Course overview

- What are our goals in this course?
- What is trust?
- What is security?
- What is privacy?
- Who are the adversaries?
- Terminology
- Common defence methods

What are our goals in this course?

- To be able to identify security, privacy, and trust issues in various aspects of computing, such as:
  - Programs
  - Operating systems
  - Networks
  - Distributed systems
  - Internet applications
- The ability to critically read and digest the key elements of research papers in the field
- The awareness of how security, privacy, and trust can be achieved in practice

The landscape

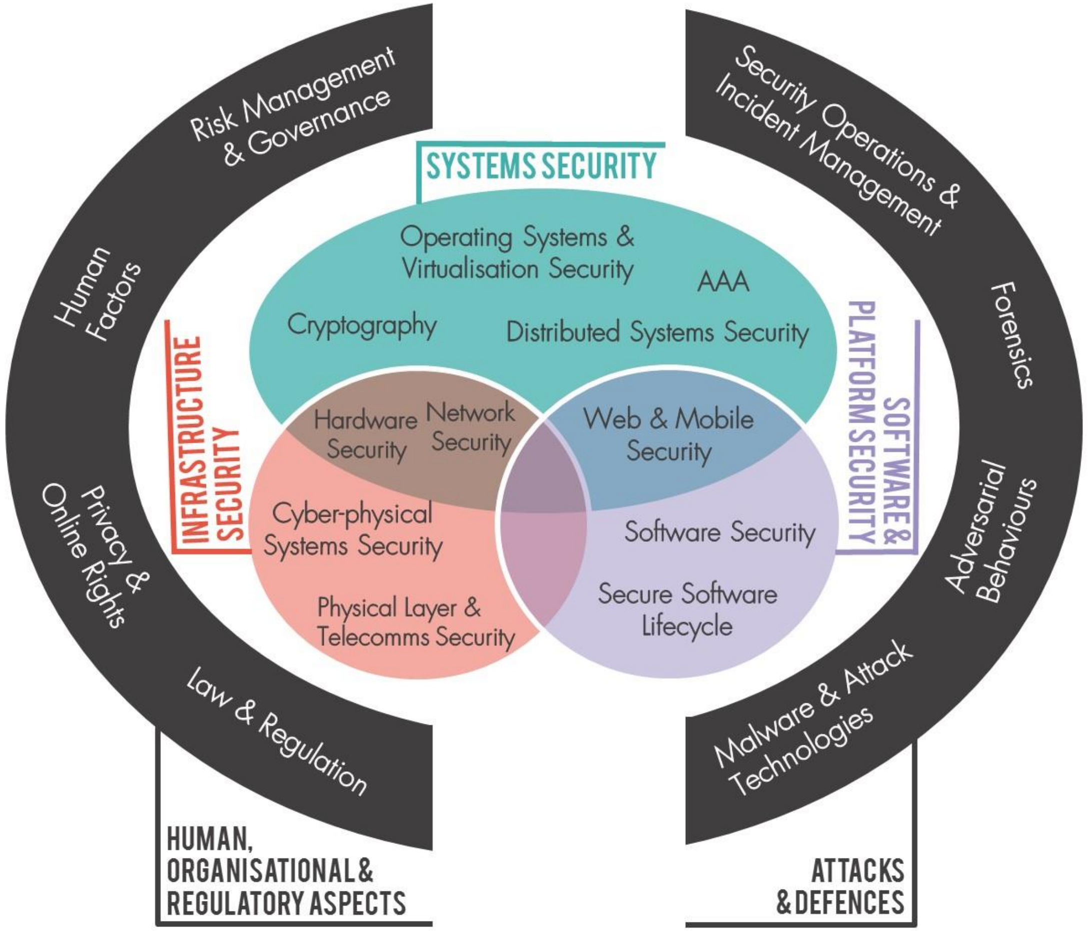
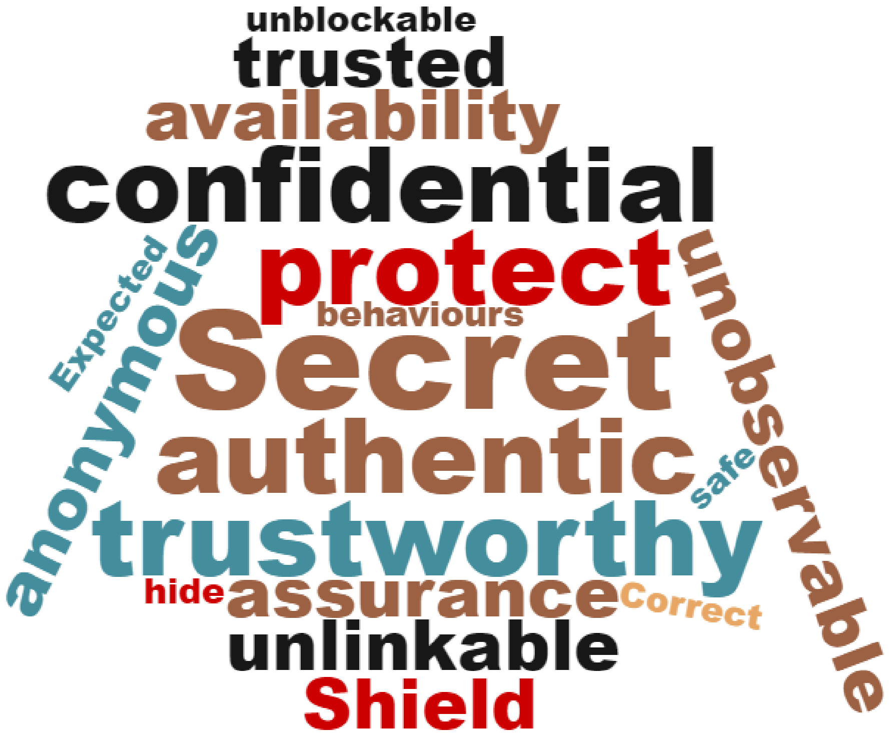

