



# 332:466/591 Optoelectronics I

Instructor: Wei Jiang

Sec. 1. Introduction

## About Instructor

- Dr. Wei Jiang
- Room: EE 215
- Phone: (732) 445-2164
- Email: [wjiangnj@rci.rutgers.edu](mailto:wjiangnj@rci.rutgers.edu)

## About this Course

- Class Time: T,Th 6:40 pm – 8:00 pm (change to Thur 6:40 – 9:20 pm??)
- Location: ECE 240
- Office hours: T,Th 4:00-5:00pm or by appointment
- **Prerequisites:**
  - Undergrad: 332:382 EM Fields and 332:361 Electronic Devices
  - Graduate: (332:580 *EM waves*) **and** (332:581 Introduction to SOLID STATE ELECTRONICS or 583 SEMICONDUCTOR DEVICES I)
- Homework: 5 assignments
- Two exams and Final exam

## Textbooks

- B. E. A. Saleh & M. C. Teich, *Fundamentals of Photonics*, Wiley-Interscience, 2nd edition (2007), ISBN 0471358320 (primary text).
- S. O. Kasap, *Optoelectronics and photonics: principles and practices*, Prentice-Hall,
- (2001), ISBN 0201610876 (substitute)
- Pallab Bhattacharya, *Semiconductor Optoelectronic Devices*, Prentice Hall; 2nd edition (1996), ISBN 0134956567 (supplement on Semiconductors).
- Amnon Yariv, *Quantum Electronics*, ISBN 0471609978, (advanced)
- All material will be covered in lecture notes.

