The management information is transferred between the nodes by using the embedded data communications channel (DCC) provided in the STM section overhead (see Figure 2).

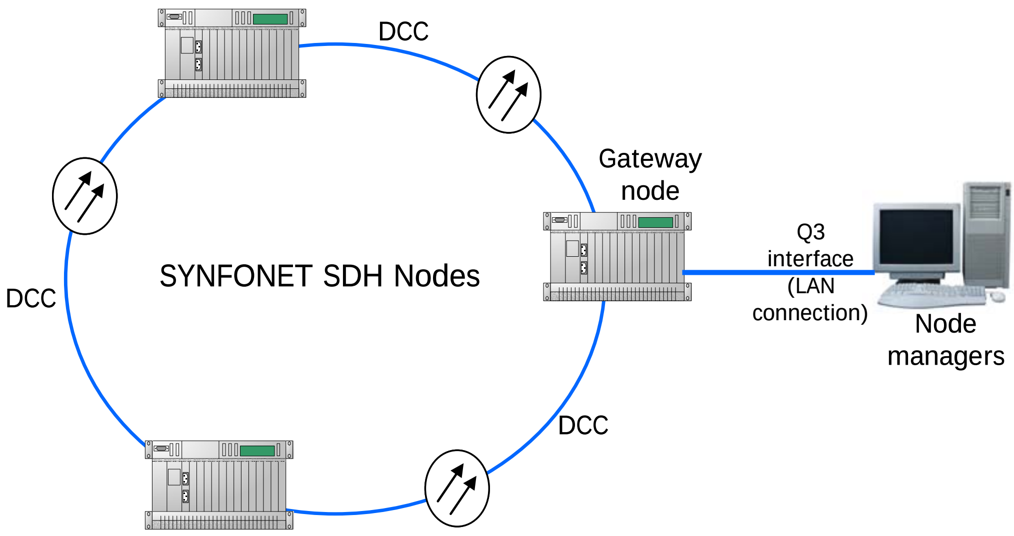

Figure 2 Architecture of the management network.

d. Network tester

The network tester used is a Wandel & Goltermann Advanced Network Tester (ANT-20E) shown in Figure 3. Among others it has the following capabilities:

■ Test for correct path switching and configuration

■ Editing and analyzing section/path overhead

■ Alarms and responses

■ Synchronization tests

■ Jitter and wander tests

■ Pointer simulation and analysis

■ BER test

Testin g mapping of PDH and ATM traffic to SDH frames

Figure 3 The ANT-20E network tester.

e. Primary multiplexing equipment

Nokia DYNANET DM2+ primary multiplexing equipment used for multiplexing analogue speech and signaling as well as data channels of different bit rates into a common 2 Mbit/s frame. In the experiment a test signal will be pulse code modulated and inserted in 2 Mbit/s multiplex before being sent over the SDH network.

f. Signal generator

The test signal will be an audio (music) signal produced by a CD player and sent over the SDH network as a PCM signal to a speaker in the laboratory.

2. THE LABORATORY WORK

2.1 Defining transmission needs

You are an employee of an SDH network operator and have been given the task to commission a network for a valued enterprise customer. The nodes were installed previously and hence your main task is to setup STM circuits of sufficient capacity along requested routes. The nodes are installed at three different locations. One is at the customer's headquarters in Helsinki, one is at their branch office in Tampere and one is at a top secret R&D department in the woods of Imatra. The customer needs the connections and the bit rates listed Table 1.

Table 1 Customer requirements between different locations

Connection:	Bit rate:
Helsinki -Tampere	n. 400 Mbit/s
Helsinki -Imatra	30 Mbit/s, protected
Tampere -Imatra	30 Mbit/s, protected

The connection routing plan is depicted in Figure 4. The working (solid blue lines) and protection (dashed red lines) connections are realized on fiber-optic transmission lines.

