S1: Introduction

Instructor: Behnam Momeni

Fall 2018
Outline

- Course information
- Covered topics
- Grading
- Introductory level review of
  - Packet/Circuit switching
  - Layering
  - ISO OSI Model
  - Hourglass Model
Course Information

- **Professor:**
  - Behnam Momeni, PhD
  - [http://ce.sharif.edu/~b_momeni/](http://ce.sharif.edu/~b_momeni/)
  - b_momeni@ce.sharif.edu

- **Course webpage:**
  - [http://ce.sharif.edu/~b_momeni/adv-net/advnet-971.html](http://ce.sharif.edu/~b_momeni/adv-net/advnet-971.html)
  - Class 1 [11:00 – 12:30]
  - Class 2 [13:30 – 15:00]
Covered Topics: what to learn?

- Course Vision
  - Understanding network protocols, architectures, design principles, and applications in depth
  - Learning how to do networking related research
  - Obtaining a mix of theoretical and hands-on experience

- How is it different from the undergraduate Computer Networks course?
  - Learning how it works vs. why it is designed in that way
  - Learning how to use vs. how to evaluate and redesign
Covered Topics: resources?

- Check the website regularly for updates about:
  - Lectures of each session and related papers
  - Important announcements such as assignments, project sample ideas, quiz, exams, and their solutions
- For each session, some related papers are available on the course webpage
  - Read them before the class for maximum throughput!
How to read a paper?

Read in multiple passes

Cover more details in next passes
How to read a paper (3-pass approach)

1. Skim abstract/intro + section headings + references (5-10min)
   - Make rough assessment of paper
   - Many people will read your paper at this level

2. Read but ignore details (e.g. proofs) (1hr)
   - Good general understanding of techniques
   - Identify related work you need to look at

3. ”Virtual re-implementation” (1-3hrs)
   - Identify hidden assumptions
   - Identify issues with techniques used
How to read a paper

- Learn to be critical
  - Many papers are part “marketing” – trying to show their design in the best possible light
  - Some papers may be “old”

- Learn to be positive
  - Very easy to become overly critical especially once you know topic area
  - Focus on what you learned from the paper

- Why or why not keep this paper in syllabus?
- What issues are left open for future research?
- What are the important implications of the work?
- What would you have done differently or differently now?
We cover state-of-the-art and evolving topics from peer-reviewed manuscripts

- There is not a single text book

For background materials, you can use the following books

- Computer Networks: A Systems Approach
  - by Larry L. Peterson, Bruce S. Davie
- Computer Networks
  - by Andrew S. Tanenbaum
Acknowledgement

- This course is mainly based on the 15-744 course from the Carnegie Mellon University (CMU) which is presented by Dr. Srinivasan Seshan
- http://www.cs.cmu.edu/~srini/
- http://www.cs.cmu.edu/~15744/
Class Coverage

- Little coverage of physical and data link layer
- Little coverage of undergraduate material
  - Students expected to know this or learn this along the way
- Focus on network to application layer
- We will deal with:
  - Protocol rules and algorithms
  - Investigate protocol trade-offs
  - Why this way and not another?
Lecture Topics

Traditional
- Layering
- Internet architecture
- Routing (IP)
- Transport (TCP)
- Queue management (FQ, RED)
- Naming (DNS)

Recent Topics
- Data centers
- Mobility/wireless
- Security
- Content delivery
- SDN
- P2P systems
- Privacy

+ some TBD slots
Covered Topics: teaching method?

- Check the course webpage; on the topic of each session:
  - There are **main** manuscripts that
    - Will be covered during the class
    - You should read them before the class for better understanding
    - Their contents may be asked in exams
  - There are **optional** manuscripts that
    - Give deeper insight about the topic
    - You can optionally read them, but
    - Their contents are not asked in exams
Grading: class activity (10%)

- Each student should
  - Select one optional manuscript for one session
  - Present its contents within 10 minutes
  - Coordinate it since one week ahead

- Grading percentages in the title of slides are tentative and subject to change by end of the semester
Grading: homework (20%)

- Three assignments
  - Covers both theoretical and practical aspects
  - Write a report in PDF format for each assignment
  - Deliver the PDF file and all related stuffs to the class coordinator
Grading: project (30%)

- One research project
  - Make it a useful achievement for yourself!
- Form groups (2 or 3 persons)
- Check course webpage for sample project ideas
  - You can select and propose your own new project ideas too
- Identify a problem and its related works
  - Look for improvement areas, alternative solutions, unsound assumptions, etc.
- Evaluate your solution
- Write a paper
Grading: exams (55%; yes, there is 15% bonus!) 

- Quiz (5%)
  - Will be announced a week ahead
- Midterm (25%)
  - Covers about half of the course materials
  - Closed-book, in-class
- Final (25%)
  - Anything which is not covered in the midterm
  - Closed-book, in-class
Design Considerations:
to prepare for the next week

- How to split a functionality across
  - Different network nodes
  - Different protocol layers

- **Main manuscripts** *(all students should read them)*:
  - End-to-End Arguments in System Design
  - The Design Philosophy of the DARPA Internet Protocols

- **Optional manuscripts** *(a volunteer student may present one of these manuscripts in 10 minutes at the end of the class)*
  - Architectural Considerations for a New Generation of Protocols
  - Tussle in Cyberspace: Defining Tomorrow’s Internet
Introduction

History, Layering, and Models
What is the Objective of Networking?

