EC4219: Software Engineering

Lecture 0 — Course Overview

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Basic Information

- **Instructor:** Sunbeom So (소순범)
- **Position:** Assistant professor in Dept. of EECS, GIST
- **Research area:** programming languages, software engineering, and software security
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- **Office hours:** by appointment

Software and Software Engineering[1]

- **Software**: is a collection of computer programs and associated documentation.
  - E.g., specification, instruction manual
  - In this course, we will interchangeably use the terms between program and software.
- **Software Engineering**: is an **engineering discipline** that is concerned with all aspects of **software production process**. The goal is to achieve cost-effective software development.

[1] "Software Engineering" by Sommerville

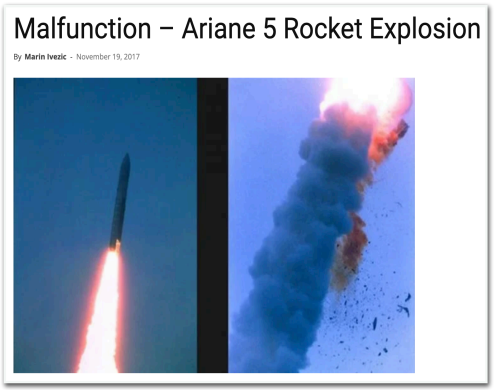
Software Production Process[2]

- A structured set of activities required to develop a software system.
- Examples include:
  - Specification: defining what the system should do.
  - Design and Implementation: defining the organization of the system and implementing the system.
  - Validation: checking that the system meets what the customer wants.
  - Evolution: changing the system in response to changing customer needs.
- In this course, **we will focus on studying the validation** for ensuring software safety, correctness, and quality.
  - Why? The validation (SW testing and debugging) is the key. It comprises over 50% of the cost of software development.
  - Why should we invest so much in validation? Why is it so important? SW is written by humans, and humans make mistakes.

[2] "Software Engineering" by Sommerville

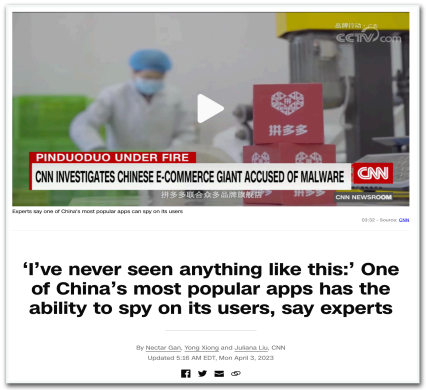
Motivation: Software Errors are Everywhere

SW disasters due to SW bugs have become increasingly prevalent.

