Welcome to

5. Basic Cryptography

KEA Kompetence Computer Systems Security 2023

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Slides are available as PDF, kramse@Github

5-basic-cryptography.tex in the repo security-courses

Goals for today

Todays goals:

- Introduce Encryption
- Present the common algorithms, protocols, and tools used
- Start focus on various sub projects related to encryption in organisations

Photo by Thomas Galler on Unsplash

Plan for today

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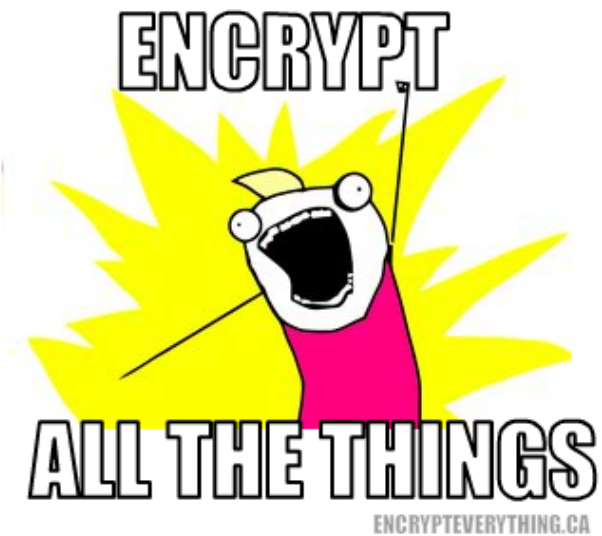
Subjects

- Basic cryptography - Encryption Decryption - Hashing
- Symmetric Cryptosystems
- Data Encryption Standard (DES) / Advanced Encryption Standard (AES)
- Public Key Cryptography
- Stream and Block Ciphers
- Example cryptosystems OpenPGP, IPsec, Transport Layer Security (TLS)
- Authentication and Password security, NIST guidelines
- Short introduction to algorithms RSA, AES
- Diffie Hellman exchange and Transport Layer Security (TLS)



Exercises

- sslscan scan various sites for TLS settings, Qualys SSLLabs https://www.ssllabs.com/ and sslscan locally on Kali
- Try Nmap and Ikescan
- Try ssh scanners, similar to sslscan
- Crack your own passwords

Reading Summary

MLSH chapter 5: Securing Your Server with a Firewall — Part 2

Skim: MLSH chapter 6: Encryption Technologies

TLS1.2 RFC5246 table of contents - but only ToC, not the whole document!

Skim NIST Special Publication 800-63B

Enterprise Survival Guide for Ransomware Attacks

IT Security Guidelines for Transport Layer Security

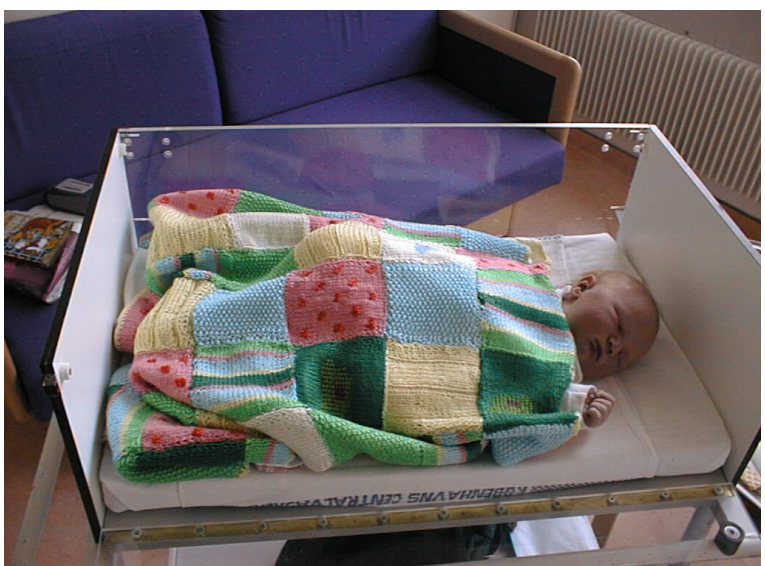
Home-work, look into https://en.wikipedia.org/wiki/Elliptic-curve_cryptography

What is data?

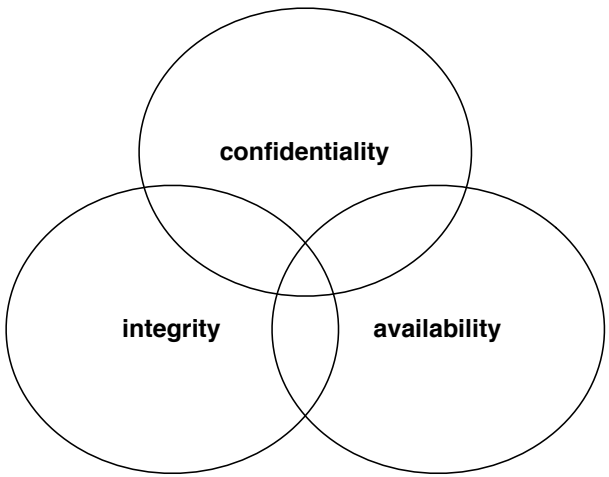
Personal data you dont want to loose:

- Wedding pictures
- Pictures of your children
- Sextapes
- Personal finances

Source: picture of my son less than 24 hours old - precious!



Confidentiality Integrity Availability



We want to protect something

Confidentiality - data holdes hemmelige

Integrity - data ændres ikke uautoriseret

Availability - data og systemet er tilgængelige når de skal bruges

Why think of security?

> Privacy is necessary for an open society in the electronic age. Privacy is not secrecy. A private matter is something one doesn't want the whole world to know, but a secret matter is something one doesn't want anybody to know. Privacy is the power to selectively reveal oneself to the world. A Cypherpunk's Manifesto by Eric Hughes, 1993

Copied from https://cryptoparty.org/wiki/CryptoParty

Solidaritetskryptering

Hvorfor skal vi kryptere?

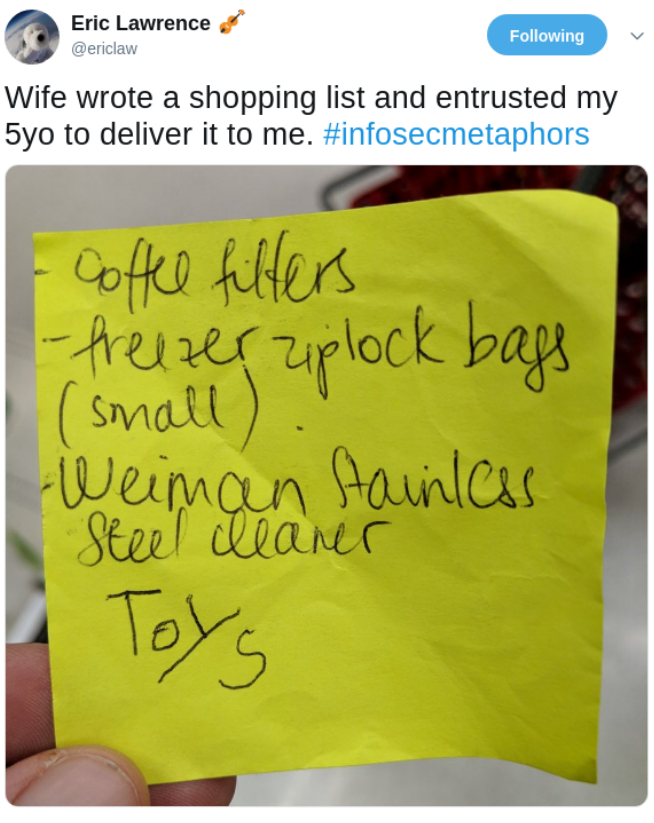
```
      Køn
                      Seksualitet
Tro religion       hatecrimes

Politisk overbevisning, eller blot aktiv

Whistleblowers              soldater      diplomater
```

Du bestemmer ikke hvem der diskrimineres eller trues i andre lande

Når vi krypterer hjælper vi andre! **Solidaritetskryptering**

Basic cryptography

- Confidentiality - data holdes hemmelige
- Integrity - data ændres ikke uautoriseret
- A common attack category is children intercepting messages
- or MiTM Mini in the Middle in this case



Cryptography

Cryptography or cryptology is the practice and study of techniques for secure communication

Modern cryptography is heavily based on mathematical theory and computer science practice; cryptographic algorithms are designed around computational hardness assumptions, making such algorithms hard to break in practice by any adversary

Symmetric-key cryptography refers to encryption methods in which both the sender and receiver share the same key, to ensure confidentiality, example algorithm AES

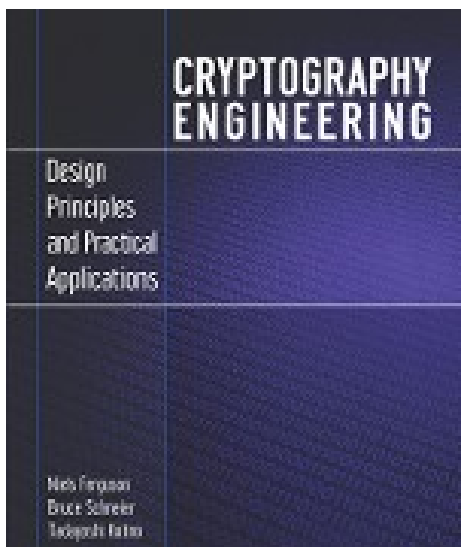
Public-key cryptography (like RSA) uses two related keys, a key pair of a public key and a private key. This allows for easier key exchanges, and can provide confidentiality, and methods for signatures and other services

