Standard Security Protocols

Going up the stack:

TLS, IPsec, Kerberos and all that

Next hour...

- Yawning
- Why standards?
- Standards Development Organisations (aka alphabet soup)
- Couple of examples
- When to standardise?

Why?

- Generic reasons:
  - Multi-Vendor Interoperability
  - “Open”-ness
- Security Reasons
  - Remember: Crypto => Interop is hard!
  - Review: Many (non-security) standards decrease security
- NB: Not everything needs to be standardised!

A Possibly New Why?

- Human Rights Protocol Considerations Research Group
  - https://irtf.org/hrpc
- “Rethinking Privacy Online and Human Rights: The Internet’s Standardisation Bodies as the Guardians of Privacy Online in the Face of Mass Surveillance”
  - Adamantia Rachovitsa, Conference Paper No.5/2016 2016 ESIL Research Forum, Istanbul, 21-22 April 2016 (see materials page for copy and link to original)

Standards Devlopment Organisations (SDOs)

- International organisations
  - e.g.: UN/ITU, ISO
- "Open" Internet Standards Development Organisations
  - e.g.: IEEE, IETF, W3C
- Commercial Enterprise Driven SDOs
  - e.g.: OASIS, FIDO Alliance
- Company-specific pet projects
  - e.g.: FB Free basics
- Open-source projects
  - e.g.: Apache, WHATWG
- Open-source commercial alliances
  - e.g.: OpenStack
- Operational entities:
  - e.g. ICANN, RIPE, ARIN,...
- Topic specific alliances
  - e.g. M3AAWG

Types of standards

- All SDOs have difference categories of standard
  - RFC1149; http://www.blug.linux.no/rfc1149
  - Draft versions may be published or not, long-lived or not, rubbish or not
- Almost all interesting standards are openly available - some for a fee!
- But note: All SDOs have some business model, even the best ones:-)

ISO/ITU-T

- National bodies are members (NIST, Enterprise-Ireland)

https://www.iso.org https://www.itu.int

- Security stuff:
  - Child online protection (ITU?)
  - Cryptographic mechanisms (ISO)
    - Recent good news there wrt “lightweight” crypto/NSA: https://www.schneier.com/blog/archives/2017/09/iso_rejects_nsa.html
  - Even more X.509 (PKI stuff ITU-T)
  - Various ITU telephony specs
    - Some inheriting from/profiling IETF

Internet Engineering Task Force (IETF)

- No members: a group of individuals developing the Internet

https://www.ietf.org https://www.irtf.org

- Security:
  - About 1-2 dozen of about 100 working groups usually doing interesting security stuff
- Best of a bad lot really! (But I would say that:-)

World-Wide-Web Consortium (W3C)

- Membership organisation ($5-50k per annum) plus strong “team” plus invited experts

https://www.w3.org

- Some interesting old security groups
  - XML Sig, Enc, XKMS
- Currently:
  - WebCrypto, WebAppSec, WebRTC
  - Focus more on browser APIs and not protocols

IEEE Standards Association

- Individual memberships but meeting attendance counts

https://www.ieee.org/

- Security:
  - IEEE 802 – various security things, WPA etc.
  - Privacy study group looking at MAC address randomisation

OASIS

- Membership organisation ($5-10k per annum)

https://www.oasis-open.org/

- Vendor driven
- “Cyber threat intelligence” (CTI)
- Lots of oldish security groups:
  - SAML, XrML, XACML, WSS, DSS

Others

- Trusted Computing Group https://www.trustedcomputinggroup.org/
- Bluetooth https://www.bluetooth.com/
- 3GPP http://www.3gpp.org/
- GSMA http://www.gsma.org/
- ANSI https://www.ansi.org
- ETSI https://www.etsi.org
- WHATWG https://whatwg.org/
- Open Mobile Alliance http://www.oma.org

