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)

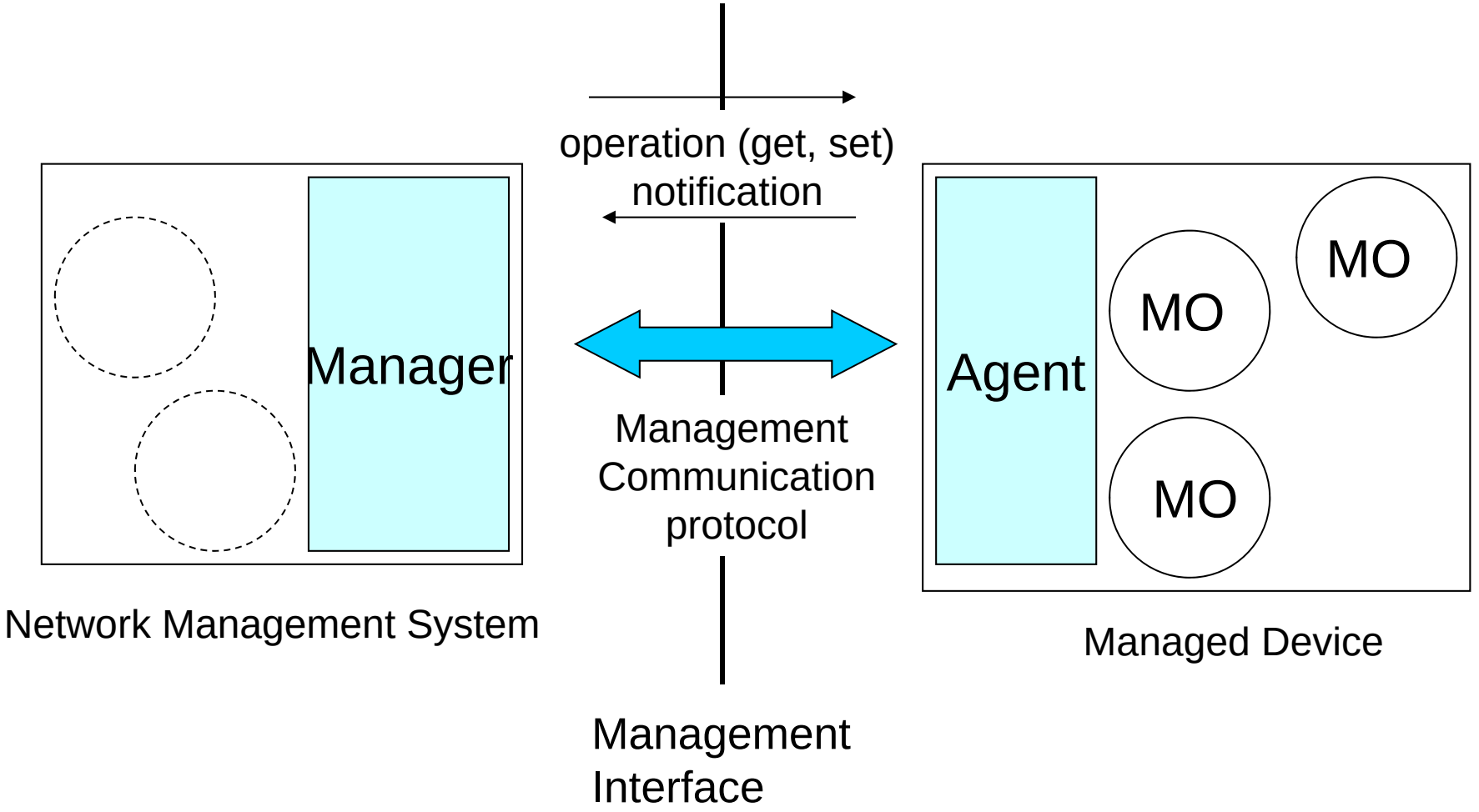
Why essential?

