Realization of a Diffraction-Based 1xN Optical Switch

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A 1x100 diffraction-based optical switch was designed for use in data centers. The switch decouples the send- and receive-side components, allowing for independent scaling of the two-sides, is bandwidth-invariant, and boasts a rapid reconfiguration time. These properties combine to create a dynamic technology capable of adapting to the rapidly changing demands of a data center, addressing a key bottleneck in data centers, rigidity.

Introduction

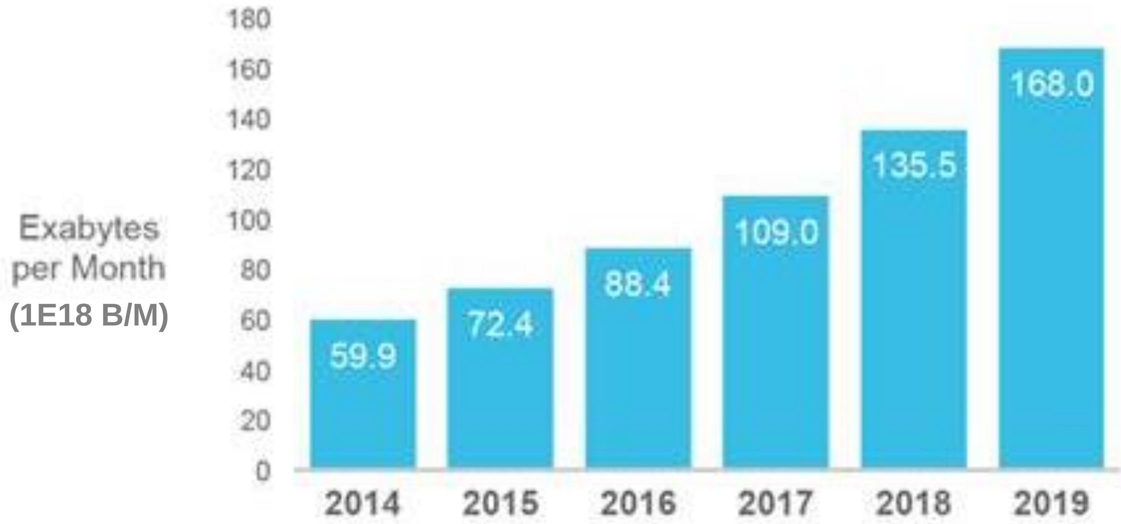
Switches

- Optical fibers are widely used in signal transmission because of their large bandwidth
- Switches-Interconnect different fibers, reroute information
  - "Old way": optical → electrical → optical signal
    - Bandwidth bottleneck, slow, rigid

Motivation

- Significant increases in data traffic and an exponential increase in mobile traffic
  - Leads to rapidly changing demands

→Very important that switches be dynamic



Data traffic per month; Image courtesy of Cisco Sytems, Inc

DMD

- Bistable (±12°)
- Large number of elements (1024x768)
- Rapid reconfiguration time (12 μs)
- Robust (Lifetime of 10^{12} flips)
- Cheap (<$100)

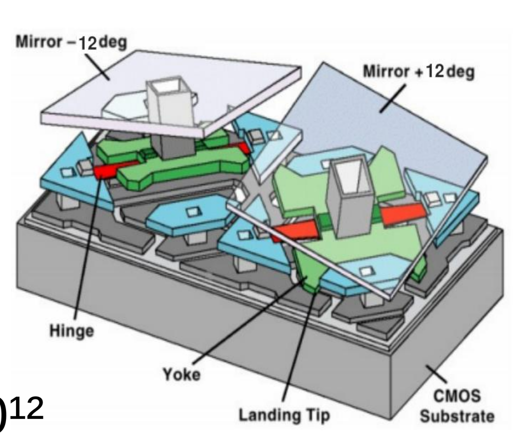
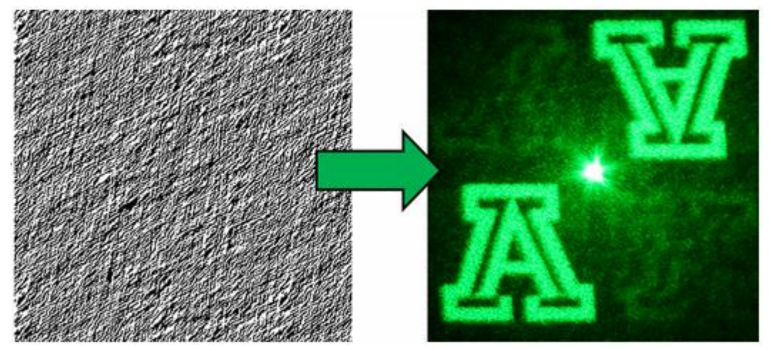


