Systems Hardening
Preliminary Meeting - SS 2022 - Season IV

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Intro

Your tutors:
• Marius Momeu\(^1\) (momeu@sec.in.tum.de)

\(^1\)I’m posting theses / guided research topics at: https://www.sec.in.tum.de/i20/people/momeu-marius
Intro

Your tutors:

- Marius Momeu¹ (momeu@sec.in.tum.de)
- Sergej Proskurin (proskurin@sec.in.tum.de)

¹I’m posting theses / guided research topics at: https://www.sec.in.tum.de/i20/people/momeu-marius
Objectives

This seminar is structured for preparing you to publish research at scientific conferences or journals.

Thus, you will exercise and expand a broad spectrum of research skills, such as formulating a clear (and potentially novel) hypothesis, validating it, and, most importantly, writing about and presenting your findings.

To facilitate that, your tutors will propose state-of-the-art offensive and defensive topics in systems hardening research.

There will generally be two types of topics you can choose from:

• Prototyping topics that require building and evaluating a prototype for limitations in existing research, and
• SoK topics require systemizing the knowledge on a popular concept/issue with lots of existing research.

Finally, you will gradually build a paper on the obtained results, and you will present your findings throughout the semester.

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2 you are welcome to propose a topic of your own
Scientific Content

We are generally interested in researching ways to improve the security of software running in IoT devices, cloud servers, and desktop environments.

As such, the following list captures some high-level areas we will pick topics from:

- **Hardware security extensions**
  - such as Intel VT-x/MPK/CET/HLAT and ARM PAC/MTE
  - for hardening OS kernels, unikernels, μkernels
  - via code/data isolation, control-flow and data-flow integrity

- **Static program analysis**
  - for generating Control-Flow and Data-Flow policies
  - on closed- and open-source software (OS kernel and applications)

- **Confidential computing in Trusted Execution Environments (TEEs)**
  - such as ARM TrustZone, Intel SGX/MKTE/TXT, AMD-SEV-*
  - both their security benefits and shortcomings

- **Remote (control-flow and data-flow) attestation**

- **Fuzzing low-level software** (e.g., OS kernels, device drivers, and hypervisors)

- **Microarchitectural flaws** and side-channels for leaking secrets, revealing stealthy monitors, etc.
Hands-On Format

Throughout this seminar you should expect to touch on hands-on stuff, including but not limited to:

- Remotely operating servers or IoT devices via the command-line terminal (bash on Unix systems)
- 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\(^3\)), 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-*)
- 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)
- System administration (e.g., spawning VMs, managing partitions, compiling and deploying kernels/unikernels)

\(^3\)via PTs and EPTs on Intel’s architecture
Tentative Timeline | Deliverables

- **Research exposé**
  - motivation
  - research goals
  - roadmap

- **First paper draft**
  - introduction
  - technical background
  - threat model
  - related work

- **Final paper draft**
  - design
  - implementation
  - evaluation
  - limitations
  - ...

- **Camera-ready version**

- **Draft slides for the final presentation**

### Deliverables

- **05.04**
  - Tutors publish catalogue of topics
  - Task for Students

- **12.04**
  - Tutors assign topics to students
  - Task for Tutors

- **03.05**
  - Students send shortlist of 3 preferred topics

- **24.05**
  - Our feedback on your first draft

- **31.05**
  - Peer review

- **05.07**
  - Our feedback on your final draft
  - Final paper draft

- **12.07**
  - Camera-ready version

- **25.07**
  - Draft slides for the final presentation

- **26.07**
  - Our feedback on your slides
Tentative Timeline | Sessions

- **Research exposé**
  - motivation
  - research goals
  - roadmap

- **First paper draft**
  - introduction
  - technical background
  - threat model
  - related work

- **Final paper draft**
  - design
  - implementation
  - evaluation
  - limitations
  - ...

- **Camera-ready version**

- **Draft slides for the final presentation**

- **Final talks**

- **Hints on Scientific Writing**

- **System design presentations**

- **System implementation & evaluation presentations**

- **Peer review**

- **Final peer review**

- **Hints on Paper Reviewing & Hints on Public Speaking**

- **Deliverables Sessions**
  - Task for Students
  - Task for Tutors

- **Students send shortlist of 3 preferred topics**

- **Tutors publish catalogue of topics**

- **Tutors assign topics to students**

- **Our feedback on your first draft**

- **Our feedback on your final draft**

- **Our feedback on your slides**

- **05.04**
  - Deliverables

- **12.04**
  - Students send shortlist of 3 preferred topics

- **26.04**
  - Research exposé presentations
  - motivation
  - research goals
  - roadmap

- **03.05**
  - Research exposé
  - motivation
  - research goals
  - roadmap

- **24.05**
  - First paper draft
  - introduction
  - technical background
  - threat model
  - related work

- **31.05**
  - System design presentations

- **21.06**
  - System implementation & evaluation presentations

- **05.07**
  - Final paper draft
  - design
  - implementation
  - evaluation
  - limitations
  - ...