- 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



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

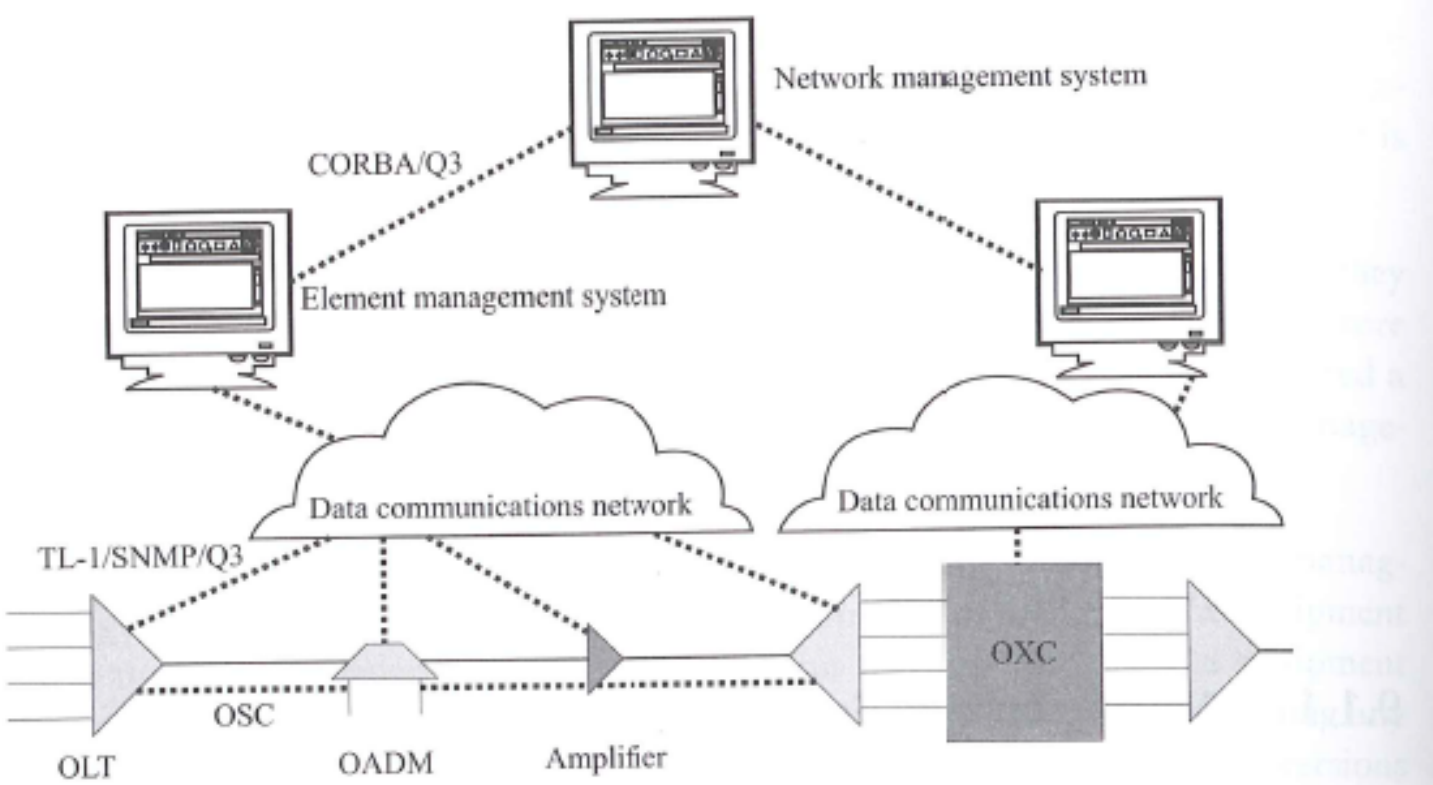


Figure 9.1 Overview of network management in a typical optical network, showing the network elements (OLTs, OADMs, OXCs, amplifiers), the management systems, and the associated interfaces.

