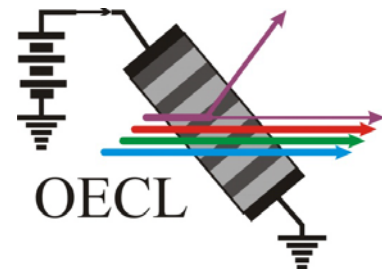
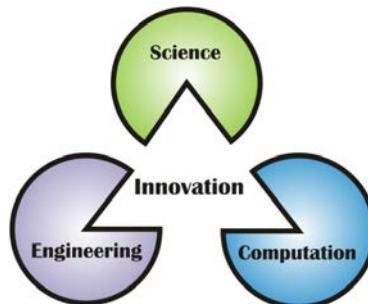
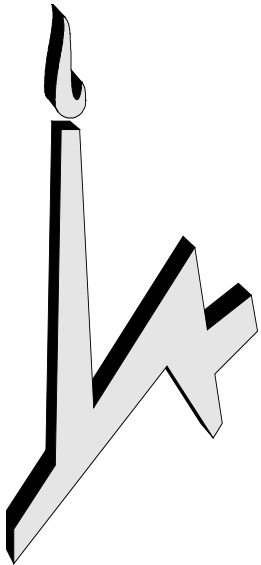


Crossing the Chasm:  
Transforming inventions conceived in the  
academia to become enabling technologies

Aharon J. Agranat

The Brojde Center for Innovative Engineering and Computer  
Science,

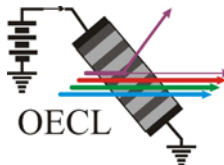
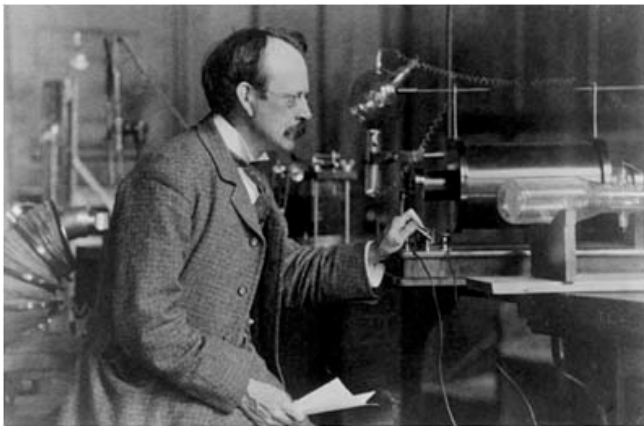
And the Department of Applied Physics  
The Hebrew University of Jerusalem



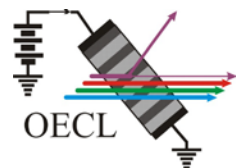
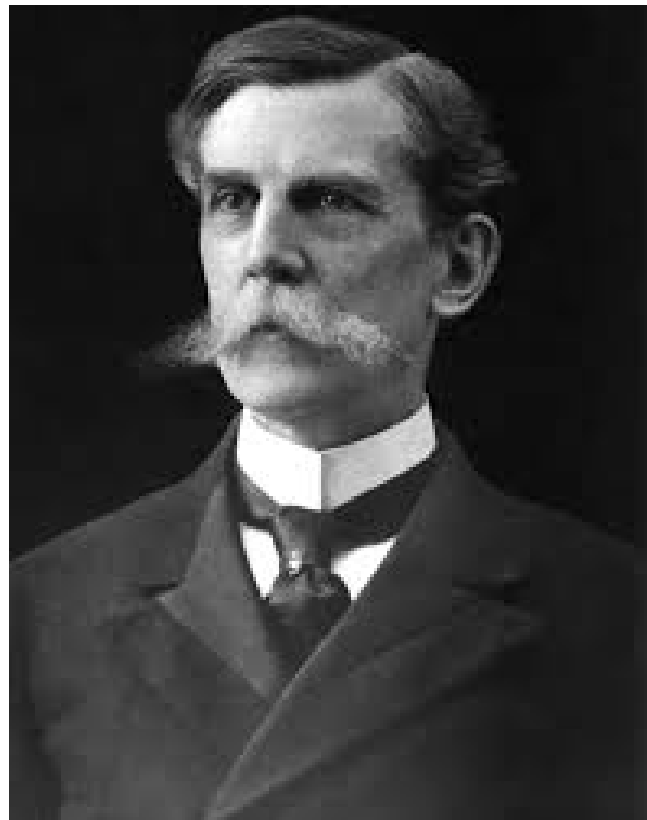
*... if Government and industrial laboratories had been operating in the Stone Age we should have wonderful stone axes but no-one would have discovered metals!*

**J. J. Thomson**

(Discoverer of the electron).



# Chief Justice Oliver Wendell Holmes on the train to Boston:



# A past/future case history

**Our destination:**

**Solving the Data traffic overload  
in the Data Centers problem**

Computer  
Engineering

**The Ticket for Boarding the train:**

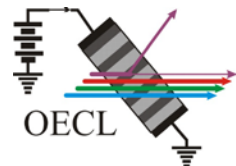
**Dynamic Optical Circuit Switching**

Optical  
Communication  
Engineering

**The Train for getting to**

**the destination: Electroholography**

Electrooptical  
Device Physics



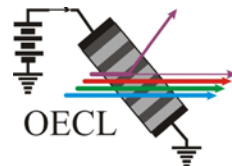
# *“Tell me Vin, What Exactly is Electroholography?”*



Alexander Haig  
Secretary of State of the United States  
1981 - 1982

Vinton Cerf  
The Father of the Internet

**First: who are these people ?**



# Data Centers

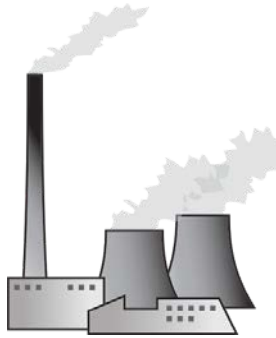
Data centers (DCs) are facilities that are being used for housing a variety of cloud computing services such as **distributed computing**, **distributed storage**, **big data analysis**, **virtual machine (VM) migration**, **video on demand (VOD)**, and online games.