Risk Management & Governance
Human Factors
Privacy & Online Rights
Law & Regulation
HUMAN, ORGANISATIONAL & REGULATORY ASPECTS
SYSTEMS SECURITY
Operating Systems & Virtualisation Security
AAA
Cryptography
Distributed Systems Security
INFRASTRUCTURE SECURITY
Hardware Security
Network Security
Cyber-physical Systems Security
Physical Layer & Telecomms Security
Web & Mobile Security
Software Security
Secure Software Lifecycle
SOFTWARE & PLATFORM SECURITY
Security Operations & Incident Management
Forensics
Adversarial Behaviours
Malware & Attack Technologies
ATTACKS & DEFENCES

Image: CyBOK

What do we want?



What do the we mean when we say…?

- Authentic

- Safe

- Common language/sense → (more) Formal language/models
  - Based on definitions
  - Properties of the system, the data, usage, and abilities of the participants
  - Wide-spread agreement (in some areas; still evolving)

Who is we?

- Ordinary citizen
- Whistle blower
- Corporate worker
- Dissident activist
- Secret agent

What is security?

- The main general properties are:
  - Confidentiality
    - Information access to only authorized entities

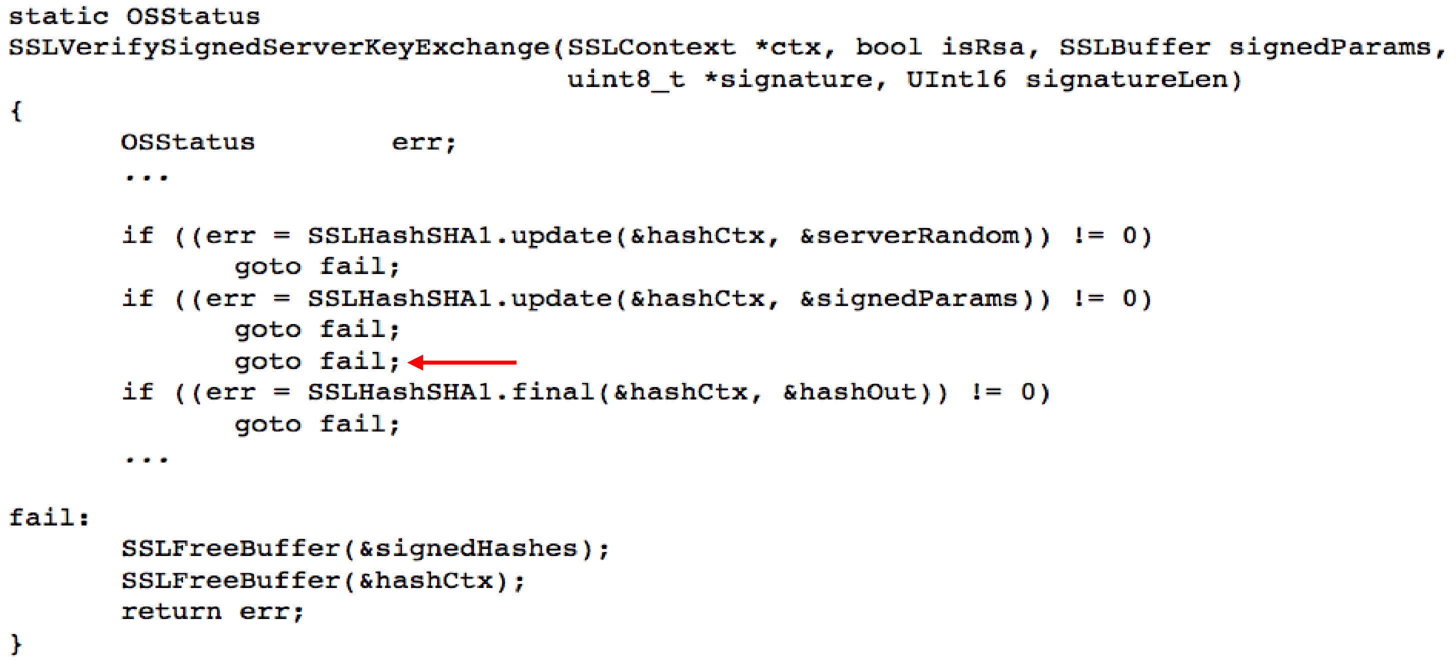
Authenticity

  - Integrity
    - The data is untampered and uncorrupted
  - Availability
    - Both the data and the system that provides access to it are there when you need them
- Are these enough? What can still go wrong?

Failure of Security: Apple Security Cert Validation Bug

- The bug occurs in code that is used to check the validity of the server's signature on a key used in an SSL/TLS connection.

- An active attacker (a “man-in-the-middle”) could potentially exploit this flaw to get a user to accept a counterfeit key that was chosen by the attacker.



```
static OSStatus
SSLVerifySignedServerKeyExchange(SSLContext *ctx, bool isRsa, SSLBuffer signedParams,
                                 uint8_t *signature, UInt16 signatureLen)
{
        OSStatus        err;
        ...

        if ((err = SSLHashSHA1.update(&hashCtx, &serverRandom)) != 0)
                goto fail;
        if ((err = SSLHashSHA1.update(&hashCtx, &signedParams)) != 0)
                goto fail;
                goto fail;
        if ((err = SSLHashSHA1.final(&hashCtx, &hashOut)) != 0)
                goto fail;
        ...

fail:
        SSLFreeBuffer(&signedHashes);
        SSLFreeBuffer(&hashCtx);
        return err;
}
```

Failure of Security: Meltdown/Spectre

- Speculative execution speeds up CPUs
- Does not respect/check memory access permissions (i.e. protected memory regions)
- Specially crafted ops can cause timing based information leaks
- Allows adversary to read secrets that are in cache