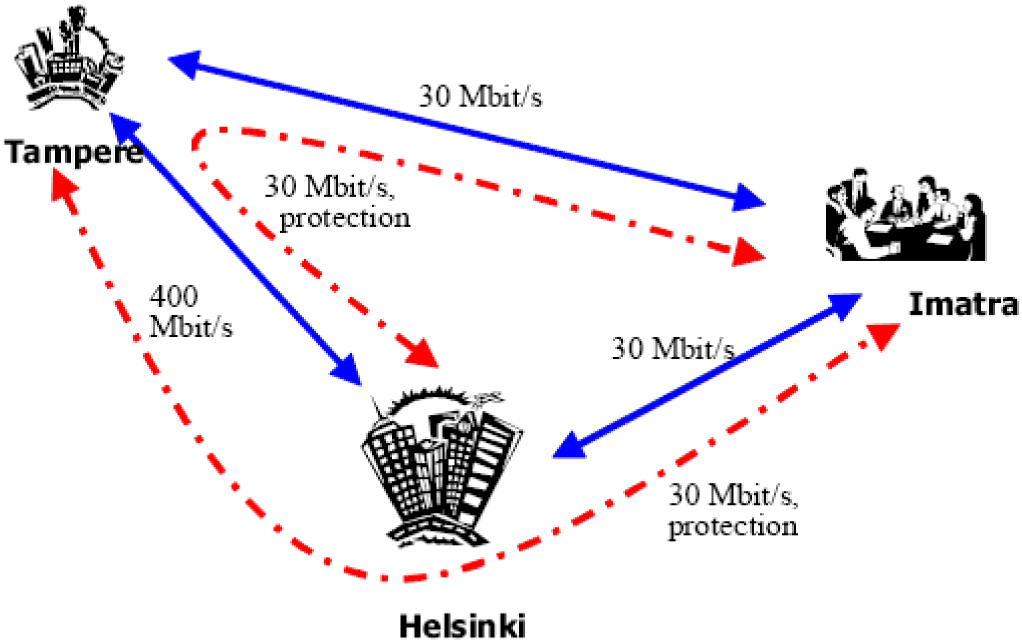

Figure 4 Customer's connections between different cities.

Exercise 1: Try and figure out which STM optical interface plug-in units would you require for each of the above connections

2.2 Connecting the nodes with cables

The SDH network is to be configured into a subnetwork connection protection (SNCP) ring. Therefore, the next task would be to interconnect the nodes using fiber cables (in this case using fiber patch cords) to enable SNCP configuration.

Exercise 2: Interconnect the three nodes as shown in Figure 5. For each link connect the cable to the TX connector in transmitting side (port marked OT) to the RX connector in the receiving side (port marked OR). In this experiment we will assume that there some possible defects in the cable of the Helsinki to Imatra route. To represent these defects install a variable optical attenuator between the TX connecter in Helsinki and the RX connector in Imatra.

Note that when connecting the nodes the interfaces at either end should match. So for instance, one cannot connect an STM-1 plug-in unit to an STM-4 plug-in unit. It is also important to make sure that the connectors are fastened correctly because bad connections may give cause unexpected coupling losses. Furthermore, exercise caution by not pointing the transmitted beam at your eye!