Network management functions

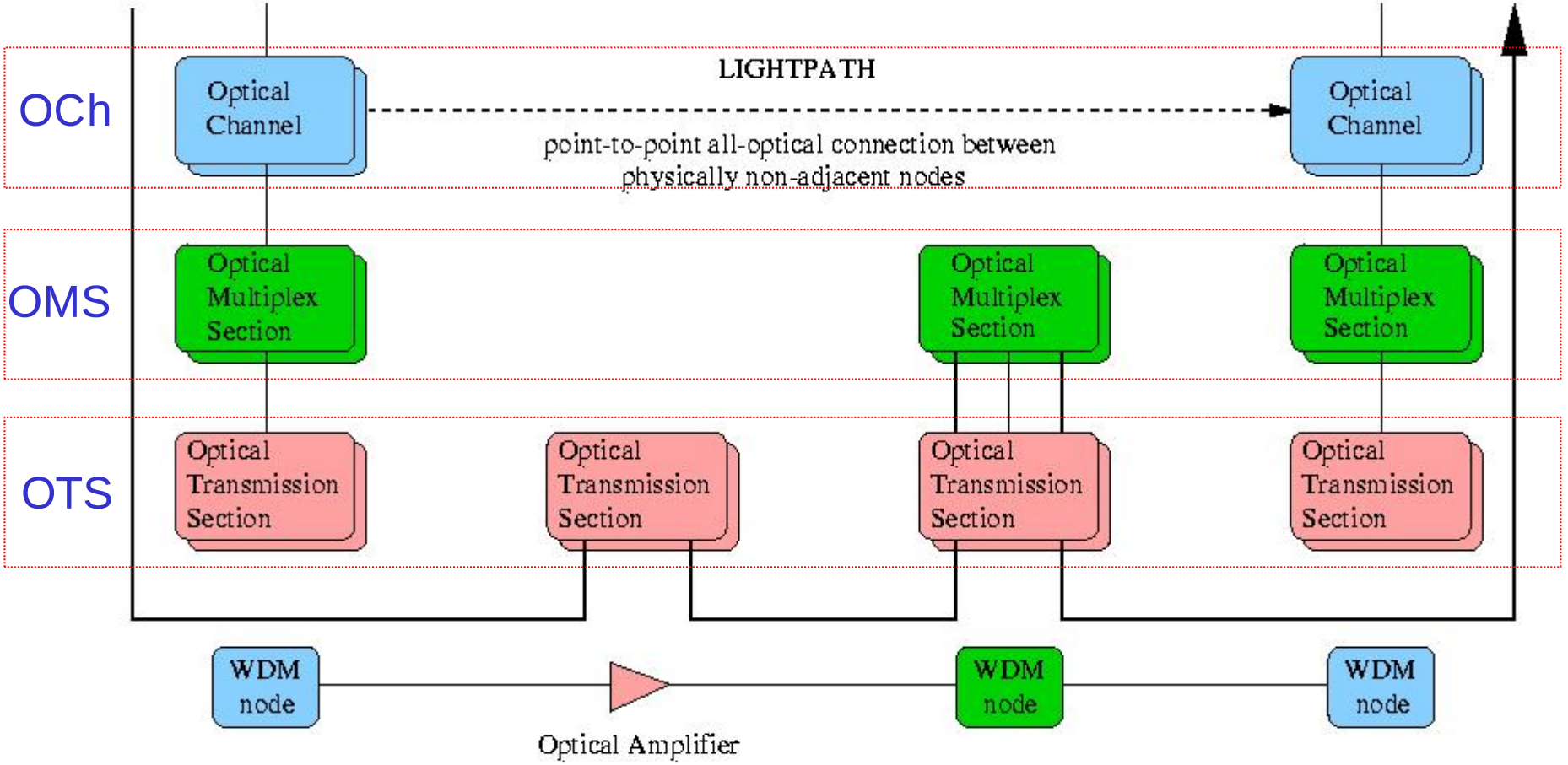
- Security management
  - authentication and selected access to management and control functions (specific partitions depending on role)
  - data integrity (encryption, data isolation)
- Accounting management
  - billing and history recording
  - no specific issues for optical networks
- Configuration 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