- **12.07**
  - Peer review

- **19.07**
  - Camera-ready version

- **25.07**
  - Draft slides for the final presentation

- **26.07**
  - Final talks

- **29.07**
  - Final talks
Tentative Timeline

- Research exposé
  - motivation
  - research goals
  - roadmap
- First paper draft
  - introduction
  - technical background
  - threat model
  - related work
- Final paper draft
  - design
  - implementation
  - evaluation
  - limitations
  - ...

- Students send shortlist of 3 preferred topics
- Tutors publish catalogue of topics
- Tutors assign topics to students
- Read related literature & setup prototyping environment
- Sketch design
- Prototype implementation and evaluation
- Optimization and evaluation
- Hints on Scientific Writing
- Research exposé presentations
  - motivation
  - research goals
  - roadmap
- System design presentations
- System implementation & evaluation presentations
- Peer review
- Camera-ready version
- Draft slides for the final presentation
- Final talks
- Hints on Paper Reviewing & Hints on Public Speaking

Sessions
- Deliverables
- Task for Students
- Task for Tutors
- 05.04
- 12.04
- 26.04
- 03.05
- 24.05
- 31.05
- 21.06
- 05.07
- 12.07
- 19.07
- 25.07
- 26.07
- 29.07
Grading

**Graded** deliverables:
- Final "camera-ready" paper
- Final presentation
- Design/ prototype / experiments

**Mandatory ungraded** deliverables:
- Research exposé
- Paper drafts
- Intermediate presentations
- Peer review

**Optional** deliverables:
- Draft for the final presentation

50 % Final Paper (Content, Style, Language, Scope, …)
40 % Final Talk (Presentation and Q&A)
10 % Design / Prototype / Experiments

∑ 100 % Final Grade
Deliverables’ Format

Research exposé:
- 2-3 pages
- one-column
- note: focus on the motivation for your topic and on the research goals that you will address in this seminar

Presentation:
- TUM presentation template\(^5\)
- custom templates can be used as well
- 16:9 aspect ratio

Paper:
- IEEE conference proceedings template\(^4\)
- maximum 10 pages, excluding References and Appendix
- two-column

Peer review:
- format similar to peer reviews in scientific conferences
- one page with summary, strengths, and weaknesses of reviewed paper

Generally, we encourage you to use \LaTeX\ for writing.

\(^4\)https://www.ieee.org/conferences/publishing/templates.html
\(^5\)https://latex.tum.de/templates/608c2650db4bc7007f58c931
Orga

**When?** irregularly, on Tuesdays, at 10:00 h (subject to change)

**Where?** Onsite or online (via BBB) depending on the regulations

**Capacity:** 8 students

**Language:** English

**Course of study:** both Master’s and Bachelor’s students

**Registration:** via the matching system
Seminar Resources

We will setup a Moodle\(^6\) page for announcements, for submitting deliverables, and for uploading lecture slides.

We will create Gitlab\(^7\) repositories on LRZ’s git server for versioning the paper’s and prototype’s source code.

Depending on the topic, we can configure accounts for you in our chair’s test network and let you access our **hardware for prototyping**.

**Matrix\(^8\)** for instantaneous communication.

\(^6\) [https://www.moodle.tum.de/](https://www.moodle.tum.de/)
\(^7\) [https://gitlab.lrz.de/](https://gitlab.lrz.de/)
\(^8\) [https://matrix.tum.de/](https://matrix.tum.de/)
Task for Matching Prioritization

Please send us a letter of motivation of **maximum two pages** stating **up to 3 topic areas** from slide *Scientific Content* that you would like to work on during the seminar. In your letter, describe **why do you want to work with these and why do you find them important for systems security**?

Send it to: momeu@sec.in.tum.de and proskurin@sec.in.tum.de
In your email, use the subject: *Matching - Systems Hardening - SS 2022*

**Deadline:** Sunday, 20th of February, EoD

Also, please mention in your report if you have attended any of the following courses:

- Rootkit Praktikum, Binary Exploitation
- Software Security Analysis, Trusted Execution Environment, Reverse Engineering
- IT Security, Secure Mobile Systems
- Computer Architecture, Operating Systems
- Any other course where you have tackled the topics / technologies we have mentioned above
Questions?

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