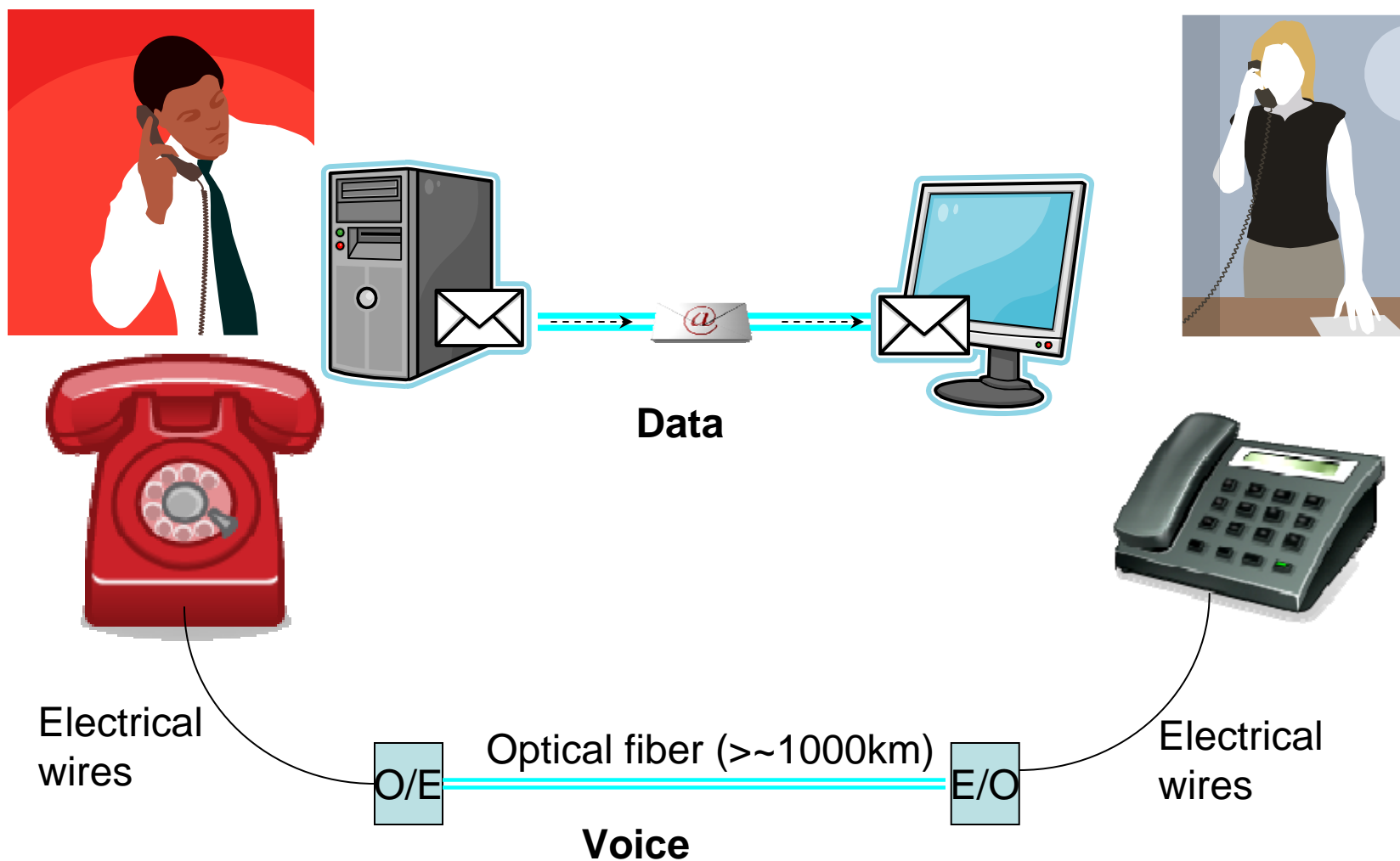
## Course Outline

- Goal: Overview optoelectronic device technology
- Emphasis: device physics/operating principles (mainly concepts, less on maths), along with some structural engineering, fabrication
- Introduction
- Dielectric Waveguides and Optical Fibers
- Review Quantum Mechanics & Semiconductor Physics
- LEDs, Lasers, and Optical Amplifiers
- Modulators, switches
- Photo-Detectors
- Other Optoelectronic Devices (solar cell, WDM?)
- Hot research topics (brief intro): Photonic Crystals, Plasmonics (if time allows)

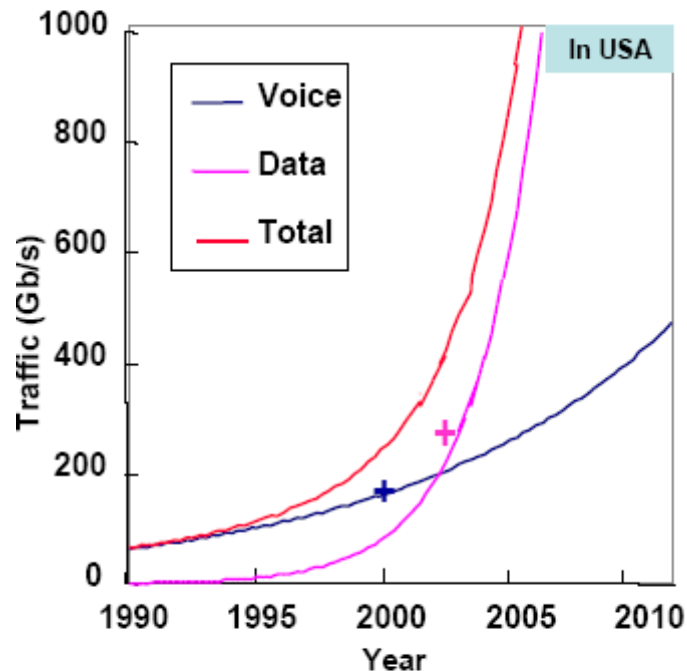
## Difference between undergraduate and graduate sections

- Different homework and exam questions
  - Undergraduate: more focus on conceptual questions
  - Graduate: more quantitative questions
- Advanced materials for graduate students only
  - Undergraduates are encouraged to learn, but not required

# Optoelectronic Technology in Your Life Everyday



## NETWORK TRAFFIC: THE SHIFT TO DATA (Historical Projection – 1998)



### Year 1998 Projection:

- Voice growth assumed 10%
- Data growth assumed 100%
- Data overtakes voice in 2001

### Year 2006 Traffic Data:

- Traffic crossing the network growing at ~80% annually
- AT&T traffic load is 5.1 PB/day (~1 Tb/s, assuming a 12-hr day)

