# EECE 513: Fault-tolerant digital systems

Introduction to the course

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# Administrivia

- **Class hours**: Tuesday & Thursday 10:30-12:00 pm, MCLD 207
- **Office hours**: Wednesday 1-2 PM
- **Textbook:** No text book (I will distribute notes/slides online)
- **Reference Books:**
  - D. P. Siewiorek and R. S. Swarz, *Reliable Computer Systems - Design and Evaluation*, 3rd edition, 1998, A.K. Peters, Limited.
  - K. Trivedi, *Probability and Statistics with Reliability, Queuing and Computer Science Applications*, 2nd edition, 2001, John Wiley & Sons.
  - Dhiraj K. Pradhan, Fault tolerant computer system design, Prentice Hall, 1996.

# Prior Background

- **Mathematical background**: I assume you've had some basic exposure to probability theory
  - Both discrete and continuous probability distributions
  - Can pick up easily from the Trivedi book (Chap 1-4)
  - Talk to me if you don't have this background (today)

- **Programming/architecture background**
  - At least one course in software design (e.g., software engg., operating systems) – proficient in programming
  - At least one course in hardware (e.g., architecture)

# Class Structure

- **Lectures and paper readings (30 %)**
  - I will lecture roughly every 3 out of 4 classes
  - We will discuss papers in other classes (you need to submit paper reviews ahead of time – 15%)
  - Discussion leading counts for 5% of grade
  - Class participation counts for 10 % of grade

- **Assignments (30 %)**
  - Three assignments each counting for 10%
  - Due in late Sept, Oct and Nov respectively

# Class Project

- **Major component of course grade (40 %)**
- To be done in teams of 2 (3 people allowed in a team if warranted – discuss with me first)
- **You are encouraged to integrate it with your own research, but this is not necessary**
  - But cannot be the same thing you do for research
  - Talk to your advisor first to ensure this is OK

# Final project: Milestones

- In a week or two from today (by Sep 22nd)
  - Setup a time to talk to me about project
- By end of September: 2-page proposal (5%)
- By end of October: mid-term report (10%)
- By early December: Presentation (10%)
- By December 15th -> final report (15%)
  - Must be in the form of a conference paper (10 pages)
  - Demo may be shown for implementation projects

# Paper Readings

- We will read papers on fault-tolerance techniques at different layers of system stack
  - Each of you needs to submit a 2 page review of the papers by noon the day before the discussion
  - All reviews will be open to everyone after then.
  - Discussion leader summarizes each paper (5 mins), and the points raised by the class along with his/her own points for leading discussion.
  - **No late submissions on the reviews, please.**

# Assignments

- **Assignment 1: Basic concepts & probabilities**
  - To be done with pencil and paper (maybe Excel)
- **Assignment 2: Modeling of computer system**
  - Using Mobius tool from UIUC (Markov/SAN modeling)
  - Demonstration of analytical modeling & simulation
- **Assignment 3: Fault-injection and analysis**
  - Use of simulator or prototype fault-injector
  - Requires some programming/scripting experience

# Why Study Reliable Computing -1

- **Traditional needs**
  - Long-life applications (e.g. space missions )
  - Life-critical, short-term applications (e.g., aircraft engine control, fly-by-wire)
  - Defense applications and Nuclear industry

- **Newer critical-computation applications**
  - Health industry
  - Automotive industry
  - Industrial control systems, production lines

# Why Study Reliable Computing -2

- **Networks and Internet**
  - Wired and wireless networked applications
  - Large data-centers such as Google, Amazon
  - E-commerce, Web 2.0 applications

- **Scientific computing**
  - Reliability is an important issue with the advent of large-scale machines (e.g., Blue Waters will have on the order of hundred thousand processors)
  - Check-pointing and recovery don't scale well

