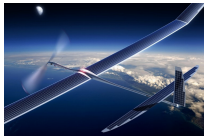




CPR E 489:
Computer Networking and Data Communications

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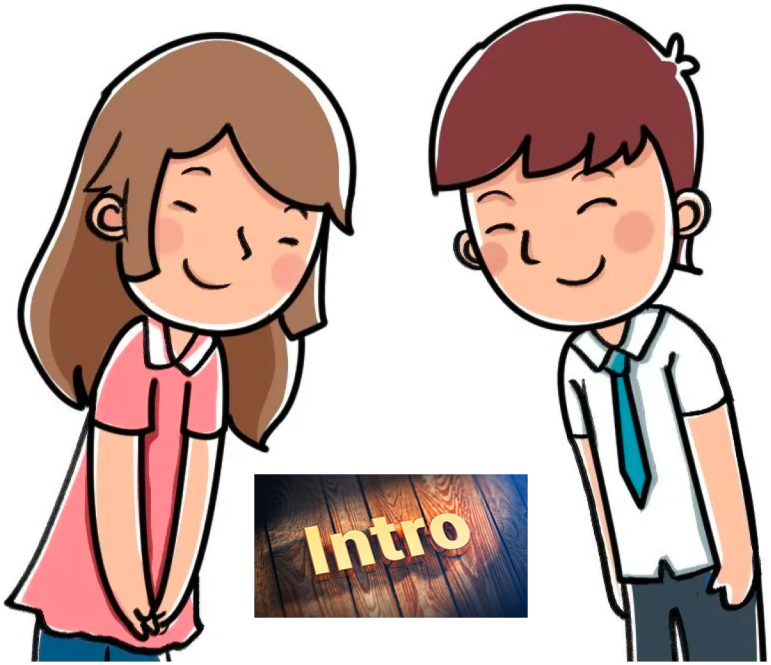
IOWA STATE UNIVERSITY
Electrical and Computer Engineering



- Why this course?
- Past experience with networks and internals?
- Anything fun in summer (that is also related to networking)?
- Fun facts about yourself?

Learning Objectives of the Course

- Understanding the *state of the art* in network systems design and implementation
  - Approach
    - How to address the fundamental issues in developing a new network technology?
  - Perspectives
    - Network architecture
    - Key network protocols
      - Network protocol reasoning from "distributed systems" point of view (Think distributedly!)
    - Efficient, reliable protocol implementation
      - Develop running systems/code!
- Gaining *hands-on experience* with using, designing, and implementing network systems

Topics to cover

- Introduction
  - *Internet and beyond*: history, current status, and future directions of computer networks
  - *Foundation*: system requirements, network architecture, implementation issues, performance metrics and evaluation
  - Socket programming

- Network protocol and systems design
  - *Direct link networks*: error detection, reliable transmission, media access control
  - *Packet switching*: store-and-forward switches, bridges and extended LANs, SDN
  - *Internetworking*: best-effort service model, global addressing scheme, IP, ARP, DHCP, ICMP, virtual networks, Internet routing, multicast
  - *End-to-end protocols*: TCP (connection establishment/termination, sliding window, flow control, adaptive timeout), UDP, remote procedure call
  - *Congestion control and resource allocation*: queuing discipline, TCP congestion control, congestion avoidance, quality of service control (integrated services, differentiated services)
  - *Elements of distributed computing*: naming, caching, replication

Perspectives

- Internet
- Wireless cyber-physical systems networks
  - wireless sensing and control networks, IoT, AR/VR
  - vehicular networks

  etc

Reference Books

- Required:
  - **[R0]** Larry Peterson and Bruce Davie, *Computer Networks: A Systems Approach*, open source at https://book.systemsapproach.org/.
- Recommended references:
  - **[R1]** George Varghese, *Network Algorithmics*, Morgan Kaufmann.
  - **[R2]** Mohamed G. Gouda, *Elements of Network Protocol Design*, John Wiley & Sons.
  - **[R3]** Anurag Kumar, D. Manjunath, Joy Kuri, *Communication Networking: An Analytical Approach*, Morgan Kaufmann.
  - **[R4]** Dimitri Bertsekas and Robert Gallager, *Data Networks*, Prentice Hall.
  - **[R5]** Sheldon M. Ross, *Introduction to Probability Models*, Academic Press.
  - **[R6]** W.R. Stevens, B. Fenner, and A.M. Rudoff, *UNIX Network Programming, Vol. 1: The Sockets Networking API*, 3rd Ed., Addison-Wesley, 2003

Hands-on Labs and Bonus Project

- Labs
  - Network utilities
  - Socket programming: UDP, TCP
  - Error detection and Go-Back-N ARQ protocol
  - GENI introduction, static routing
  - CISCO switch/router configuration
  - Mininet and/or SDN
- Bonus projects (opt-in)
  - Experiment-with/implement network protocols in Contiki or OpenAirInterface

