A Case Study of a WDM Agent

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Abstract

This paper presents a case study of the development of a WDM Agent for the control of two prototype photonic network elements, an Optical Add/Drop Multiplexer and an Optical Cross-Connect. Even though the hardware developed for these prototypes is too small for a commercial device, the software is fully featured, and with modifications, could support devices of many times the complexity of the prototypes. The agent is developed using a WDM information model developed at Alcatel, and support two kinds of protection.

Keywords

Information models, Case Studies and Experiences

1. Introduction

For many years we have experienced continuous and dramatic growth in the bit rates of single-wavelength fiber-optic transmission systems. Although wavelength-division multiplexing seemed to have promise for the future, it was always possible to achieve more cost-effective results by replacing existing single-wavelength transmission systems with new single-wavelength transmission systems of ever-higher bit rates. Today, however, the rate of increase in bit rates of single-wavelength systems appears to be leveling off. At least in the backbone network, Dense Wavelength Division Multiplexing (DWDM) appears to be the technology of choice for increasing bandwidth in the next decade. It is time to develop software to deploy, administer, and protect those DWDM systems.

The European Commission, as part of the ACTS program, is funding two prototype WDM networks named MEPHISTO [1] [2] and PELICAN. MEPHISTO is a laboratory demonstration network of three OADMs connected in a single ring.

PELICAN is a field demonstration of a simple mesh network that spans several cities. These prototypes will demonstrate the practicality of the WDM layer. They will show that a large WDM network can operate reliably, and that it can be administered with techniques that strongly resemble those currently used with SONET/SDH networks.

Alcatel will contribute a prototype Optical Add/Drop Multiplexer (OADM) to the MEPHISTO project and a prototype Optical Cross-Connect (OXC) to the PELICAN project. The OXC is all optical in the sense that the payload is never converted to electrical format unless it drops at an electrical port. The OADM is nearly all optical with the exception of a single electronic transponder on the output side of the matrix. Both the OADM and the OXC have electronic control systems.

Our contributions to the OADM and OXC are two TMN-style software agents (one for the OADM and one for the OXC). The two agents are of a type that might be used in an embedded control system with a Q3-like interface. The information model used was developed by Alcatel, and contains classes inherited from classes defined in M.3100 [3].

2. OVERVIEW OF THE WDM AGENT

The WDM agent has two interfaces. On one side is the Q3 interface between itself and the manager. On the other side is the Functional Resources interface (FR interface) between itself and the FR module. The FR module is like low-level driver. See Figure 1. When the agent looks at the FR module through the FR interface it sees the network element as it really is, made of real hardware, like space switches and tunable filters. When the manager looks at the agent through the Q3 interface it sees the hardware as a generic network element (as defined in the WDM information model). This generic model is made of mythical standardized parts like Optical Trail Section Trail Termination Points (OTSTTPs). The job of an agent is to make the real model look like the mythical model.

To do this the agent has one class for each kind of mythical component in the information model. These classes are generated automatically in C++ by a tool named COMET developed at Alcatel. COMET is in a class of tools called GDMO/ASN1 compilers. COMET takes the definition of the objects from the formal languages of GDMO and ASN1 found in many standards documents and translates them into C++. COMET (along with other tools) also provides run-time support for the Q3 interface between the agent and the manager.

GDMO typically does not formally specify all of the behavior of a class. It specifies part of the behavior formally and part of the behavior informally. COMET can only translate the formal part of the class specification, so the C++ classes generated automatically by COMET only implement part of the behavior of the class. The programmer must manually create subclasses that implement the full behavior.

These subclasses know that they themselves are only mythical objects. They know the only real hardware is in the FR layer below them, when they receive a command from the manager they make that command happen by sending commands to one or more real hardware objects in the FR layer.

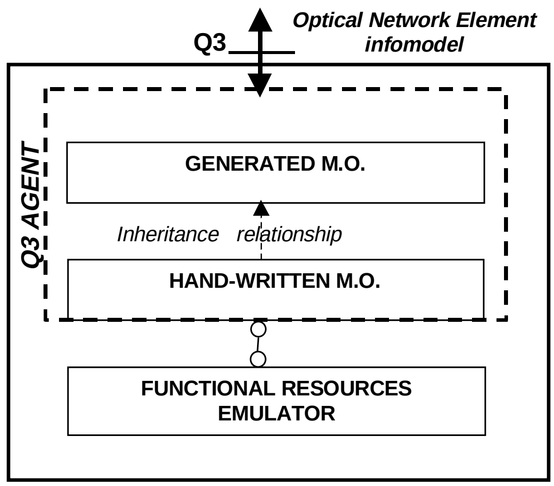

Figure 1 : WDM Agent architecture overview

3. THE INFORMATION MODEL

The WDM layer information model developed at ALCATEL is modeled after the SDH/SONET information model. Like the SDH/SONET model it has three "layers". In SONET the three layers are section, line, and path. In the WDM layer they are Optical Trail Section (OTS), Optical Multiplex Section (OMS), and Optical Channel (OCH). See Figure 2.