Source: https://en.wikipedia.org/wiki/Cryptography

Kryptografi er svært

Åbent kursus på Stanford
http://crypto-class.org/

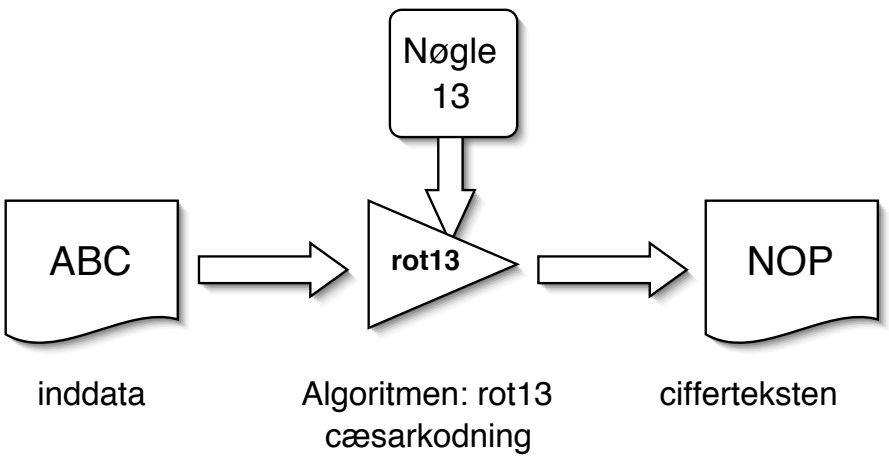
Kryptering: Cryptography Engineering



Cryptography Engineering by Niels Ferguson, Bruce Schneier, and Tadayoshi Kohno
https://www.schneier.com/book-ce.html

Encryption Decryption

Kryptografi

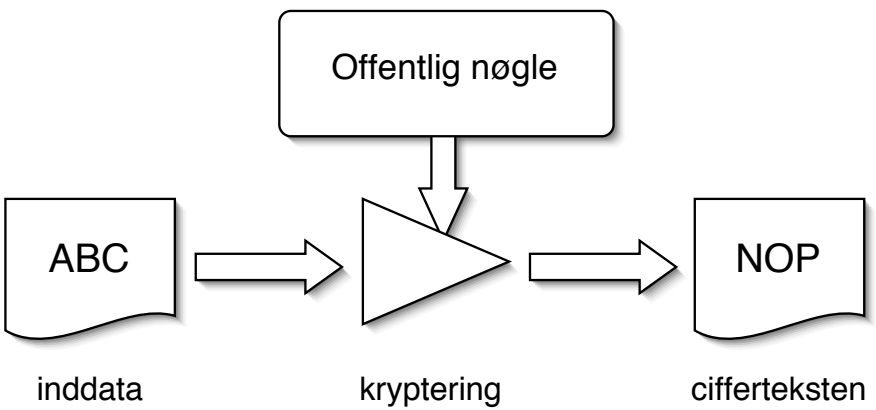


Kryptografi er læren om, hvordan man kan kryptere data

Kryptografi benytter algoritmer som sammen med nøgler giver en ciffertekst

- der kun kan læses ved hjælp af den tilhørende nøgle

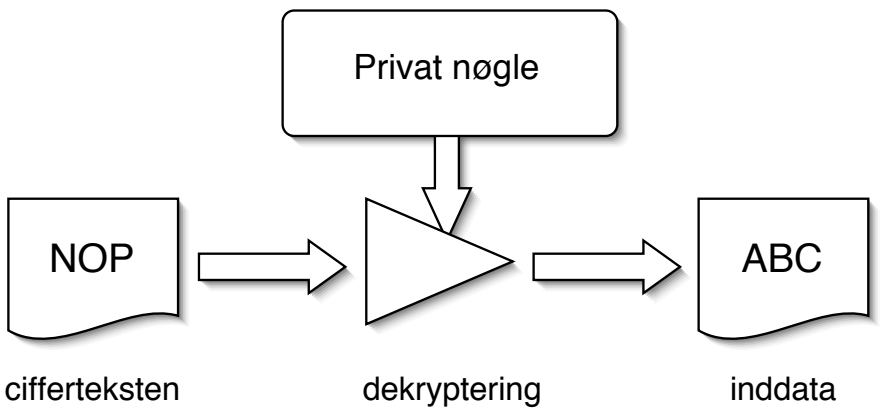
Public key kryptografi - 1



privat-nøgle kryptografi (eksempelvis AES) benyttes den samme nøgle til kryptering og dekryptering

offentlig-nøgle kryptografi (eksempelvis RSA) benytter to separate nøgler til kryptering og dekryptering

Public key kryptografi - 2



offentlig-nøgle kryptografi (eksempelvis RSA) bruger den private nøgle til at dekryptere

man kan ligeledes bruge offentlig-nøgle kryptografi til at signere dokumenter
- som så verificeres med den offentlige nøgle

NB: Kryptering alene sikrer ikke anonymitet

Kryptografiske principper

Algoritmerne er kendte

Nøglerne er hemmelige

Nøgler har en vis levetid - de skal skiftes ofte

Et successfuldt angreb på en krypto-algoritme er enhver genvej som kræver mindre arbejde end en gennemgang af alle nøglerne

Nye algoritmer, programmer, protokoller m.v. skal gennemgås nøje!

Se evt. Snake Oil Warning Signs: Encryption Software to Avoid
http://www.interhack.net/people/cmcurtin/snake-oil-faq.html

DES, Triple DES og AES

DES kryptering - gammel og pensioneret!

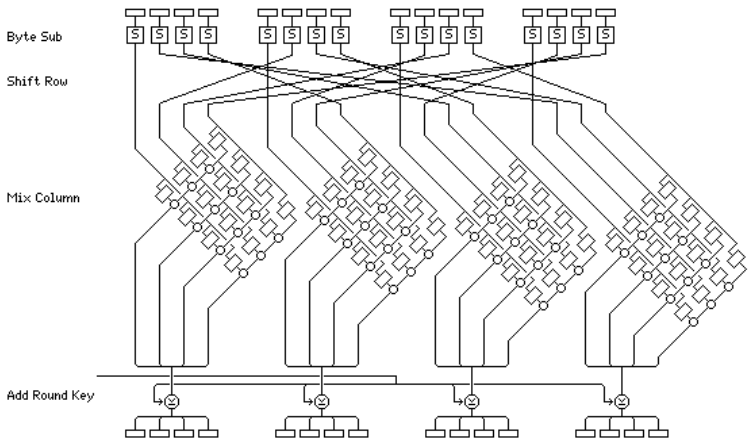
Der blev i 2001 vedtaget en ny standard algoritme Advanced Encryption Standard (AES) som afløser Data Encryption Standard (DES)

Algoritmen hedder Rijndael og er udviklet af Joan Daemen og Vincent Rijmen.

Se også https://en.wikipedia.org/wiki/Advanced_Encryption_Standard

Findes animationer (med fejl) https://www.youtube.com/watch?v=mIzxpkdXP58

AES Advanced Encryption Standard



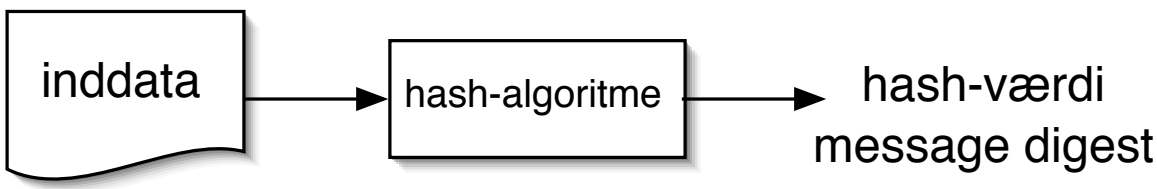
- The official Rijndael web site displays this image to promote understanding of the Rijndael round transformation [8].
- Key sizes 128,192,256 bit typical
- Some extensions in cryptosystems exist: XTS-AES-256 really is 2 instances of AES-128 and 384 is two instances of AES-192 and 512 is two instances of AES-256
- https://en.wikipedia.org/wiki/RSA_(cryptosystem)

RSA

> RSA (Rivest–Shamir–Adleman) is one of the first public-key cryptosystems and is widely used for secure data transmission. ... In RSA, this asymmetry is based on the practical difficulty of the factorization of the product of two large prime numbers, the "factoring problem". The acronym RSA is made of the initial letters of the surnames of Ron Rivest, Adi Shamir, and Leonard Adleman, who first publicly described the algorithm in 1978.

- Key sizes 1,024 to 4,096 bit typical
- Quote from: https://en.wikipedia.org/wiki/RSA_(cryptosystem)

Hashing - MD5 message digest funktion



HASH algoritmer giver en næsten unik værdi baseret på input

værdien ændres radikalt selv ved små ændringer i input

MD5 er blandt andet beskrevet i RFC-1321: The MD5 Message-Digest Algorithm

Både MD5 og SHA-1 er idag gamle og skal ikke bruges mere

Idag benyttes eksempelvis https://en.wikipedia.org/wiki/PBKDF2

Old skool NT hashes

NT LAN manager hash værdier er noget man typisk kunne samle op i netværk

det er en hash værdi af et password som man ikke burde kunne bruge til noget - hash algoritmer er envejs

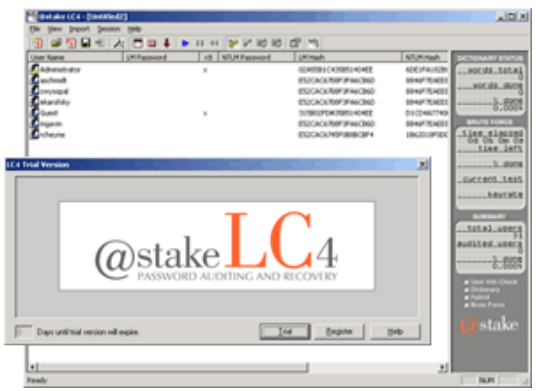
opbygningen gør at man kan forsøge brute-force på 7 tegn ad gangen!

en moderne pc med l0phtcrack kan nemt knække de fleste password på få dage!

og sikkert 25-30% indenfor den første dag - hvis der ingen politik er omkring kodeord!

ved at generere store tabeller, eksempelvis 100GB kan man dække mange hashværdier af passwords med almindelige bogstaver, tal og tegn - og derved knække passwordshashes på sekunder. Søg efter rainbowcrack med google

l0phtcrack LC4



Consider that at one of the largest technology companies, where policy required that passwords exceed 8 characters, mix cases, and include numbers or symbols...

