IO2654 Optical Networking

WDM network management

Paolo Monti

Optical Networks Lab (ONLab),

Communication Systems Department (COS)

http://web.it.kth.se/~pmonti/

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)
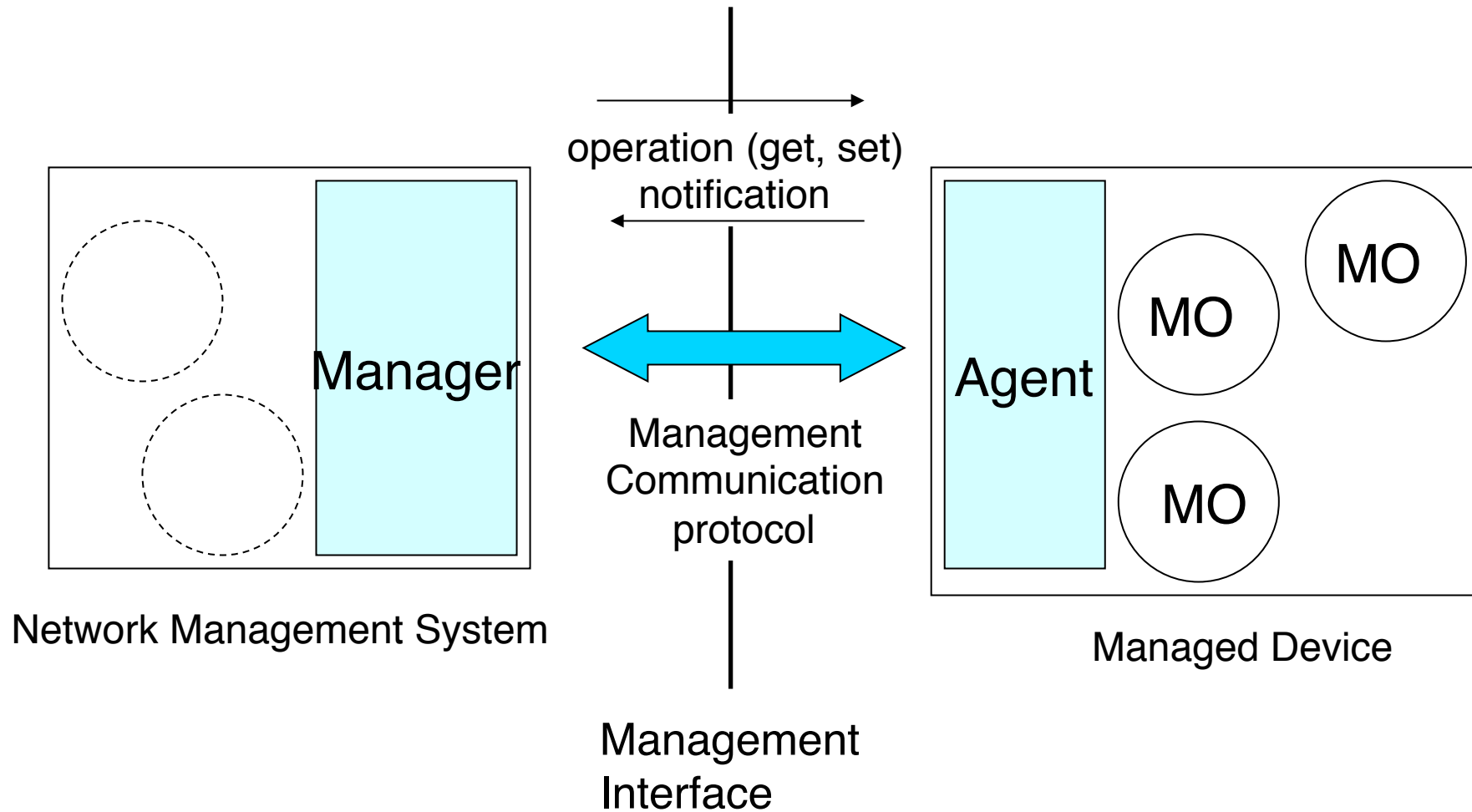
Why essential?

