

AII-OPTICAL SWITCHING

All-Optical Switching is a new direction for the future of high-bandwidth switching technologies. In All-Optical Switching technology light is directed through an optical fiber without first converting into electrical signals.

Workgroup switches remain primarily Fast Ethernet based, which in turn have gigabit uplinks to core switches via fiber. Fiber has the potential of pushing multi-gigabit data speeds through a single strand, with great scalability. Switching technology, in relation to fiber, is no different than switching copper networks – at least as far as corporate networks and internal uplinks are concerned.

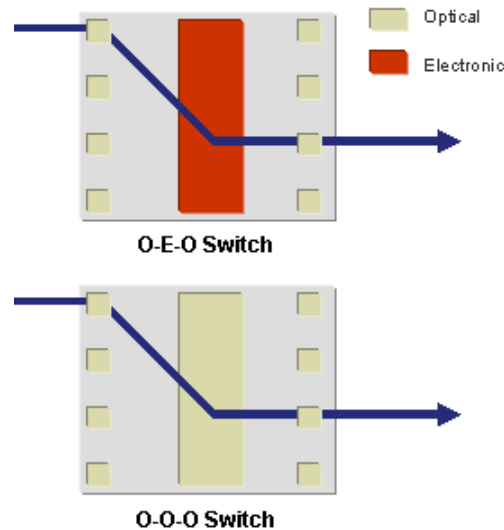
Optical-Electrical-Switching (O-E-O)

The fiber uplink modules that we see on core and workgroup switches merely act as transceivers, once the signal enters the switch, the data is converted into electrical signals, which are operated upon and then transmitted out again in the form of light. This is O-E-O (Optical Electrical Switching) process. The switching technology is still electrical and subject to certain limitations. A typical fiber link can carry anywhere between 10Gbps and 40Gbps of data. Switching technology lags far behind, regardless of recent developments of multi gigabit switches and routers.

The All-Optical network

Simply put, an All-Optical network is one where there is no optical electrical conversion between source and destination. Having an all-optical network for the enterprise applications is neither feasible nor possible at this point. However Carrier

Networks, MANs (Metropolitan Area Networks) and long-haul links may choose to have it.



With an optical switch which uses O-O-O (Optical-Optical-Optical) process, light is reflected or otherwise directed down a different route without being converted into electrical signals – this saves time and it is cheaper. The other benefit of all-optical devices may be their greater scalability over OEOs. In fact, All-Optical switches are completely bit-rate transparent. They are also protocol transparent. All-Optical switches make switching decisions based on wavelength, putting them in the analog domain rather than the digital. Fiber circuits can be switched to other routes and backed up in the event of a break down very easily.

The Imaginative approach

One solution to the optical switching problem is the O-E-O-O-O-E-O system. It combines the advantages of O-E-O systems on a per port basis, while using an optical backplane for scalability. Each port can have an intermediate electrical conversion, which regenerates the signal and may also allow monitoring of BER (Bit-Error-Rate). Plus you get to choose this on a per port basis.

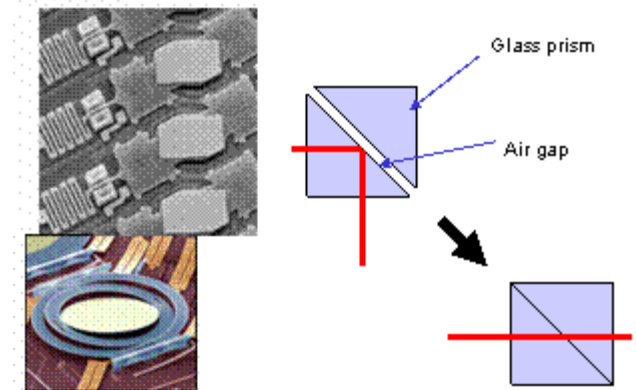
By putting the electrical element in the port rather than the backplane, you get to use an all-optical backplane, thus increasing scalability.

Optical Switching Technologies

All-Optical Switches get their name from being able to carry light from their input to their output ports in its native state, i.e. as pulses of light rather than changes in electrical voltage

MEMS

Micro Electro-Mechanical Systems (MEMS) use tiny mirrors (capable of being tilted) built onto a chip to physically reflect light into other directions. Since the density of mirrors on a chip is high, the per-port costs go down. But being mechanical in nature, MEMS-based setups are typically slow to switch. By applying more current or by changing the mirror design it is possible to achieve faster switching speeds. This technique is known as "fast MEMS."