**The Number of servers in large Data Centers approaches 1,000,000**



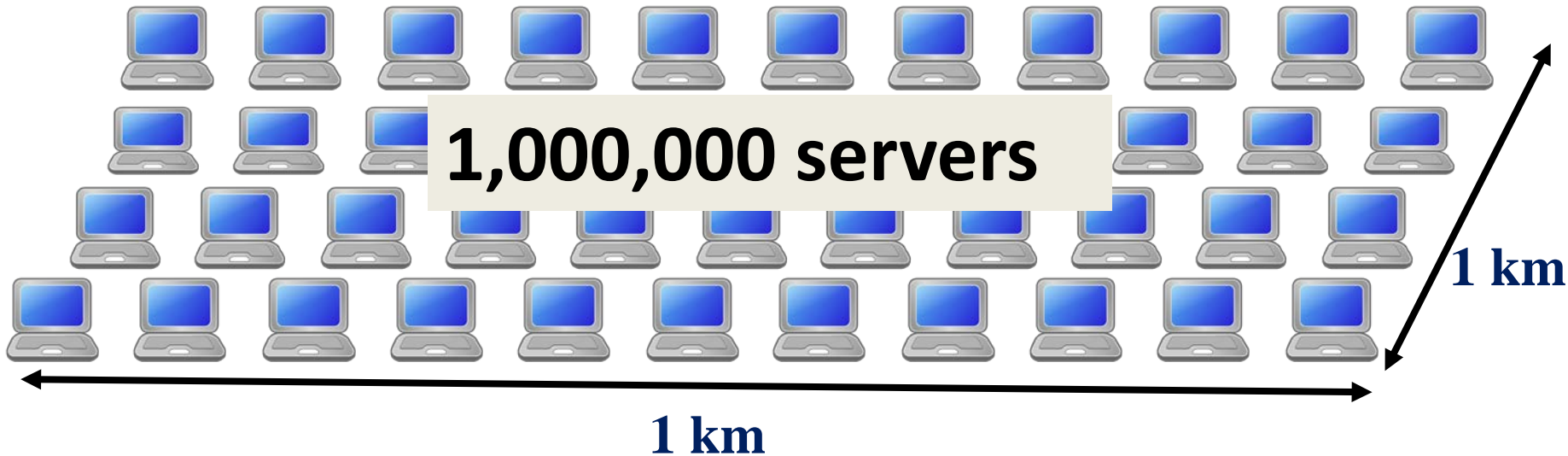
# Data Centers



**Data Centers in the US  
consume 2% of US electricity**

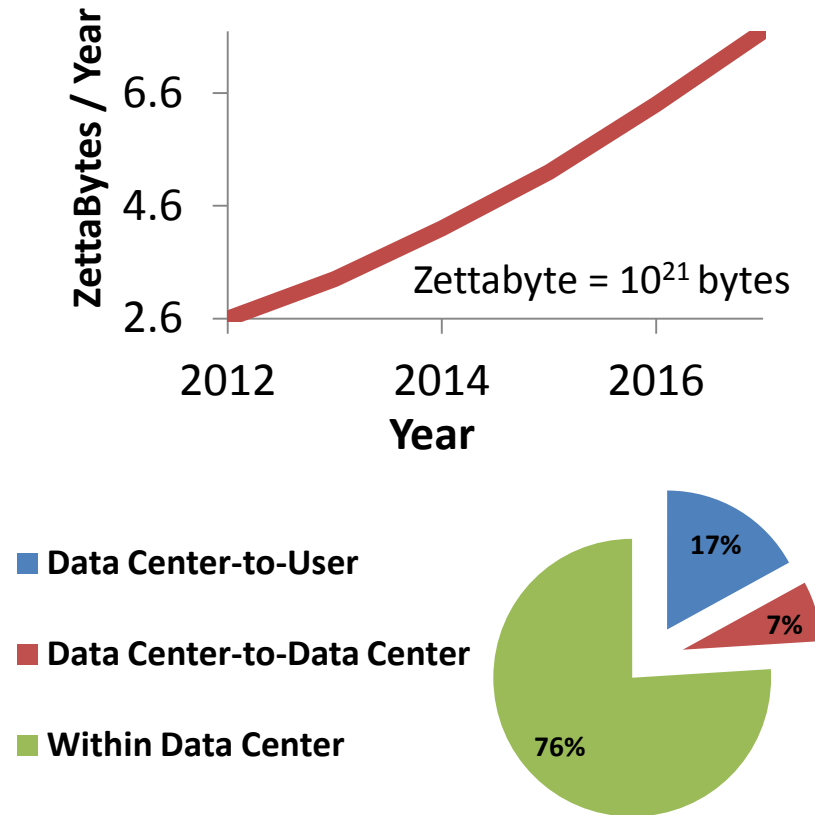


**1,000,000 servers**



# Data Centers Numbers

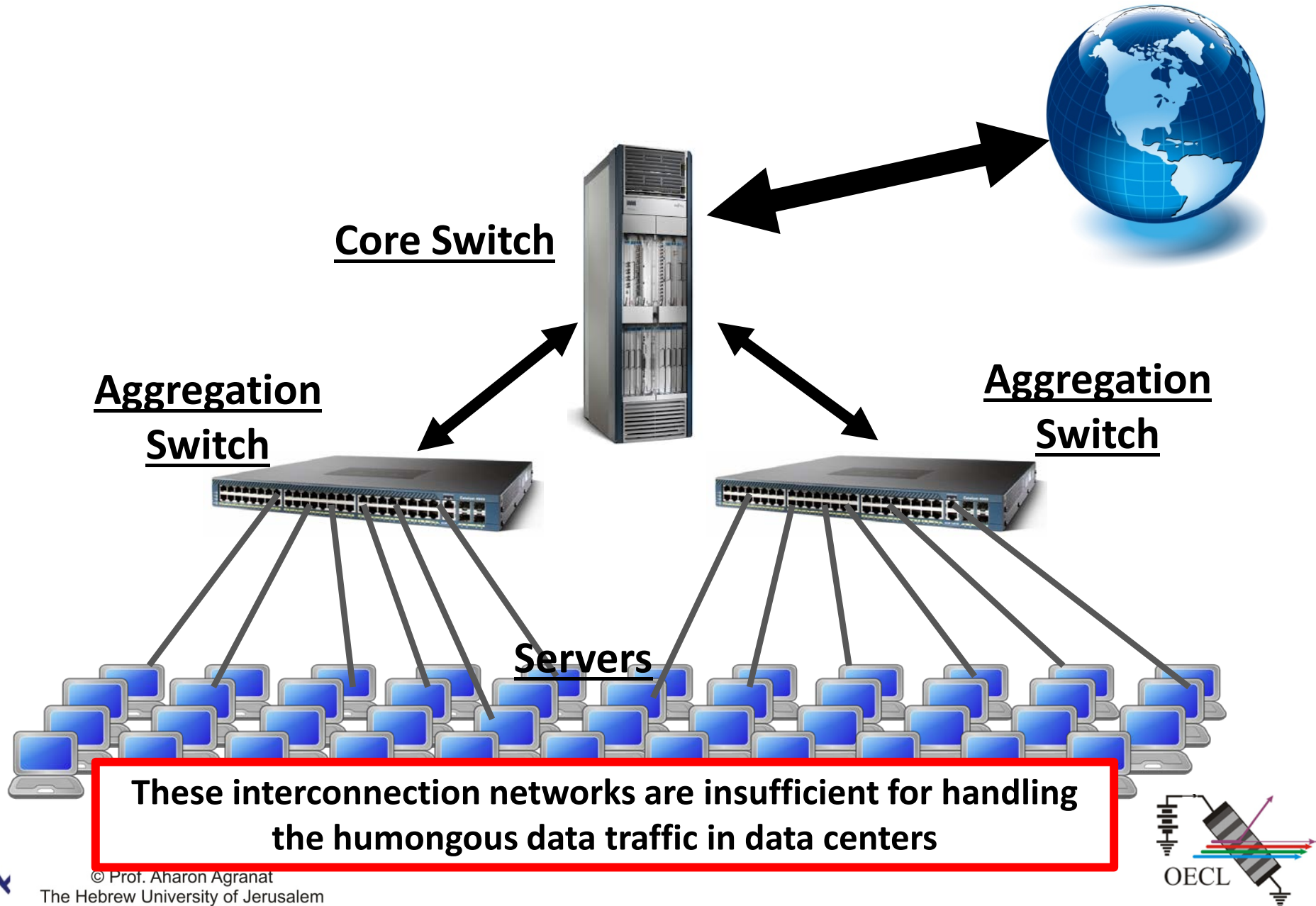
## Data traffic to from and within the Data Center



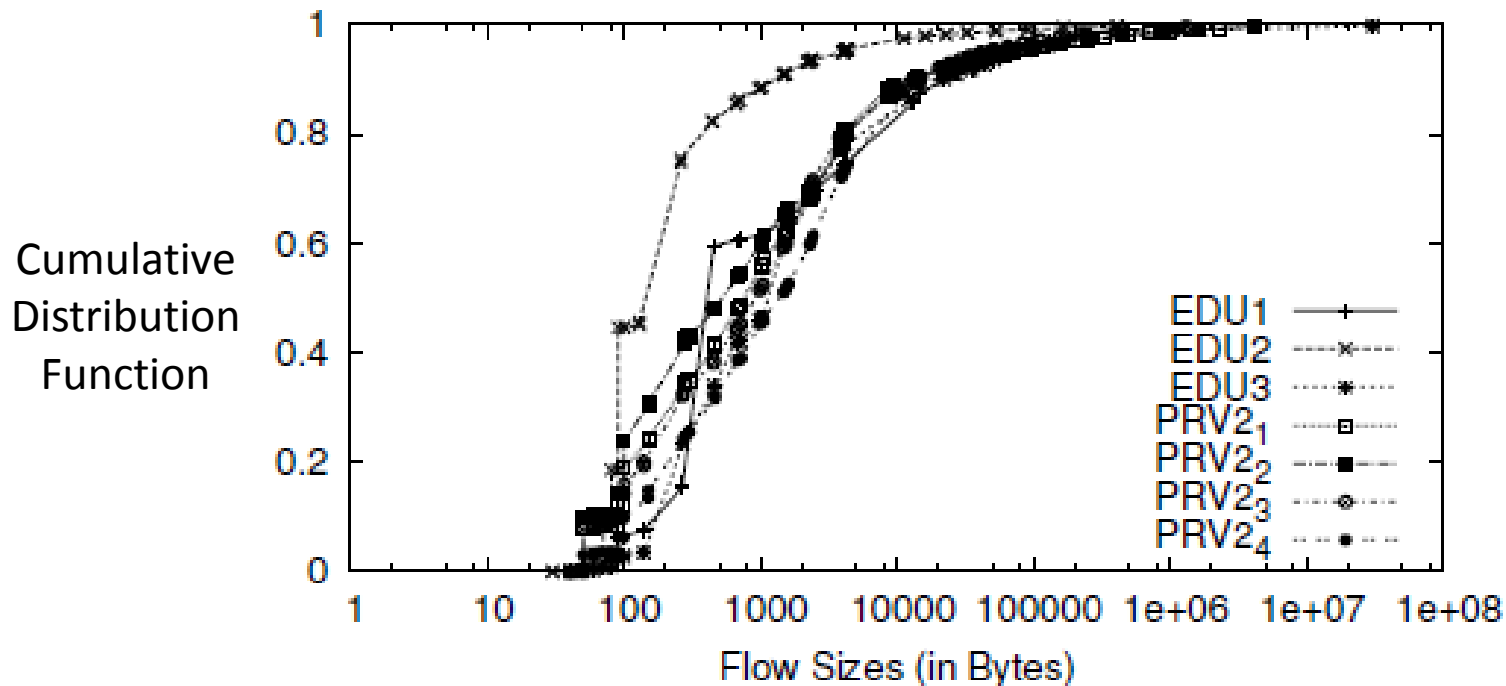
**How this humongous data traffic is handled?**



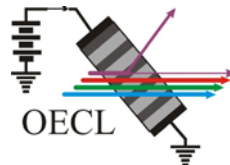
# The Interconnection Network of the Data Centers