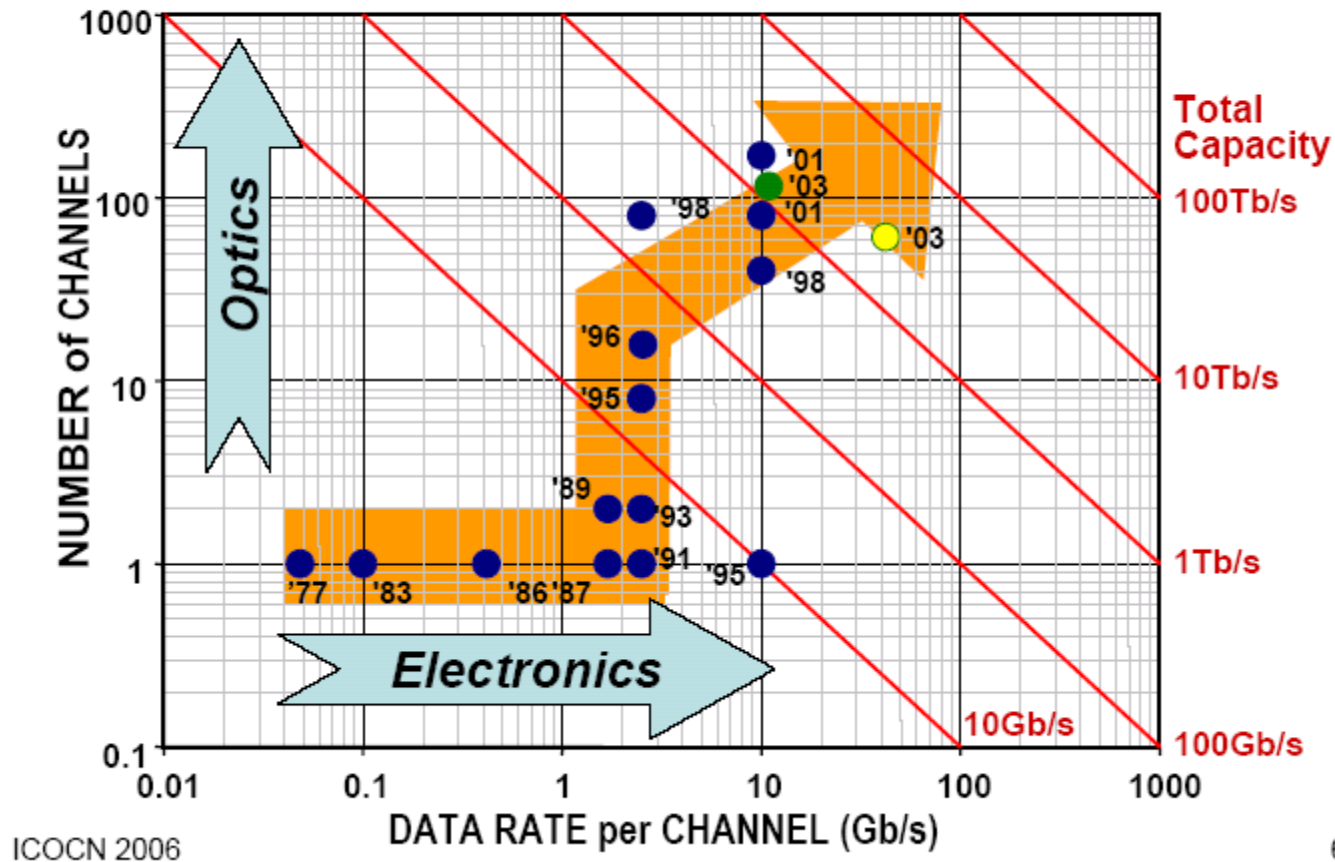
ICO CN 2006

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Source: Coffman and Odlyzko (AT&T Labs, 1997); Cambron (AT&T Labs, 2006)

Tingye Li, AT&T Labs-Research (Retired), ICO CN 2006.

## CAPACITY OF COMMERCIAL LIGHTWAVE SYSTEMS *Doubled Annually*



ICOON 2006

Source: H. Kogelnik (Lucent)

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Tingye Li, AT&T Labs-Research (Retired), ICOON 2006.

## DILEMMAS AND CHALLENGES OF SERVICE AND NETWORK PROVIDERS

- **Data traffic** (*doubling annually*) >> voice traffic
- **Data revenue** << voice revenue (~1:3 for US)
- **Traditional revenue stream** disrupted by new technologies and competition
- **Expenses** increasing faster than revenue and profits
- **Continuous network evolution** essential
- **Problems of innovative** accounting practices
- **New sources of business revenue** compelling

***Resulting in Industry Consolidation:  
Bankruptcies, Mergers and Acquisitions,  
And Creation of New Business Opportunities***

## THE TRANSFORMATION OF AT&T

- 1984:** AT&T divested its Regional Bell Operating Companies (RBOCs)
- 1996:** AT&T divested its manufacturing units (Lucent and Avaya)
- 2005:** AT&T acquired by SBC (an RBOC) and re-emerged as the new AT&T
- 2006:** The reborn AT&T will acquire Bell South, another RBOC, and (once again) become the biggest telecom company in the US (and in the world)

	AT&T	Bell South	Verizon/(MCI)	China Mobile	Vodaphone
Market Cap. (8/4/06)	\$120B	\$73B	\$99B	\$126B	\$116B
Operating Rev. (1H06)	\$32B	\$10B	\$45B		
No. of Employees	186K	63K			

## CONSOLIDATION OF TELECOM SUPPLIERS

- **The Bubble**
  - Irrational fervor; religious vision; over-supply
- **The Long, Harsh Winter**
  - Bankruptcies of start-ups; down-sizing of incumbents
- **Recovery and Growth**
  - Telecom capex growing: (\$205B in 2005; \$236 in 2009)<sup>a</sup>
  - Carriers' needs: cost savings and new revenue (*new services*)
- **Consolidation**
  - Fewer customers and broader technology scope
  - Mergers to match customers' scope and size

e.g. Alcatel/Lucent (\$21.5B)\*  
 Ericsson/Marconi (\$20.3B)\*  
 Nokia/Siemens (\$19.8B)\*

