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Data Communications and Networks
IS 450/IS 650 – Spring 2015

Course Logistics

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University of Maryland Baltimore County

Welcome to IS 450/IS 650

- Timings: Tuesday; 4:30pm to 7:00pm
- Location: Math & Psychology 106
- Instructor: Nirmalya Roy

  Faculty in IS,

  MS in CSE: UT-Arlington, 2004

  PhD in CSE: UT-Arlington, 2008

  Postdoc in ECE: UT-Austin, 2010

  Faculty at Washington State University, 2013

  Research Interest: Mobile, Pervasive and Ubiquitous Computing http://userpages.umbc.edu/~nroy/mpsc.html

- Office hours: Thursday 1pm – 2:30pm or by appointment

  Email: nroy@umbc.edu

  Office: ITE 421

Welcome to IS 450/IS 650

- Course website
  - http://userpages.umbc.edu/~nroy/courses/spring2015/dcn/
  - Course related information will be posted on the website
  - Please check the course website frequently

- Prerequisite:
  - MATH 215 or MATH 221

- Make up classes
  - Will be occasionally necessary due to travel

Welcome to IS 450/IS 650

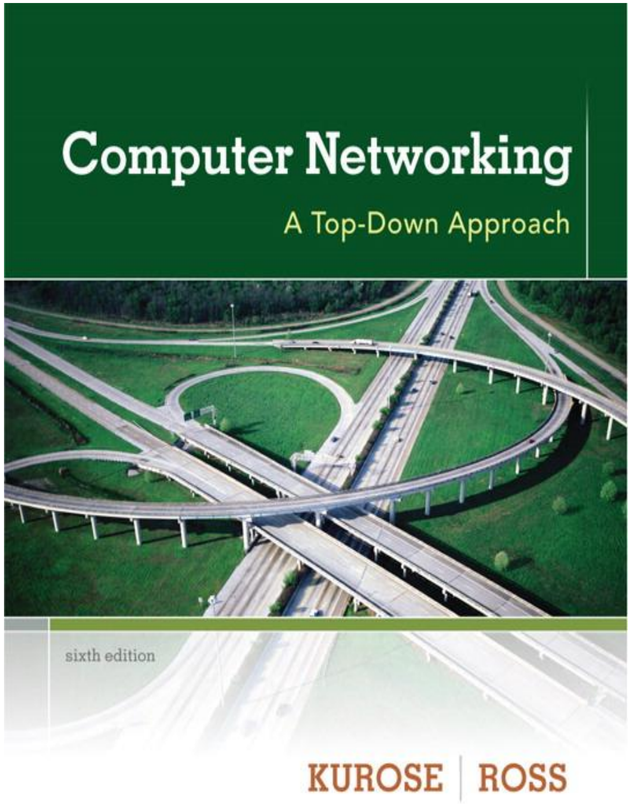
- Grading:
  - Homework/Quizzes/Class Participation: 30%
  - Hands-on Data Communications Research & Development Project 20%
  - 1 mid-term exam: 20%
  - Final exam: 30%

Course Expectations

- Attendance
  - You should attend class
  - Lecture notes will be made available, but they should not be considered a substitution for attending class
- Collaboration
  - Collaboration is good in general but do not copy from each other

Course Information

- Course materials:
  - Text:
    Computer Networking: A Top Down Approach, 6th Ed., by James F. Kurose and Keith W. Ross. Addison-Wesley, 2012
  - Class notes/slides
  - Some supplementary reading materials



What is this course about?

- First undergraduate and graduate level course in computer networking
  - BS and MS students

- Learn principles of computer networking
- Learn modeling and analysis of computer networking
- Learn practice of computer networking
- Internet architecture/protocols as case study
- Real wireless networks and devices as case studies
- Introduction to next generation networking
- Learn how to find an interesting networking research and development problem

Course Information

- At the end of the course
  - You understand variety of concepts ……………
  - Internet, HTTP, DNS, P2P, …
  - Sockets, Ports, …
  - Congestion Control, Flow Control, TCP, …
  - Routing, Basic Graphs, Djikstra's Algorithm, IP, …
  - DSL , Cable, Aloha, CSMA, TDMA, Token, WiFi 802.11, …
  - Security, RSA, …
  - Cellular Networks, Mobile Networks, Satellite Networks, …
  - Wireless Multihop Networks (ad hoc, mesh, WLANs)
  - Sensor Networks
  - Tackling a research & development problem
  - …