L0phtCrack obtained 18% of the passwords in 10 minutes
90% of the passwords were recovered within 48 hours on a Pentium II/300
The Administrator and most Domain Admin passwords were cracked
http://www.atstake.com/research/lc/

Cracking passwords

- Hashcat is the world's fastest CPU-based password recovery tool.
- oclHashcat-plus is a GPGPU-based multi-hash cracker using a brute-force attack (implemented as mask attack), combinator attack, dictionary attack, hybrid attack, mask attack, and rule-based attack.
- oclHashcat-lite is a GPGPU cracker that is optimized for cracking performance. Therefore, it is limited to only doing single-hash cracking using Markov attack, Brute-Force attack and Mask attack.
- John the Ripper password cracker old skool men stadig nyttig

Source:
http://hashcat.net/wiki/
http://www.openwall.com/john/

Encryption key length - who are attacking you

Encryption key lengths & hacking feasibility

Type of Attacker	*Budget*	Tool	*Time & Cost/Key 40 bit*	*Time & Cost/Key 56 bit*
Regular User	Minimal $400	Scavenged computer time FPGA	1 week 5 hours ($.08)	Not feasible 38 years ($5,000)
Small Business	$10,000	FPGA [1]	12 min.($.08)	556 days ($5,000)
Corporate Department	$300,000	FPGA ASIC [2]	24 sec. ($.08) 0.18 sec. ($.001)	19 days ($5,000) 3 hours ($38)
Large Corporation	$10M	ASIC	0.005 sec.($0.001)	6 min. ($38)
Intelligence Agency	$300M	ASIC	0.0002 sec.($0.001)	12 sec. ($38)

Source: http://www.mycrypto.net/encryption/encryption_crack.html

More up to date: In 1998, the EFF built Deep Crack for less than $250,000

https://en.wikipedia.org/wiki/EFF_DES_cracker

FPGA Based UNIX Crypt Hardware Password Cracker - 100 EUR in 2006

http://www.sump.org/projects/password/

Pass the hash

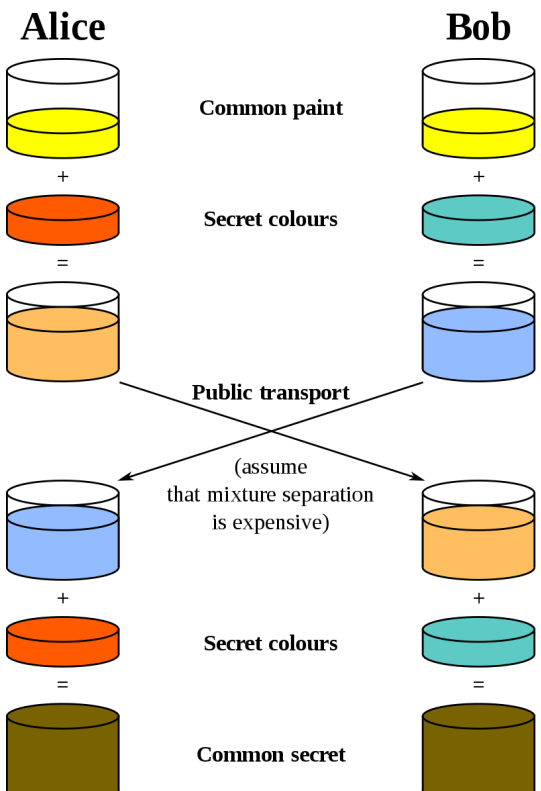
Lots of tools in pentesting pass the hash, reuse existing credentials and tokens *Still Passing the Hash 15 Years Later* http://passing-the-hash.blogspot.dk/2013/04/pth-toolkit-for-kali-interim-status.html

> If a domain is built using only modern Windows OSs and COTS products (which know how to operate within these new constraints), and configured correctly with no shortcuts taken, then these protections represent a big step forward.

Source:
http://www.harmj0y.net/blog/penetesting/pass-the-hash-is-dead-long-live-pass-the-hash/ https://samsclass.info/lulz/pth-8.1.htm

Diffie Hellman exchange

Diffie–Hellman key exchange (DH)[nb 1] is a method of securely exchanging cryptographic keys over a public channel and was one of the first public-key protocols as originally conceptualized by Ralph Merkle and named after Whitfield Diffie and Martin Hellman.[1][2] DH is one of the earliest practical examples of public key exchange implemented within the field of cryptography. ... The scheme was first published by Whitfield Diffie and Martin Hellman in 1976



- Quote from: https://en.wikipedia.org/wiki/Diffie-Hellman_key_exchange
- Today we also use elliptic curves with DH
  https://en.wikipedia.org/wiki/Elliptic-curve_cryptography

Elliptic Curve

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> Elliptic-curve cryptography (ECC) is an approach to public-key cryptography based on the algebraic structure of elliptic curves over finite fields. ECC requires smaller keys compared to non-EC cryptography (based on plain Galois fields) to provide equivalent security.[1]

- Today we use https://en.wikipedia.org/wiki/Elliptic-curve_cryptography

Transport Layer Security (TLS)

Oprindeligt udviklet af Netscape Communications Inc.

Secure Sockets Layer SSL er idag blevet adopteret af IETF og kaldes derfor også for Transport Layer Security TLS TLS er baseret på SSL Version 3.0

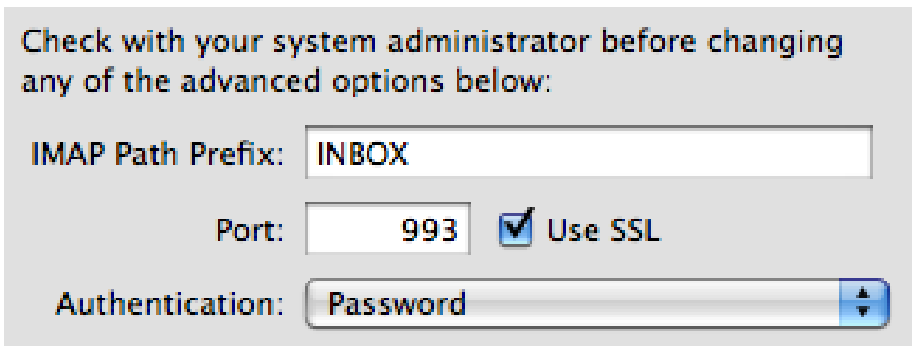
RFC-2246 The TLS Protocol Version 1.0 fra Januar 1999

RFC-3207 SMTP STARTTLS

Det er svært!

Stanford Dan Boneh udgiver en masse omkring crypto
https://crypto.stanford.edu/~dabo/cryptobook/

SSL/TLS udgaver af protokoller



Mange protokoller findes i udgaver hvor der benyttes SSL

HTTPS vs HTTP

IMAPS, POP3S, osv.

Bemærk: nogle protokoller benytter to porte IMAP 143/tcp vs IMAPS 993/tcp

Andre benytter den samme port men en kommando som starter:

SMTP STARTTLS RFC-3207

Secure protocols

Securing e-mail

- Pretty Good Privacy - Phil Zimmermann
- OpenPGP = e-mail security

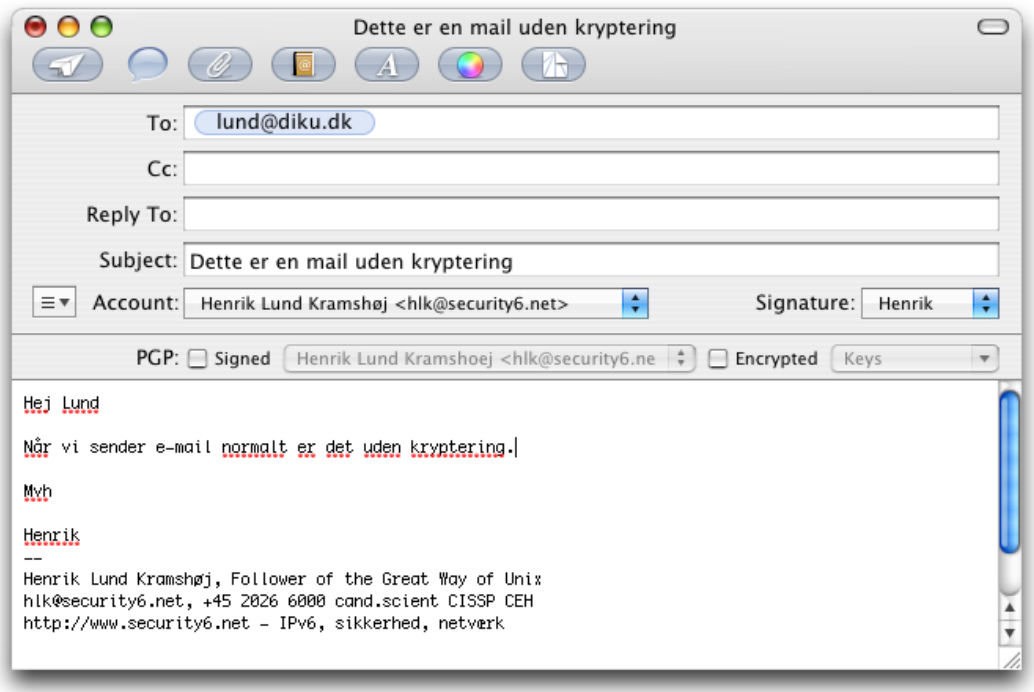
Network sessions use SSL/TLS

- Secure Sockets Layer SSL / Transport Layer Services TLS
- Encrypting data sent and received
- SSL/TLS already used for many protocols as a wrapper: POP3S, IMAPS, SSH, SMTP+TLS m.fl.

