Computer Network Architecture

ECE 156 Fall 2007

Romit Roy Choudhury
Dept. of ECE and CS

Duke
UNIVERSITY

Course Logistics

Welcome to ECE 156

- Timings: Tu/Thu 1:15pm to 2:30pm
- Location: 212 Engineering
- Course TA: TBA

- Insructor: Romit Roy Choudhury
  - New faculty in ECE & CS.
  - Ph.D from UIUC in Summer, 2006
  - Research in Networking and Distributed Sys.

- Office hours: Tu/Th 2:30-3:30 or appointment
  - Email me at romit@ee.duke.edu
  - and visit me at 203 Hudson Hall

Welcome to ECE 156

- Prerequisite: ECE 52

  Else, come and talk to me

- Further courses:
  - ECE 256 (previously 299.02):

    Wireless Networking and Mobile Computing
    - Spring 2008

Welcome to ECE 156

- Class broadcast email:

  ece_156_01@ee.duke.edu

- Course Website:

  http://www.ee.duke.edu/~romit/courses/f07/ece156-f07-networking.html

  - Most course related information will be posted on the website

- Please check the course website frequently

Welcome to ECE 156

- Make up classes
  - Will be occasionaly necessary due to travel
  - Would like to schedule on a case by case basis

Welcome to ECE 156

- Grading:
  - Participation/Presentation: 10%
  - Homework: 20%
  - Programming Assignments: 20%
  - 1 mid-term exam: 20%
  - Final exam: 30%

  - Programming project may be in groups of 2
  - One of the exams is likely to be open book

Finally

- Academic honesty
  - Please please please …
  - A few points is not worth a tarnished career
  - In the long run, GPA does not matter as much as you think it does
- More importantly
  - Let's not make the CNN headlines for the wrong reasons anymore

Course Summary
(Very Briefly)

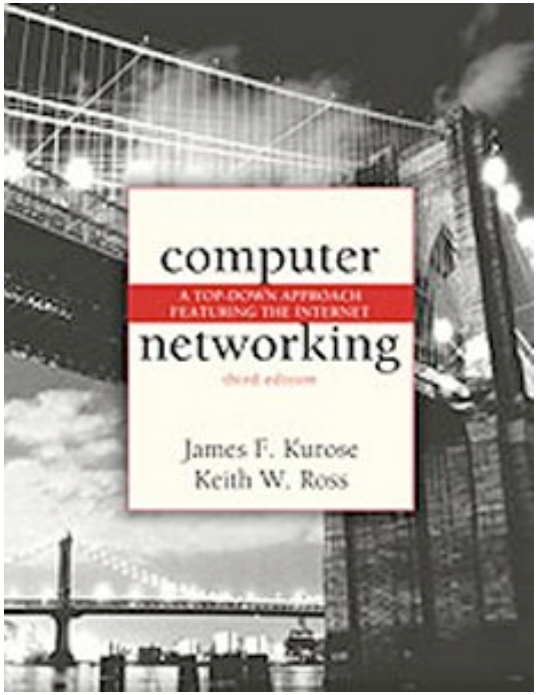
Course information

- Course materials:
  - Text:

    Computer Networking: A Top Down Approach Featuring the Internet, J. Kurose & K. Ross, Addison Wesley, 3rd ed., 2005

  - Class notes

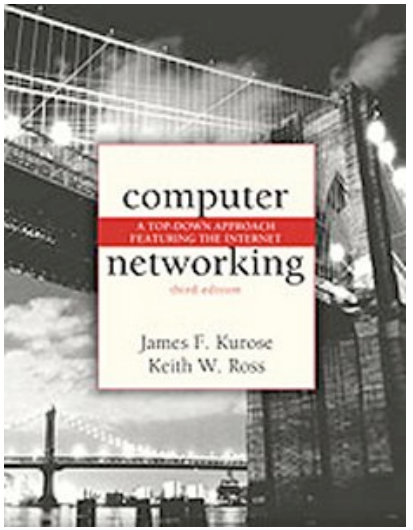
  - Some supplementary reading material



What is this course about?