\* 2005 Revenue attributable  
 to service providers

ICO CN 2006

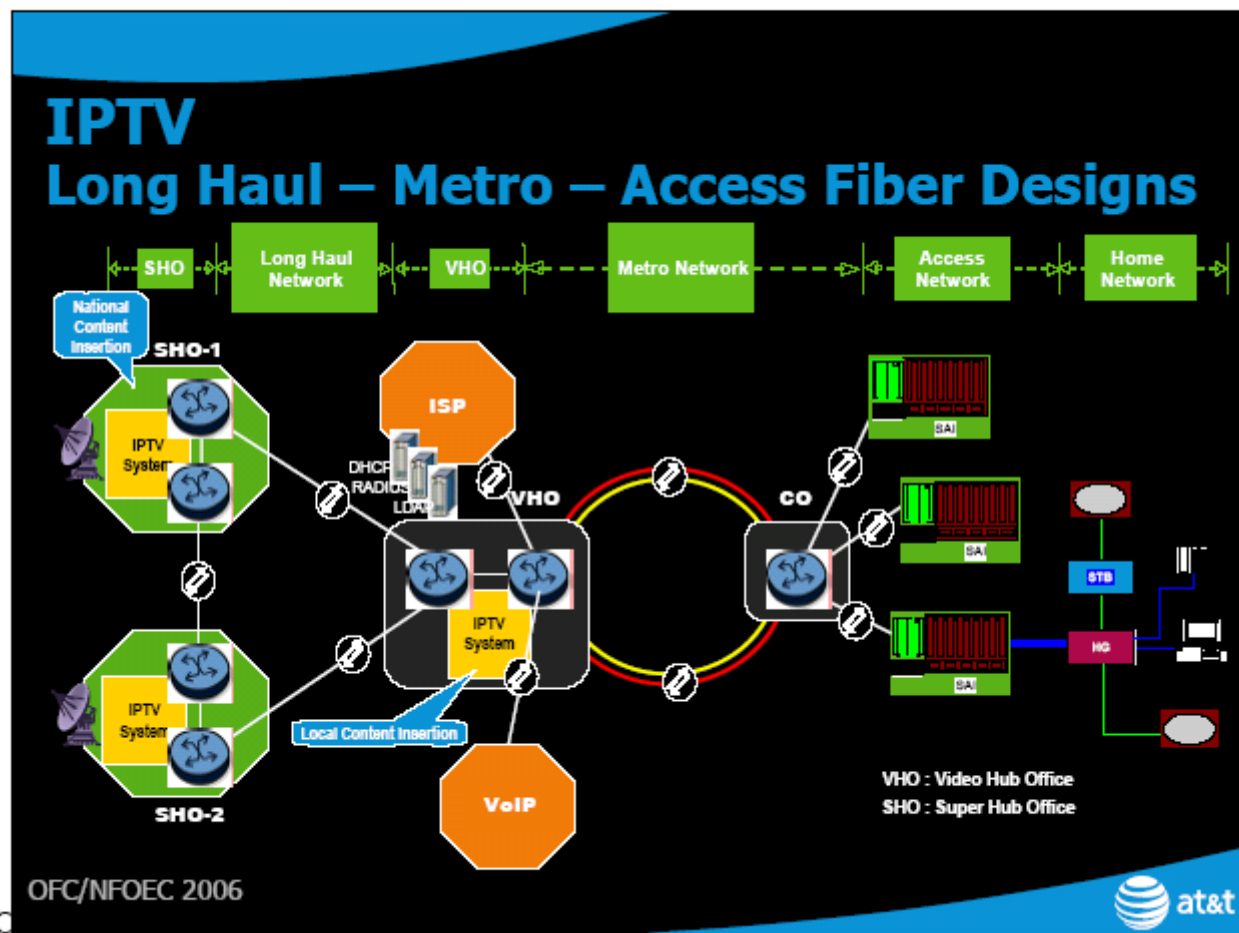
\*\* Source: [www.infonetics.com](http://www.infonetics.com)<sup>9</sup>

Tingye Li, AT&T Labs-Research (Retired), ICO CN 2006.

## NEW APPLICATIONS AND COMPETITION (VoIP and IPTV)

- **VoIP** (Voice-over-IP)
  - Requires broadband access (>200 kb/s)
  - Competition among ILEC, CLEC, MSO, ISP & NNP
  - ILECs projected to lose ~\$96B by 2010 \*
- **IPTV** (Video-on-Demand,...)
  - Perceived as “*The Next Big New Application*”
  - Competition among ILEC, CLEC, MSO, ISP & NNP
  - Upgrade of core and metro networks (IP-based NGN)
  - Deployment of FTTH, FTTP,...