Encrypting traffic at the network layer - Virtual Private Networks VPN

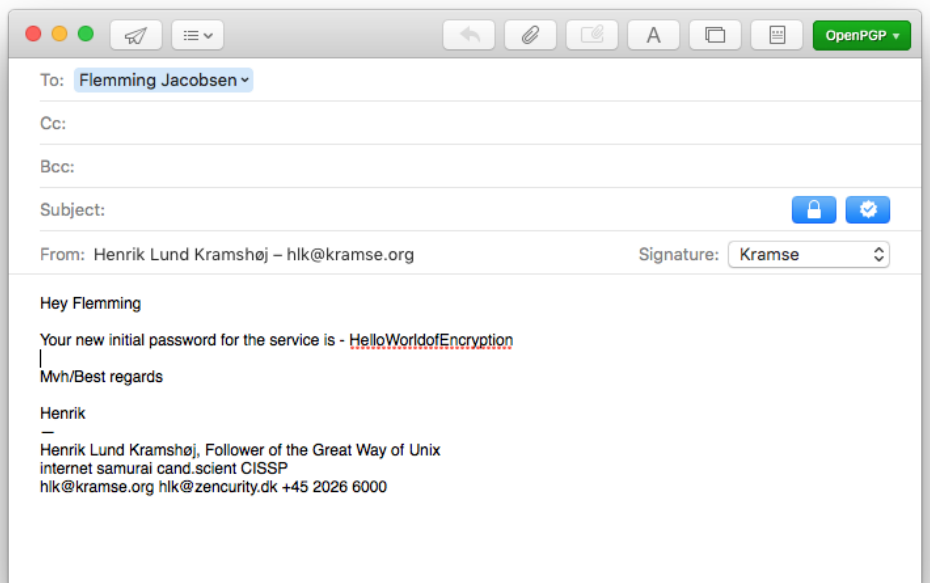
- IPsec IP Security Framework, se også L2TP
- PPTP Point to Point Tunneling Protocol - dårlig og usikker, brug den ikke mere!
- OpenVPN uses SSL/TLS across TCP or UDP

Email er usikkert



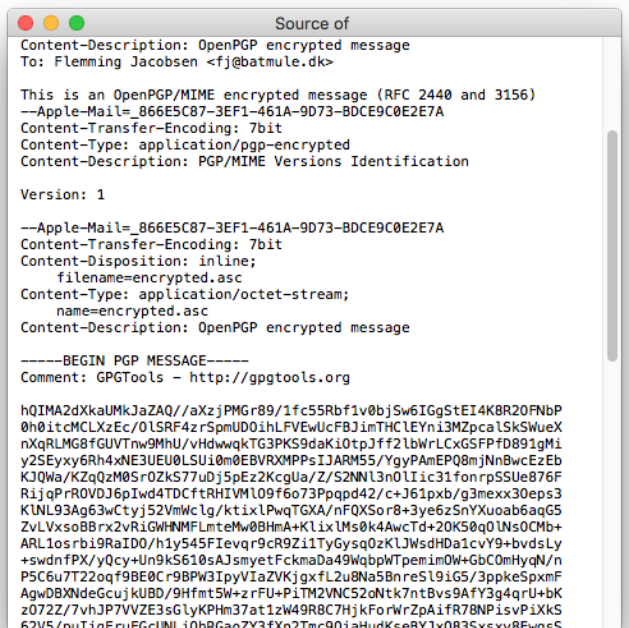
Email uden kryptering - er som et postkort

Email med OpenPGP kryptering - afsendelse



En sikker krypteret email er ikke sværere at sende

Krypteret OpenPGP Email under transporten



En sikker krypteret email er beskyttet undervejs

Fokus: TLS og VPN indstillinger

```
ssl_prefer_server_ciphers on;
ssl_protocols TLSv1 TLSv1.1 TLSv1.2; # not possible to do exclusive
ssl_ciphers 'EDH+CAMELLIA:EDH+aRSA:EECDH+aRSA+AESGCM:EECDH+aRSA+SHA384:EECDH+\
  \aRSA+SHA256:EECDH:+CAMELLIA256:+AES256:+CAMELLIA128:+AES128:+SSLv3:!aNULL:!\
  \eNULL:!LOW:!3DES:!MD5:!EXP:!PSK:!DSS:!RC4:!SEED:!ECDSA:CAMELLIA256-SHA:AES256\
  \-SHA:CAMELLIA128-SHA:AES128-SHA';
add_header Strict-Transport-Security max-age=15768000; # six months
# use this only if all subdomains support HTTPS!
# add_header Strict-Transport-Security "max-age=15768000; includeSubDomains";
```

Listing 2.6: *SSL settings for nginx*
[configuration/Webservers/nginx/default]

- De fleste har https nu, men er det konfigureret optimalt
- Vi bruger også VPN til at forbinde sites, kontorer
- Anbefaler at alle indstillingerne gennemgås!

Nmap efter SSL og TLS

Example Usage

```
nmap -sV -sC <target>
```

Script Output

```
443/tcp open   https   syn-ack
| sslv2:
|   SSLv2 supported
|   ciphers:
|     SSL2_DES_192_EDE3_CBC_WITH_MD5
|     SSL2_IDEA_128_CBC_WITH_MD5
|     SSL2_RC2_CBC_128_CBC_WITH_MD5
|     SSL2_RC4_128_WITH_MD5
|     SSL2_DES_64_CBC_WITH_MD5
|     SSL2_RC2_CBC_128_CBC_WITH_MD5
|_    SSL2_RC4_128_EXPORT40_WITH_MD5
```

Nu vi har lært Kali og Nmap at kende

- Find nemt alle ssl version 2 og 3
  `nmap --script ssl-enum-ciphers`
- Brug ssllabs https://www.ssllabs.com/

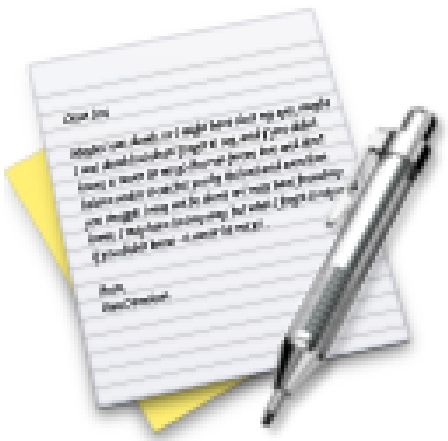
sslscan

```
root@kali:~# sslscan --ssl2 web.kramse.dk
Version: 1.10.5-static
OpenSSL 1.0.2e-dev xx XXX xxxx

Testing SSL server web.kramse.dk on port 443
...
  SSL Certificate:
Signature Algorithm: sha256WithRSAEncryption
RSA Key Strength:    2048

Subject:  *.kramse.dk
Altnames: DNS:*.kramse.dk, DNS:kramse.dk
Issuer:   AlphaSSL CA - SHA256 - G2
```

Source: Originally sslscan from http://www.titania.co.uk but use the version on Kali

SSLscan can check your own sites, while Qualys SSLLabs only can test from hostname

Exercise

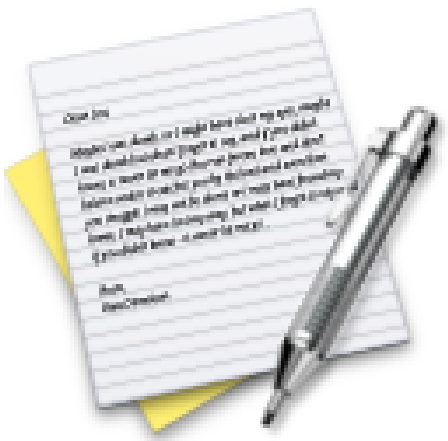


Now lets do the exercise

⚠ SSL/TLS scanners 15min

which is number **24** in the exercise PDF.

Exercise

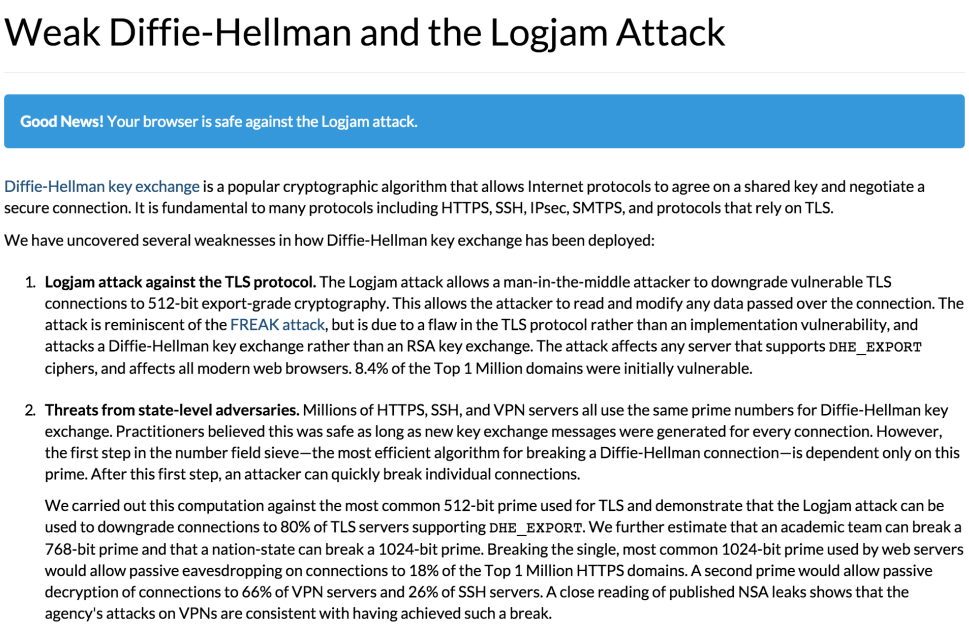


Now lets do the exercise

Nmap Ikescan IPsec 15min

which is number **25** in the exercise PDF.