Labs

Lab	Week of the Semester (not including Thanksgiving Week)
1. Network utilities	2
2. UDP socket programming	3-4
3. TCP socket programming	5-6
4. Error Detection and Go-Back-N ARQ Protocol	7-8
5. GENI introduction	9
6. IPv4 routing configuration	10
7. Using Cisco IOS to configure switches	11
8. OSPF routing with Cisco switches	12
9. Mininet and/or SDN	13-14


Bonus Project: Option 1 (Contiki)

- Hands-on project with Contiki, an operating system for resource-constrained devices in the Internet of Things (IoT)
- Contiki wiki: https://github.com/contiki-ng/contiki-ng/wiki
  - Setting-up Contiki-NG
  - Programming Contiki-NG
    - Code repository structure
    - Multi-tasking and scheduling, processes & events, synchronization primitives, timers, memory management, packet buffers etc
  - Key networking modules and services
  - Tutorials: basics (e.g., "Hello, World!" example, timers and events), networking, simulation via Cooja

- Objectives of project
  - Understand the IETF-standard (RFC) compliant implementation of the link/MAC, network, and transport layers of Contiki
    - TSCH, 6TiSCH, RPL, COAP, LWM2M
    - DNS, UDP, TCP, IPv6, WebSocket
  - Conduct an experimental study with the networking stack of Contiki
    - E.g., agriculture sensing, factory sensing, oil/gas field sensing

- Deliverables of project
  - 3-minute video summarizing your project
  - Written project report, in the form of a research report, summarizing the design and implementation of the Contiki network stack as well as the findings from the experimental study
    - Design and implementation of individual components/layers
    - Interfaces and inter-relations between components/layers

- References
  - Using IEEE 802.15.4e Time-Slotted Channel Hopping (TSCH) in the Internet of Things (IoT): Problem Statement, RFC 7554
  - 6TiSCH: deterministic IP-enabled industrial internet (of things), IEEE Communications Magazine, December 2014
  - RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks, RFC 6550
  - The Constrained Application Protocol (CoAP), RFC 7252

Bonus Project: Option 2 (OpenAirInterface)

- Hands-on project with OpenAirInterface, an open source implementation of 5G cellular network stack including both radio access network (RAN) and core network (CN)
- OpenAirInterface: https://www.openairinterface.org/
  - Overview: https://www.openairinterface.org/?page_id=2762
  - Getting started: https://www.openairinterface.org/?page_id=25
  - Tutorials: https://gitlab.eurecom.fr/oai/openairinterface5g/wikis/OpenAirUsage

- Objectives of project
  - Understand LTE and 5G network stack and its implementation in OpenAirInterface
  - Implement and experiment with a real-time scheduling protocol for real-time wireless communication (e.g., for supporting AR/VR and control applications)

- Deliverables of project
  - 3-minute video summarizing your project
  - Written project report, in the form of a research report, summarizing the design and implementation of the OpenAirInterface network stack as well as the findings from the experimental study
    - Design and implementation of individual components/layers
    - Interfaces and inter-relations between components/layers

- References
  - OpenAirInterface: A Flexible Platform for 5G Research
  - Probabilistic Per-Packet Real-Time Guarantees for Wireless Networked Sensing and Control, IEEE TII, 14(5), 2018
  - 4G, LTE-Advanced Pro and The Road to 5G, Elsevier, 2014

Project: Option 3 (Define Your Own)

- Define your own project
- Requirements for self-defined project
  - It shall be related to cyber-physical systems networking
  - It shall have similar ambition/complexity of Project Options 1 and 2
  - Need approval of instructor

Project: Logistics

- Team work
  - Students can form teams to work on bonus projects
- Timeline
  - [20%] By 09/13/2019: select project option and form your project team
    - If selecting Project Option 3, need to define the project too
  - [30%] By 10/31/2019: submit a project preliminary report outlining the Contiki/OpenAirInterface network stack (or if Project Option 3, your draft/expected project results) and the design of your experiment study
  - [50%] By 12/19/2019: submit final project report & 3-minute video

Canvas Learning Management System

- Login to Canvas at https://canvas.iastate.edu/
  - login using ISU Net-ID and password

- Important features:
  - Lecture slides
  - Homework, lab, bonus project assignments
  - Announcements, discussion board
  - Grades

- Check out Canvas often!
  - Make sure you configure your Canvas account so that you will receive automatic Canvas notifications such as those for new "Announcements" and "Discussion" posts

Policy on Homeworks

- Assigned after each major milestone of course; ~6 homeworks
- Submitted online through Canvas as .pdf files
  - "CamScanner" smartphone app
  - "Print to PDF" in MAC (https://support.apple.com/kb/PH25326)
  - CutePDF in Windows (http://www.cutepdf.com/)
  - jpg2pdf (http://jpg2pdf.com/)
- Due by 10:00pm on Mondays
  - 10 minutes grace period, 2% penalty for every extra minute late
    - For example, for a homework that scores 265/300 but submitted at 10:15am, the actual score will become 235/300. (Penalty = 5x2% = 10%, i.e., 30 points)

Policy on Labs

- Students are supposed to work on each lab *individually*, unless stated otherwise in the lab description.
- *Lab reports are due one week from completion of the lab* unless otherwise specified. They are to be submitted through Canvas as .pdf files. They are due by 10:00pm on Mondays (10 minutes grace period, 2% penalty for every extra minute late).
- No make-up labs.