- Communication between applications on different computers
- Must understand application needs/demands
  - Traffic data rate
  - Traffic pattern (bursty or constant bit rate)
  - Traffic target (multipoint or single destination, mobile or fixed)
- Delay sensitivity
- Loss sensitivity
Back in the Old Days…
Packet Switching (Internet)
## Packet Switching

### Positives
- Interleave packets from different sources
- Efficient: resources used on demand
  - Statistical multiplexing
- General
  - Multiple types of applications
- Allows for bursty traffic
  - Addition of queues

### Challenges
- Store and forward
  - Packets are self contained units
  - Can use alternate paths – reordering
- Contention
  - Congestion
  - Delay
Internet[work]

- A collection of interconnected networks
- Host: network endpoints (computer, PDA, light switch, …)
Internet[work]

- A collection of interconnected networks
- Host: network endpoints (computer, PDA, light switch, …)
- Router: node that connects networks
Challenge

- Many differences between networks
  - Address formats
  - Performance – bandwidth/latency
  - Packet size
  - Loss rate/pattern/handling
  - Routing
- How to translate between various network technologies?
Challenge 1: Address Formats

• Map one address format to another?
  • Bad idea → many translations needed

• Provide one common format
  • Map lower level addresses to common format
Challenge 2: Different Packet Sizes

• Define a maximum packet size over all networks?
  • Either inefficient or high threshold to support
• Implement fragmentation/re-assembly
  • Who is doing fragmentation?
  • Who is doing re-assembly?
Gateway Alternatives

- **Translation**
  - Difficulty in dealing with different features supported by networks
  - Scales poorly with number of network types ($N^2$ conversions)

- **Standardization**
  - “IP over everything” (*Design Principle 1*)
  - Minimal assumptions about network
IP Standardization

• Minimum set of assumptions for underlying net
  • Minimum packet size
  • Reasonable delivery odds, but not 100%
  • Some form of addressing unless point to point

• Important non-assumptions:
  • Perfect reliability
  • Broadcast, multicast
  • Priority handling of traffic
  • Internal knowledge of delays, speeds, failures, etc
How To Find Nodes?

Computer 1

Internet

Computer 2

Need naming and routing
Naming

What’s the IP address for www.cmu.edu?

It is 128.2.11.43

Computer 1

Local DNS Server

Translates human readable names to logical endpoints
Routing

Routers send packet towards destination

H: Hosts
R: Routers
Meeting Application Demands

- Reliability
  - Corruption
  - Lost packets
- Flow and congestion control
- Fragmentation
- In-order delivery
- Etc…
What if the Data gets Corrupted?

Problem: Data Corruption

Solution: Add a checksum
What if Network is Overloaded?

Problem: Network Overload

• Short bursts: buffer
• What if buffer overflows?
  • Packets dropped
  • Sender adjusts rate until load = resources → “congestion control”

Solution: Buffering and Congestion Control
What if the Data gets Lost?

Problem: Lost Data

GET index.html

Solution: Timeout and Retransmit

GET index.html

GET index.html
What if the Data Doesn’t Fit?

Problem: Packet size

- On Ethernet, max IP packet is 1.5kbytes
- Typical web page is 10kbytes

Solution: Fragment data across packets

GET index.html
What if the Data is Out of Order?

Problem: Out of Order

Solution: Add Sequence Numbers

GET x.htindex.html
Lots of Functions Needed

• Link
• Multiplexing
• Routing
• Addressing/naming (locating peers)
• Reliability
• Flow control
• Fragmentation
• Etc....
What is Layering?

- Modular approach to network functionality

Example:

<table>
<thead>
<tr>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Application</td>
</tr>
<tr>
<td>Application-to-application channels</td>
</tr>
<tr>
<td>Host-to-host connectivity</td>
</tr>
<tr>
<td>Link hardware</td>
</tr>
</tbody>
</table>
Protocols

- Module in layered structure
- Set of rules governing communication between network elements (applications, hosts, routers)
- Protocols define:
  - Interface to higher layers (API)
  - Interface to peer
    - Format and order of messages
    - Actions taken on receipt of a message
Layering Characteristics

- Each layer relies on services from layer below and exports services to layer above
- Interface defines interaction
- Hides implementation - layers can change without disturbing other layers (black box)
Layering: technique to simplify complex systems
E.g.: OSI Model: 7 Protocol Layers

- Physical: how to transmit bits
- Data link: how to transmit frames
- Network: how to route packets
- Transport: how to send packets end2end
- Session: how to tie flows together
- Presentation: byte ordering, security
- Application: everything else
OSI Layers and Locations

Application
Presentation
Session
Transport
Network
Data Link
Physical

Host
Switch
Router
Host
IP Layering (Principle 2)

- Relatively simple
- Sometimes taken too far
IP Hourglass

- Need to interconnect many existing networks
- Hide underlying technology from applications
- Decisions:
  - Network provides minimal functionality
  - “Narrow waist”

*Tradeoff:* No assumptions, no guarantees.
Is Layering Harmful?

• Sometimes..
  • Layer N may duplicate lower level functionality (e.g., error recovery)
  • Layers may need same info (timestamp, MTU)
  • Strict adherence to layering may hurt performance
Layer Encapsulation
Protocol Demultiplexing

- Multiple choices at each layer