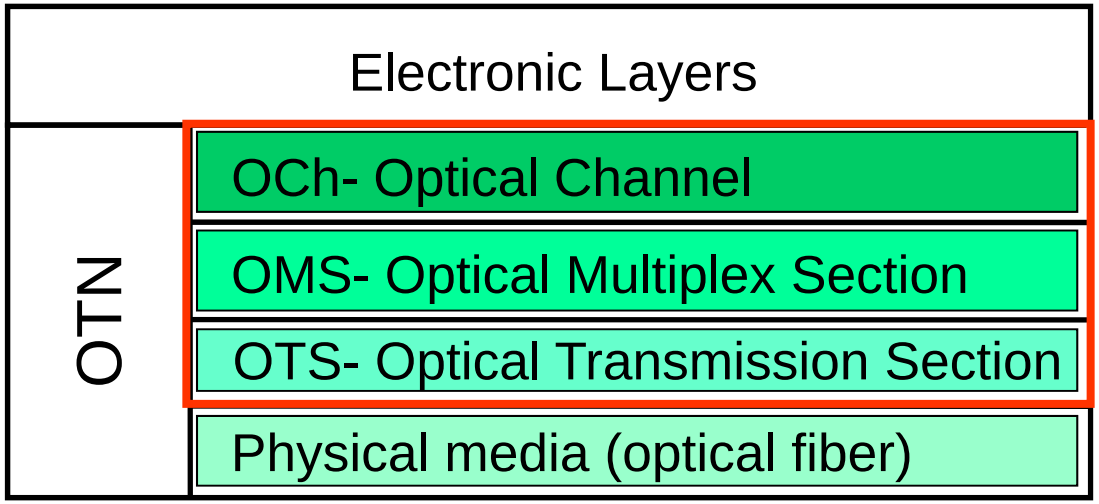
Optical Sub-Layers

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

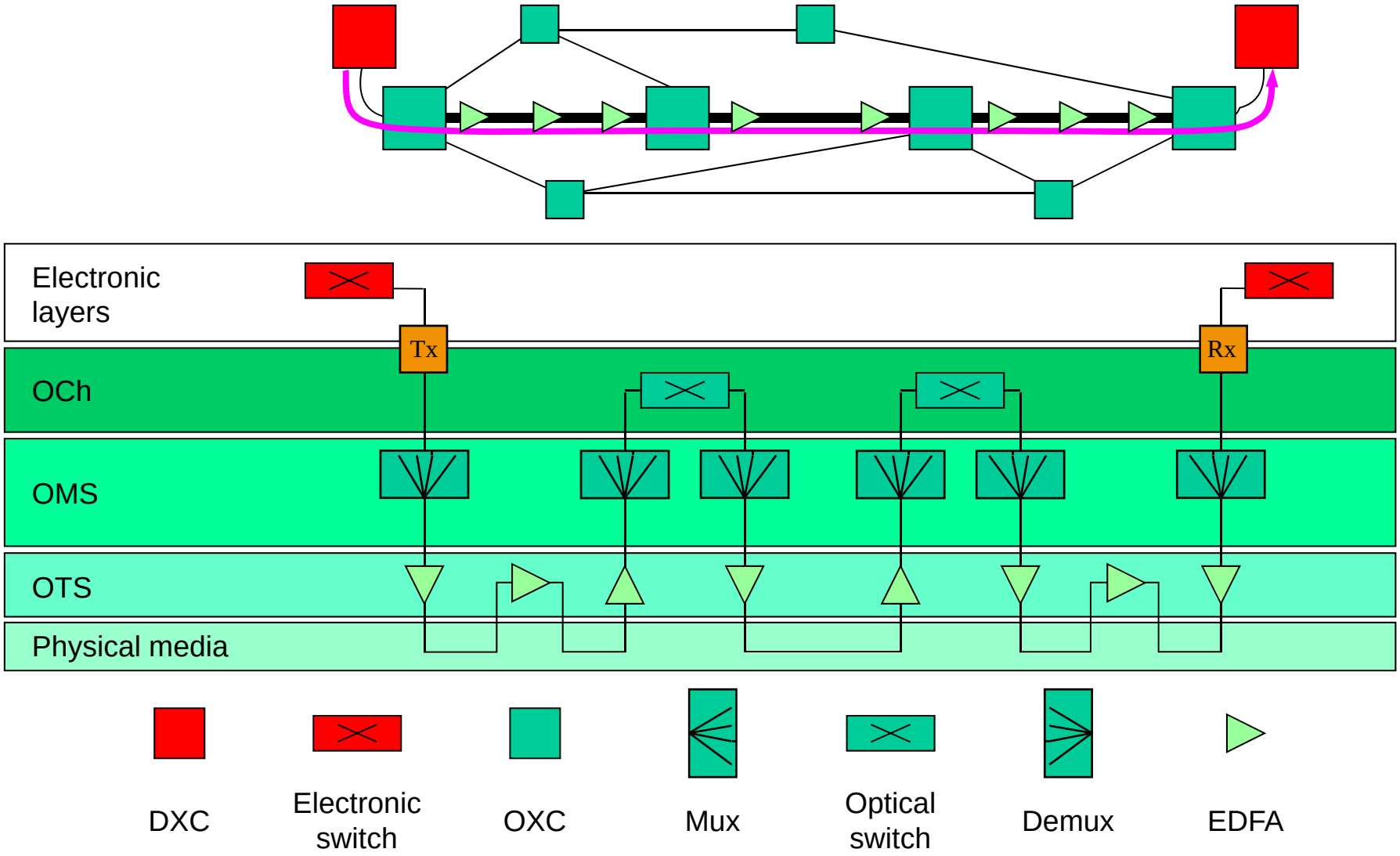


Optical Transport Network protocol layers

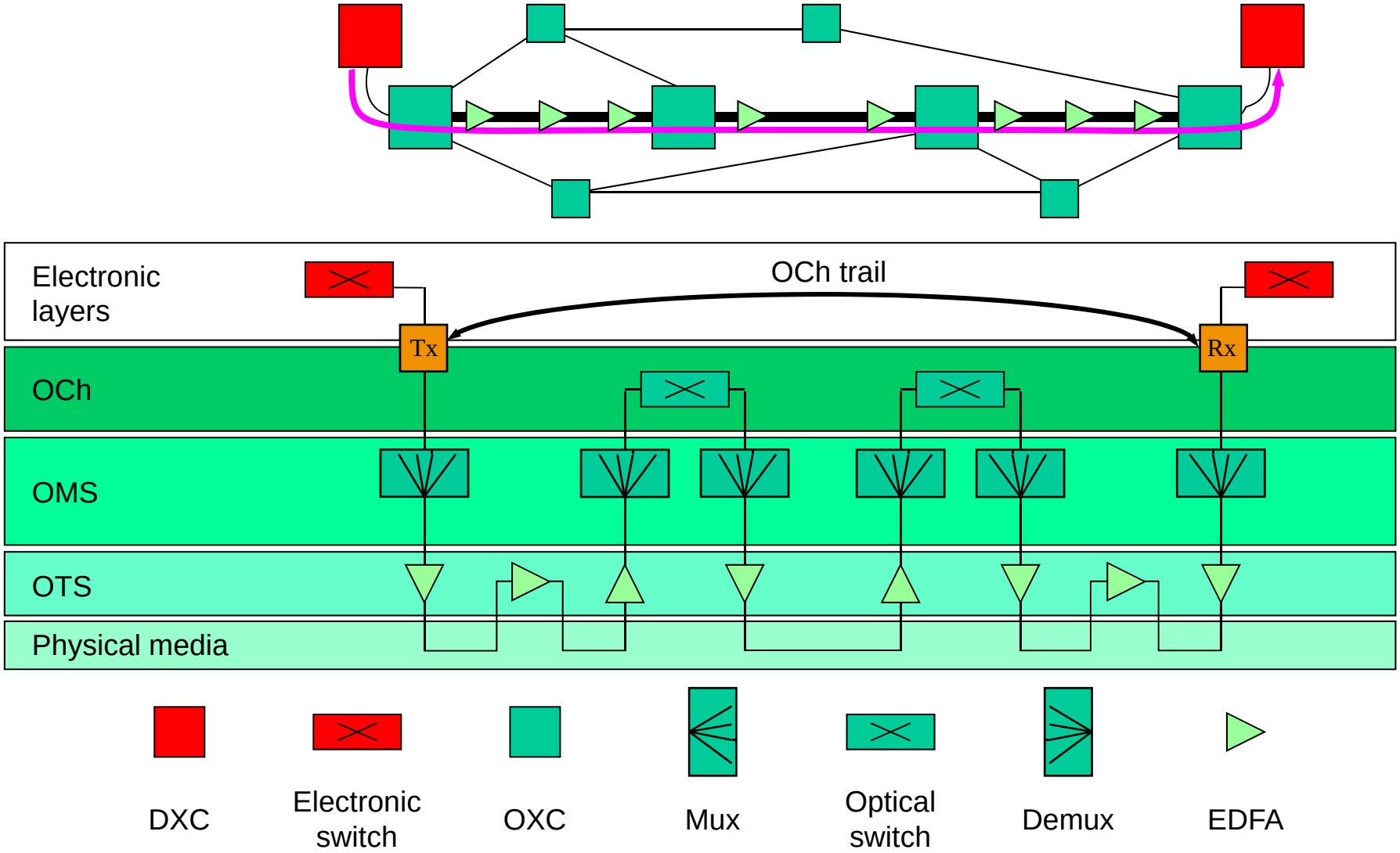
- Four layers in the OTN layer-stack:
  - Optical channel sublayer (OCh)
  - Optical multiplex section (OMS)
  - Optical transmission section (OTS)
  - Physical media layer
    - Fiber-type specification, developed in other Recommendations



