Security

CDK 11

MDS E2015
Søren Debois

Meta

Next week

- Mini-project 2.
- To be carried out in the week before and after the fall-break.
- Not in the week *of* the fall-break.

Plan

- Introduction to Security
- Applied cryptography
- [Propaganda]

Summary

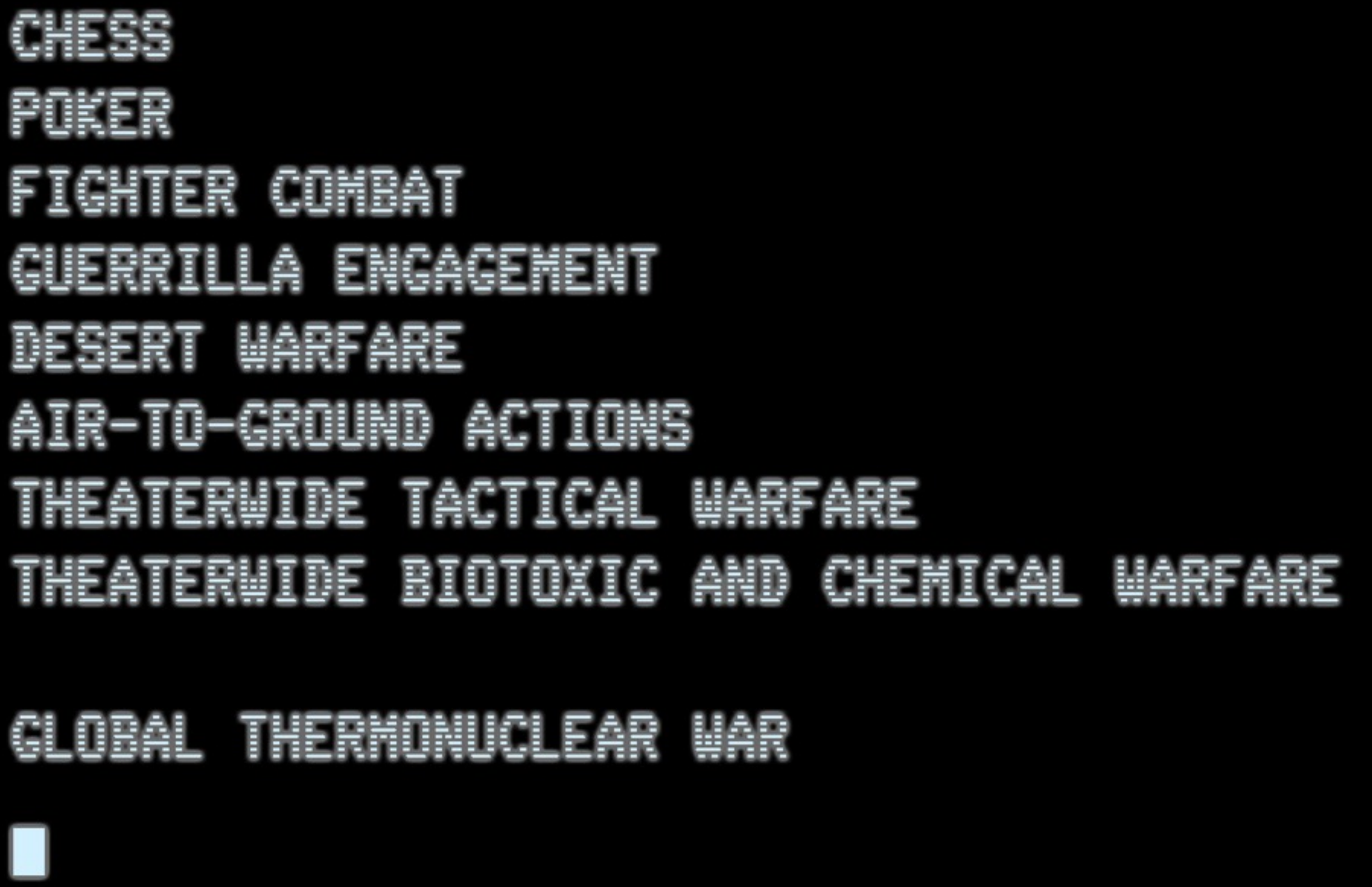
Summary

- Importance of time.
- Synchronising clocks.
- Logical time, happens-before
- Global state
- Snapshot

Introduction to IT-security

Premise

Beware the adversary.


CHESS
POKER
FIGHTER COMBAT
GUERRILLA ENGAGEMENT
DESERT WARFARE
AIR-TO-GROUND ACTIONS
THEATERWIDE TACTICAL WARFARE
THEATERWIDE BIOTOXIC AND CHEMICAL WARFARE
GLOBAL THERMONUCLEAR WAR

Goals

Security goals

- Confidentiality
  “Prevent unauthorised access to information.”

- Integrity
  “Prevent unauthorised altering of information.”

- Availability
  “Ensure the availability of the system for authorised uses.”

- Accountability
  “Actions of a principal may be traced uniquely to that principal.”

Leakage

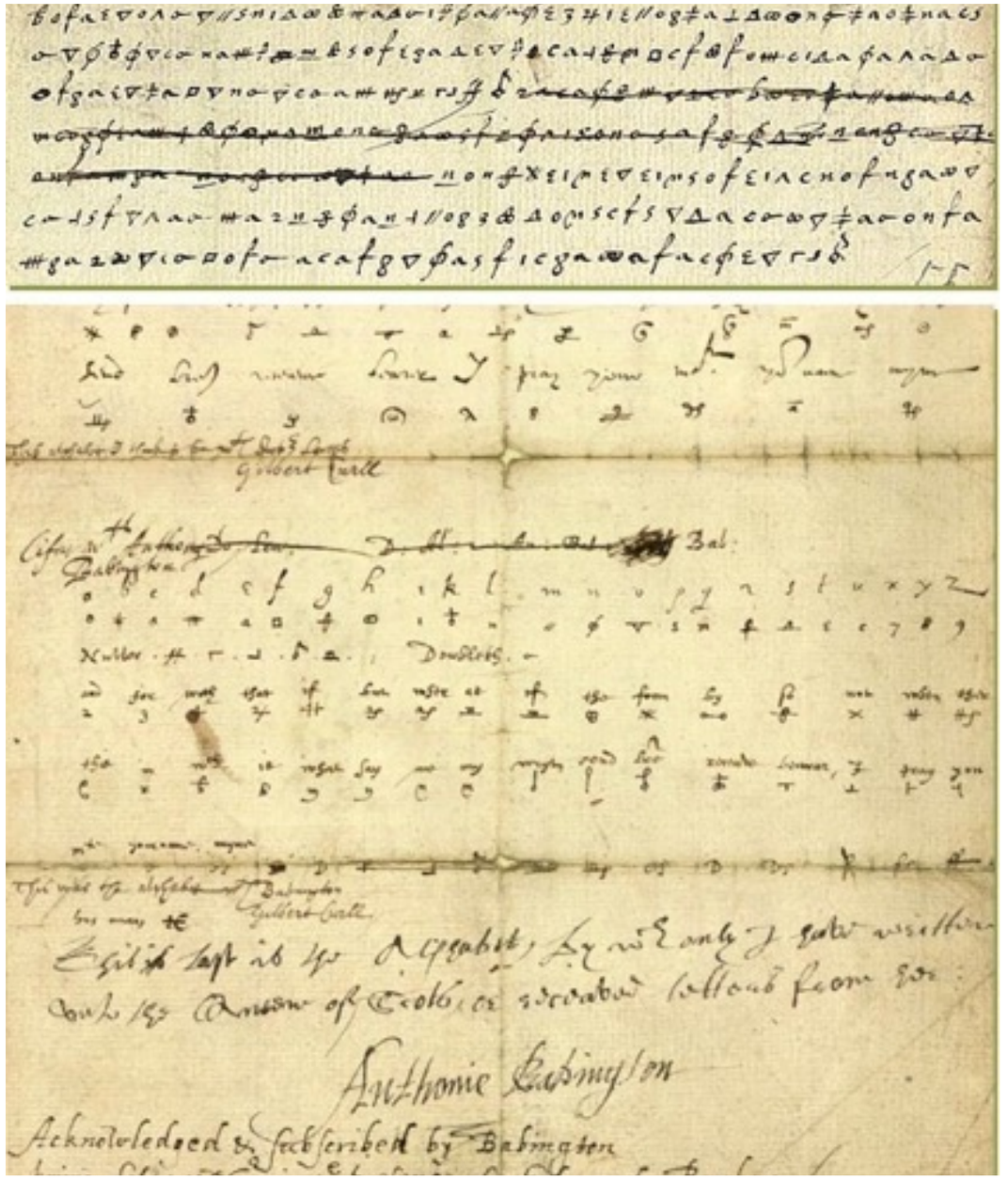
- The adversary acquires privileged information

- E.g.: *eavesdropping*

- Nets-skandalen (2008-2011)

