Lecture 1: EE 179 Course Introduction

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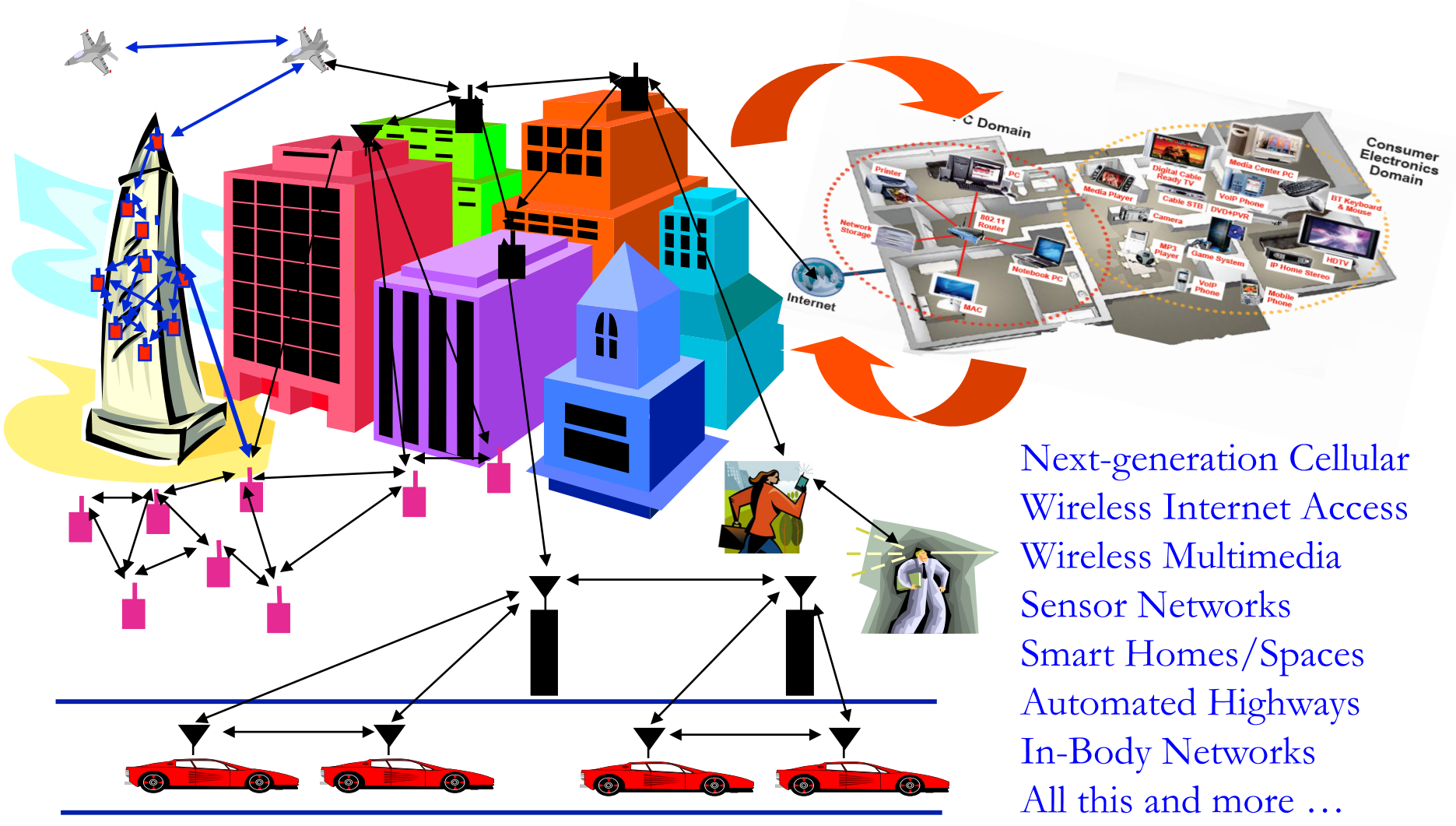
Course Introduction