Simplified view of an optical connection



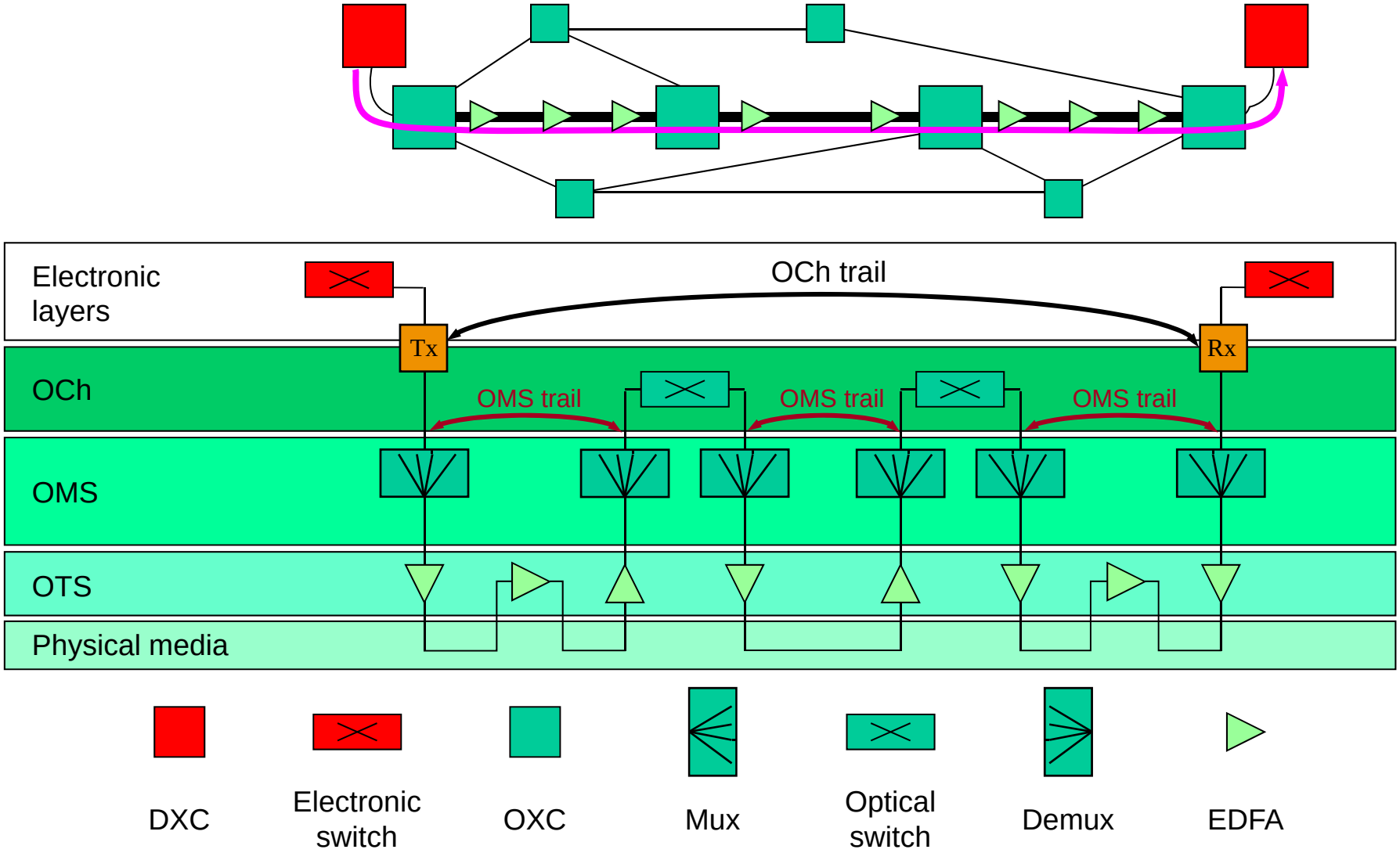
OCh sub-layer



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)