- *Introductory* (first) course in computer networking
  - Undergrads, early MS students

- learn principles of computer networking
- learn practice of computer networking
- Internet architecture/protocols as case study
- Real wireless networks as case studies
- Intro to next generation networking



Course information

- By the time you are finished …
  - You understand variety of concepts (not just factoids)
  - Internet, HTTP, DNS, P2P, …
  - Sockets, Ports, …
  - Congestion Control, Flow Control, TCP, …
  - Routing, Basic Graphs, Djikstra's Algorithm, IP, …
  - DSL Vs Cable, Aloha, CSMA, TDMA, Token, 802.11, …
  - Security, RSA, …
  - Cellular Networks, Mobile Networks, Satellite Networks, …
  - Wireless Multihop Networks (ad hoc, mesh, WLANs)
  - Sensor Networks

If you understand 75% of these terms, you shouldn't be here

What this Course Does Not Cover

- Not a "communications" course
- Does not cover
  - Modulation schemes
  - Transmitter/Receiver design
  - Signal processing and antenna design
  - Etc.

- This is course on
  - Understading, analysing, and (perhaps) designing of protocols and algorithms in wired/wireless networking systems

What's the difference between

Communications

And

Networking Systems

Finally

- I cannot / will not / should not be speaking alone in class
  - Questions
  - Comments
  - Disagreements
  - Debates … are highly encouraged
- This course can be real fun
- Whether it will be …
  - Is up to you and me


Hello!
I am ECE 156

Acknowledgments:

Many slides borrowed from Jim Kurose (UMass)

On the Shoulders of Giants

- 1961: Leonard Kleinrock published a work on packet switching
- 1962: J. Licklider described a worldwide network of computers called Galactic Network
- 1965: Larry Roberts designed the ARPANET that communicated over long distance links
- 1971: Ray Tomilson invents email at BBN
- 1972: Bob Kahn and Vint Cerf invented TCP for reliable packet transport

On the Shoulders of Giants …

- 1973: David Clark, Bob Metcalfe implemented TCP and designed ethernet at Xerox PARC
- 1975: Paul Mockapetris developed DNS system for host lookup
- 1980: Radia Perlman invented spanning tree algorithm for bridging separate networks
- Things snowballed from there on …

