Reconfigurable OADMs

- Reconfigurability is a very desirable attribute in an OADM.
- Reconfigurability refers to the ability to select the desired wavelengths to be dropped and added on the fly, as opposed to having to plan ahead and deploy appropriate equipment.
- This allows carriers to be flexible when planning their network and allows lightpaths to be set up and taken down dynamically as needed in the network.
- The architectures that we considered and were not reconfigurable in this sense.

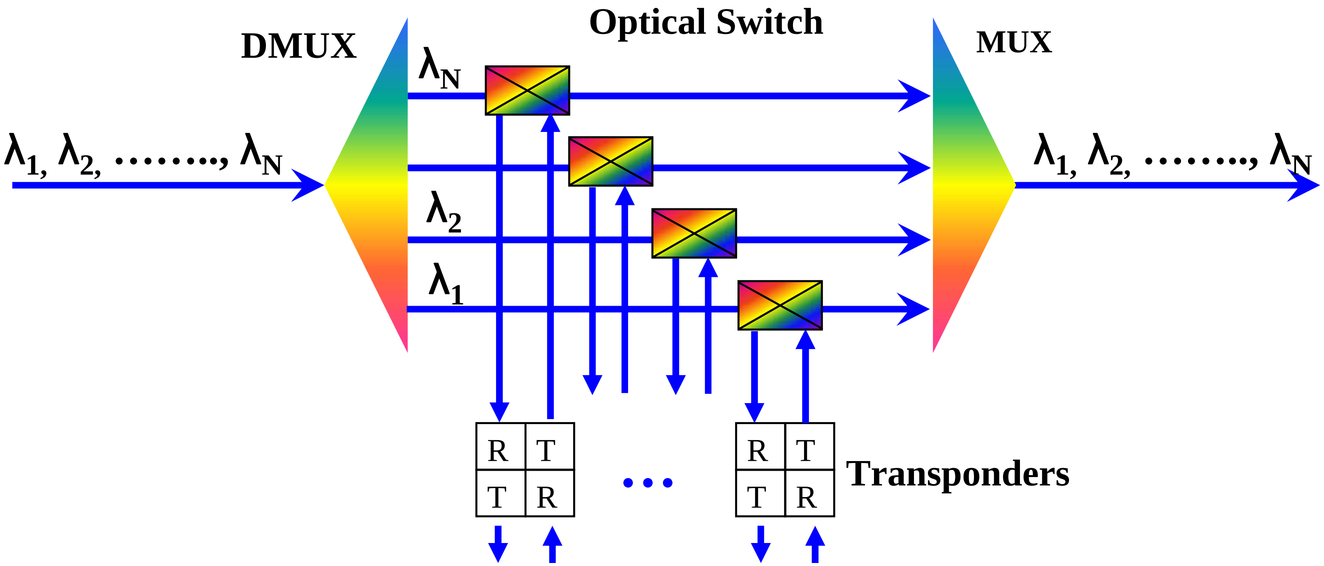
Reconfigurable OADMs

- Both of these architectures only partially address the reconfigurability problem because transponders are still needed to provide the adaptation into the optical layer.
- We distinguish between two types of transponders: a fixed-wavelength transponder and tunable transponder.
- A fixed-wavelength transponder is capable of transmitting and receiving at a particular fixed wavelength.
- This is the case with most of the transponders today.
- A tunable transponder, on the other hand, can be set to transmit at any desired wavelength and receive at any desired wavelength.