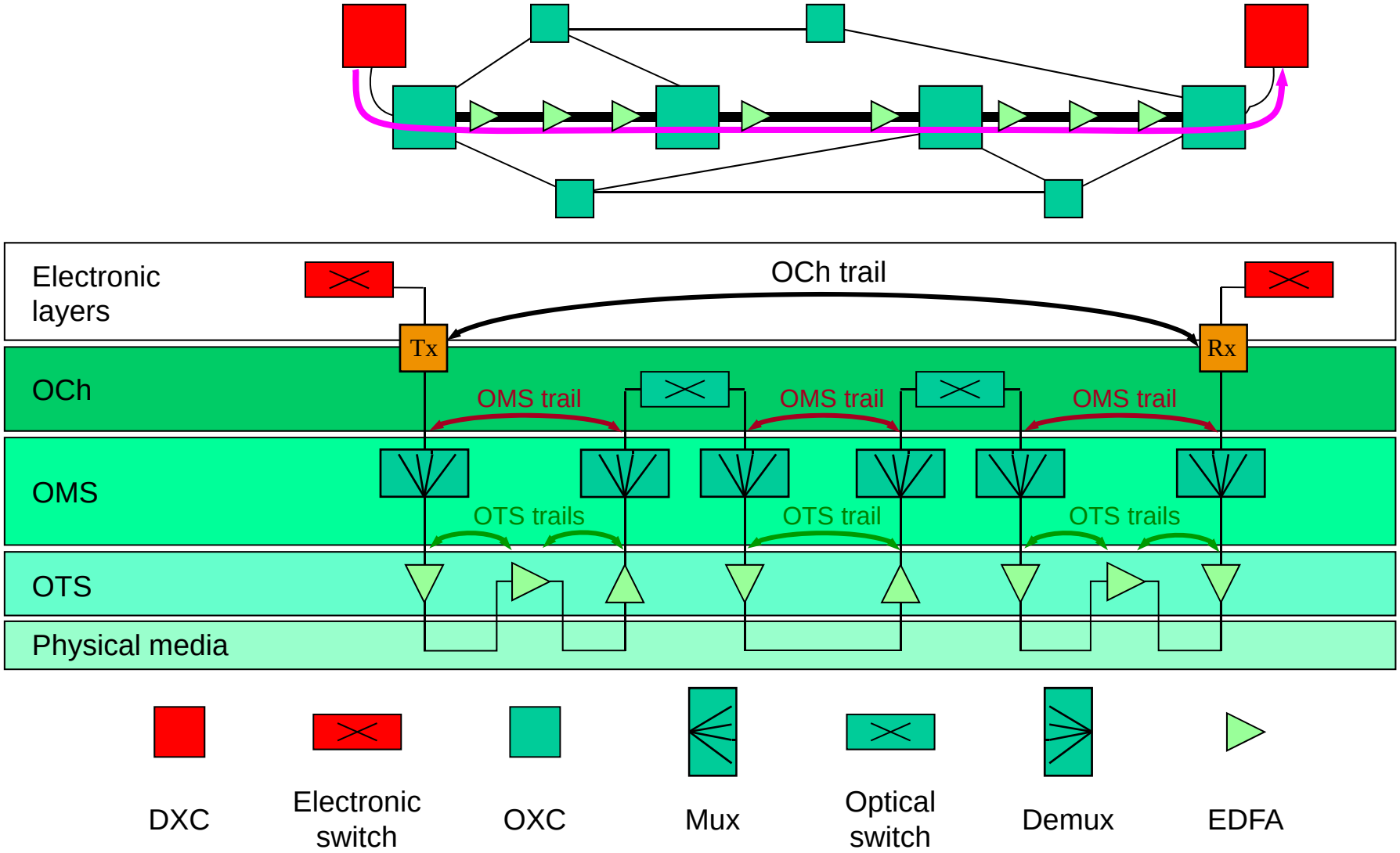
OMS sub-layer



OMS sub-layer

- 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



OTS sub-layer

- 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
    - 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
    - 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