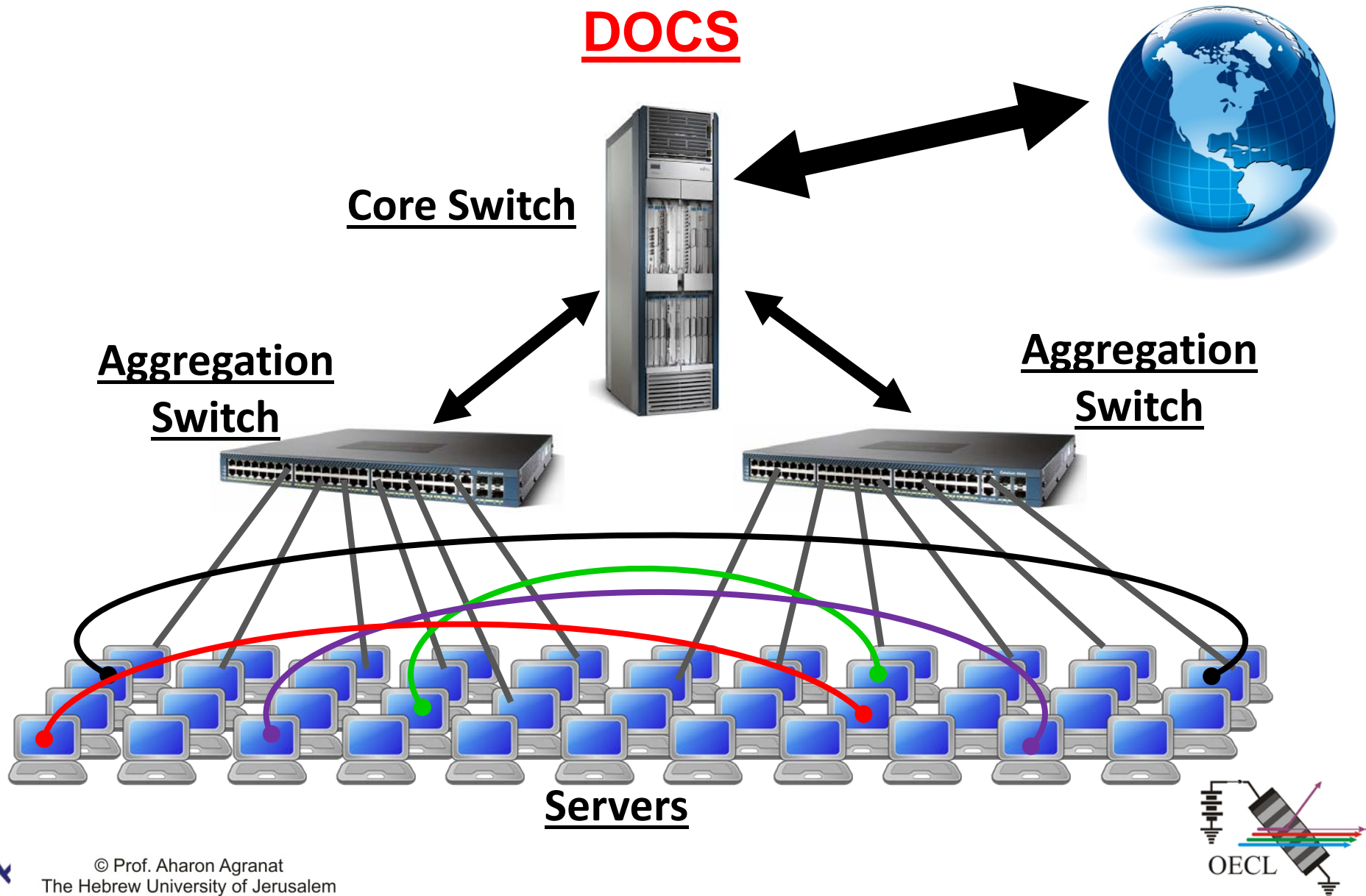
# Mice and Elephants



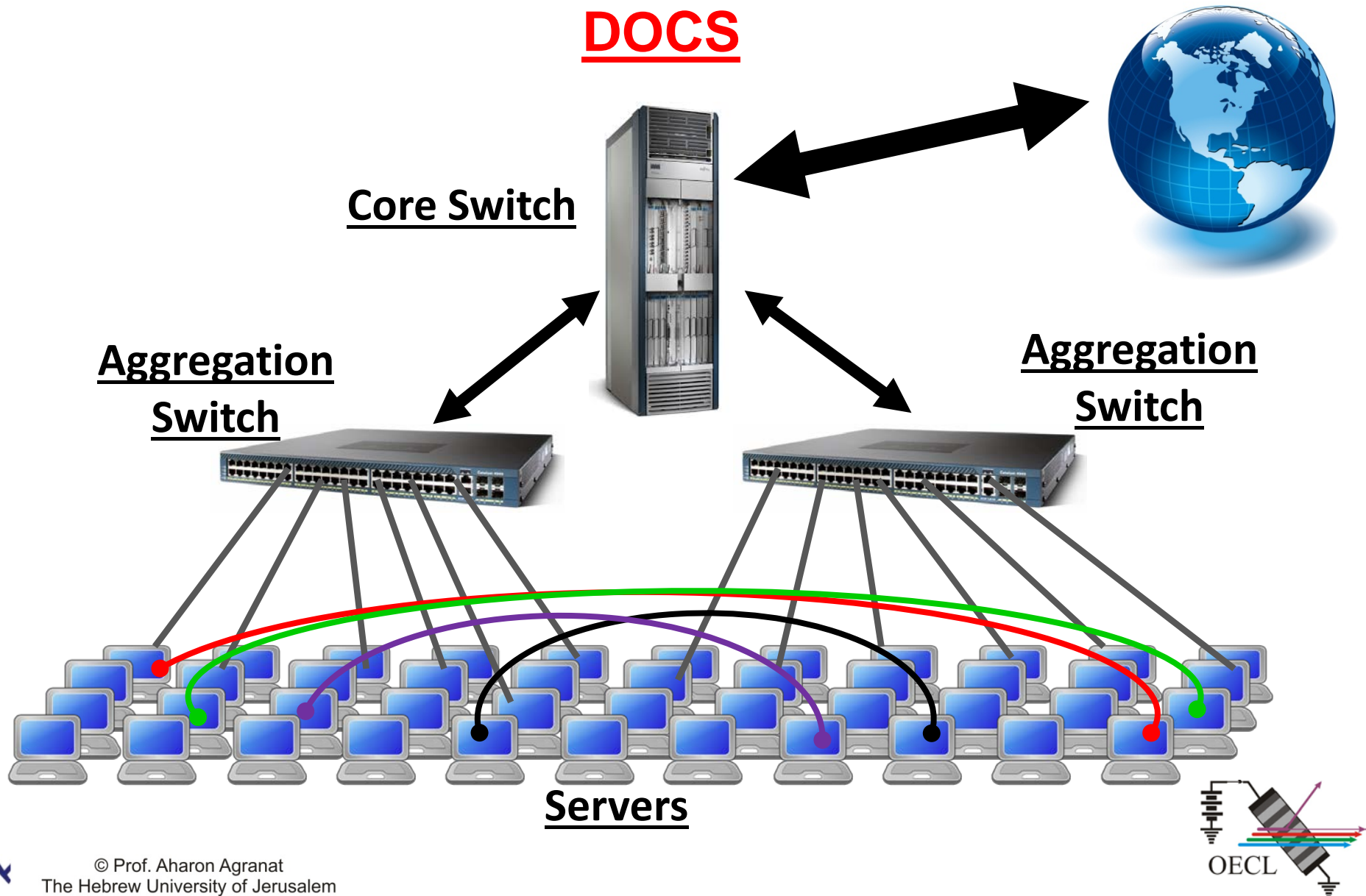
- **Mice:** 99% of flows are smaller than 100MB .
- **Elephants:** More than 90% of bytes are in flows between 100MB and 1GB.