What this Course Does Not Cover

- We will not discuss
  - Large-scale path loss, small scale fading and multipath
  - Modulation schemes; channel coding
  - Transmitter/Receiver design, signal processing, antenna design etc.
- This is course on
  - Understanding, analyzing, and designing of protocols and algorithms in networking systems (wired Internet/Ethernet and wireless cell/WiFi)

Hands-on Data Communications Project

- Deploy, test, compare and if needed make changes to have access to real data on real devices commercially available in the market
  - Energy Education through Green Building
    - Constellation Energy
  - Smart Plugs
    - Enmetric
    - Z-Wave
    - iMeterSolo
    - SiteStage (previously was known as eMonitor)
  - ....

Hands-on Data Communications Project

- Understand the working principle and pros & cons of different types of communication protocols
  - Wi-Fi (IEEE 802.11.x)
  - ZigBee (IEEE 802.15.4)
  - Bluetooth
  - X10
  - ANT
  - Bluetooth low energy (BLE) or Bluetooth Smart
  - Powerline communication protocol (PLC)
  - ....

Hands-on Data Communications Project

- Device selection
  - Form a team (3 for undergrad and 2 for grad students)
  - Decide a team leader
  - Choose a device related to your tentative R&D project
  - Choose the most cost effective device
    - Our plan is to deploy the system ultimately at large scale in smart environments
- Email me the device specification, the tentative title of your project and purpose and link
  - Deadline for selecting the appropriate device is by the last class in February, 2/24

Selecting the Appropriate Device

- Select a device which is ubiquitous, easy to set up, easy to use and most importantly less expensive and has huge potential for the real deployment

- Discuss with me through emails

- Let’s look at some potential choices

Potential Devices & Equipment

- Energy metering and communication
  - Z-Wave Smart Energy Power Strip
  - iMeter Solo - INSTEON Power Meter (quite a few in the lab)
  - PowerLinc Modem - INSTEON USB Interface

- Z-wave Smart Metering and Communication
  - Aeon Labs DSA02203-ZWUS Z-Stick Series 2
  - Aeon Labs DSC24-ZWUS Smart Switch Z-Wave Appliance Module
  - Aeon Labs DSC06106-ZWUS - Z-wave Smart Energy Switch
  - Aeon Labs Aeotec Z-Wave Smart Energy Power Strip

Potential Devices & Equipment

- Insteon Energy Metering and Communication
  - iMeter Solo - INSTEON Power Meter (Plug-In)
  - PowerLinc Modem - INSTEON USB Interface (Dual-Band)

- Enmetric System for Intelligent Plug load Management and Power Telemetry Communication
  - Enmetric PowerPort
  - Enmetric Wireless Bridge

Potential Devices & Equipment

- PeoplePower
  - Presence Pro Energy - for Android

- Nest Lab
  - Nest Thermostat

- Wattics: Innovative Energy Management

- Tendril: Changing the way the world uses energy

Potential Devices & Equipment

- EnergyHub: Powers positive relationships with millions of energy users every day

- Baltimore Energy Challenge

https://baltimoreenergychallenge.org/

Hands-on Data Communications Project

- Projects consist of 3 parts:
  - Choosing an interesting low-cost device
    - Identifying what you can do
  - Install the required SDK to make it work
  - Think about a novel application
    - Collect DATA for a period of at least 2-3 weeks or more
    - Based on the data propose a novel application
  - Results
    - Identify the different communication protocols
    - Test with different settings based on the range, distance, interference, environment, user body position etc.
    - Draw the important inferences or conclusions from the results
      - Is it good for what it’s meant for?
      - How does it make the environment more smarter, healthy and sustainable?

Hands-on Data Communications Project

- Mid semester progress update in end of March
- Final demonstration to the class and report submission in May
  - 3-page report (undergrads team)
  - 6-page report (grads team)

- Energy related projects and Course best project may get a chance to present their projects to *Constellation Energy*
- Bonus points will be given to the Best 3 projects in the class (up to 3 points)

Other Assignments

- Homework, Quizzes will be given appropriately as we make progress
- Attending class and participation in class discussion will be equivalent to the credit of an assignment