Example Weak DH paper



Weak Diffie-Hellman and the Logjam Attack

Good News! Your browser is safe against the Logjam attack.

Diffie-Hellman key exchange is a popular cryptographic algorithm that allows Internet protocols to agree on a shared key and negotiate a secure connection. It is fundamental to many protocols including HTTPS, SSH, IPsec, SMTPS, and protocols that rely on TLS.

We have uncovered several weaknesses in how Diffie-Hellman key exchange has been deployed:

1. **Logjam attack against the TLS protocol.** The Logjam attack allows a man-in-the-middle attacker to downgrade vulnerable TLS connections to 512-bit export-grade cryptography. This allows the attacker to read and modify any data passed over the connection. The attack is reminiscent of the FREAK attack, but is due to a flaw in the TLS protocol rather than an implementation vulnerability, and attacks a Diffie-Hellman key exchange rather than an RSA key exchange. The attack affects any server that supports `DHE_EXPORT` ciphers, and affects all modern web browsers. 8.4% of the Top 1 Million domains were initially vulnerable.

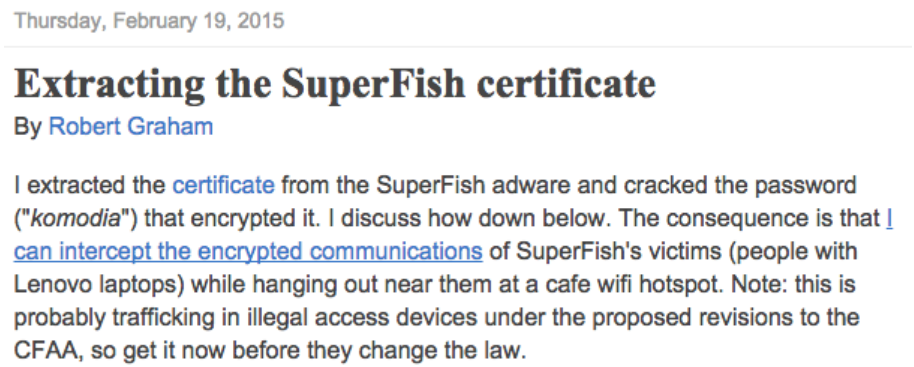
2. **Threats from state-level adversaries.** Millions of HTTPS, SSH, and VPN servers all use the same prime numbers for Diffie-Hellman key exchange. Practitioners believed this was safe as long as new key exchange messages were generated for every connection. However, the first step in the number field sieve—the most efficient algorithm for breaking a Diffie-Hellman connection—is dependent only on this prime. After this first step, an attacker can quickly break individual connections.

   We carried out this computation against the most common 512-bit prime used for TLS and demonstrate that the Logjam attack can be used to downgrade connections to 80% of TLS servers supporting `DHE_EXPORT`. We further estimate that an academic team can break a 768-bit prime and that a nation-state can break a 1024-bit prime. Breaking the single, most common 1024-bit prime used by web servers would allow passive eavesdropping on connections to 18% of the Top 1 Million HTTPS domains. A second prime would allow passive decryption of connections to 66% of VPN servers and 26% of SSH servers. A close reading of published NSA leaks shows that the agency's attacks on VPNs are consistent with having achieved such a break.

Source: https://weakdh.org/ and
https://weakdh.org/imperfect-forward-secrecy-ccs15.pdf

Every year in different SSL/TLS implementations there have been problems.

Why?, because things like Superfish February 2015



Thursday, February 19, 2015

Extracting the SuperFish certificate

By Robert Graham

I extracted the certificate from the SuperFish adware and cracked the password ("*komodia*") that encrypted it. I discuss how down below. The consequence is that I can intercept the encrypted communications of SuperFish's victims (people with Lenovo laptops) while hanging out near them at a cafe wifi hotspot. Note: this is probably trafficking in illegal access devices under the proposed revisions to the CFAA, so get it now before they change the law.

Lenovo laptops included Adware, which did SSL/TLS Man in the Middle on connections. They had a root certificate installed on the Windows operating system, WTF!

Sources:

https://en.wikipedia.org/wiki/Superfish

http://blog.erratasec.com/2015/02/extracting-superfish-certificate.html

http://www.version2.dk/blog/kibana4-superfish-og-emergingthreats-81610

https://www.eff.org/deeplinks/2015/02/further-evidence-lenovo-breaking-https-security-its-laptops

FREAK March 2015

kea

> "A group of cryptographers at INRIA, Microsoft Research and IMDEA have discovered some serious vulnerabilities in OpenSSL (e.g., Android) clients and Apple TLS/SSL clients (e.g., Safari) that allow a 'man in the middle attacker' to downgrade connections from 'strong' RSA to 'export-grade' RSA. These attacks are real and exploitable against a shocking number of websites – including government websites. Patch soon and be careful."

Source: Matthew Green, cryptographer and research professor at Johns Hopkins Univ

http://blog.cryptographyengineering.com/2015/03/attack-of-week-freak-or-factoring-nsa.html

https://www.smacktls.com/ https://freakattack.com/

OpenSSL, LibreSSL, Apple SSL flaw exit exit exit!, Android SSL, certs certs!!!111, SSLv3, Heartbleed, MS TLS

PS From now on its TLS! Not SSL anymore, any SSLv2, SSLv3 is old and vulnerable

Heartbleed CVE-2014-0160

The Heartbleed Bug

The Heartbleed Bug is a serious vulnerability in the popular OpenSSL cryptographic software library. This weakness allows stealing the information protected, under normal conditions, by the SSL/TLS encryption used to secure the Internet. SSL/TLS provides communication security and privacy over the Internet for applications such as web, email, instant messaging (IM) and some virtual private networks (VPNs).

The Heartbleed bug allows anyone on the Internet to read the memory of the systems protected by the vulnerable versions of the OpenSSL software. This compromises the secret keys used to identify the service providers and to encrypt the traffic, the names and passwords of the users and the actual content. This allows attackers to eavesdrop on communications, steal data directly from the services and users and to impersonate services and users.

Nok det mest kendte SSL/TLS exploit

Source: http://heartbleed.com/

Heartbleed hacking

```
06b0: 2D 63 61 63 68 65 0D 0A 43 61 63 68 65 2D 43 6F  -cache..Cache-Co
06c0: 6E 74 72 6F 6C 3A 20 6E 6F 2D 63 61 63 68 65 0D  ntrol: no-cache.
06d0: 0A 0D 0A 61 63 74 69 6F 6E 3D 67 63 5F 69 6E 73  ...action=gc_ins
06e0: 65 72 74 5F 6F 72 64 65 72 26 62 69 6C 6C 6E 6F  ert_order&billno
06f0: 3D 50 5A 4B 31 31 30 31 26 70 61 79 6D 65 6E 74  =PZK1101&payment
0700: 5F 69 64 3D 31 26 63 61 72 64 5F 6E 75 6D 62 65  _id=1&card_numbe
0710: XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX XX   r=4060xxxx413xxx
0720: 39 36 26 63 61 72 64 5F 65 78 70 5F 6D 6F 6E 74  96&card_exp_mont
0730: 68 3D 30 32 26 63 61 72 64 5F 65 78 70 5F 79 65  h=02&card_exp_ye
0740: 61 72 3D 31 37 26 63 61 72 64 5F 63 76 6E 3D 31  ar=17&card_cvn=1
0750: 30 39 F8 6C 1B E5 72 CA 61 4D 06 4E B3 54 BC DA  09.l..r.aM.N.T..
```

- Obtained using Heartbleed proof of concepts - Gave full credit card details
- "can XXX be exploited- yes, clearly! PoCs ARE needed
  without PoCs even Akamai wouldn't have repaired completely!
- The internet was ALMOST fooled into thinking getting private keys from Heartbleed was not possible - scary indeed.

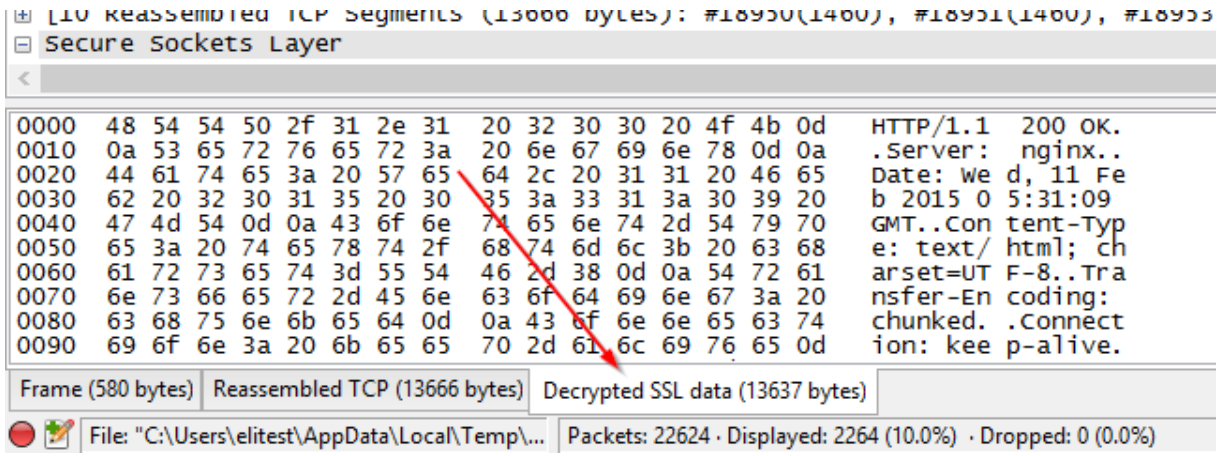
Key points after heartbleed

Source: picture source

https://www.duosecurity.com/blog/heartbleed-defense-in-depth-part-2

- Writing SSL software and other secure crypto software is hard
- Configuring SSL is hard
  check you own site https://www.ssllabs.com/ssltest/
- SSL is hard, finding bugs "all the time"http://armoredbarista.blogspot.dk/2013/01/a-brief-chronology-of-ssltls-attacks.html

Feb 2015 Decrypting TLS Browser Traffic With Wireshark



Firefox and Chrome both support logging the symmetric session key used to encrypt TLS traffic to a file

Wireshark can read this file - and decrypt sessions - Nifty trick

Source: great blog article about the features used

https://jimshaver.net/2015/02/11/decrypting-tls-browser-traffic-with-wireshark-the-easy-way/

HTTPS Everywhere

HTTPS Everywhere is a Firefox extension produced as a collaboration between The Tor Project and the Electronic Frontier Foundation. It encrypts your communications with a number of major websites.

