Experimental Investigation of a Unidirectional Three Node Optical Highway using large free space optical components

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Role of Electronics and Optics in Computing.

•Electronic circuits are most effective as switches and dominate the IC industry.

•Current IC technologies are limited by the interconnect transmission speeds that are a fraction of the speed of light. The maximum bandwidth of electronic systems has been estimated by Burton Smith (Tera Corp.) and David Miller (Bell Labs) as "500 x Aspect Ratio"

•Optical signals with negligible cross communication contribution and high speed has advantages over electronics as a candidate for interconnect transmission.

•Low power requirements, low loss transmission range, parallel connections and significantly higher bandwidth are additional characteristics pushing optics into the interconnect arena.

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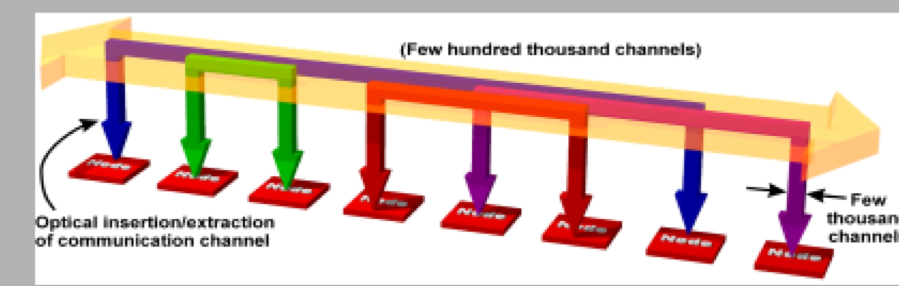
Comparison of Electronics and Opt-electronics

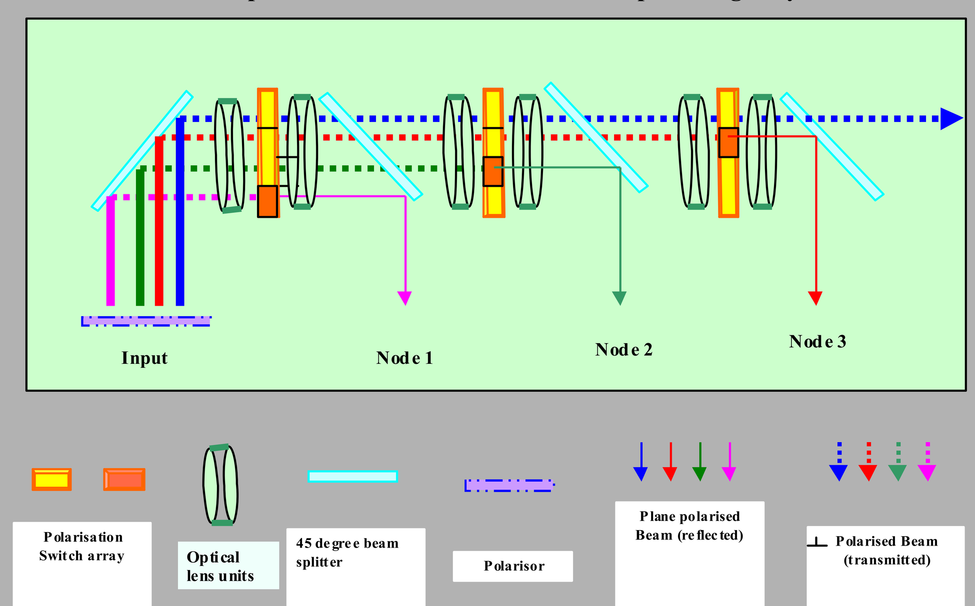
- **Strides in high speed IC devices:** CMOS process development transitioned from 0.5 micron on 4 inch silicon wafers to less than .12 micron on 12 inch wafers within a decade, dramatically increasing yield and high speed performance of micro-processor devices used in computing.
- **Costly IC technology:** As the IC industry moves into Deep Submicron Integrated Circuit (DSIC) and perceives 35nm as a process reality, the prohibitive costs (billions of dollars) in building state of the art process research and fabrication facilities dominate improvements in the switching and transportation speeds of complex microprocessor chips .
- **Cost Effectiveness of Optical Interconnects:** A combination of electronics for switching and optics for transportation can deliver competitive speed and bandwidth to handle the design complexity, using much simpler process technology and perhaps a fraction of the cost of IC research and manufacturing.

Optical Highways



The Optical Highway has been conceived as a high band-width, high-speed optical channel transporting information created by high speed electronic switching devices .