Image courtesy of Texas Instruments

Diffraction-Based Optical Switch

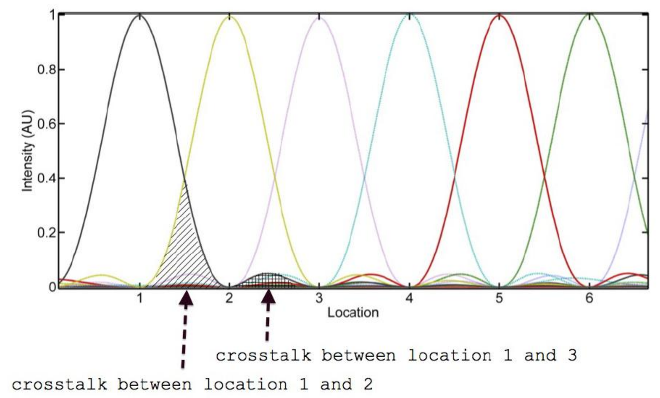
- Uses digital micromirror device (DMD) as active beam steering element
  - Protocol- and bandwidth-invariant
  - Fast (12 μs)
  - Decouples transmit and receive-side components



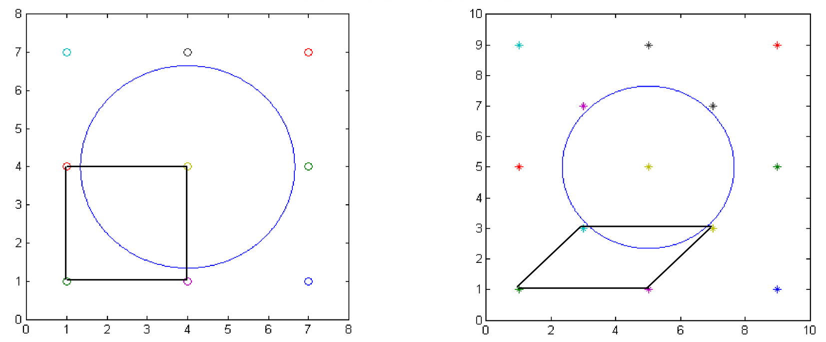
Computer generated hologram and the resulting diffraction pattern

Accessible Points

- # of DMD pixels = # possible diffracted beams
  - Can't use all beams because the crosstalk between adjacent locations is too high
- Crosstalk-when signal for one detector is measured at another undesired detector
  - Need crosstalk below -40 dB



