Lec 1: Introduction

IS561: Binary Code Analysis and Secure Software Systems

Sang Kil Cha

Who am I?

Sang Kil Cha

- Researcher and Software Engineer.

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- Researcher and Software Engineer.
- Leader of SoftSec. Lab.

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- Researcher and Software Engineer.
- Leader of SoftSec. Lab.
- Director of CSRC (Cyber Security Research Center)
- Chief professor of GSIS.
- Research Keywords:
  - Binary Analysis
  - Vulnerability Discovery
  - Exploit Verification
  - Malware Analysis

Contact

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My Research

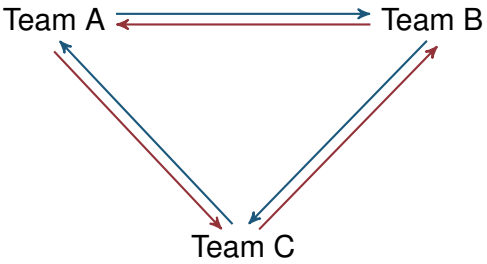
My research is all about building ***large*** and ***complex*** systems that automatically analyze programs to resolve security problems.

My Research: Automatic Exploit Generation

Fully automated hacking and defense
(e.g., DARPA's Cyber Grand Challenge)


CYBER
GRAND CHALLENGE
DARPA
CYBER
SCORING
SECURE
DARPA

Normal CTFs



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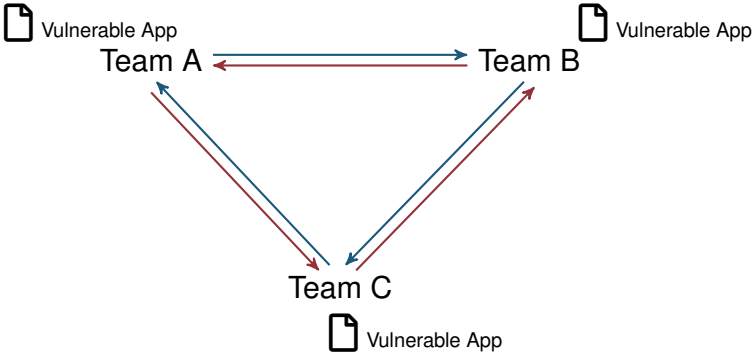
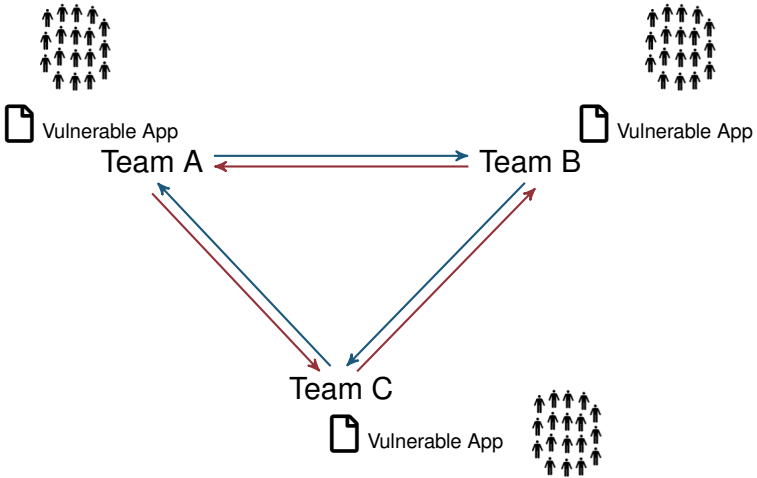
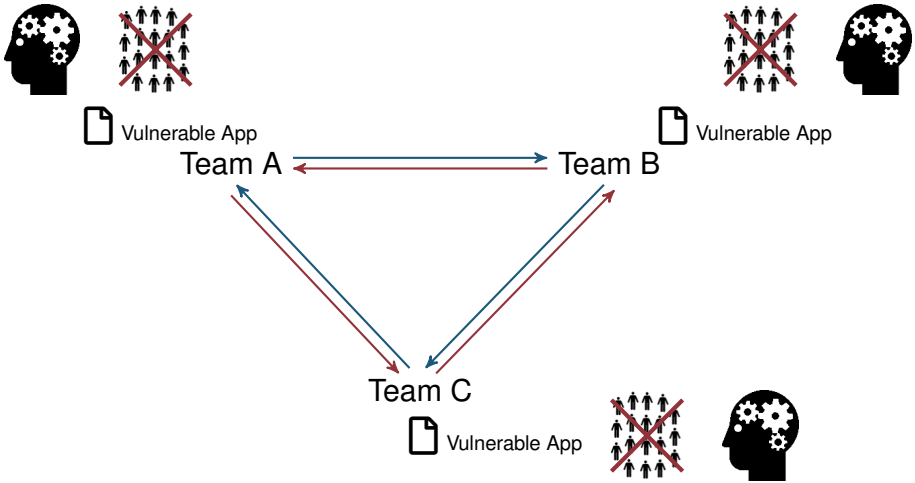