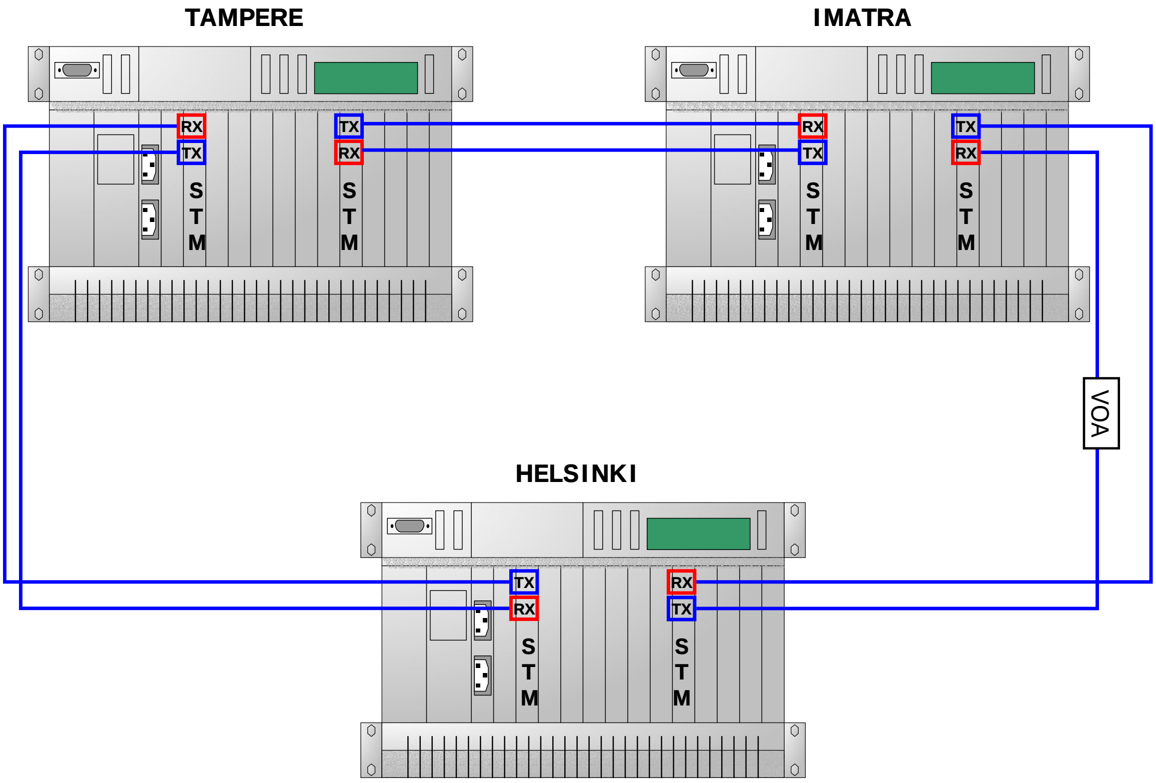

Figure 5 The 3 node SNCP ring.

<u>When all the cables are in places ask the supervisor to check the connections you have made</u>.

2.3 Defining node addresses and names

Step 1: Open the SYNFONET Node Manager (SNM) program by double-clicking on **STM-14 SNM C2.21** icon on the desktop. The following window appears to you.