# The Solution (The Ticket): Dynamic Optical Circuit Switching DOCS

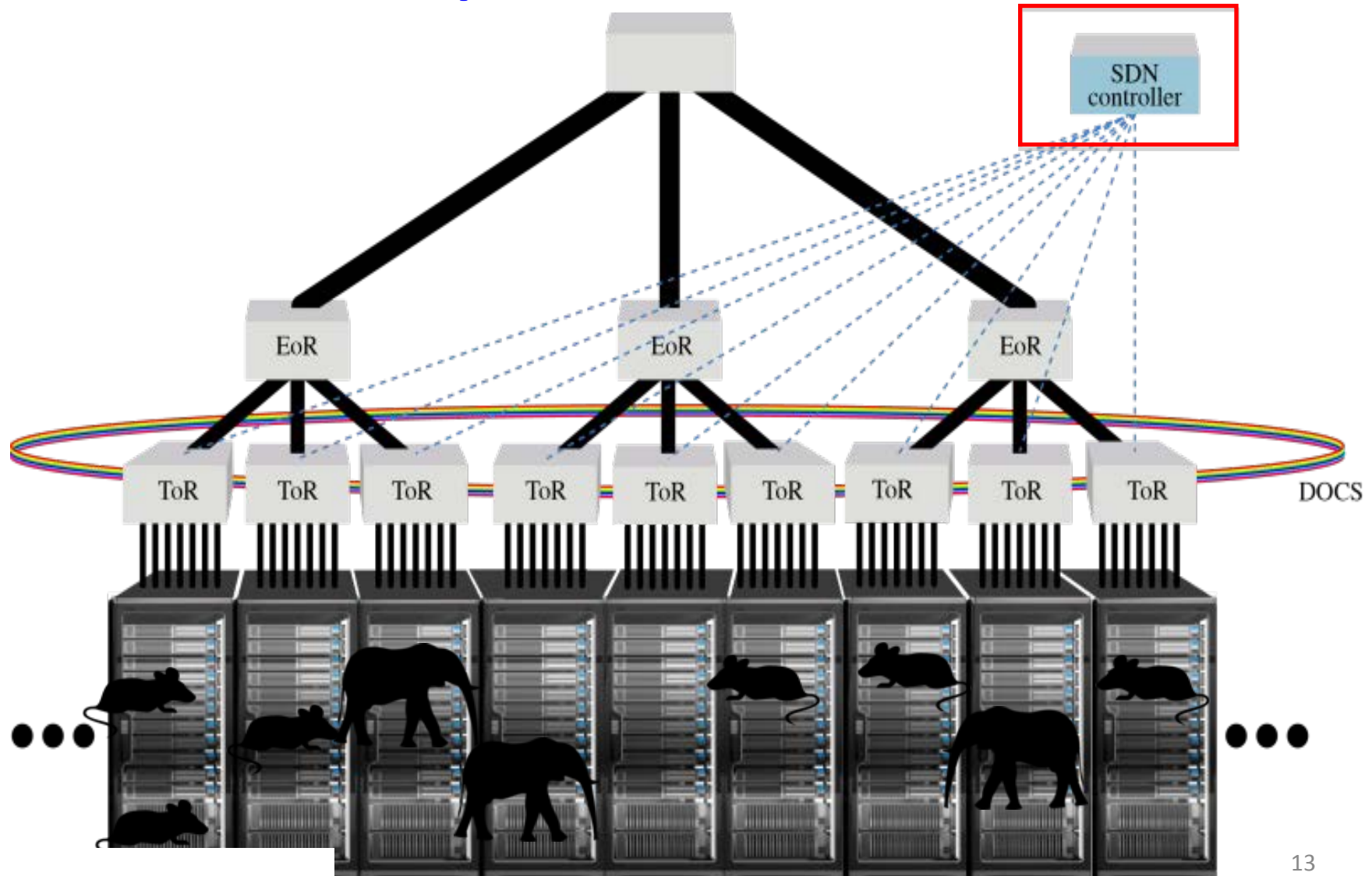


# The Solution (The Ticket): Dynamic Optical Circuit Switching DOCS

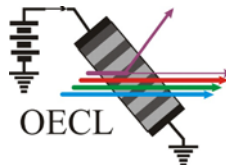
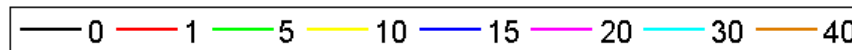
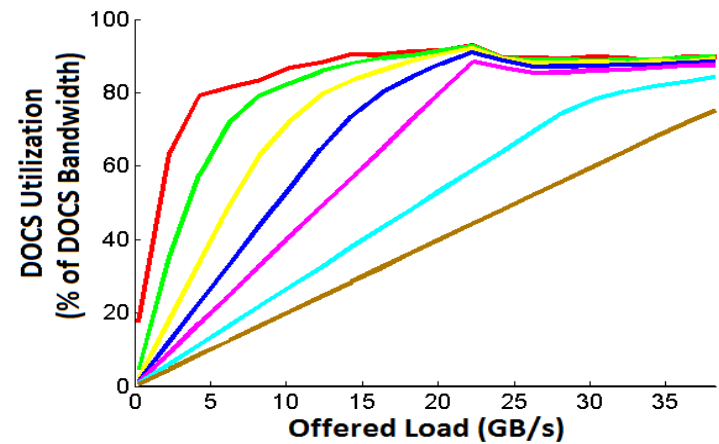
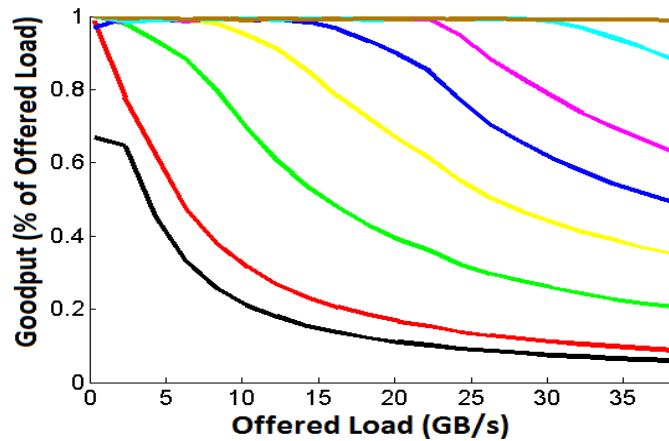
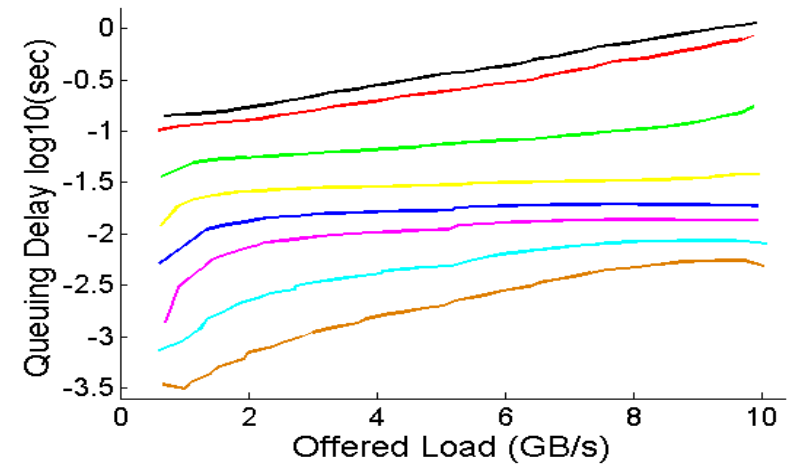
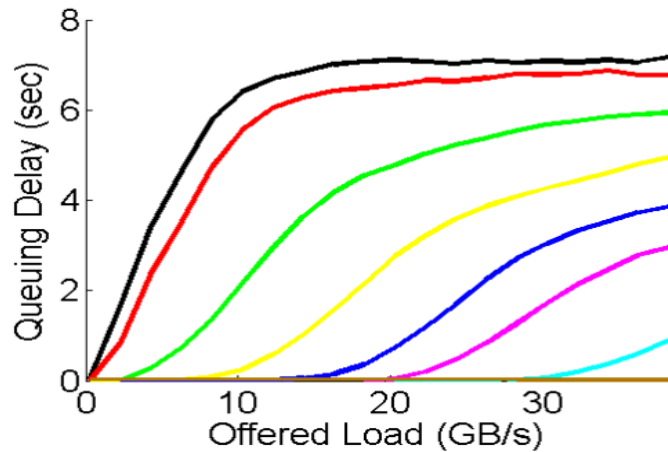


