CISC883: LECTURE 1 INTRODUCTION TO ULSS

Cor-Paul Bezemer

Today's lecture

- Course summary
- Introduction to ULSS

Course Summary

- Course Notes:
  - Ultra-Large-Scale Systems: The Software Challenge of the Future, Linda Northrop

http://sailhome.cs.queensu.ca/~corpaul/cisc883_2016
  - Will be updated weekly so **check back**

- Feedback: bezemer@cs.queensu.ca

- Please send me an email with your name indicating that you are a CISC883 student!

Course Summary

- Instructor:
  - Cor-Paul Bezemer
  - Email: bezemer@cs.queensu.ca
  - Office: 156 Barrie St

- Lectures:
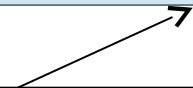 - Time: Wednesday, 14:30 – 17:30
  - Place: 521 Goodwin Hall

Course Summary: Course Plan

- First 5 weeks: Lectures
- Weeks 6-12: Presentations/Deliverables/ Discussions

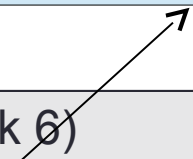| 5%	ULSS Design Position Paper (week 6)
20%	2 In-class presentations about two topics
30%	Weekly reviews + paper recommendations
15%	Project Proposal Presentation (week 8)
5%	Project Proposal (week 8)
10%	Review of 3 other projects (week 9)
15%	Class participation

Course Summary: Course Deliverables

- Due Week 6
- 2-4 page position paper (IEEE style) discussing how 1 ULSS of choice matches Lampson's design principles
- More details next week (week 2)

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Course Summary: Course Deliverables

- Every week (6-12) is assigned a theme topic in ULSS
- Students send me 7 topics ordered by preference
- I assign every student 2 topics
- Student presents (45 mins) in the 2 weeks of their topics

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Course Summary: Course Deliverables

- Every week (6-12) is assigned a theme topic in ULSS
- Each week via email:
  - recommend a paper in the topic (public)
  - I will post the recommend papers on the website
  - Submit a review of another paper in the topic (private)

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Course Summary: Course Deliverables

- Submit 5 pages, IEEE Latex style (week 8)
- 10 min presentation in week 8
- Submit reviews of 3 other proposals (week 9)
- More details in week 3

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NOTE: YOU NEED TO PASS ALL ELEMENTS!

About me

- Post-Doctoral Fellow

- BSc, Msc. & PhD: Delft University of Technology
    - (in the Netherlands, Europe)
- 1.5 years post-doc in Delft, 1.5 years post-doc in SAIL lab

- Research interests
    - Software engineering
    - Software performance

- And you?

Next two lectures

- Week 2
  - Move to Sep 19, 20 or in the morning?

- Week 3
  - No lecture: time to read!

Motivation: Trend in Systems & Software

- Dramatic increase:
  - Size & complexity of systems
  - Size of the information manipulated & analyzed by these systems

- Systems are composed of increasingly complex & distributed platforms, heterogeneous networks, hybrid hardware/software components, etc.

- Future Systems … much more complex !

Challenge & Motivation for ULSS Research

"Given the issues with today's software engineering, how can we build the systems of the future that are likely to have *billions of lines of code*?"

Issues ??! I thought we're doing just fine !

Issues ? …The Chaos Report

- Standish Group (2003)

  - Research advisory firm, i.e., uses case-based reasoning tools to deliver research services & advice.

  - Data: accumulated from a survey on success/failure of 13,522 large software projects in the private sector.

	Success rate	Failure rate
1994	16 %	31 %
2003	34 %	15 %

Improvement … Not Enough

Issues? … The Stock Market (1)

- New York Stock Exchange (NYSE): Hybrid Stock Market
  - Shares can be traded electronically or on the floor

- Knight Capital Group trading on the NYSE
  - 30/7/2012: Installed new software at night to execute rapid-fire trades on a new NYSE platform
  - 1/8/2012: First 30 minutes of trading with the new software led to $440 million in losses … obsolete function in the new software !

- Headlines: "**Knight Shows How to Lose $440 Million in 30 Minutes**"

Issues? … The Stock Market (2)

- May 6, 2010 Flash Crash

- Dow Jones Industrial Average lost 1000 points (~9%) of total value

- **Reason:** One trader used spoofing algorithms

- Losses were recovered in minutes

Wicked Problems

- Problems that are difficult or impossible to solve
- Cause: Incomplete, contradictory, or changing requirements (no stopping rule)

- System: Hardware + Software + Network...
  - software is the most problematic element
  - software failure is more prevalent than hardware failure

- Such large systems will have to be based on a premise of continual change/adaptation & (re)negotiation of user needs

Challenge & Motivation for ULSS Research

"Given the issues with today's software engineering, how can we build the systems of the future that are likely to have ***billions of lines of code***?"

