CS 458 / 658
Computer Security and Privacy

Module 1
Introduction to Computer Security and Privacy

Fall 2023

Instructors

Yousra Aafer

- yousra.aafer@uwaterloo.ca
- https://cs.uwaterloo.ca/~yaafer/

Urs Hengartner

- urs.hengartner@uwaterloo.ca
- https://cs.uwaterloo.ca/~uhengart/

- Office hours: Mondays 3:00 – 4:00 pm virtual (or by appointment); Link on Piazza

Teaching Assistants

- Andre Kassis
- Adrian Cruzat La Rosa
- Jumana Jumana
- Parjanya Vyas
- Syeda Mashal Abbas
- Ruizhe Wang
- Andy Yu

Office hours on Thursdays 12:00pm to 1:00pm;
See assignment instructions for location

Course Mechanics

- Campus and CS VPNs: remote working
- student.cs account: code submission
  - If you don't have a student.cs account for some reason, ask `cscfhelp@uwaterloo.ca` for help
- LEARN: self-tests, assignments, etc.

Course Mechanics

- Important course announcements will be made on Piazza.
  - Please keep up with the information there.
- Use discussion forums in Piazza for all communication
  - Use a private question for questions not of general interest
- Use email only as a last resort and then it must be from your uwaterloo.ca email address
- Some communication might be sent to your uWaterloo email address
  - Check your uWaterloo email account regularly or have email forwarded to your regular account

Course Mechanics

- Piazza: Q&A, general discussions
- Logistics, office hours links, assignment due dates, etc
- Module Discussions – the place to ask questions about that module's content
- Assignment Discussions – the place to ask questions about assignments
- …

Course Mechanics

- Course website: syllabus, slides, public materials
- infodist: individual information (scores, comments)

Course Syllabus

- https://crysp.uwaterloo.ca/courses/cs458/F23-material/F23-syllabus.html
- You are expected to be familiar with the contents of the course syllabus
- If you haven't read it, read it after this lecture

Course Website

- https://crysp.uwaterloo.ca/courses/cs458/F23-material/modules.php
- Contains the lecture slides (and corresponding readings)
- A draft of the lecture slides for each module will be made available before the module begins.
- The final version of the lecture slides will be made available after the module is completed

Course Calendar

- Piazza and LEARN

- Assignment (and milestone) due dates
- Self-test due dates
- Survey due dates (applies to CS658 only)