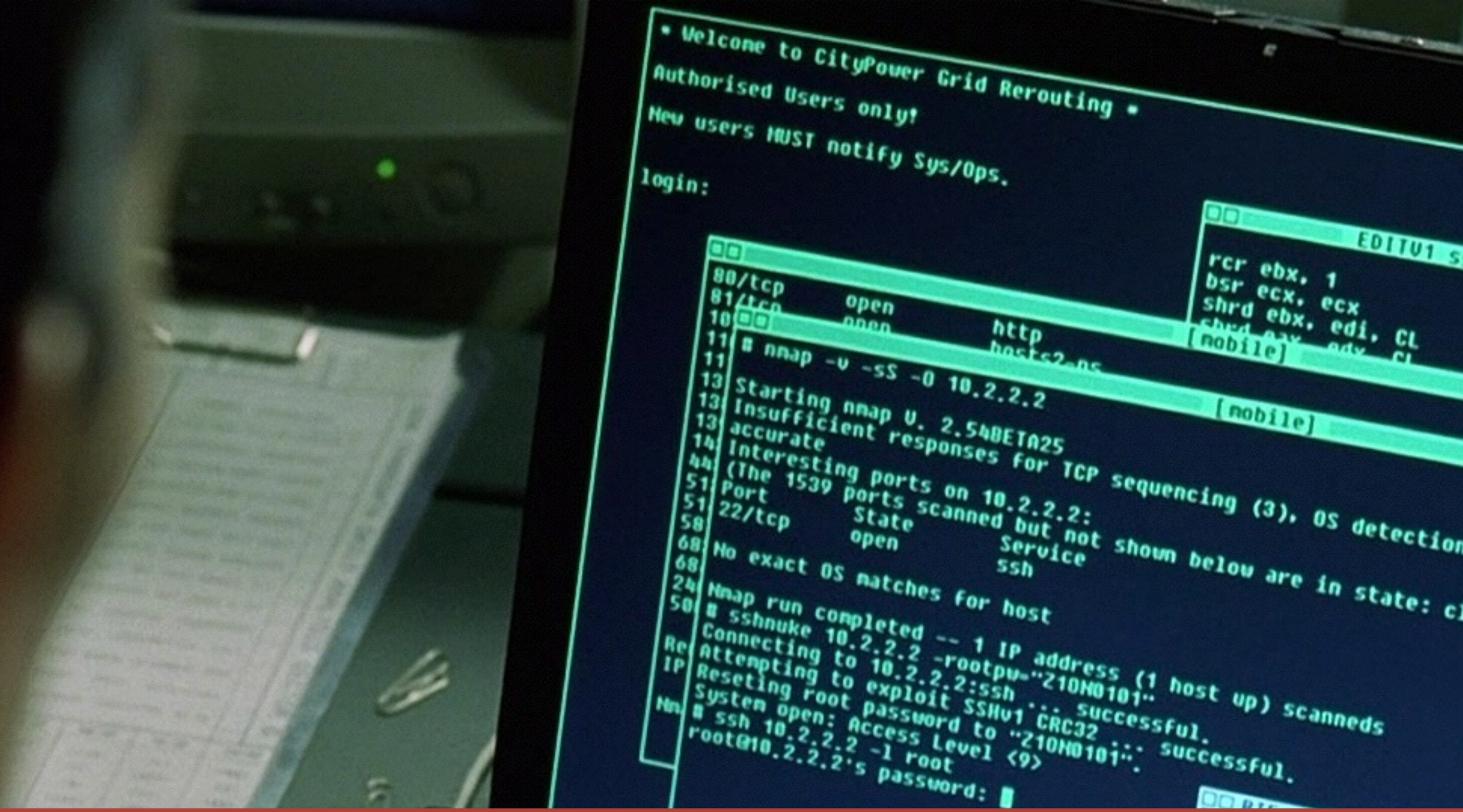
Tampering

- The adversary alters information
- Techniques: *Masquerading, message tampering, replaying*
- July 17, 1586: Thomas Phelippes confounds the Babington plot to murder Queen Elisabeth and install Queen Mary as regent.
- He intercepted and decrypted a letter, then added:
- “I would be glad to know the names and qualities of the six gentlemen which are to accomplish the [deed], …”

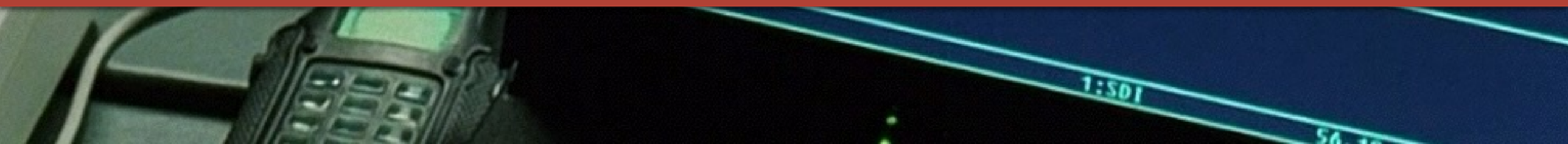


Vandalism

- The adversary interferes with the operation of the system
- Technique: *Distributed Denial of Service (DDos).*
- April 11, 2013: “Torsdag morgen fra ca. kl. 5-8 har det været svært eller umuligt at logge på med NemID i både netbanken og på offentlige og private hjemmesider.”

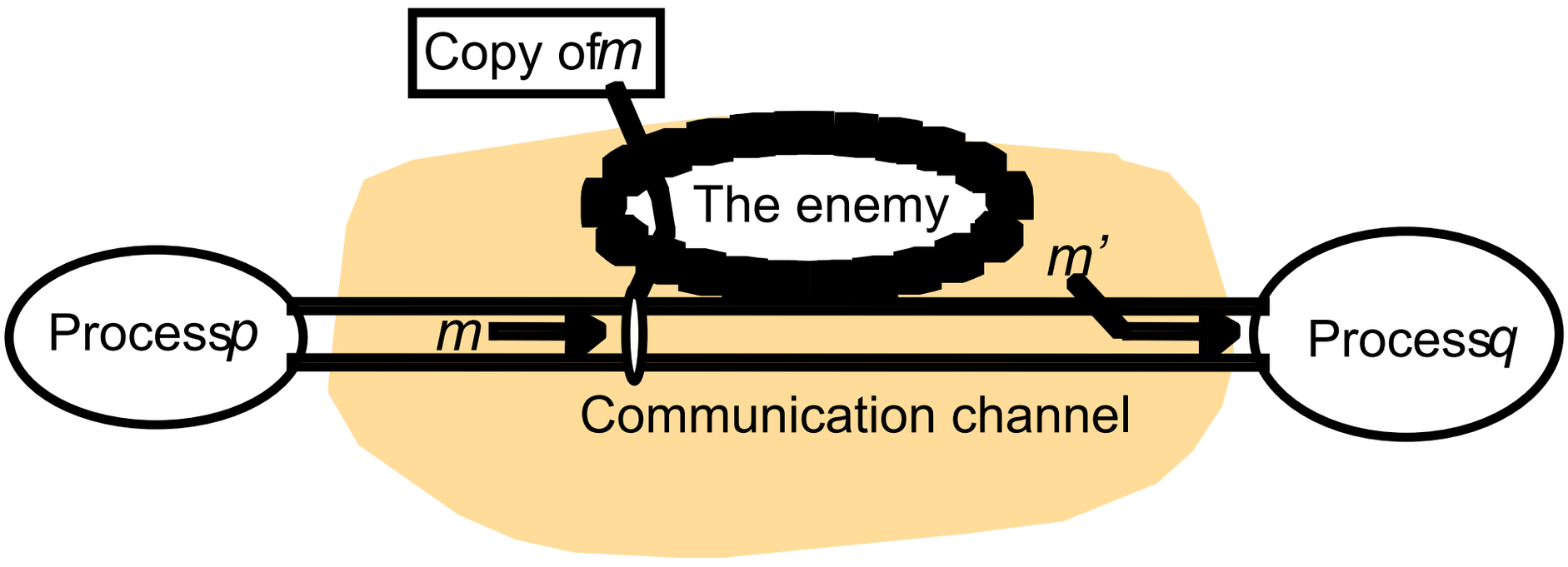


Assumptions



“The adversary”

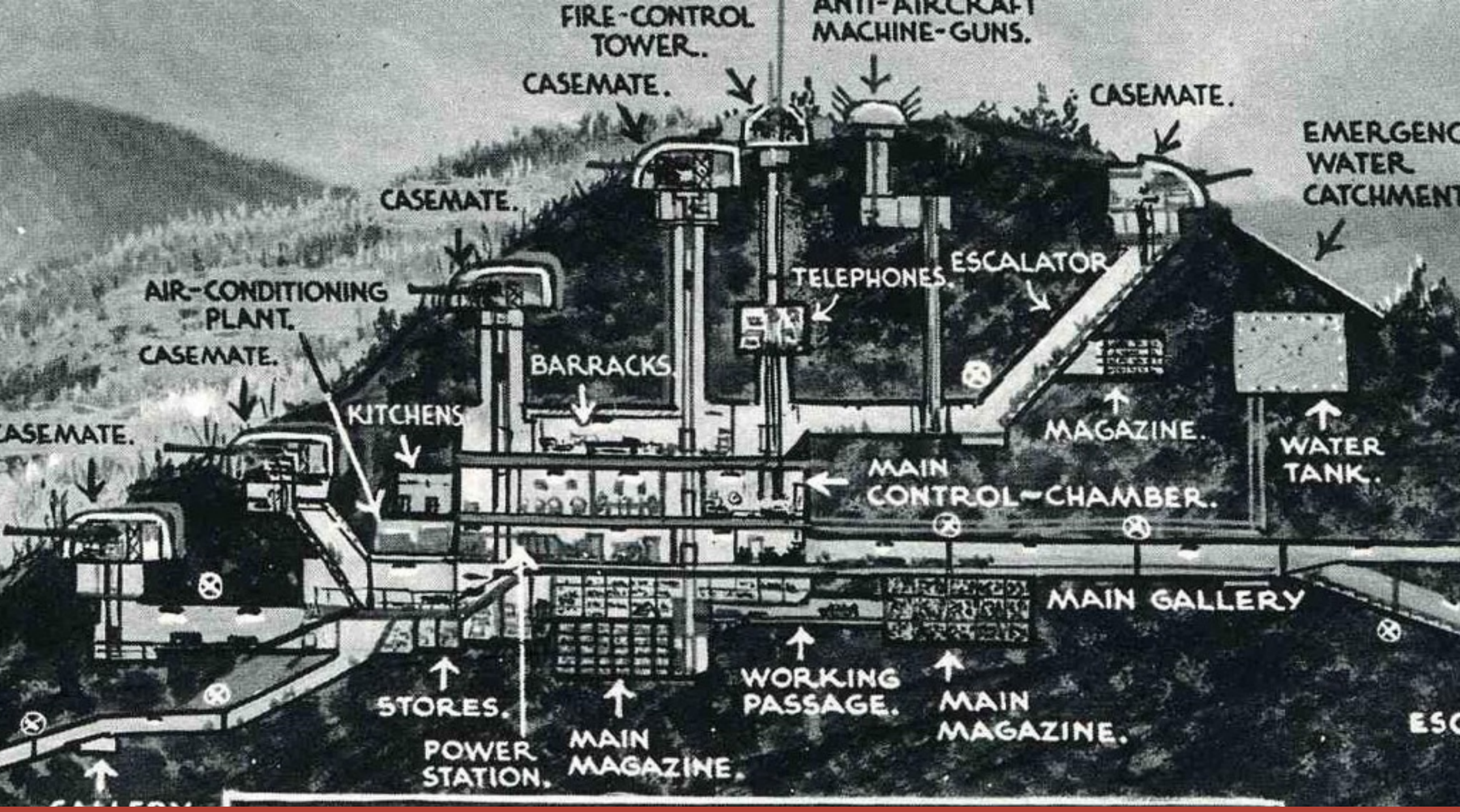
can intercept, replay, modify, remove, and create messages



but cannot guess your secrets (e.g. keys)
- unless given enough time!