Vulnerable App
Team A
Team B
Vulnerable App
Team C
Vulnerable App

Normal CTFs


Vulnerable App
Team A
Team B
Vulnerable App
Team C
Vulnerable App

CGC


Vulnerable App
Team A
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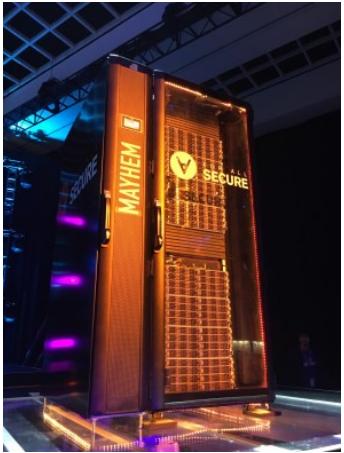
Vulnerable App

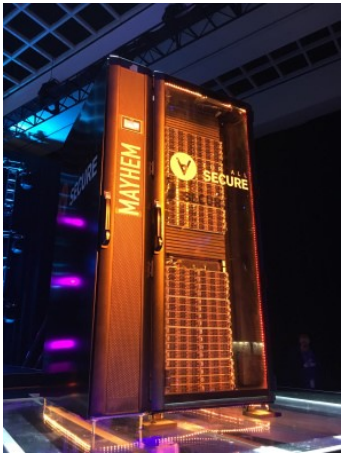
Winner = Mayhem



ForAllSecure (Carnegie Mellon University)

Image from https://forallsecure.com/wp-content/uploads/2016/08/mayhem-crs.jpg

Winner = Mayhem



ForAllSecure (Carnegie Mellon University)

2012 IEEE Symposium on Security and Privacy

Unleashing MAYHEM on Binary Code

Sang Kil Cha, Thanassis Avgerinos, Alexandre Rebert and David Brumley
Carnegie Mellon University
Pittsburgh, PA
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Image from https://forallsecure.com/wp-content/uploads/2016/08/mayhem-crs.jpg

IEEE S&P Test-of-Time Award 2022

My Research: Windows Error Reporting

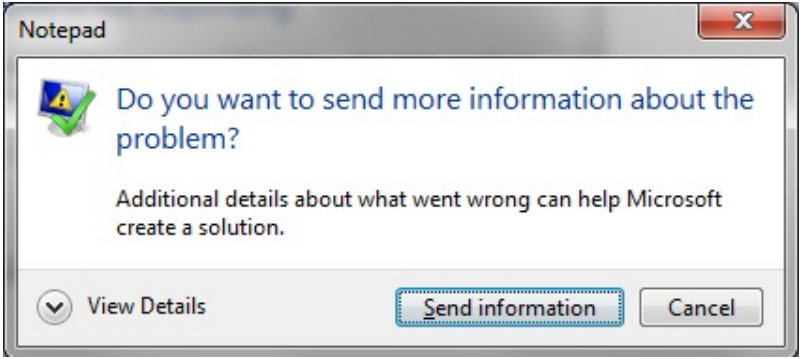
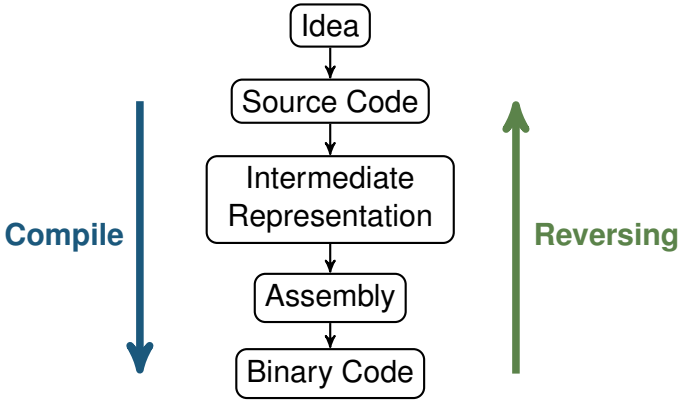


Image from https://goo.gl/PLekyZ

My Research: Automatic Bug Finding

- Targeting ***various software products***: browsers, kernels, smart contracts, etc.
- Practical impact: numerous CVEs, algorithms used by mainstream fuzzers, etc.
- Academic impact
  - 2020 FSE Distinguished Paper Award.
  - 2022 TSE Best Paper Award.
  - 2022 ASE Distinguished Paper Award.

My Research: Binary Analysis



My Research: B2R2

- The fastest binary analysis frontend.
- Academic impact
  - 2019 NDSS BAR Best Paper Award.

My Research: Windows Binary Analysis

- Windows binary analyzer built on top of ***B2R2***.
- Published in 2021 IEEE Security & Privacy.

- Earned 25,000 USD bounty for finding zero days.

My Research: Online Game Security

- Automatic aimbot detection.
- Reverse engineered CS:GO binaries to collect real-time game data.
- 2023 USENIX Security ***Distinguished Paper Award***.