- Make sure to check regularly

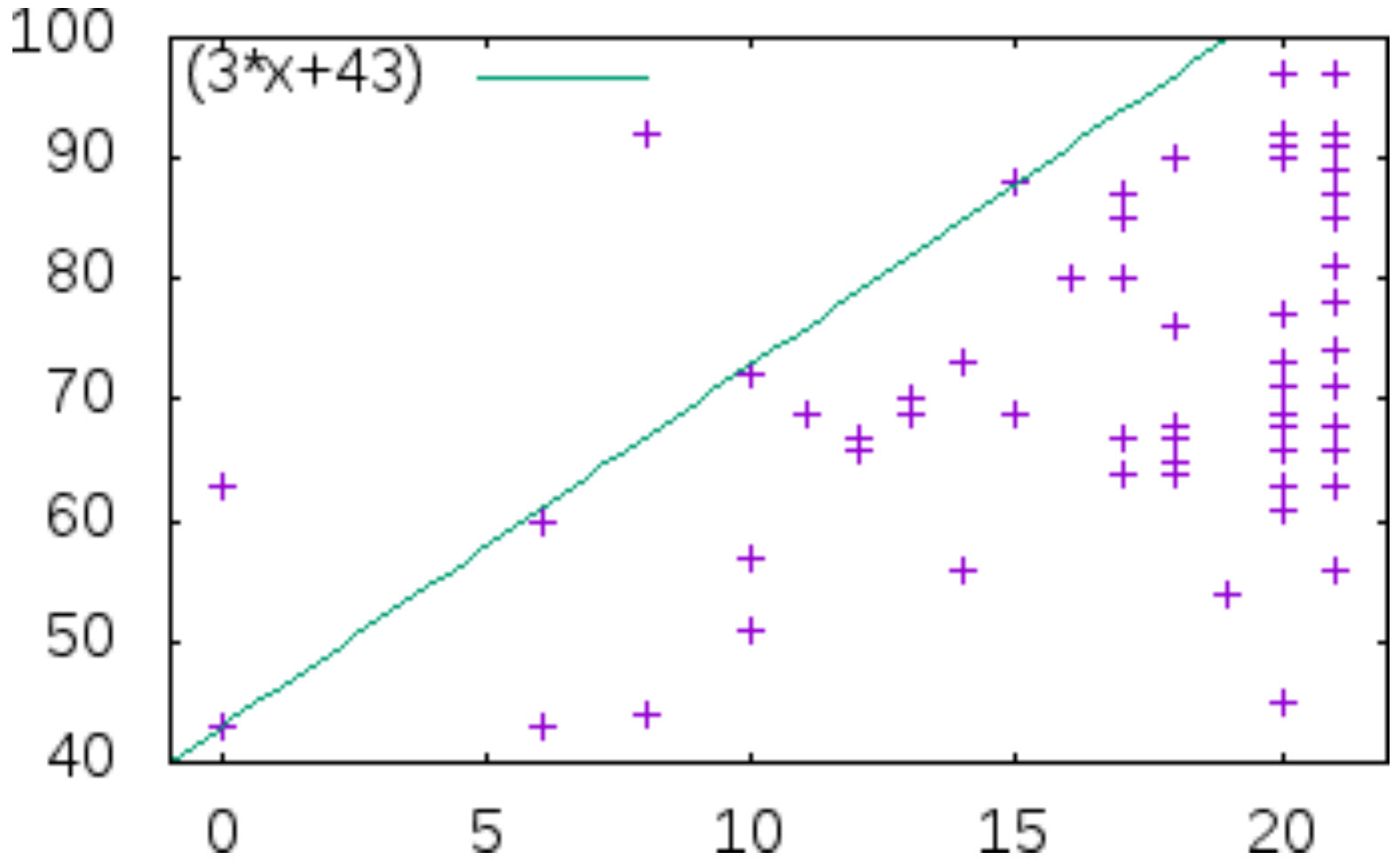
Per-student information

- Per-student information will be distributed using Infodist:

  https://crysp.uwaterloo.ca/courses/cs458/infodist/

- Assignment marks and comments
- Login accounts for assignment machines

Attend the Lectures!



Grading Scheme

- Assignments (3×23% = 69%)
  - contain written and programming portions
  - work alone
- Self-tests (6%)
- Final assessment (25%)

- Additional research survey paper for CS 658
  - See syllabus for more details
- See syllabus for late and reappraisal policies, academic integrity policy, and other details

Assignments

- Assignments will be due at 3pm Waterloo time.
- Late submissions will be accepted up to 48 hours after due date
  - No doctor's note or supporting documents required
  - No penalty will be given
  - Applicable to Assignments 1, 2, 3 only
- BUT
  - No assistance will be given after due date
  - No assignments will be accepted after the 48-hour grace period
  - Only assignments submitted with the official submission system will be accepted

Late Policy

- The purpose of the late policy is to deal with temporary problems occurring before the assignment due date
- If the problem occurs only during the 48 hours after the due date, you are out of luck
  - Submit early and submit often
- You must notify your instructor well before the due date of any severe, long-lasting problem preventing you from completing an assignment on time
- No lates are accepted for the final assessment, self-tests, and CS 658 proposal and survey paper

Plagiarism and Academic Offenses

- We take academic offenses very seriously
  - Even (especially?) in fourth year
- Nice explanation of plagiarism online
  - https://uwaterloo.ca/math/academic-matters/academic-integrity
- Read this and understand it
  - Ignorance is no excuse!
  - Questions should be brought to instructor
- Plagiarism applies to both text and code.
- You are free (even encouraged) to exchange ideas, but no sharing code or text.