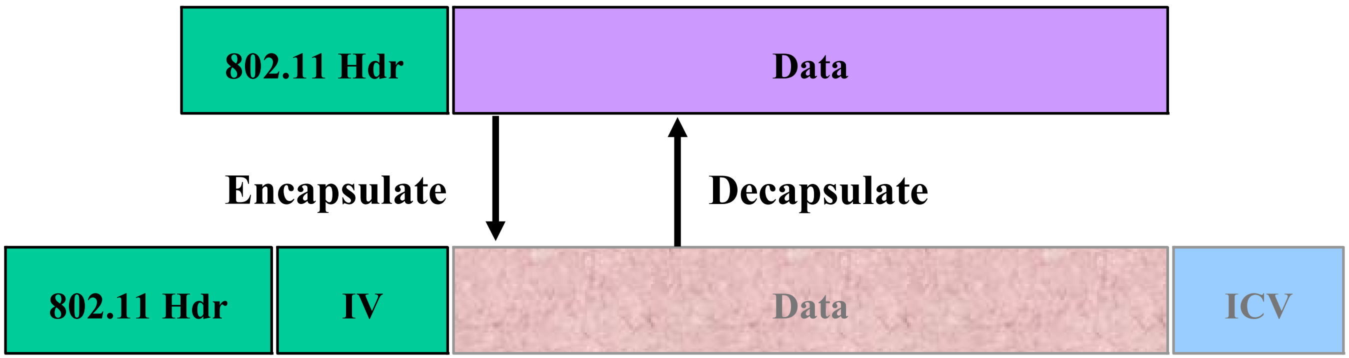
“Good" examples

- Really good: RFC822/2822/5322 – Mail message format
- Middling: RFC3185 “Re-use of CMS Content Encryption Keys”
  - (Ahem!) Co-author present :-)
  - Length: 10pp (-crud=3pp)
  - Duration: ~18 months
  - Purpose: Fix a problem for RADIUS/Diameter
  - BUT: Zero implementations

“Bad” examples

- Many to choose from
- IETF: IKE
- IEEE: WEP (or is it?)

WEP Encapsulation

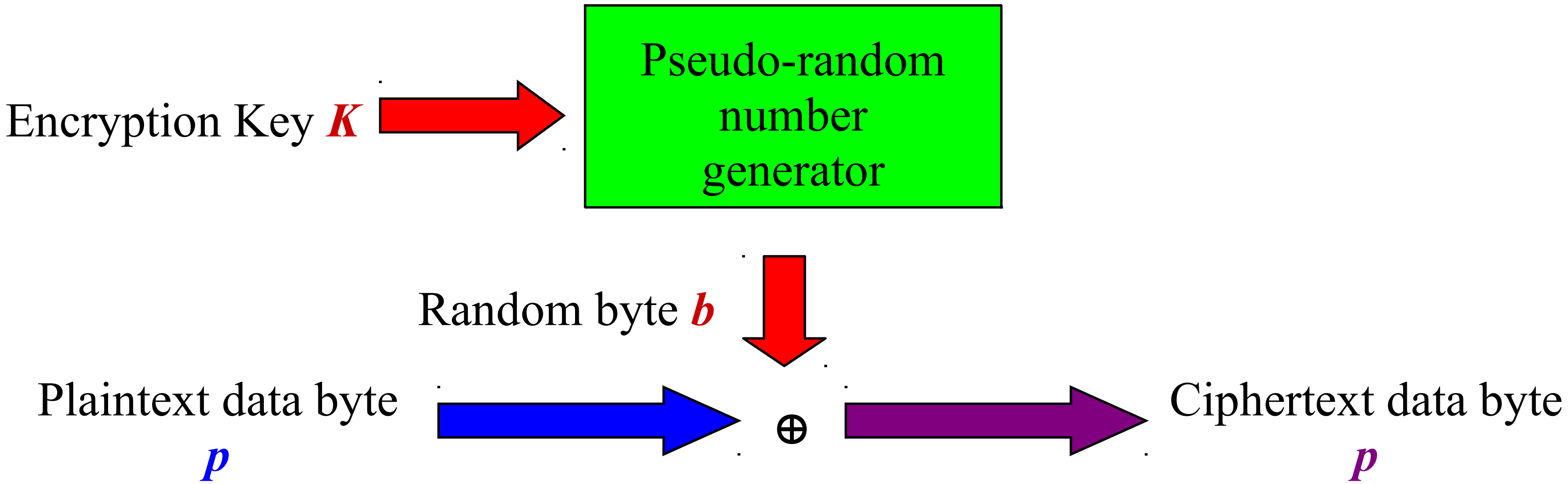


WEP Encapsulation Summary:

- Encryption Algorithm = RC4
- Per-packet encryption key = 24-bit IV concatenated to a pre-shared key
- WEP allows IV to be reused with any frame
- Data integrity provided by CRC-32 of the plaintext data (the “ICV”)
- Data and ICV are encrypted under the per-packet encryption key