Data Communications and Networks

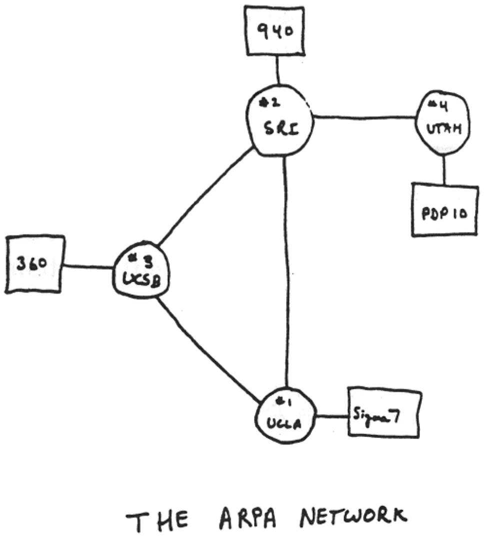
- Past
- Present
- Future

Internet History

1961-1972: Early packet-switching principles

- 1961: Kleinrock - queueing theory shows effectiveness of packet-switching
- 1964: Baran - packet-switching in military nets
- 1967: ARPAnet conceived by Advanced Research Projects Agency
- 1969: first ARPAnet node operational

- 1972:
  - ARPAnet public demonstration
  - NCP (Network Control Protocol) first host-host protocol
  - first e-mail program
  - ARPAnet has 15 nodes



Internet History

1972-1980: Internetworking, new and proprietary nets

- 1970: ALOHAnet satellite network in Hawaii
- 1974: Cerf and Kahn - architecture for interconnecting networks
- 1976: Ethernet at Xerox PARC
- late70's: proprietary architectures: DECnet, SNA, XNA
- late 70's: switching fixed length packets (ATM precursor)
- 1979: ARPAnet has 200 nodes

Cerf and Kahn's internetworking principles:

- minimalism, autonomy - no internal changes required to interconnect networks
- best effort service model
- stateless routers
- decentralized control

define today's Internet architecture

Internet History

1980-1990: new protocols, a proliferation of networks

- 1983: deployment of TCP/IP
- 1982: smtp e-mail protocol defined
- 1983: DNS defined for name-to-IP-address translation
- 1985: ftp protocol defined
- 1988: TCP congestion control

- new national networks: Csnet, BITnet, NSFnet, Minitel
- 100,000 hosts connected to confederation of networks

Internet History

1990, 2000's: commercialization, the Web, new apps

- Early 1990's: ARPAnet decommissioned
- 1991: NSF lifts restrictions on commercial use of NSFnet (decommissioned, 1995)
- early 1990s: Web
  - hypertext [Bush 1945, Nelson 1960's]
  - HTML, HTTP: Berners-Lee
  - 1994: Mosaic, later Netscape
  - late 1990's: commercialization of the Web

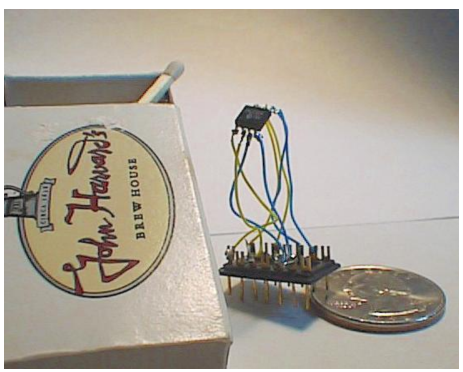
Late 1990's – 2000's:

- more killer apps: instant messaging, P2P file sharing
- network security to forefront
- est. 50 million host, 100 million+ users
- backbone links running at Gbps

