EITA25 Computer Security (Datasäkerhet)

Lectures and Course Responsibility
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Projects
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Course Organisation

- Credits: 7,5 hp
- Lectures
  - 14 x 2 hours
    - See webpage/schedule for time and place
- Mandatory examination will give you grade 3
  - 2 Projects
  - 3 Labs
  - 3 online quizzes
- Optional examination for grade 4 or 5
  - Written exam
    - Friday, March 22, 14-19, MA8
- Web: http://www.eit.lth.se/kurs/eita25

Projects and labs

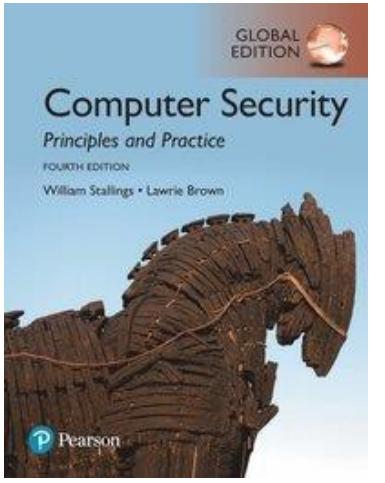
- Laboratories: 2 students/computer
  - Lab 1: Windows security, week 4
  - Lab 2: Unix/Linux security, week 5
  - Lab 3: Network security, week 7
- Project 1
  - 3-4 students/group
  - Digital certificates. Set up a secure connection with SSL/TLS.
- Project 2
  - 3-4 students/group
  - Using your connection from project 1, implement a server and a client and perform a security evaluation.
- You sign up in pairs or alone, then we form groups
- Group list will be posted on webpage when we know who is active on the course

Quizzes

- Will be released when topics have been covered on lectures
- Open 14 days, you get one attempt per 16 hours
- You have 90 minutes to finish a quiz
- 80% needed for passing each quiz
- You may consult book, internet, slides, notes etc, but you must do it yourself

Course Book

- W. Stallings and L. Brown: Computer Security, Principles and Practice, 4th edition, Pearson, 2018, ISBN: 9781292220611



- Course content is defined by
  - Book (the parts that are lectured)
  - Lectures + Lecture slides
  - Project material
  - Laboratory material

Security Courses

Basic Courses

- **Computer Security** (G1)
  - VT1
  - 7.5 credits
- **Web Security** (G2)
  - HT1
  - 4 credits

Advanced Courses

- **Secure Systems Engineering**
  - NEW 2020
  - VT1
  - 7.5 credits
- **Advanced Computer Security** (A)
  - HT1
  - 7.5 credits
- **Advanced Web Security** (A)
  - HT2
  - 7.5 credits
- **Cryptology** (A)
  - HT2,
  - 7.5 credits

Content of this course

- General introduction to the very broad world of computer security
  - Basic cryptography
  - Access control
  - Operating system security
  - Network security
  - Mobile security
  - Software security

About the course

Advice from previous students

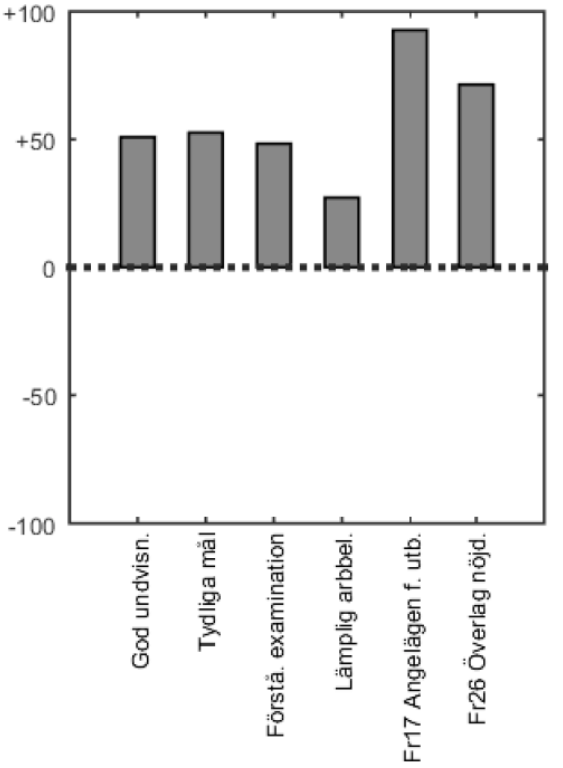
- Start doing the preparatory assignments for the second lab early
- Project 2 takes more time than project 1