- 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 (same type) or set of them (same vendor)

- 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

operation (get, set)
notification

Manager

Management
Communication
protocol

Agent

MO

MO

MO

Network Management System

Managed Device

Management
Interface

Management Protocols

- **Simple network management (SNMP) framework**
  - protocol with the same name
  - runs over Internet protocol stack (TCP/IP)
- **Transaction Language-1 (TL1)**
  - Simple text or ASCII based interface
  - Inherited from terminal command set past
- **Telecommunication management networks (TMN) framework**
  - Common management information protocol (CMIP)
  - Runs over the OSI protocol stack (with Q3 interface)
  - Hierarchical principle and object oriented information model good, but perceived as complicated
- **Common object request broker (CORBA) model**
  - Allows network elements from different vendors to come with their own management system
  - Software standard that allows interoperability
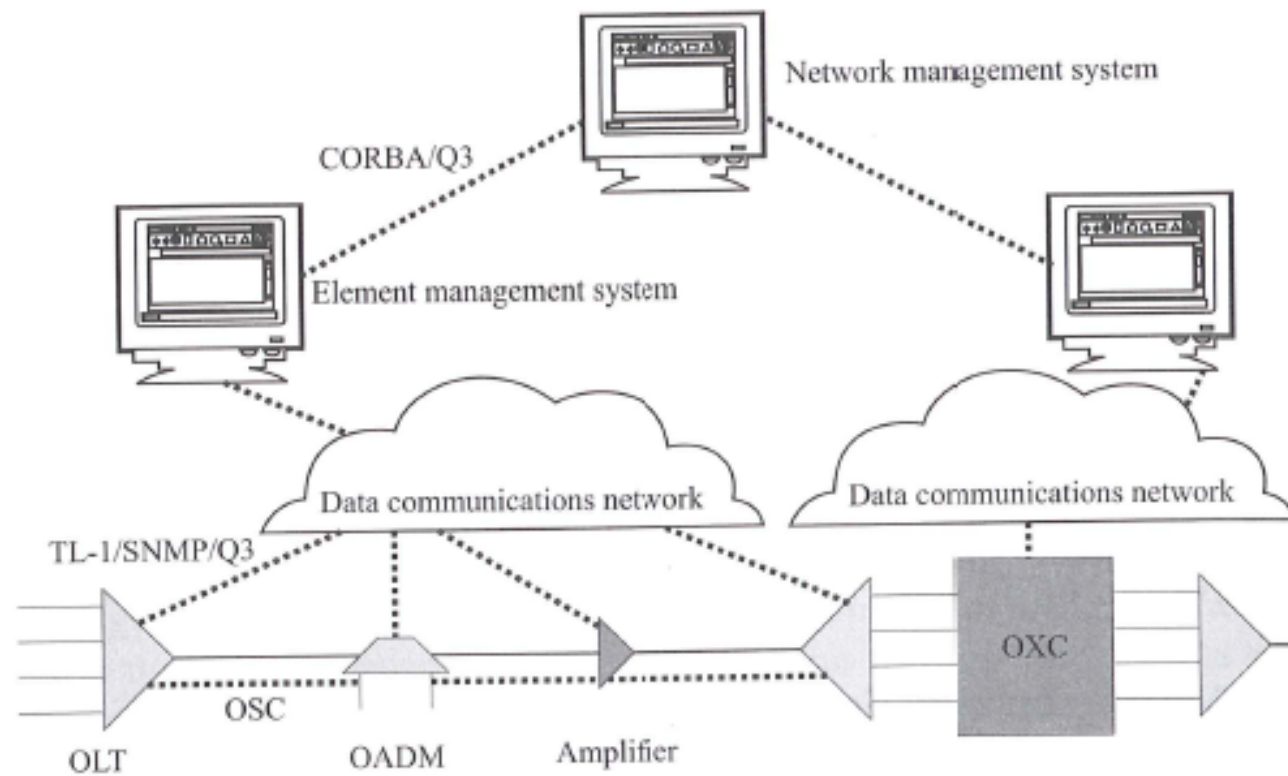
Management system: an example