What we have today is beyond any of the inventors' imagination …

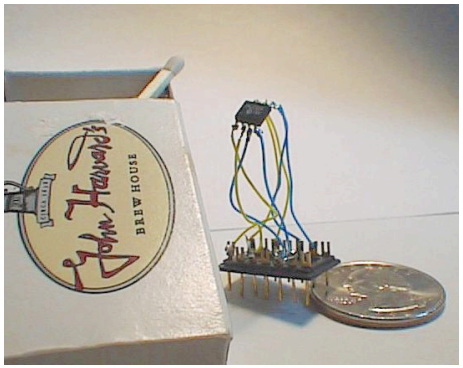

And YOU are here

And by "YOU" I mean …

"Cool" internet appliances

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

Web-enabled toaster +
weather forecaster



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

Internet phones

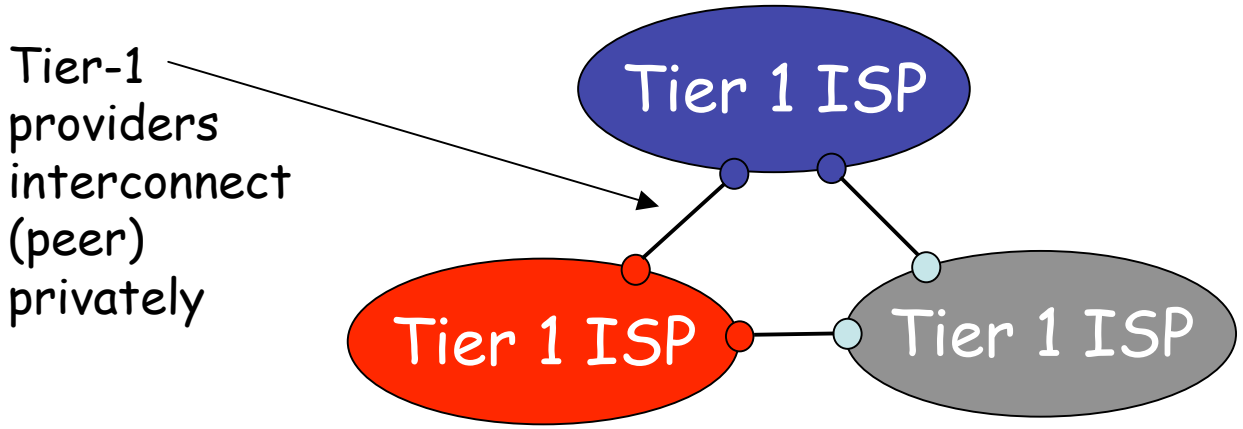
And Of Course YOU and ME …

InterNetwork

- Millions of end points (you, me, and toasters) are connected over an 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 strcture called the Internet
  - With a capital I
  - Defined as the network of networks