Common misconception

- There is too much programming in the course considering it is not a programming course

Do not see your education as a set of independent courses

CEQ 2018



Prerequisites

- You should be comfortable with Java programming.

Diversity among students

- C Students
  - Programmeringsteknik
  - Programmeringsteknik – fördjupningskurs
  - **Kommunikationssystem**
  - **Informationsöverföring**
  - **Internetprotokoll**
- D students
  - Programmeringsteknik
  - Programmeringsteknik – fördjupningskurs
  - **Objektorienterad modellering och design**
  - **Datorkommunikation**
  - **Digitalteknik**
  - **Datorteknik**
  - **Algoritmer, datastrukturer och komplexitet**

This has been taken into account. Similar for BME, E, F and I.

You. Only. Need. To. Know. Some. Java.

Goal for this course

- Be familiar with the main concepts in computer security
  - Definitions, models, evaluation, etc...
- Have a basic understanding of means and methods that provide increased security
  - SSL, IPsec, key agreement protocols, etc...
- Have a basic understanding of security vulnerabilities
  - Attacks, implementation mistakes, etc…

- Get hands-on experience with digital certificates, secure connections, logon techniques, computer scanning, network sniffing, OpenSSL

Laboratory and project part

Computer Security

> Measures and controls that ensure **confidentiality**, **integrity**, and **availability** of information system assets including hardware, software, firmware, and information being processed, stored, and communicated.
>
> The NIST Internal/Interagency Report NISTIR 7298 (*Glossary of Key Information Security Terms* , May 2013)

- Confidentiality, Integrity, Availability - Sometimes memorized as CIA

- **Confidentiality:** prevent unauthorized disclosure of information.
- **Integrity:** prevent unauthorized modification of information.
- **Availability:** prevent disruption of access to or use of information.
- Other aspects:
  - **Authenticity**
  - **Accountability**
  - **Nonrepudiation**

Confidentiality

- Prevent unauthorized disclosure of information
- Related to the *reading* of data
  - More generally – the *learning* of data
- Two aspects
  - **Data confidentiality:** protection of private and confidential information.
  - **Privacy:** Assures that individuals control or influence information related to them.
- Achieved by encryption, access control
- Confidentiality also applies to existence of data

Integrity

- Prevent unauthorized modification of information.
- Related to the *writing* of data
- **Two aspects**
  - **Data integrity:** Assures that information and programs are changed only in a specified and authorized manner.
  - **System integrity:** Assures that a system performs its intended function, free from unauthorized manipulation.
- **Other definitions**
  - **ITSEC:** prevent unauthorized modification of information (prevent unauthorized writing).
  - **Clark and Wilson**: No user of the system, even if authorized, may be permitted to modify data items in such a way that assets or accounting records of the company are lost or corrupted.
  - **Orange Book:** Data Integrity - The state that exists when computerized data is the same as that in the source document and has not been exposed to accidental or malicious alteration or destruction.