Assumptions

- Exposed interfaces
- Insecure networks
- Algorithms/code available to attackers


FIRE-CONTROL TOWER.
ANTI-AIRCRAFT MACHINE-GUNS.
CASEMATE.
CASEMATE.
CASEMATE.
CASEMATE.
EMERGENCY WATER CATCHMENT
AIR-CONDITIONING PLANT.
CASEMATE.
TELEPHONES.
ESCALATOR
BARRACKS
KITCHENS
MAGAZINE.
WATER TANK.
MAIN CONTROL-CHAMBER.
MAIN GALLERY
STORES.
POWER STATION.
MAIN MAGAZINE.
WORKING PASSAGE.
MAIN MAGAZINE.

Defenses


DIRECTOR-OFFICER AND SIGHT-SETTER.
MESSAGE

Trade-offs

- No perfect security

- Your security is measured in the resources required of the succesful attacker

Main defenses

- Authentification
- Role-based access control
- Cryptography

Security is impossibly hard

- You must defend against all possible attacks.
- The adversary needs to find just one that works.

What is the most common, most effective attack on IT security?

Hint: It wasn't mentioned yet.

Hint: How would you get access to someone else's MDS 2014 grades?

Social engineering

"Catch me if you can", Spielberg, 2002, 141 min.

Summary

- Goals
  (Integrity, confidentiality, availability, accountability)

- Assumptions
  (Attacker has control of network; can't break crypto)

- Defenses
  (Crypto. Hard, though: for all/exist, social engineering.)

Applied Cryptography

Motivation

- Preserve confidentiality: only the intended recipient of a message should be able to read it.

- Preserve integrity: An adversary cannot (undetectedly) tamper with a message.

Plan

- Hashes
- Symmetric encryption schemes
- Asymmetric encryption schemes
- Signatures
- Certificates
- SSL/TLS

Hashes & Digests

Hashes, digests

- Hash function: Function taking arbitrary length data (“message”) to fixed-length value (“digest”).

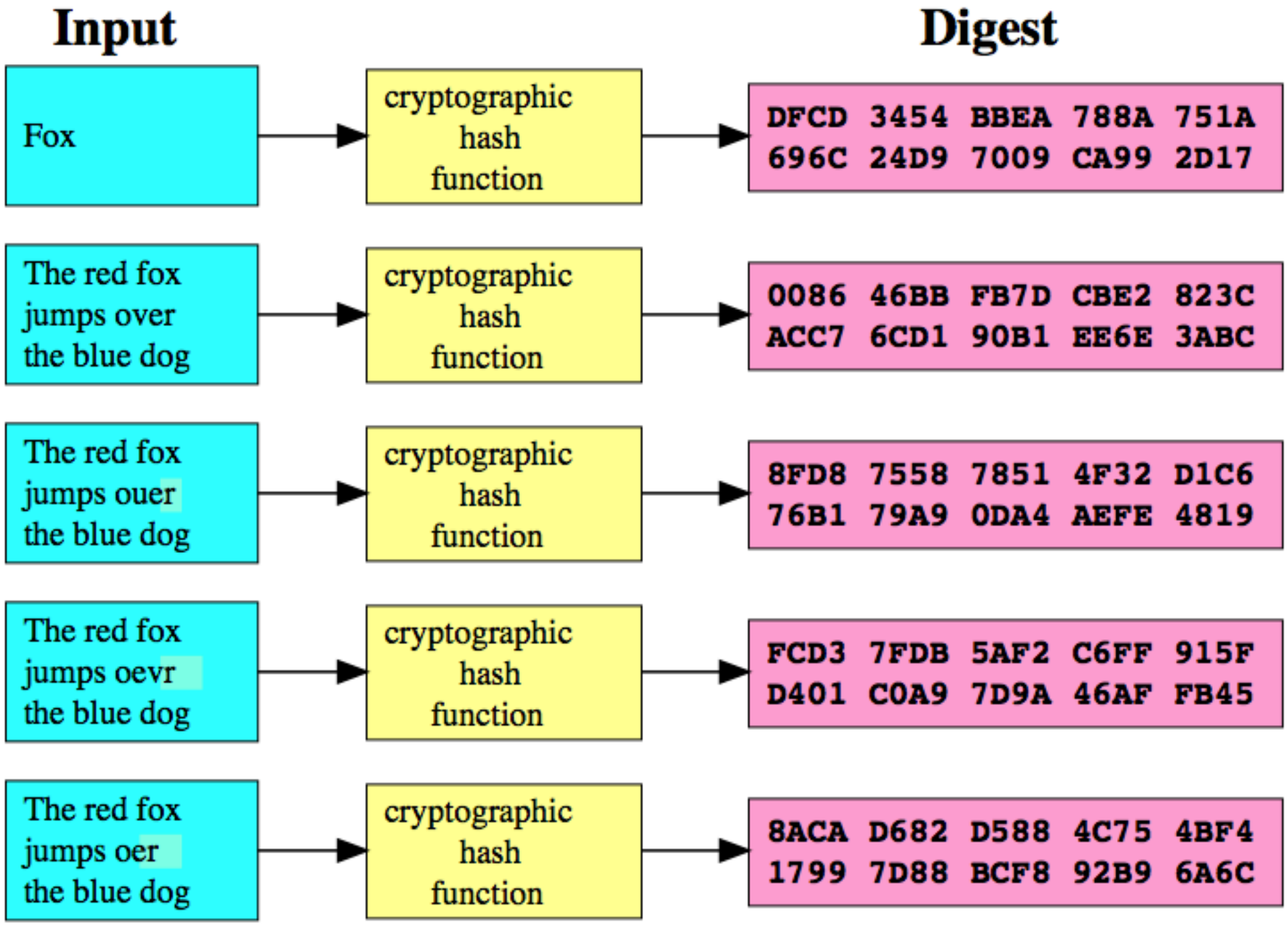
- H(M) = h.

- Used in, e.g., hashing, hash table http://en.wikipedia.org/wiki/File:Cryptographic_Hash_Function.svg s (duh).

- Used in, e.g., verifying integrity.

- Used for storing passwords.

Example


Input
Digest
Fox
cryptographic hash function
DFCD 3454 BBEA 788A 751A
696C 24D9 7009 CA99 2D17
The red fox jumps over the blue dog
cryptographic hash function
0086 46BB FB7D CBE2 823C
ACC7 6CD1 90B1 EE6E 3ABC
The red fox jumps ouer the blue dog
cryptographic hash function
8FD8 7558 7851 4F32 D1C6
76B1 79A9 0DA4 AEFE 4819
The red fox jumps oevr the blue dog
cryptographic hash function
FCD3 7FDB 5AF2 C6FF 915F
D401 C0A9 7D9A 46AF FB45
The red fox jumps oer the blue dog
cryptographic hash function
8ACA D682 D588 4C75 4BF4
1799 7D88 BCF8 92B9 6A6C

Hash properties

- Given M, H(M) = h should be easy to compute
- Given h, M s.t. H(M) = h should be infeasible to compute
- Given M, finding M’ with H(M) = H(M’) should be infeasible to compute.

Implementations

- MD5. Broken ca. 2005. Collisions are easy to find.
- SHA-1. Discovered likely insecure ca. 2005. Used in SSL.
- SHA-2 aka SHA-256 or SHA-512.
  As yet unbroken.

Salt

- Recall we store hashes of passwords. Users password input is hashed and compared with the stored hash.

- This works when inverting the hash is computationally infeasible. But:

- An adversary might precompute hashes for a large collection of typical passwords.

- To avoid this, we pick a random value, a *salt*, and add it to password before hashing.

- (Obviously, you need to store the salt with the password.)

Symmetric schemes

Symmetric algorithms

- Encryption: function from *secret key* and *plaintext* to *cipher text*

- Decryption: function from *secret key* and *ciphertext* to *plaintext*.

- $E(K,M) = \{M\}_K$
  $D(K,\{M\}_k) = M$

- Security depends on assumption that $D(\_, \{M\}_K)$ is *infeasible* to compute when you don't know K.

- Best attack: brute-force, chosen plaintext.