Properties of Vernam Ciphers (1)

The WEP encryption algorithm RC4 is a Vernam Cipher:



Decryption works the same way: $p = c \oplus b$

Properties of Vernam Ciphers (2)

Thought experiment 1: what happens when p_1 and p'_2 are encrypted under the same "random" byte b?

$$c'_1 = p'_1 \oplus b \qquad\qquad c_2 = p_2 \oplus b$$

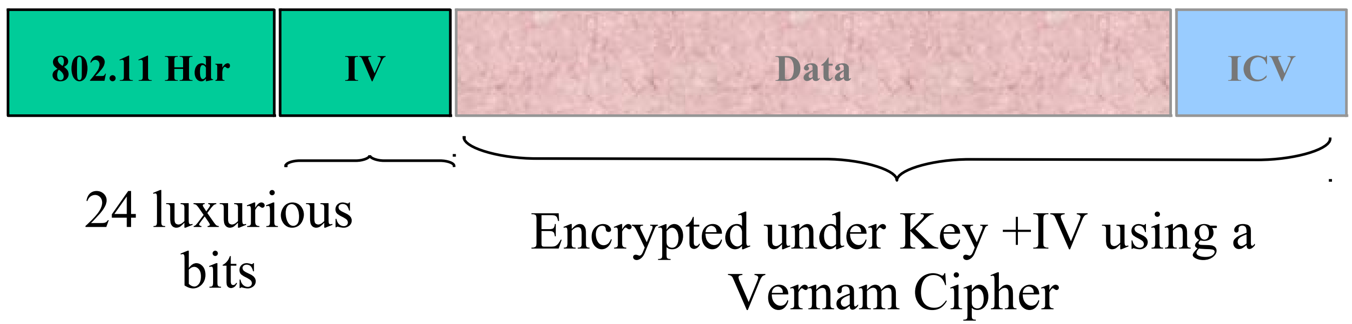
Then:

$$c'_1 \oplus c_2 = (p'_1 \oplus b) \oplus (p_2 \oplus b) = p'_1 \oplus p_2$$

Conclusion: it is a very bad idea to encrypt any two bytes of data using the same byte output by a Vernam Cipher PRNG.

Ever.

How to Read WEP Encrypted Traffic (1)



- By the Birthday Paradox, probability P_n two packets will share same IV after n packets is $P_2 = 1/2^{24}$ after two frames and $P_n = P_{n-1} + (n-1)(1-P_{n-1})/2^{24}$ for $n > 2$.
- 50% chance of a collision exists already after only 4823 packets!!!
- Pattern recognition can disentangle the XOR'd recovered plaintext.
- Recovered ICV can tell you when you've disentangled plaintext correctly.
- After only a few hours of observation, you can recover all 2^{24} key streams.

How to Read WEP Encrypted Traffic (2)

- Ways to accelerate the process:
  - Send spam into the network: no pattern recognition required!
  - Get the victim to send e-mail to you
    - The AP creates the plaintext for you!
  - Decrypt packets from one Station to another via an Access Point
    - If you know the plaintext on one leg of the journey, you can recover the key stream immediately on the other
  - Etc., etc., etc.

When to standardise

- When many implementer’s codebases have to talk a protocol
  - HTTP, SMTP,... (many, many examples)
- When one implementer has to use another vendor's API
  - WebRTC, PKCS#11
- When serious review is required
  - Routing changes like RED, AES alg.

When not to…

- When you just want your name in “lights”
- When your clever algorithm is the tenth way to do the job
- When your scheme is patented
  - Or secretly about to be patented!
- When no-one cares
- See RFC 6417 for guidance for researchers

More, on when not to…

- If you’re an open-source team and don’t have the cycles to engage with all the nuts who’ll get involved when you engage in a really open process (and they will) – e.g. Tor
- If you claim that implementation agility and speed is more important than multi-implementer interop - e.g. Signal

Questions

- Question: How many cryptographic algorithms should we standardise and when?
- Question: WEP was broken when deployed, and then fixed. Same is true of SSL/TLS. Was that better or worse than IPsec/IKE which took 10 years to develop?

Standard Security Structures and Protocols

PKI, S/MIME, SSL, Kerberos, IPsec and all that jazz

Materials

- Lots of RFCs
- https://datatracker.ietf.org/wg/
- Bleichenbacher/"Avoiding the million-message”

Next hour(s)...

