Fall 2014

CS 436: Distributed Computer Systems

Facts

Title:	CS436: Distributed Computer Systems (**held with CS 636**)
Offering:	Fall 2014
WWW	Please use Piazza at: **piazza.com/uwaterloo.ca/fall2014/cs436**
Lectures:	Tuesday & Thursday, 1600 - 1720, MC 2034
Instructor:	Prof. S. Keshav, keshav@uwaterloo.ca **,** DC 3621
TA:	Omid Ardakanian, **oardakanian@gmail.com** , DC 3562
Office hours	By appointment (send email)

Overview

Course description

CS436 provides an introduction to computer networks, protocols, and distributed system architecture for students who are not computer science majors. It provides an introduction to principles, algorithms, protocols, and technology standards used in computer networks and distributed systems. It is intended for 3rd- or 4th-year students with an interest in Computer Science and is not open to Computer Science students. The course will be taught in a 'flipped' mode, with students required to watch an online lecture before class and class periods used for interactive discussions about the lecture material. It will be held with CS 636: CS 636 students will participate in the class using Adobe Connect**.**

Related courses (see calendar for official details)

Predecessors: CS 230 or CS 241 or CS 251.
Conflicts: CS 454, CS 456, ECE 428, ECE 454.

Hardware/Software used

UNIX, any programming language, preferably Python.

References (no required text)

- James F. Kurose and Keith W. Ross, *Computer Networking: A Top-Down Approach*, 5th Ed., Addison-Wesley.
- Andrew S. Tanenbaum and Maarten Van Steen. *Distributed Systems: Principles and Paradigms*, Prentice Hall.

Prerequisites

Prospective students should be able to:

Write simple imperative programs using lists, iteration, and array indexing for both read and write (mutable memory model).

Describe data representations used by computer hardware at the bit level, operate on these representations, and compute their values.

Explain the basic build process for computer software.

Exemplify basic functionality and components of an operating system.

Learning objectives

At the end of the course, students should be able to:

Recall, explain, and compare transmission media and access control schemes.

Recall, explain, and compare addressing and message forwarding paradigms, including path computation.

Recall, summarize, and exemplify connection management and reliable message transmission.

Recall, explain, and compare naming and name resolution techniques, including mobility.

Recall, summarize, and exemplify contemporary network protocols and techniques.

Recall, summarize, and explain security/privacy concepts in network protocols and distributed systems

Recall, explain, and compare high-level communication services and distribution services.

Compare how existing distributed applications use network services.

Course expectations

It is expected that students view all lectures online, attend all classes, and complete the required assignments. Online lectures will diverge substantially from the prescribed texts because these texts are written for CS majors. All online lecture material will be extensively discussed in class. Any material discussed in class will be examinable unless specifically noted.

Topics

We will take a 'top-down' approach to networking and distributed systems, focussing on the networking concepts and distributed systems mechanisms underlying widely-used networked applications and systems.

I. Introduction: Internet topology, services, protocols, layering.

II. Application layer

i. Networked applications: WWW, BitTorrent, DNS (URLs and names), Email, YouTube, Facebook, Twitter, Skype, ssh, NFS

ii. Application layer protocols: HTTP, BitTorrent, DNS, SMTP, SSH, NFS etc.

iii. P2P and Cloud computing: client-server vs. P2P, Data centre organization, DC networks, distributed computing, P2P systems, DC protocols (MapReduce, BigTable, `memcached`)

III. Transport layer

i. Socket programming and concurrency (locking)
ii. Transport layer overview: TCP vs. UDP semantics, port numbers, multiplexing, connection management
iii. Reliable data transfer and rate control
iv. TCP (Reno, Tahoe, Cubic, Compound)

IV.Network layer

i. Datagrams and virtual circuits, network layer services, IP header, IP addresses, fragmentation and reassembly
ii. Routing principles: link state and distance vector algorithms, hierarchical routing, routing in a LAN, routing in an area, routing among autonomous systems (routing policies)
iii. Routing protocols: OSPF, RIP, BGP
iv. Hubs, bridges, switches, routers, and gateways, scheduling and buffer management
v.Address allocation and local routing: IANA, NAT, DHCP, ARP, Rendezvous, Bonjour, MDNS

V. Link Layer

i. LANs, link layer error correction, addressing, ALOHA, CSMA/CD
ii. WiFi: Access points, CSMA/CA, Enterprise WLANs, roaming
iii. Cellphone networks: architecture, roaming, generations of cellular networks