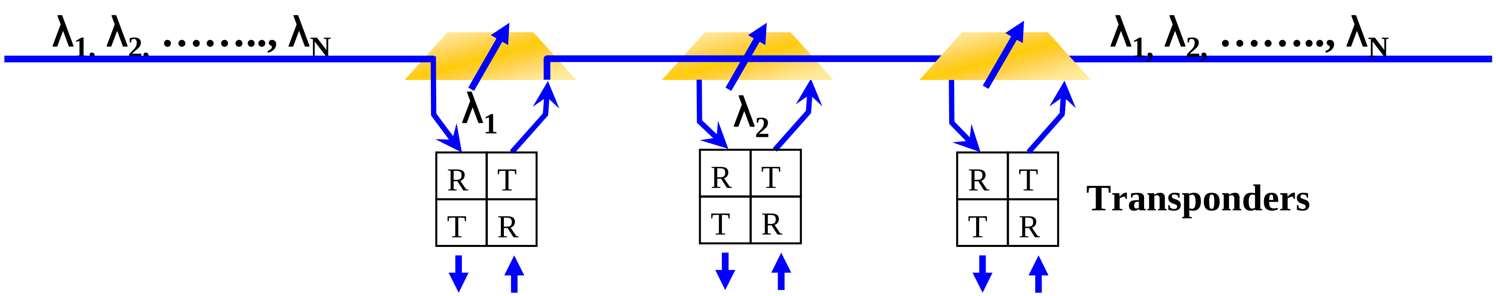
Reconfigurable OADMs

- A tunable transponder uses tunable WDM laser and a broadband receiver capable of receiving any wavelength.
- With fixed-wavelength transponders, in order to make use of the reconfigurable OADMs shown in Figure 7.7(a) and (b), we need to to deploy the transponders ahead of time so that they are available when needed.
- This leads to two problems: first, it is expensive to have transponder deployed and not used while the associated OADM is passing that wavelength through.

Reconfigurable OADM architectures



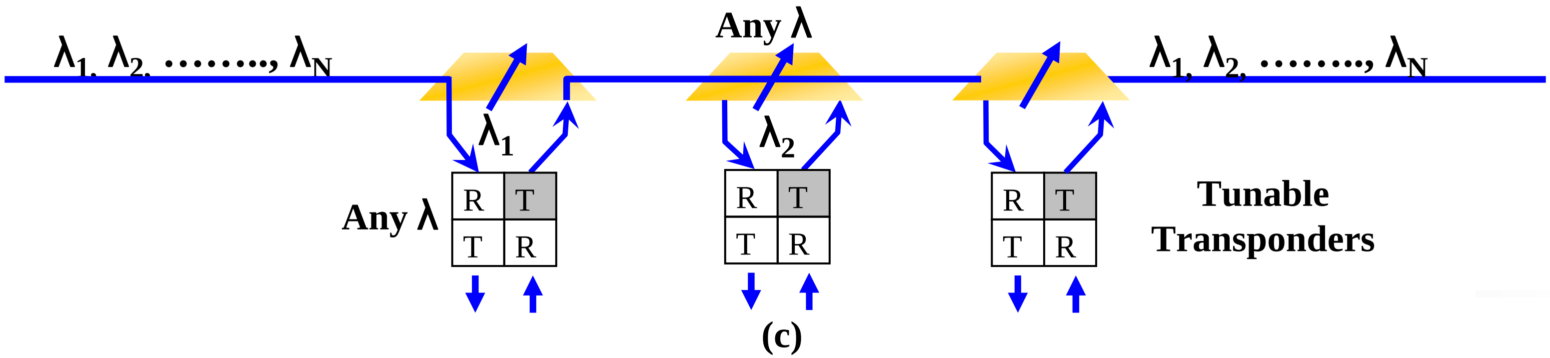
(a) A partially tunable OADM using a parallel architecture with optical add/drop switches and fixed-wavelength transponders.