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 – vertical and horizontal - 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, i.e., 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
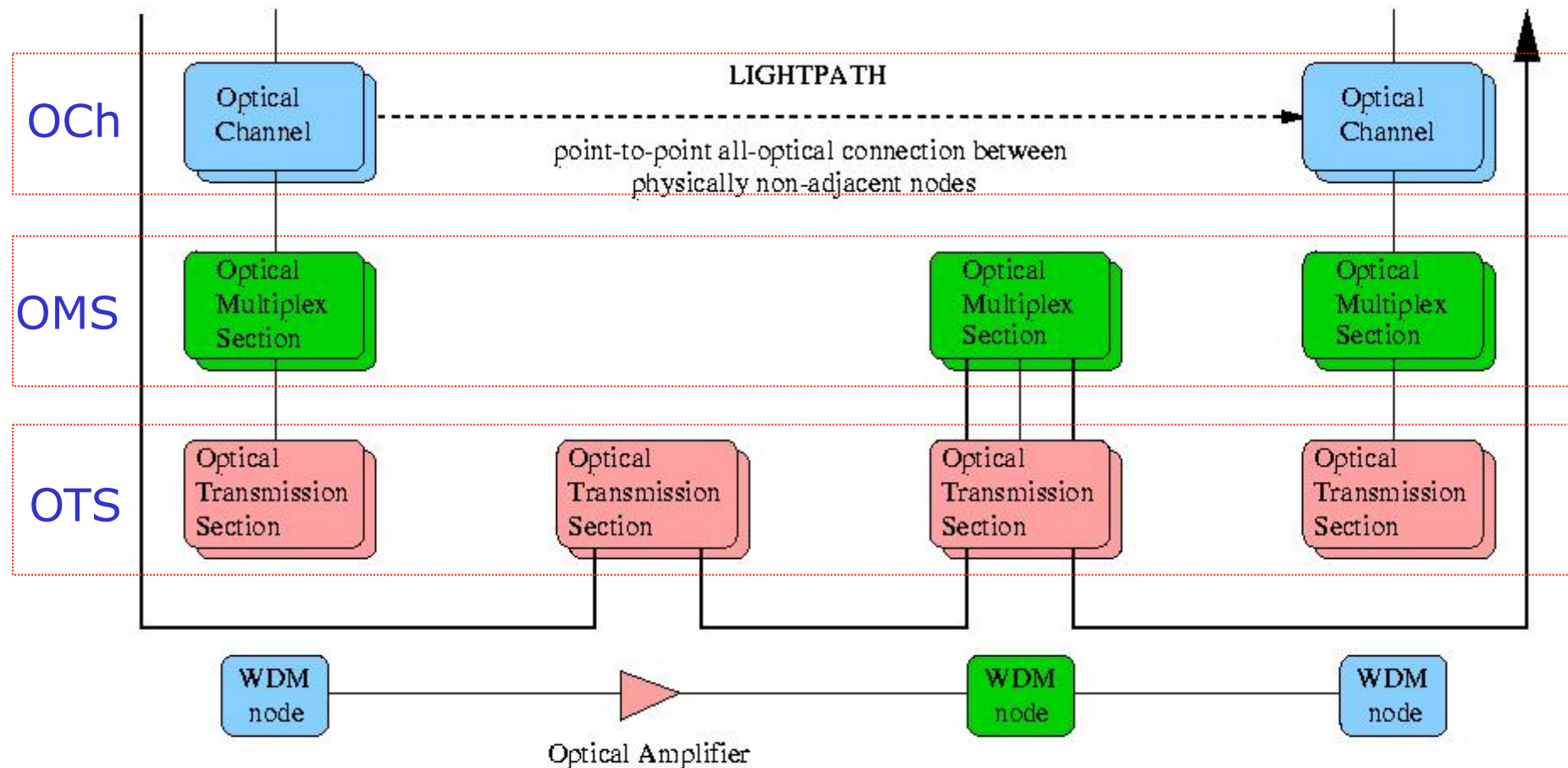
Optical Transport Network protocol layers