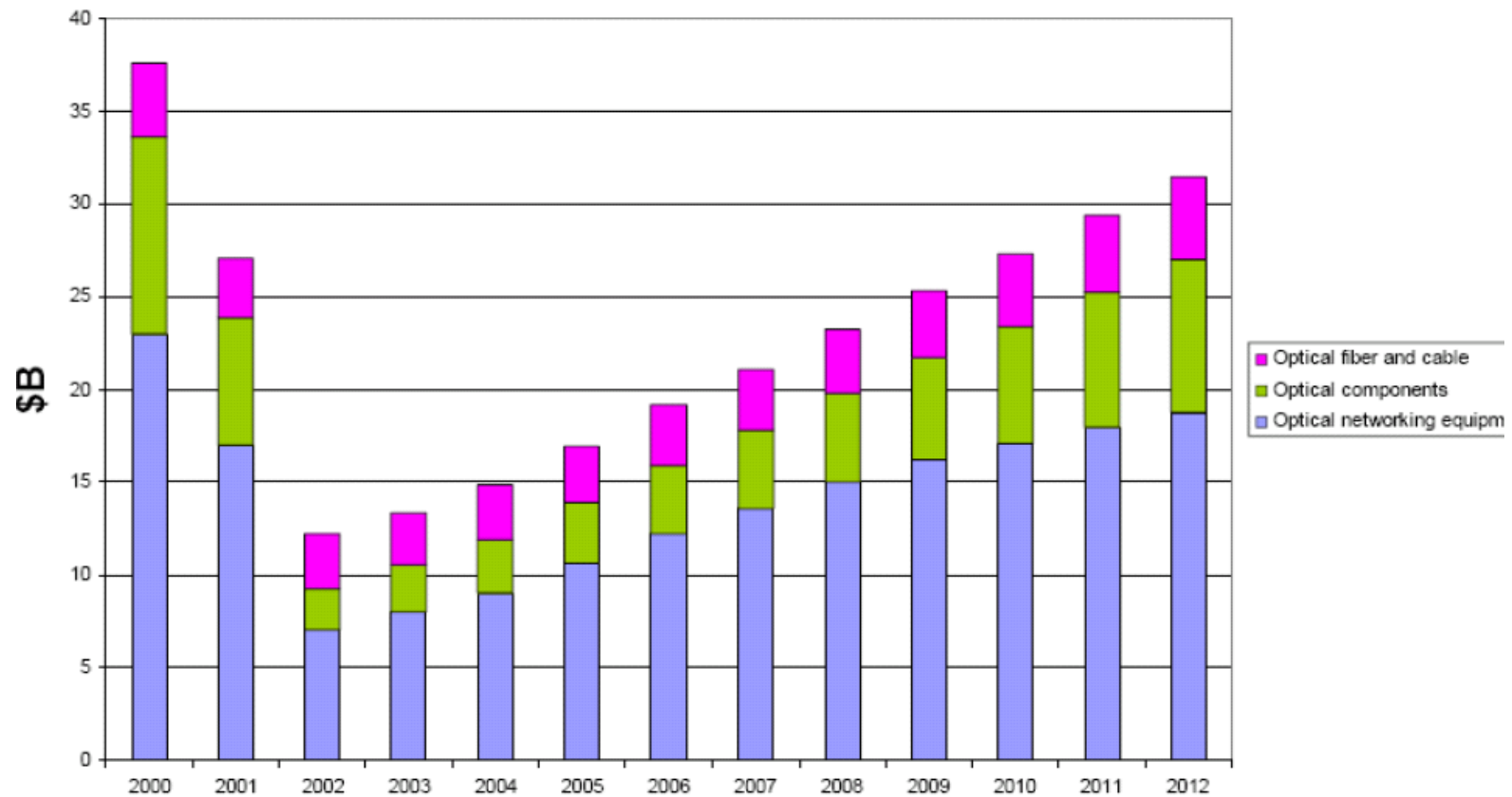
# Service Provider Adapting to New IP Applications



Source: K.Cambron (AT&T): OFC 2006

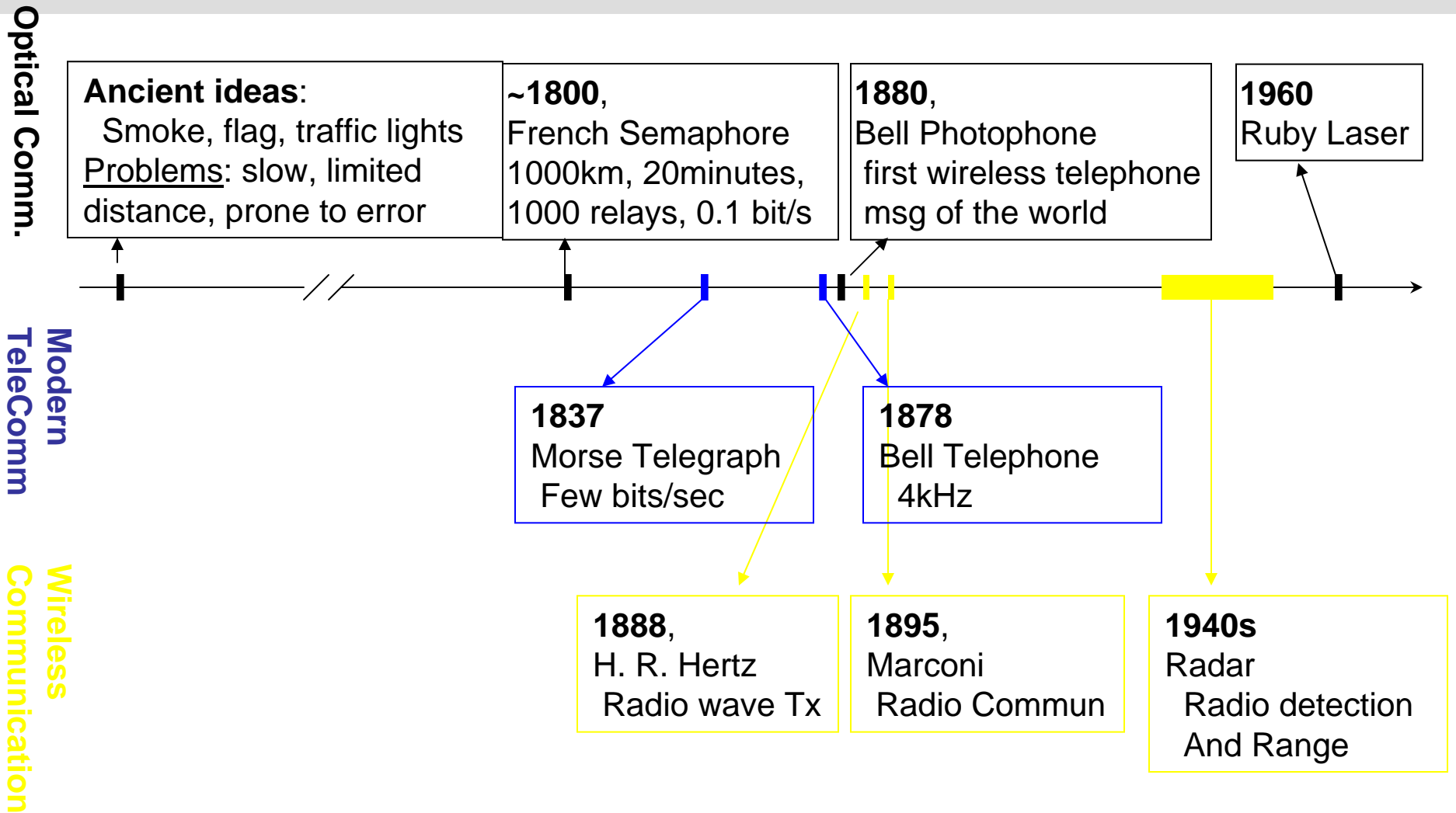
Tingye Li, AT&T Labs-Research (Retired), ICOCN 2006.