Integrity cont'd

- **Integrity in communications:** detection (and correction) of modifications of transmitted data, including both intentional modifications and random transmission errors.
- **In the most general sense:** make sure that everything is as it is supposed to be; the data in a computer system should correctly reflect some reality outside the computer system.
- Integrity is a prerequisite for many other security services. Operating systems security has a lot to do with integrity.
  - Circumventing confidentiality protection can be done by circumventing integrity protection
- Integrity can be achieved by CRCs, hash functions, Message Authentication Codes (MACs), Digital Signatures
  - All have different properties

Availability

- Assures that systems work promptly and service is not denied to authorized users
- **CTCPEC:** The property that a product's services are accessible when needed and without undue delay.
- **ISO 7498-2:** The property of being accessible and usable upon demand by an authorized entity.

- **Denial of Service (DoS):** The prevention of authorized access of resources or the delaying of time-critical operations.
  - Send malformed network packets to crash a computer
  - Utilize all capacity of a given host
  - Registering the domain with the name of a company may affect the availability for that company.

Accountability and Authentication

- We can not prevent authorized actions
- Users should be held responsible for their actions

- **Accountability (Orange Book):** audit information must be selectively kept and protected so that actions affecting security can be traced to the responsible party.
- Users are *identified* and *authenticated* to have a basis for access control decisions.
- The security system keeps an audit log (audit trail) of security relevant events to detect and investigate intrusions.
  - Access to the log must be controlled so that no one can change previous entries

Nonrepudiation

- A way to guarantee that the sender of a message cannot later deny having sent the message and that the recipient cannot deny having received the message.
- Divided into (from common criteria)
  - **Nonrepudiation of origin:** Ensures that the originator of information cannot successfully deny having sent the information.
  - **Nonrepudiation of receipt:** Ensures that the recipient of information cannot successfully deny having received the information.
- **Example:** You should not be able to deny having signed a contract.
- Can be achieved by *digital signatures*

Assets of Computer System

Security is about protecting assets!

Hardware – Computer system, storage and storage devices, communications devices

Software – Operating system and applications

Data – Files and databases

Communication lines and networks – LAN/WAN communication links, bridges, routers

Vulnerabilities, Threats and Attacks

Threats

- Threats are hypothetical events capable of exploiting vulnerabilities
  - Can create loss of confidentiality, integrity and/or availability
- Potential security harm to an asset or a resource
  - Person or event
  - Deliberate, accidental or act of nature

Examples of Threats

	Availability	Confidentiality	Integrity
Hardware	Equipment is stolen or disabled, thus denying service.	An unencrypted DVD or USB device is stolen.	Hardware is modified to perform unintended tasks
Software	Programs are deleted, denying access to users.	An unauthorized copy of software is made.	A working program is modified, either to cause it to fail during execution or to have it do some unintended task
Data	Files are deleted, denying access to users.	An unauthorized read of data is performed. An analysis of statistical data reveals underlying data.	Existing files are modified or new files are fabricated.
Communication lines and networks	Messages are destroyed or deleted. Communications lines or networks are rendered unavailable.	Messages are read. The traffic pattern of messages is observed.	Messages are modified, delayed, reordered, or duplicated. False messages are fabricated.

Vulnerabilities, Threats and Attacks

Vulnerabilities

- A vulnerability is an issue that can result in a successful attack
- Inherent weakness in the design, implementation, configuration or management of a system
- Something that allows the threat to be realized
- Categories
  - Corruption – loss of integrity
  - Leaky – loss of confidentiality
  - Unavailable or very slow – loss of availability