Next-generation Cellular
Wireless Internet Access
Wireless Multimedia
Sensor Networks
Smart Homes/Spaces
Automated Highways
In-Body Networks
All this and more …

Based on Notes from John Gill

Today's Topics

- Course Information and Policies
- Course Syllabus
- Communication Systems Today
- Examples of Communication Systems
- Design Challenges

Course Information

- Instructor: John Pauly, `pauly@stanford.edu`
  Packard 358, 650-723-4569
  Office hours: Th 11-12.
- Class homepage: http://ee179.stanford.edu
- Prerequisites: EE 102A or equivalent
- Recommended Textbook: Lathi & Ding, *Modern Digital and Analog Communications Systems*, 5th ed.
- Weekly homework/lab assignments due on Fridays
- Grading: HW and Labs 40%, midterm project 20%, final project 40%

Assignments and Projects

- Homework and Labs
  - Assigned on Fridays, due following Friday at class time.
  - You are free to talk with other students about the homework and problems, but everyone should turn in their own write up.
- Midterm and Final Projects
  - Midterm will be a short project (essentially a lab you do on your own)
  - The final project topic will be given to you. Last time it was decoding the digital packets that planes use to identify themselves.
  - Final project presentations will be during the scheduled final time, Wed 8, form 7-10 PM. You will have 10 minutes to present your project and results.

Labs

- The labs will be based on acquiring and processing real RF data
- You will be given software defined radios to capture RF data
  - Currently we have RTL-SDR's, which are receive only
  - We have Lime SDR's on order, which transmit and receive. Unfortunately the chip shortage is real!
- Processing will be in matlab and gnuradio
- Friday classes will be devoted to talking about the new lab, and acquiring and processing data.
- Be sure to bring your computers and sdr's on Fridays

Amateur Radio License

- We'll be having a zoom class on getting your Amateur Radio License
- This is a great way to really learn and use what we cover in this class
- Thursday evenings at 7 PM, starting next week
- We'll give you a free VHF/UHF handheld radio when you pass
- If we get the Lime SDR's you will need a license to be able to transmit.

Course Outline

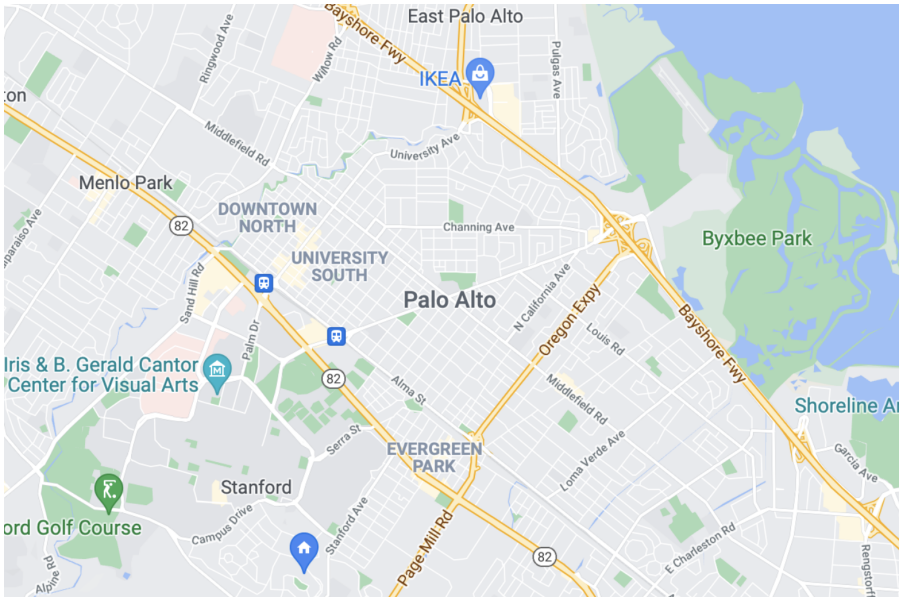
- Modern communications systems
- Focus on transport layer. How do you encode information on a carrier?
- Signal processing in $2\pi f$, instead of ω as in 102A
- Finding your way around the RF spectrum
- Analog Systems
  - Amplitude modulation (AM, SSB, QAM)
  - Pulse modulation (PAM, PWM, PPM)
  - Angle modulation (FM, PM, PSK, and FSK)
- Digital systems
  - Sampling and Quantization
  - Pulse code modulation (PCM)
  - Digital modulation (PAM, ASK, FSK, PSK, QPSK, and QAM)
  - Line Coding and ISI
- SNR and performance