Symmetric

Caesar-cipher

Easy to break

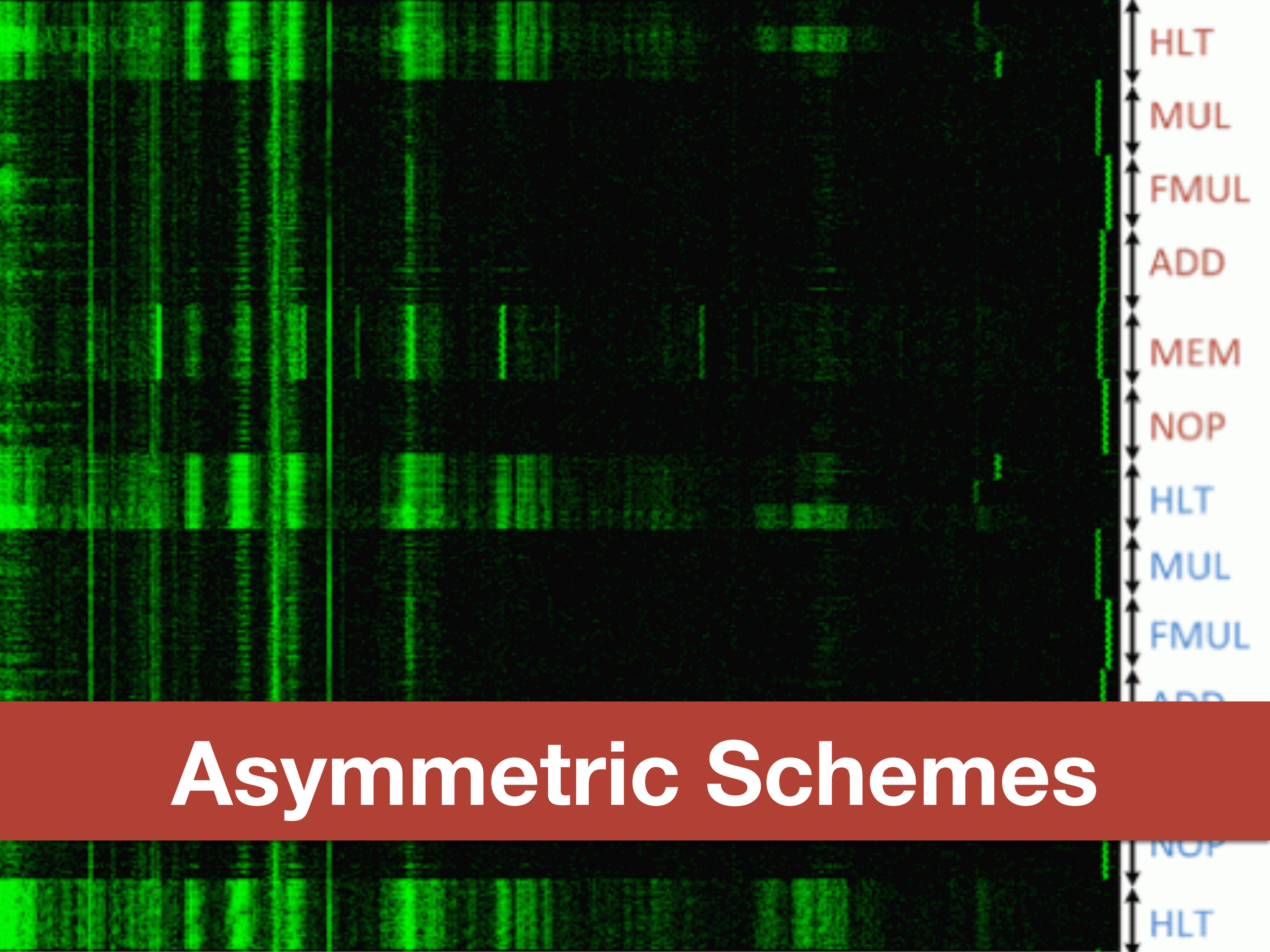
Frequency table for English text:
e: 12.7%, t: 9.1%, a: 8.2%, o: 7.5%

Implementations

- rot13
- DES (broken 1999, use Triple-DES)
- AES (Rijndael). No feasible attacks.
- RC4. Broken.

Symmetric scheme challenges

- Key distribution.
- E.g., how do a bank get key to every customer?
- In general, n parties need n^2 keys.



Asymmetric Schemes

Assymmetric encryption schemes

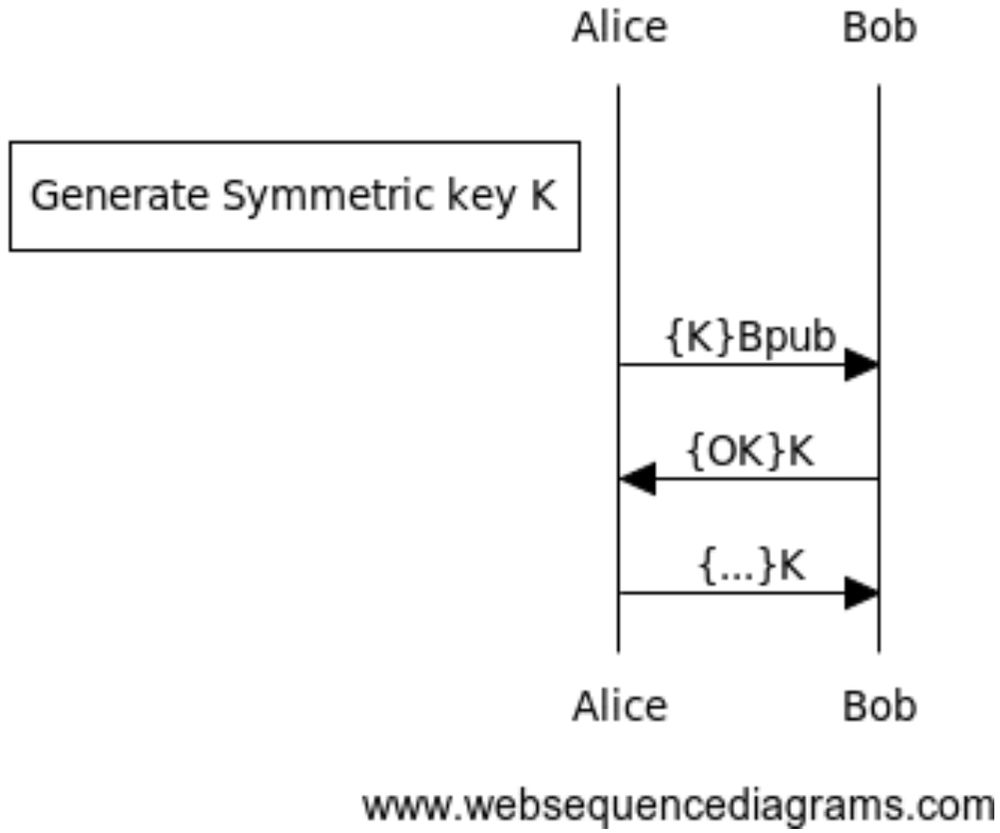
- Pair of keys K_{priv}, K_{pub}
- K_{priv} is secret, I tell it to no-one.
- K_{pub} is public, I tell it to everyone.
- Encryption: $E(K_{pub}, M) = \{M\}_{Kpub}$
- Decryption: $D(K_{priv,} \{M\}_{Kpub}) = M$
  i.e., $D(K_{priv,} E(K_{pub}, M)) = M$

Key distribution?

- Partially solves key distribution; now n parties need only n key-pairs.

Assymmetric Algorithms

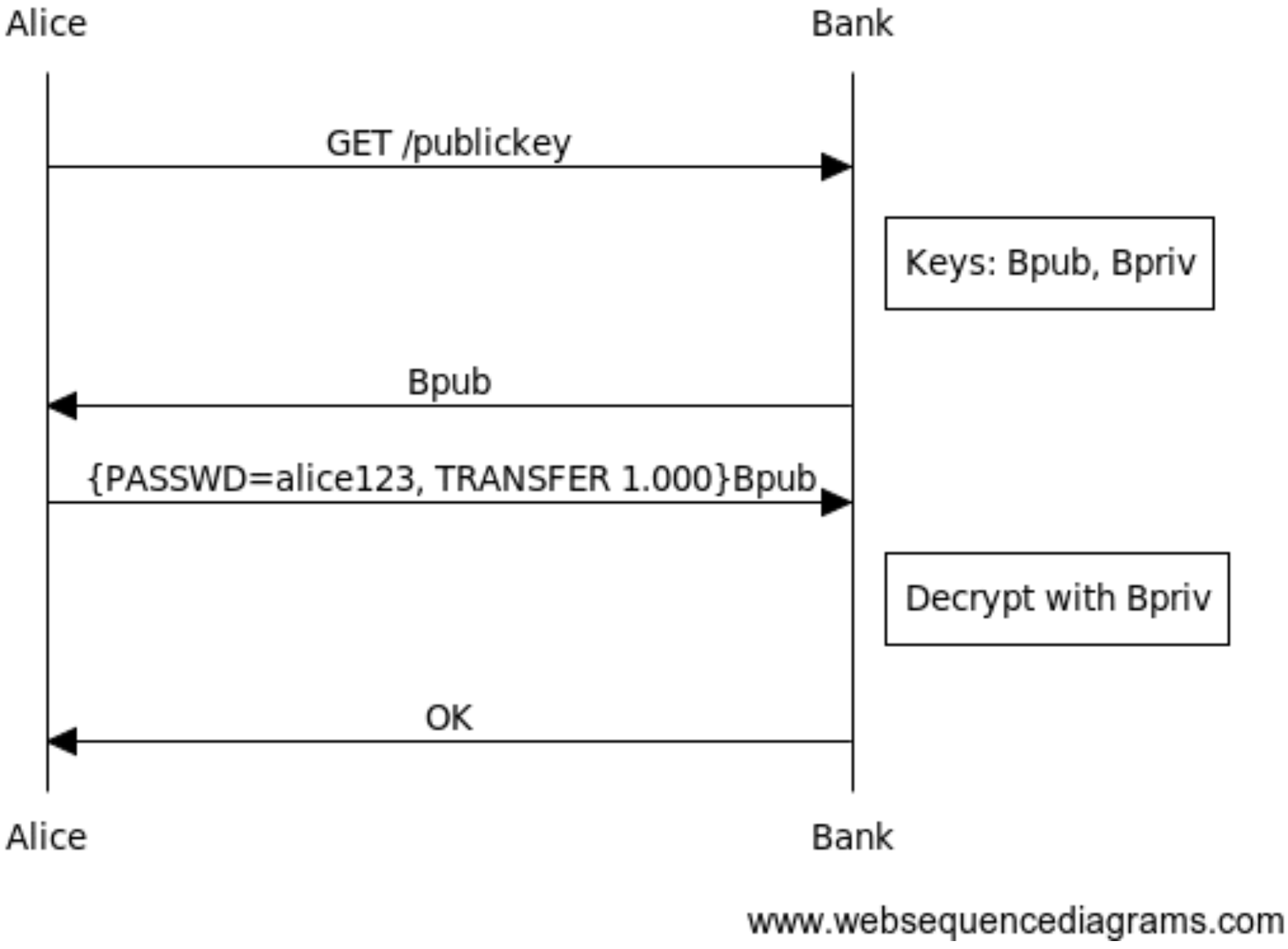
- Slow to compute in practice
- Often used for agreeing on a secret key for a symmetric algorithm.
- RSA. Considered secure for sufficiently large key sizes. (768 bit key broken in 2009 using 2000 years of computing time.)



Question

- I’m a bank; my clients net secure net-banking.
- I put my public key K_{pub} on my webpage.
- Clients should:
  - download the public key.
  - encrypt their requests with my public key and send it to me.
  - requests are now communicated securely.
- Yes? No?