- 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

Electronic Layers	
OTN	OCh- Optical Channel
	OMS- Optical Multiplex Section
	OTS- Optical Transmission Section
	Physical media (optical fiber)
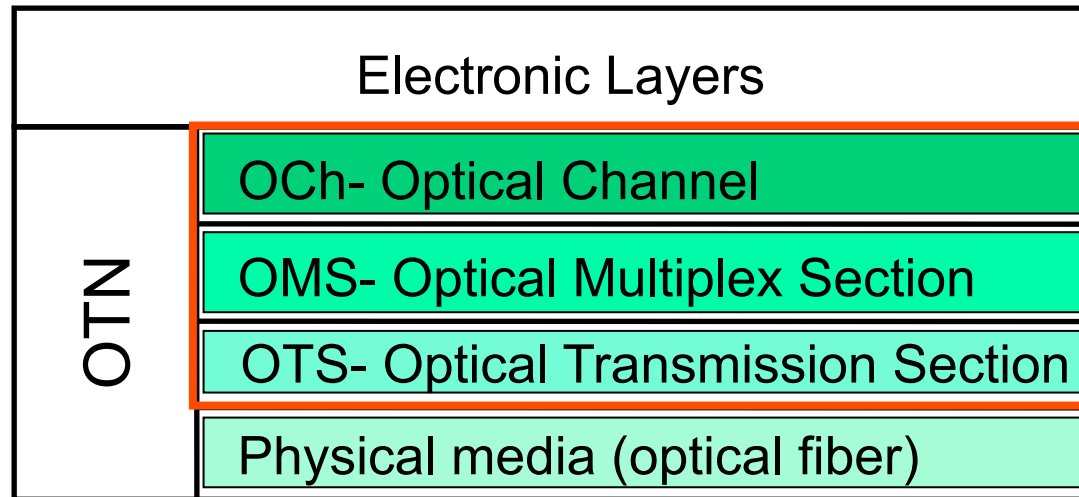
# Simplified view of an optical connection
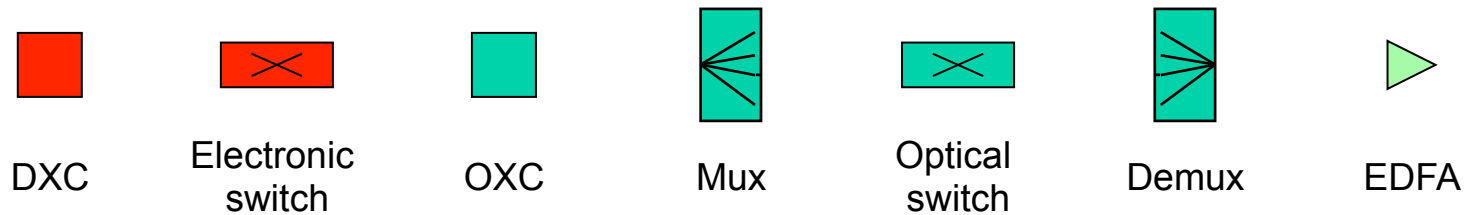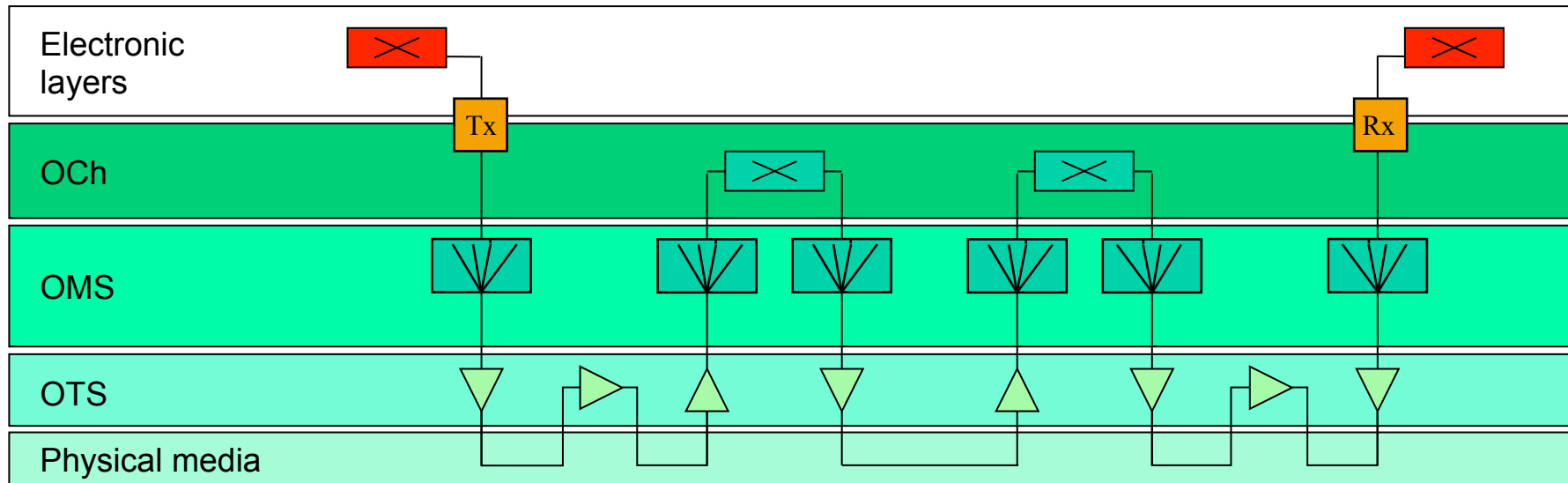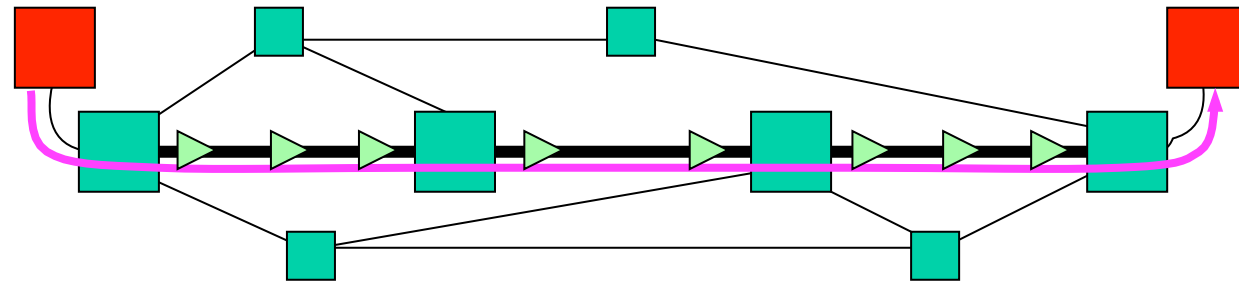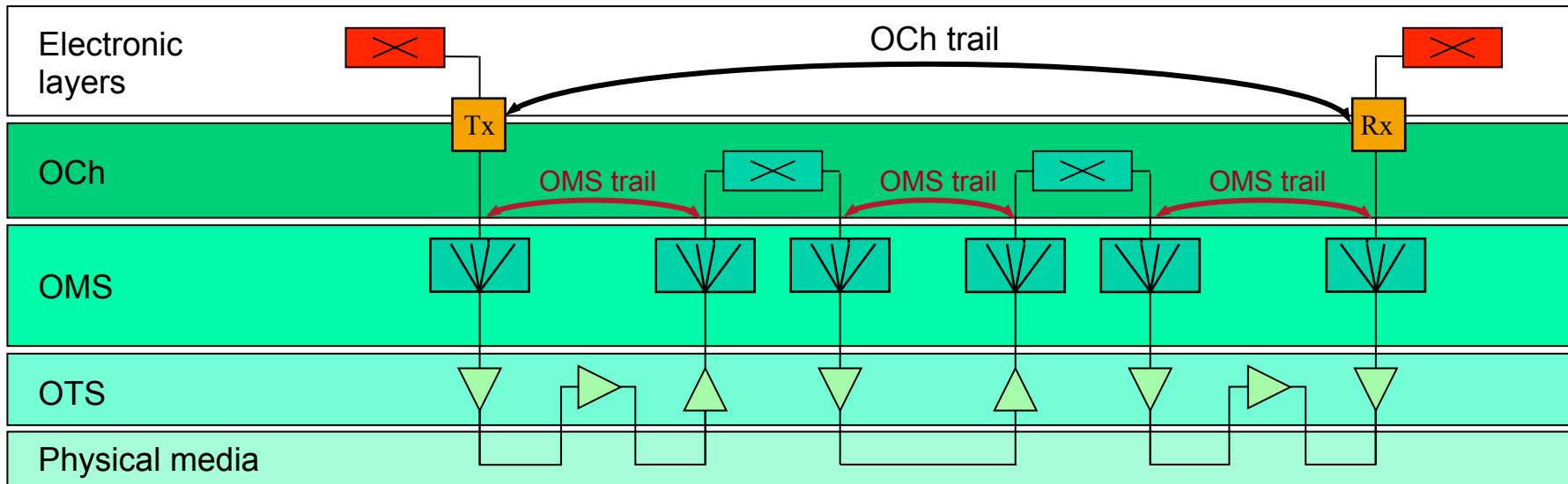