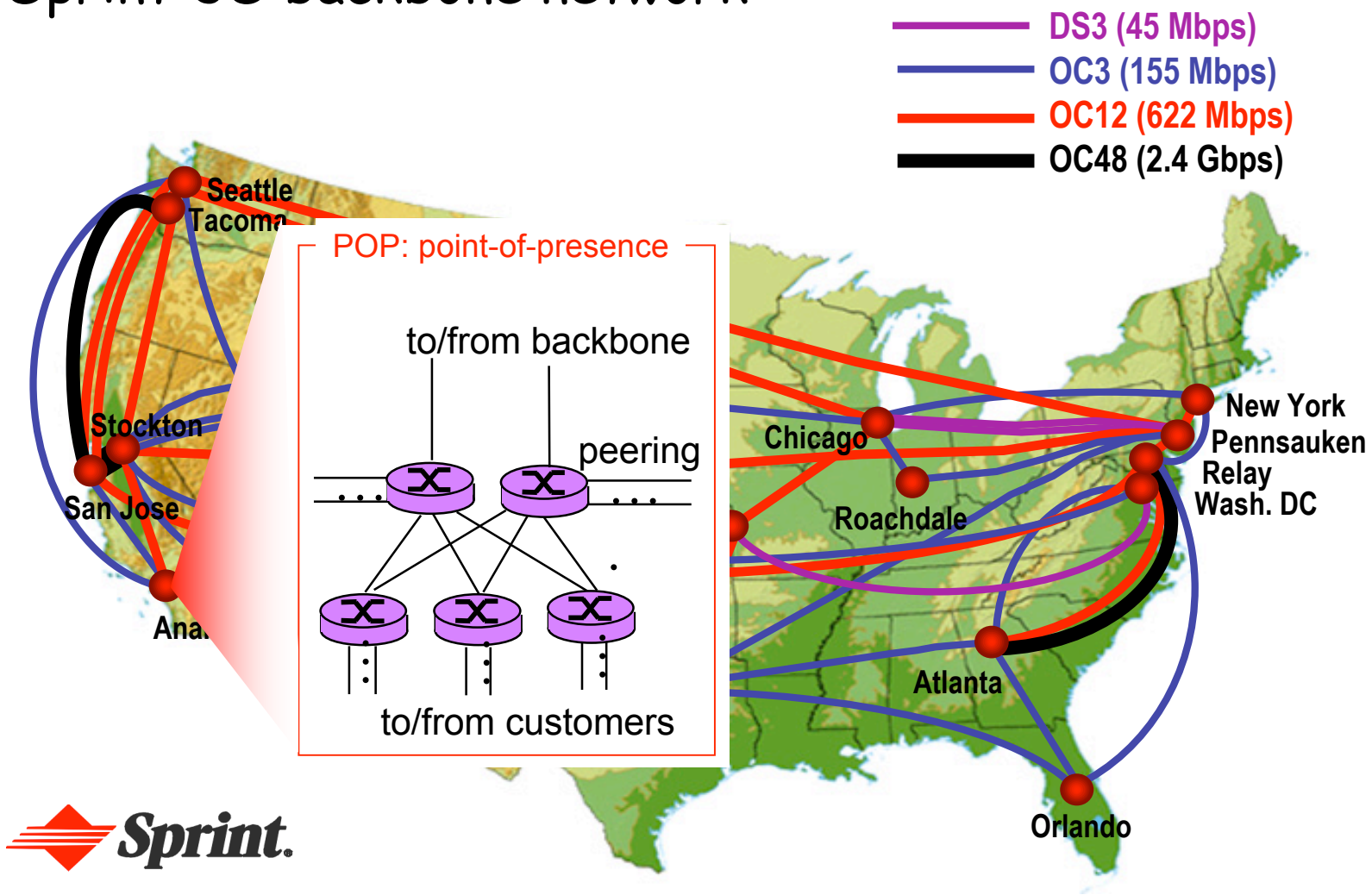
Internet structure: network of networks

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



Tier-1 ISP: e.g., Sprint

Sprint US backbone network

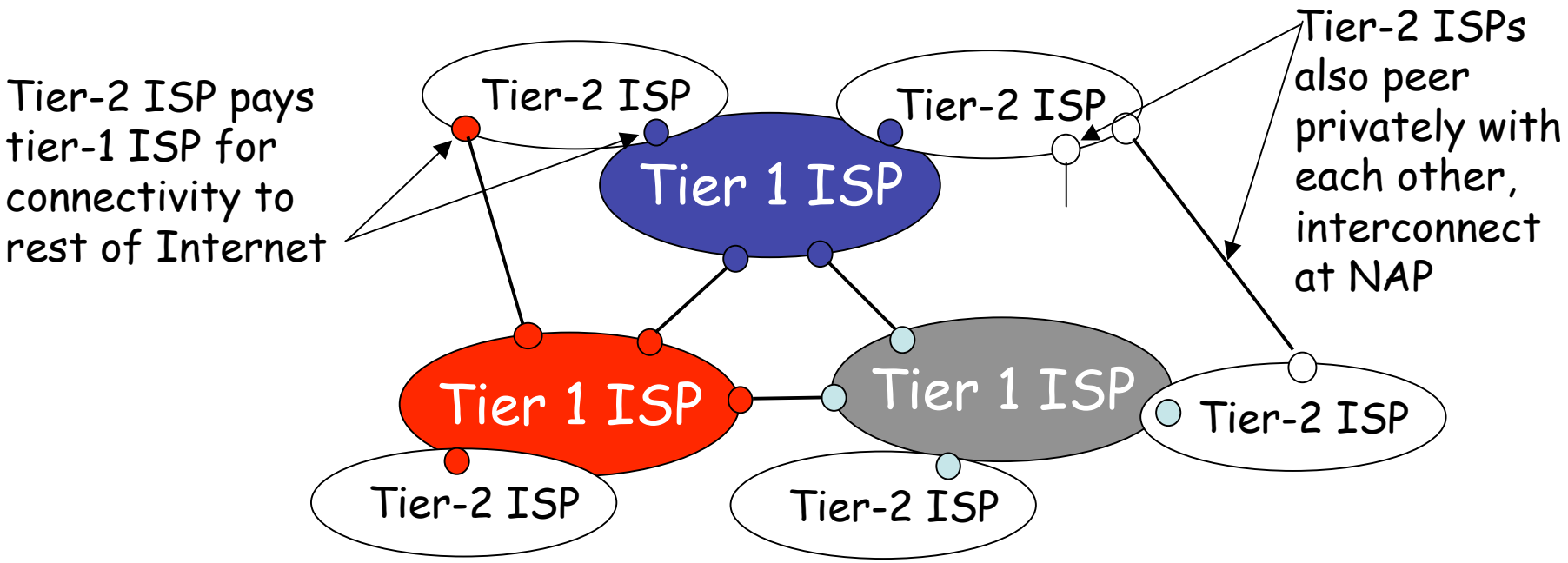


Sprint.