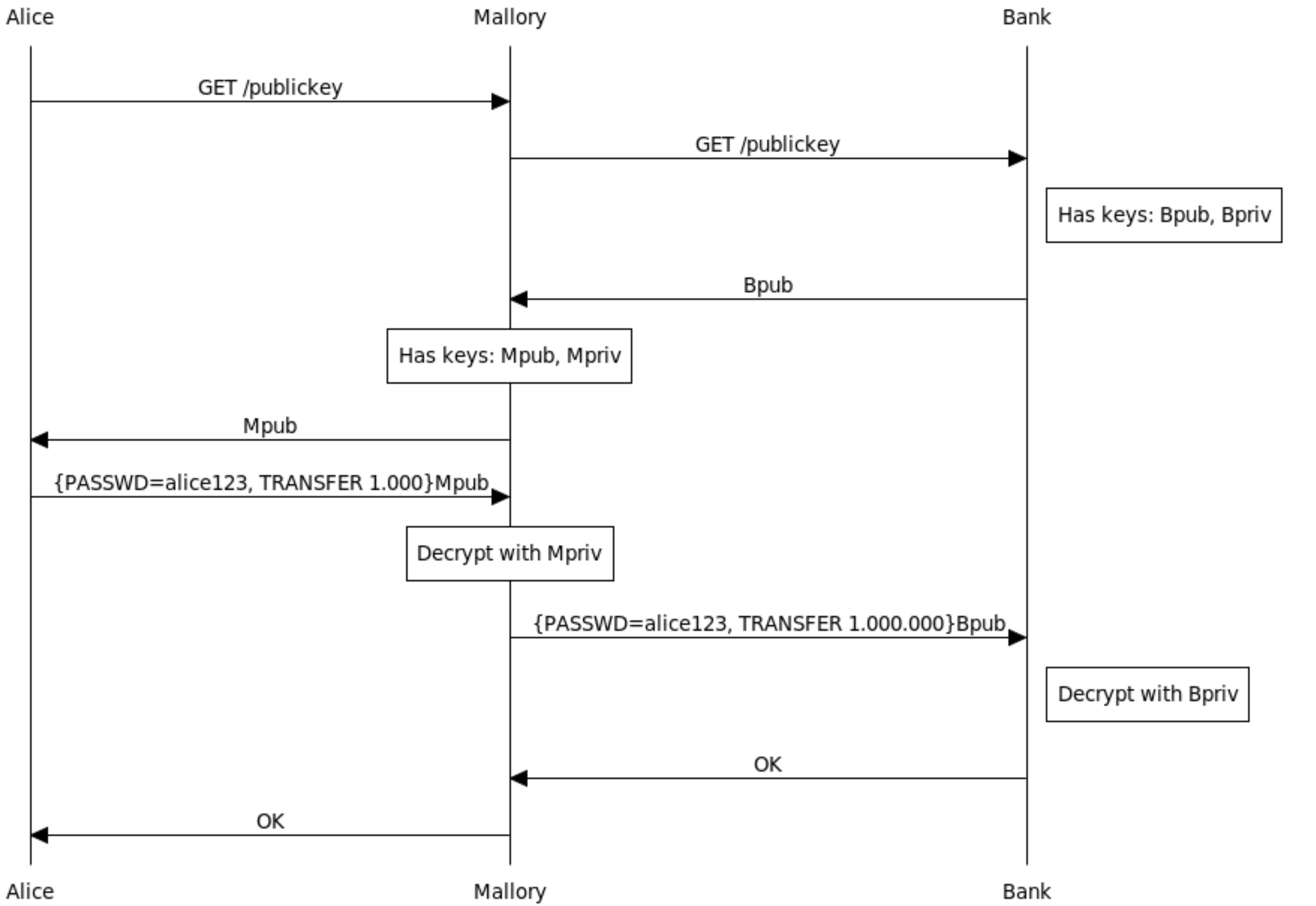
That is, this?


Alice
Bank
GET /publickey
Keys: Bpub, Bpriv
Bpub
{PASSWD=alice123, TRANSFER 1.000}Bpub
Decrypt with Bpriv
OK
Alice
Bank
www.websequencediagrams.com

Man-in-the-middle attack

- No!

- If the adversary intercepts my traffice, he can replace the public key of the bank with his own.


Alice
Mallory
Bank
GET /publickey
GET /publickey
Has keys: Bpub, Bpriv
Bpub
Has keys: Mpub, Mpriv
Mpub
{PASSWD=alice123, TRANSFER 1.000}Mpub
Decrypt with Mpriv
{PASSWD=alice123, TRANSFER 1.000.000}Bpub
Decrypt with Bpriv
OK
OK
Alice
Mallory
Bank
www.websequencediagrams.com

Besitzzeugnis.

Für ehrenvolle Teilnahme am Weltkriege 1914/18
ist auf Antrag des Preußischen Landes-Kriegerverbandes dem Kameraden

Hans S a c h s , Berlin W 15

Mitglied des Deutschen Reichskriegerbundes „Kyffhäuser"
die Kriegsdenkmünze 1914/18

unter dem 13. Oktober 1933 verliehen worden.

DEUTSCHER REICHSKRIEGERBUND „KYFFHÄUSER" BERLIN

Deutscher Reichskriegerbund „Kyffhäuser"

von Hindenburg
Generalfeldmarschall, Ehrenpräsident

General der Artillerie a. D., Präsident

Der Präsident des Preußischen Landes-Kriegerverbandes

General der Artillerie a. D.

Deutscher Soldaten

Signatures & Certificates

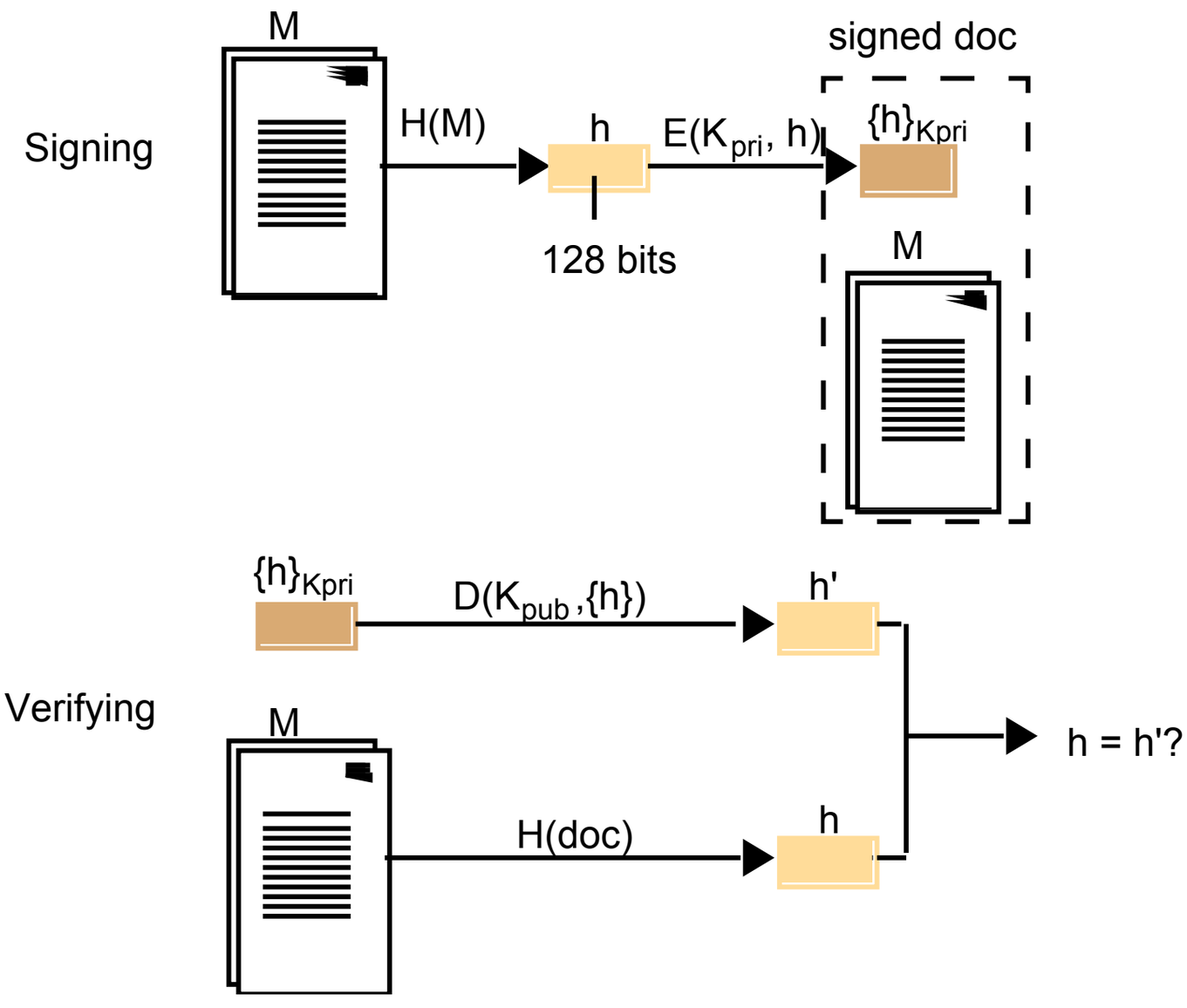
Signatures

- Authenticity of messages (signee, contents)