Plagiarism (2)

- Common mistakes
  - Excess collaboration with other students
    - Share ideas, but no design or code!
  - Using solutions from other sources
  - Asking public questions containing (partial) solutions
  - Posting (partial) solutions to websites (e.g., github)
- Possible penalties
  - First offense (for assignments; exams are harsher)
    - 0% for that assignment, -5% on final grade
  - Second offense
    - More severe penalties, including suspension
- Penalties for graduate students are more severe
- More information linked to from course syllabus

Self-tests

- The self-tests are worth 6% of your grade
- They're meant to help you keep up with the material, and gauge your grasp of it on an ongoing basis
- Check the calendar (LEARN /course website) for the release and deadline for each self-test
  - First test: available today, deadline next week (Fri at 3:00 pm). Late self-tests cannot be made up for any reason, including students signing up for the class late
  - You can (re)do each self-test multiple times before its deadline; your last grade is the one recorded.
- Format: online (on LEARN), usually multiple-choice questions

Final Assessment

- Covers the entire syllabus
- Must pass (≥ 50%) to pass course
- You will have 2.5 hours to complete the assessment
- Date: To be determined by school

A Note on Security

- In this course, you will be exposed to information about security problems and vulnerabilities with computing systems and networks.
- To be clear, you are not to use this or any other similar information to test the security of, break into, compromise, or otherwise attack, any system or network without the express consent of the owner
- In particular, you will comply with all applicable laws and University policies.
- See syllabus for more details.

Recommended Textbooks

- **Computer Security and the Internet: Tools and Jewels from Malware to Bitcoin (2nd Edition)**, Paul van Oorschot, Springer, 2021.
- **Security in Computing**, 5th edition, Charles P. Pfleeger, Shari Lawrence Pfleeger, Jonathan Margulies, Prentice-Hall, 2015.

- Digital copies are available via the library website (linked from LEARN)
- You are expected to know all the material presented in class, even if it's not in the textbooks.

Other readings

- From time to time, there will be additional assigned readings
- Links will be provided in the course website https://crysp.uwaterloo.ca/courses/cs458/F23-material/modules.php
- There will be both mandatory and optional readings
- You must read the mandatory ones before the class in which we will discuss them.
    - There is such a reading for the next lecture

Course Modules

1. Introduction to Security and Privacy
2. Program Security
3. Operating System Security
4. Network Security
5. Internet Application Security and Privacy
6. Data Security and Privacy
7. Non-Technical Aspects of Security and Privacy

Module outline

1. What is our goal in this course?
2. What is security?
3. What is privacy?
4. Who are the adversaries?
5. Assets, vulnerabilities, threats, attacks, and defences
6. Methods of defence

What is our goal in this course?

- Our primary goal is to be able to identify security and privacy issues in various aspects of computing, including:
  - Programs
  - Operating systems
  - Networks
  - Internet applications
  - Databases
- Secondarily, to be able to use this ability to design systems that are more protective of security and privacy.

What is security?

- In the context of computers, security generally means three things:
  - **C**onfidentiality
    - Access to systems or data is limited to authorized parties
  - **I**ntegrity
    - When you receive data, you get the “right” data
  - **A**vailability
    - The system or data is there when you want it
- A computing system is said to be secure if it has all three properties
  - Well, usually

Security and reliability

- Security has a lot to do with “reliability”
- A secure system is one you can rely on to (for example):
  1. Keep your personal data confidential
  2. Allow only authorized access or modifications to resources
  3. Ensure that any produced results are correct
  4. Give you correct and meaningful results whenever you want them

What is privacy?

- There are many definitions of privacy
- A useful one: "informational self-determination"
  - This means that you get to control information about you
  - "Control" means many things:
    - Who gets to see it
    - Who gets to use it
    - What they can use it for
    - Who they can give it to
    - etc.

Example: PIPEDA

- PIPEDA (Personal Information Protection and Electronic Documents Act) is Canada's private-sector privacy legislation
- Lists ten Fair Information Principles companies need to abide by:
  1. Identify the purpose of data collection
  2. Obtain consent
  3. Limit collection
  4. Limit use, disclosure and retention
  5. Use appropriate safeguards
  6. Give individuals access
  7. Be accurate
  8. Be open
  9. Be accountable
  10. Provide recourse

(Read more: https://www.priv.gc.ca/leg_c/p_principle_e.asp)

Consumer Privacy Protection Act

- Forthcoming legislation to regulate private sector use of personal information.
- Modernizing protection: meaningful consent, right to erasure, etc.
- Stronger provisions for enforcement.
- Private right of action.

Security vs. privacy

- Sometimes people place security and privacy as if they’re opposing forces.
- Are they really? Do we have to give up one to get the other?

Who are the adversaries?

- Who's trying to mess with us?
- Various groups:
  - Murphy
  - Amateurs
  - "Script kiddies"
  - Crackers
  - Organised crime
  - Government "cyberwarriors"
  - Terrorists
- Which of these is the most serious threat today?