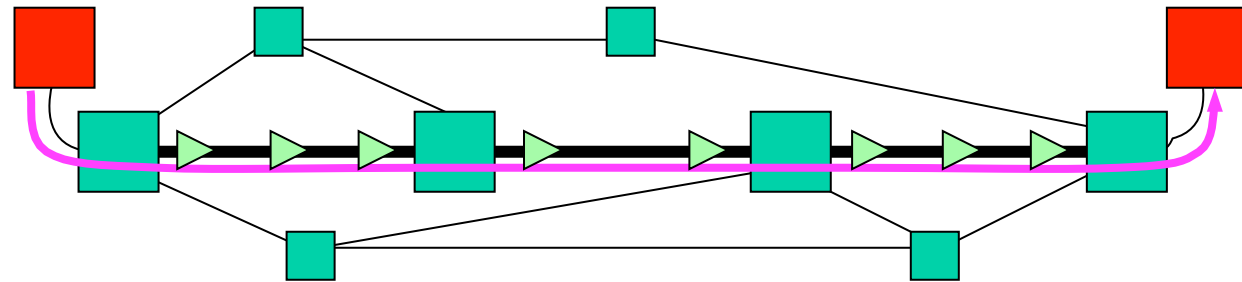
OCh sub-layer
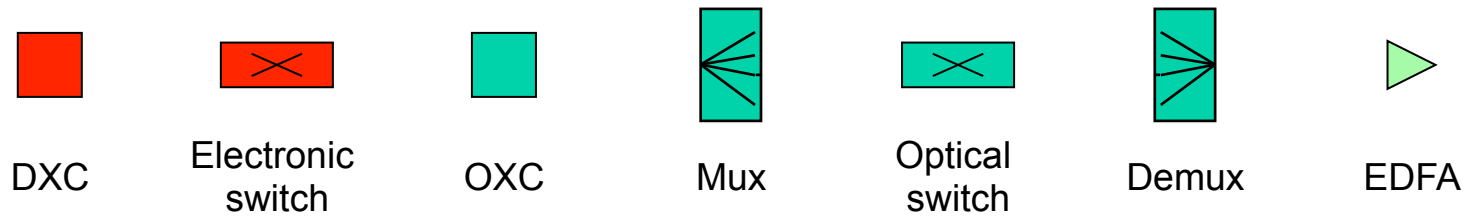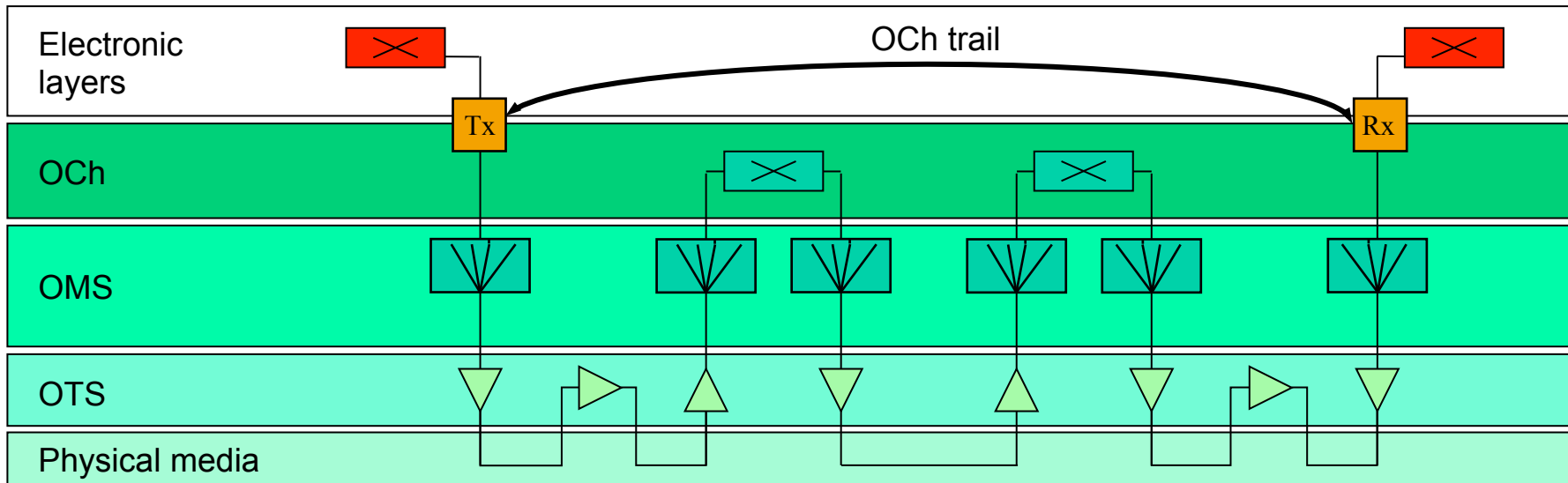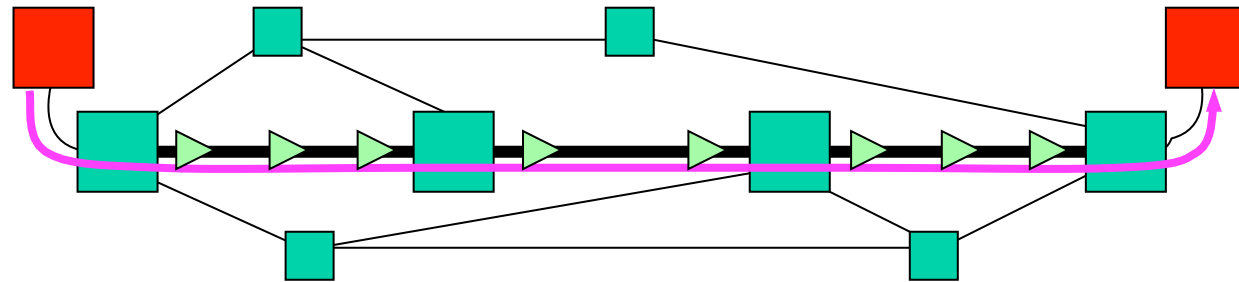
Optical channel sub-layer

