Cryptography and Embedded System Security CRAESS_I

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Time table

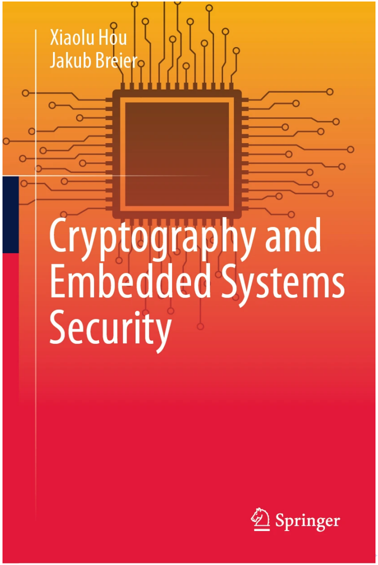
- Lectures (prednášky)
  - Friday 10 – 11:50
- Tutorials (cvičenia)
  - Friday after the lecture
  - 12 – 13:50
- Consultations (konzultácie)
  - By appointment, xiaolu.hou@stuba.sk
  - Office 4.03

Grading

- 50 marks – six assignments
  - Assignments with questions
    - Solution to be written with latex, submission of PDF in AIS
  - Programming assignments
    - Submission of code in AIS
    - Individual presentation of implementation details
    - Assignments 4 and 5 also require short answers for a few questions to be submitted in PDF in AIS
  - 0 grade for late submission
- 10 marks – quiz
- 10 extra marks
  - Find mistakes in textbook
- 40 marks – final exam
  - To sit in the final exam, you should obtain at least 30 marks during the semester

Textbook

- Cryptography and Embedded Systems Security
- Springer link: `https://link.springer.com/book/10.1007/978-3-031-62205-2`
- Free version: `https://xiaoluhou.github.io/Textbook.pdf`
- Library: 6 copies, I*6K-Kryptografia, šifrovanie



Mistakes in the book

- 1 mistake – 1 mark
- At most 10 marks in total
- Mistakes, grammar errors, confusing sentences, etc
- Report mistakes: in team group message, email, or just talk to me
- Only newly found errors will be awarded marks
- Errors identified during the lectures do not count
- Up to date version: `https://xiaoluhou.github.io/Textbook.pdf`
- Errata: `https://xiaoluhou.github.io/Errata.pdf`

Attendance

- Mandatory tutorials
  - Week 4: presentation of Assignment 3
  - Week 9: presentation of Assignment 4
  - Week 10: presentation of Assignment 5 solution
  - Lectures might end early, so better come at least half an hour before the tutorial starts
- Week 6: Quiz, 10-11:50am, lecture will be after quiz
- If cannot attend, a valid excuse note should be submitted, otherwise 0 marks

Course materials

`https://xiaoluhou.github.io/Teaching_material/`

or

`https://github.com/XIAOLUHOU/Teaching_material`

Note

- Some lectures might be online - pay attention to announcements in teams group chat and emails

Datasets and analysis code for SCA

All datasets and analysis code related to SCA can be found here

`https://github.com/XIAOLUHOU/SCA-measurements-and-analysis----Experimental-results-for-textbook/tree/main`

Extra reading materials

- Menezes, A. J., Van Oorschot, P. C., & Vanstone, S. A. (2018). Handbook of applied cryptography. CRC press.
  - Free online: `https://cacr.uwaterloo.ca/hac/`
- Stinson, Douglas R. Cryptography: theory and practice. Chapman and Hall/CRC, 2005.
  - Free online: `http://sutlib2.sut.ac.th/sut_contents/H97066.pdf`
- Lecture notes, Hardware and Embedded Systems Security, `https://creativecommons.org/licenses/by-sa/3.0/`
- Buchmann, Johannes. Introduction to cryptography. Vol. 335. New York: Springer, 2004.
- Mangard, Stefan, Elisabeth Oswald, and Thomas Popp. Power analysis attacks: Revealing the secrets of smart cards. Vol. 31. Springer Science & Business Media, 2008.
- EC council course, `https://codered.eccouncil.org/course/cryptography-and-embedded-systems-security?logged=true`

Why are we interested in cryptography?

- Cryptography is an indispensable tool used to protect the information in computing systems
- Used everywhere and by billions of people worldwide on a daily basis
  - ATM
  - email
  - Electronic passport
  - Security token
  - ...

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picture source: https://en.wikipedia.org/wiki/Visa_requirements_for_Slovak_citizens
https://www.slovensko.sk/_img/CMS4/Navody/eID_client_Application_User_Guide.pdf

Why are we interested in physical attacks?

- Cryptography provides algorithms that enable secure communication in theory
- In the real world, these algorithms have to be implemented on real devices:
  - software implementations: microcontroller
  - hardware implementations: FPGA
- To evaluate the security level of cryptographic implementations, it is necessary to include a physical security assessment

Targets and Attack Goals

Targets

- Credit cards
- Passports
- Key Fob
- ...

Goals:

- Recovery of the secret key
- Privilege escalation
- IP theft
- ...

picture source: https://goodtimes.ca/how-many-credit-cards-is-too-many/

Different Physical Attack Methods

- Side-channel analysis attacks
  - EM/Power analysis
  - Timing analysis
  - Cache attacks
- Fault attacks
  - Optical fault injection
  - Electromagnetic fault injection
  - Clock/voltage glitch
- Hardware Trojans
- ...

picture source: `https://nl.dreamstime.com/stock-foto-s-hamer-die-computer-boos-tonen-raken-image34210923`

What will we cover in this course?

- Abstract algebra and number theory (week 1)
- Introduction to cryptography (week 2)
- Modern cryptography and implementations (week 3 – 4)
- Power analysis attacks, fault attacks, and countermeasures (week 5 – 11)
- Practical aspects of physical attacks (week 12)
  - Invited speaker, Dr. Jakub Breier, Senior security manager, TTControl GmbH
- Consultation (week 12) – most exam questions will be from examples during the lectures

An important notation

- Decimal point is denoted by . not ,

$$\frac{1}{2} = 0.5$$

- We do not use

$$\frac{1}{2} = 0,5$$

- Ten thousand is written as $10,000$
- If there are more confusing notations for you, do let me know!

PhD Research Topics

- **Fault Attacks and Countermeasures**
  - Cryptographic implementations
  - Neural network implementation
- **Side-Channel Analysis: Attacks and Countermeasures**
  - Cryptographic implementations
  - Neural network implementation
  - AI for side-channel analysis

- You are strongly encouraged to pursue your Ph.D. studies with me
- This course provides a solid foundation and a strong starting point for doctoral research
- The later modules of the course are based on recent research publications