# Why Study Reliable Computing -3

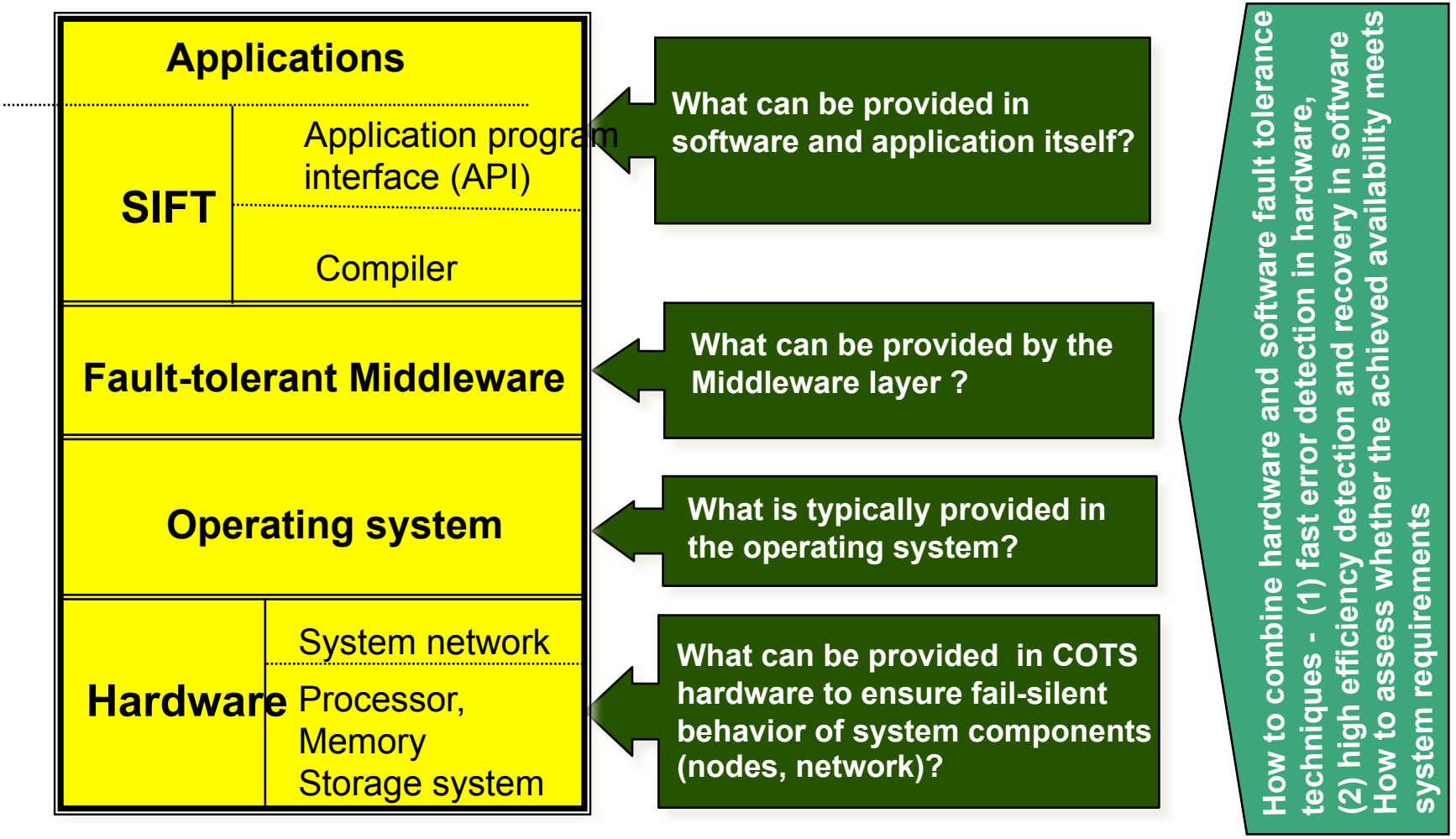
- **Desktop computing**
  - Reliability problems can impact system security
  - Power consumption is becoming important, so we cannot overprovision as we used to in the past
  - Users don't want to deal with system management

- **Ubiquitous computing**
  - We are seeing an increase in the number of devices around us, and are increasingly relying on their correct operation (e.g., smart phones, sensors … )