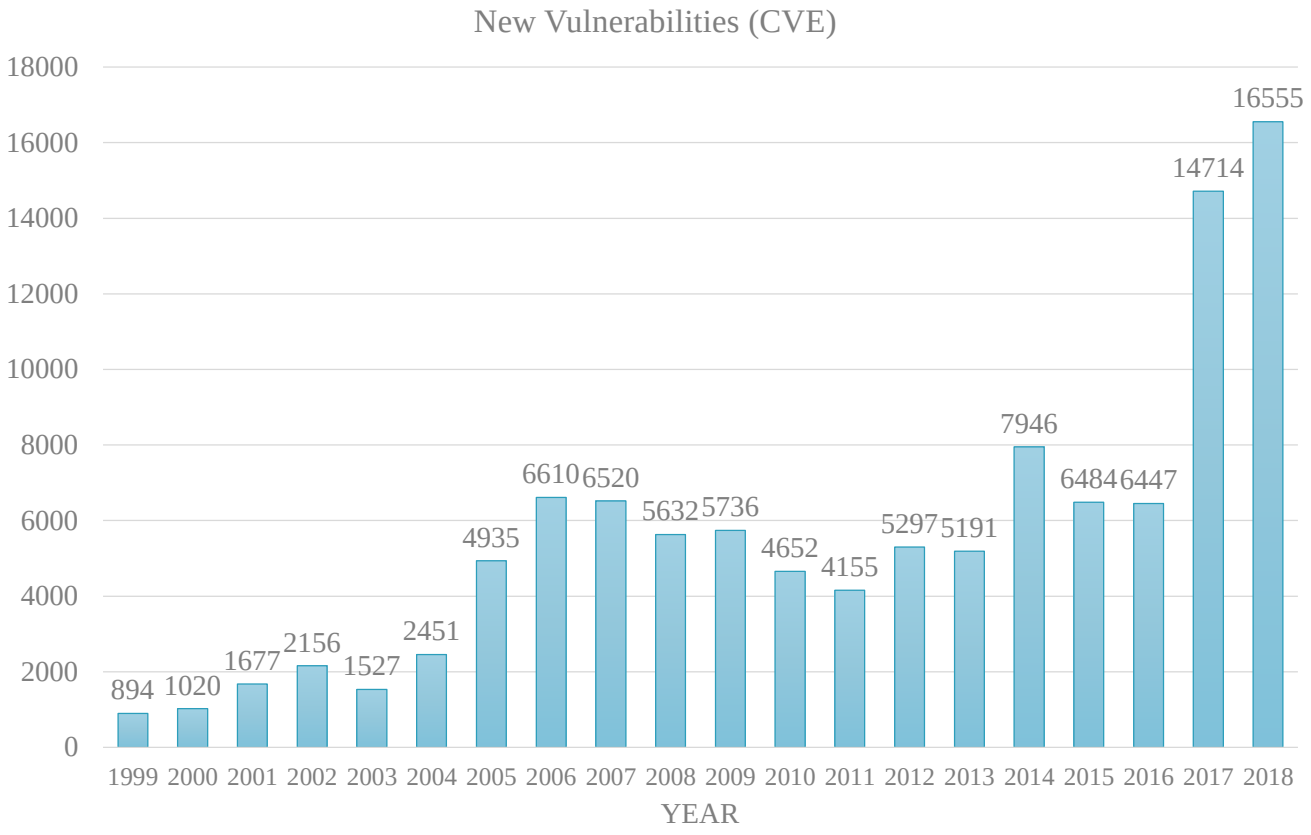
Example, CVE

- Common Vulnerabilities and Exposures
- Administered by Mitre
- NIST provides a database with more information and analysis of each vulnerability
- Includes severity rating
- Database includes more than 100 000 vulnerabilities

CVSS v3.0 Severity and Metrics:

Base Score: 6.1 MEDIUM
Vector: AV:N/AC:L/PR:N/UI:R/S:C/C:L/I:L/A:N (V3 legend)
Impact Score: 2.7
Exploitability Score: 2.8

Attack Vector (AV): Network
Attack Complexity (AC): Low
Privileges Required (PR): None
User Interaction (UI): Required
Scope (S): Changed
Confidentiality (C): Low
Integrity (I): Low
Availability (A): None


New Vulnerabilities (CVE)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
894
1020
1677
2156
1527
2451
4935
6610
6520
5632
5736
4652
4155
5297
5191
7946
6484
6447
14714
16555
1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018
YEAR

Vulnerabilities, Threats and Attacks

Attack

- Threat that is carried out – sometimes taking advantage of a vulnerability
  - Also called *threat action*
  - Done by *attacker* or *threat agent*