Yeah :(Reports on multi-billion dollar failures due to "wicked problems"

ULSS Report

- A study commissioned by the US Department of Defense (2006) on the future of software.
- Ultra Large Scale Systems (ULSSs)
- Defines ULSSs, their characteristics, challenges, & identifies research areas.
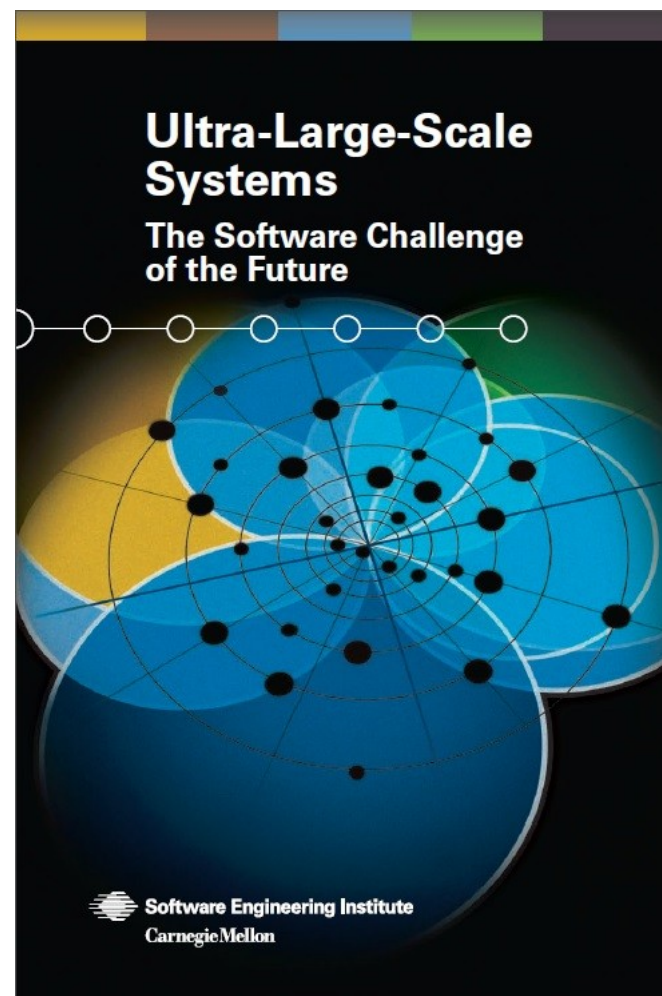
*U*ltra *L*arge *S*cale *S*ystems (ULSSs)

- Systems of unprecedented scale, in any imaginable dimension
  - Lines of code (LOC)
  - Size of manipulated data
  - # of hardware/software components
  - # of functionalities, emergent behaviors
  - # of stakeholders involved (developers, users, testers)
  - # of conflicting requirements of stakeholders
  - Etc.

- E.g. Global Information Grid (GIG)

Ultra-large?

- When does a system stop being just large?

- Suggestion 1: systems with billions of lines of code

- Suggestion 2: Interdependent webs of software-intensive systems, people, policies, cultures, & economics.

-

Ultra-large?

- When does a system stop being just large?

- Suggestion 1: systems with billions of lines of code

- Suggestion 2: Interdependent webs of software-intensive systems, people, policies, cultures, & economics.

- More precise definition?
- Relative to System of Systems (SOSs)
  - Definition
  - Characteristics
  - Types