# Global Optical Communications Revenue and Projection

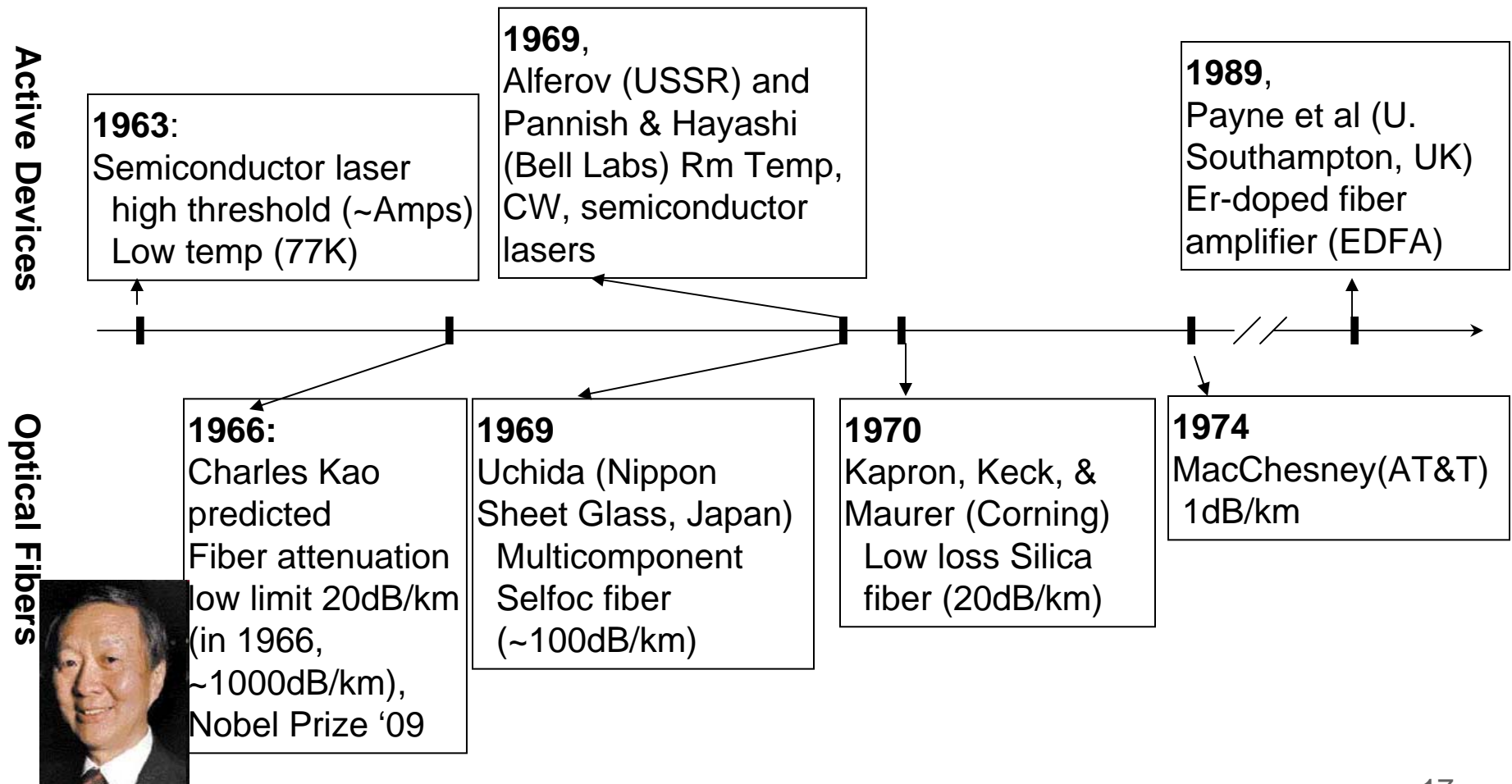


Ray Chen, Univ. of Texas at Austin, 2006.

