Chair of IT Security
Department of Informatics
Technical University of Munich

Low-Level Software Security

Preliminary Meeting - WS 2022/23 - Season I

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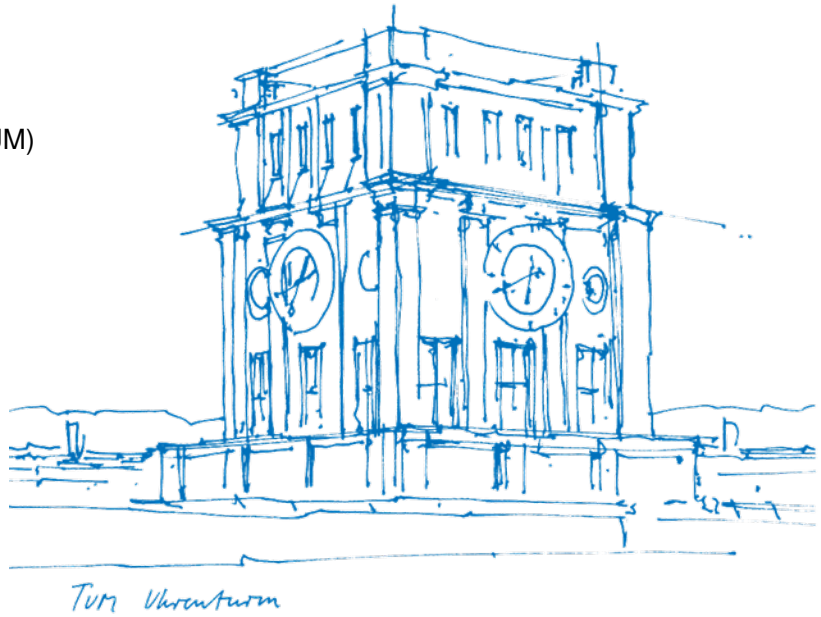

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Intro

Your tutors:

- Marius Momeu (momeu@sec.in.tum.de)

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Your tutors:

- Marius Momeu (momeu@sec.in.tum.de)
- Manuel Andreas (manuel.andreas@tum.de)

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Objectives

This lab will be a playground where you can build practical prototypes, which aim to solve limitations of trending topics in the area of *low-level software security*[1].

As such, your tutors will define tasks based on state-of-the-art research, which you will have to **design, implement, and evaluate a prototype** for[2].

Alongside that, you will **describe your prototype and findings in a final written report**, and **present them in a final talk** at the end of the semester.

[1] aka *systems software security*

[2] you are welcome to propose topics of your own

Technical Content

We are generally researching ways to improve the security of *low-level* software running on most popular processor architectures: **ARM and x86 (Intel and AMD)**. As such, the following list captures some high-level areas we will pick topics from[3]:

- **Software Hardening**
  - using hardware extensions such as *Intel VT-x/MPK/CET/HLAT* and *ARM PAC/MTE*
  - to design code/data isolation, code/data debloating, control-/data-flow integrity schemes
  - for hardening OS kernels, unikernels, μkernels
- **Software analysis**
  - via static/dynamic program analysis for generating and enforcing control-/data-flow policies
  - or via program testing (fuzzing or symbolic execution) for finding bugs
  - in closed- and open-source low-level software (OS kernels, device drivers, hypervisors)
- **Confidential computing in Trusted Execution Environments (TEEs)**
  - such as *ARM TrustZone, Intel SGX/MKTME/TXT, AMD-SEV-**
  - both security guarantees and vulnerabilities
- **Remote (control-flow and data-flow) attestation**
- **Microarchitectural flaws** and side-channels for leaking secrets, revealing stealthy monitors, etc.

[3] see more concrete examples on the lab's webpage description.