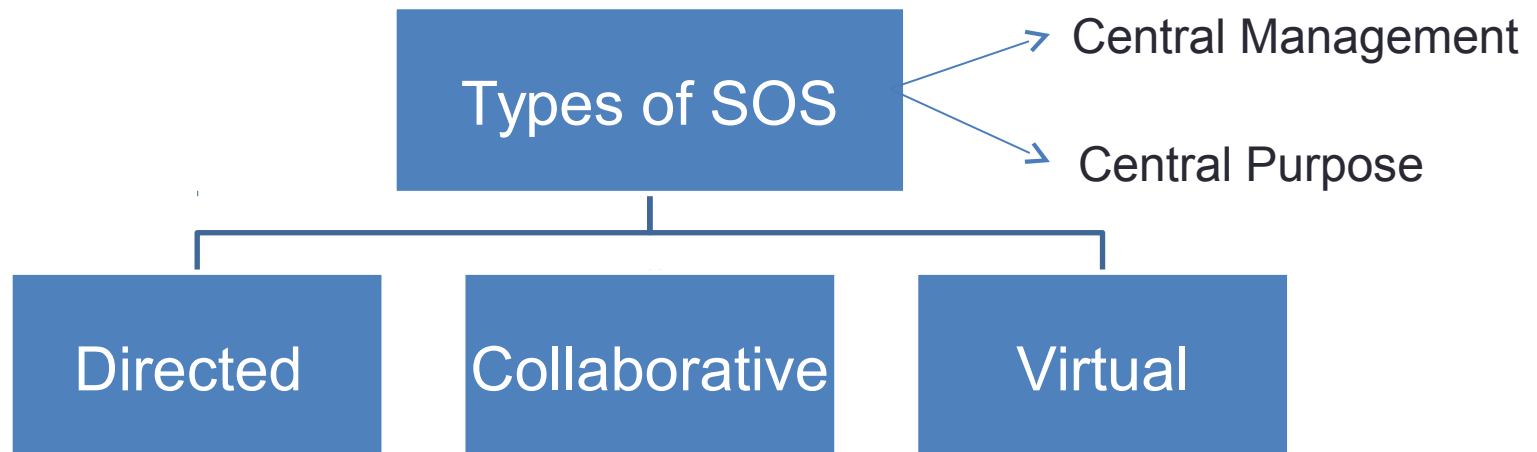# System of Systems (SOSs): *Definition*, Characteristics, Types

- A system comprising independent, self-contained systems that, taken as a whole, satisfy a specific need.

- A collection of task-oriented or dedicated systems that pool their resources & capabilities together to obtain a new, more complex 'meta-system' which offers more functionality than the sum of the constituent systems

- Different than large monolithic systems
  - At some level, a subjective definition
  - e.g., a computer- hard drive, monitor, processor, etc.

System of Systems (SOSs): Definition, *Characteristics*, Types

1. operational independence of elements
2. managerial independence of elements
3. evolutionary development
4. emergent behavior
5. geographic distribution

System of Systems (SOSs): Definition, Characteristics, *Types*

Types of SOS → Central Management

Types of SOS → Central Purpose

Directed · Collaborative · Virtual

	Central Management	Central Agreed Upon Purpose
Directed	✔️	✔️
Collaborative	✖️	✔️
Virtual	✖️	✖️

ULSS Systems Definition - Relative to SOSs

- ULSSs are similar to virtual SOS

- ULSSs are SOSs at internet scale

- ULSSs are beginning to emerge
  - Financial markets.
  - Study funded by the DoD implies that military systems tracking sensors, weapons, fighters, etc. consists of a ULSS.

Questions …

- Can't we stick to `SOSs'? Why the new name `ULSSs'?
  - The scale will dominate in ULSSs
  - Thus, ULSSs will pose new demands & challenges on management, production, documentation, usage, etc.

- What kinds of challenges are posed?
  - Major gaps in our understanding of software development at the scale of ULSSs
  - Software development for existing SOSs is problematic.
  - We can't go bigger by extending established research!
  - A new conception of the nature of ULSSs & new development ideas are needed… ***socio-technical ecosystems***!

Analogy: ULSS Systems & Ecosystems

- A change in perspective of system development:
  - **From**: Technology-centric, traditional, top-down engineering process
  - **To**: regulation of complex, ***decentralized socio-technical ecosystems.***

- ***Ecosystems***
  - Exhibit high degrees of complexity & organization.
  - Not engineered.

- Analogy important?