The New Millennium: “Cool” Internet Applications

IP picture frame
http://www.ceiva.com/

Internet phones



World’s smallest web server
http://www-ccs.cs.umass.edu/~shri/iPic.html

Web-enabled toaster +
weather forecaster

Network Edge

- End points need not be devices

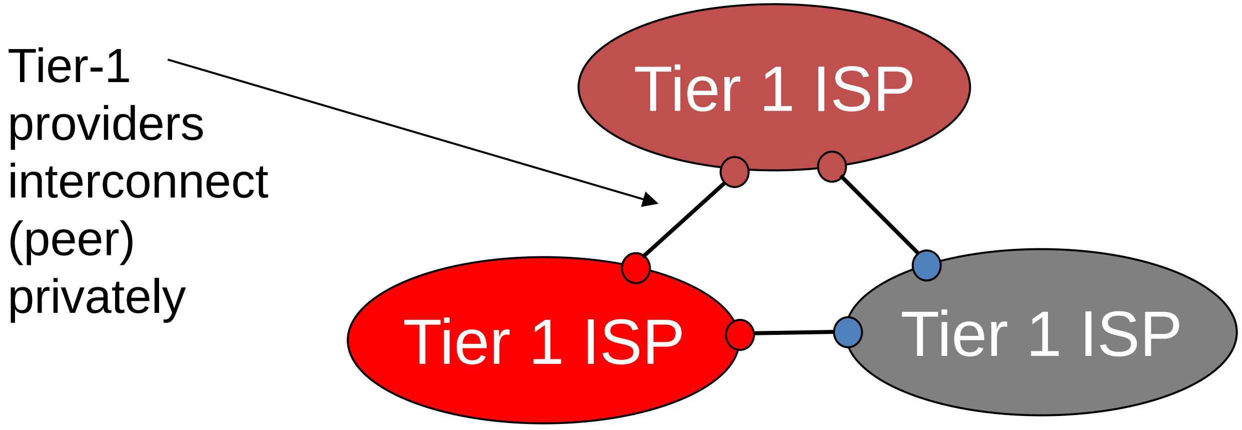
- Imagine locations as end points, and associated with email addresses in the future …
  - You could email your grocery list to aisle 3 in Safeway
  - I could email “running late” to whiteboard in the class

InterNetwork

- Millions of end points (you, me, and toasters) are connected over a network
  - Many end points can be addressed by numbers
  - Many others lie behind a virtual end point
- Many networks form a bigger network
- The overall structure called the Internet
  - Defined as *the network of networks*

Internet Structure: Network of Networks

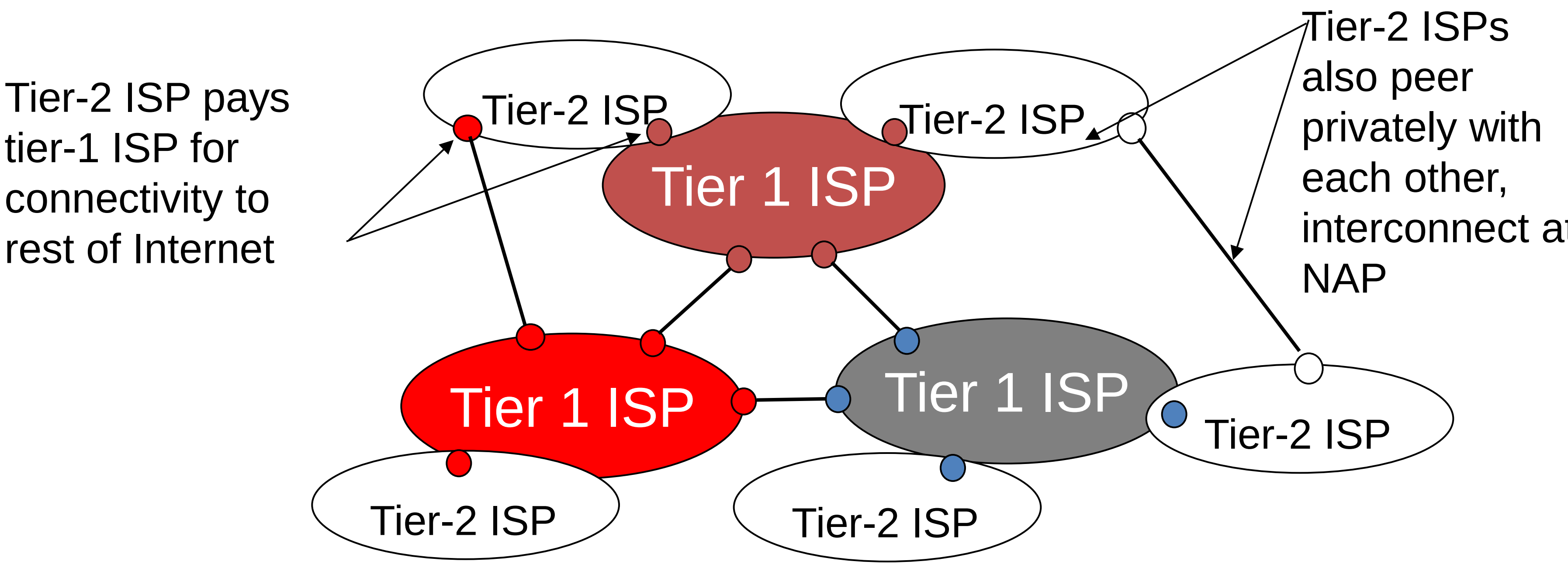
- roughly hierarchical
- at center: "tier-1" ISPs (e.g., MCI, Sprint, AT&T, Cable and Wireless), national/international coverage
  - treat each other as equals