Both an OTS and an OMS are made of one or more optical wavelengths multiplexed together, but while the network elements on both ends of an OMS multiplex and de-multiplex the signal, the network element on at least one end of an OTS must process the multiplexed signal as a whole. Another way of saying the same thing is, OTS has an amplifier or one or both ends, and an OMS is between two OADMs or OXCs.

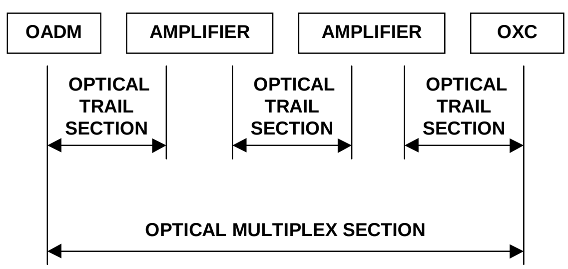

Figure 2 : An Optical Trail Section is between two amplifiers, and an Optical Multiplex Section is between two OADMs or OXCs. Both are composed of several wavelengths multiplexed together.

An OCH is a single optical path through the WDM layer from a port where the channel enters the network to a port where it exits. See Figure 3. An OCH may pass through several OMSs. In each OMS it uses one WDM channel. It does not have to use the same WDM channel in every OMS. The classes associated with a cross-connection within an OADM or OXC are also considered to be part of the OCH layer.

The WDM layer information model has classes for each of the three layers. As in the SDH/SONET model, there are two possible class for each layer, called Trail Termination Points (TTPs) and Connection Termination Points (CTPs). There are also classes associated with add and drop ports of an OADM. These are referred to as “client” class.

A more concrete way of looking at the information model is that it is really just a model of a patch panel.

- A CrossConnection is like a jumper cable.
- An OCHCTP or an OCHTTP is a plug for a jumper cable.
- An OMSTTPSource is a demultiplexer.
- An OMSTTPSink is a multiplexer.
- An OMSCTPSink and an OTSTTPSink together make a receiver.
- An OMSCTPSource and an OTSTTPSource together make a transmitter.
- ClientCTPSource is an add port.
- ClientCTPSink is a drop port .

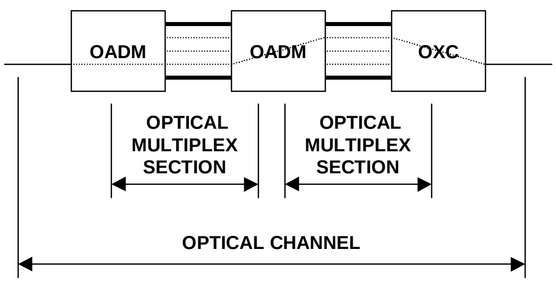

Figure 3 : An optical channel may use one WDM channel in each of several OMSs. It does not have to use the same WDM channel in every OMS.

4. THE FUNCTIONAL RESOURCES MODEL

In the functional resources layer there are classes for each of the real hardware devices found in our OADM and OXC. See Figure 4. Figures 5 and 6 show the schematic diagrams for the MEPHISTO OADM and the PELICAN OXC. In the OXC the payload stays photonic all the way through the system, from input to output. In the OADM a pass-through channel is converted to electronic format only once in the output wavelength converter.

As can be seen from the schematic diagrams, the prototype hardware for both the OADM and the OXC is quite simple, but the control software is not. With some modification, the software would be capable of controlling a system many times larger.

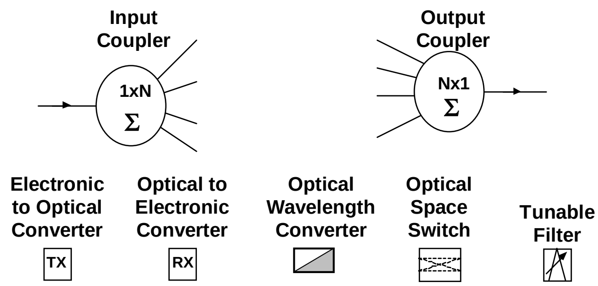

Figure 4 : Classes in the Functional Resources model.