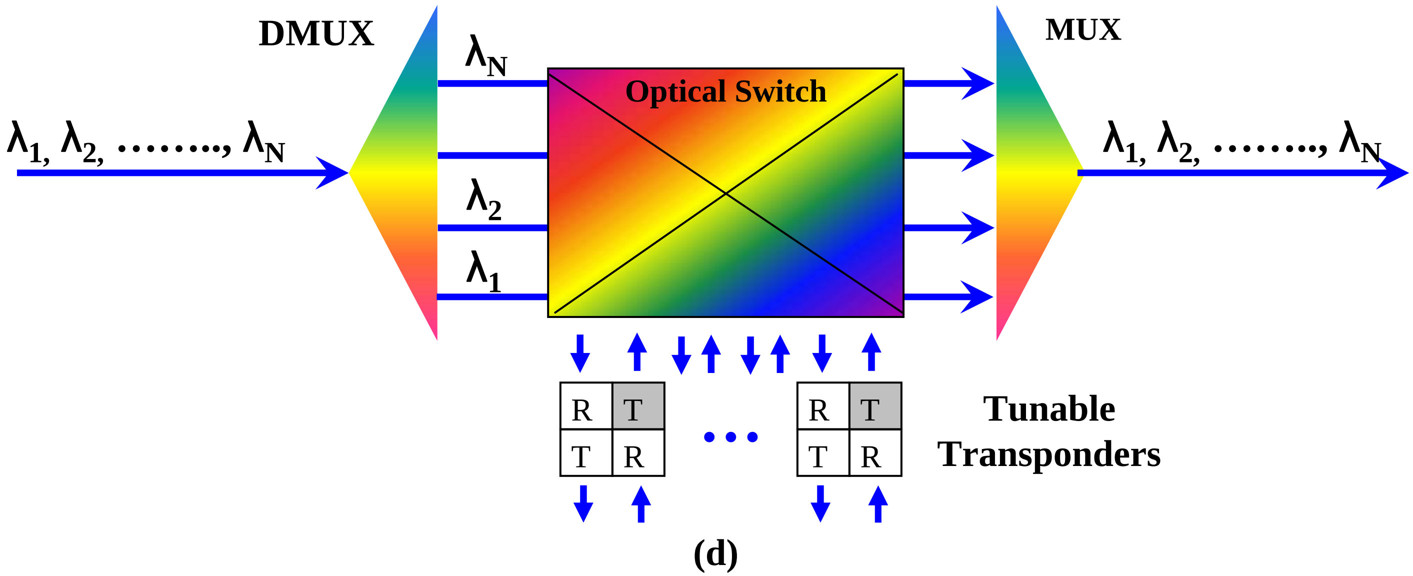
(b)

(b) A partially tunable OADM using a serial architecture with fixed wave-length transponders.

Figure: 7.7



(c) A fully tunable OADM using a serial architecture with tunable transponders. This transponder uses a tunable laser (marked T in shaded box) and a broadband receiver



(d) A fully tunable OADM using a parallel architecture with tunable transponders.

Figure: 7.7

Reconfigurable OADMs

- But let us suppose that this cost is offset by the added value of being able to set up and take down lightpaths rapidly.
- The second problem is that although the OADMs are reconfigurable, the transponders are not.
- So we still need to decide ahead of time as to which set o wavelengths we will need to deploy transponders for, making the network planning problem more constrained.
- Avoiding these problems requires the use of tunable transponders, and even more flexible architectures than the ones shown in Figure 7.7(a) and (b). For example, figure 7.7(c) shows a serial architecture where we have full reconfigurability.

Reconfigurable OADMs

- Each tunable SC-OADM is capable of adding/dropping any single wavelength and passing the others through, as opposed to a fixed wavelength.
- The adaptation is performed using a tunable transponder.
- This provides a fully reconfigurable OADM.
- Likewise, Figure 7.7(d) shows a parallel architecture with full reconfigurability.
- A partially tunable OADM using a parallel architecture with optical add/drop switches and fixed-wavelength transponders.
- A partially tunable OADM using a serial architecture with fixed-wavelength transponders.

Reconfigurable OADMs

- A fully tunable OADM using a serial architecture with tunable transponders.
- A fully tunable OADM using a parallel architecture with tunable transponders.
- Architecture requires the use of a large optical switch.
- This exactly the optical crossconnect that we will study next.

Reconfigurable OADMs

- So what would an ideal OADM look like? Such an OADM
- (1) would be capable of being configured to drop a certain maximum number of channels,
- (2) would allow the user to select what specific channels are dropped/added and what are passed through under remote software control, including the transponders, without affecting the operation of existing channels,
- (3) would not require the user to plan ahead as to what channel may need to be dropped at a particular node,, and
- (4) would maintain a low fixed loss regardless of how many channels are dropped/added versus passed through.

