



Towards Sensory Intelligence
SENSOR NETWORKS

ANNUAL INDUSTRY CONFERENCE

Center for Neuromorphic Systems Engineering

Lee Center for Advanced Networking

May 16 - 17, 2001



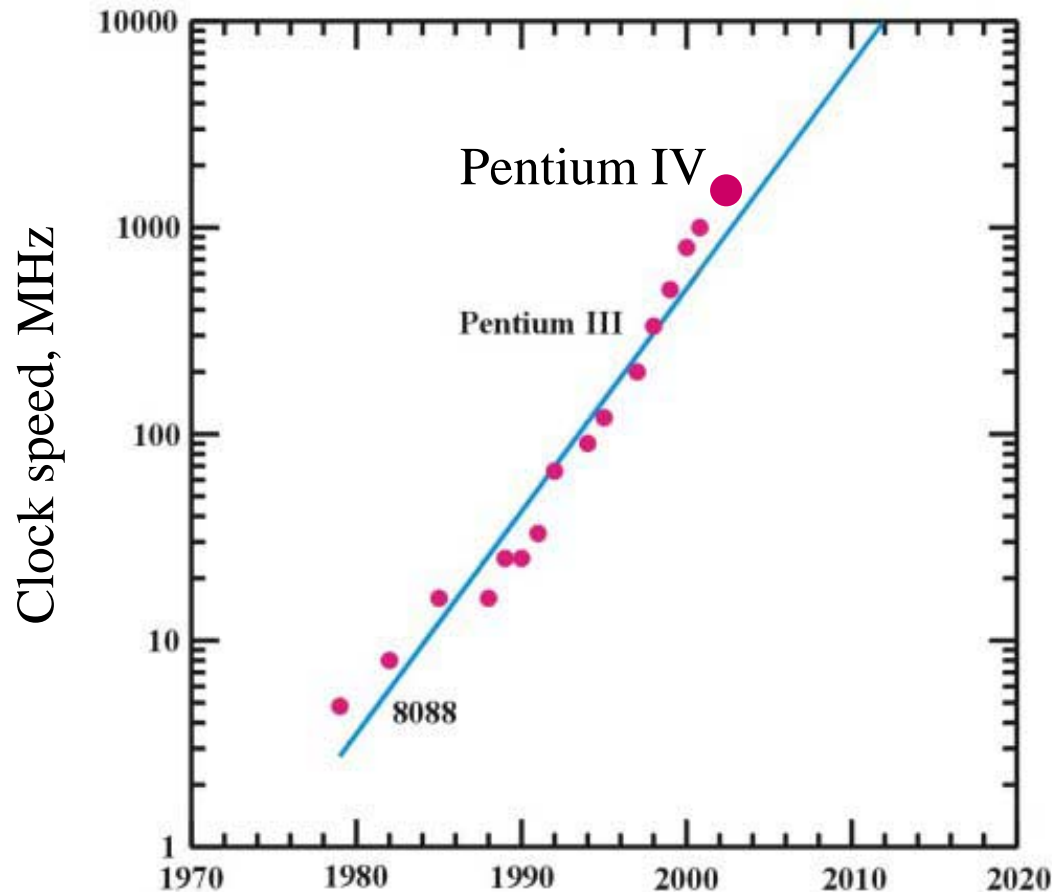
Lee Center for Advanced Networking

David Rutledge, Director

- \$10M donation from David Lee, Caltech alumnus and trustee, and first president of Global Crossing
- 10-year research program in high-speed fiber systems, distributed computing, and wireless networking
- 11 faculty members in 5 departments: Electrical Engineering, Computer Science, Applied Physics, Control and Dynamical Systems, Economics