Some terminology

- Assets
  - Things we might want to protect, such as:
    - Hardware
    - Software
    - Data
- Vulnerabilities
  - Weaknesses in a system that may be able to be exploited in order to cause loss or harm
  - e.g., a file server that doesn't authenticate its users

Some terminology

- Threats
  - A loss or harm that might befall a system
  - e.g., users' personal files may be revealed to the public

  - There are four major categories of threats:
    1. Interception
    2. Interruption
    3. Modification
    4. Fabrication

  - When designing a system, we need to state the threat model
    - Set of threats we are undertaking to defend against
    - Whom do we want to prevent from doing what?

Some terminology

- Attack
  - An action which exploits a vulnerability to execute a threat
  - e.g., telling the file server you are a different user in an attempt to read or modify their files
- Control/Defence
  - Removing or reducing a vulnerability
  - You control a vulnerability to prevent an attack and defend against a threat.
  - How would you control the file server vulnerability?
  - Our goal: control vulnerabilities

Methods of defence

- How can we defend against a threat?
  - Prevent it: prevent the attack
  - Deter it: make the attack harder or more expensive
  - Deflect it: make yourself less attractive to attacker
  - Detect it: notice that attack is occurring (or has occurred)
  - Recover from it: mitigate the effects of the attack
- Often, we'll want to do many things to defend against the same threat
  - "Defence in depth"

Example of defence

- Threat: your car may get stolen
- How to defend?
  - Prevent: Immobilizer? Is it possible to absolutely prevent?
  - Deter: Store your car in a secure parking facility, use “The Club”
  - Deflect: Have sticker mentioning car alarm, keep valuables out of sight
  - Detect: Car alarms, OnStar
  - Recover: Insurance

How secure should we make it?

- Principle of Easiest Penetration
  - "A system is only as strong as its weakest link"
  - The attacker will go after whatever part of the system is easiest for them, not most convenient for you.
  - In order to build secure systems, we need to learn how to think like an attacker!
  - How would you get private information from the US Social Security Administration database?

- Principle of Adequate Protection
  - "Security is economics"
  - Don't spend $100,000 to protect a system that can only cause $1,000 in damage

Weakest link

Defence of computer systems

- Remember we may want to protect any of our assets
  - Hardware, software, data
- Many ways to do this
  - Cryptography
  - Software Controls
  - Hardware Controls
  - Physical Controls
  - Policies and Procedures

Defence of computer systems

- Cryptography
  - Protecting data by making it unreadable to an attacker
  - Authenticating users with digital signatures
  - Authenticating transactions with cryptographic protocols
  - Ensuring the integrity of stored data
  - Aid customers' privacy by having their personal information automatically become unreadable after a certain length of time

Defence of computer systems

- Software controls
  - Passwords and other forms of access control
  - Operating systems separate users' actions from each other
  - Virus scanners watch for some kinds of malware
  - Development controls enforce quality measures on the original source code
  - Personal firewalls that run on your desktop

Defence of computer systems

- Hardware controls
  - Not usually protection of the hardware itself, but rather using separate hardware to protect the system as a whole
  - Fingerprint readers
  - Smart tokens
  - Firewalls, intrusion detection systems
  - Trusted Execution Environments (TEEs)

Defence of computer systems

- Physical controls
  - Protection of the hardware itself, as well as physical access to the console, storage media, etc.
  - Locks
  - Guards
  - Off-site backups
  - Don’t put your data centre on a fault line in California
  - Don’t put your nuclear power plant in a tsunami zone

Defence of computer systems

- Policies and procedures
  - Non-technical means can be used to protect against some classes of attack
  - If an employee connects their own Wi-Fi access point to the internal company network, that can accidentally open the network to outside attack
    - So don't allow the employee to do that!
  - Rules about choosing passwords
  - Training in best security practices

Recap

- What is our goal in this course?
  - Identify security and privacy issues
  - Design systems that are more protective of security and privacy
- What is security?
  - Confidentiality, Integrity, Availability
- What is privacy?
  - Informational self-determination

Recap

- Who are the adversaries?
  - Learn to think like an attacker
- Assets, vulnerabilities, threats, attacks and controls
  - You control a vulnerability to prevent an attack and block a threat
- Methods of defence
  - Cryptography, software controls, hardware controls, physical controls, policies and procedures