Software Engineering Research

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What makes us tick?

GOAL: Produce software at lower cost, with fewer people, at a faster schedule.

Approach: Improve software engineering activities:

- Requirements
- Design
- Coding
- Quality Control

Example results.

- "I've invented a new language to program security in distributed systems that allows 3rd party development"
- "I've invented a new tool which automatically finds defects in programs that query databases"
- "I've discovered a way to predict defect rates in java classes based on their structure"
- "I've discovered a new way to organize software teams to produce IT applications faster, cheaper, and better"
- "I've discovered that what we believe about n-version programming is wrong, wrong, wrong".

What's the field like?

- Source of problems.
- Solutions come from related fields:
  - programming languages+compilers
  - algorithms
  - formal methods,
  - social science

What goes on here?

- Devanbu: programming models, middleware, software quality, open-source development.
- Su, Chen, Levitt: Software Quality, analysis, theory of programming languages.
- Pandey: programming models for new paradigms (sensor networks)
- Olsson: Concurrent Programming.

The Lay of the Land

- Major conferences: SIGSOFT, ICSE (~15% acceptance rate).
- Major Journals: ACM TOSEM, IEEE TSE, Software Practice & Experience.
- Major Universities: UCI, CMU, MIT, Toronto, UBC, Waterloo, UT Austin, UC Davis, USC, U Washington, U Virginia, U Colorado.
- Faculty Jobs: Usually more openings than candidates.

Main topics.

Improving Software Cost, Quality, Interval

- Models: theories, abstractions (e.g., UML, Z, Formal Logic, Petri nets)
- Methods: Procedures (e.g., Extreme Programming, coverage testing)
- Tools: Automation/Support (e.g., debuggers.

Example: Model

Problem: How do we develop distributed, heterogeneous systems?

Solution: Easier programming w/CORBA

How?

* Interface definition Language
* Tools to generate code
* Type-checked development.
* Run-time environment support

Validation:

Examples, Comparison with old way. Performance evaluation.

Example: Tool

Problem: Developing concurrent systems is hard, e.g., device drivers

Solution: Find defects automatically in source code.

How?

* Abstract a finite-state model
* Describe the desired property
* Check the finite model.

Validation:

* Can we prove that it is sound?
* How efficient is it? Scaling?
* What is the rate of false positives?

Example: Process

Problem: Allocating scarce inspection time.

Solution: Find defect-prone elements of systems.

How?

* Identify process goal & metric.
* Define plausible predictive product metrics
* Make stastical prediction.

Validation:

* Theoretically validate metrics (axiomatics).
* statistical (non-parametric?) validation using historical data.

So, where is the field going?

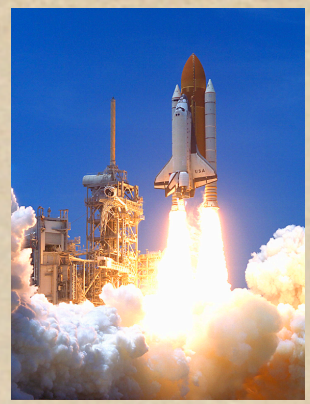
What are the interesting problems?

How do I find a thesis topic?

How do I publish papers?

How do I find an academic job?

Burning Issues



- Separation vs. crosscutting
- Abstraction vs. Performance
- Protection vs. performance
- Agility, flexibility vs. Reliability, Quality.
- Precision vs. Scaling

Separation vs. Crosscutting

Goal: Separation of concerns (why?)

Problem: Some concerns are hard to decompose (e.g., Security, Fault-tolerance, billing etc affect all components).

Approaches: Aspect-Oriented programming, Reflection, Monadic programming, Mixin Layers

Issues: Correctness, Efficiency, Understandability.

Abstraction vs. Performance

Goal: Brevity, Comprehensibility, SoC

Problem: Performance, and inflexibility.

Approaches: multi-layer optimization, partial evaluation.

Issues: Correctness, ease of use.

Protection vs. Performance

Goal: Protect critical resources

Problem: Inflexibility.

Approaches: "safe" extension mechanisms, such as sandboxes.

Issues: Correctness, power.

Agility and Flexibility vs. Reliability and quality.

Goal: The software process must be fast, flexible, and still be well controlled.

Problem: Control inhibits speed.

Approaches: Extreme Programming, Open source Development.

Issues: Applicability of these processes? Why do they work (specially open-source)

Precision vs. Scalability.

Goal: Build analysis tools that find defects accurately.

Problem: Undecidability & combinatorial blow-up.

Approaches: Build sound but imprecise tools.

Issues: Improving precision. Specialization. Interactivity. Better algorithms, hardware.

Succeeding in Research

- Read, read, read.
- Be a fashion plate and a name dropper.
- Write Code. Hack. Read Code.
- Attend Seminars: Systems, PL, but also security and theory.
- Talk, argue, canoodle, discuss.
- Question everything, and everyone.

Writing Papers-1

- The Role of Conferences.
- The reviewing process in conferences.
- The burden on the authors. Must write with extreme care!!!! Wordsmith!!
- Give your advisor a draft 2 weeks before the due date.

Writing Papers 2.

- Outline: Introduction, example(s), broad related work, solution, evaluation, narrow work, conclusion.
- Role of each section.

Writing Papers -3

- Introduction: Problem explained in broadest setting (clarify, don't oversell).
- Example: Be current, simple, and to the point.
- Broad related work: Why is the example not solved?
- Contribution: Explain model, method, and tool. Explain roles (new ones).

Writing Papers-4

- Evaluation: consider the culture of your audience!! Formal, Examples, Performance studies, statistical validity etc.
- Close Related work: Be very precise, and non-judgement. Be shamelessly diplomatic. Look at the program committee, don't be stupid.
- Conclusion. Summarize carefully, don't oversell. Give web page for some software (even prototype).

Finding Academic Jobs

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- Plan your graduation time carefully, based on your ambitions.
- Talk to your advisor about an external member.
- Go to workshops, conferences, chat up the big wigs. Ask them for letters.
- Have your advisor email colleagues in target universities.

Summary

- Exciting, inter-disciplinary field, requiring "lateral" thinking.
- The "action" is in managing tradeoffs of current interest.
- Conference papers are critical, and not easy.
- Academic job market is stable, and good.