Internet Structure: Network of Networks

- “Tier-2” ISPs: smaller (often regional) ISPs
  - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

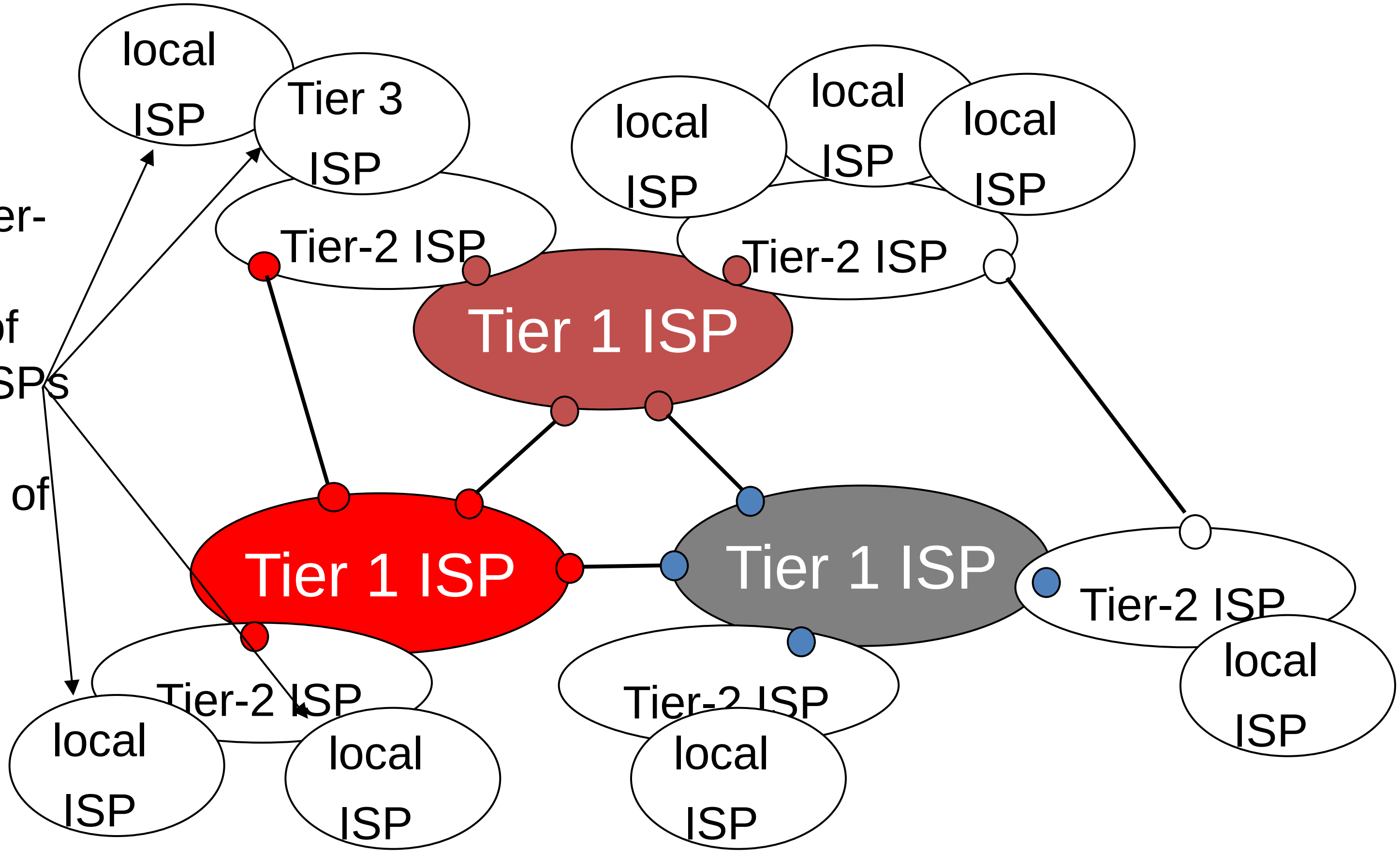
- France telecome, Tiscali, etc. buys from Sprint