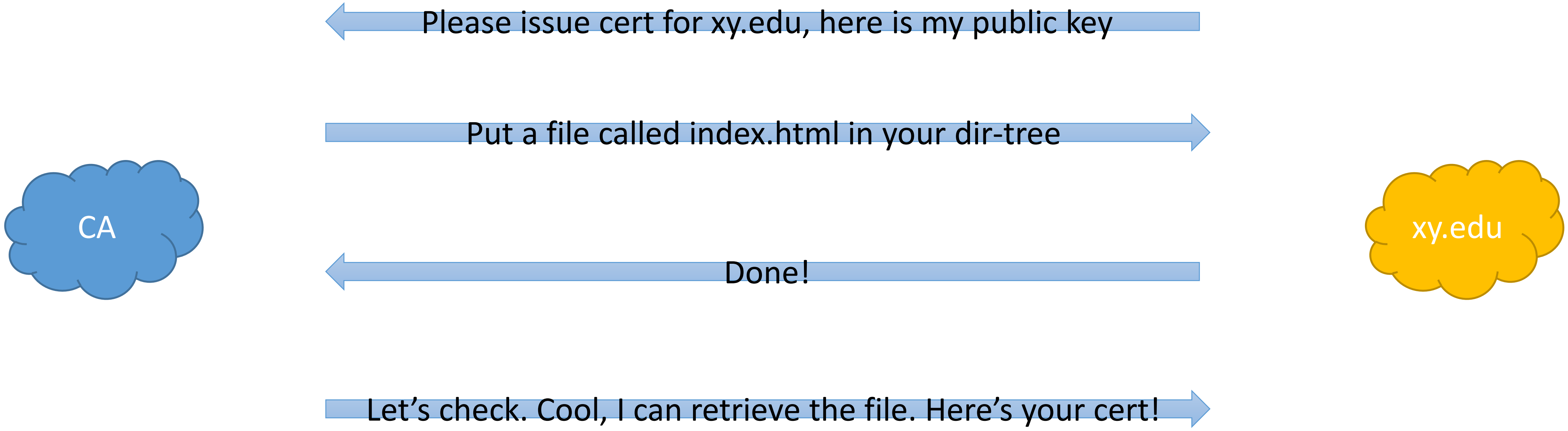
Image: Google/Natascha Eibl

What is trust?

- Generally, we trust when we have:
  - Assurance
    - The means to know that the system is secure
  - Reliability/Resilience
    - To operate intact in the face of natural disasters and human-launched attacks
  - Accountability
    - The means to verify that the system is operating as designed (i.e. securely)

NB: There is a difference between trustworthy and trusted

Failure of Trust:
CA Domain Control Validation



Please issue cert for xy.edu, here is my public key

Put a file called index.html in your dir-tree

Done!

Let’s check. Cool, I can retrieve the file. Here’s your cert!