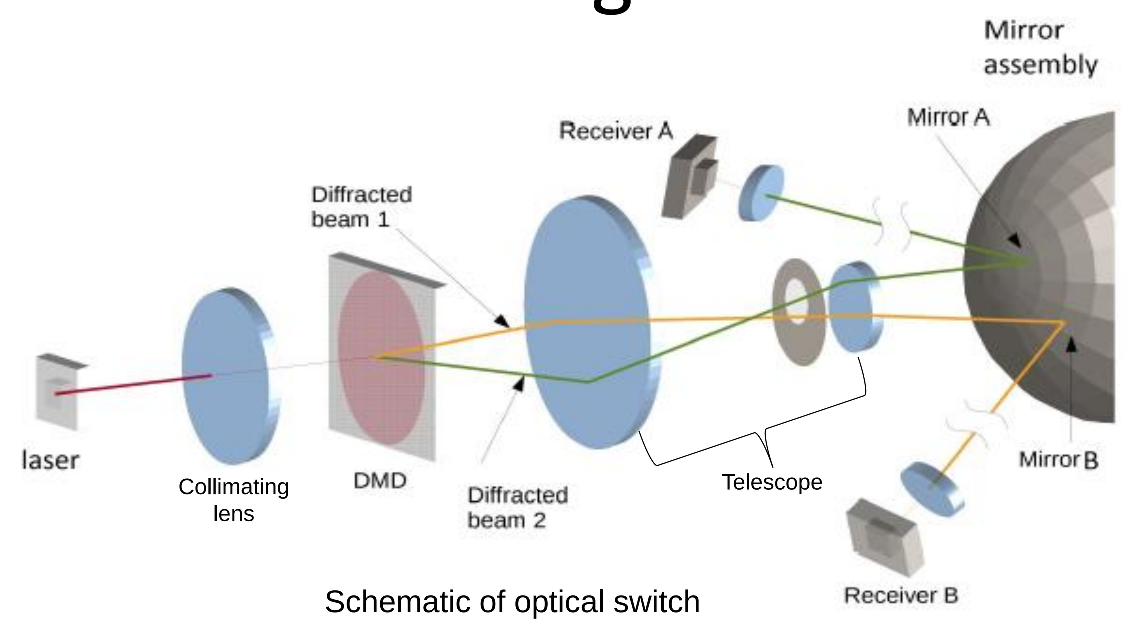
Adjacent beams diffracted by the DMD; crosstalk is equal to the area of overlap between beams



Square and parallelogram packing configuration

- Parallelogram increases number of points by 12.5% (44k to 50k)

Design



Schematic of optical switch

- DMD with precalculated computer generated hologram acts as active steering element
  - Limited angular range (3°)→ restricted spatial span
- Mirror assembly increases reach of switch and redirects light from source to destination rack

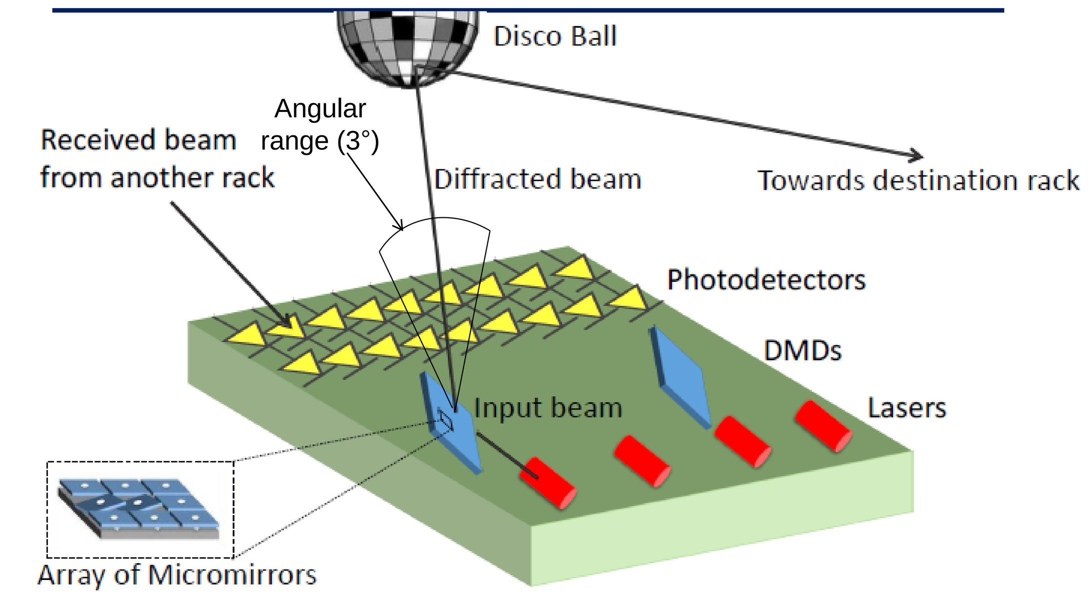
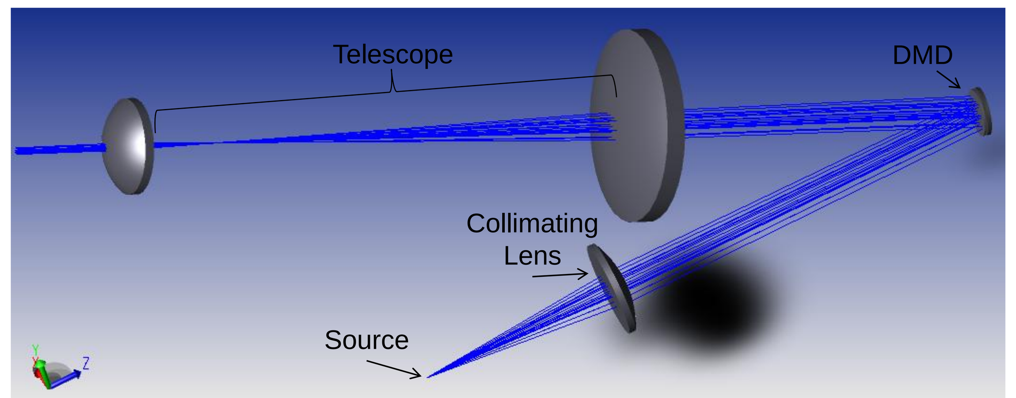