- **End-to-end networking. Functions:**
  - optical channel connection <u>rearrangement</u> for flexible network routing
  - optical channel <u>overhead processing</u> for ensuring integrity of the optical channel adapted information
  - optical channel <u>supervisory functions</u> 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:** <u>the lightpath</u> (or optical circuit)

OMS sub-layer
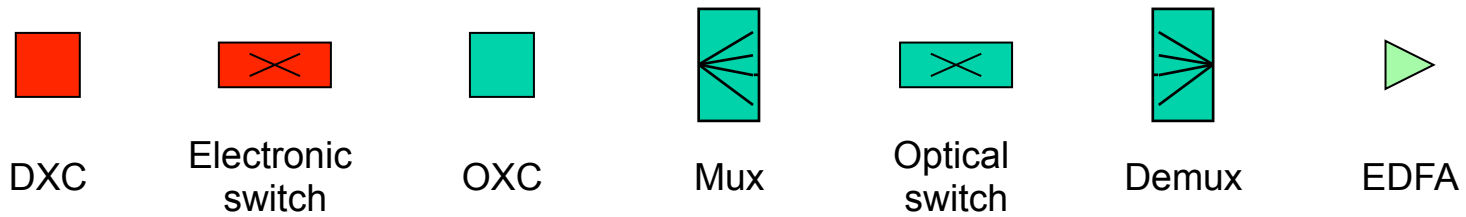
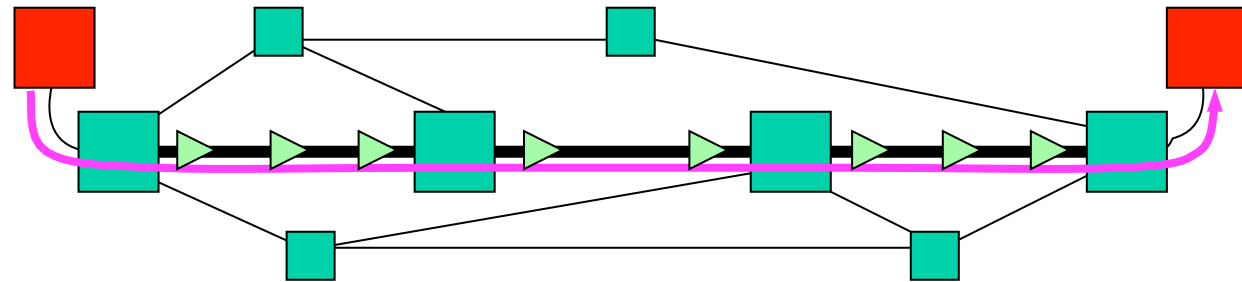# OMS sub-layer

- Networking of a multi-wavelength optical signal (including the case of just one optical channel)

- The capabilities of OMS sublayer:

    - OMS <u>overhead processing</u>

    - OMS <u>supervisory functions</u> and management functions, such as multiplex section survivability