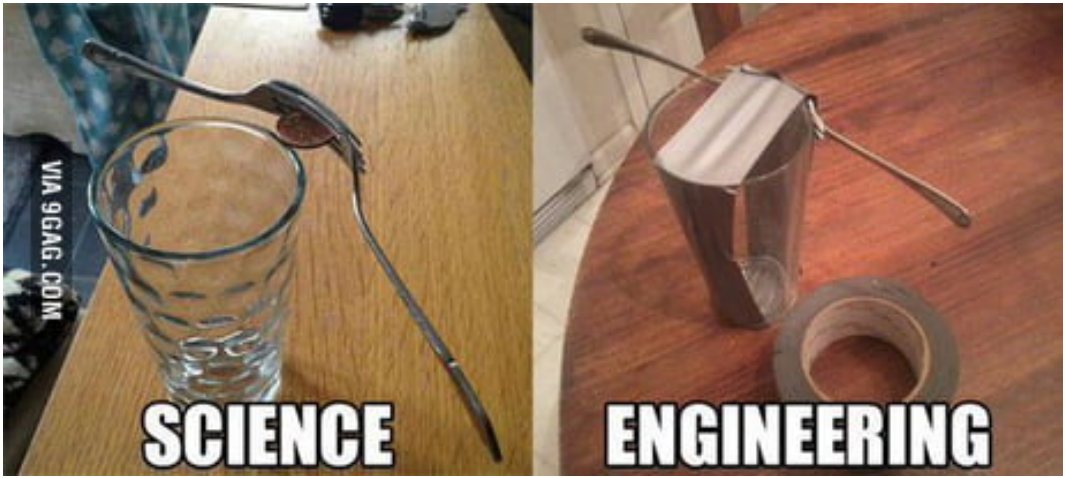
Software Security

Software Security

- Software security is a broad topic.
  - Binary code analysis
  - Program analysis
  - Exploit verification
  - Vulnerability discovery
  - Bug detection & classification
  - Malware analysis
  - ...

What is the difference between science and engineering?

Science vs. Engineering



Where there is engineering, there is a ***security problem***.

Engineering Failure

Why?

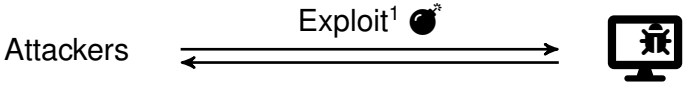
Why?

Humans always make ***mistakes***.

And Software is No Exception

- We see hacking attacks, i.e., software failures, every day.
- Because software engineers make ***mistakes***.

Software Bug is the Root of Evil



- Stealing private data
- Executing arbitrary commands
- ...

[1] Exploit is a malicious input that triggers bug(s).

Software Security is About Software Bugs

- Find software bugs
- Exploit software bugs
- Patch software bugs

Goal of This course

Understand general ***principles*** of

- How attackers find and exploit bugs
- How current defense techniques work
- How to engineer secure software systems

This course is ***NOT*** about learning hacking skills.

This course is about learning the ***principles***.

Software Security Researcher = Hacker?

- Security research vs. Hacking research?
- Security conference vs. Hacking conference?

Key Takeaway

Security researchers do not need to be like a hacker, but should be like an ***engineer***, because

- There's no provably secure software artifacts,
- Thus, We should make things work (and secure).

Key Takeaway (cont'd)

$$\text{Good Hacker} \not\rightarrow \text{Good Engineer}$$
$$\text{Good Engineer} \rightarrow \text{Good Hacker}$$

Key Takeaway (cont'd)

$$\text{Good Hacker} \not\rightarrow \text{Good Engineer}$$
$$\text{Good Engineer} \rightarrow \text{Good Hacker}$$

You don't need to be a hacker to do security research, although you can always become a hacker if you need to.

The Course

Target Audience

- Possess ***systems programming*** skills (C/C++)
  (prerequisite)
- Possess knowledge about how to ***compile***, ***link***, and ***debug*** programs on Linux (e.g., `gcc`, `gdb`, etc.)
  (prerequisite)
- Possess basic knowledge about ***computer architecture*** and ***compiler***
  (prerequisite)

Course Resources

- Course web: `https://softsec.kaist.ac.kr/courses/2024f-is561/`.
- We use ***KLMS*** for Q&A and announcements.

Course Logistics

- 5% Reading critique, in-class participation
- 20% Homework
- 35% Midterm
- 40% Final

Our Environment

- Linux on x86-64
- GNU Debugger (GDB)
- GCC compiler
- No commercial tools, such as IDA Pro
- We provide a VM.

Vagrant VM

- Vagrant VM
  - Install latest version of VirtualBox
  - Install latest version of Vagrant
  - mkdir YOUR_PATH; cd YOUR_PATH
  - Download box from (redacted: please find the URL from KLMS)
- Read the Vagrant manual
- Basic Vagrant usage (in cmdline prompt)
  - `vagrant box add is561 is561_2024.box`
  - `vagrant init is561`
  - `vagrant up`
  - `vagrant ssh`

Reading Critique (by tomorrow)

See the course web page.

What Makes Good RC?

- Show your own unique view.
- Do not nitpick on aesthetics. Focus more on the idea.
- Make it easy to read.
- Be concise. Avoid lengthy sentences and paragraphs.

Question?