Internet structure: Network of Networks

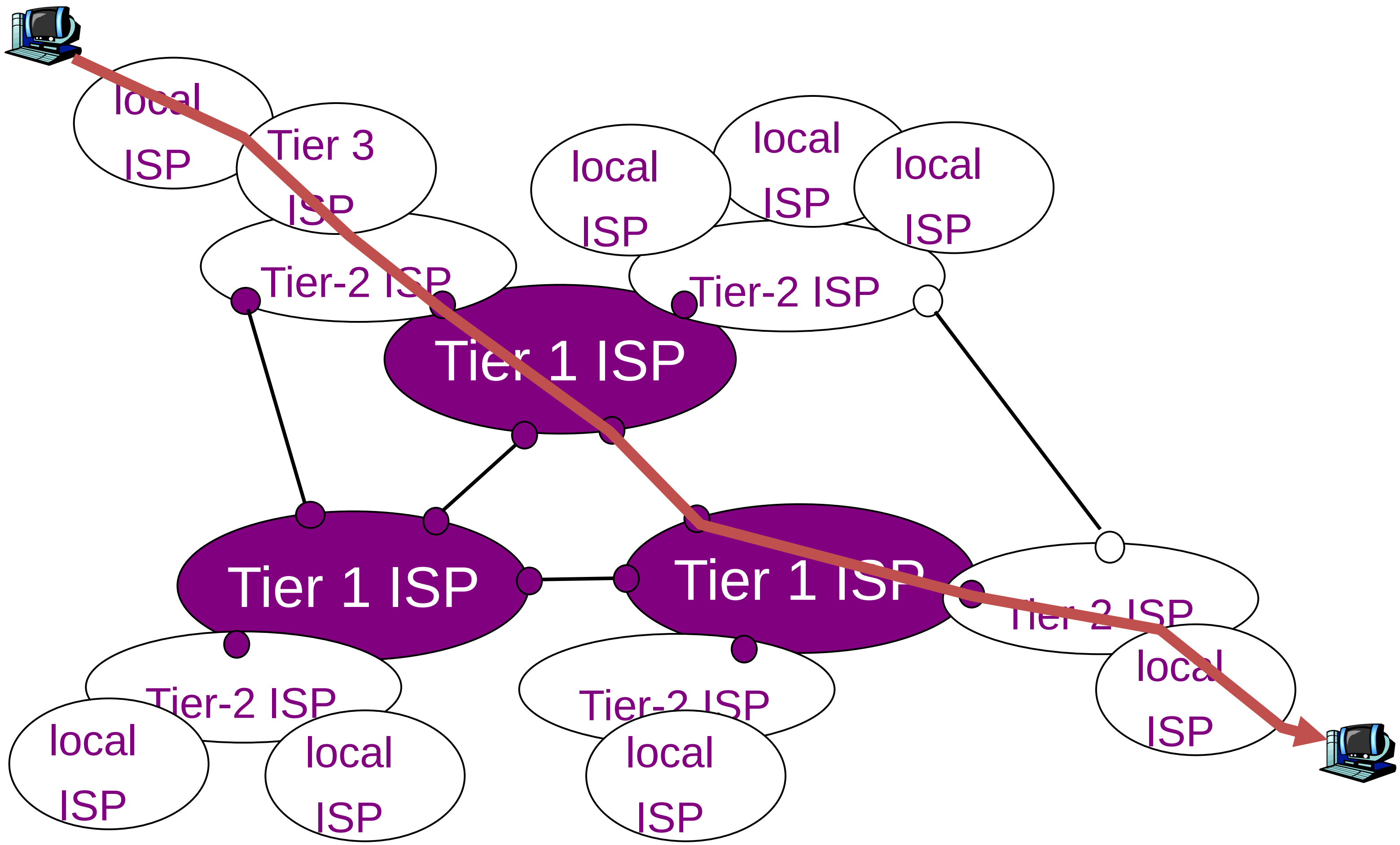
- "Tier-3" ISPs and local ISPs (Time Warner, Earthlink, etc.)
  - last hop ("access") network (closest to end systems)

Local and tier-3 ISPs are *customers* of higher tier ISPs connecting them to rest of Internet



Internet Structure: Network of Networks

- a packet passes through many networks!
  - Local ISP (taxi) -> T3 (bus) -> T2 (domestic) -> T1 (international)



Organizing the giant structure

Networks are complex!