Early Communication Systems

- Telegraph
  - 1830, Joseph Henry
  - 1832, Pavel Schilling
  - 1837, Samuel B. Morese, Morse code
  - 1844, What Hath God Wrought
- Telephone
  - 1876, Alexander G. Bell ("Watson come here; I need you.")
  - 1888, Strowger stepper switch
  - 1915, US transcontinental service (requires amplifiers)
- Wireless telegraphy
  - 1895, Jagadish Chandra Bose builds radio transmitter
  - 1896, Marconi patents radio telegraphy
  - 1901, Marconi, first transatlantic transmission
- Radio
  - 1906, Reginald Fessendend, first broadcast
  - 1920, first commercial AM radio station (Montreal XWA $\rightarrow$ CINW)

West Coast End of the AT&T Transcontinental Wireless Telegraph

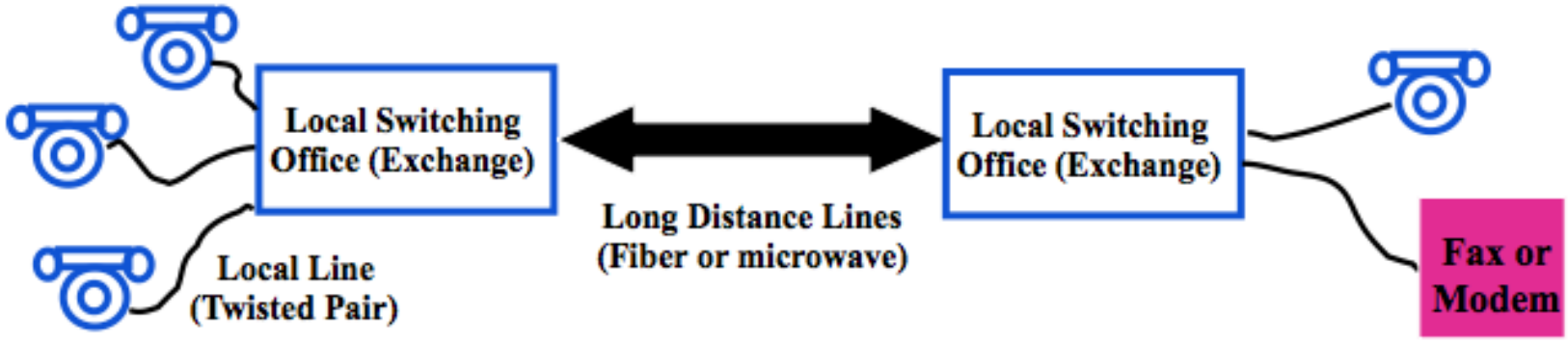
Bixby Park, Palo Alto Baylands



Communication Systems Today

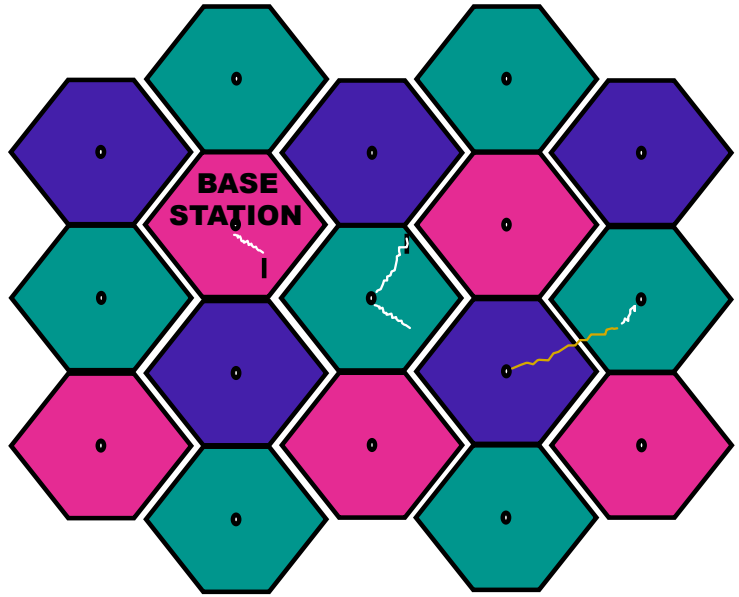
- Public Switched Telephone Network (PSTN) for voice, fax, modem
- Radio and TV broadcasting
- Citizens' band radio; ham short-wave radio
- Computer networks (LANs, WANs, and the Internet)
- Satellite systems (pagers, voice/data, movie broadcasts)
- Cable television (CATV) for video and data
- Cellular phones
- Bluetooth
- GPS
- Many others...

PSTN Design



- Local exchange
  - Handles local calls
  - Routes long distance calls over multiplexed high-speed connections
- Circuit switched network tailored for voice
- Faxes and modems modulate data for voice channel
- DSL uses advanced modulation to get 1.5-6.0 Mbps