Failure of Trust:
BGP Certificate Authority Attacks

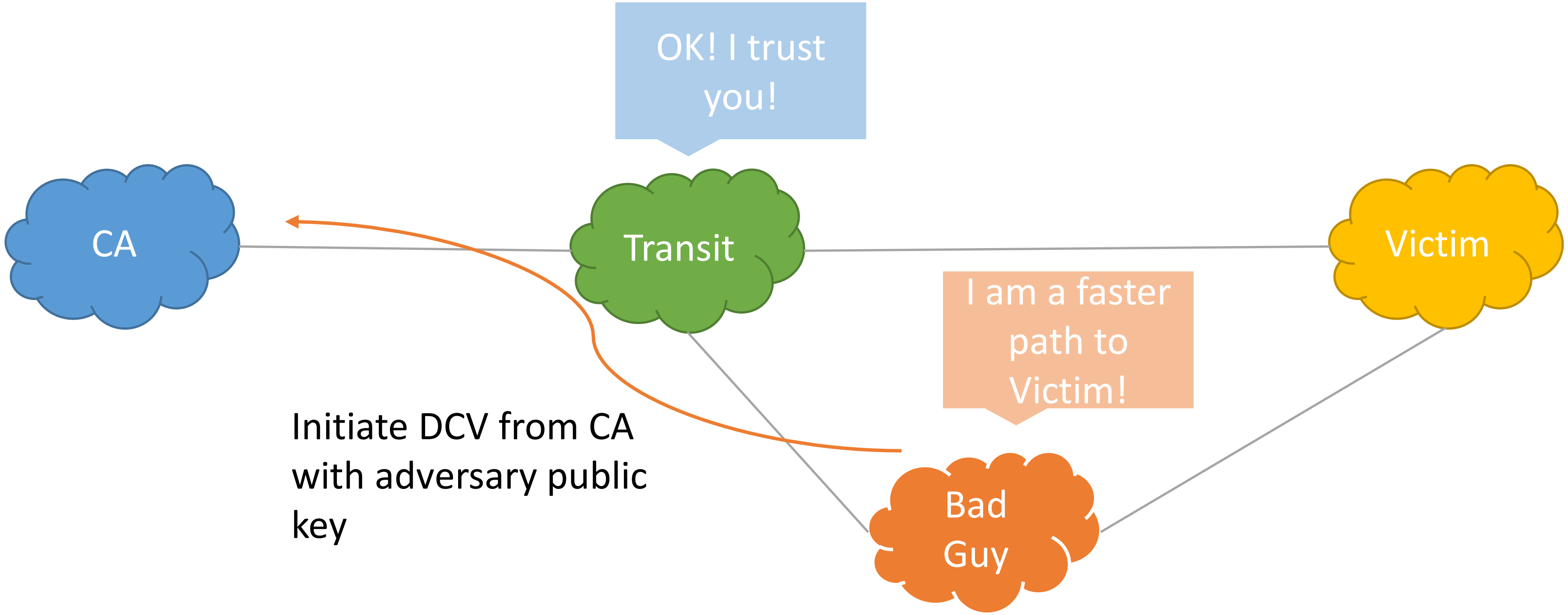
- Adversary announces more specific route to victim domain

- Intercepts Domain Control Validation message

- Responds (before the real destination)

- Gets the Certificate issued for victim domain using the private key controlled by adversary

Failure of Trust:
BGP Certificate Authority Attacks



OK! I trust you!

CA

Transit

Victim

I am a faster path to Victim!