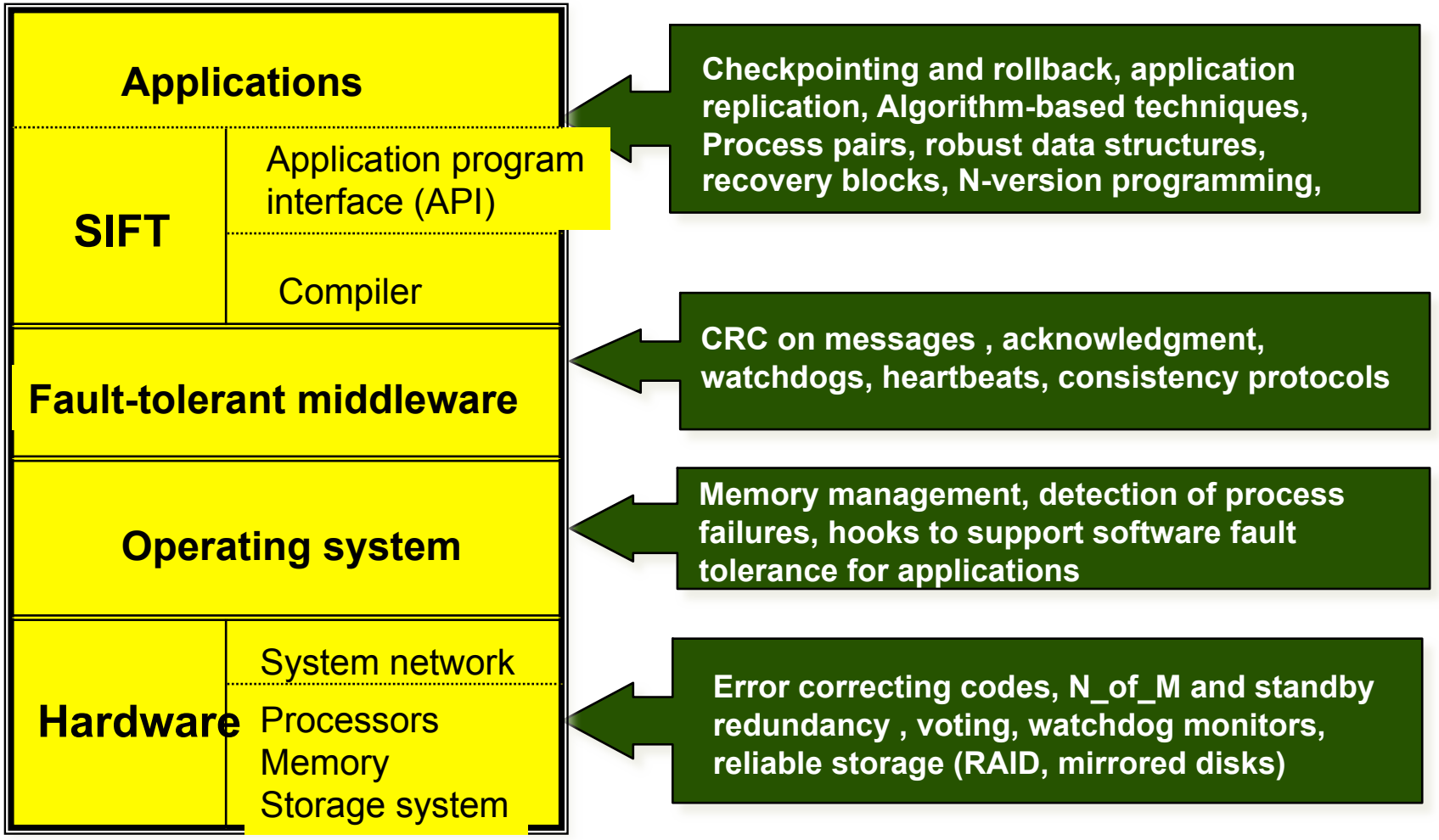
# Fault-tolerance

- **The ability to provide continued correct operation despite the presence of faults**
  - Encompasses a broad rage of techniques ranging from low-level devices to application software
  - Important to ensure that the service behaves as expected provided fault belongs to fault-model
  - There is no such thing as perfect fault-tolerance Every fault-tolerance technique has a coverage and a fault-model over which it is evaluated.

# Hierarchical fault-tolerance - 1



# Hierarchical Fault-tolerance- 2



# What will you learn in this course ?

- **Dependable systems design**
  - Hardware dependability
  - Duplication and TMR
  - Software approaches
  - Parallel systems
  - Distributed systems
  - Case studies of real-world systems
- **Dependability evaluation techniques**
  - Combinatorial methods
  - Markov models
  - Stochastic Activity Networks (SANs)
  - Fault-injection
  - Formal methods
  - Statistical methods

# Why take this course ?

- Exposure to state of the art and traditional techniques in fault-tolerant systems design
- Deep understanding of design choices and trade-offs in real-world fault-tolerant systems
- Rigorous methods and tools for dependability evaluation (useful for industry and research)
  - Opportunity to learn to use tools of the trade

# Other reasons to take this class

- **Chance to explore a dependability idea related to your research or other interests**
  - Talk to your research supervisor first (if applicable)
  - Talk to me if you don't have a research area or don't want to align with your research
- **You get a chance to hone your research skills**
  - Paper discussions, presentations etc. are important, especially for new graduate students
  - Also important for industry jobs, future opportunities

# Policies etc.

- All homeworks are due at the **beginning** of the class on which they're due (typically Tue/Thu)
- Late submissions will be penalized by 10% for everyday they are late up to 3 days maximum
- Please review UBC's policy on plagiarism and academic conduct. Ignorance of the same will not be an acceptable excuse for lapses.
- You are expected to attend (and participate in) all lectures and paper discussions in class.

# By end of class today …

- **Please fill out the form I've handed out**
  - Due by Sep 8th, 2011 (next class)
  - Helps me tailor the course content to your interest
- **Read the paper on dependability concepts linked from the course website**
  - Don't have to go into details – I'll do that in class
  - Will assume you're familiar with the basic terms

# Final thoughts

- The goal is to have fun while we learn !
  - I certainly hope you have fun in this course …

- I am always open to suggestions and critical comments on the course. **Such critical comments will not impact your grade in any way.** On the other hand, good suggestions may even earn you some extra credit/cookies