# Dynamic Optical Circuit Switching (DOCS)

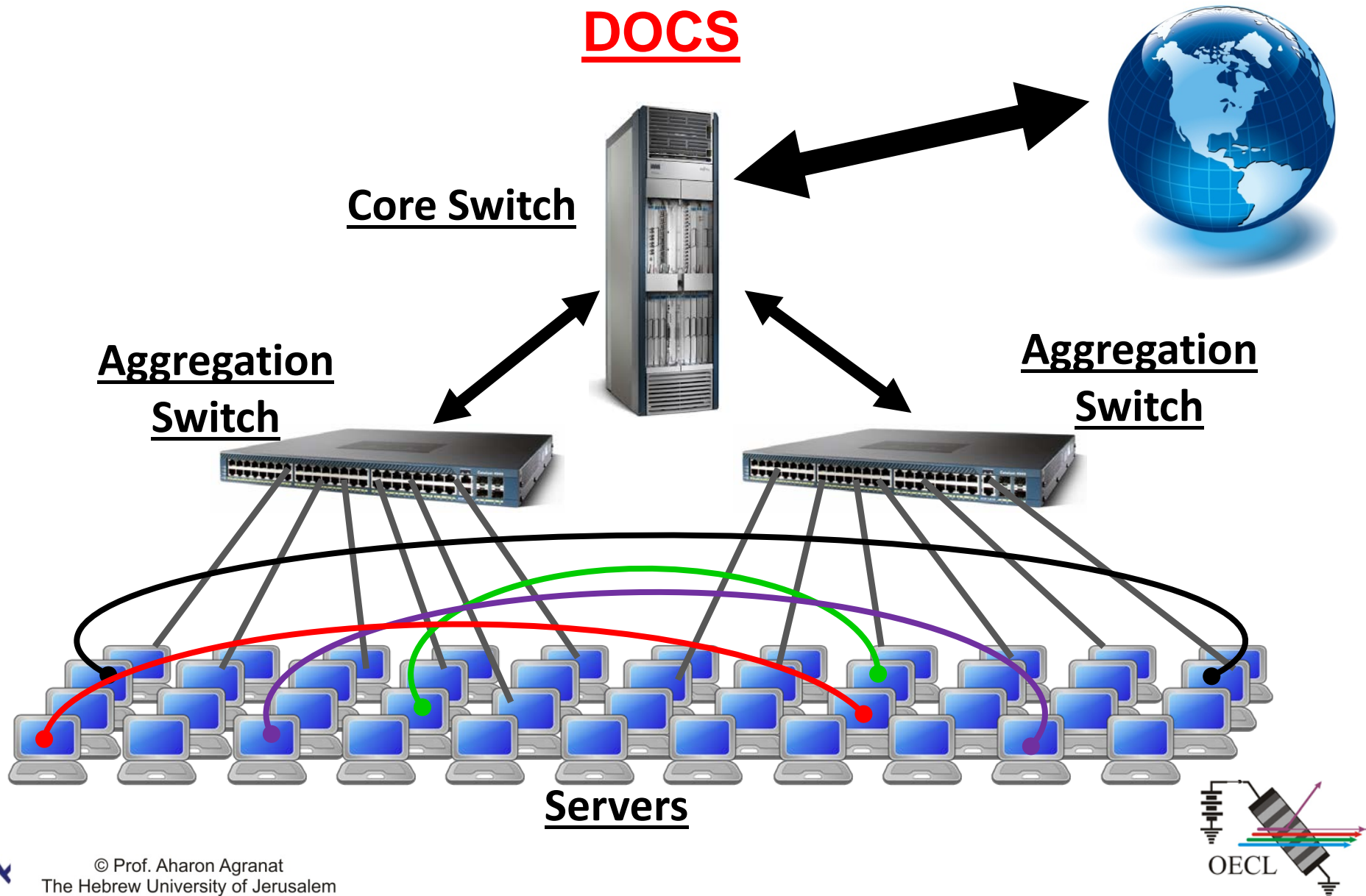
## Proposed Architecture



# Validating **DOCS** by Simulations

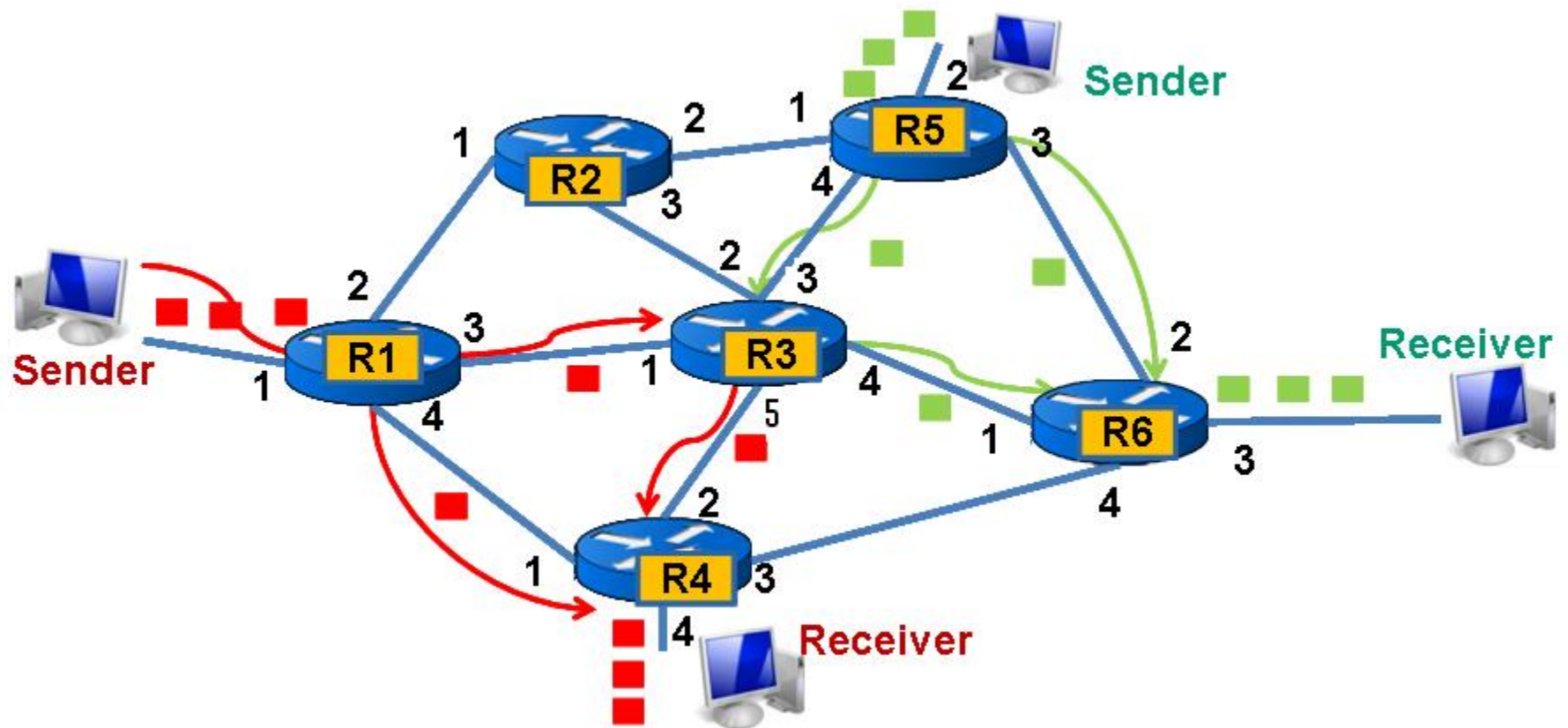


# The Solution (The Ticket): Dynamic Optical Circuit Switching DOCS



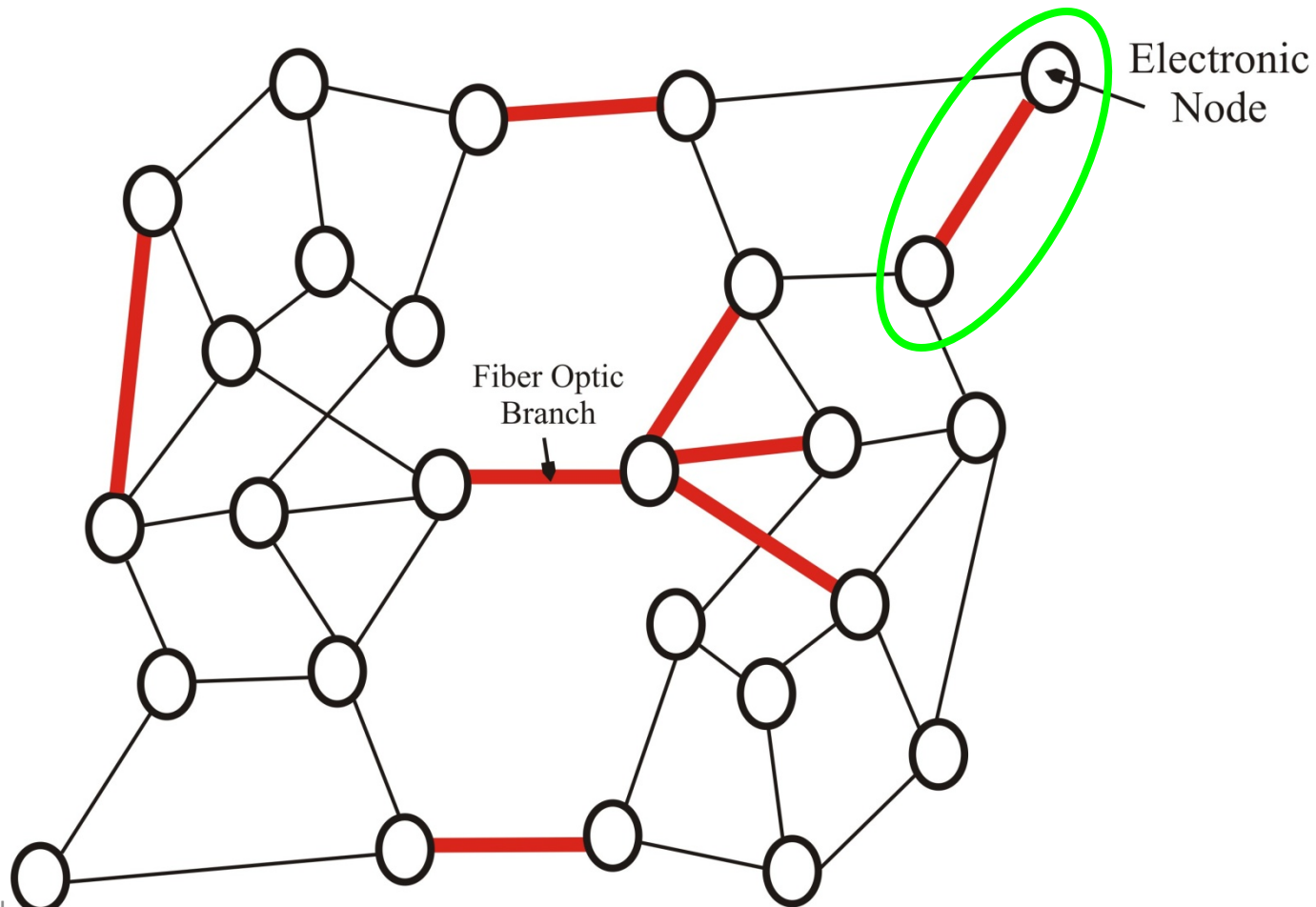


# Packet Switching

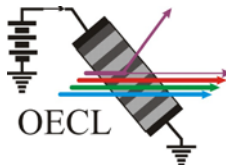
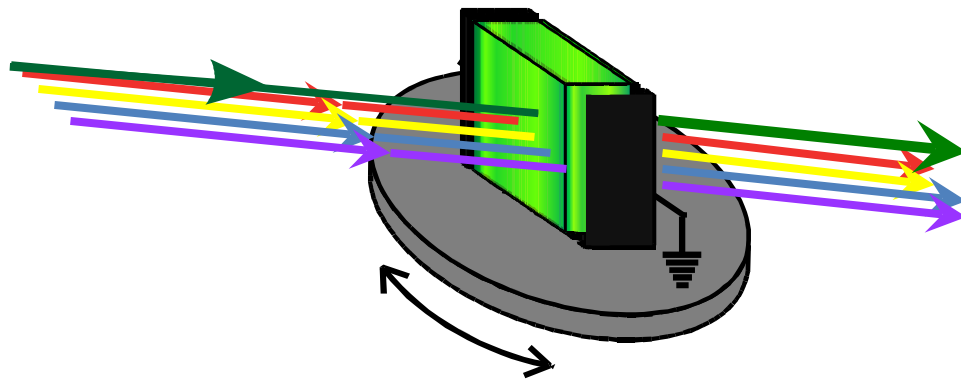




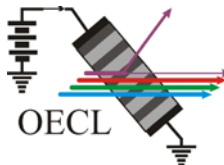
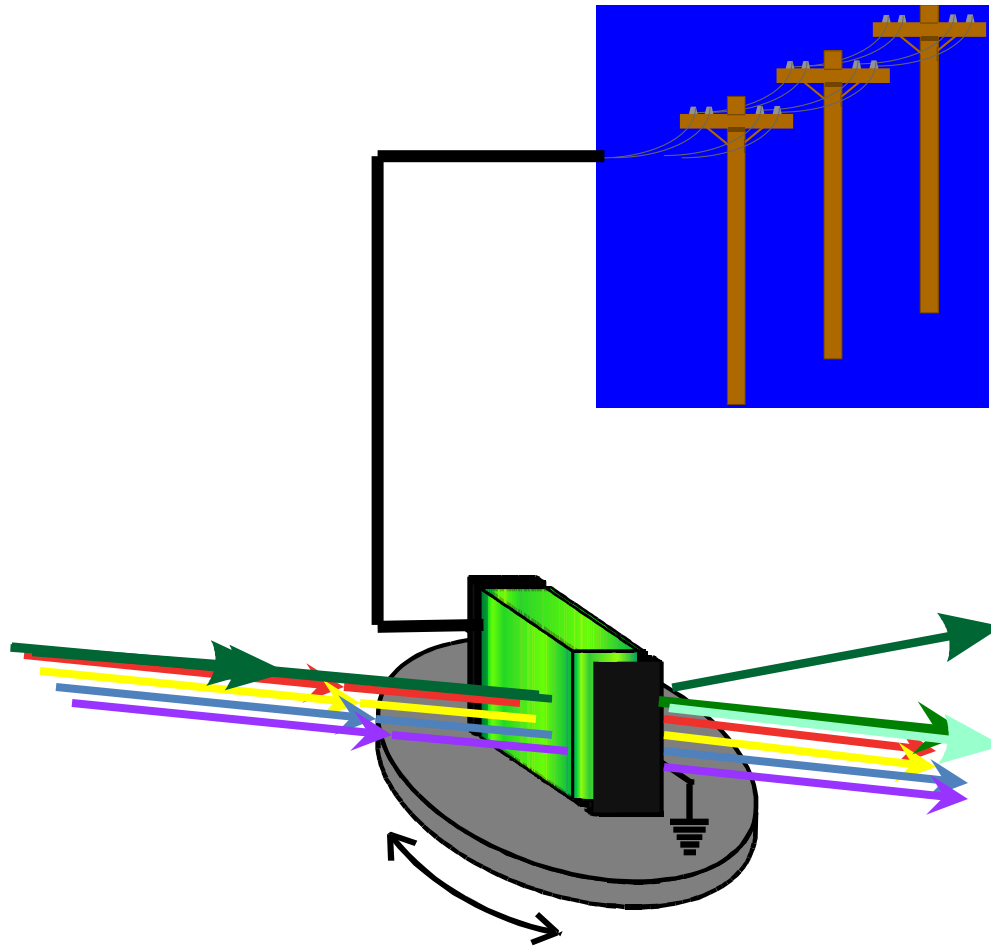
# The Network is Electronic – Some of the Nodes are Optical