Internet structure: network of networks

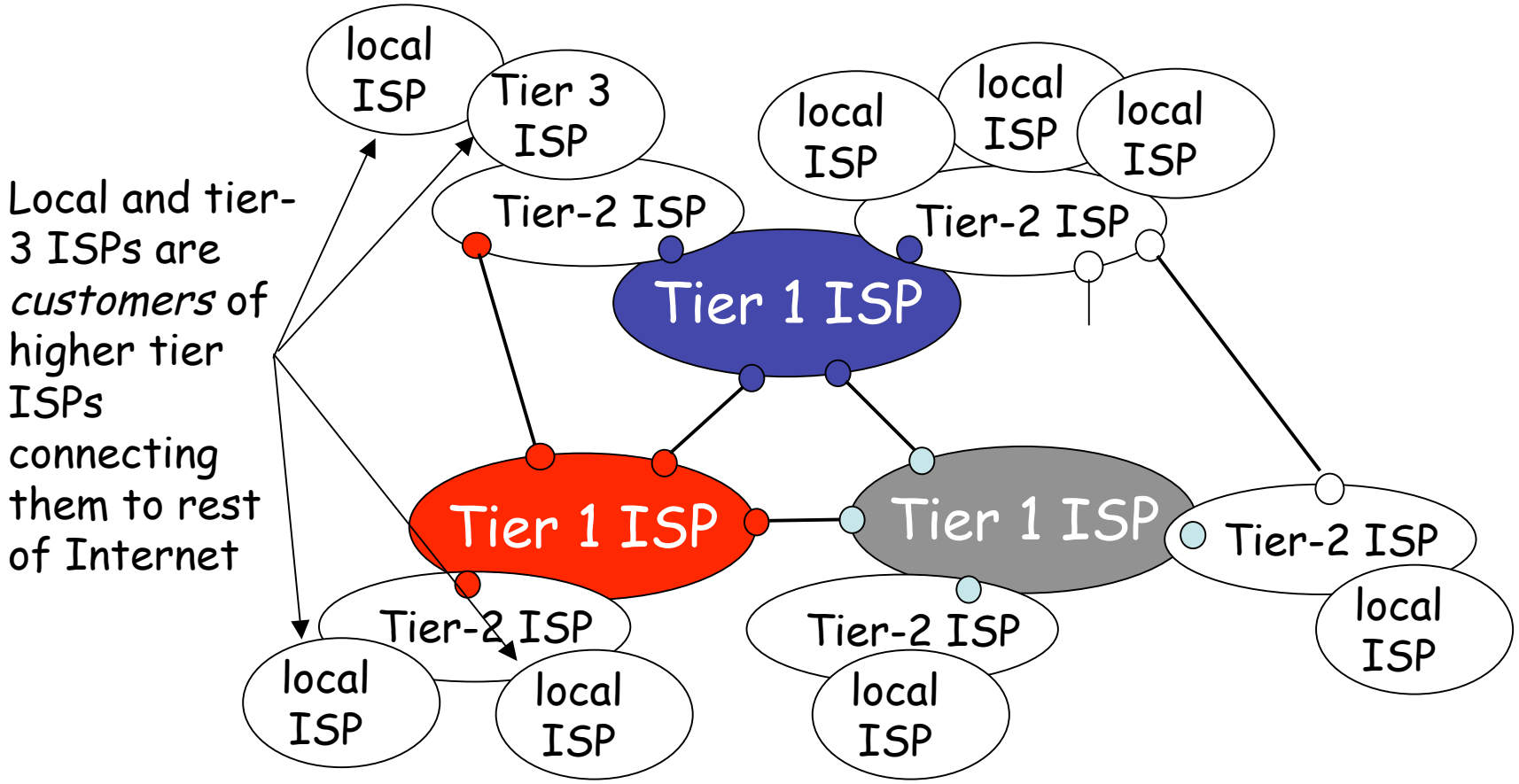
- "Tier-2" ISPs: smaller (often regional) ISPs
  - Connect to one or more tier-1 ISPs, possibly other tier-2 ISPs