VI. Security and privacy

i. Principles: confidentiality, integrity, availability , cryptography, keys
ii. Protocols: HTTPS, SSH, TLS, Signed binaries

VII. Distributed systems: Requirements, Design principles, Algorithms

i. Requirements: Consistency, fault tolerance, time synchronization, heterogeneity, scalability, performance, transparency, support for mobility
ii. Design principles: End-to-end principle, hierarchy, policy vs. mechanism, interfaces, data and control planes, placement of functionality.
iii. Algorithms: RPC, transactions, replication and failover, consensus, pub/sub.

Assignments

There will be 20 homework assignments, one for nearly every class. Each homework assignment will test the material taught in an online lecture and will be due in class at the start of the discussion section for that lecture. For instance, the homework for lecture 2 will be due at the start of the class when the material for lecture 2 will be discussed, i.e., 4 pm on September 11. Each such homework assignment should take no

more than ten minutes of work (over and above the time required to view the lecture) and will be worth one mark. Homework assignments will be posted on Piazza.

There will also be three more substantial assignments. While the assignments are fairly large, you will have almost one month to complete each. Try not to leave these until the last minute.

Assignments should be done in teams of two unless an exception has been arranged with the instructor. We may apply MOSS to compare all handed-in assignments to each other to check for undocumented collaboration. Marked assignments and the midterm will be returned in class.

Assessment

	Marks
20 homework assignments	20
Midterm	20
Final	20
Assignment 1	10
Assignment 2	15
Assignment 3	15
Bonus mark for attendance > 90%	1

Schedule

Lecture number	Date	Topics discussed
1	Sep 9	Introduction
2	Sep 11	Application layer: common networked applications **Assignment 1 handed out, paper reports due in class on Sep 30 (individual work)**
3	Sep 16	Application layer protocols
4	Sep 18	Application layer protocols (continued)
5	Sep 23	P2P and cloud organization
6	Sep 25	Transport layer: socket programming

Lecture number	Date	Topics discussed
7	Sep 30	Transport layer: overview
8	Oct 2	Transport layer: reliable data transfer **Assignment 2 handed out, assignment to be uploaded to LEARN by 5pm Oct 30 (groups of 2)**
9	Oct 7	Transport layer: TCP
10	Oct 9	Transport layer: TCP
11	Oct 14	Network layer: overview
12	Oct 16	Network layer: routing principles
13	Oct 21	Network layer: routing protocols
	Oct 23	Midterm 7-9 pm on topics covered in lectures 1-13.
14	Oct 28	Network layer: switches, routers, hubs
15	Oct 30	Network layer: address allocation and local routing
16	Nov 4	Link layer: Ethernet **Assignment 3 handed out, assignment to be uploaded to LEARN by 5pm Dec 2 (groups of 2)**
17	Nov 6	Link layer: Wifi
18	Nov 11	Link layer: Cellular networks
19	Nov 13	Security: principles
20	Nov 18	Security: protocols
21	Nov 20	Distributed systems: requirements
22	Nov 25	Distributed systems: design principles
23	Nov 27	Distributed systems: algorithms
24	Dec 2	Distributed systems: algorithms

Policies

Late policy

No late work will be accepted without prior discussion and documentation.

Academic Integrity

In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check www.uwaterloo.ca/academicintegrity/ for more information.]

Grievance

A student who believes that a decision affecting some aspect of his/her university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4, www.adm.uwaterloo.ca/infosec/Policies/policy70.htm. When in doubt please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline

A student is expected to know what constitutes academic integrity [check www.uwaterloo.ca/academicintegrity/] to avoid committing an academic offence, and to take responsibility for his/her actions. A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate Associate Dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline, www.adm.uwaterloo.ca/infosec/ Policies/policy71.htm. For typical penalties check Guidelines for the Assessment of Penalties, www.adm.uwaterloo.ca/ infosec/guidelines/penaltyguidelines.htm.

Appeals

A decision made or penalty imposed under Policy 70 (Student Petitions and Grievances) (other than a petition) or Policy 71 (Student Discipline) may be appealed if there is aground. A student who believes he/she has a ground for an appeal should refer to Policy 72 (Student Appeals) www.adm.uwaterloo.ca/infosec/Policies/policy72.htm.

Note for Students with Disabilities

The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.