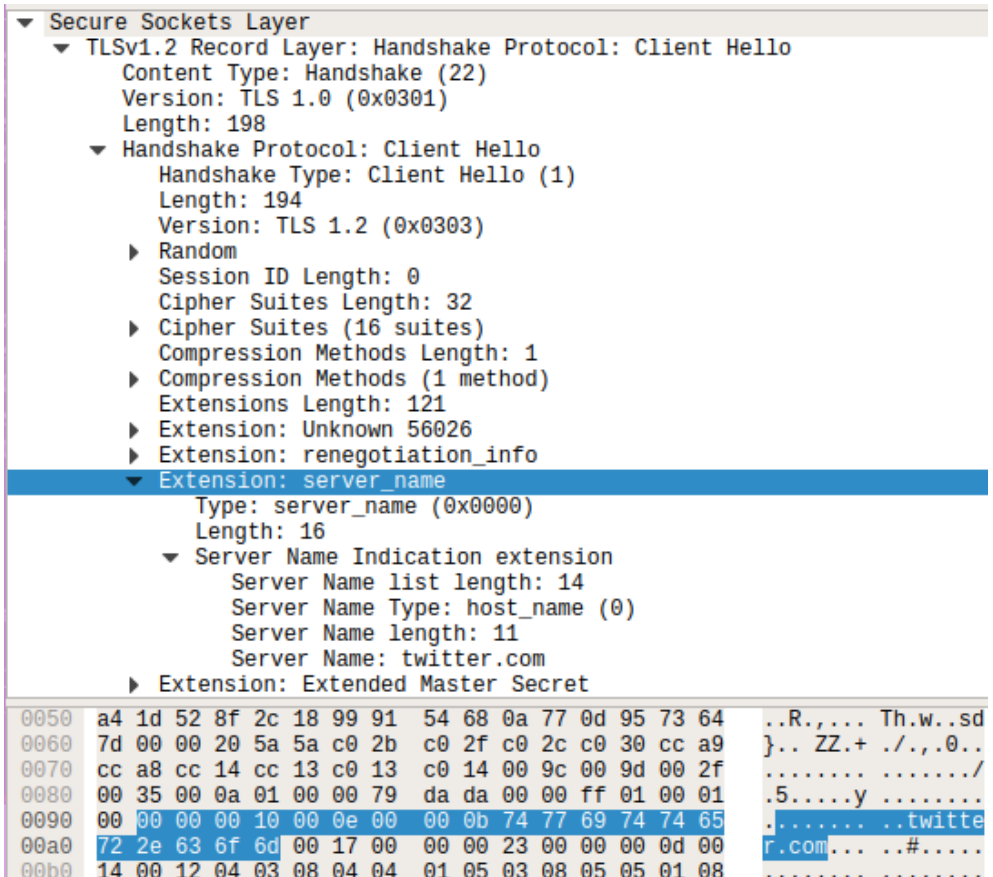
http://www.eff.org/https-everywhere

TLS Server Name Indication extension

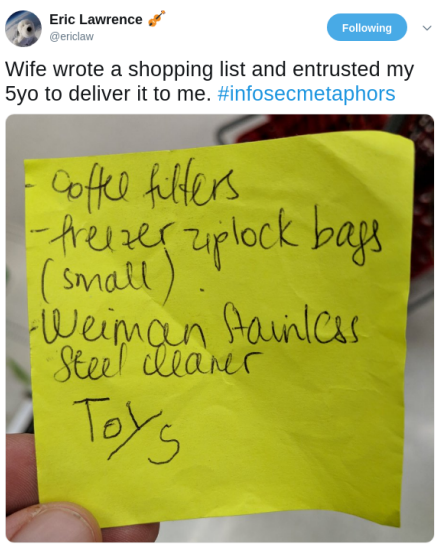
Vi skal kryptere, men desværre så skjuler vores HTTPS ikke hvad site vi tilgår.

- HTTPS er idag TLS Transport Layer Security
- Verifikation sker med certifikater der præsenteres af server
- Der kan være flere sites på en enkelt IP - med SNI
- Desværre vælges det rigtige certifikat før krypteringen starter

TLS Server Name Indication example


Secure Sockets Layer
TLSv1.2 Record Layer: Handshake Protocol: Client Hello
Content Type: Handshake (22)
Version: TLS 1.0 (0x0301)
Length: 198
Handshake Protocol: Client Hello
Handshake Type: Client Hello (1)
Length: 194
Version: TLS 1.2 (0x0303)
Random
Session ID Length: 0
Cipher Suites Length: 32
Cipher Suites (16 suites)
Compression Methods Length: 1
Compression Methods (1 method)
Extensions Length: 121
Extension: Unknown 56026
Extension: renegotiation_info
Extension: server_name
Type: server_name (0x0000)
Length: 16
Server Name Indication extension
Server Name list length: 14
Server Name Type: host_name (0)
Server Name length: 11
Server Name: twitter.com
Extension: Extended Master Secret
0050 a4 1d 52 8f 2c 18 99 91 54 68 0a 77 0d 95 73 64 ..R.,... Th.w..sd
0060 7d 00 00 20 5a 5a c0 2b c0 2f c0 2c c0 30 cc a9 }.. ZZ.+ ./.,.0..
0070 cc a8 cc 14 cc 13 c0 13 c0 14 00 9c 00 9d 00 2f ..../
0080 00 35 00 0a 01 00 00 79 da da 00 00 ff 01 00 01 .5.....y ....
0090 00 00 00 00 10 00 0e 00 00 0b 74 77 69 74 74 65 ....twitte
00a0 72 2e 63 6f 6d 00 17 00 00 00 23 00 00 00 0d 00 r.com... ..#.....
00b0 14 00 12 04 03 08 04 04 01 05 03 08 05 05 01 08 ....

Basic cryptography



- A common attack category is children intercepting messages
- or MiTM Mini in the Middle in this case

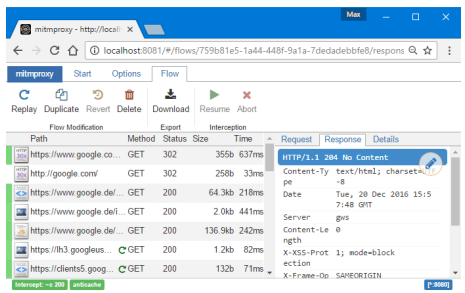
sslstrip - transparently hijack HTTP

> This tool provides a demonstration of the HTTPS stripping attacks that I presented at Black Hat DC 2009. It will transparently hijack HTTP traffic on a network, watch for HTTPS links and redirects, then map those links into either look-alike HTTP links or homograph-similar HTTPS links. It also supports modes for supplying a favicon which looks like a lock icon, selective logging, and session denial. For more information on the attack, see the video from the presentation below.

https://moxie.org/software/sslstrip/

- *First, arpspoof convinces a host that our MAC address is the router's MAC address, and the target begins to send us all its network traffic.*
- *supplying a favicon which looks like a lock icon*

mitmproxy - interactive HTTPS proxy



https://mitmproxy.org/

- Command line, Web interface, Python API
- Intercept HTTP and HTTPS requests and responses and modify them on the fly
- Reverse proxy mode to forward traffic to a specified server
- Make scripted changes to HTTP traffic using Python
- SSL/TLS certificates for interception are generated on the fly

sslsplit - transparent SSL/TLS interception

Overview
SSLsplit is designed to transparently terminate connections that are redirected to it using a network address translation engine. SSLsplit then terminates SSL/TLS and initiates a new SSL/TLS connection to the original destination address, while logging all data transmitted. Besides NAT based operation, SSLsplit also supports static destinations and using the server name indicated by SNI as upstream destination. SSLsplit is purely a transparent proxy and cannot act as a HTTP or SOCKS proxy configured in a browser.

https://www.roe.ch/SSLsplit

- SSLsplit implements a number of defences against mechanisms which would normally prevent MitM attacks or make them more difficult
- SSLsplit can deny OCSP requests in a generic way. For HTTP and HTTPS connections, SSLsplit mangles headers to prevent server-instructed public key pinning (HPKP), avoid strict transport security restrictions (HSTS), avoid Certificate Transparency enforcement (Expect-CT) and prevent switching to QUIC/SPDY, HTTP/2 or WebSockets (Upgrade, Alternate Protocols)

We will not really run SSLsplit, but its interesting

Other crypto related stuff

PRNG

kea

Debian OpenSSL [edit]

In May 2008, security researcher Luciano Bello revealed his discovery that changes made in 2006 to the random number generator in the version of the OpenSSL package distributed with Debian GNU/Linux and other Debian-based distributions, such as Ubuntu, dramatically reduced the entropy of generated values and made a variety of security keys vulnerable to attack.[10][11] The security weakness was caused by changes made to the openssl code by a Debian developer in response to compiler warnings of apparently redundant code.[12] This caused a massive worldwide regeneration of keys, and despite all attention the issue got, it could be assumed many of these old keys are still in use. Key types affected include SSH keys, OpenVPN keys, DNSSEC keys, key material for use in X.509 certificates and session keys used in SSL/TLS connections. Keys generated with GnuPG or GNUTLS are not affected as these programs used different methods to generate random numbers. Non-Debian-based Linux distributions are also unaffected. This security vulnerability was promptly patched after it was reported.

https://en.wikipedia.org/wiki/Random_number_generator_attack#Debian_OpenSSL

The random number generator is VITAL for crypto security

Check out modern CPUs and Linux response to this
https://en.wikipedia.org/wiki/RdRand

Fokus: DNS og email

- Vi er afhængige af email, modtagelse og afsendelse
- Når vi modtager skal det helst gå hurtigt
- Når vi sender skal vi ikke ende i spam mappen
- Phishing, hvem kan sende *fra vores domæne*

Various key attack types, clients and employees

- Phishing - sending fake emails, to collect credentials
- Spear phishing - targetted attacks
- Person in the middle - sniffing and changing data in transit
- Drive-by attacks - web pages infected with malware, often ad servers
- Malware transferred via USB or email
- Credential Stuffing, Password related, like re-use of password, see slide about being pwned

If we all wait a bit, and not click links immediately

Hackers try to create "urgency", click this or loose money

DNS er mere end navneopslag

kea

består af resource records med en type:

- adresser A-records
- IPv6 adresser AAAA-records
- autoritative navneservere NS-records
- post, mail-exchanger MX-records
- flere andre: md , mf , cname , soa , mb , mg , mr , null , wks , ptr , hinfo , minfo , mx ....