Intel Microprocessor Clock Speeds

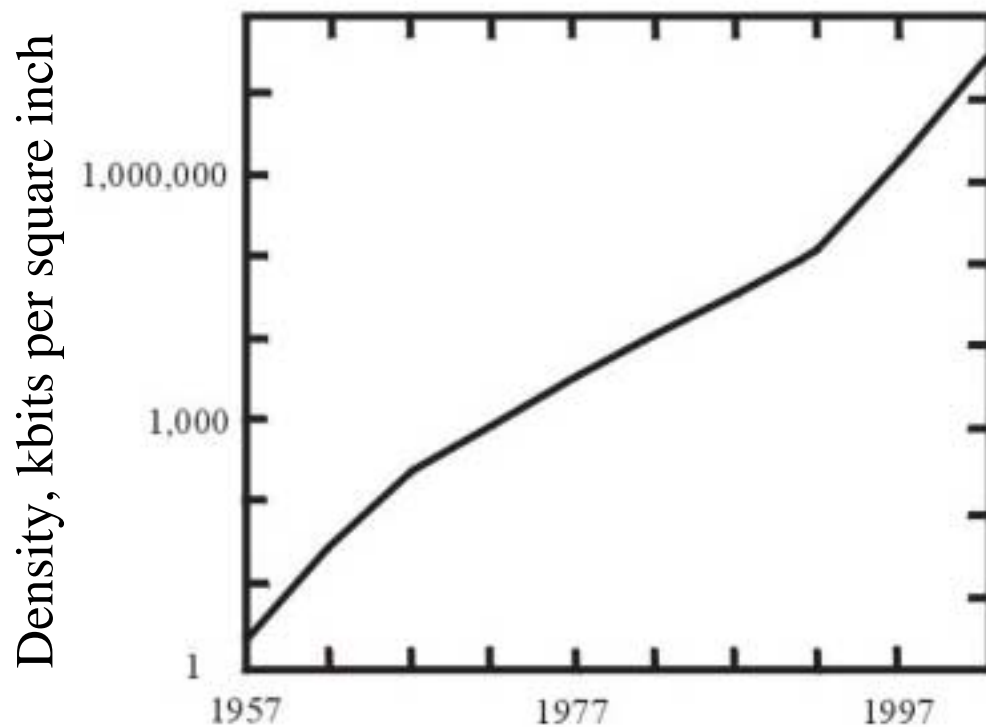


Doubles every
three years

*Courtesy: Mike DeLisio
University of Hawaii*



Increasing Magnetic Hard-Disk Data Densities

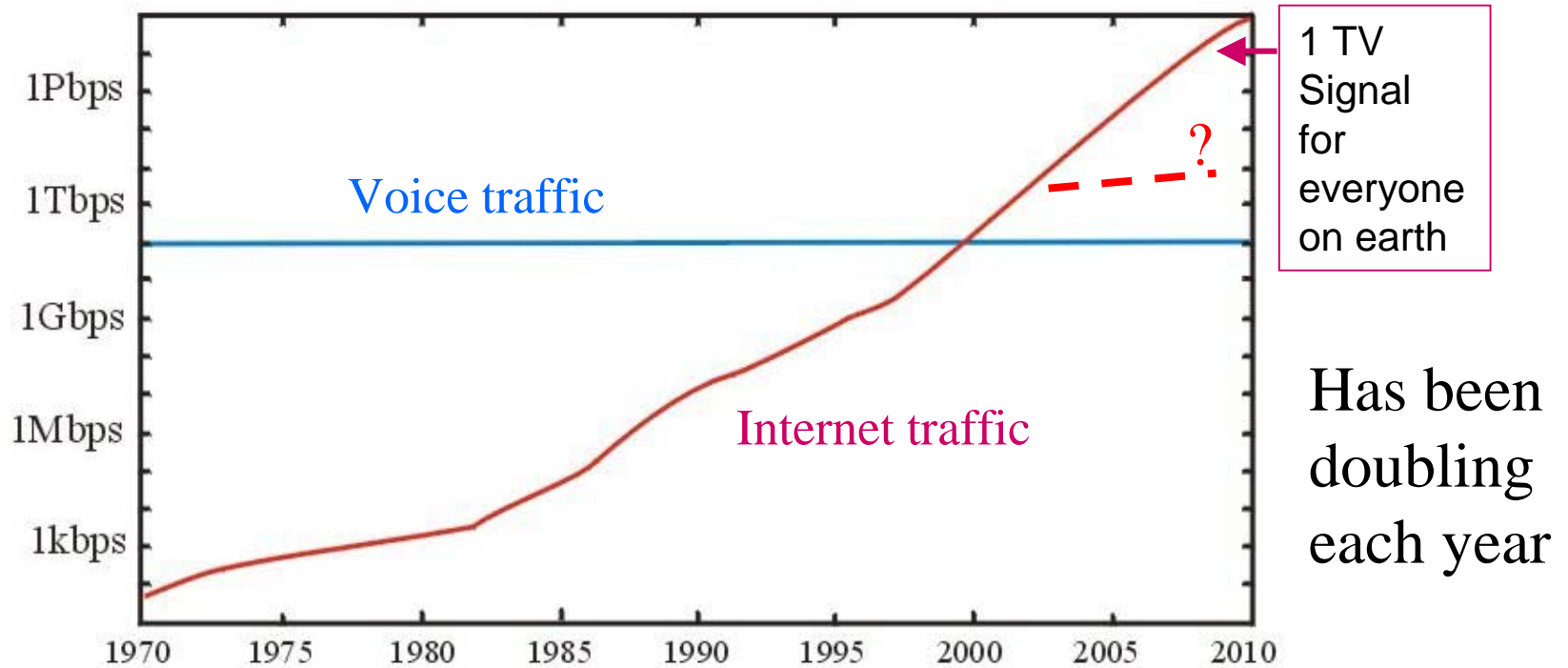