Cellular System Basics

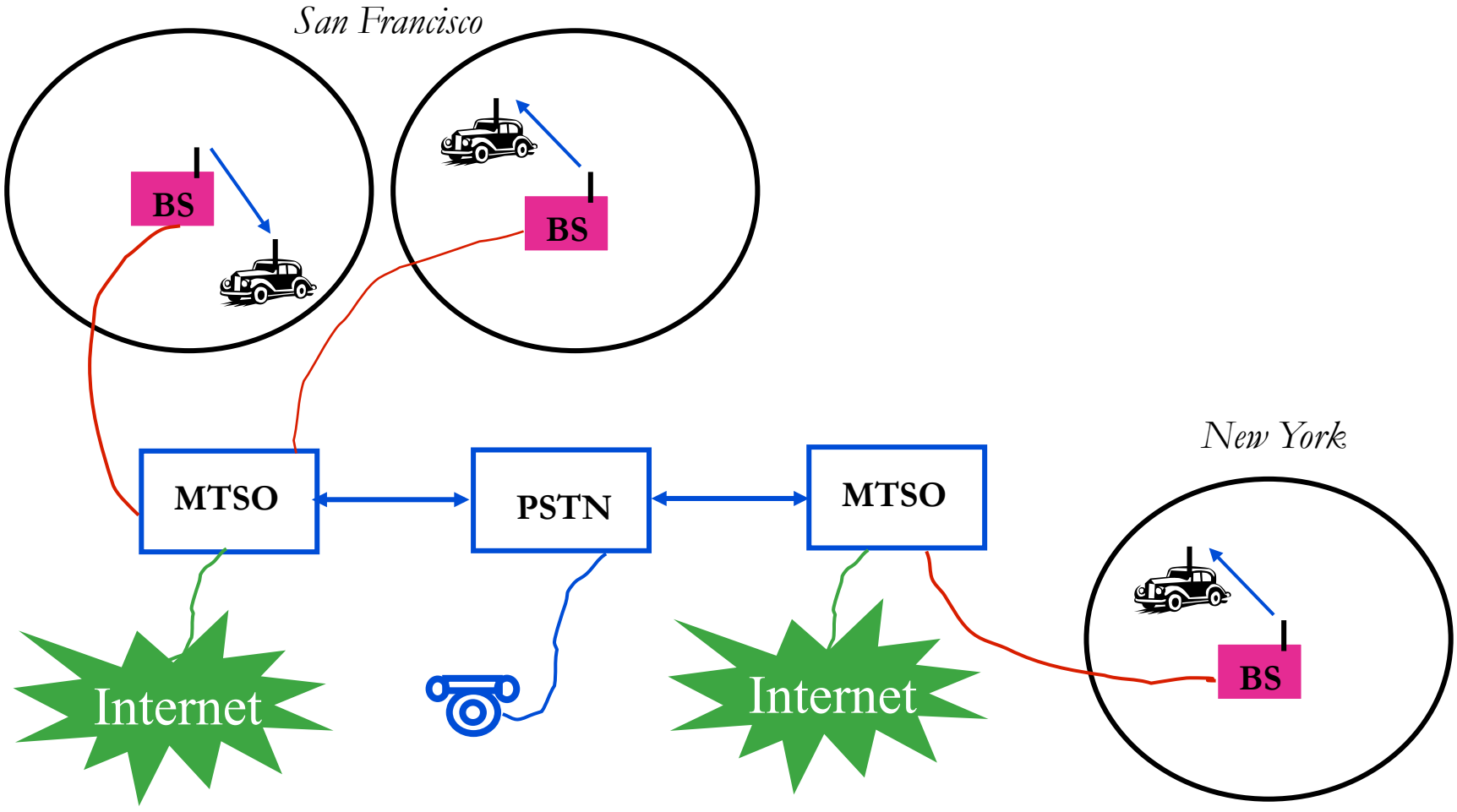


- Geographic region divided into hexagonal cells[1]
- Frequencies/timeslots/codes are reused at spatially-separated locations. (Analog systems use FD, digital systems use TD or CD.)