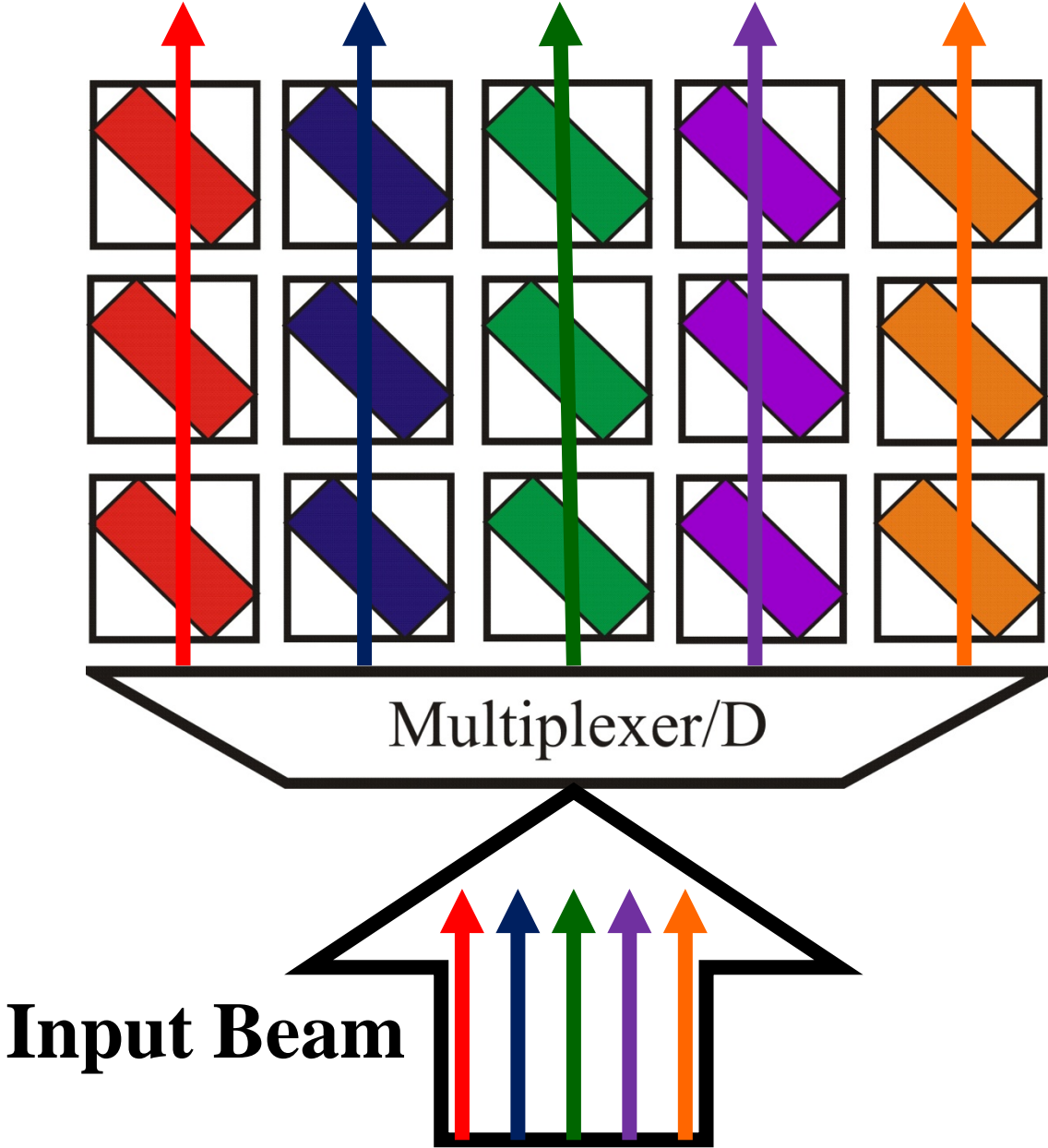
# Electroholography in the $g_{11}$ Configuration



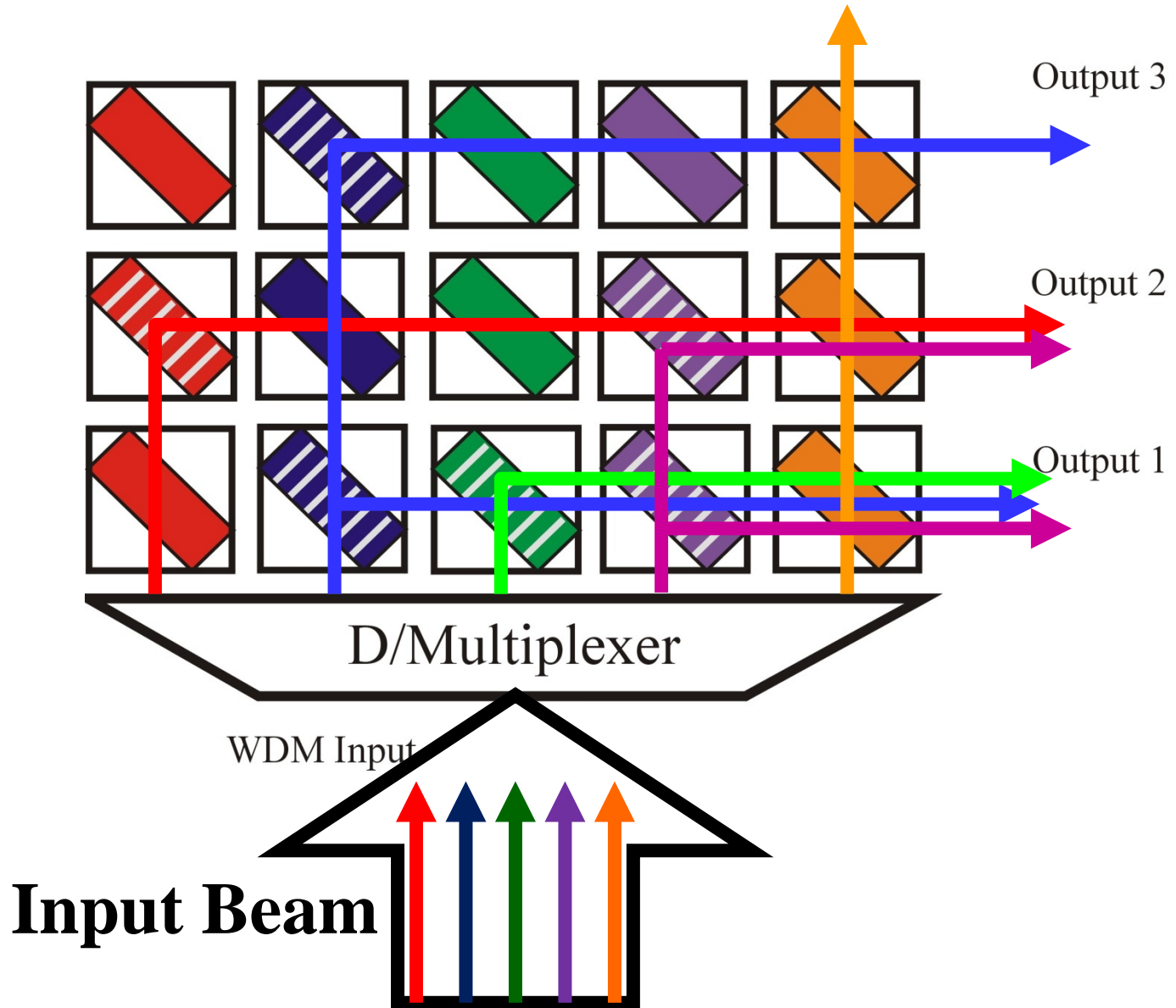
# Electroholography in the $g_{11}$ Configuration



# Output Beams

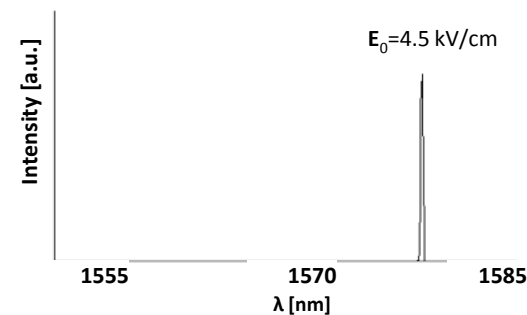
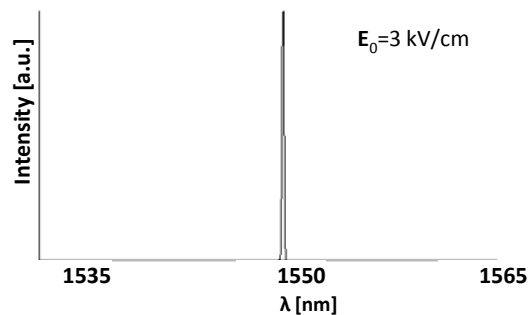
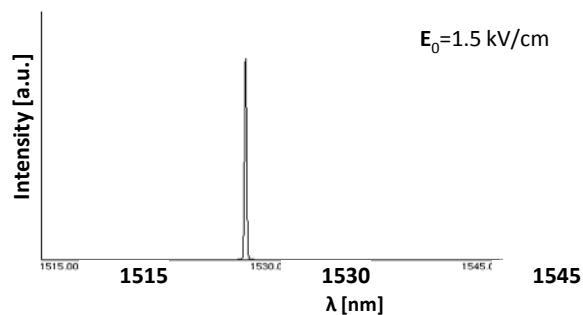
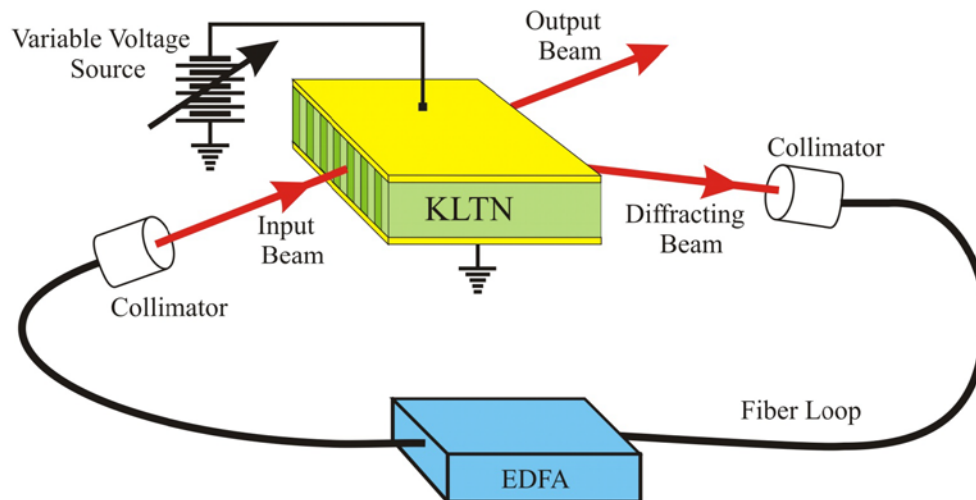