Doubles every
two years

Scientific American
May 2000



Growth in Internet Traffic



from Lawrence Roberts, "Beyond Moore's Law, *Computer* magazine, January 2000



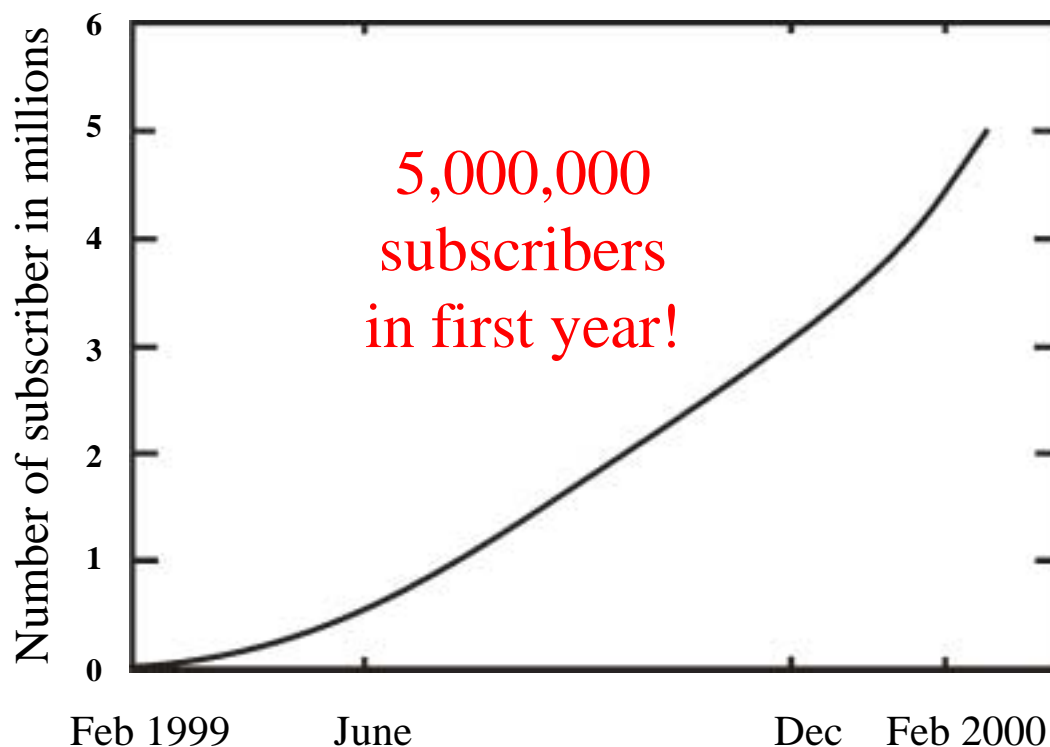
High-Speed Solutions for the Last Mile(s)