- Passive vs. active attacks
  - *Passive attack* - attempt to learn or make use of information from the system without affecting system resources
  - *Active attack* - attempt to alter system resources or affect their operation

- Insider vs. outsider attacks (attack origin)
  - *Insider* - Initiated by an entity inside the security perimeter
  - *Outsider* - Initiated from outside the perimeter, by an unauthorized or illegitimate user of the system

Example of Passive Attack (2018)

Tinder App

Threat to **confidentiality:** Someone might read the data sent on the network in order to obtain information about users' actions

Vulnerability:

User profile pictures taken from unencrypted HTTP
→ Can be eavesdropped

Swipe gestures submitted to encrypted API

Expected result:
An eavesdropper can see who you are viewing, but not your decision

Vulnerability:

- Left swipe gives 278 byte response from API
- Right swipe gives 374 byte response
- Match gives 581 byte response

Actual result:
An eavesdropper can see who you are viewing and your decision for that person

Attack:

1. Connect to same network as victim
2. Eavesdrop and analyze data

Computer Security Strategy

Three aspects

1. Specification/Policy – Description of desired behavior. Considerations:

- What assets are being protected?
- System vulnerabilities.
- Potential threats and likelihood of attacks.
- Ease of use versus security.
- Cost of security versus cost of failure.

2. Implementation – How to obtain the desired behavior. Divided into

- Prevention
- Detection
- Response
- Recovery

3. Assurance and evaluation – How to know that it actually works. A degree of confidence. Does the design meet the requirements? Does the implementation meet the specification?

Implementation

Example – Stolen passwords (service provider perspective)

- **Prevention:**
  - Use up-to-date software *(perhaps obvious to most)*
  - Protect the actual passwords *(We will talk about this in detail)*
  - Validate all user input coming from web forms and open APIs *(Details in web security course, some aspects in this course)*
- **Detect:**
  - Reports from users about strange activity in their account
    - provide an easy way for users to file these reports
  - Password file published on Internet
    - Scan typical places where these are published
- **Response:**
  - Tell all users to change password (Who will do it? How will it be done?)
  - Know how to handle media, e.g., say that the attackers were extremely sophisticated and it could have happened to anyone, even though you know it's bullshit. (Who will talk to media?)
- **Recovery:**
  - Analyze attack and look over the prevention mechanisms (Who will do that?)

This does happen

Some examples of attacks on passwords/accounts:

- **Feb 2008 –** 24 000 hashed passwords from dataföreningen
- **April 2008 –** 1 000 000 accounts on Spray stolen
- **Dec 2009 –** 32 million RockYou passwords published on Internet
- **Oct 2011 –** 93 000 hashed passwords to bloggtoppen published on Internet
- **June 2012 –** 6.5 million hashed passwords from LinkedIn published on Internet
- **July 2012 –** 450 000 passwords from Yahoo published on Internet
- **Oct 2013 –** 150 000 000 encrypted passwords from Adobe published on Internet
- **Aug 2015 –** 36 000 000 hashed passwords from Ashley Madison published on Internet
- **June 2018** – 92 300 000 hashed passwords were leaked from MyHeritage

Example, cont'd

- With good **prevention** the attacks (at least some) could have been avoided
- With good **detection** the attacks could have been detected before passwords reached wide spread
- With good **response and recovery** users might stay with the provider
- Example, Spray attack April 2008. (One) **response**

> *...vi håller faktiskt just nu på att byta leverantör på vårt mejlsystem så det här kommer inte att kunna hända oss igen.*
>
> Article in Aftonbladet, April 20, 2008

- Spray was hacked again in May 2008. (One) **response**

> *Hackare kommer alltid på nya sätt att attackera sidor. Det går inte att skydda sig till hundra procent.*
>
> Article in SvD, May 30, 2008

Assurance and Evaluation

Who Should Evaluate?