- France telecome, Tiscali, etc. buys from Sprint



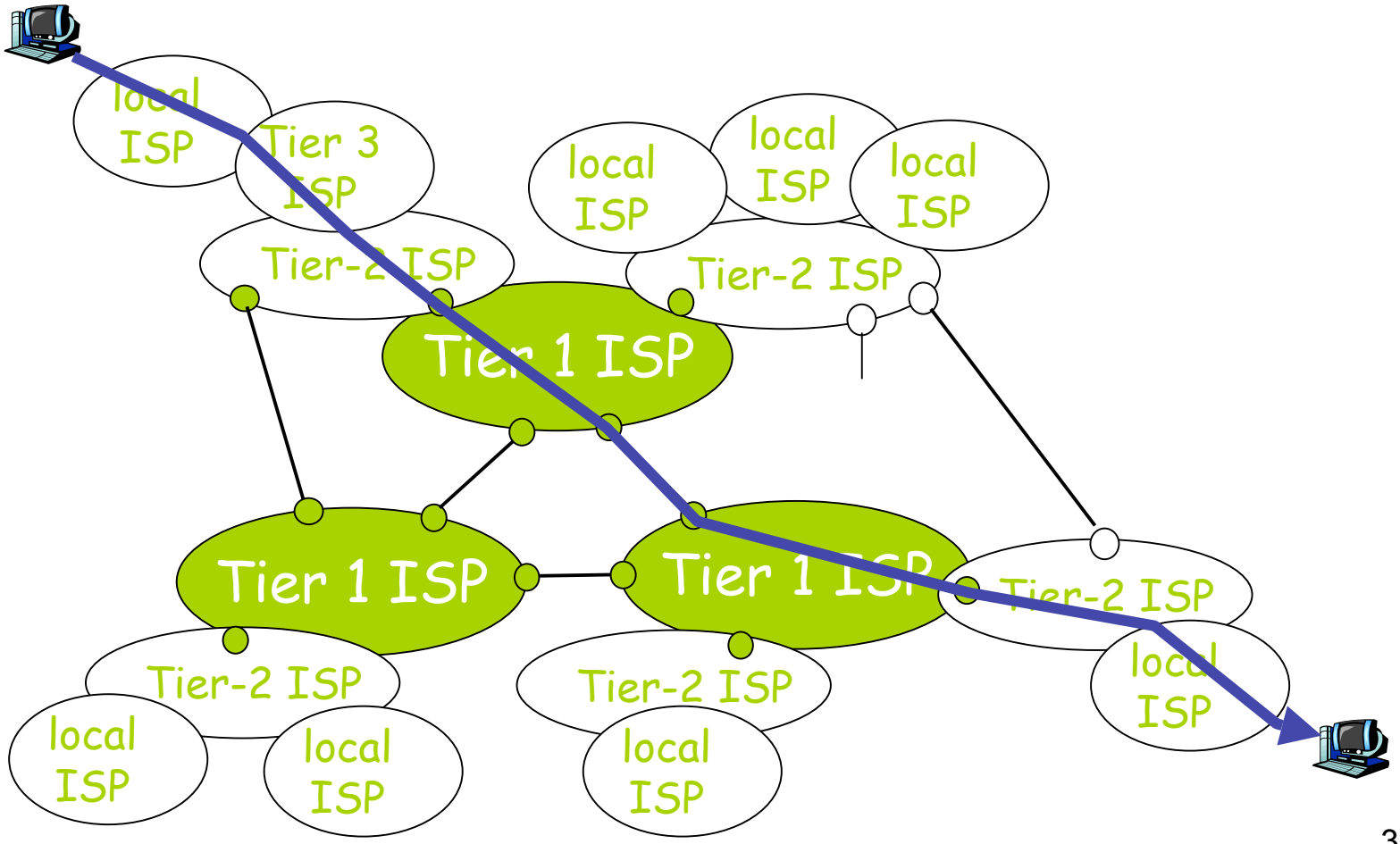
Internet structure: network of networks

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



Internet structure: network of networks

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



Organizing the giant structure

Networks are complex!