- Fiber optics: the ultimate, but expensive, may be limited to new housing developments
- Cable modems: shared resource
- DSL: upgrade of telephone lines, must be close to central exchange
- 3rd generation wireless: upgrade of cellular telephone system
- Satellite systems: good for rural areas



The Wireless Internet

DoCoMo's *i*-mode



- E-mail
- Internet
- 20 million subscribers now!



Lee Center Research Topics

- Plott: frequency auctions for wireless networks.
- Chandy: crisis management, wireless networking for campus
- Doyle: power laws in networks
- Hickey: Reliable computing for networks
- Low: Network congestion and flow control, seminar series
- Bruck: protocols and models for wireless worldwide web
- Effros: image data compression for wireless networks
- McEliece: turbo codes for wireless networks
- Vahala: channel dropping filters for photonic networks
- Hajimiri: RF silicon IC's for wireless networks
- Rutledge: phased arrays for millimeter-wave networks

Kerry Vahala: Microsphere Laser

Erbium-doped
silica microsphere
(40- μm diameter)

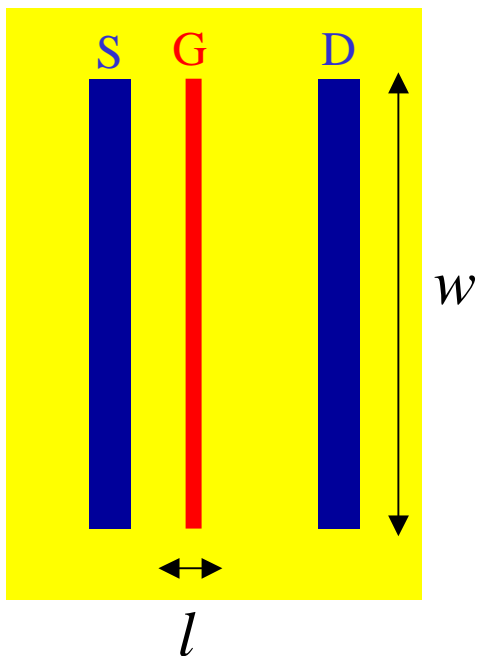
Optical-fiber taper

Green light from
whispering-gallery mode





Power Laws for Transistors

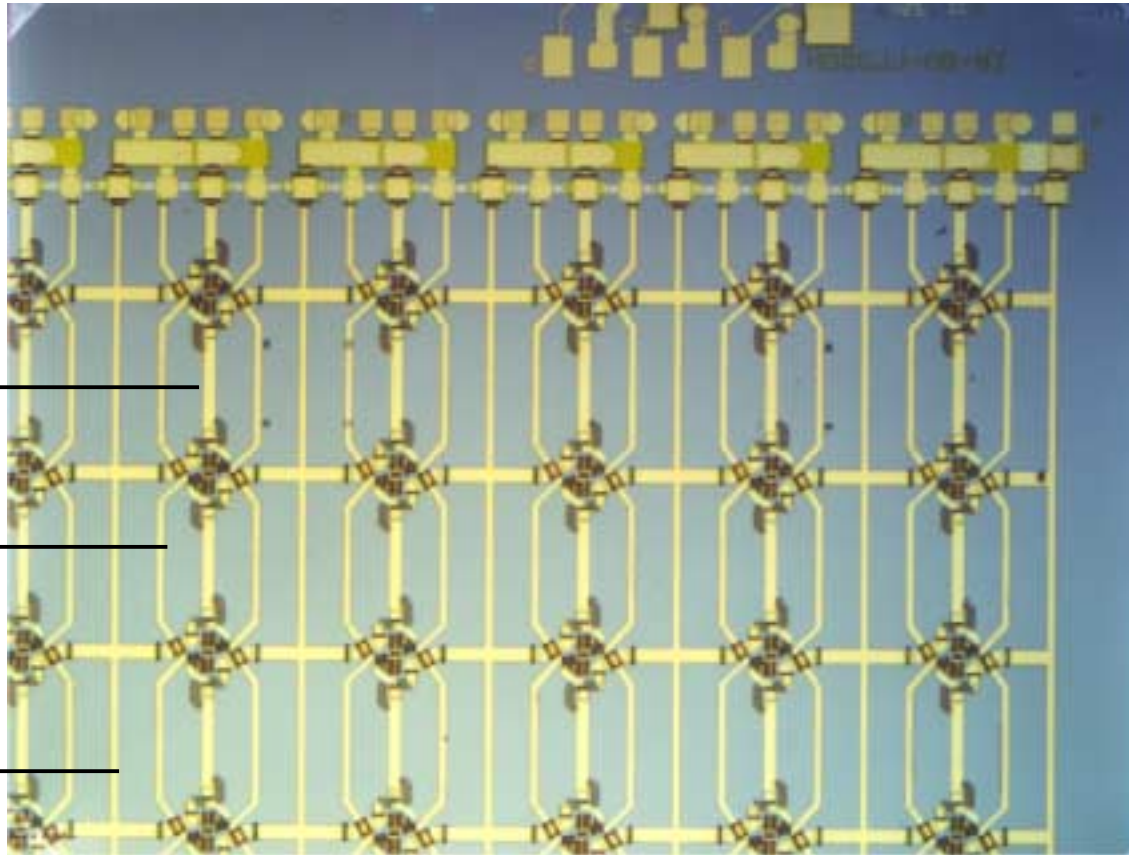


- $P \propto lw \rightarrow P \propto 1/f^2$
- Power combining needed at high frequencies



5-W, 37-GHz Grid Amplifier

Blythe Deckman



Gate
bias

Source
bias

Drain
bias

512 transistors
1-cm square
80- μm gate
width

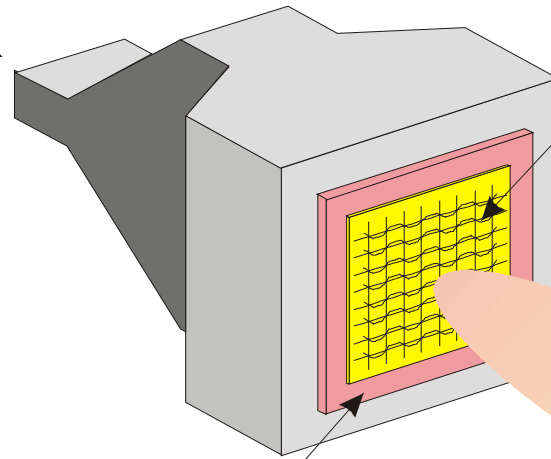
Input polarization
↑

→ Output
polarization



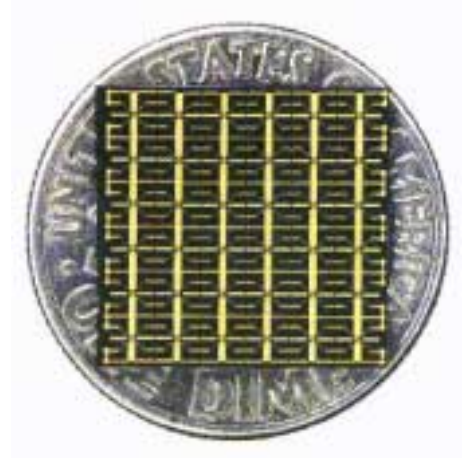
Transmitters for Satellite Ka-Band Internet Uplinks