- **Alternative 1:** One government body
  - Fair, since the same body does all evaluations
  - Not all products are accepted for evaluation
  - Slow, for the same reason
- **Alternative 2:** Private evaluators
  - More difficult to make it fair: Will evaluations be consistent?
    - **Repeatability**: re-evaluation by the same team
    - **Reproducability**: re-evaluation by a different team
    - Formulation of criteria is important so there is no room for interpretation
  - More evaluators → faster evaluation

Functionality vs. Assurance

- Functionality is evaluated – Assurance is the result
- Two contrasting approaches

Orange Book (TCSEC)
- U.S. Department of defense 1983
- Primarily for operating systems
- Evaluation service offered for free (sometimes with long delays)
- Evaluation performed by government body

Evaluation level **combined** functionality and degree of assurance

Only recognized in the U.S.

ITSEC
- European initiative 1990
- EU recommendation 1995
- Suitable for both systems and products (TOE)
- Fee for evaluation
- National bodies issued certificates and controlled and approved evaluators

Evaluation **level only based on assurance** – functionality completely flexible

Only recognized in Europe

Common Initiative – Common Criteria

- A common standard is more commercially attractive
- Common Criteria initiated in 1998 (ISO 15408)

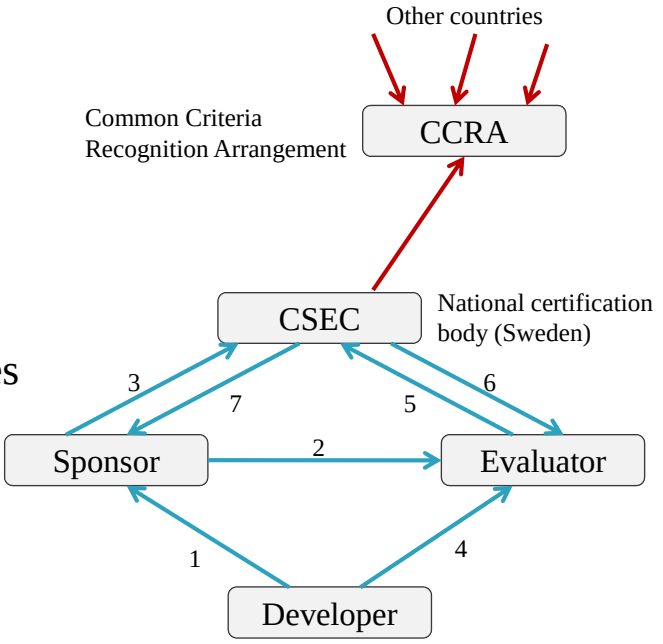
- Similar to ITSEC in that it separates functionality and assurance
- Uses **protection profiles (PP)** to identify and collect security requirements relevant to certain areas, e.g., operating systems, databases, firewalls, smart cards, etc
- **Evaluation Assurance Level (EAL)** is used to define the degree of confidence
  - EAL1 – EAL7
- CC evaluation required by some public sector customers

Criticism

- Expensive (sometimes 10% - 40% of development cost)
- Time delay
- Only applies to one version and one configuration
  - "Assurance continuity" allows minor changes

CC – Evaluation and Certification

1. Evaluation Agreement. Developer not needed for EAL1.
2. Evaluation order – produce a certification application together
3. Certification order – application is sent
4. Send documentation, source code etc.
5. Evaluation report – Evaluator follows procedures given in Common Criteria in the evaluation process
6. Report is approved after an independent review of the report
7. Send certificate and a certificate report



Some Problems in Computer Security

- Some secret information has to be stored somewhere
  - Keys, passwords, etc...
- The designer has to eliminate ALL weaknesses – an attacker only needs to find ONE weakness
- Security solutions might be very different even between products that seem similar. New solutions means new potential weaknesses.
- A system is only as secure as its weakest link
- Even if the system, product, computer, protocol etc, is completely secure, there are humans using them.
- Some people tend to design their own security without proper knowledge.