Initiate DCV from CA with adversary public key

Bad Guy

Failure of Trust:
Operational security of digital certs

- Symantec has a track record of fumbling certificate issuance, once even wrongly issuing one for google.com

- Google chrome, among other browsers removes Symantec as a root CA

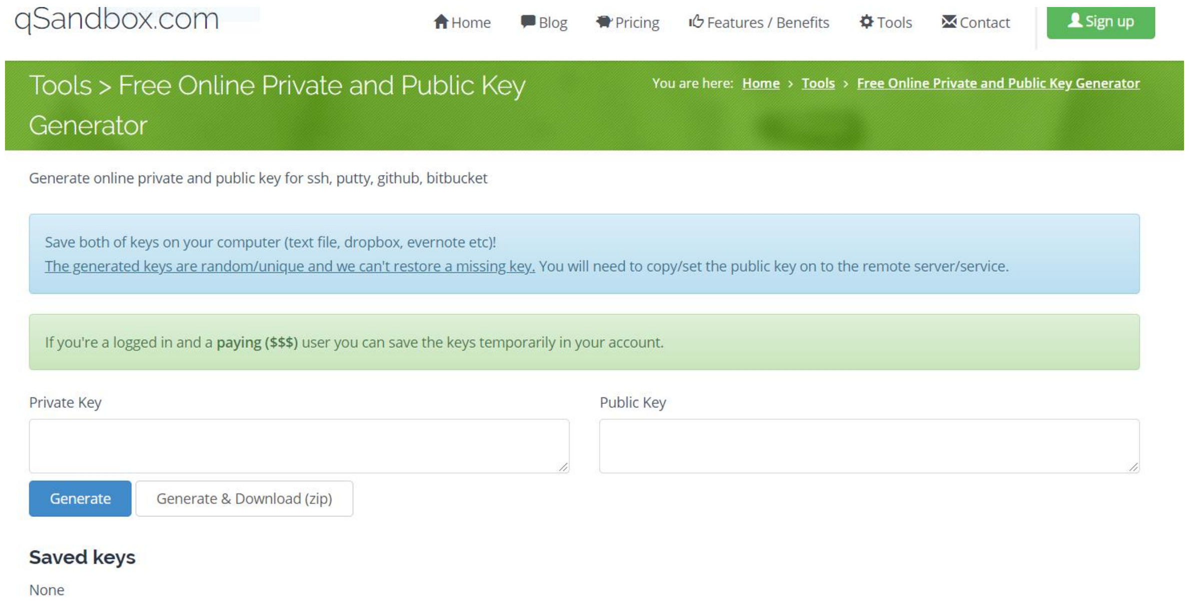
- Trustico (Symantec reseller) emails 23,000 private keys for certs they issued, thus invalidating them (how did they get them?)