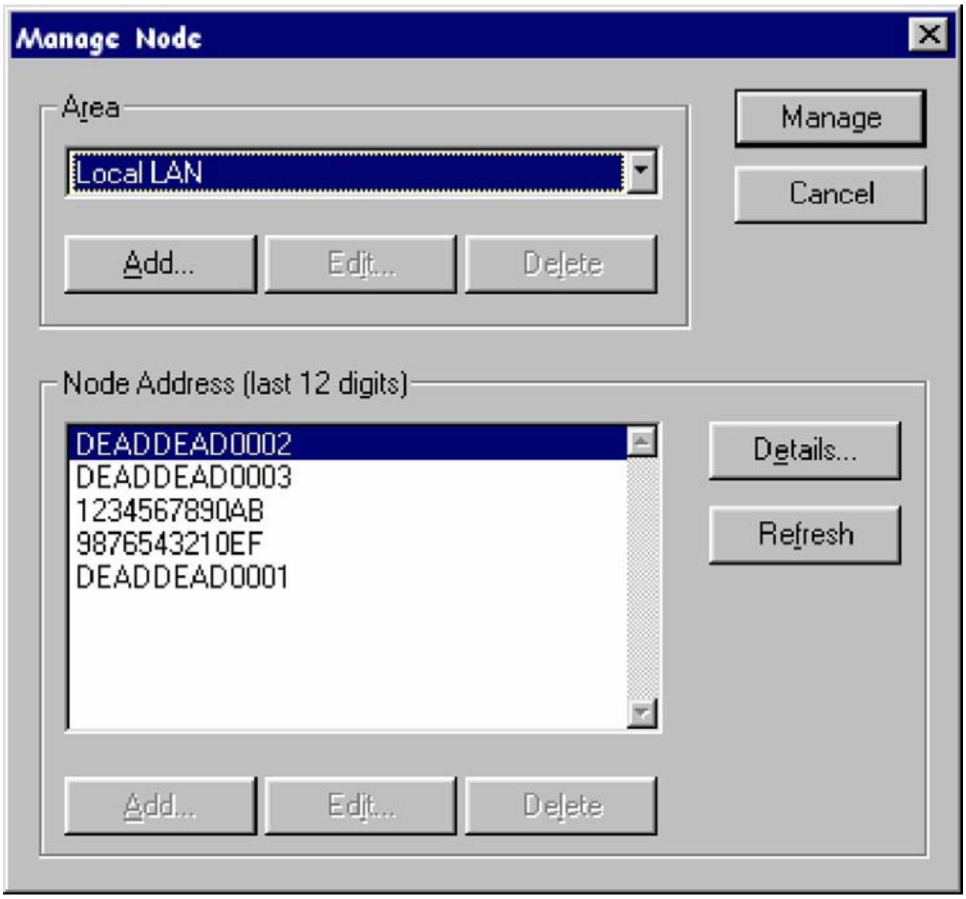

Figure 6 The Manage Node screenshot.

The correspondence between the System ID (Node Address) of Figure 6 and actual name of the site of node is shown in Table 3.

Table 3 Name and ID codes for nodes

Name of the node site:	System ID:
Helsinki	DEADDEAD0001
Tampere	DEADDEAD0003
Imatra	DEADDEAD0002

There are three nodes and each one can be managed by the SNM program.

Step 2: For convenience open a separate SNM program for each node. By doing this it is possible to configure all the three nodes simultaneously.

2.4 Configuration of nodes and enabling monitoring

Exercise 3: Before making the actual configurations it is useful to know if there is a signal in the cables and enable monitoring.

Step 1: In the Manage Node window press the **Manage** button. After short delay the window of Figure 7 appears. It shows the plug-in units that are managed and their position in different slots of the shelf. A green box indicates that the plug-in unit is in good working condition.

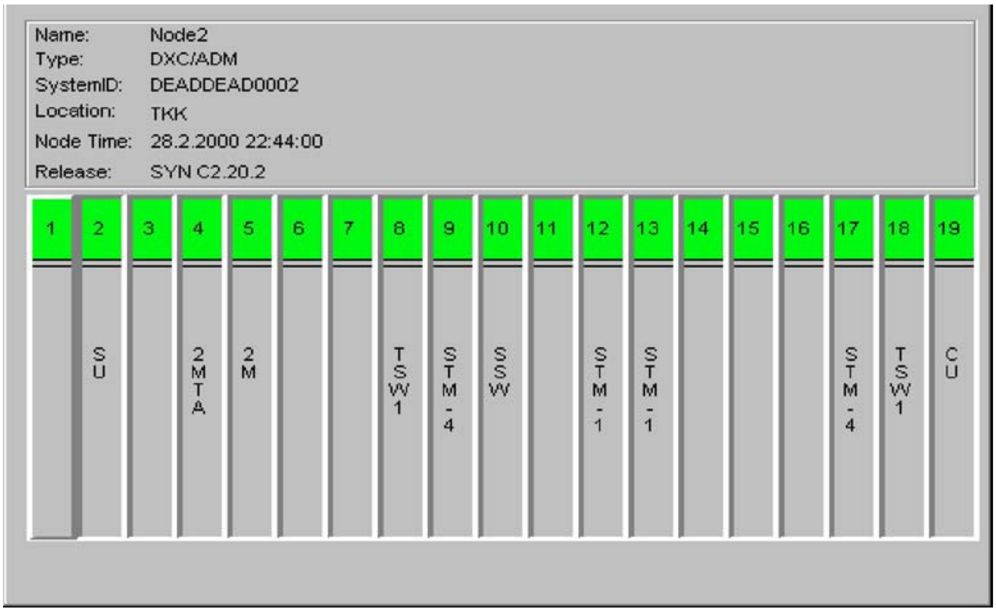

Figure 7 The DCS plug-in units to be configured and their position in different slots of the shelf.

Step 2: Double-click on the STM plug-in unit that is to be examined. The window of Figure 8 appears.

