OXCs

Switching in the Optical Domain

- Principal form of optical switching is realy nothing more than a sophisticated digital cross-connect.
- In the early days of data networking, dedicated facilities were created by manually patching the end points of a circuit at a patch panel, thus creating a complete four-wire circuit.
- Digital cross-connect is really a simple switch, designed to establish “long-term temporary” circuits quickly , accurately, and inexpensively.
- Traditional cross-connect systems worked fine in the optical domain, provided that no problem going through the O-E-O conversion process occurred.

Switching in the Optical Domain

- First of these to arrive on the scene was Lucent Technologies' LambdaRouter.
- Based on a switching technology called Micro Electrical Mechanical System (MEMS).
- LambdaRouter was the world's first all-optical cross-connect device.
- MEMS relies on micro-mirrors, which can be configured at various angles to ensure that an incoming lambda strikes one mirror, and is then reflected out an egress fiber.
- A schematic diagram of the MEMS technology is shown in Figure 3.12.

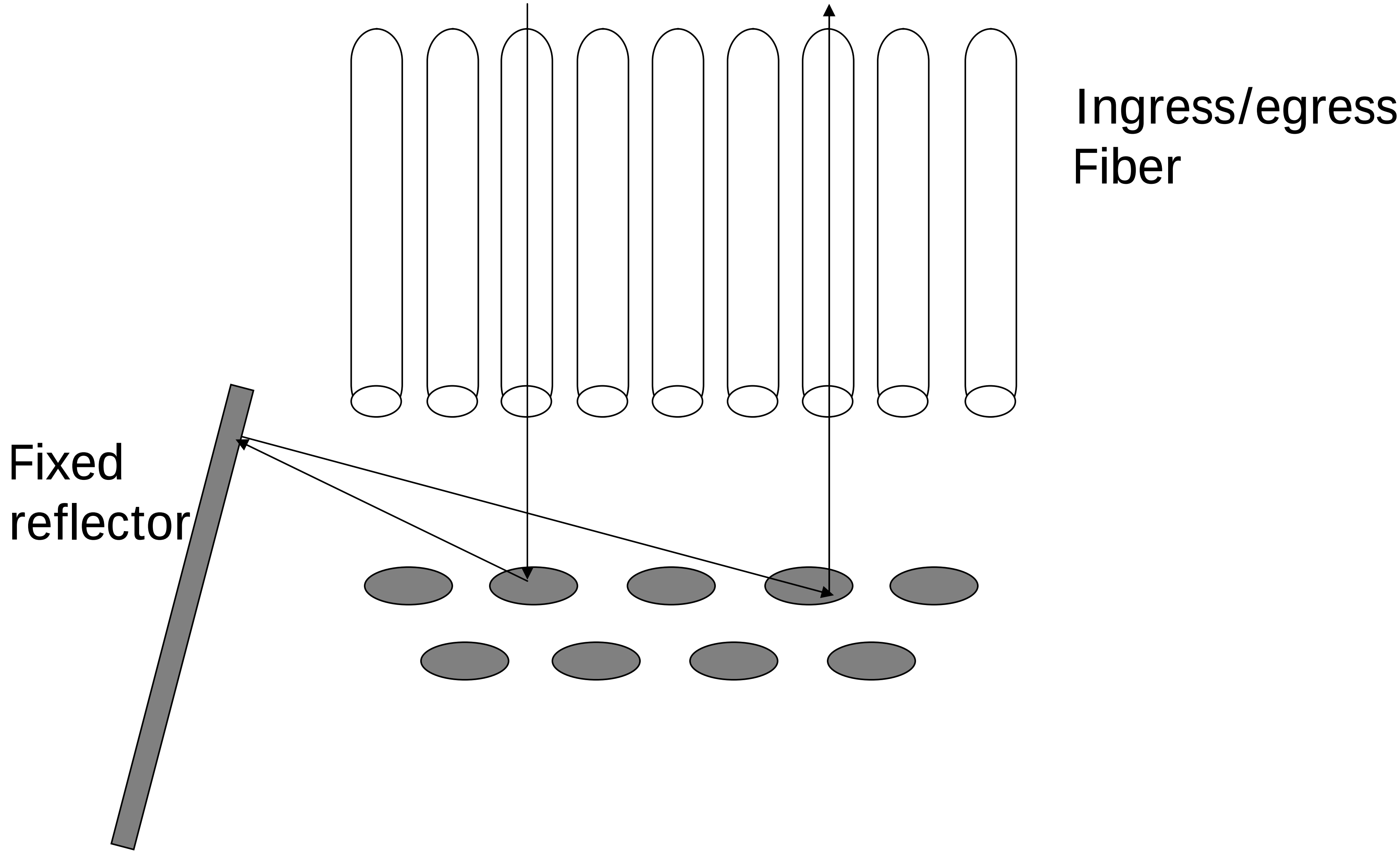
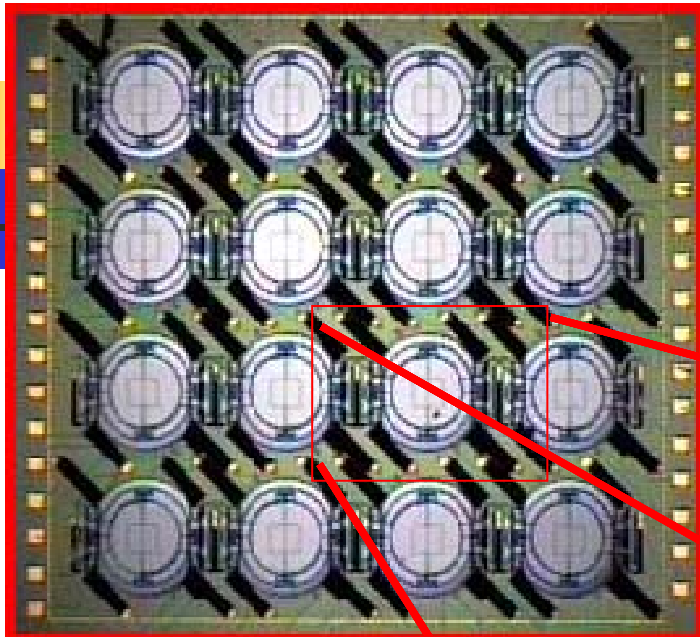
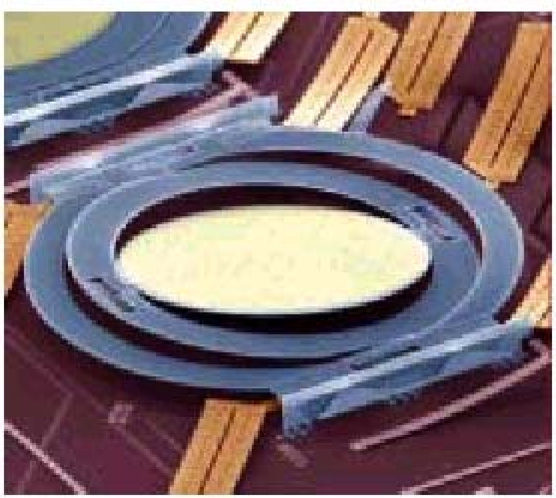