- All 23,000 certs are revoked within 24 hours

*Logo from Trustico website

Convenient insecurity

- Offer a service to generate public/private key pairs
- Do not delete the keys afterwards
- ???
- Profit



Tools > Free Online Private and Public Key Generator

You are here: Home › Tools › Free Online Private and Public Key Generator

Generate online private and public key for ssh, putty, github, bitbucket

Save both of keys on your computer (text file, dropbox, evernote etc)!
The generated keys are random/unique and we can't restore a missing key. You will need to copy/set the public key on to the remote server/service.

If you're a logged in and a **paying ($$$)** user you can save the keys temporarily in your account.

Private Key

Public Key

Saved keys

None

What is privacy?

- Concerns individuals and their expectations on how their data, behaviours, and interactions are recorded, utilized, and spread

- A useful definition: “Information self-determination”
  - A person gets to control information about themselves

  - Controls can include:
    - Who gets to see it
    - Who gets to use it
    - What they can use it for
    - Who they can give it to

Failure of Privacy:
Vancouver Coastal Health

- Hospital paging systems broadcast medical data
- Data is unencrypted
- Anyone with some knowledge and time can intercept
- Data includes name, age, diagnosis, room number, among other details
- Ongoing as of 9/9/2019

https://openprivacy.ca/blog/2019/09/09/open-privacy-discovers-vancouver-patient-medical-data-breach/

Failure of Privacy:
New York Taxi Database

- Database released for research

- Taxi numbers and licence numbers pseudonymized
  - MD5 hash
  - Same input = Same result

- Taxi/Lic. numbers have structure
  - Results in reduced number of possible values
  - Brute force is feasible on 24 million numbers

https://www.theguardian.com/technology/2014/jun/27/new-york-taxi-details-anonymised-data-researchers-warn

Failure of Privacy:
New York Taxi Database

Taxi #	Lic. #
3A3D444BB	01001EDFD
…	…
…	…
ADE034523	B0BB321AA

DATABASE

1. Enumerate all values with structures:
5X55, XX555, XXX555, 5XXXXXX, 5XXXXXXX

2. Hash all values above with MD5

3. Compare results with database on left

How could we have prevented this?

- Was the problem lack of education?
- Could some processes have helped?
- Were the problems obvious?
- Were the right stakeholders involved?

Who are the adversaries?

- All systems are vulnerable to all manner of threats

- Adversary types:
  - Nature
  - Script kiddies
  - Crackers/Hackers
  - Organised Crime
  - Governments
  - Terrorists

- Who should we worry about most? Can we ignore anyone?

Threat Modelling

- Who is the adversary (the system may protect against many types)?

- What are they allowed to do? Or, what can’t we prevent them from doing?
  - The adversary need not be malicious, he could merely be curious

- What do we want to prevent the adversary from doing or learning?
  - What is the adversary’s aim, or, when does he win?

- The set of threats we want to protect against given this (set of) adversaries
  - When do we win?
  - When does the adversary win?