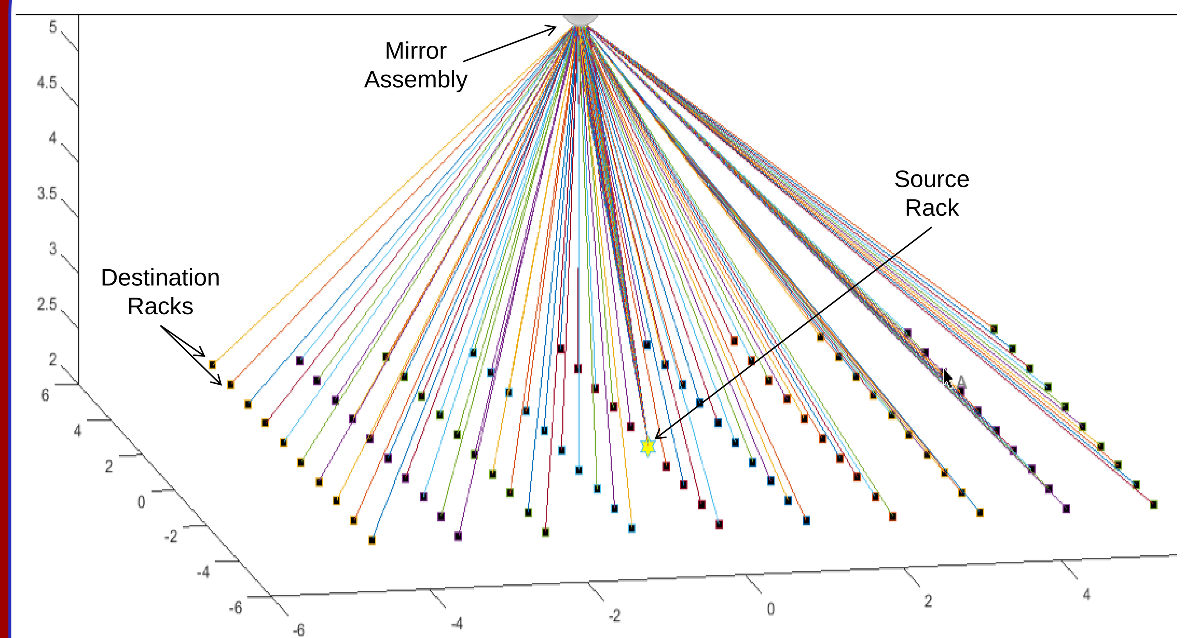
Diagram of the top of a rack with an optical switch on it within a data center

- System was modeled and optimized in Zemax



Ray tracing diagram of portion of switch modeled in Zemax

Results



Ray tracing diagram from source rack to destination racks for1x100 diffraction-based optical switch

- Switch, minus the mirror assembly, has been modeled in Zemax

Future Work

- Design mirror assembly in Solidworks and manufacture
- Experimentally test design
- Increase number of output ports

References

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