- Co-channel interference between same color cells
- Handoff and control coordinated through cell basestations

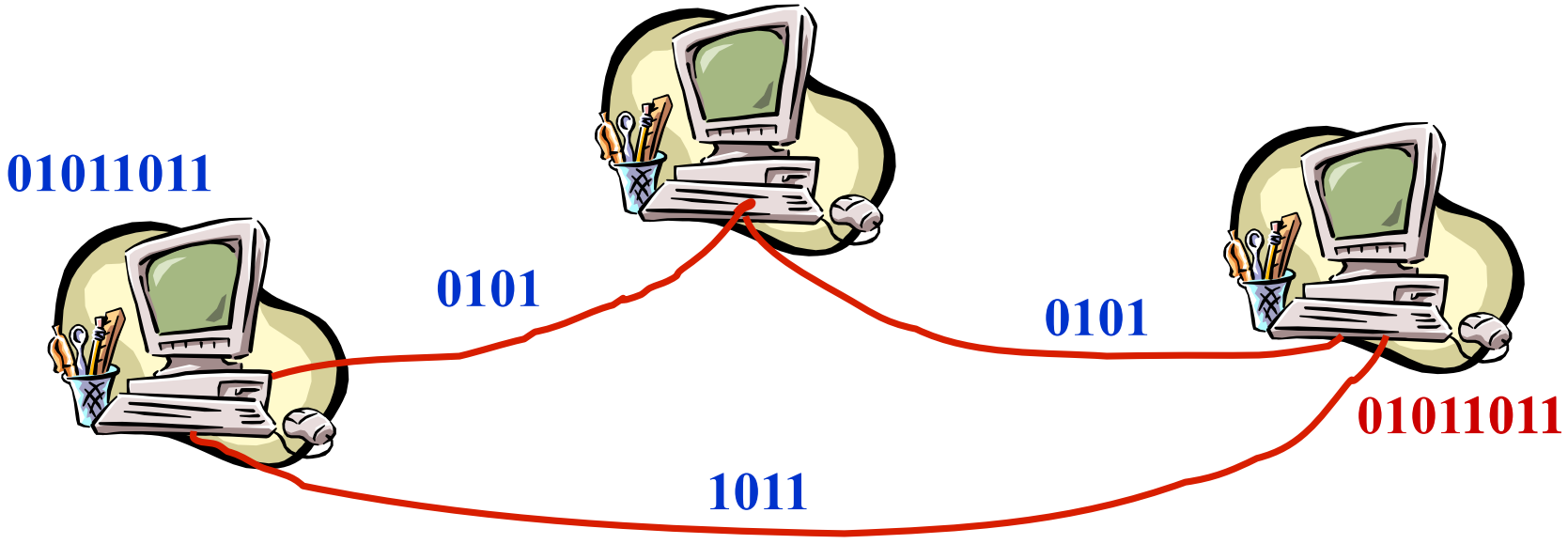
[1] proposed in 1947 by Douglas H. Ring and W. Rae Young, Bell Labs engineers