Tiny Mirrors in MEMS

Prisms in FTIR

Frustrated Total Internal Reflection

FTIR (Frustrated Total Internal Reflection) is a technique based on the differing refractive indices of different mediums. A switching element based on this technology consists of two prisms placed

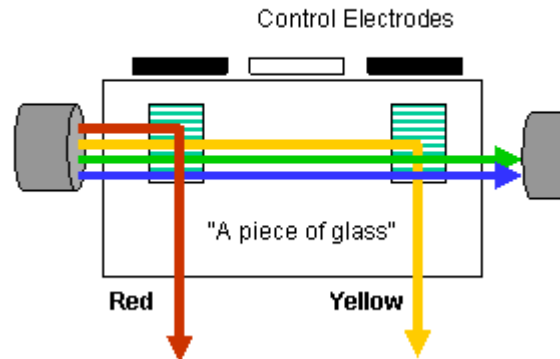
together to form a cube. In this form, light will pass through completely. If the prisms are separated by a small gap, light will enter the first prism, hit the prism-air boundary and be reflected internally. Simply by creating or removing the air gap between the two prisms, we've a switch element. It's a wideband technique; you can use it to switch all the channels on a single fiber at the same time, and so it's good as a protection switch.

Grating and Circulators

By applying a specific wavelength of laser to a conventional fiber, it's possible to change the properties of the fiber core to act as a grating. This lets certain wavelengths of light pass through while reflecting others. When combined with a system called circulator, it's possible to build static optical switches. These aren't usable for dynamic switching, since to switch other wavelengths, the grating has to be changed physically.

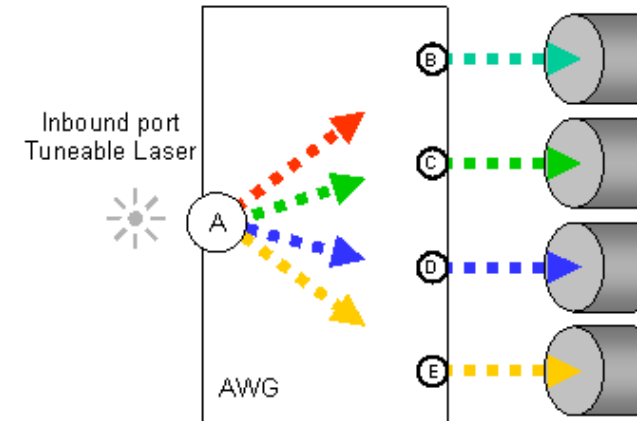
first exit, but then it hits the grating, which is reflective to λ_1 and bounces right back. Meanwhile, λ_2-8 have passed right through the grating and are added to λ_1 . The combined λ s now exit together, and we've performed an add operation. We can reverse this configuration to selectively drop wavelengths, too.

Electrode causes hologram of Bragg Grating to "appear"

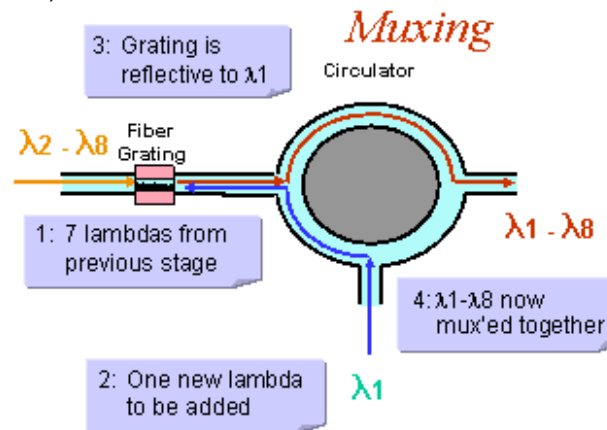


Space Switching

You can create optical switching using elements called AwGs (Arrayed Waveguide Gratings), which are essentially more efficient, discriminating prisms, and combining them with tunable lasers.



On the left side of the picture we have a range of λ s entering from a previous stage (λ_2-8).



At the bottom we are adding a new λ . λ_1 enters the circulator and leaves at the

Holographic Switches

Holographic switches are an exciting development. They are completely solid state, with no moving parts, and are extremely fast. The basic element is a piece of glass with λ -specific gratings become effective only when acted upon by a current. When inert, light simply passes through, but when active light is reflected. So using a series of gratings, all wavelengths can be switched. However downside is that while going through holograms, you incur a loss – a flaw that needs to be addressed in the design of the switch.

Waveguides

All optical fibers are waveguides, using total internal reflection to guide the light through the core. By using appropriate materials, you can change the refractive index of a material using thermal or electrical stimuli. In this way, light can be guided down a particular path or waveguide depending on how it is reflected from a control point.

AWGs are solid-state and switching speeds depend primarily on how fast the input laser can be returned. By tuning the laser to the red wavelength, the light will exit at Port B. If we tune the laser to the blue wavelength, this causes the light to exit at Port D, and so on.

Conclusion

There is lot of potential in all-optical switching, but being a nascent field, it leaves much to be desired. On the plus side, it solves some very basic problems for carriers.

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