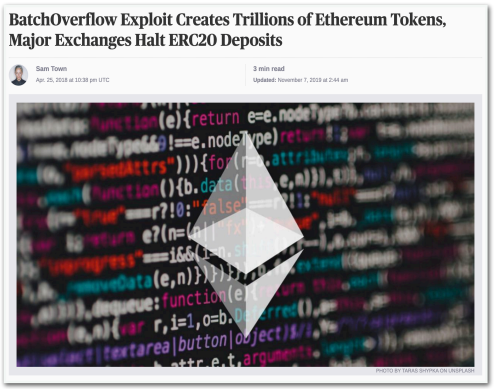


Rocket SW

Aircraft SW



Mobile App



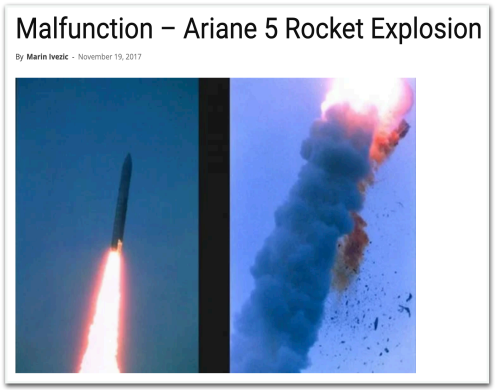
Blockchain SW

Medical SW

Self-driving SW

The Worst SW Disaster in History

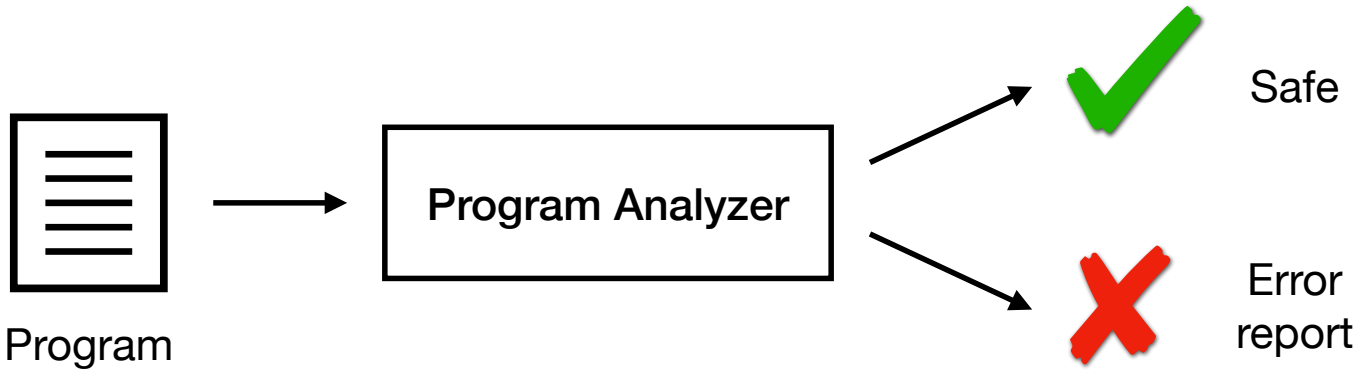
- The Ariane 5 Rocket Explosion (1996)



- Cost: 10 years and $7 billion – gone 37 seconds after its launch
- The catastrophe was caused due to the integer overflow error.
  - Attempted to fit 64-bit format data into 16-bit space (during takeoff to convert one piece of data – the sideways velocity of the rocket)
  - The number was too big to fit and resulted in an overflow.
  - This error was misinterpreted by the rocket's onboard computer as a signal to change the course of the rocket.

We will learn fundamental, modern technologies to prevent SW disasters in advance.

Program Analysis



Program analysis is a technology for discovering bugs or proving safety/correctness. Examples include:

- Verification: is this program correct with respect to specifications?
- Bug-finding: does this program have integer-overflow bugs?
- Compiler optimization: Does the optimized program preserve the semantics of the original one?
- many others

Taxonomy of Program Analysis

Program analysis techniques can be broadly classified into three kinds.

- Dynamic analysis: the class of run-time analyses. These analyses discover information by running the program and observing its behavior.
- Static analysis: the class of compile-time analyses. These analyses discover information by inspecting the source code or binary code.
- Hybrid analysis: combines aspects of both dynamic and static analyses, by incorporating runtime and compile-time information in certain ways.

Examples: Dynamic Analysis Tools

Dynamic analyzers infer facts of the program by monitoring its runs.

- Purify: a tool for checking memory accesses, such as array bounds, in C and C++ programs.
- Valgrind: a tool for detecting memory leaks in x86 binary programs.
- Eraser: a tool for detecting data races in concurrent programs.
- Daikon: a tool for finding likely invariants.[3]

[3] An invariant is a program fact that is true in every run of the program.

Examples: Static Analysis Tools

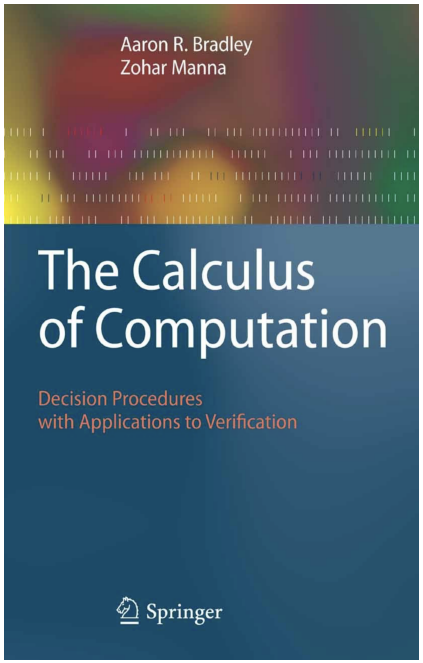
Static analyzers infer facts of the program by inspecting its source (or binary) code.