Reconfigurable OADMs

- The architecture of Figure 7.7(d) meets these criteria but may not be suitable for small-sized nodes where only a few channels need be dropped, due to its relatively high up-front cost.

Optical Crossconnects

- OADMs are useful network elements to handle simple network topologies, such as the linear topology show in figure 7.4 or ring topologies, and a relatively modest number of wavelengths.
- An additional network element is required to handle more complex mesh topologies and large numbers of wavelengths, particularly at hub locations handling a large amount of traffic.
- This element is the optical crossconnect (OXC). We will see that though the term “optical” is used, an OXC could internally use either a pure optical or an electrical switch fabric.

Optical Crossconnects

- The OXC shown in figure 7.8 performs this function.
- An OXC is also the key network element enabling reconfigurable optical networks, where lightpaths can be set up and taken town as needed, without having to be statically provisioned.
- Consider a large carrier central office hub.
- This might be an office in a large city for local service providers or a large node in long-haul service provider's network.
- Such an office might terminate several fiber links, each carrying a large number of wavelengths.

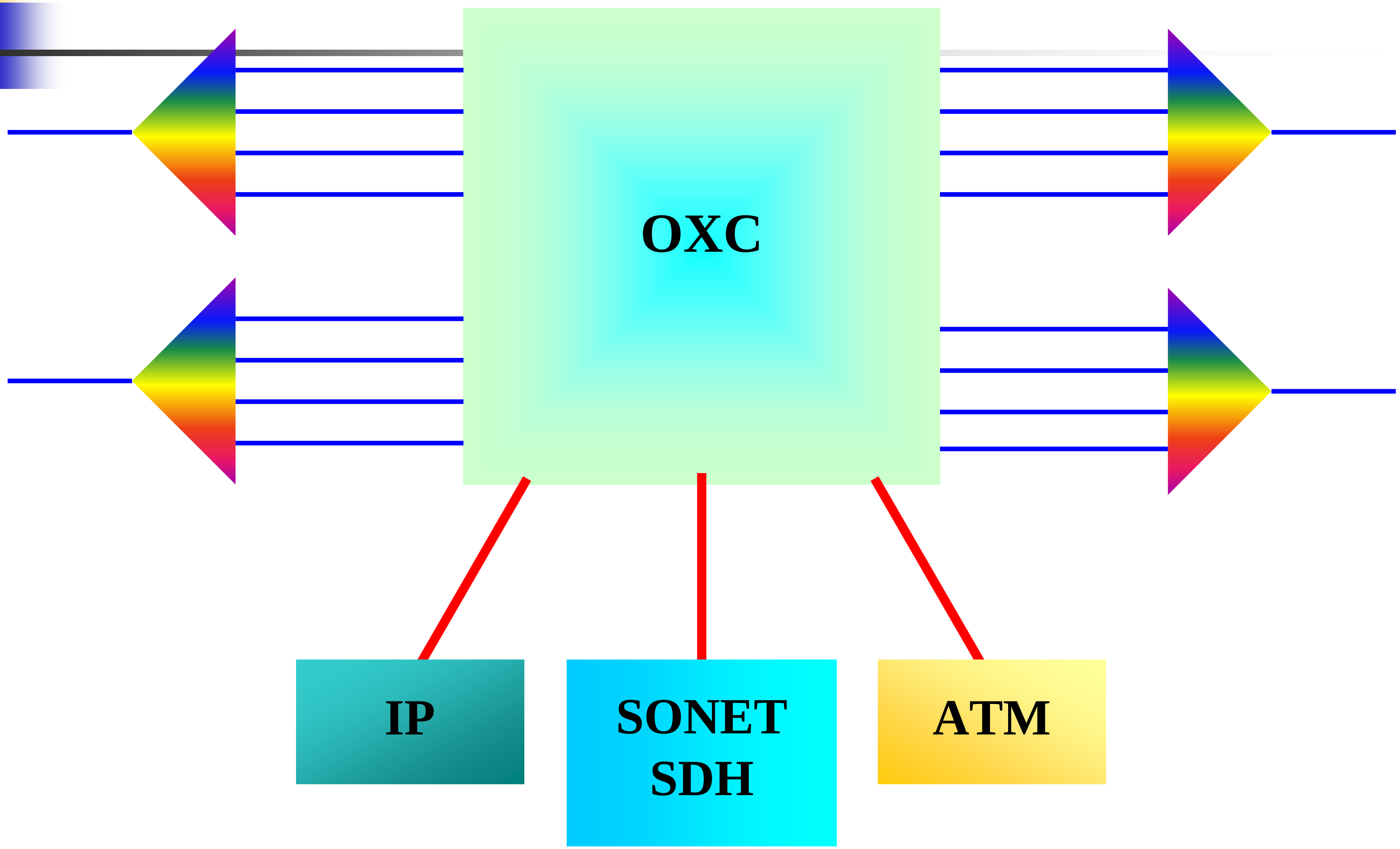


Fig 7.8

Optical Crossconnects

- A large number of these wavelengths might not need to be terminated in that location but rather passed through to another node.
- OXCs work alongside SONET/SDH network elements as well as IP routers and ATM switches, and WDM terminals and add/drop multiplexrs as shown in figure 7.8.
- Typically some OXC ports are connected to WDM equipment and other OXC ports to terminating devices such as SONET/SDH ADMs, IP routers, or ATM switches.

Optical Crossconnects

- Thus, the OXC provides cost-effective passthrough for express traffic not terminating at the hub as well as collects traffic from attached equipment into the network.