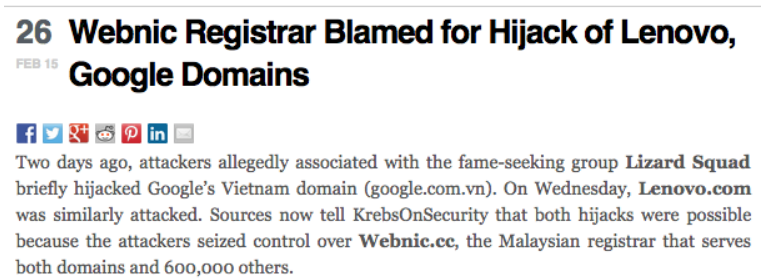
```
IN      MX      10      mail.zencurity.dk.
IN      MX      20      mail2.zencurity.dk.
```

SMTP Simple Mail Transfer Protocol

```
hlk@bigfoot:hlk$ telnet mail.kramse.dk 25
Connected to sunny.
220 sunny.kramse.dk ESMTP Postfix
HELO bigfoot
250 sunny.kramse.dk
MAIL FROM: Henrik
250 Ok
RCPT TO: hlk@kramse.dk
250 Ok
DATA
354 End data with <CR><LF>.<CR><LF>
hejsa
.
250 Ok: queued as 749193BD2
QUIT
221 Bye
```

- RFC-821 SMTP Simple Mail Transfer Protocol fra 1982
- http://en.wikipedia.org/wiki/Simple_Mail_Transfer_Protocol

DNS attacks, Your registrar



26 FEB 15

Webnic Registrar Blamed for Hijack of Lenovo, Google Domains

Two days ago, attackers allegedly associated with the fame-seeking group **Lizard Squad** briefly hijacked Google's Vietnam domain (google.com.vn). On Wednesday, **Lenovo.com** was similarly attacked. Sources now tell KrebsOnSecurity that both hijacks were possible because the attackers seized control over **Webnic.cc**, the Malaysian registrar that serves both domains and 600,000 others.

DNS insecurity has huge impact on your security!

Most are denial of service, by may create Mitm or confidentiality concerns

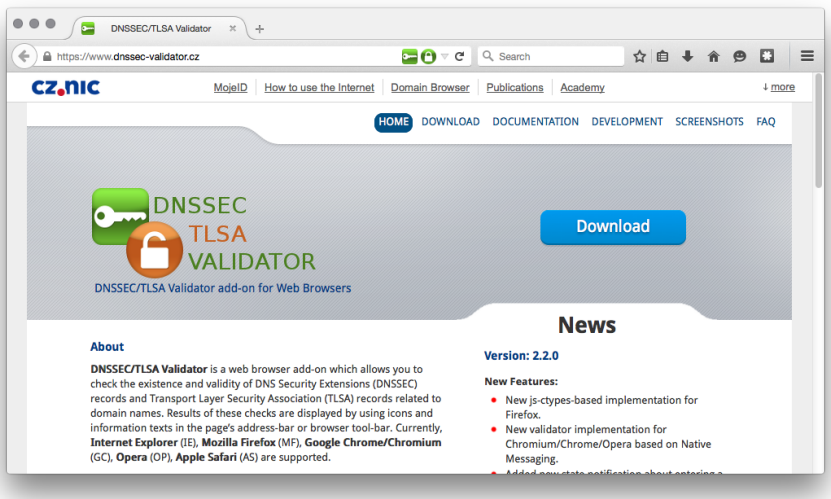
Select DNS providers with care

Sources:

https://krebsonsecurity.com/2015/02/webnic-registrar-blamed-for-hijack-of-lenovo-google-domains/

http://www.version2.dk/artikel/google-og-lenovo-defaced-som-foelge-af-overset-sikkerhedsproblemstilling-91295

DNSSEC get started now



"TLSA records store hashes of remote server TLS/SSL certificates. The authenticity of a TLS/SSL certificate for a domain name is verified by DANE protocol (RFC 6698). DNSSEC and TLSA validation results are displayer by using several icons."

DNSSEC and DANE

"Objective:

Specify mechanisms and techniques that allow Internet applications to establish cryptographically secured communications by using information distributed through DNSSEC for discovering and authenticating public keys which are associated with a service located at a domain name."

DNS-based Authentication of Named Entities (dane)

Email security - Goals

- SPF Sender Policy Framework

  https://en.wikipedia.org/wiki/Sender_Policy_Framework
- DKIM DomainKeys Identified Mail

  https://en.wikipedia.org/wiki/DomainKeys_Identified_Mail
- DMARC Domain-based Message Authentication, Reporting and Conformance

  https://en.wikipedia.org/wiki/DMARC
- DANE DNS-based Authentication of Named Entities

  https://en.wikipedia.org/wiki/DNS-based_Authentication_of_Named_Entities
- Brug allesammen, check efter ændringer!

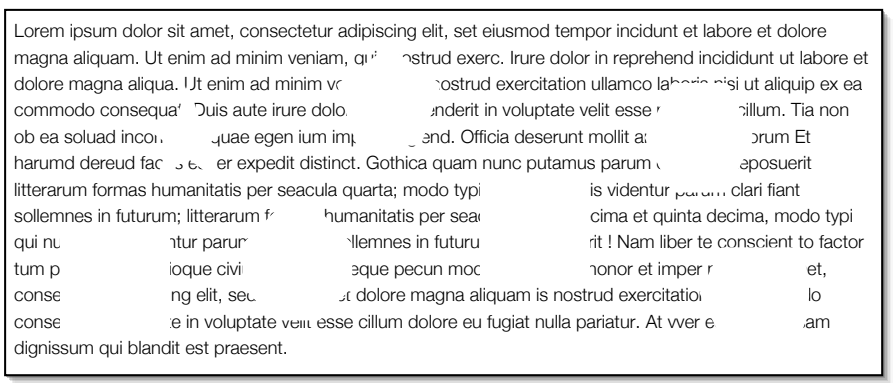
Fokus: Laptop sikkerhed

- Relevant for alle
- Hvordan sikrer vi at vi ikke mister værdierne, hardware og data typisk

Secure Laptops

- Laptops (og mobile enheder)
- Hvad kendetegner en laptop?
- Hardware naturligvis, en Macbook koster officielt mere end en brugt mellemklassebil
- - og husk brugen af laptops
- Er laptops sikre, og hvad betyder det?

Are your data secure - data at rest



Stolen laptop, tablet, phone - can anybody read your data?

Do you trust ”remote wipe”

How do you in fact wipe data securely off devices, and SSDs?

Encrypt disk and storage devices before using them in the first place!

Circumvent security - single user mode boot

Unix systems often allows boot into singleuser mode
press command-s when booting Mac OS X

Laptops can often be booted using PXE network or CD boot

Mac computers can become a Firewire disk
hold t when booting - firewire target mode

Unrestricted access to un-encrypted data

Moving hard drive to another computer is also easy

Physical access is often - **game over**

Encrypting hard disk

Becoming available in the most popular client operating systems

- Microsoft Windows Bitlocker
- Apple Mac OS X - FileVault
- FreeBSD GEOM og GBDE - encryption framework
- Linux LUKS distributions like Ubuntu ask to encrypt home dir during installation
- Some vendors have BIOS passwords, or disk passwords

Attacks on disk encryption

- Firewire, DMA & Windows, Winlockpwn via FireWire
  Hit by a Bus: Physical Access Attacks with Firewire Ruxcon 2006
- Removing memory from live system - data is not immediately lost, and can be read under some circumstances
  Lest We Remember: Cold Boot Attacks on Encryption Keys
  http://citp.princeton.edu/memory/
- This is very CSI or Hollywoord like - but a real threat
- VileFault decrypts encrypted Mac OS X disk image files
  https://code.google.com/p/vilefault/
- FileVault Drive Encryption (FVDE) (or FileVault2) encrypted volumes
  https://code.google.com/p/libfvde/

So perhaps use both hard drive encryption AND turn off computer after use?