Analogy: ULSS Systems & Ecosystems

Engineered	Not Engineered
Bee Hive	Forest
Systems	ULSS
Buildings	Cities
Internet protocols	The web
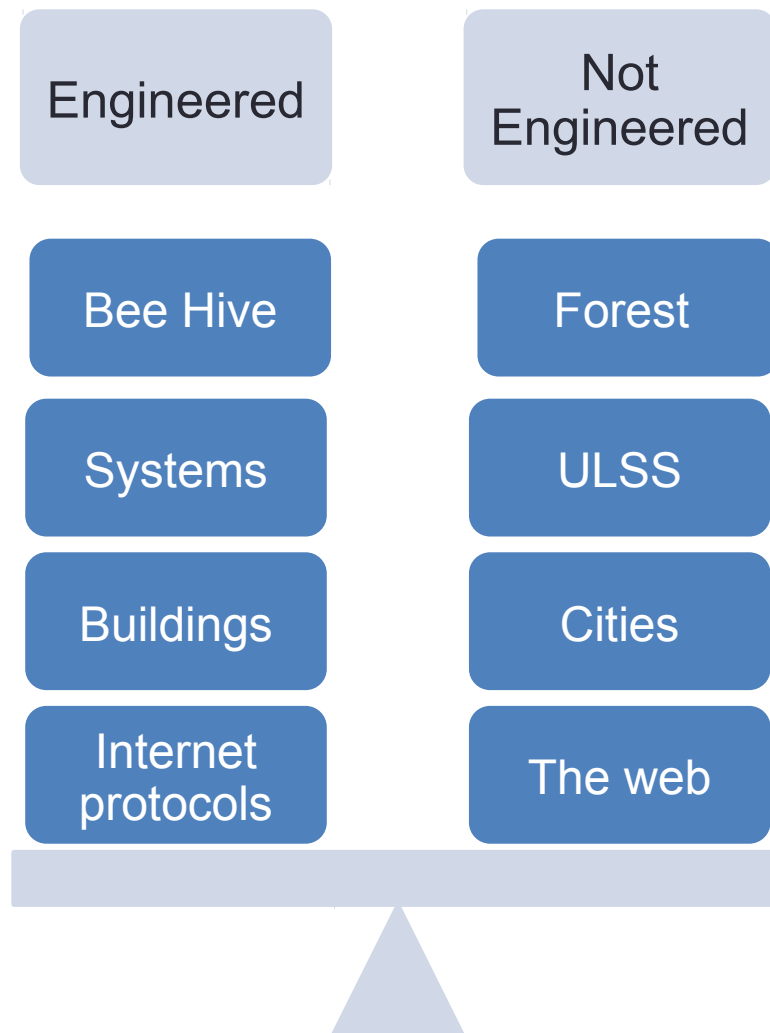
Assignment

- Due: Week 6, Wednesday, 19 October, 2:30 pm
  - 2-4 page position paper discussing how one ULSS system of choice matches Lampson's design principles
  - IEEE style in Latex!

- Before next class, please read Lampson - Hints for Computer System Design (found on website)

Presentation Topics/ Themes

1. Large-Scale Applications
2. Web APIs and Web Services
3. Hosted Applications
4. Infrastructure for Rent
5. Autonomic computing and monitoring platforms & approaches
6. Mobile App Platforms
7. Tools for Large-Scale Analysis

Large-Scale Applications

- Applications that are designed to run at a large scale

- Youtube, Facebook, Twitter

Web APIs and Web Services

- An API (Application Program Interface) is an interface to a service
- Web APIs allow you to use someone else's service without having to install their code

- Google Maps API, Twitter API

Hosted Applications

- Services that host an application for you
- Software-as-a-Service

- Salesforce.com, GitHub, JIRA

Infrastructure for Rent

- Services that offer infrastructure

- Amazon EC2, Rackspace

Autonomic Computing and Monitoring

- Goal: systems that run without human intervention
- Self-* properties:
  - Self-organizing
  - Self-healing
  - Self-monitoring
  - Self-tuning
  - ...

- DB2, Internet of Things (IoT)

Mobile App Platforms

- Platforms for distribution mobile apps
- 'A new way of software distribution'

- Google Play Store, App Store

Tools for Large-Scale Analysis

- Large-scale application have tons of data – how to analyze this data?

- NoSQL, Hadoop, Twitter Storm

Weekly Deliverables (7)

- Each week **k** of weeks 6-12 will be assigned a topic "x"
-
- For each topic, every student must submit the following:
  - Weekly paper recommendation for topic "x" (in week **k-2**)
    - Papers can only be recommended once (so be on time)
    - Motivate why you are recommending this paper
  - Weekly paper review for one of the recommended papers for topic "x" (in week **k+1**)

- Every student will have two 45-min individual in-class presentations about two topics. Presentation will be done in the week in which the topic is assigned.

Example

-

Week	To Dos
4	- The topic of week 6 is "Large-scale applications" - Everyone emails me a paper that they recommend on this topic - I will put the recommended papers on the website - I'll ask people presenting in this topic to send the technology they'll be presenting (suggestions will be given by email) - 1st come - 1st served & replies **must be sent before week 5**
6	- People who were assigned to present in the topic of week 6 will present for 45 mins in the lecture of week 6 - I'll ask you to send to me privately a review of one paper of the uploaded paper recommendations for "Large-scale applications" (Review a paper other than the one you recommended !)
7	- The review of the paper you chose from the recommended papers for the "Large-scale applications" topic must be emailed before week 7's lecture.

Project Proposal

- 10-minute presentation (hard limit)
  - Week 8
- 5-page IEEE format project proposal (Latex!)
  - Week 8
- Review of three project reports
  - Week 9

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