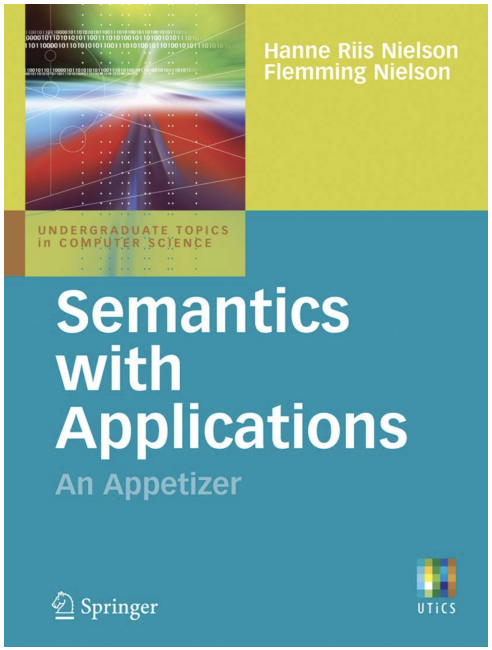
- Infer (Facebook): a tool for detecting memory leaks in Android applications.
- SLAM (Microsoft): a tool for whether C programs respect API usage rules. This tool is used by Windows developers to check whether device drivers use the API of the Windows kernel correctly.
- VeriSmart: an analyzer for finding security vulnerabilities in smart contracts.

We will learn fundamental theories behind these tools.

Course Materials & References

- Self-contained slides will be provided.
- "The Calculus of Computation" by Aaron R. Bradley and Zohar Manna
- "Semantics with Applications: An Appetizer" by Hanne Riis Nielson and Flemming Nielson





Prerequisites & Notes

- **Prerequisites:** To succeed in this course, you should:
  - have completed of the basic CS courses (e.g., Automata Theory, Data Structures, Algorithms).
  - have extensive experience in computer programming.
- **Notes:** This is an **ADVANCED** course. Complaints like below are not acceptable.
  - "Teach me more about the syntax of OCaml language."
  - "Programming assignments are too hard."

Grading Policy

- Mid-term/Final exam (100 points for each).
- 2-4 programming assignments in OCaml.[4]
  - I will provide basic guidance about OCaml, but will not explain every single detail from one to ten.
- **Neither relative nor absolute grading.** If you deserve an A+, you get an A+. In some cases, you may get an A (not an A+) even if you are the top in this class.
- You must attend more than 2/3 of the classes according to GIST regulations (see No.25 of ER-322-07).
  - As long as you conform to this rule, attendance will not affect your letter grade. So, you do not need to send me an email before your absence.

[4] `https://ocaml.org/`

Academic Integrity: Read Carefully

- All assignments (i.e., writing code) must be your own work. **No discussions are allowed**.
  - You should not share/show your code.
  - You should not post your code on public websites.
  - You should not modify other students' code.
- **Cheating on assignments will result in an F.**
- I will have a one-on-one meeting with each student under suspicion.
- If you fail to prove your integrity in the meeting,[5] I will consider that you cheated on your assignments, even if you do not admit your cheating.
- Your grade is not negotiable. Do not send me an email for it after the grade notification. If you send me an email (a type of cheating), your final grade will drop by 2 levels (e.g., A $\rightarrow$ B).

By registering for this course,
I will assume you agree with this policy.

[5] e.g., failing to answer my questions about the details of your submissions

Summary

- Software engineering is an engineering discipline concerned with all aspects of software production process.
- In the software process, validation is highly important due to the prevalence of SW errors.
- Program analyses are fundamental and modern technologies that can effectively help the SW validation process.