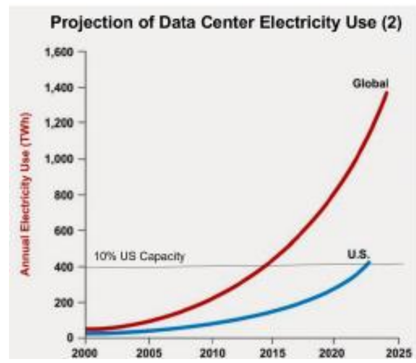
Holographic Switch for Data Centers

Post-Quantum Tek (PQT)

Data center switches:

Data centers contain a multitude of computers in racks, where they store information. When an external query arrives at the data center, such as an Amazon order, a Facebook post, or a credit card payment, the information is retrieved from computers in the appropriate racks and sent on to the intended recipient. The information is aggregated and routed using **switches** that direct the data where it needs to go.

Today's technology relies on **electronic switches**, even though the data is transported in the form of photons traveling in optical fibers. So, at each and every switch, the photons are converted into electrons during a detection process and a laser is turned on at the end of the correct receiving fiber to regenerate the signal into optical format and send it where it belongs.



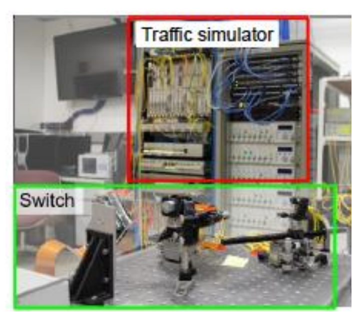
This process of optics-electronics-optics (OEO) conversion uses a great deal of electricity, which costs data centers a lot of money. In 2014, data centers were **consuming 5% of the total US electrical energy** production: 200 TWh.[1] Furthermore, this trend is growing exponentially due to new applications on cell phones, cloud computing, and the Internet of Things (IoT).

Optical switches:

Optical switches exist and are used today. However, the problem is their speed. The mirror takes ~1/1,000th of a second to get reoriented, but the data arrive much faster (250 Mbps). This **prevents the use** of the current optical switch technology in most applications.

Optical switches based on current principles have reached their **physical limits** and it is not possible to make them faster.

Holographic switches:



Optical switch prototype in Internet traffic simulator

The holographic switch is the next generation of optical switch. It uses a new type of MEMS (micro-electro-mechanical system) chip with smaller mirrors, which make them **1,000 times faster than past technology.** Because the mirrors are smaller, light does not reflect from them, but gets diffracted. Diffraction is the same phenomenon that creates a hologram, hence the name for this new switch.

There are two added benefits to the mirrors being much smaller: 1) much lower voltage to move them, thus using less energy (**reduces opex (operating**

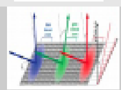
expenses)) and 2) a single switch can have many more mirrors, so it can address more fibers, thereby reducing the total number of switches needed in the data center (**reduced capex (capital expenditures)**.[2]

The holographic switch is agnostic to the data rate and the data format, making it future proof.

Where we are now:

The PQT team has already demonstrated the validity of the holographic switch. We have built several generations of prototypes and tested them in a controlled environment: a 3 rack data center in a Microsoft Research lab. [3]

The PQT holographic switch has been compared to other, current technologies and has demonstrated superior performance. The results are presented in the following table:

Technology		Port count	Loss	speed	Power
3D MEMS Calient/CrossFiber/ Gimmerglass		High (100s)	Low (3dB)	ms	High (45 W)
Micro-actuation Polatis/DirectLight		Moderate (100)	Low (3dB)	ms	Very high (128W)
LCoS (WSS) JDSU/Nistica/CoAdna		High (100s)	Low (3dB)	ms (300Hz)	Low (1W)
AWG/SOA NTT/Academia		High (100s)	Moderate (6dB)	ns	Very high (50W)
Holographic with DLP Demonstrated		Very high (1000s)	Moderate (10dB)	ms (10kHz)	Low (1W)
Holographic with new MEMS		Very high (10,000s)	Low (3dB)	ns (10MHz)	Low (1W)

1. Patrick Thibodeau , “Data centers are the new polluters”, Computerworld, Aug 26, 2014

2 . P.-A. Blanche et al., “Diffraction-Based Optical Switching with MEMS“, MDPI Applied Sciences, 7(4), 411 (2017).

3. Ghobadi, Monia, et al. “Projector: Agile reconfigurable data center interconnect.” *Proceedings of the 2016 conference on ACM SIGCOMM 2016 Conference*. ACM, 2016.

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