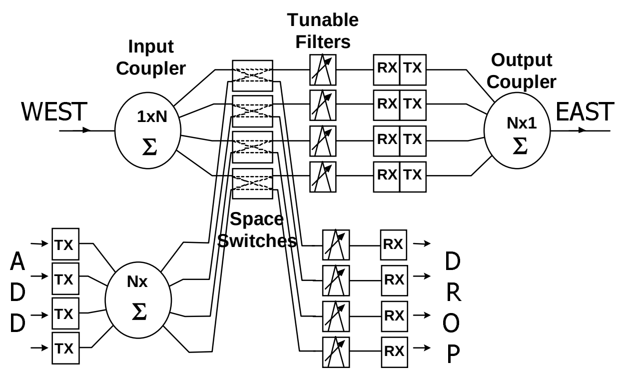

Figure 5 : The Functional Resources model for the MEPHISTO OADM.

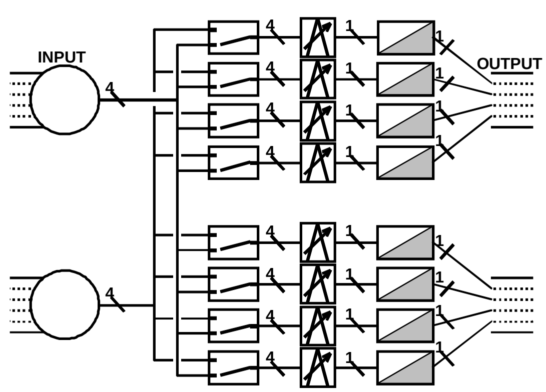

Figure 6 : The Functional Resources model for the PELICAN OXC.

5. THE TEST SYSTEM

Software for the WDM Agent prototype is being developed in two places. The Managed Object layer is being developed in Richardson Texas in the USA, and the Functional Resources layer is being developed in Marcoussis in France. The prototype hardware is available only in Marcoussis. The Richardson software must be written without the hardware, so we have developed a functional resources emulator with which to test the MO layer.

The functional resources emulator has a Graphical User Interface (GUI). The GUI is written with Tcl/Tk, and can also be used to visualize the operation of the real functional resources module. The functional resources emulator also has a GUI builder that simplifies the job of modifying the GUI for different kinds of hardware.

The agent will be tested with both real Q3 managers and a manager emulator developed in Richardson. The manager emulator has limited capabilities and will be used for testing and for demonstrations of the MEPHISTO prototype OADM ring in the Marcoussis lab.

The manager emulator also has a GUI that can show both a network view and a network element view. The network view shows WDM paths through the network from the port where they add to the port where they drop. The Network Element view shows the states of managed objects within individual OADMs.

6. PROTECTION

The WDM Agent will support two protection schemes, 1+1 SNCP and MSDP ring [4], [5]. Both of these schemes are nearly exact copies of their SDH counterparts. The only two differences being:

- In the WDM version of 1+1 SNCP the transmitter is turned off on the protect fiber.
- There are difference in the way the protection protocol is multiplexed with the payload.

In SDH/SONET the overhead for the protection protocol is multiplexed with the payload the same way the payloads are multiplexed with each other, with Time Division Multiplexing (TDM). In our WDM prototype we have two ways of multiplexing overhead channels with the payload.

- A wavelength called the supervisory channel is dedicated to only overhead traffic.
- A “pilot tone” channel can be superimposed on an SDH signal.

The specification of which of these two overheads is to be used for which restoration scheme has yet to be officially defined.

7. CONCLUSION

The OADM for the Mephisto network will begin field trials in June, and the OXC for the larger Pelican network is scheduled for its first field trial in late 1999. In these field trials the agent will inter-operate with other optical network elements and management systems from several vendors. It is our goal to demonstrate that a large-scale high-bandwidth WDM network can operate reliably, and can be administered in a way that is familiar to network operators experienced with SONET/SDH technology.

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[3] ITU-T, “Generic Network Information Model”, Recommendation M.3100, 1995.

[4] ITU-T, “General Aspects of Digital Transmission Systems Synchronous Digital Hierarchy (SDH) Management of the Subnetwork Connection Protection for the Network Element View”, Recommendation G.774-4, 1995.

[5] ITU-T, “Types and Characteristics of SDH Network Protection Architectures”, Recommendation G.841, 1995.

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