WDM network management

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For some material in this lecture check the additional reading pointer in course website
Lecture objectives

- Overview of the control and management issues in optical networks
- Network management functions
- Optical layer services and layers within the optical layer
Network Management

• Network management refers to the activities, methods, procedures, and tools that support
  - operation
  - administration
  - maintenance
  - provisioning of networked systems

• The combination of hardware and software used to monitor and administrate the network is called Network Management System (NMS)
Why essential?

- The “obvious” managing role
- Efficient network management is a network optimization issue
- Quality of Service (QoS) enhances competitiveness
- Minimize CAPEX and OPEX
Management systems

• Hierarchical systems, from bottom to top we have

• Element management systems (EMS)
  ▪ Separate for amplifiers, OLT, OADM and OXC (also vendor dependent)
  ▪ Communicates with elements by a data communication network (DCN) and fast signaling channel (e.g., optical supervisory channel - OSC)
  ▪ EMS normally does not have comprehensive network view - focused on single element(s)

• Network management system (NMS)
  ▪ Has a network wide view, with elements from various vendors
  ▪ Carries out operator-set policies
  ▪ Manages elements singularly via the EMS
Manager-Agent paradigm

Network Management System

Manager

Agent

Managed Device

operation (get, set)
notification

Management Communication protocol

Management Interface

MO

MO

MO
Management Protocols

• Simple network management (SNMP) framework
  ▪ protocol with the same name
  ▪ runs over Internet protocol stack

• Telecommunication management networks (TMN) framework
  ▪ Common management information protocol (CMIP)
  ▪ Runs over the OSI protocol stack

• Common object request broker (CORBA) model
  ▪ Allows network elements from different vendors to come with their own management system
  ▪ Software standard that allows interoperability
Management system: an example

Figure 9.1 Overview of network management in a typical optical network, showing the network elements (OLTs, OADMs, OXCs, amplifiers), the management systems, and the associated interfaces.
Network management functions

- **Security** management
  - authentication and selected access to management and control functions (specific partitions depending on role)
  - data integrity (encryption, data isolation)

- **Accounting** management
  - billing and history recording
  - no specific issues for optical networks

- **Configuration** management
  - ensures orderly changes in the network
    - equipment management (adding/removing)
    - connection management (setup, teardown, book keeping)
    - adaptation management (signal conversion)

- **Performance** management
  - In charge of QoS guarantee but also makes sure clients comply to their requirements

- **Fault** management
  - fault detection and isolation
  - fault recovery
Optical layer services

- Providing lightpaths Set up and tear down lightpaths
- Agreed bandwidth (capacity)
- Adaptation to and from client layers
- Guaranteed level of performance
  - Bit error rate (BER)
  - Jitter
  - Maximum delay
- Multiple levels of protection
- Fault management
Optical Sub-Layers

- Optical layer: lambda multiplexing, switching, routing, and monitoring
- For efficient management it is useful to define a number of sub layers

[Diagram showing OCh, OMS, OTS layers with WDM node connections and Optical Amplifier]
### Optical Transport Network protocol layers

- Four layers in the OTN layer-stack:
  - Optical channel sublayer (OCh)
  - Optical multiplex section (OMS)
  - Optical transmission section (OTS)
  - Physical media layer
    - Fiber-type specification, developed in other Recommendations

<table>
<thead>
<tr>
<th>Electronic Layers</th>
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<tbody>
<tr>
<td><strong>OTN</strong></td>
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<tr>
<td>OCh- Optical Channel</td>
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<tr>
<td>OMS- Optical Multiplex Section</td>
</tr>
<tr>
<td>OTS- Optical Transmission Section</td>
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<tr>
<td>Physical media (optical fiber)</td>
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</tbody>
</table>
Simplified view of an optical connection

Electronic layers:
- DxC
- Electronic switch
- OXC
- Mux
- Optical switch
- Demux
- EDFA

OCh

OMS

OTS

Physical media
Optical channel sub-layer

• **End-to-end networking. Functions:**
  - optical channel connection *rearrangement* for flexible network routing
  - optical channel *overhead processing* for ensuring integrity of the optical channel adapted information
  - optical channel *supervisory functions* for enabling network level operations and management functions, such as connection provisioning, quality of service parameter exchange and network survivability

• **Typical involved devices**: switching subsystems of OXCs and OADMs

• **Optical channel entity**: the **lightpath** (or optical circuit)
OMS sub-layer

Electronic layers

OCh

OMS

OTS

Physical media

DXC  Electronic switch  OXC  Mux  Optical switch  Demux  EDFA
• Networking of a multi-wavelength optical signal (including the case of just one optical channel)

• The capabilities of OMS sublayer:
  ▪ OMS overhead processing
  ▪ OMS supervisory functions and management functions, such as multiplex section survivability

• Typical involved devices: multiplexing/demultiplexing subsystems of OXCs OADM
OTS sub-layer

Diagram showing the OTS sub-layer with various components and layers. The diagram includes:

- Electronic layers
- OCh
- OMS
- OTS
- Physical media

Key components:

- TX
- RX
- OCh trail
- OMS trail
- OTS trail

Equipment icons:

- DXC
- Electronic switch
- OXC
- Mux
- Optical switch
- Demux
- EDFA
• Transmission of optical signals on the optical transmission media

• The capabilities of OTS sub-layer:
  ▪ OTS overhead processing
  ▪ OTS supervisory functions

• Typical involved devices: optical amplifiers (e.g., EDFA gain-control, etc.), transponders, all-optical regenerators
Configuration management

- **Equipment management**
  - Inventory of equipment in the network

- **Adaptation management**
  - Conversion between client signals and optical layer signals

- **Connection management**
  - Topology management
  - Route computation
  - Signaling protocol
  - Signaling network
Adaptation management

- Converting the user’s signal to appropriate wavelength, optical power level, etc.
  - Adaptation interfaces
    - Compliant wavelength interface
    - Noncompliant wavelength interface
    - Subrate multiplexing
- Adding and removing overheads
- Policing
Connection management

• Centralized control or distributed control

• Distributed connection control
  ▪ Topology management
    o Discover the topology by exchanges with neighbors
    o Updates by flooding (OSPF or IS-IS)
  ▪ Route computation
    o Routing and wavelength assignment (RWA) problem
  ▪ Signaling protocol
    o To set up and tear down lightpaths
  ▪ Signaling network
    o The DCN
DCN and signaling

- Standard data network
  - TCP/IP or OSI

- Connectivity
  - Outside optical network
    - Leased lines
    - Not available to optical amplifiers (e.g., under water)
  - Optical supervisory channel (only for OTS, OMS, not available of OCh)
  - Framing information
    - SDH/SONET data channel
    - Digital wrapper