Fig 3-12

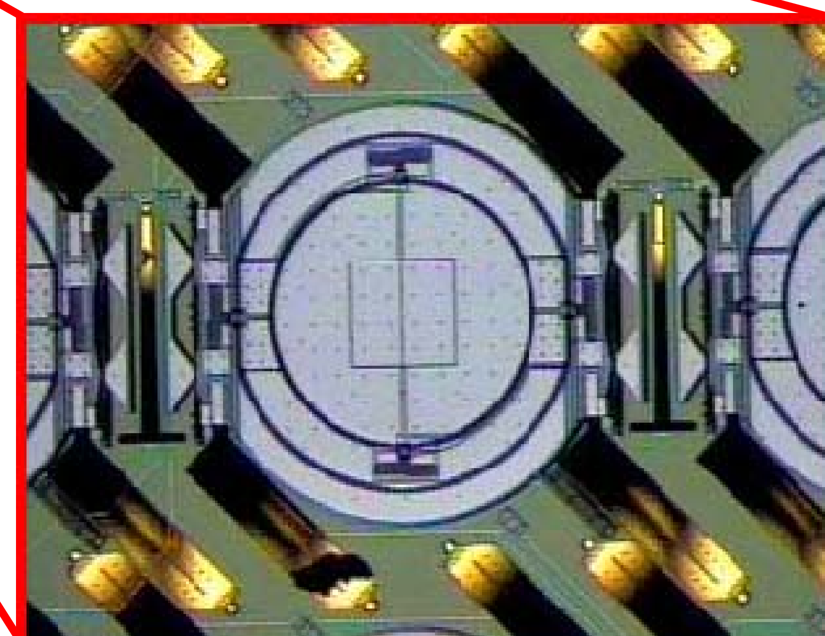
MEMS Operation

DWDM Components
MEMS Switch Technology



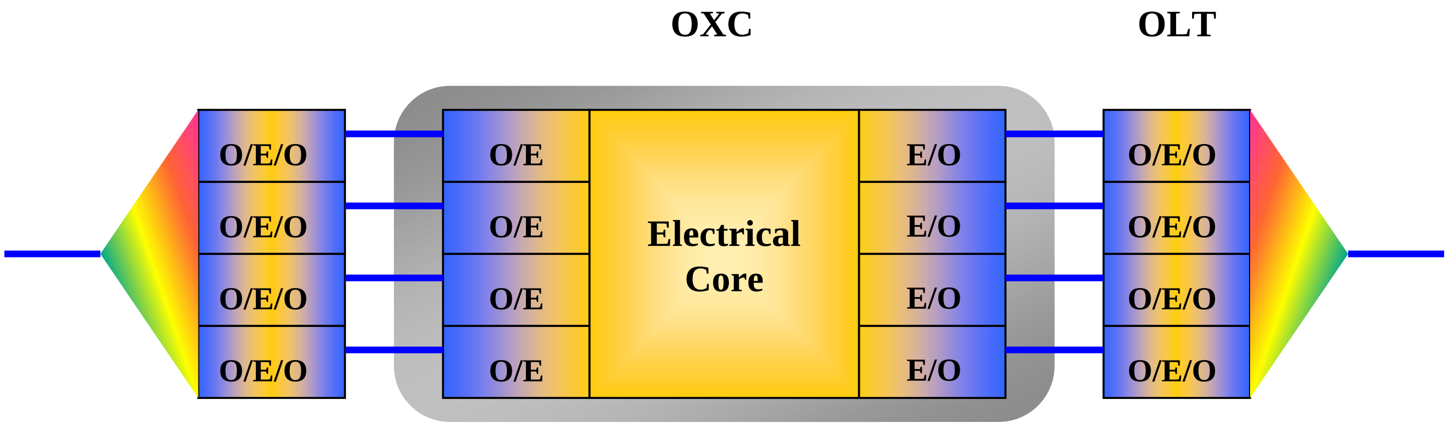


Source: Sandia National Labs and Lucent Technologies



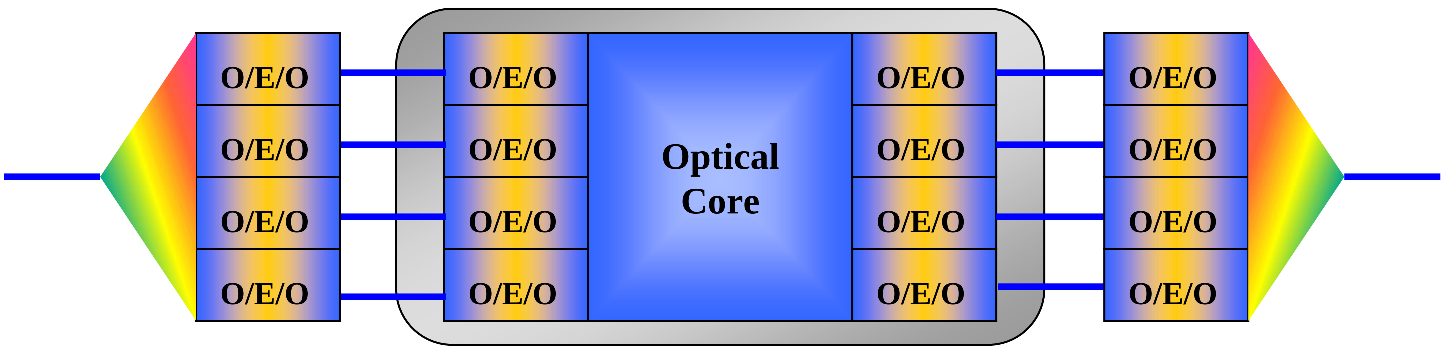
Switching in the Optical Domain

- Device eliminates all O-E-O conversion, is bit rate and protocol transparent, switches on a lambda-by-lambda basis, and is immensely scalable.
- Mirror-based MEMS technology is the best-known wavelength switching technique.



