Introduction to Computer Systems

March 1, 2001

Course Goals

Why are we here?

- Learn about a variety of existing computer systems
- Learn how to critically analyze computer systems
- Practice synthesizing your own computer system design
- Practice presenting and debating your ideas

➡ Be prepared to apply what you learn to next month's course - you'll need it!

Course Goals, cont.

Be prepared for something completely different

- No "wrong" or "right" in systems research
- Need to learn how to critically analyze computer systems
- Few theorems, many hints, lots of case studies
- Initially, lots of perceived fuzziness
- Difficulty will be in learning to make order from the perceived chaos

Course Structure

Participation is everything

- Groups of 2
- Assignments: Daily reading and writing assignments
- Recitation: Group presentation and discussion of writing assignment
- One quiz - covers all readings AND recitation discussions
- Final Project

Final Project - Survivor: aD Uni

- 17 teams will enter, one team will survive
- Write and defend an NSF/ARPA systems proposal to win
- You + teaching staff will decide who wins
- Survivor team gets fame, fortune, and a handsome reward
- Details forthcoming…

Grading

- Daily Assignments - 20%
- Participation in recitation (both discussion + presentations) - 20%
- Quiz - 20%
- Final Project - 40%

➡ Attending and participating in recitation is mandatory - it should also be fun

aD Uni web site

- Assignments will be posted on the web site
- Handouts and lecture notes will be posted on the web site
- Subscribe and use the Systems bboard

Who am I?

- Luis Rodriguez - call me “Luis”
- S.B., S.M. at MIT - Coarse-grained Parallelism using Meta-Object Protocols
- Ph.D., MIT - View-Based Abstraction: Enhancing Maintainability and Modularity in the Presence of Implementation Dependencies
- 2 years at McKinsey
- Co-founder of photo.net
- Permanent Personal Website: www.lcrm.com
- email: LHR@visto.com or LHR@photo.net (try both)

What is a system?

- From Saltzer & Kaashoek: A system is a set of interconnected components that has a specified behavior observed at the interface with its environment
- Components/Environment - what is and is not part of the system
- Interface - points of interaction between the system and the environment
- Computer System - A system intended to store, process, or communicate information

Identifying a system's components

- Purpose - What does the system accomplish?
  - E.g., your home
- Granularity - Which details must be exposed, and which can be hidden?
  - E.g., the Internet

➡ Before discussing a system, make sure everyone agrees on what the system actually is

Why build systems?

- **Speed** - SETI, biological simulations, decryption
- **Fault Tolerance** - Power outages, bad components
- **Reliability** - System does not "forget" operations it told you were completed
- **Protection against security threats** - Intentional (Denial of Service Attacks), unintentional (file deletes)
- **Availability** - Anytime, anywhere access
- **Robustness** - Failures to be managed gracefully
- **Maintainability** - Repairs, scheduled maintenance, upgrades, enhancements don't bring down the system
- **Scalability** - A linear increase in the system's load does not produce an exponential decrease in performance

What makes a system hard to build?

- Complexity - lack of understanding of the system's behavior. No absolute measurement, so we look for symptoms of complexity:
  - Large number of components
  - Large number of interactions between components
  - Small amount of regularity
  - Difficult to describe system methodically
  - More than one person required to understand the system

The Role of Complexity

Origins of of complexity:

- Emergent Properties
- Propagation of Effects
- Incommensurate Scaling

➡ Problem: Lack of predictive power - we're all "Lucky Bozos"

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The Role of Complexity, cont.

Emergent Properties

- Properties that show up when components are integrated
- Brain cells
- Resonant frequency of a bridge or building
- Computer + Internet + Music + Napster
- Two pieces of high-grade Uranium + conventional explosives + high-tech detonator

➡ How can you predict emergent properties?

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The Role of Complexity, cont.

Propagation of Effects

- Localized phenomenon grows to have global impact
- Changing a design to use a non-standard part e.g., Larger doors in your dream house, larger wheels on a car
- My favorite - the guy in Star Wars who kept the droids from being destroyed 15 minutes into Episode IV

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The Role of Complexity, cont.

Incommensurate Scaling

- A system behaves according to a different set of rules as it scales in size, speed, or other characteristics
- Einstein - Time dilatation, speed of object or gravitational force on object
- Over-clocking a processor
- Mouse scaled to the size of an elephant; structure and metabolism
- Super-cooled atoms

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Critical thinking about systems

An approach:

- What is the problem being solved?
- What approach is being used?
- What experiments are being performed?
- What are the key results of the experiments?
- What conclusions can be drawn?
- What are the next steps?

➡ Use this approach in every paper you read, and in every discussion you have on systems

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Critical thinking about systems, cont.

Can airplanes really fly?

- Weight grows with cube of size, whereas lift (based on cross-section) grows w/the square
- At small dimensions, (e.g., a kite, a bird), the lift can support the weight
- Larger flying machines based on winged-lift, however, will not work

➡ Don't believe everything you read, even if it seems to make sense!

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