Cellular Phone Backbone Network

Mobile telephones depend on the PSTN — except for mobiles within the same MTSO (mobile telephone switching office)

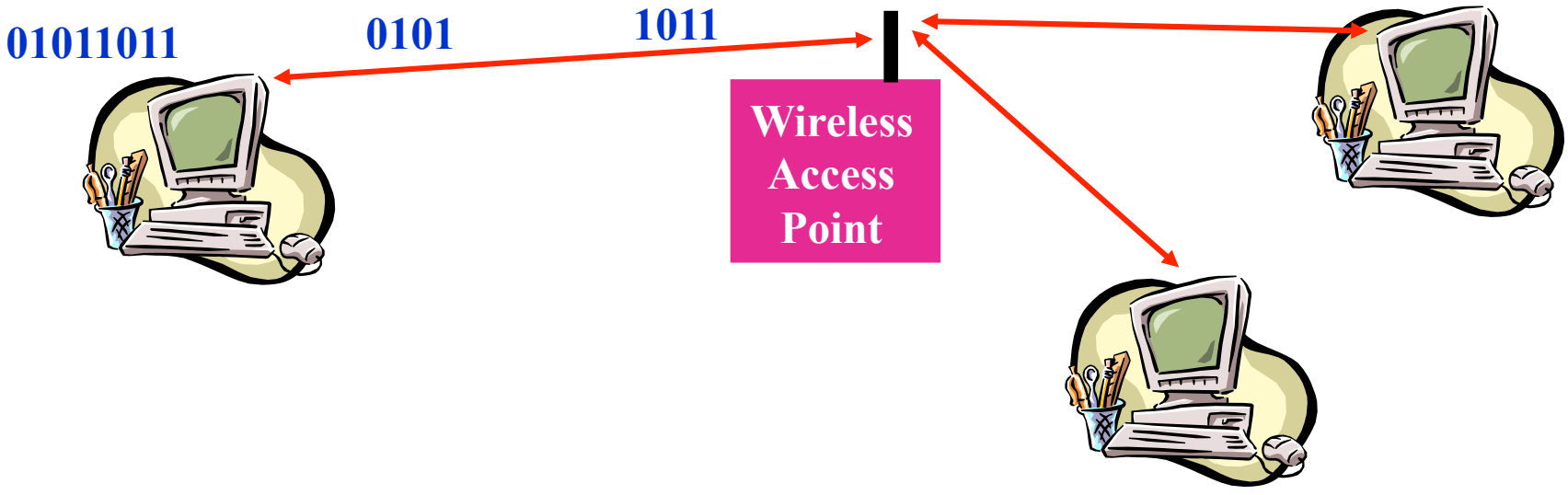


Local Area Networks (LAN)