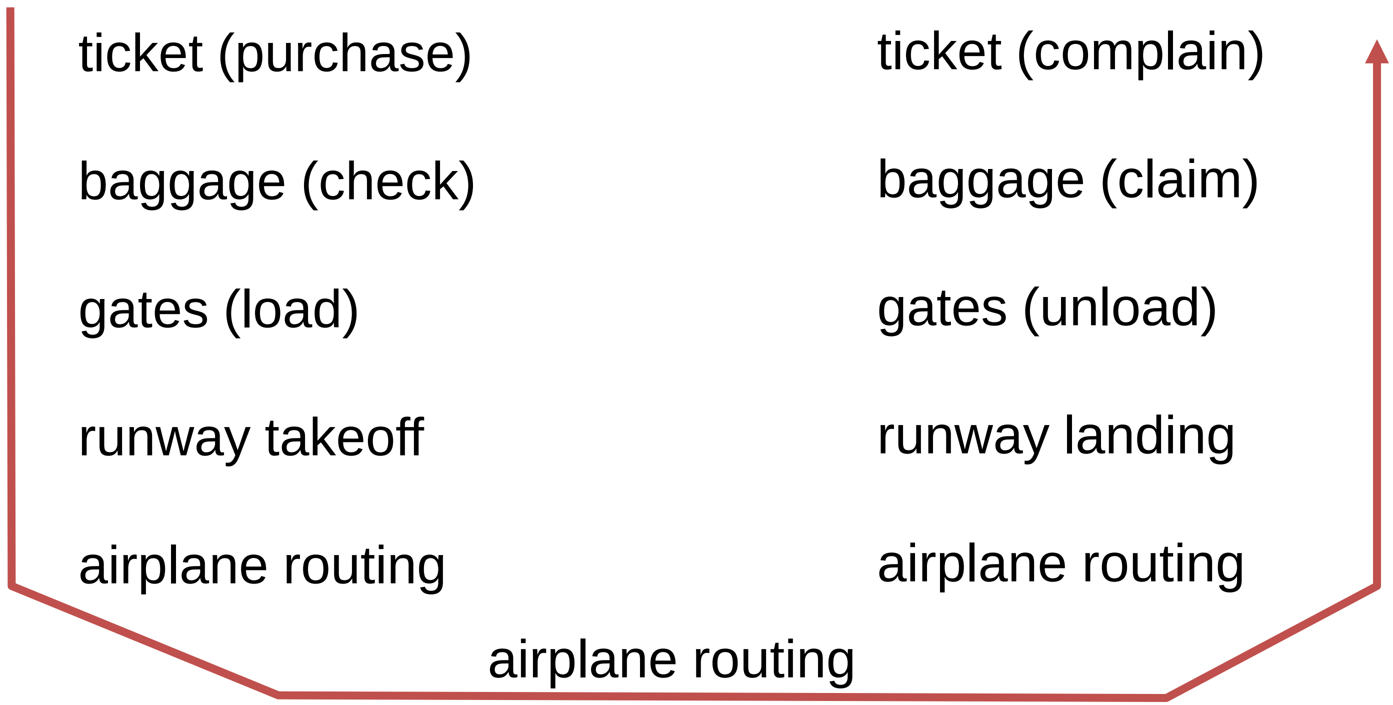
- many "pieces":
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

Question:

Is there any hope of *organizing* structure of network?

