

Special Topics in Software Engineering: Dependable Systems

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Topics

- Overview
- What are dependable systems?
 - Why do we care about them?
- Why do systems stop?
 - What can we do about it?
- Topics
- Class format

Overview

- Class website available from my home page
 - <http://www.eecg.toronto.edu/~ashvin>
- Sign up for class by joining class mailing list
 - Instructions available from class website
- Seminar style course
 - Reading, discussion, presentation
- No assignments
- Project, presentation
- No quizzes or final exams

What are Dependable Systems?

Dependable Systems

- Hard to define, but examples are easy to find
 - Transportation, e.g., cars, airplanes
 - Appliances, e.g., toaster, fridge, TV
 - Medical devices, e.g., MRI, X-rays, prosthesis
- Properties
 - Traditionally, have redundancy, keep running
 - Easily understood operation model
 - Allow monitoring for (well-documented) errors
 - Degrade gracefully
- Bug free? No configuration needed?

Computer Systems

- Tightly intertwined with our lives
 - Increased networking, e.g., wireless
 - Cheap devices, e.g., cell phones
- Complex and failure-prone
- Hard to manage

- Dependability issues dominate total cost of ownership

Current Challenges

- “The products of forty years of OS research are sitting in everyone's desktop computer, cell phone, car, etc., — and it is not a pretty picture.”
 - Researchers from Microsoft, 2005.
- Some key problems
 - *Dependability*: frequent unexpected behavior
 - *Security*: systems protect users from each other, not from outside threats
 - *Configuration*: DLL hell

Insight

- Performance is not the only concern today
 - Few applications require all available resources
- Use resources to improve dependability
- Examples
 - Store all data versions to guard against data loss
 - Read “A Conversation with Jim Gray” (acmqueue.org)
 - Replicate processes, data
 - Isolate sub-systems to reduce fault propagation
 - Use bug detection, recovery methods

Why Do Systems Stop?

Jim Gray, 1985

Conventional TP Systems

- On average, fail for 90 min every 2 weeks
- Restart time includes
 - Detection time
 - Time to take snapshot for later analysis
 - OS, database, communication n/w reboot
 - Client (e.g, ATM machines) reboot
 - Users take time to refocus on job
- How available is the system?
 - 99.6% availability (2 weeks / (2 weeks + 90 min))
 - Sounds wonderful, isn't!

Highly Fault-Tolerant System

- Analyzed failure reports of 2000 systems running a fault-tolerant Tandem system
- Analysis covered 10M system hours
 - 1300 system years!
- 166 failures reported
- Mean time between failure (MTBF) = 7.8 years!
- Where did the failures occur?

Breakup of Failures

- 59 “infant mortality” failures
 - Recurrent failures due to new software or hardware
 - Bugs should have been fixed before deployment
- Contributors to the other 107 failures

Administration	42%
Software	25%
Hardware	18%
Environment	14%

← Maintenance,
operations
configuration

← Fire, flood,
>4 hr power loss

Implications

- Reliability requires tolerating *software faults* and *administration errors*
- Hardware becomes more reliable over time
 - Hardware fault tolerance is feasible
- New and changing systems have higher failure
 - If it's not broken, don't fix it
- High % of outages caused by known bugs
 - Install software and hardware fixes ASAP
- Contradiction?

H/W Fault Tolerance

- Modularize hardware to limit faults
- Make each module fail-fast
 - Either it does the right thing or stops
- Detect faults promptly
 - Have module signal failure
- Configure extra backup modules
- Resulting MTBF is in years to decades!

S/W Fault Tolerance

- Use techniques similar to h/w fault tolerance?
- Software modularity via processes and messages
- Fail-fast modules
- Process-pairs to tolerate transient software faults
 - Bohrbug/Heisenbug hypothesis
- Transactions to provide data integrity
- Combine process-pairs and transactions

Administration Errors

- “Dealing with system configuration, operations and maintenance remains an unsolved problem”
— Jim Gray, 1985.

Topics

Main Topics

- Bugs and race detection
- Testing and debugging
- Fault isolation
- Failure recovery
- Fault tolerance
- Updating software
- System misconfiguration

Weekly Topics

- Week 1: Introduction
- Week 2: Detecting Races
- Week 3: More Races
- Week 4: Detecting Bugs
 - First project report due (Oct 1)
- Week 5: no class (instructor at a conference)
- Week 6: Testing and Debugging
- Week 7: Fault Isolation

Weekly Topics

- Week 8: Generic Failure Recovery
 - Second project report due (Oct 29)
- Week 9: Storage Failure Recovery
- Week 10: Application and OS Failure Recovery
- Week 11: Hardware Fault Tolerance
- Week 12: Updating Software
- Week 13: System Misconfiguration
- Week 14: Project presentations
 - Final project report due (Dec 10)

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Reading and Discussion

- Advanced
- Background in OS, distributed systems
- 2 papers per week
 - Unless marked optional, all papers are required reading
- Will take about 3-6 hours per week!
- Allows discussion in class
- It will show if you don't do the reading!

Presentation

- For discussion, you *must* prepare five questions
 - One slide for *each* question
 - Then one slide for *each* of your answers
 - That is a total of 10 slides at the end of the presentation
 - The order is Q1, A1, Q2, A2, ..., Q5, A5
- Detailed instructions on website
- Please follow carefully
 - E.g., make sure you number slides!
 - Fonts should be reasonably large (>24)
 - Follow this style

Choosing A Paper

- First-come, first served
- Pick 2 papers from website
- Fill form available from website
- Make sure that your choice is not taken

Assignments

- There will be no assignments in this course

Project

- Choose a project based on topics covered
- Sample topics will be posted on website
- Options
 - Implement and evaluate a system
 - Evaluate existing system
 - Write a research paper
- Write up your work
 - 8-10 pages
- Present your work

Grading Policy

- Class presentation: 30%
- Class project: 50%
- Class participation: 20%

**Please join class mailing list
at**

<http://www.eecg.toronto.edu/~ashvin>

Thanks !