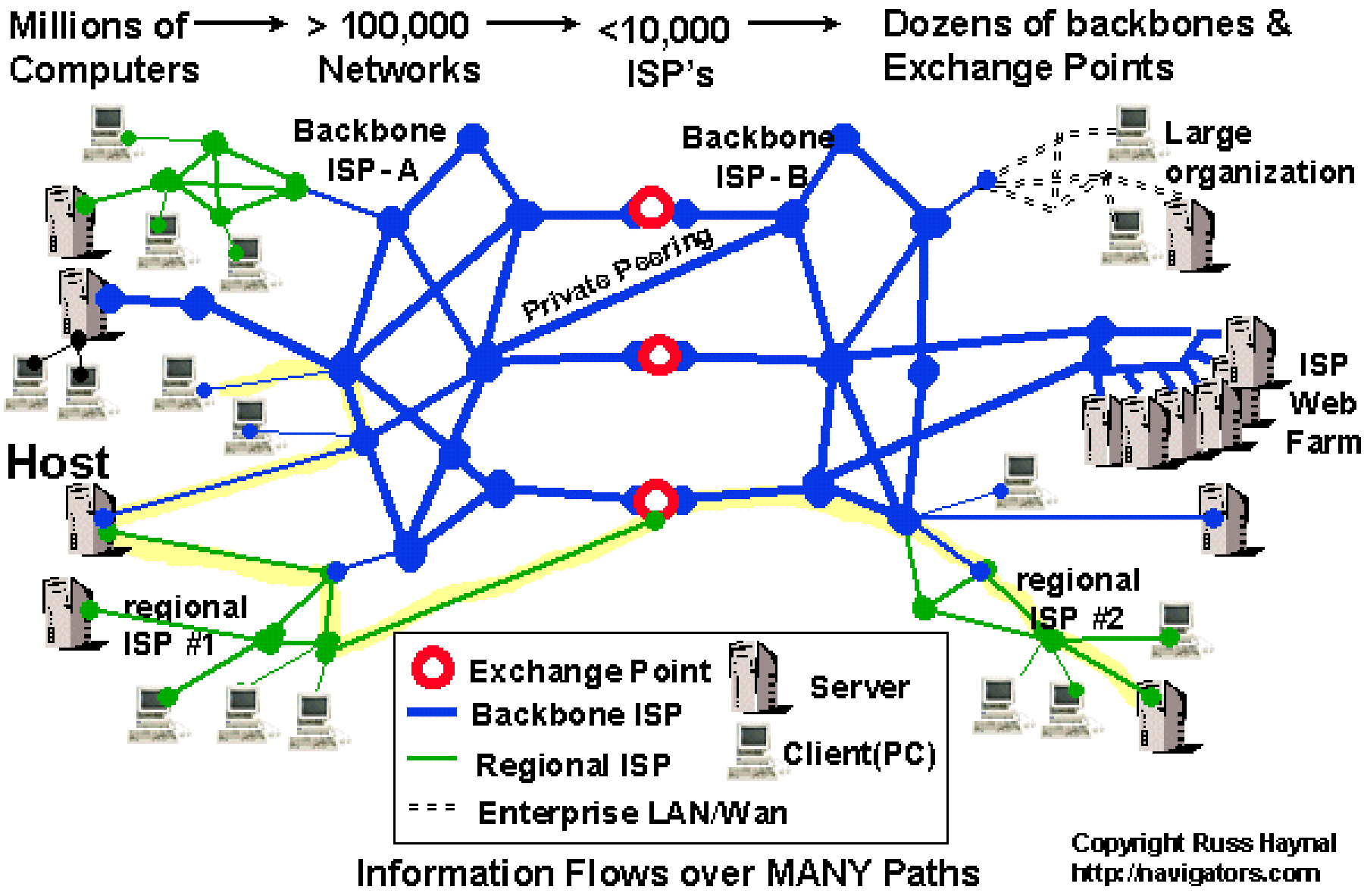
- "Local" means every computer can hear every other computer
- Packet switching instead of circuit switching (no dedicated channels)
- Data is broken down into packets
- Originally proprietary protocols; e.g., Ethernet was a collaboration between Intel, DEC, and Xerox. (DEC?)