Microwave
input



Aluminum nitride
heat spreader

Output
beam



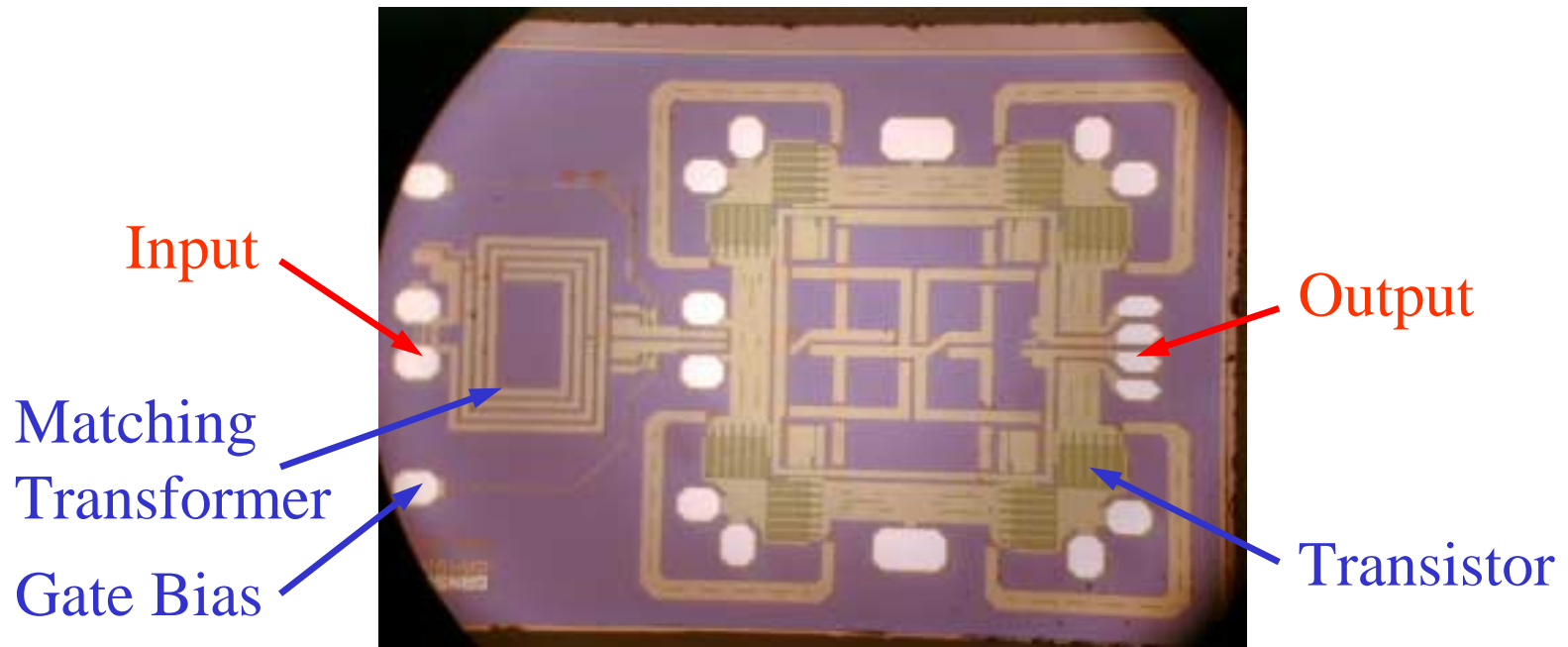
Amplifier
grid



CONEXANT™

First 2.4-GHz Fully Integrated 0.35- μm CMOS Power Amplifier

Ichiro Aoki, Ali Hajimiri, David Rutledge



Record output power level of 2W with a 2-V supply
Suitable for a notebook computer



Previous Work

- June 00, Int. Microwave Sym., 100mW at 1.9GHz (3V, 16%)
- Feb 01, J. Solid-State Circuits, 90mW at 0.9 GHz (3V, 30%)
- This work: 1.9W at 2.4GHz (2V, 41%)