# The $\lambda$ Switch



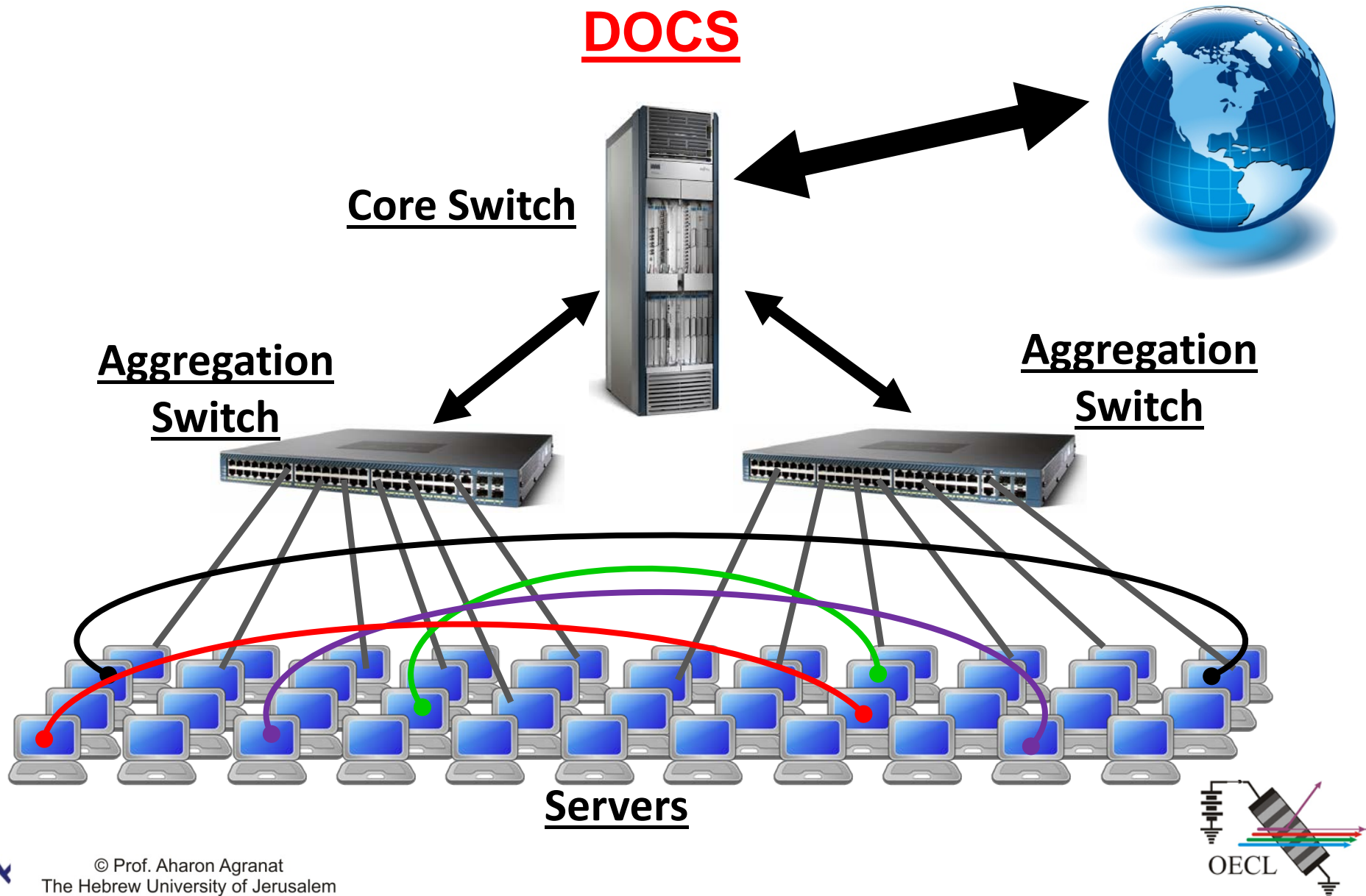
# Electroholography in the $g_{44}$ Configuration