(a)

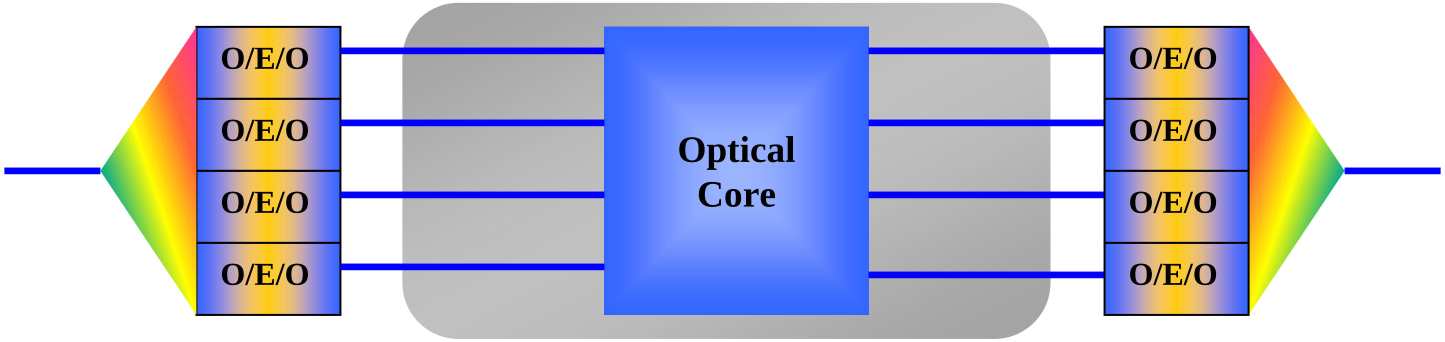
(a) Electrical switch core:



(b)

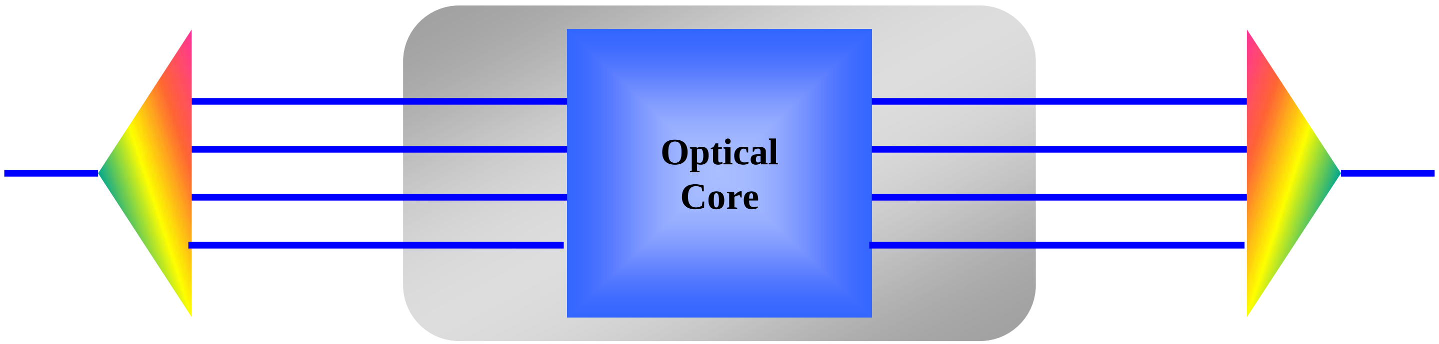
(b) Optical switch core surrounded by O/E/O converters:

Fig 7.9



(c)

(c) Optical switch core directly connected to transponders in WDM equipment:



(d)

(d) Optical switch core directly connected to the multiplexer/demultiplexer in the OLT

Fig 7.9

Optical Crossconnects

- An electrical switch core can groom traffic at fine granularities and typically includes time division multiplexing of lower-speed circuits into the line rate at the input and output ports.
- Today, we have electrical core OXCs switching signals at granularities of STS-1 (51 Mb/s) or STS-48 (2.5 Gb/s).
- In contrast, a true optical switch core does not offer any grooming.
- It simply switches signals from one port to another.
- An electrical switch core is designed to have a total switch capacity, for instance, 1.28 Tb/s.