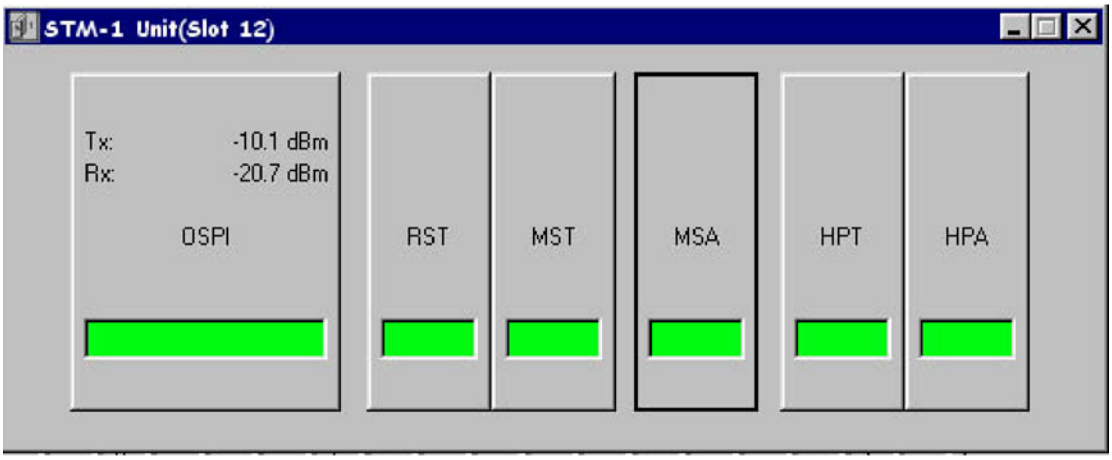

Figure 8 An STM-1 plug-in unit configuration window.

Step 3: Double-click the OSPI (optical SDH physical interface) button and change the Physical Interface status from **Not Monitored** to **Monitored.**

Step 4: Now you need to terminate the STM-N circuits destined for the different nodes. To do this, first double-click the MSA (Multiplex Section Adaptation) button in the configuration window of Figure 8. From here choose path terminated. This means that you have terminated the VC-4 you wanted and it will now be possible to configure (cross-connect) the lower-order virtual containers (e.g. VC-12) within it. When finished close the STM Unit window.

Step 5: Update the node with new configuration by sending the information to the node by going **Data -> Send to Node** from the toolbar or by pressing **Ctrl + S**. Always remember to do this step after each new configuration. Without this the nodes won't get the information about the configuration and will carry on functioning as before.

Step 6: Repeat Steps 2-5 for every STM plug-in unit that will be used all the nodes.

2.5 Making cross-connections

Cross-connections are made when there is a need to transmit lower-level signals with higher bit rate or when there is a need to extract these lower-level signals from higher-level signal.

Exercise 5: So far there has been no need for these cross-connections. But now an important 2 Mbit/s PCM signal from Helsinki has to be transmitted to the R&D center in Imatra. The PCM signal contains a top-secret live audio signal that is produced in Helsinki is only meant to be heard at Imatra. Note that the copper cables transporting the PCM signal from the primary multiplexing equipment (PME) to the Helsinki node and from the Imatra node to the PME have already been connected. Also make sure that the CD player is on and playing already so that you will hear the music as soon as signal is mapped on to the Helsinki-Imatra connection.

Step 1: Let's start the mapping in Helsinki. First open the window to configure the cross-connection either by clicking cross-connect icon on the main window toolbar or by going **Configure -> Cross connection** or via the keyboard by pressing **Ctrl + X.** Now the signal to be transmitted is a 2 Mbit/s PCM signal, so it is mapped into a

VC-12 (see slide 28 of Lecture 5). In the **Connection Name** enter a name e.g. Test Signal. Choose VC-12 in the cross-connect window and press the **Add** button. The Edit Cross-Connections window appears as shown in Figure 9. In this window you can see all the possible plug-in units which are capable to map VC-12 signals. **CP1** (Connection Point 1) means the connector/interface where the signal is arriving and **CP2** means the connector/interface where the signal is going from CP1.