## Example: The Electroholographic Tunable Laser



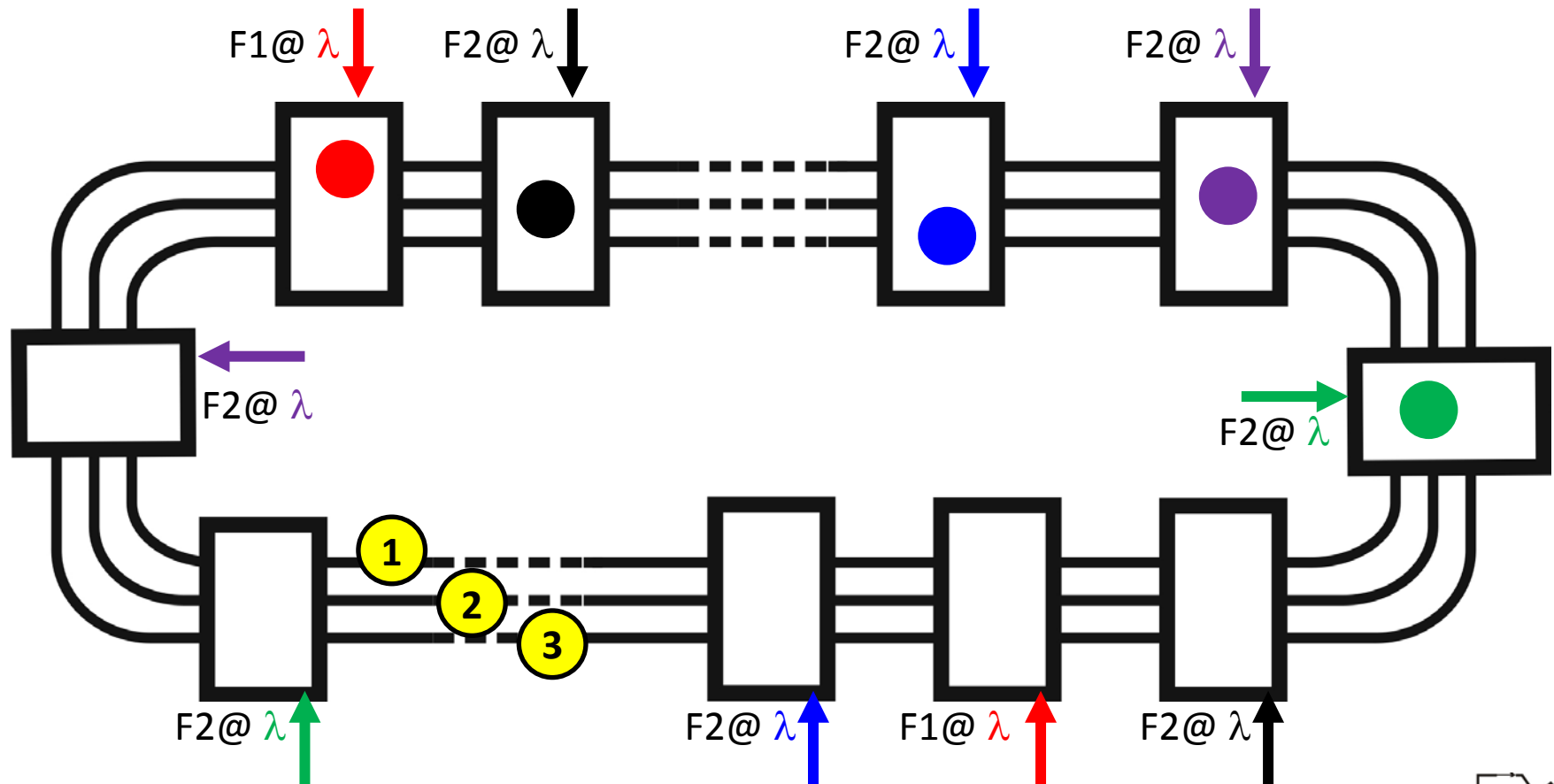
$$\Delta\lambda(E) = 51 \text{ nm}$$

# The Solution (The Ticket): Dynamic Optical Circuit Switching DOCS



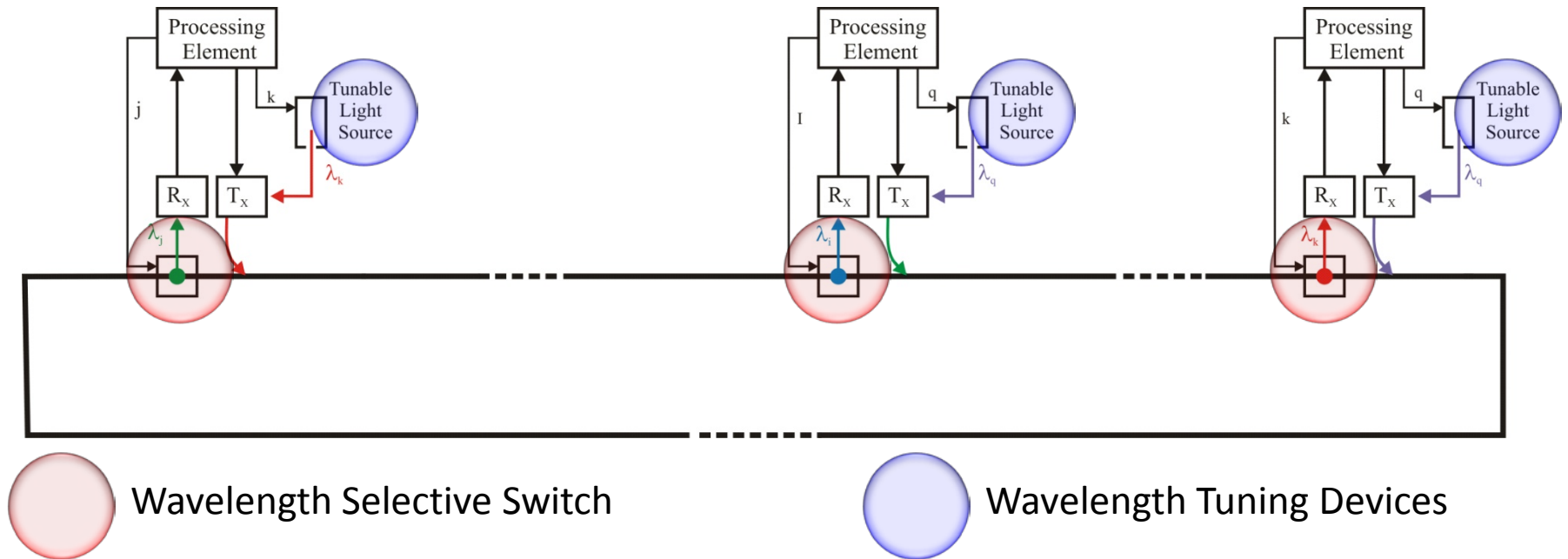
# The Physical Implementation of DOCS: Employing “Wavelength Routing”

A DOCS circuit is implemented by a wavelength – fiber pair





# What are the devices that are needed for implementing DOCS?

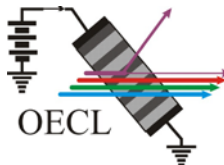


➤ The state of the art of photonics engineering cannot implement these functions in single integrated devices.

➤ A roadmap for their implementation is not anticipated.

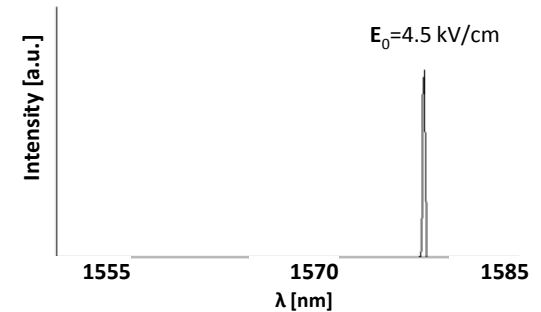
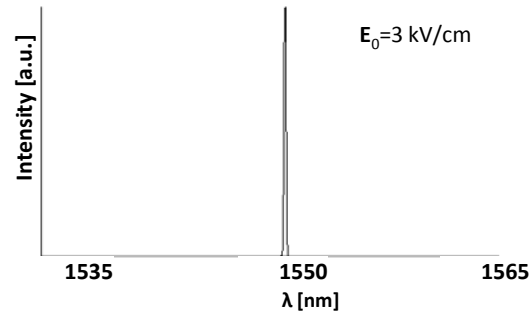
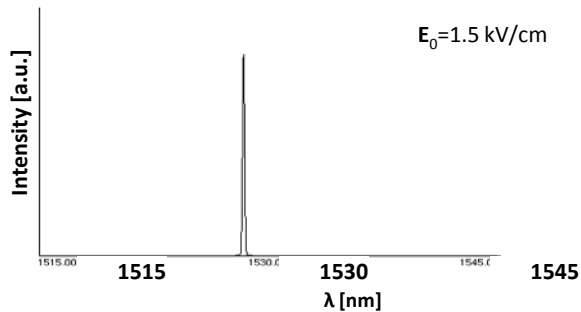
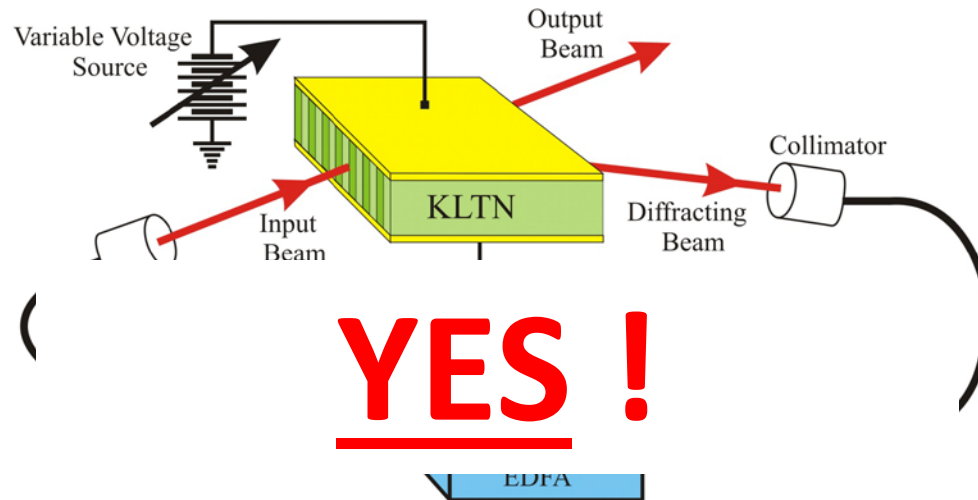
It is finally time to **to Board Train**

**Electrohology** can be the basis for  
constructing the necessary switches  
and devices for implementing **DOCS**



# Can Electroholography be the basis for a viable technology for implementing **DOCS** ?

## Example: The Electroholographic Tunable Laser



$$\Delta\lambda(E) = 51 \text{ nm}$$

# But, What Does it Take ?

## Basic Research in the realm of the Academia

Novel **Functionality**:

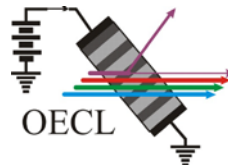
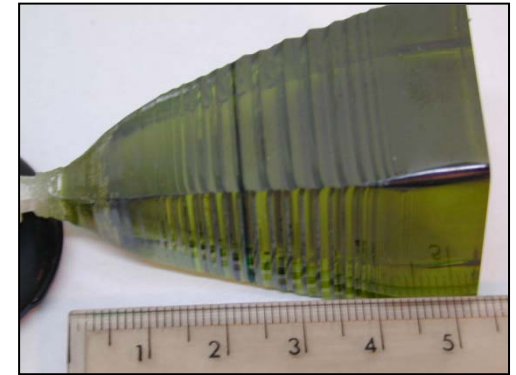
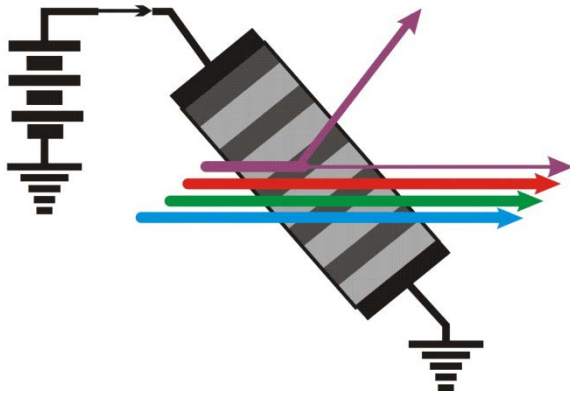
Electroholography

The **Device Physics** for its  
Implementation:

Paraelectric Electrooptics

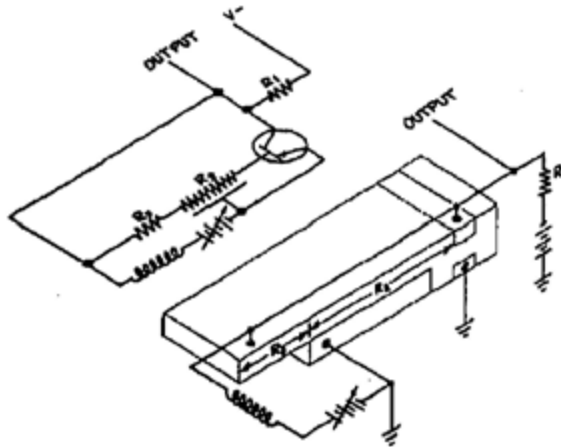
The **Material System** in  
which the devices can be  
realized:

The KLTN Crystal

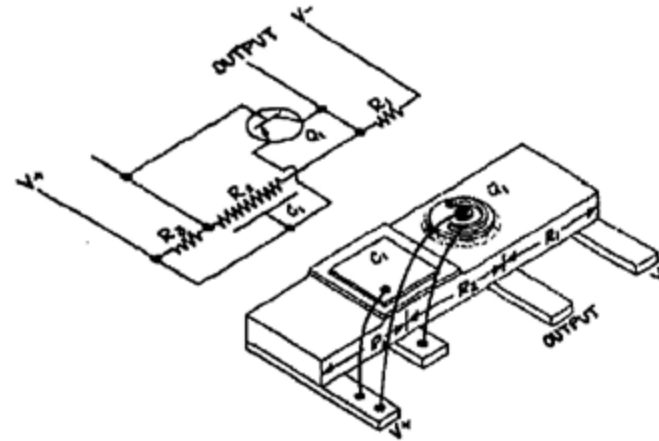


# Example: The History of Digital Microelectronics

1953 H. Johnson



1959 J. Kilby



1958-1959  
Robert Noyce, Jean  
Hoerni, Jack Kilby  
and Kurt Lehovec  
all took part in de-  
veloping the inte-  
grated circuit.

## One Final Comments:

*“If Columbus had an advisory committee, he would probably still be at the dock.”*

**Arthur J. Goldberg**, Associate Justice of the Supreme Court, 1962–1965.