A Simple Linear Unidirectional 3- Node Optical Highway



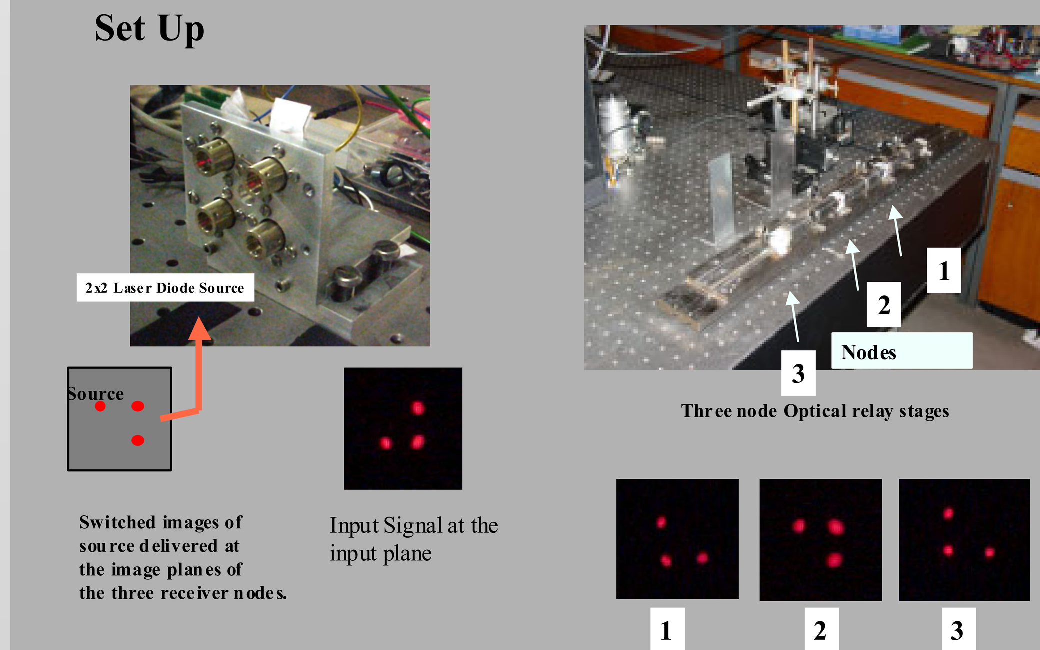
An Experimental Test of the Optical Highway

- A unidirectional leg of an Optical multi-node channel was designed to check feasibility and optical performance capability of the highway.
- The circuit consists of a 2x2 array of large signals collimated and delivered to one or more nodes using 670nm laser diodes, polariser plates and large free space optical devices and basic alignment.
- Each beam path is the equivalent of a single interconnection which can be switched through external electronic controls, changing the delivery points from one input node to another.
- The experimental set up explores the input and output signal pattern and power at the source plane and three output planes.

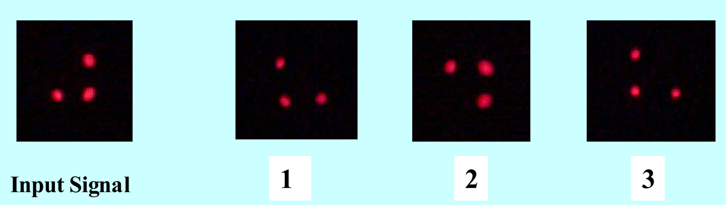
Experimental Set Up

- Collimated beam (670nm source) from a 2x2 Laser Diode array was transmitted through a polarising film and reflected through three sets of 45° polarising beam splitter and 4-f lens system units with polarisation switching device in the path of the beam at each node.
- The switching was manually controlled and the beam was split and delivered to the three nodes for testing the signal pattern.
- The experimental set up was built using available components with minimal consideration for maximising beam throughput and loss.
- Optical beam intensity was measured at the input point and the three output nodes with and without beam splitting.

Set Up



Results



Output Signal at each node

The beam intensity was measured in the input and output planes using Newport Optical Power Meter calibrated at 670nm and background subtracted

The average beam power through each leg of the system decreased by about 40% through the lens - beam splitter system. The following readings were in μW

W in	W1 out	W2 out	W3 out
10.904	6.267	3.607	1.375

Results and Observations

The lens / beam splitter/ polariser system contributed approximately 40% loss with the current set up at each leg

The signal pattern replicated the computational model of the pattern transfer through the lens-mirror system

Conclusions

Demonstrated the feasibility of free space optical interconnect using polarised optical input array, polarisation switches at multiple output nodes.

The signal pattern transfer matched the computational model for the lens/mirror system.

The signals were detected at each node with sufficient intensity indicating that several additional nodes could be added.

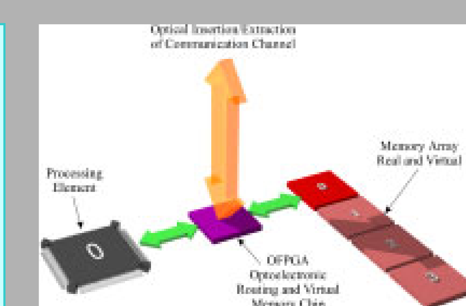
Signals were detected simultaneously at all three nodes even with beam splitting efficiency of the reflected beam at about 20%.

Custom built components could minimise loss significantly as this test was designed to show feasibility of design and verification of the output pattern.

Future Work

Design a large externally controled Liquid crystal Switch to independently switch each signal in the array

Replace input/out put laser diode array with electronic processor and memory via an OFPGA interface



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