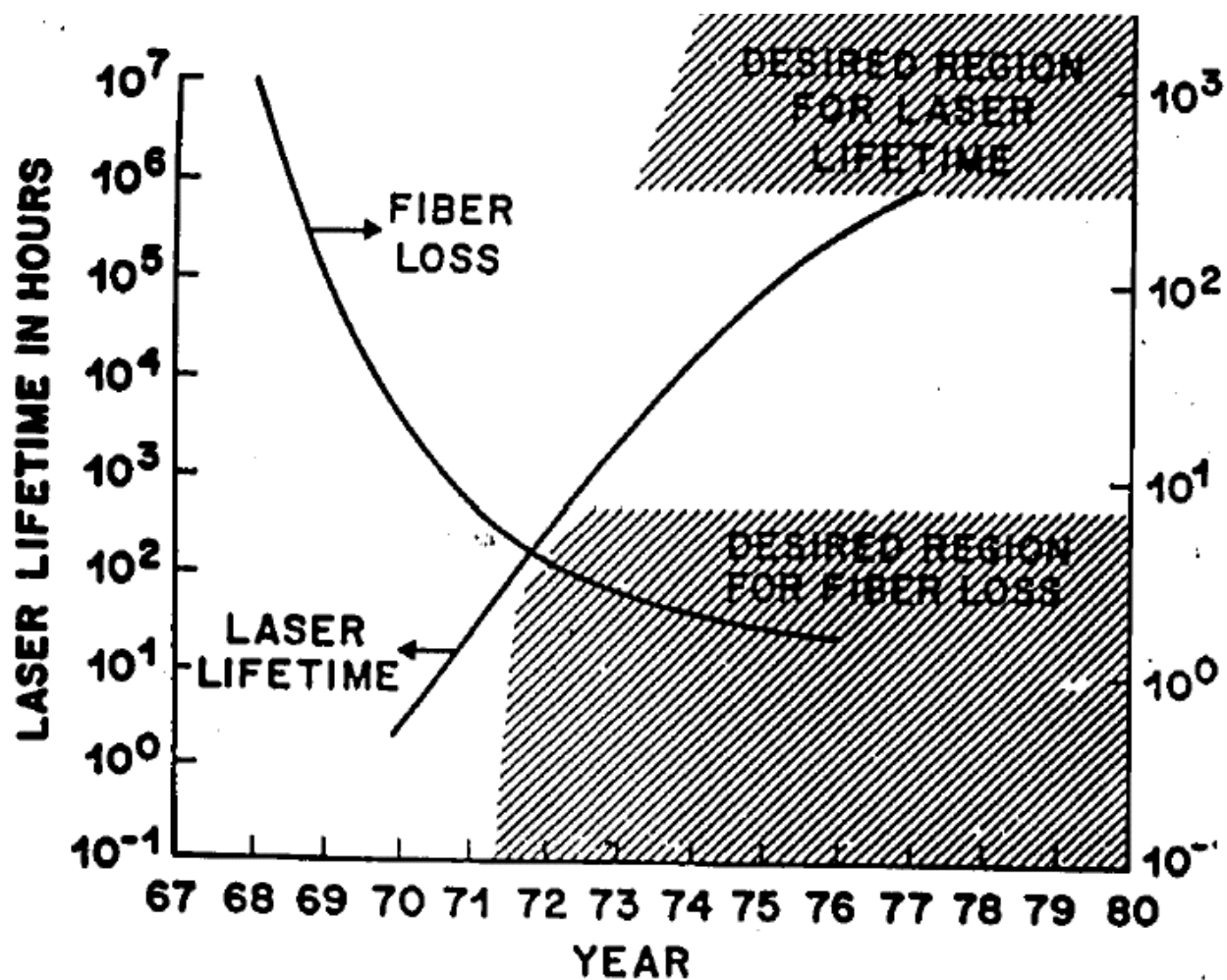
# History of Optical Communication



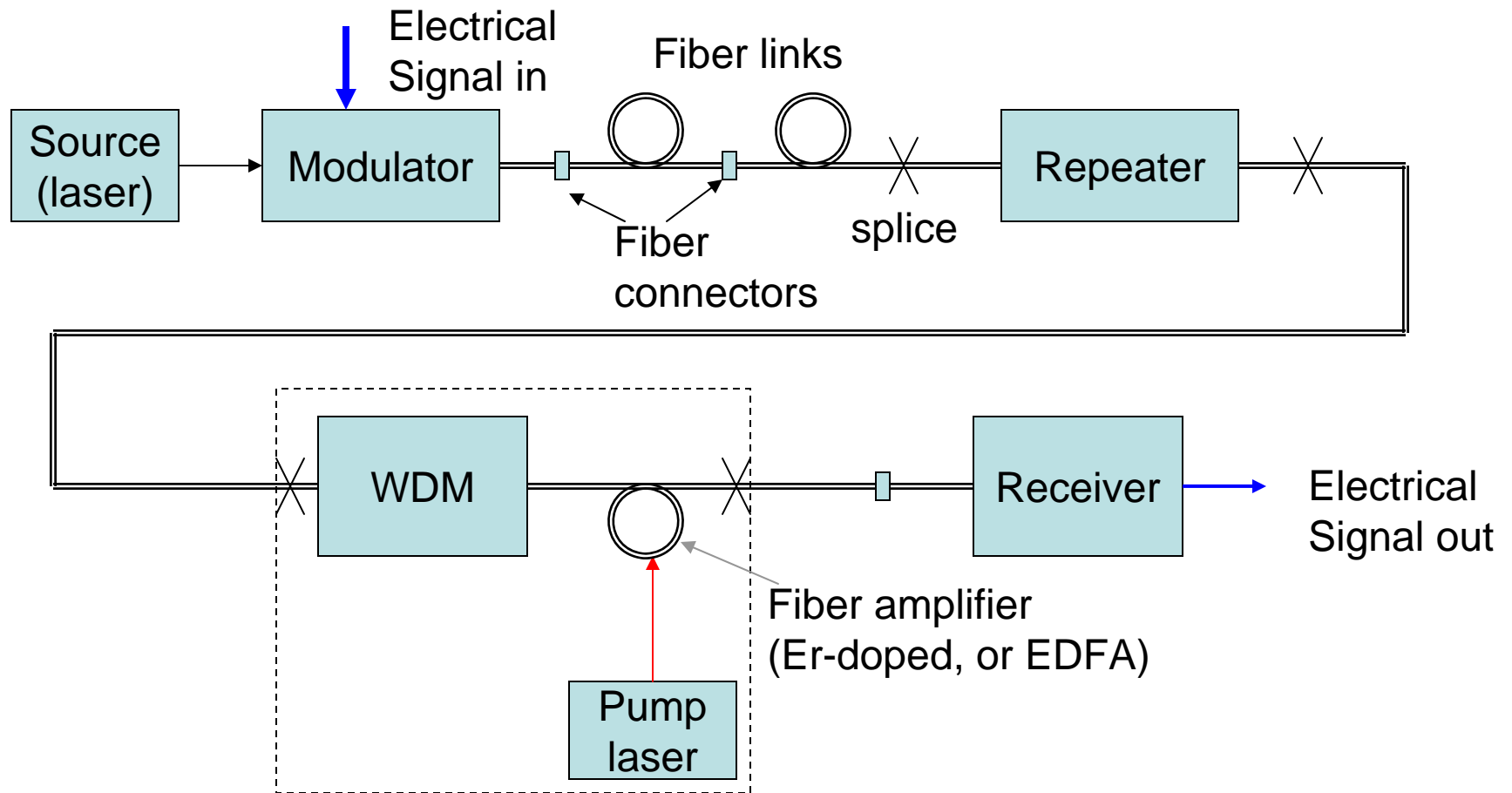
# History of Fiber Optical Communication



# Fiber Loss & Laser Lifetime – Advances Year by Year



# Typical Fiber Optical Communication System



# Other applications

## Commercial Electronics



Solar cells



Optical data storage  
(CD, DVD, Blu ray...)



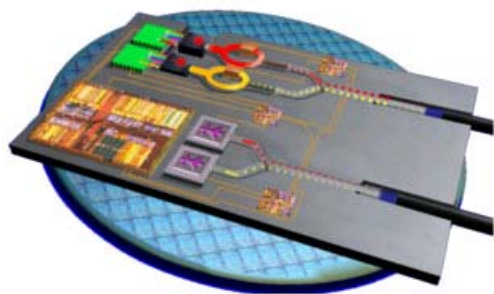
LEDs



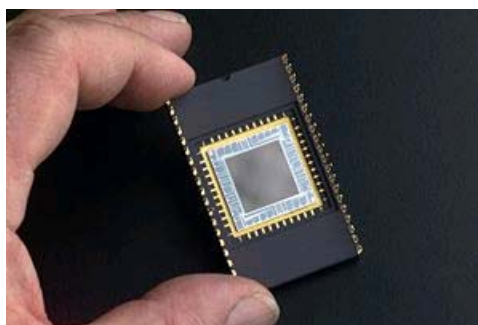
display



lighting



Optical interconnects



CCD image sensor

## Other Applications of Optoelectronics

- Commercial Electronics
  - Before 2000, Optoelectronic technology was mainly driven by Optical Communications (for ~30 years)\*
  - Optical Storage: CD, DVD, Blu-ray, etc.
  - Display: LCD, LEDs etc
  - Solid State Lighting
  - Optical interconnects.
  - Imaging Sensors
  - Solar cells
- Defense applications
  - laser communications (free-space)
  - laser radars
  - weapons
- Biomedical: laser surgery, spectroscopy, sensors, imaging

\* Communication devices are probably the most sophisticated among all optoelectronic devices in many aspects, and are regarded as the cornerstone of optoelectronics.