Wireless Local Area Networks (WLAN)

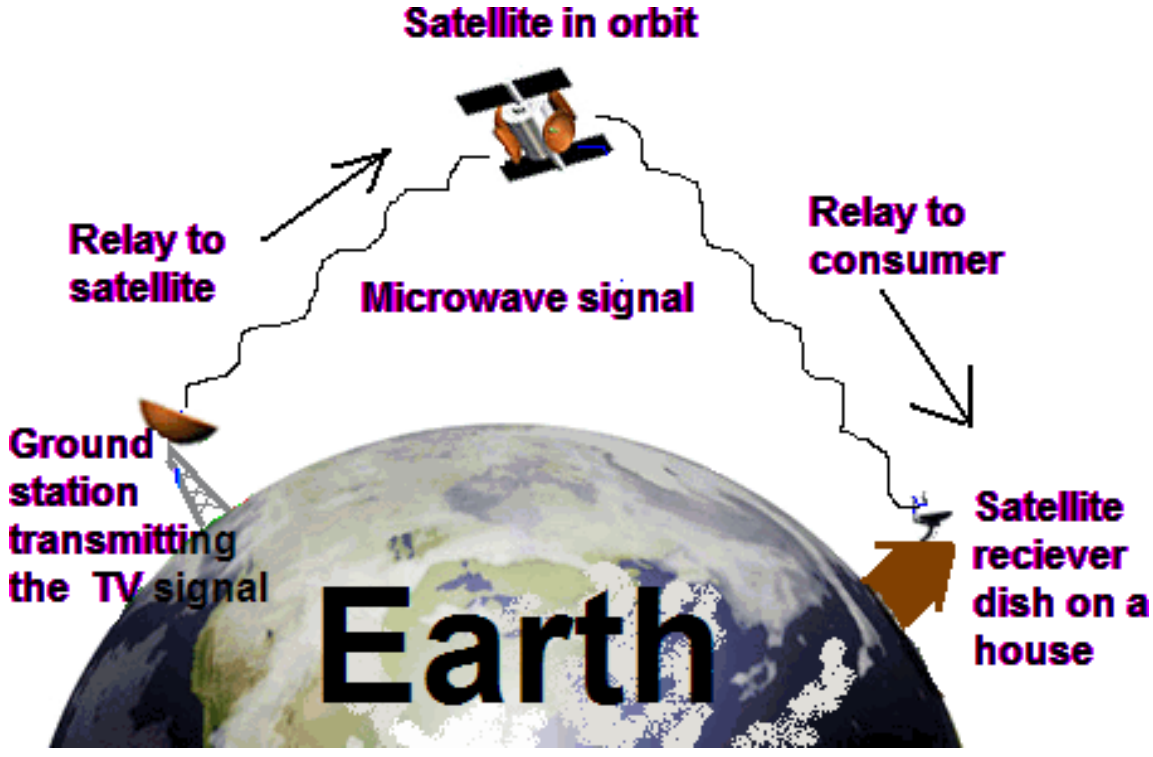


- WLANs connect "local" computers (100m range) to an access point
- As with LANs, data is broken down into packets
- Channel access is shared (random access)
- Access protocols for WLANs are much more complex than for LANs
- Backbone Internet provides best-effort service (no QOS guarantee)

Wide Area Networks; the Internet



Satellite Systems



- Satellites cover very large areas
- Different orbit heights: GEOs (39000 Km) versus LEOs (2000 Km)
- Optimized for one-way transmission, such as radio (XM, DAB) and television (SatTV) broadcasting
- Latency (round trip delay) can be a problem

Bluetooth

- Ericsson, 1994, named for King Harald Blåtand Gormsen
- Intended as replacement for cables, such as RS-232
  Now used for input devices, cell phones, laptops, PDAs, etc.
- Short range connection (10–100 m)
- Bluetooth 1.2 has 1 data (721 Kbps) and 3 voice (56 Kbps) channels, and rudimentary networking capabilities