- Non-repudiability of messages

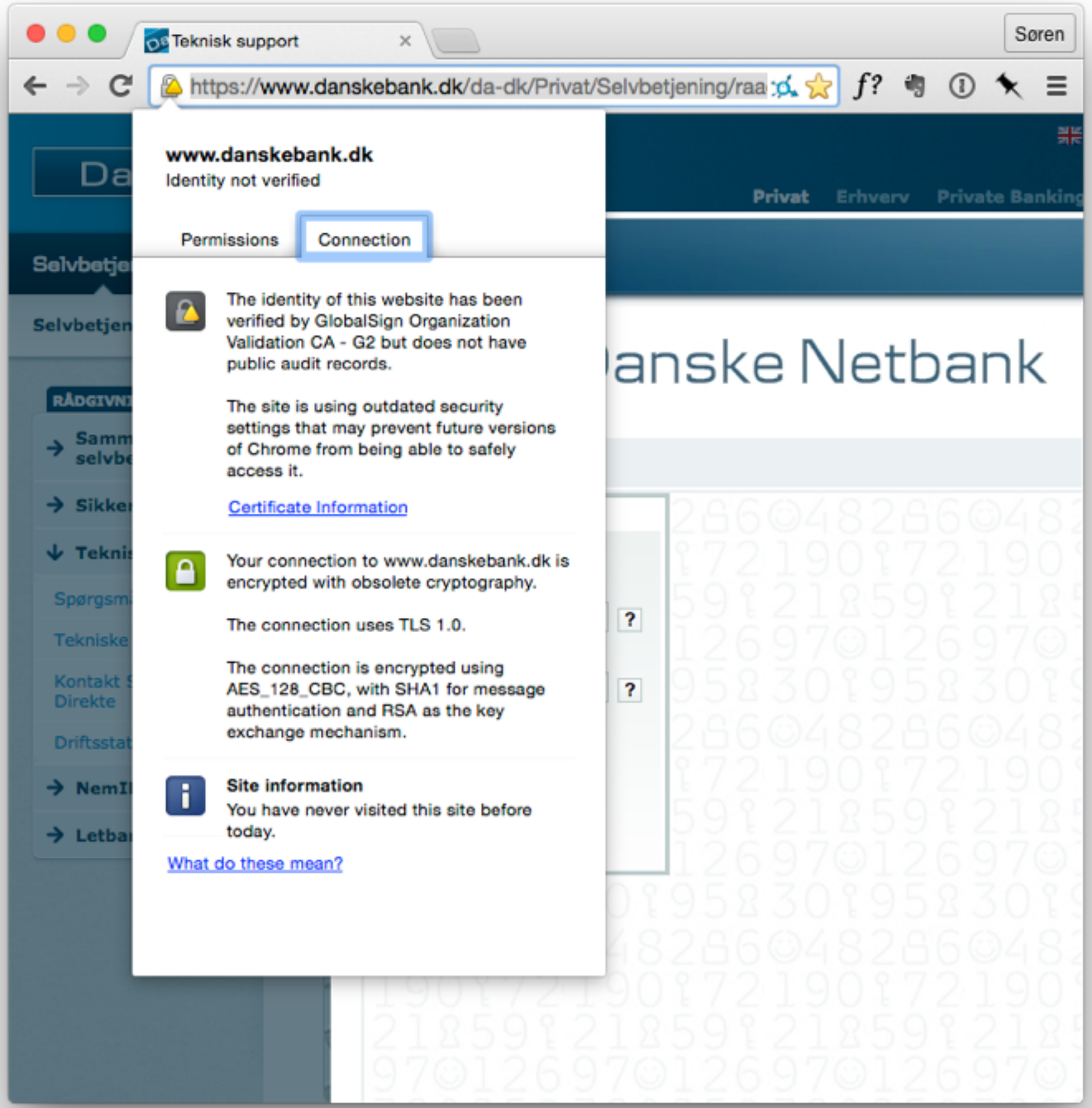
… with asymmetric scheme:

- I have keys K_{pub}, $K_{priv.}$ and a message M.
- I compute a digest (hash) H(M).
- I encrypt the hash with my *private* key $S = E(K_{priv}, H(M))$
- I send $[M]_K = M,S$
- Recipient decrypts S with $K_{pub,}$ checks himself if $H' = D(K_{pub,} S) =? H(M)$.
- Adversary can't tamper with M, because H' won't match H(M).



Certificates

- Signed public keys.
- I am a Certificate Authority. I have keys K_{pub}, $K_{priv.}$
- The bank “International Bank A/S” has keys B_{pub}, B_{priv}.
- I sign a message M containing B_{pub} and the words “I believe this is the public key of International Bank A/S“, producing S = E(K_{priv}, H(M)). This is the certificate.
- Only I have Kpriv, so only I could have made such a certificate.
- International Bank A/S presents the certificate along K_{pub}.
- Anyone who has my public key can verify that I believe K_{pub} belongs to International Bank A/S.


Teknisk support
Søren
https://www.danskebank.dk/da-dk/Privat/Selvbetjening/raa
www.danskebank.dk
Identity not verified
Permissions
Connection
The identity of this website has been verified by GlobalSign Organization Validation CA - G2 but does not have public audit records.
The site is using outdated security settings that may prevent future versions of Chrome from being able to safely access it.
Certificate Information
Your connection to www.danskebank.dk is encrypted with obsolete cryptography.
The connection uses TLS 1.0.
The connection is encrypted using AES_128_CBC, with SHA1 for message authentication and RSA as the key exchange mechanism.
Site information
You have never visited this site before today.
What do these mean?
Privat
Erhverv
Private Banking
anske Netbank

Teknisk support

Søren

https://www.danskebank.dk/da-dk/Privat/Selvbetjening/raa

GlobalSign Root CA

GlobalSign Organization Validation CA - G2

*.danskebank.dk

***.danskebank.dk**

Issued by: GlobalSign Organization Validation CA - G2

Expires: Tuesday 8 November 2016 13 h 50 min 24 s Central European Standard Time

This certificate is valid

Details

Subject Name	
Country	DK
State/Province	DK
Locality	Copenhagen
Organization	Danske Bank A/S
Common Name	*.danskebank.dk
Issuer Name	
Country	BE
Organization	GlobalSign nv-sa
Common Name	GlobalSign Organization Validation CA - G2
Serial Number	11 21 41 C2 21 3A 64 06 23 9E 34 14 98 8B A5 9A 6D 1E
Version	3
Signature Algorithm	SHA-1 with RSA Encryption (1.2.840.113549.1.1.5)
Parameters	none
Not Valid Before	Wednesday 9 November 2011 13 h 50 min 24 s

OK

Selvbetjening

RÅDGIVNING

Sikkerhed

Spørgsmål og

Tekniske krav

Driftsstatus

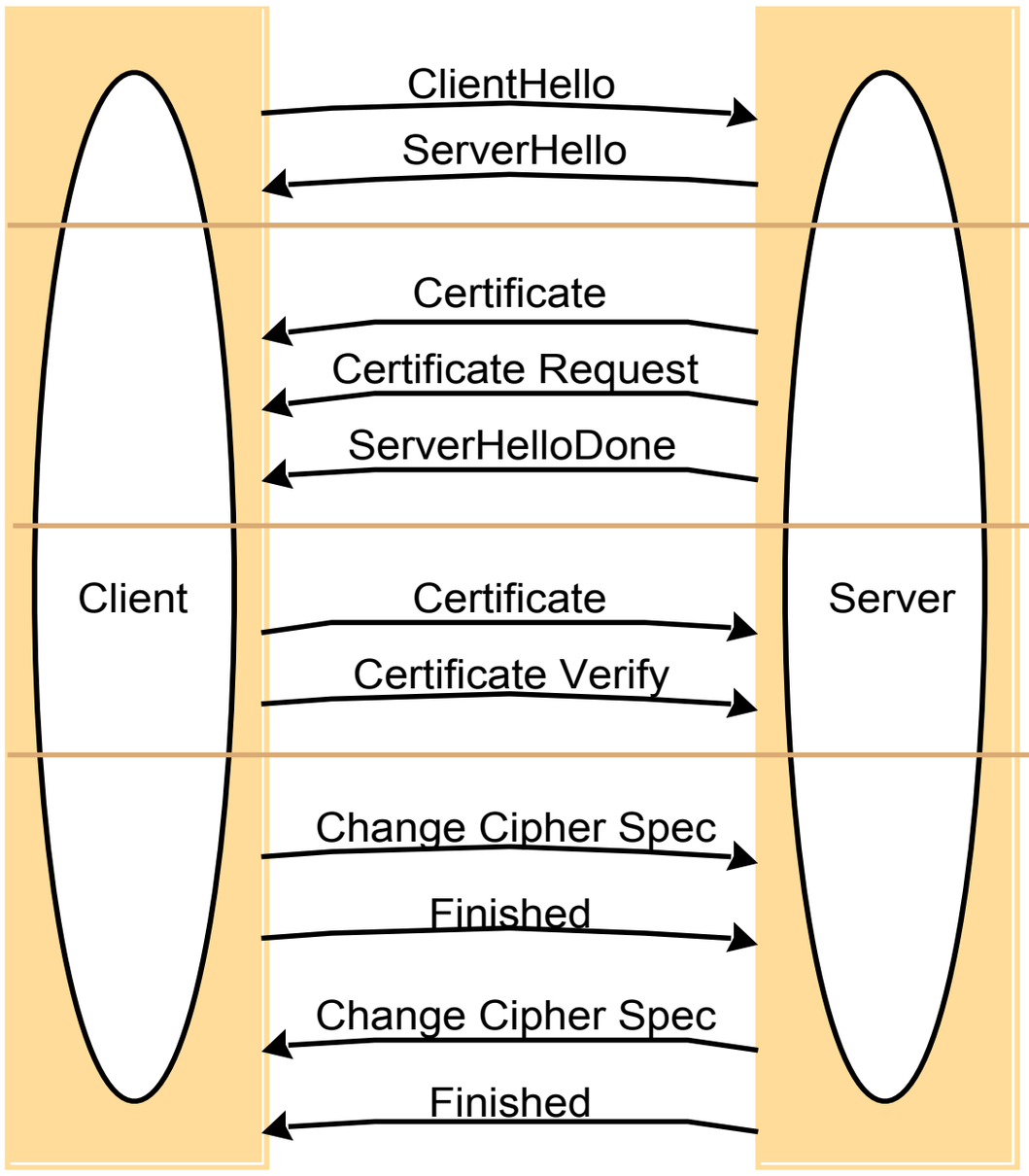
NemID

Private Banking

TLS

- Transport Layer Security.
- Replaces earlier SSL. (viz. Danske Bank.)
- Handshake enables
  - exchange of certificates
  - agreement on symmetric key for subsequent encrypted communication.