- Some people thinks of an OXC as a crossconnect switch together with the surrounding OLTs.
- However, our definition of OXC doesn't include the surrounding OLTs, because carriers view crossconnects and OLTs as separate products and often buy OXCs and OLTs from different vendors.
- An OXC provides several key functions in a large network:

Service provisioning

- An OXC can be used to provision lightpaths in a large network in an automated manner, without having to resort to performing manual patch panel connections.
- Important when we deal with large numbers of wavelengths in a node or with a large number of nodes in the network.
- It also becomes important when the lightpaths in the network need to be reconfigured to respond to traffic changes.
- Manual operation of sending a person to each office to implement a patch panel connection is expensive and error prone.
- Remotely configurable OXCs take care of this function.

Protection

- Protecting lightpaths against fiber cuts and equipment failures in the network is emerging as one of the most important functions expected from a crossconnect.
- Crossconnect is an intelligent network element that can detect failures in the network and rapidly reroute lightpaths around the failure.
- Crossconnects enable true mesh networks to be deployed
- These networks can provide particularly efficient use of network bandwidth, compared to the SONET/SDH rings.

Bit rate transparency

- Ability to switch signals with arbitrary bit rates and frame formats is a desirable attribute of OXCs.

Performance monitoring,test access, and fault localization

- OXCs provide visibility to the performance parameters of a signal at intermediate nodes.
- Allow test equipment to be hooked test port where the signals passing through the OXC can be monitored in a non-intrusive manner.

Wavelength conversion

- In addition to switching a signal from one port to another port, OXCs may also incorporate wavelength conversion capabilities.