2018 attack

Drive	1	2	3	4	5	6	7	8	9	Impact
Crucial MX100 (all form factors)	✗	✗	✗							✗ Compromised
Crucial MX200 (all form factors)	✗	✗	✗							✗ Compromised
Crucial MX300 (all form factors)	✓	✓	✓		✗	✓	✓	✓	✓	✗ Compromised
Samsung 840 EVO (SATA)	✗	✓	✓		✓	✓	✓	✗	✓	∼ Depends
Samsung 850 EVO (SATA)	✗	✓	✓		✓	✓	✓	✓	✓	∼ Depends
Samsung T3 (USB)				✗						✗ Compromised
Samsung T5 (USB)				✗						✗ Compromised

[1] Cryptographic binding in ATA Security (High mode)
[2] Cryptographic binding in ATA Security (Max mode)
[3] Cryptographic binding in TCG Opal
[4] Cryptographic binding in proprietary standard
[5] No single key for entire disk
[6] Randomized DEK on sanitize
[7] Sufficient random entropy
[8] No wear leveling related issues
[9] No DEVSLP related issues

self-encrypting deception: weakness in the encryption of solid state drives (SSDs) https://www.ru.nl/publish/pages/909282/draft-paper.pdf

Sniff, there leaks my BitLocker key

Full disk encryption is one of the cornerstones of modern endpoint protection. It is not only an effective method to protect sensitive data against physical theft, but it also protects data integrity against tampering attacks. If this protection method could be compromised without significant effort, it would break the fundamental idea of endpoint protection.

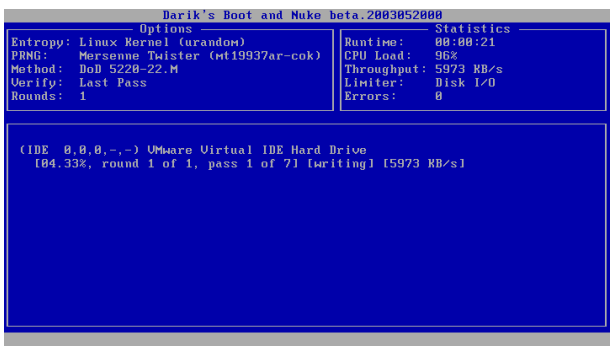
...

In this post, we research a sniffing attack against an SPI interface of Trusted Platform Module (TPM) by using publicly available tools at a reasonable cost. In addition, we release a tool which extracts the BitLocker key from the sniffed SPI traffic.

Source: Henri Nurmi, 21 December 2020
https://labs.f-secure.com/blog/sniff-there-leaks-my-bitlocker-key/

- Let's take 5-10minutes talking about this
- Remember your users, should you ask them to enter password upon boot?

... and deleting data



Getting rid of data from old devices is a pain

Some tools will not overwrite data, leaving it vulnerable to recovery

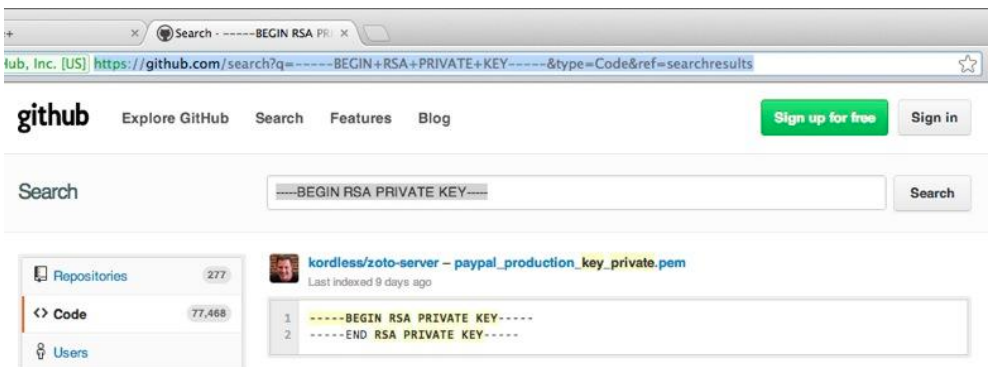
Even secure erase programs might not work on SSD
- due to reallocation of blocks

I have used Darik's Boot and Nuke ("DBAN")
http://www.dban.org/

Today I feel more confident physically destroying device

Best case if data was never on device unencrypted

Github Public passwords?



Sources:

https://twitter.com/brianaker/status/294228373377515522

http://www.webmonkey.com/2013/01/users-scramble-as-github-search-exposes-passwords-security-details/

http://www.leakedin.com/

http://www.offensive-security.com/community-projects/google-hacking-database/

Use different passwords for different sites, yes - every site!

kryptering, OpenPGP

kryptering er den eneste måde at sikre:

- fortrolighed
- autenticitet

kryptering består af:

- Algoritmer - eksempelvis RSA
- *protokoller* - måden de bruges på
- programmer - eksempelvis PGP

fejl eller sårbarheder i en af komponenterne kan formindske sikkerheden

PGP = mail sikkerhed, se eksempelvis Enigmail plugin til Mozilla Thunderbird

PGP/GPG verifikation af integriteten

Pretty Good Privacy PGP

Gnu Privacy Guard GPG

Begge understøtter OpenPGP - fra IETF RFC-2440

Når man har hentet og verificeret en nøgle kan man fremover nemt checke integriteten af software pakker

```
hlk@bigfoot:postfix$ gpg --verify  postfix-2.1.5.tar.gz.sig
gpg: Signature made Wed Sep 15 17:36:03 2004 CEST using RSA key ID D5327CB9
gpg: Good signature from "wietse venema <wietse@porcupine.org>"
gpg:                 aka "wietse venema <wietse@wzv.win.tue.nl>"
```

Secure Shell - SSH og SCP

Hvad er Secure Shell SSH?

Oprindeligt udviklet af Tatu Ylönen i Finland, se http://www.ssh.com

SSH afløser en række protokoller som er usikre:

- Telnet til terminal adgang
- r* programmerne, rsh, rcp, rlogin, ...
- FTP med brugerid/password

SSH - de nye kommandoer er

kea

kommandoerne er:

- ssh - Secure Shell
- scp - Secure Copy
- sftp - secure FTP

Husk: SSH er både navnet på protokollerne - version 1 og 2 samt programmet `ssh` til at logge ind på andre systemer

SSH tillader også port-forward, tunnel til usikre protokoller, eksempelvis X protokollen til UNIX grafiske vinduer

NB: Man bør idag bruge SSH protokol version 2!

SSH nøgler

I praksis benytter man nøgler fremfor kodeord

I kan lave jeres egne SSH nøgler med programmerne i Putty

Hvilken del skal jeg have for at kunne give jer adgang til en server?

Hvordan får jeg smartest denne nøgle?

Installation af SSH nøgle

Vi bruger login med password på kurset, men for fuldstændighedens skyld beskrives her hvordan nøgle installeres:

- først skal der genereres et nøglepar **id_dsa og id_dsa.pub**
- Den offentlige del, filen id_dsa.pub, kopieres til serveren
- Der logges ind på serveren
- Der udføres følgende kommandoer:

```
$ cd  skift til dit hjemmekatalog
$ mkdir .ssh  lav et katalog til ssh-nøgler
$ cat id_dsa.pub >> .ssh/authorized_keys  kopierer nøglen
$ chmod -R go-rwx .ssh  skift rettigheder på nøglen
```

OpenSSH konfiguration

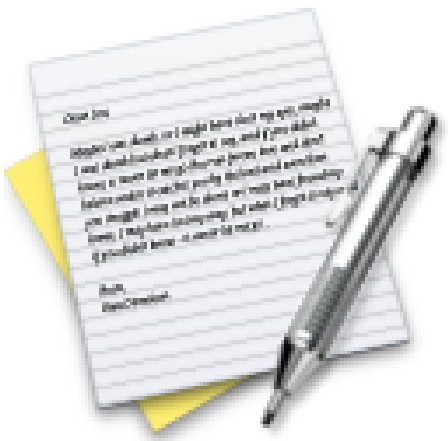
Sådan anbefaler jeg at konfigurere OpenSSH SSHD

Det gøres i filen `sshd_config` typisk `/etc/ssh/sshd_config`

```
Port 22780    // eller anden tilfældig port
Protocol 2

PermitRootLogin no
PubkeyAuthentication yes
# To disable tunneled clear text passwords, change to no here!
PasswordAuthentication no

UseDNS no
#X11Forwarding no
#X11DisplayOffset 10
#X11UseLocalhost yes
```

Det er en smagssag om man vil tillade *X11 forwarding*

Exercise

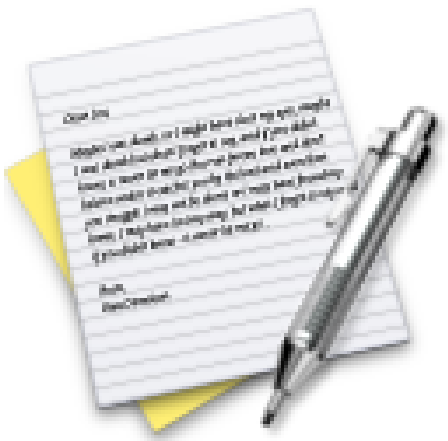


Now lets do the exercise

SSH scanners 15min

which is number **26** in the exercise PDF.

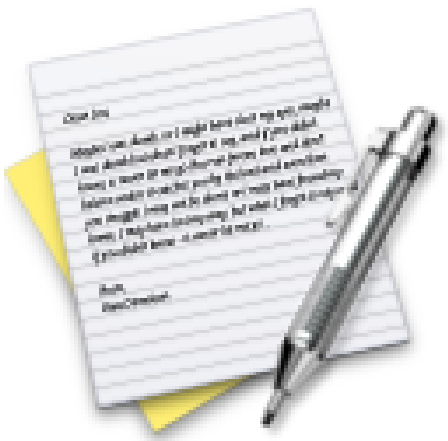
Exercise



Now lets do the exercise

⚠ Password Cracking 15min

which is number 27 in the exercise PDF.

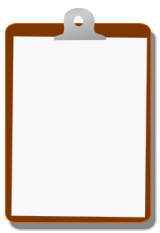


Now lets do the exercise

Configure SSH keys for more secure access

which is number **28** in the exercise PDF.

For Next Time



Think about the subjects from this time, write down questions

Check the plan for chapters to read in the books

Visit web sites and download papers if needed

Retry the exercises to get more confident using the tools