TLS



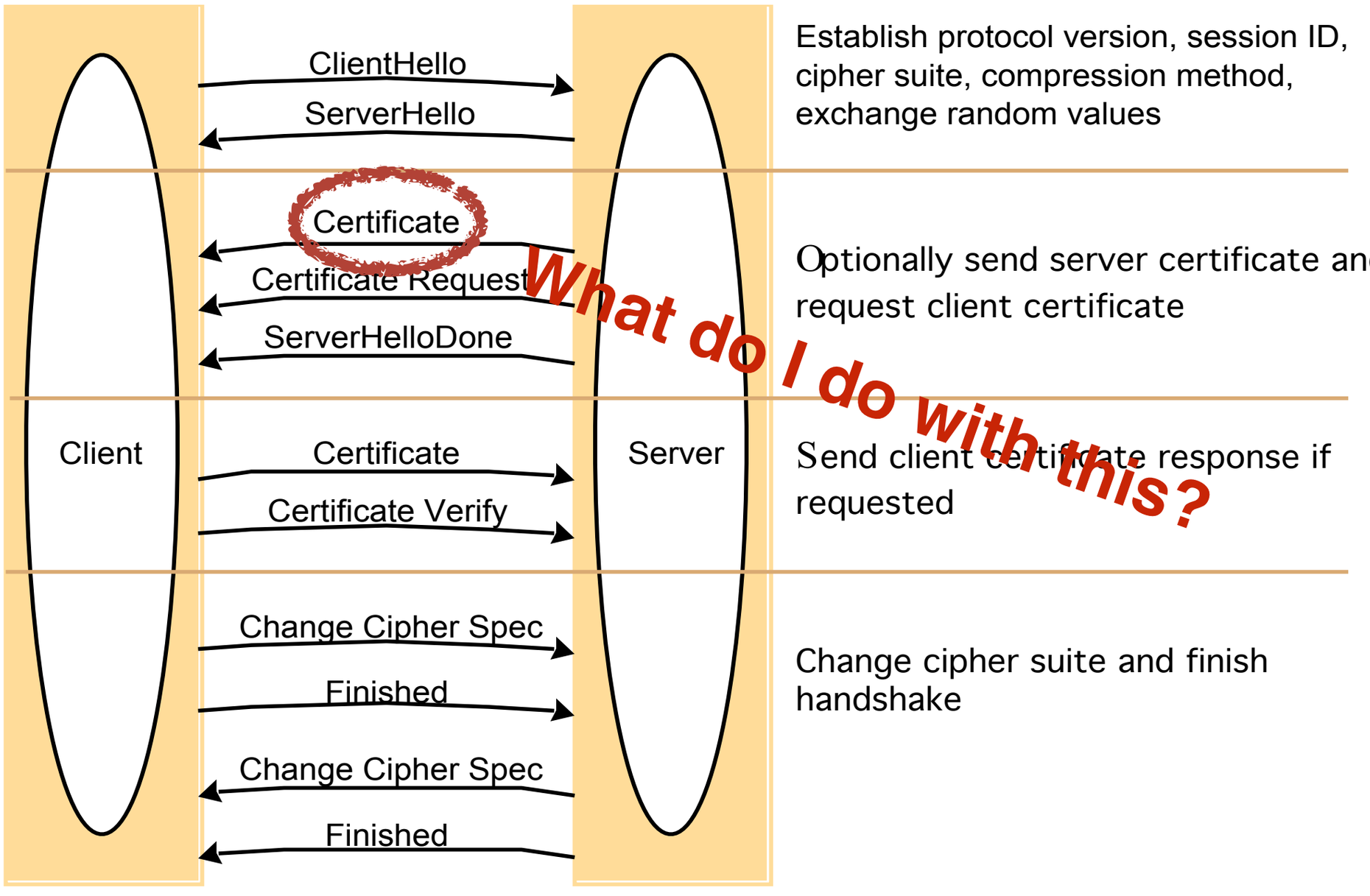
Establish protocol version, session ID, cipher suite, compression method, exchange random values

Optionally send server certificate and request client certificate

Send client certificate response if requested

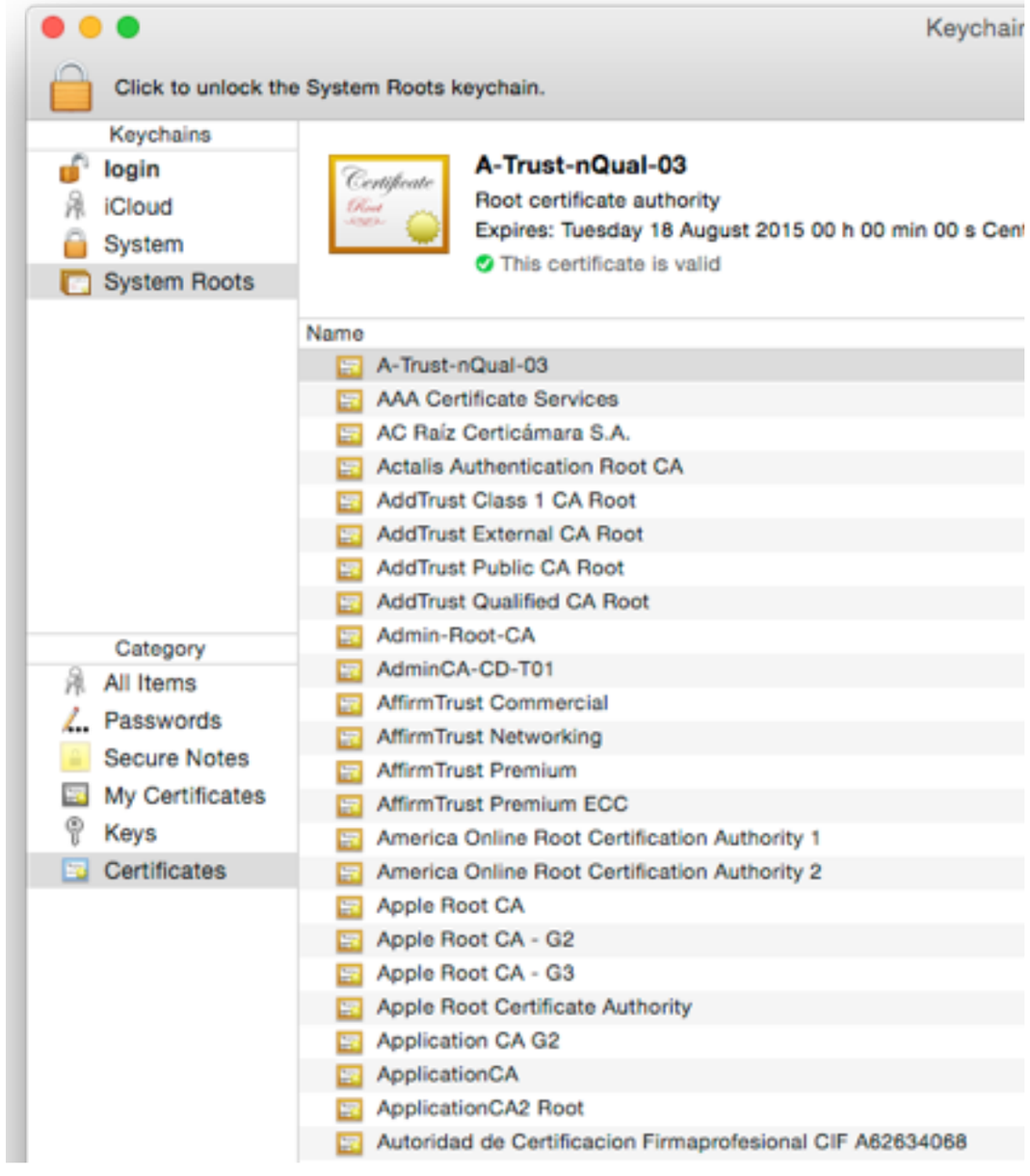
Change cipher suite and finish handshake

TLS


ClientHello
ServerHello
Certificate
Certificate Request
ServerHelloDone
Client
Server
Certificate
Certificate Verify
Change Cipher Spec
Finished
Change Cipher Spec
Finished
Establish protocol version, session ID, cipher suite, compression method, exchange random values
Optionally send server certificate and request client certificate
What do I do with this?
Send client certificate response if requested
Change cipher suite and finish handshake

Certificates and the web

- X.509 certificates
- OSes, browsers come preloaded with “root” certificates from trusted Certificate Authorities.
- Root certificates are signed by themselves and thus implicitly trusted.
- (“Here is the public key of International Bank A/S; you can trust it because I have a certificate made with the corresponding private key” doesn’t give you any connection to International Bank A/S at all.)



Certificates and the web

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- OSes, browsers come preloaded with “root” certificates.
- Root certificates are signed by themselves and thus implicitly trusted.
- (“Here is the public key of International Bank A/S; you can trust it because I have a certificate made with the corresponding private key” doesn’t give you any connection to International Bank A/S at all.)
- A certificate you receive is signed by someone.
- Hopefully that someone is someone you trust.
- So you trust the browser.

SuperFish

- Lenovo shipped machines with a self-signed root certificate from a small company called SuperFish.

- SuperFish man-in-the-middled all HTTPS traffic on the local machine in order to insert ads.

- The root-certificate was insufficiently protected; anybody can certify anything for a SuperFish compromised machine.

- Check if your Lenovo machine is affected here (bottom): http://arstechnica.com/security/2015/02/lenovo-pcs-ship-with-man-in-the-middle-adware-that-breaks-https-connections/

Summary

- Hashes
- Symmetric encryption schemes
- Asymmetric encryption schemes
- Signatures
- Certificates
- SSL/TLS

Read on your own

- Details
- Usage scenarios
- Needham-schroeder
- Certificate standards
- Kerberos
- Terrible 802.11 security
- SKIP: 11.3.1, 11.3.2.

Who is the adversary?

Who is the adversary?

- Petty criminals.
  (nem-id scams, credit card fraud, botnets, e3 thieves, extortionists…)

- Sophisticated criminals/vandals/shady companies.
  (More extortionists, Industrial espionage; e.g., Sony rootkit, Maddison-Ashley hack, Lenovo/Superfish.)

- Government organisations.
  (SONY hack, OPM hack, NSA)

- http://www.informationisbeautiful.net/visualizations/worlds-biggest-data-breaches-hacks/

[Propaganda warning]

The following slides are internal NSA slides leaked by Edward Snowden to The Guardian & The Washington Post.

They were published in 2013.

TS//SI//REL to USA, FVEY

(S//REL) iPhone Location Services

(U) Who knew in 1984...