Policy on Collaboration

- You are allowed to form study groups and discuss the homework and lab assignments with your classmates. However, each student is expected to write his/her own solutions/code/report. Sharing of solutions/code/report is not allowed.
- No collaboration is allowed for the quizzes and final exam.
- IMPORTANT: Cheating, plagiarism, and other academic misconducts will not be tolerated and will be handled according to the ISU's academic dishonesty policy:

  http://catalog.iastate.edu/academic_conduct/#academicdishonestytext

Policy on Attendance

- You are expected to attend *ALL classes, ALL quizzes, and ALL exams*.
  - If you have a valid reason to miss a class (e.g., because you are ill) then it is your responsibility to find out what have been discussed in class, e.g., any announcements that were made in class.
  - If you have to leave in the middle of a class,
    - do not interfere others (no chat/noise), and
    - it is your responsibility to find out what has happened in class
- If you want to make up any missed work, prior approval by TA/instructor and proper documentation (e.g., doctor's note) to justify your absence are required

Lab Safety

This class has a substantial hands-on laboratory section. Students will be using expensive, sensitive, and potentially hazardous equipment. Safety in the lab is a number one priority for students and instructors and to ensure a safe laboratory experience, a brief safety presentation will be given during the first lab session. It is mandatory that all students attend this presentation. Moreover, it is expected that students follow any and all posted safety guidelines. For reference, a copy of the University Laboratory Safety Manual can be found at:

http://publications.ehs.iastate.edu/labsm/

Students with Disabilities

- Iowa State University is committed to assuring that all educational activities are free from discrimination and harassment based on disability status. Students requesting accommodations for a documented disability are required to work directly with staff in Student Accessibility Services (SAS) to establish eligibility and learn about related processes before accommodations will be identified. After eligibility is established, SAS staff will create and issue a Notification Letter for each course listing approved reasonable accommodations. This document will be made available to the student and instructor either electronically or in hard-copy every semester. Students and instructors are encouraged to review contents of the Notification Letters as early in the semester as possible to identify a specific, timely plan to deliver/receive the indicated accommodations. Reasonable accommodations are not retroactive in nature and are not intended to be an unfair advantage. Additional information or assistance is available online at www.sas.dso.iastate.edu, by contacting SAS staff by email at accessibility@iastate.edu, or by calling 515-294-7220. Student Accessibility Services is a unit in the Dean of Students Office located at 1076 Student Services Building.

- Attention: Need Extra help? Talk to me.
  - If for any reason at any time you are feeling left out in the course, or need any extra help, feel free to contact me
  - If you do not ask, there is no way for me to provide help

Grading

- Grading weights
  - Class participation: 5% (in-class exercises)
  - Homework: 25%
  - Lab: 25%
  - Quiz: 20%
  - Final exam: 25%
  - *Bonus project: 10%*
- Letter grades will be assigned based on performance ***relative*** to other students;

  A tentative grading scale:

  93 – 100 = A
  90 – 92.99 = A-
  87 – 89.99 = B+
  83 – 86.99 = B
  80 – 82.99 = B-
  77 – 79.99 = C+
  73 – 76.99 = C
  70 – 72.99 = C-
  67 – 69.99 = D+
  63 – 66.99 = D
  60 – 62.99 = D-
  0 – 59.99 = F

Prerequisites & Timing

- Prerequisites
  - CPR E 381 (computer architecture) or EE 324 (signals & systems)
  - Or consent of instructor
- Classes
  - Tue Thu 11:00am-12:20pm
- Instructor office hours
  - Tue Thu 12:30pm - 1:30pm, Sweeney 1126 / Durham 311, or by appointment
- Labs
  - Tue 9:00am – 10:50am, Wed 12:10pm – 2:00pm
  - Coover 2061
- Teaching Assistant
  - Hongyi Bian, hobian@iastate.edu

How to succeed in this course?

- Attend/follow lectures, read books
- Work on homeworks, labs, and (optionally) bonus project
- Ask questions!!!

Questions?

What is this course NOT for?

- Assemble networks with switches, routers, firewalls, etc.
- Design websites

Student Survey (submit by September 1st in Canvas)

- Major / degree / year of study
- *Operating Systems* courses-taken/experience
- *Computer Architecture* courses-taken/experience
- *Computer Algorithm* courses-taken/experience
- *Computer Networking* courses-taken/experience
- What do you expect to learn from this course? Any special expectation on how this course might be taught?
- How might this course contribute to your career objectives?
- Anything else you would like to share?