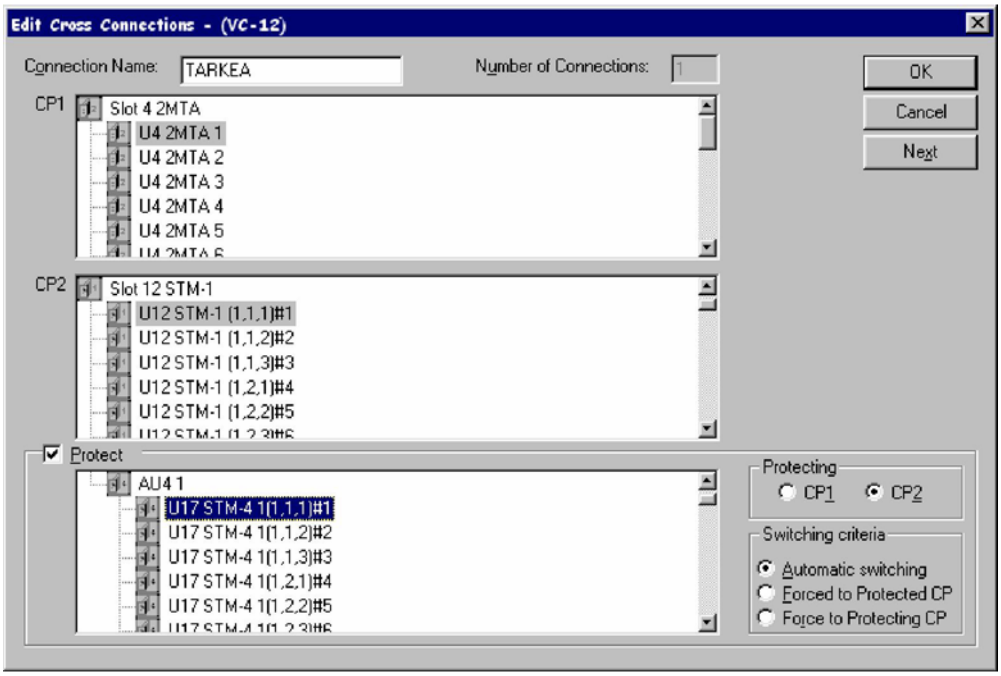

Figure 9 The Edit Cross-Connections configuration window

Step 2: Now define the plug-in unit and connector you used to connect the PCM signal into SDH network as CP1, for example double-click **Slot 4 2MTA** and select **U4 2MTA 1.** Now you have defined the entry point for the signal.

Step 3: After this you must choose the CP2, for example double-click **Slot 12 STM-1** and select **U12 STM-1 (1,1,1)#1.** Your test signal (which was mapped to a VC-12) is now going via the STM-1 plug-in unit on slot 12. Update the nodes with these changes by pressing **Ctrl + S.**

Step 4: Repeat steps 1-3 for the Imatra node, where CP1 would be an

STM-1 interface and CP2 is a 2MTA interface.

Step 5: Test the connection by listening to the PCM signal. It should be audible if the PCM signal is mapped correctly to the Helsinki-Imatra connection. Disconnect the Helsinki node from the VOA. Do you notice any alarms on Imatra's SNM program interface? Reconnect the Helsinki to the VOA and increase the attenuation. Do you notice any alarms as the attenuation increases? In both cases the audible PCM signal is lost because the Helsinki to Imatra connection is not protected.

2.6 Protecting the connection carrying the important signal

Exercise 6: The customer wishes to have 2 Mbit/s connection protected from any possible failures in the Helsinki-Imatra route. The protection is to be implemented by configuring a SNCP ring whereby a duplicate of the signal going via the Helsinki-Tampere-Imatra route as the protection connection.

Step 1: To do this check the box next to **Protect** and choose the connection to be protected. This is done by double-clicking **Slot 17 STM-4,** then double-click **AU4** 1 and select **U17 STM-4 1(1,1,1)#1.**

Step 2: Now you have to choose which connection point you want to protect under **Protection** on the right hand side of the window. In this case it is **CP2,** because it would be impossible to protect the incoming signal.

Step 3: Finally choose the switching criteria, in this exercise it is **Automatic switching.** Update the nodes with these changes by pressing **Ctrl + S.**

Step 4: At this stage your test signal is going to Imatra using both main route and a duplicate is sent on the protection route. Now configure a cross-connection in Tampere to de-map the duplicate test signal from the incoming STM-4 to the outgoing STM-1 (similar to was done in Section 2.5). Always keep mind in which VC-12 you have mapped your signal because it is the same "place" in the receiving end. Remember also which CP you are protecting.

Step 5: De-map the received duplicate test signal at Imatra from the incoming STM-1 from Tampere. This follows almost similar procedures to Steps 1-3 above.