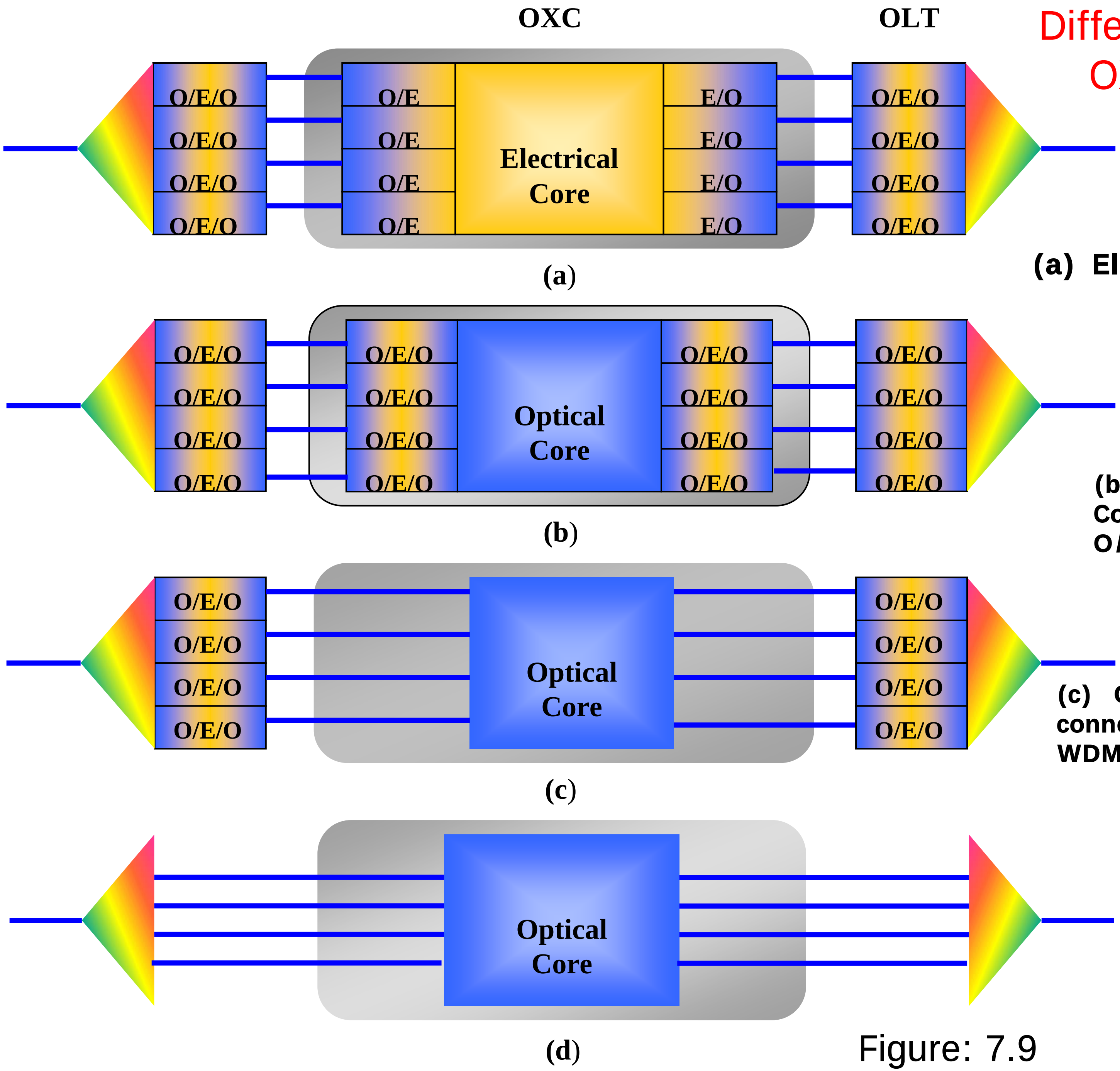
Multiplexing and grooming

- OXCs typically handle input and output signals at optical line rates.
- However, they can incorporate multiplexing and grooming capabilities to switch traffic internally at much finer granularities, such as STS-1 (51 Mb/s)

Optical Crossconnects

- An OXC can be functionally divided into a switch core and a port complex.
- Switch core houses the switch that performs the actual crossconnect function.
- Port complex houses port cards that are used as interfaces to communicate with other equipment.
- Port interfaces may or may not include optical-to-electrical (O/E) or optical-to-electrical-to-optical (O/E/O) converters.
- Figure 7.9 shows different types of OXCs and different

Different scenarios for OXC deployment



(a) Electrical Switch Core

(b) Optical Switch Core surrounded by O/E/O Converters

(c) Optical Switch Core directly connected to transponders in WDM equipment

(d) Optical Switch Core directly connected to the MUX/DMUX in the OLT

Figure: 7.9