Hands-On Format

Throughout this lab you should expect to touch on (several) hands-on stuff, including but not limited to:

- Remotely operating servers or IoT devices via the command-line terminal (bash on Unix systems)
- System administration (e.g., spawning VMs, managing partitions, compiling and deploying kernels/unikernels)
- Reading and coding in *C/C++*, Assembly (*x86, ARM*), (maybe) *Rust*, and various scripting languages
- Understanding OS concepts, such as memory management (via paging or nested-paging[4]), interrupts, (bare-metal and emulated) device drivers, syscalls/hypercalls
- Using *LLVM*'s static analysis framework and *LLVM* binary lifters
- Examining various hardware extensions in architecture manuals (*Intel VT-x/MPK/CET/HLAT, ARM PAC/MTE, AMD-SEV-**)
- Understanding/working with software testing techniques: blackbox/whitebox/graybox fuzzing (coverage guidance, input mutation), state-of-the-art fuzzers (kAFL, syzkaller), symbolic/concolic execution, constraint solvers (z3)
- Computer architecture concepts (e.g., speculative execution, return stack buffers, caches, *TLBs*)
- Exploitation know-how: code-reuse attacks, data-oriented attacks, secret leaking via covert side-channels
- Compiling/building, dynamic or static linking, binary formats (mostly *ELF*)

Disclaimer: this is not an introductory lab in software security!

[4] via *PTs* and *EPTs* on Intel's architecture

Process

Three prototype development phases:

1. Designing
2. Implementation
3. Evaluation

Four presentation meetings:

1. Research Expose
2. System Design
3. Status update and issues (bilateral)
4. Final talk

Two report deliverables:

1. Intermediate draft
2. Final version

Grading

Graded deliverables:

- Design/ Prototype / Evaluation
- Final presentation
- Final report

Mandatory ungraded deliverables:

- Intermediate presentations
- Intermediate report draft

Optional ungraded deliverables:

- Draft slides for the final presentation (to get our feedback on)

	80 %	Design / Prototype / Experiments
	10 %	Final Talk (Presentation and Q&A)
	10 %	Final Report (Content and Structure)
Σ	100 %	Final Grade

Disclaimer: The grading scheme above might suffer slight modifications.

Deliverables' Format

Prototype:

- source code (documented and cleaned-up)
- reproducible evaluation experiments
- guideline (`README`) for compiling, installing, and evaluating

Presentation:

- TUM presentation template[5]
- custom templates can be used as well
- 16:9 aspect ratio

Generally, we encourage you to use LaTeX for writing.

Report/Writeup:

- complete description and findings of the prototype
- informal language and style (no scientific writing constraints), max. 10 pages
- we will publish a template before the start

[5] https://latex.tum.de/templates/608c2650db4bc7007f58c931

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Logistics

When? irregularly ($\approx$ 4 mandatory meetings), on Tuesdays, at 10:00h (exact dates & time TBA)

Where? Most likely onsite, unless the uni enforces online teaching

Capacity: 16 students (8 teams, 2 students / team)

Language: English

Course of study: both Master's and Bachelor's students

Registration: via the matching system

Seminar Resources

Moodle[6] **page** for announcements, for submitting deliverables, and for uploading lecture slides.

Gitlab[7] **repositories** on LRZ's git server where you can keep your prototype's source code.

ARM/Intel/AMD machines for prototyping / running experiments, depending on your topic.

Matrix[8] for instant messaging with team partners and tutors.

Your tutors for brainstorming and addressing issues.

[6] https://www.moodle.tum.de/
[7] https://gitlab.lrz.de/
[8] https://matrix.tum.de/

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Matching Prioritization

Each of the following will grant you a higher prioritization in the matching, with different weights. However, **they are optional**:

1. **Highest weight**: successful completion of any of the following courses:
   - Binary Exploitation, Rootkit Praktikum
   - Systems Hardening, Software Security Analysis, Trusted Execution Environment, Reverse Engineering
   - IT Security, Secure Mobile Systems
   - Computer Architecture, Operating Systems
   - Any other course/thesis/project related to this security domain
2. **Medium weight**: letter of motivation of maximum two pages describing up to 3 concepts/technologies from the slide *Technical Content*. The description should touch on the questions **what do you know about these concepts?** and **why do you find them important for security?**
3. **Lowest weight**: presence in today's premeeting

Send 1 and 2 via email to momeu@sec.in.tum.de and manuel.andreas@tum.de
In your email, please use the subject: *Matching - LLSS - WS 2022/23*

Deadline: Sunday, 31st of July, EoD

Bonus!

We’re planning to organize guest lectures and invite some of our friends from the infosec industry and academia.

Questions?

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