Terminology

- Assets: Things we want to protect, like:
  - Hardware
  - Software
  - Information

- Vulnerabilities
  - Weaknesses in a system that may be exploited
    - Example: Public facing email server without spam protection

Terminology

- Threats
  - Loss or damage to the system, its users, or operators
    - E.g. Proprietary source code being stolen and sold
  - The six major categories of threats:
    - Interception
    - Interruption
    - Modification
    - Fabrication
    - Repudiation
    - Epistemic

Terminology

- Attack
  - An action that exploits a vulnerability to carry out a threat
    - E.g. Hacking the company public facing email server to read emails to steal company trade-secrets

- Controls
  - Mitigating or removing a vulnerability
  - The control mitigates a vulnerability to prevent an attack and that defends against a threat
  - No system is perfect: Control vulnerabilities when discovered

Security Principles

- Economy of mechanism: easy to understand, verify, and maintain
- Fail-safe defaults: conservative permissions and functionality
- Complete mediation: every access should be checked (again)
- Open design: no security by obscurity
- Separation of privilege: cooperation required to act, no single point of failure
- Least privilege: programs and users on bare minimum of access
- Least common mechanism: minimize shared means of access to resources
- Psychological acceptability: well designed UI that are intuitive and clear
- Work factor: comparable effort for the value of the resource
- Compromise recording: record failures and breaches

Common defence methods

- There are 5 common defence patterns:
  - Prevent
  - Deter
  - Deflect
  - Detect
  - Recover

  NB: Not all attacks can be prevented!

- Best practice to employ some form of all to get "defence in depth"

Trade-offs

- Can we have secure, privacy-friendly, and trustworthy (SecPrivTru) systems?
  - Privacy means potentially hiding information; can the system be assured to be safe when it does not know all the data?

- SecPrivTru vs. Cost
  - There is a cost to operating more secure systems
  - Are the assets worth the effort? (See next slide)
  - Non-technical solutions (e.g. insurance)?

- SecPrivTru vs. Performance
  - There is an overhead to gain SecPrivTru properties
  - How much performance degradation can we tolerate?
  - What properties do we really need?

How secure, private, trusted should it be?

- Weakest link
  - An adversary will attack the most vulnerable part of the system, not the one that is the easiest for you to defend
  - Requires thinking like an attacker
  - Attack trees and threat modelling can be useful tools

- Cost-Benefit Analysis
  - Economic incentives
  - Do not spend more on protecting an asset than it is worth
    - What about user privacy?

Defence tools of the trade

- Protect assets that can be
  - Hardware, software, data (PII, social graph, confidential information, etc.)

- Many forms of control
  - Cryptography
  - Software controls
  - Hardware controls
  - Physical controls
  - Policies and procedures

Cryptography

- Protects the data, making it unreadable by anyone without keys

- Authenticating users with digital signatures

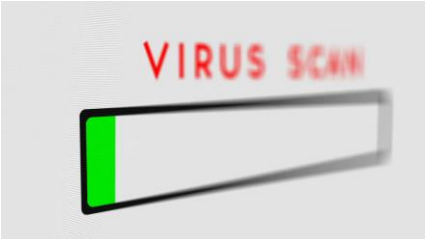
- Authenticating transactions with cryptographic protocols

- Ensures the integrity of data against unauthorized modification

Software controls

- Passwords
- Sandboxes
- Virus scanners
- Source code versioning systems
- Software Firewalls
- Privacy enhancing technologies (PETs)

KeePass



mercurial git

Hardware controls

- Fingerprint readers
- Smart tokens
- Firewalls
- Intrusion detection systems

Physical controls

- Protecting against unauthorized physical access to hardware

- Locks

- Guards

- Off-site backups

- Not placing critical systems in natural disaster zones

Policies and procedures

- Non-technical means to protect against some type of attacks
- Disallow personal hotspot within work place
- Password rules
- Security training against social engineering attacks

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, Authenticity
- What is Trust?
  - Assurance, Reliability/Resilience, Accountability
- What is Privacy?
  - Informational self-determination

Recap

- Who are the adversaries?
  - Threat modelling
  - Learn to think like an attacker
- Trade-offs
  - Security, Privacy, Performance, Cost
- 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