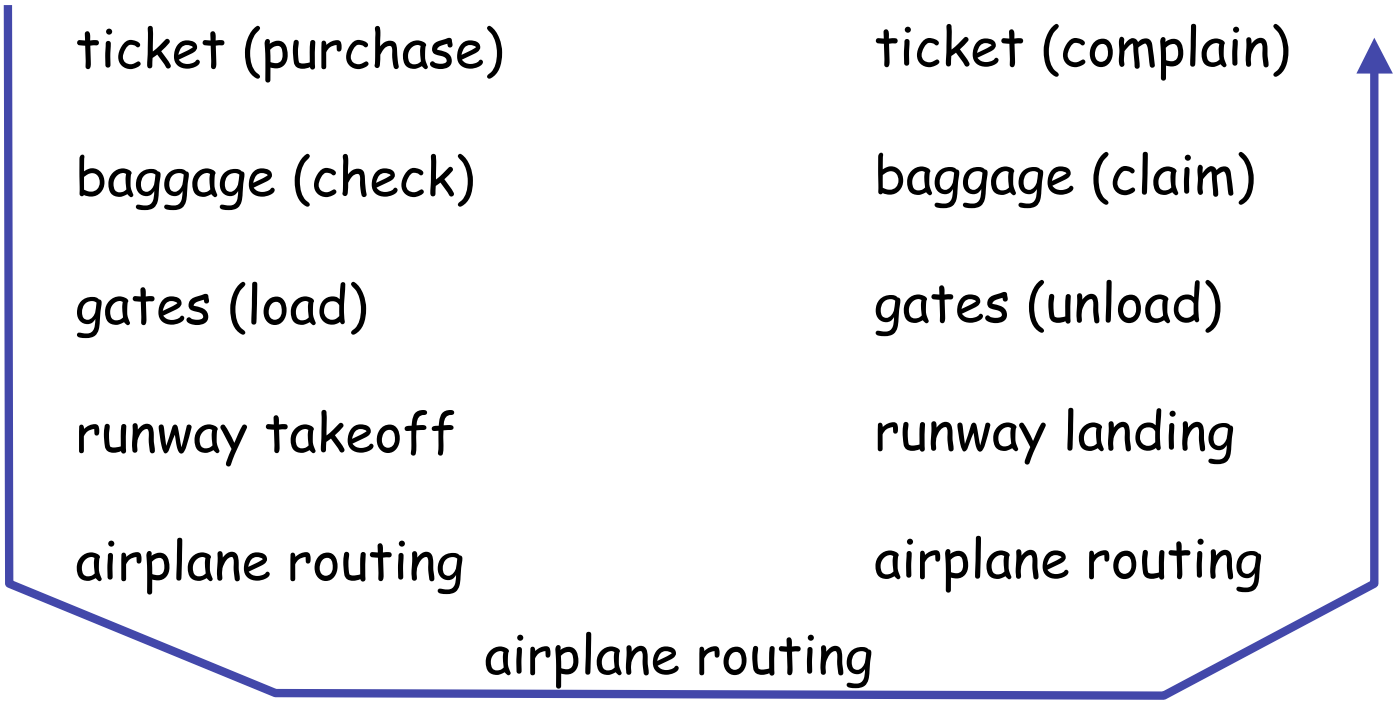
- many "pieces":
  - hosts
  - routers
  - links of various media
  - applications
  - protocols
  - hardware, software

Question:

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

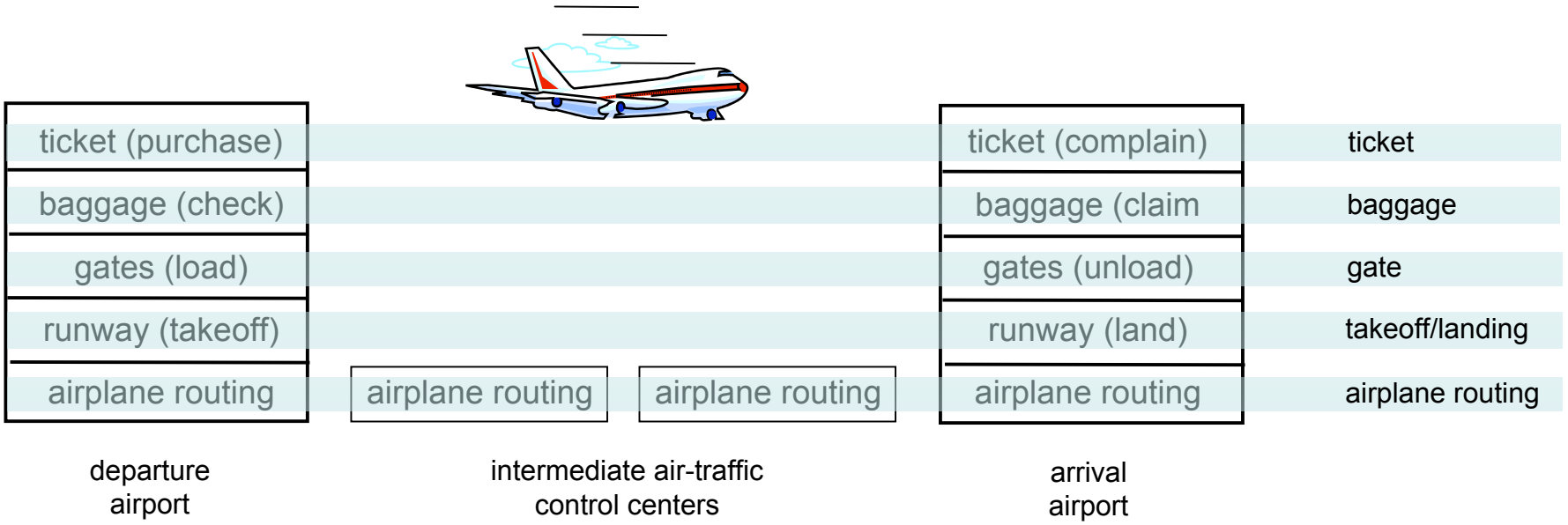
Or at least our discussion of networks?

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., change in gate procedure doesn't affect rest of system

Protocol "Layers"

- Service of each layer encapsulated

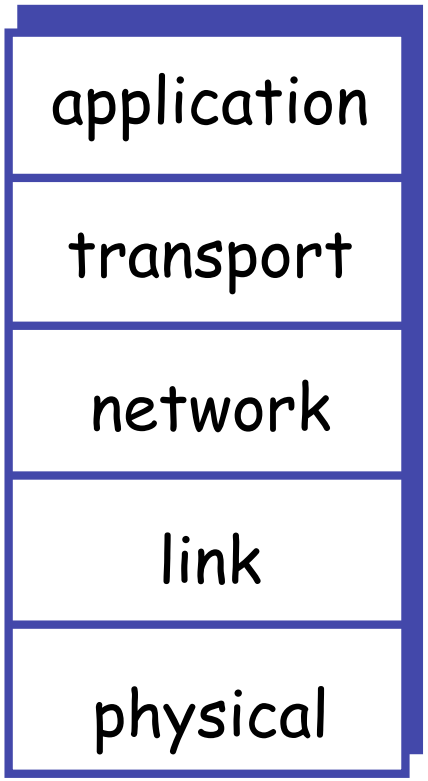
- Universally agreed services called

  PROTOCOLS

A large part of this course will focus on designing protocols for networking systems

Internet protocol stack

- application: supporting network applications
  - FTP, SMTP, HTTP
- transport: host-host data transfer
  - TCP, UDP
- network: routing of datagrams from source to destination
  - IP, routing protocols
- link: data transfer between neighboring network elements
  - PPP, Ethernet, WiFi, Bluetooth
- physical: bits "on the wire"



Success of Layering

- Protocol stack successful in Internet
- Internet uses wired physical layer links
  - Very reliable
  - BER = 10^{-8}
- What about wireless networks
  - Very unreliable due to channel fluctuations
  - Due to co-channel interference
  - Due to external noise
- Does horizontal layering still hold ?

Questions ?

Encapsulation