Step 6: Now make sure that the protection line works by disconnecting the Helsinki node from the attenuator. If you still hear the audio broadcast, the automatic protection switching (APS) is working and the protection line is configured correctly.

2.7 Effect of attenuation to 2 Mbit/s signal

Now when you have managed to map this important signal into the SDH network it is time to measure some characteristics of the network. The tester to be used in the measurements is Wandell & Goltermann's ANT-20E described in Section 1.6.

Exercise 7: First let's examine how attenuation affects on 2 Mbit/s PCM signal.

Step 1: Go to the ANT-20E interface and open file **Application -* Open** in ANT-20 application manager window. Here choose W&G and press OK. On the GUI you will find it is configured to perform the **Framed-2M-Errortest** shown in Figure 10. That is, the ANT-20E tester produces a test signal (a 2 Mbit/s pseudo-random bit sequence or PRBS) that is sent to the device under test (DUT), which is the SDH network. The test signal is then sent back from DUT to ANT-20E to measure and observe the performance of the DUT.

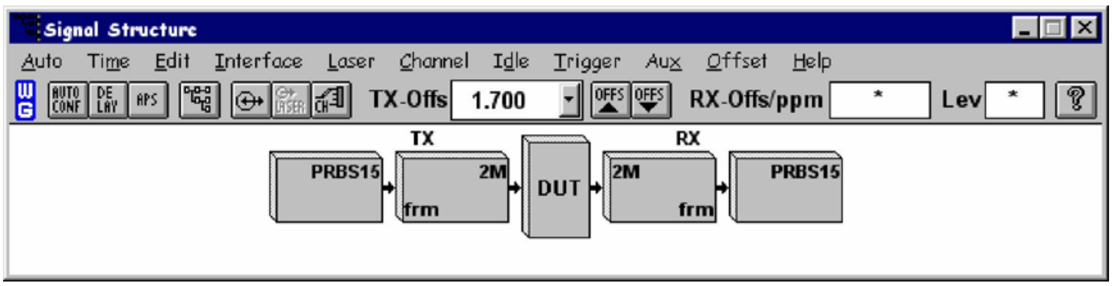

Figure 10 The ANT-20E signal structure window.

Step 2: The lab supervisor will then replace the audio test signal cables and connect the coaxial cables transporting the ANT-20E PRBS test signal in the same 2MTA add/drop ports you had used before. Now the test signal is sent to/from Imatra via the following route: Tester ^ Helsinki ^ Imatra (loop) -* Helsinki ^ Tester as shown in Figure 11.