- Typical involved devices: multiplexing/ demultiplexing subsystems of OXCs OADM

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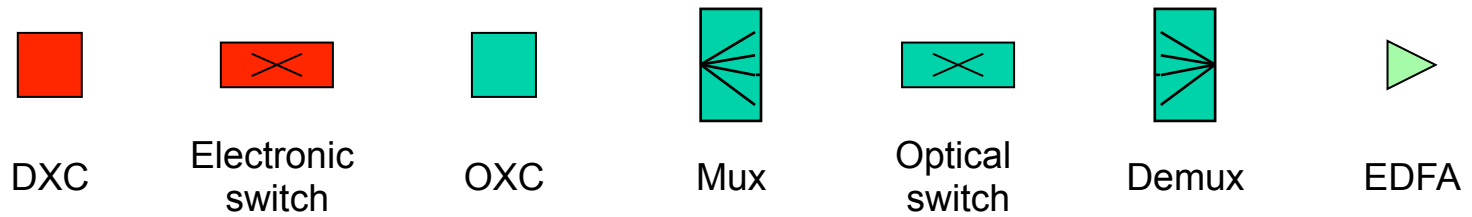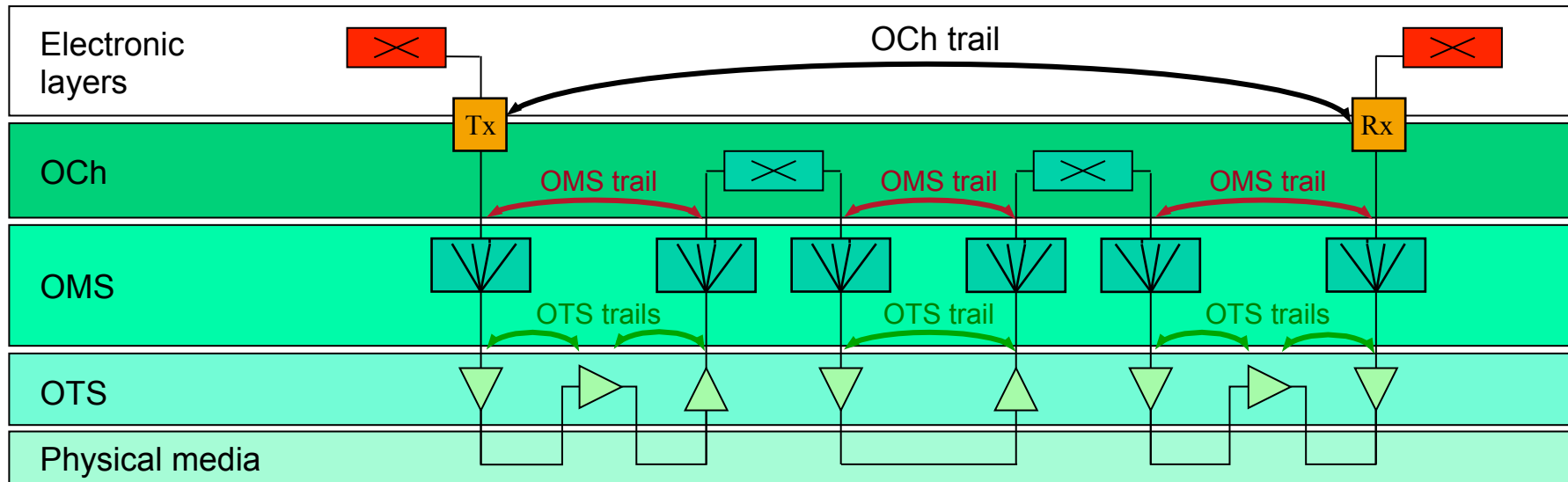
OTS sub-layer

OTS sub-layer

- Transmission of optical signals on the optical transmission media

- The capabilities of OTS sub-layer:

    - OTS <u>overhead processing</u>

    - OTS <u>supervisory functions</u>

- 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
    - Discover the topology by exchanges with neighbors
    - Updates by flooding (OSPF or IS-IS)
  - Route computation
    - Routing and wavelength assignment (RWA) problem
  - Signaling protocol
    - To set up and tear down lightpaths
  - Signaling network
    - The DCN

DCN and signaling

- **Standard data network**
  - TCP/IP or OSI

- **Connectivity**
  - Outside optical network
    - Leased lines
    - Available among equipment based in central offices, not available to optical amplifiers in remote huts
  - Optical supervisory channel (only for OTS, OMS, not available of OCh)
  - Framing information
    - SDH/SONET data channel
    - Digital wrapper

Additional reading

- R. Ramaswami, K. Sivarajan, G. Sasaki "Optical Networks: A Practical Perspective, 3rd Edition": Chapter 8