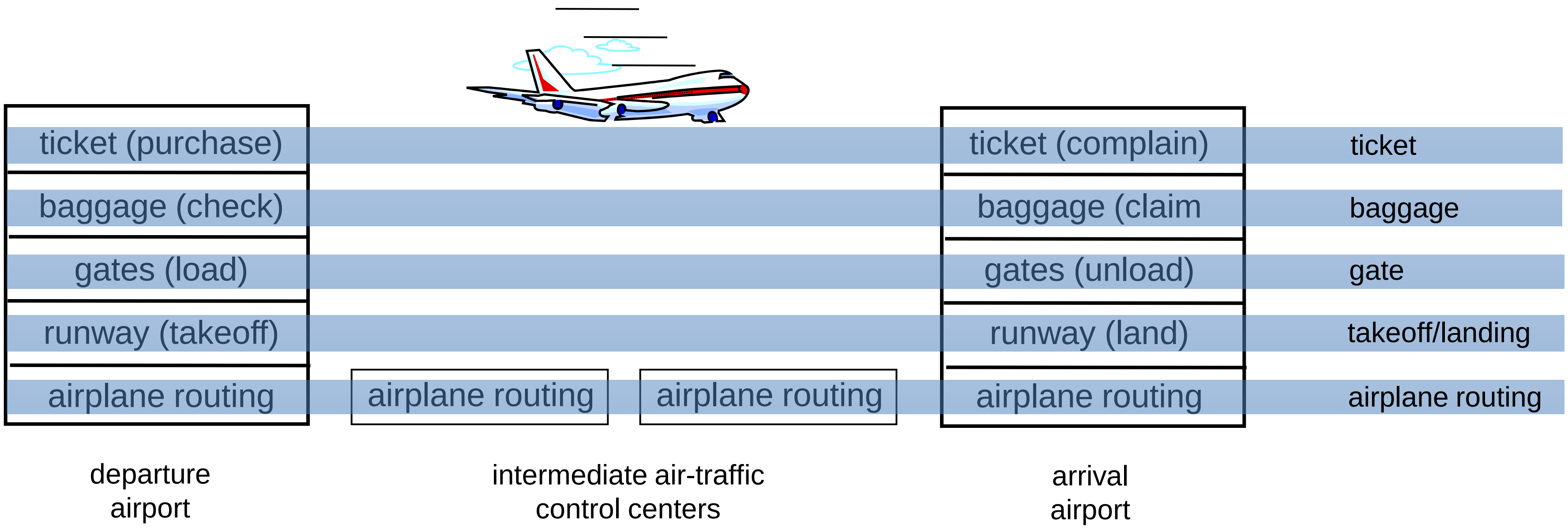
Or at least our discussion of networks?

Turn to Analogies in Air Travel



- a series of steps

Layering of Airline Functionality



Layers: each layer implements a service

- layers communicate with peer layers
- rely on services provided by layer below

Why layering?

- Explicit structure allows identification, relationship of complex system's pieces

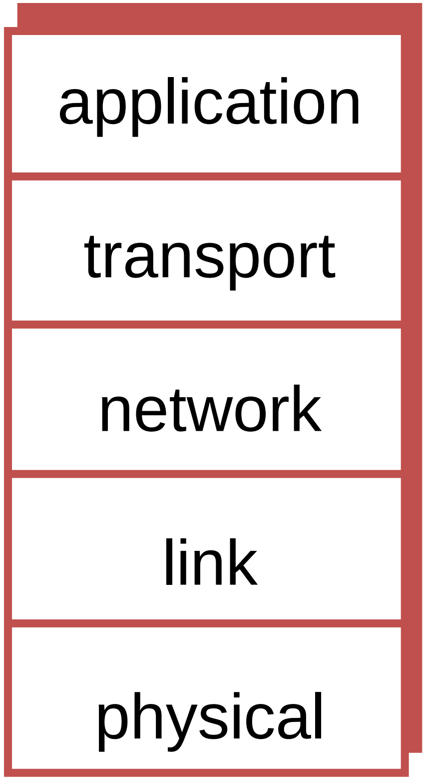
- Modularization eases maintenance, updating of system
  - change of implementation of layer's service transparent to rest of system
  - e.g., runway delay (wheels up time) depends on clearance of destination runway … doesn't affect rest of system

Protocol “Layers”

- Service of each layer encapsulated
- Universally agreed services called PROTOCOLS
- A large part of this course will focus on designing and analyzing protocols for networking systems

Internet protocol stack

- application: supporting network applications
  - FTP, SMTP, HTTP, DNS …
- transport: host-host data transfer
  - TCP, UDP …
- network: routing of datagrams from source to destination
  - IP, BGP, routing protocols …
- link: data transfer between neighboring network elements
  - PPP, Ethernet, WiFi, Bluetooth …
- physical: bits “on the wire”
  - OFDM, DSSS, CDMA, Coding …



Queueing Theory

- Waiting in lines
  - In the grocery store, on the telephone, at the airport, on the road
- Queueing theory is the mathematical study of lines
  - What are the stochastic characteristics of delay?
  - For example, what is the average delay?
  - What is the probability that delay exceeds some threshold?
  - What fraction of customers are turned away?
  - What system capacity (e.g., what number of servers) is needed to achieve a specified quality of service?
- Provide decision makers a way to efficiently allocate resources to reduce delay

Applications of Queueing Theory

- Applications to Networks
- Study of the performance of systems composed of
  - Waiting lines
  - Processing units
- Allows to estimate
  - Time spent in waiting
  - Expected number of waiting requests
  - Probability of being in certain states
- Useful for the design of systems such as networks
  - Delay, blocking probability, links, bandwidth, number of processors, buffers size

Questions

?