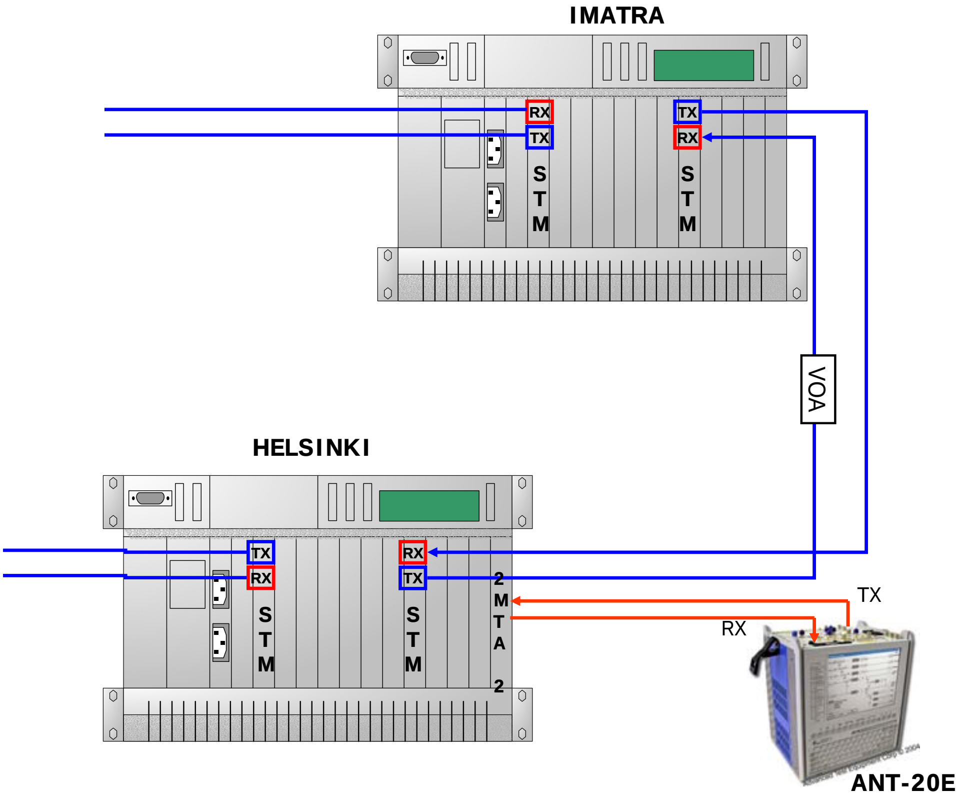

Figure 11 Configuration of SDH network and ANT-20E tester.

Step 3: The tester now is configured to do error test using framed 2 Mbit/s signal. Now press **start/stop** button in the toolbar. The tester starts sending the 2 Mbit/s signal.

Step 4: Proceed to increase the signal loss using the attenuator, until the plug-in unit in Imatra produces a loss of signal alarm. Do this attenuation relatively slow and note all the alarms that occurred during this attenuation from the tester by monitoring the alarm LED indicators on the ANT-20E tester.

2.8 Testing the APS with 2 Mbit/s signal

Exercise 8: When you have done the attenuation measurement it is time to measure how effective is the Automatic Protection Switching (APS).

Step 1: In order to do this you must make the necessary configurations to protect the ANT-20E test signal in the same way you protected the PCM test signal in Exercise 6 (Section 2.6). Now repeat the Steps ¾ of Section 2.7 and note the change in the dynamics of the alarms on the indicated on the ANT-20E tester.

Step 2: To measure the actual APS, stop the measure you had started in Step 1 and click the **APS** icon in the Signal Structure toolbar. This opens the APS Time Measurement window shown in Figure 12. Now press **START** and immediately proceed to Step 3.

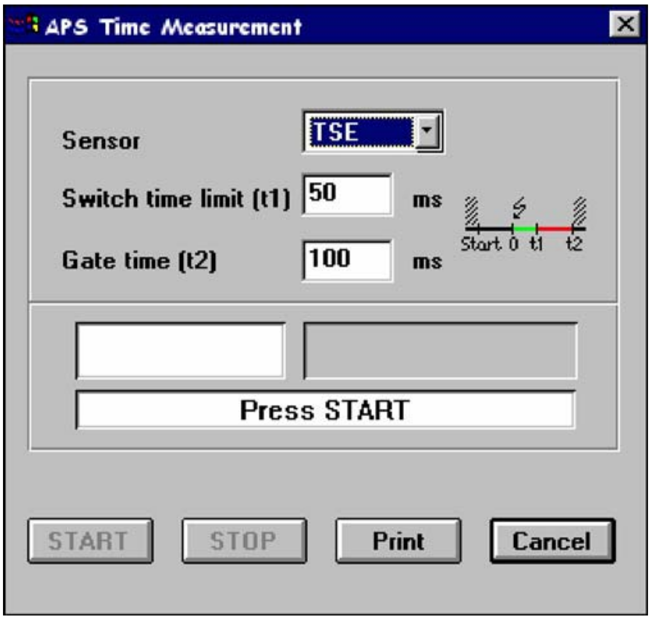

Figure 12 APS Time Measurement window

Step 3: Test the protection by disconnecting any point in the Helsinki to Imatra connection.

Step 4: Note the re-routing time on the APS Time Measurement window. Does it meet the 50 ms service restoration target? You can repeat this test to see note different APS times.

2.9 Dismantling/Decommissioning the SDH network

Exercise: The customer needs to wind up their existing operations before embarking on future expansions. The have asked you to dismantle the network you created.

Step : Disassemble next all cross-connections made in VC-12 level from every node (i.e. undo what was done in Section 2.5).

Step 2: Change all STM in all nodes from Monitored to Not Monitored state (i.e. undo what was done in Section 2.4).

Step 3: Carefully unplug all the fibers that were installed between the three nodes (i.e. undo what was done in Section 2.2).