TS//SI//REL to USA, FVEY

TS//SI//REL to USA, FVEY

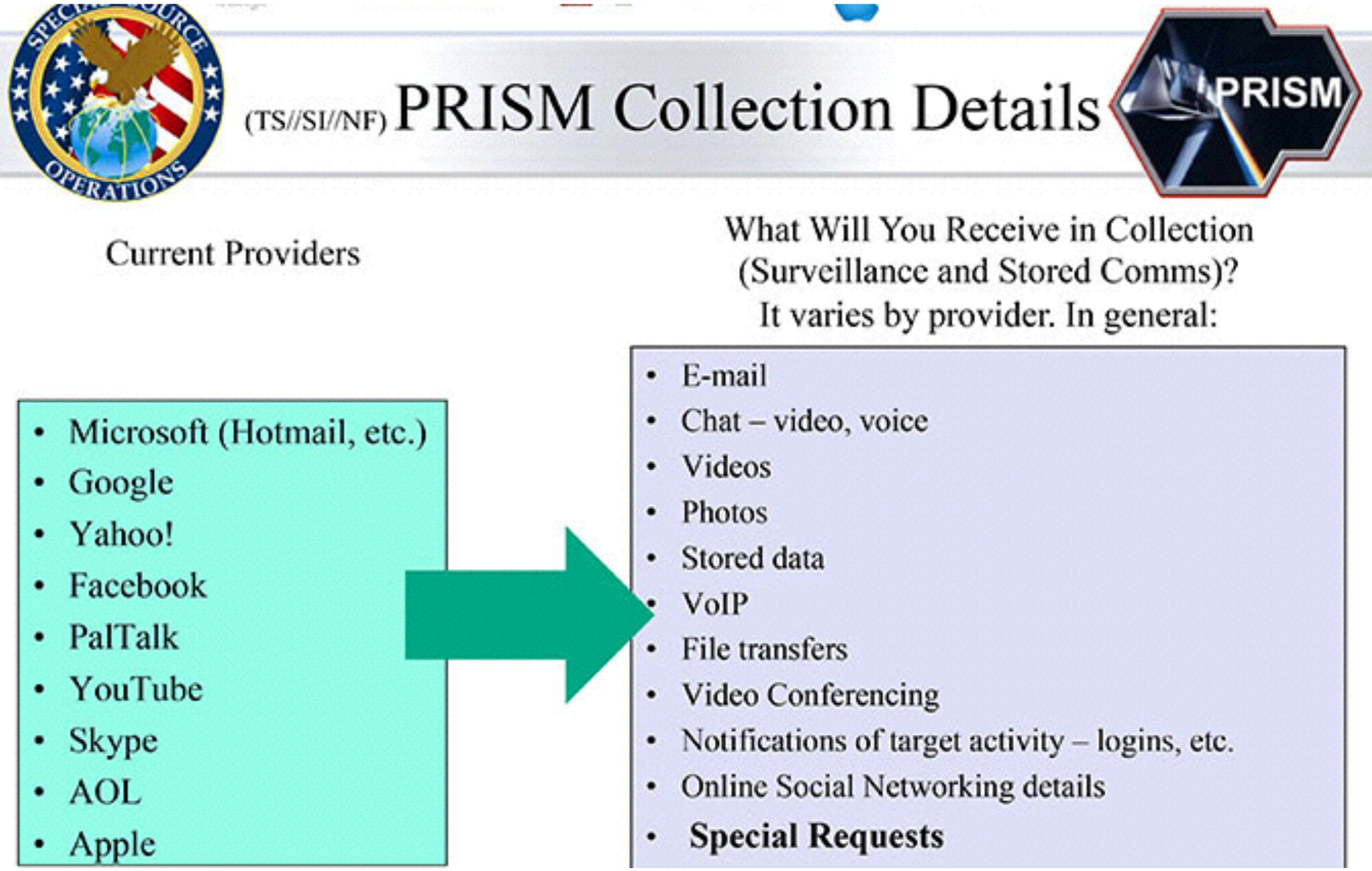
(S//REL) iPhone Location Services

(U) …that this would be big brother...

TS//SI//REL to USA, FVEY

(S//REL) iPhone Location Services

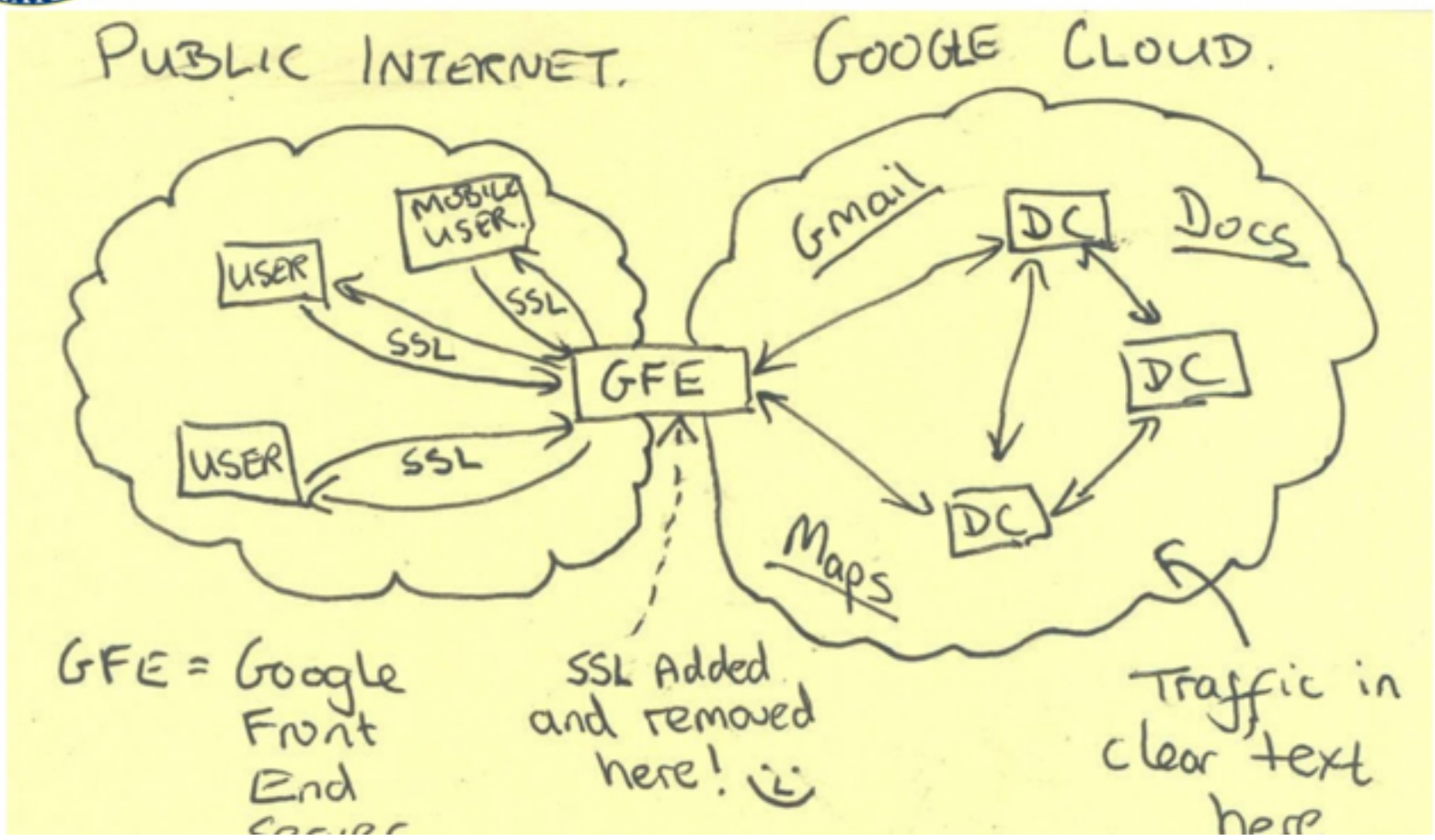
(U) ...and the zombies would be paying customers?



PRISM

Revealed by The Guardian & The Washington Post
June 6, 2013

Current Efforts - Google



MUSCULAR

Washington Post

October 30, 2013.

(U) Project Description

(TS//SI//NF) The SIGINT Enabling Project actively engages the US and foreign IT industries to covertly influence and/or overtly leverage their commercial products' designs. These design changes make the systems in question exploitable through SIGINT collection (e.g., Endpoint, MidPoint, etc.) with foreknowledge of the modification. To the consumer and other adversaries, however, the systems' security remains intact. In this way, the SIGINT Enabling approach uses commercial technology and insight to manage the increasing cost and technical challenges of discovering and successfully exploiting systems of interest within the ever-more integrated and security-focused global communications environment.

(TS//SI//REL TO USA, FVEY) This Project supports the Comprehensive National Cybersecurity Initiative (CNCI) by investing in corporate partnerships and providing new access to intelligence sources, reducing collection and exploitation costs of existing sources', and enabling expanded network operation and intelligence exploitation to support network defense and cyber situational awareness. This Project contains the SIGINT Enabling Sub-Project.

(U) Base resources in this project are used to:

- (TS//SI//REL TO USA, FVEY) Insert vulnerabilities into commercial encryption systems, IT systems, networks, and endpoint communications devices used by targets.
- (TS//SI//REL TO USA, FVEY) Collect target network data and metadata via cooperative network carriers and/or increased control over core networks.
- (TS//SI//REL TO USA, FVEY) Leverage commercial capabilities to remotely deliver or receive information

BULLRUN

The Washington Post
September 5, 2013

NSA in summary

- NSA is secret government organisation overseen by a secret court.

- Because “Terrorism!” collects any and all data about anyone. That would be, **you**.

- Actively works against publicly available good crypto and security, with the stated purpose of being able to get access to anything.

- This would have been a good premise for a “sneakily evil totalitarian state” sci-fi novel in the late 70’ies.

Now, in Denmark

- "Center for Cybersikkerhed" under FE, approved by Parliament June 11, 2014.

- "Persondataloven" does not apply.

- No warrants required, only "sikkerhedshændelse".

- FE may exchange data with, say, GHCQ, NSA.

- Monitors communication to/from Government and private institutions/companies critical to Denmark.

Why is data collection wrong?

- “I haven’t done anything wrong. It doesn’t matter if they know everything about me.”

- You’re enabling the police state.

Enabling the police state

- The police state needs a narrative where you're guilty. All of you.

- Cardinal Richelieu (1585-1642):

  "Give me six lines written by the most honest man, and I will find something there to hang him."

- Now give him your contacts, every SMS, email and facebook update you ever wrote, a log of your locations, a log of your calls, your tax returns, …

Your are the first
generation
to document
your personal lives.