Optical Crossconnects

- Optical core is typically bit rate independent.
- Optical core is thus more scalable in capacity, compared to an electrical core, making it more future proof as bit rates increase in the future.
- As bit rates increase, the cost of a port on an electrical switch increases.
- For instance, an OC-192 port might cost twice as much as an OC-48 port.
- Cost of a port on an optical core switch, on the other hand, is the same regardless of the bit rate.
- Therefore at higher bit rates, it will be more cost-effective to switch signals through an optical core OXC than an electrical core OXC.

Optical Crossconnects

- An optical switch core is also transparent: it does not care whether it is switching a 10 Gb/s Ethernet signal or a 10 Gb/s SONET signal.
- In contrast, electrical switch cores require separate port cards for each interface type, which convert the input signal into a format suitable for the switch fabric.
- Figure 7.9(a) an OXC consisting of an electrical switch core surrounded by O/E converters.
- OXC interoperates with OLTs through standard non-WDM short-reach (SR) optical interfaces, typically at 1310 nm.

Optical Crossconnects

- Figure 7.9(b)-(d) show OXCs with an optical switch core.
- Differences between the figures lie in how they interoperate with the WDM equipment.
- In figure 7.9(b), the Interworking is done in a somewhat similar fashion as in Figure 7.9 (a)- through the use of O/E/O converters with short-reach or very-short-reach optical interfaces between the OXC and the OLT.
- In Fig. 7.9(c), there are no O/E/O converters and the optical switch core directly interfaces with the transponders in the OLT.

Optical Crossconnects

- Figure 7.9(d) shows a different scenario where there are no transponders in the OLT and the wavelengths in the fiber are directly switched by the optical switch core in the OXC after they are multiplexed/demultiplexed.
- The cost, power and overall node footprint all improve as we go from figure 7.9(b) to Fig. 7.9(d).
- Electrical core option typically uses higher power and takes up more footprint, compared to the optical option, but the relative cost depends on how the different products are priced, as well as the operating bit rate on each port.

Optical Crossconnects

- OXCs in Figure 7.9(a) and (b) both have access to the signals in the electrical domain and can therefore perform extensive performance monitoring (signal identification and bit error rate measurements)
- The Bit error rate measurement as a trigger.
- These crossconnects need an out-of-band signaling channel to exchange control information with other network elements.
- With the configuration of Figure 7.9(c) the attached equipment needs to have optical interfaces that can deal with the loss introduced by the optical switch.

Optical Crossconnects

- These interfaces will also need to be single-mode fiber interfaces since that is what most optical switches are designed to handle.
- In addition, serial interfaces (single fiber pair are preferred rather than parallel interfaces (multiple fiber pairs), as each fiber pair consumes a port on the optical switch.
- The all-optical configuration of Figure 7.9(d) provides a truly all-optical network.
- However, it mandates a more complex physical layer design as signals are now kept in the optical domain all the way from their source to their destination, being switched optically at intermediate nodes.

Optical Crossconnects

- Given that link engineering is complex and usually vendor proprietary, it is not easy to have one vendor’s OXC interoperate with another vendor’s OLT in this configuration.
- It is possible to integrate the OXC and OLT systems together into one piece of equipment.
- Doing so provides some significant benefits.
- It eliminates the need for redundant O/E/Os in multiple network elements, allows tight coupling between the two to support efficient protection, and makes it easier to signal between multiple OXCs in a network using the optical supervisory channel available in the OLTs.

Optical Crossconnects

- However, this integration also has the drawback of making it a single-vendor solution.
- Service providers must then buy all their WDM equipment, including OLTs and OXCs, from the same vendor in order to realize this simplification.
- Moreover, this solution doesn't address the problem of dealing with legacy situations where the OLTs are already deployed and OXCs must be added later.