- PKI model and protocols
- SMIME formats and secure email
- SSL/TLS protocol
- IPsec
- Kerberos

Knowing one of these in detail is enough for exam purposes

Public Key Infrastructure (PKI)

- Key management is a scaling problem
- Possible to push “trust” (bad term!) up to a certification authority (CA)
- “Trust” here is: CA is responsible for binding information about an entity (esp. Name) with a public key
  - Anyone who trusts that CA for that purpose can then check that entity's signature or encrypt to it

PKI History

- Original public key concept involved publishing public keys in a newspaper
- Computing equivalent suggested in early 1980's
- First standard was X.509 in 1988
- IETF X.509 profile is in **RFC 5280**
- Used by TLS, S/MIME and lots of other protocols

X.509-based PKI Problems

- Everyone sensible hates this stuff
  - It's really old, gnarl y & horrible
- Every now and then someone suggests replacing it with <foo>
  - So far, no <foo> has been sufficiently better to displace X.509 based PKI (sadly)
- Maybe in 5-10 years it'll be less important, but for now we have to suffer with it.

Certificates (1)

```
Certificate  ::=  SEQUENCE  {
  tbsCertificate       TBSCertificate,
  signatureAlgorithm   AlgorithmIdentifier,
  signatureValue       BIT STRING  }
```

- Who knows what ASN.1 is?
  - An abstract syntax notation
  - With tag, length value encoding schemes (BER, DER, PER)
    - SEQUENCE -> 0x30, INTEGER -> 0x02
  - PITA

Certificates (2)

```
TBSCertificate  ::=  SEQUENCE  {
   version            [0]  EXPLICIT Version DEFAULT v1,
   serialNumber            CertificateSerialNumber,
   signature               AlgorithmIdentifier,
   issuer                  Name,
   validity                Validity,
   subject                 Name,
   subjectPublicKeyInfo SubjectPublicKeyInfo,
   issuerUniqueID [1]IMPLICIT UniqueIdentifier OPTIONAL,
   subjectUniqueID[2]IMPLICIT UniqueIdentifier OPTIONAL,
            -- If present, version MUST be v2 or v3
   extensions         [3]  EXPLICIT Extensions OPTIONAL
                 -- If present, version MUST be v3
   }
```

Certificate Revocation Lists

- A black-list of "bad" certificate serial numbers (plus list- and entry-extensions)
- Periodically issued by a CA
- Revocation = putting on black-list
- Also via on-line certificate status protocol (OCSP)
- Reasons to revoke: Key compromise, Key loss, Change of function, Uninstall web server...

To check a certificate

- Start with a (set of) trusted CAs
- Progress down certification path:
  - Is next-signature ok with previous public?
  - Is certifcate revoked?
  - Continue
- Missing lots (see rfc5280)
  - E.g. Policy mappings (yuk!)

PKI Entities

```
+---+
| C |                       +------------+
| e | <--------------------->| End entity |
| r |       Operational     +------------+
| t |       transactions          ^
| i |      and management         |  Management
| f |       transactions          |  transactions        PKI
| i |                             |                     users
| c |                             v
| a | =======================  +--+------------+  ===============
| t |                          ^               ^
| e |                          |               |         PKI
|   |                          v               |      management
| & |                       +------+           |       entities
|   | <---------------------|  RA  |<----+     |
| C |  Publish certificate  +------+     |     |
| R |                                    |     |
| L |                                    |     |
|   |                                    v     v
| R |                                +------------+
| e | <------------------------------|     CA     |
| p |   Publish certificate          +------------+
| o |   Publish CRL                      ^      ^
| s |                                    |      |  Management
| i |                +------------+      |      |  transactions
| t | <--------------| CRL Issuer |<-----+      |
| o |   Publish CRL  +------------+             v
| r |                                      +------+
| y |                                      |  CA  |
+---+                                      +------+
```

PKI Protocols

- You need some to operate a PKI
- Registration: PKCS#10, proprietary, CMP, CMC, EST and now **ACME**
- Certificate retrieval: LDAP, DAP, HTTP, FTP, DPD
- Certificate validation: OCSP, DPV, CRL processing
- XKMS was a W3C attempt to do similar things
  - Deployment didn't happen

Roots/Trust Points

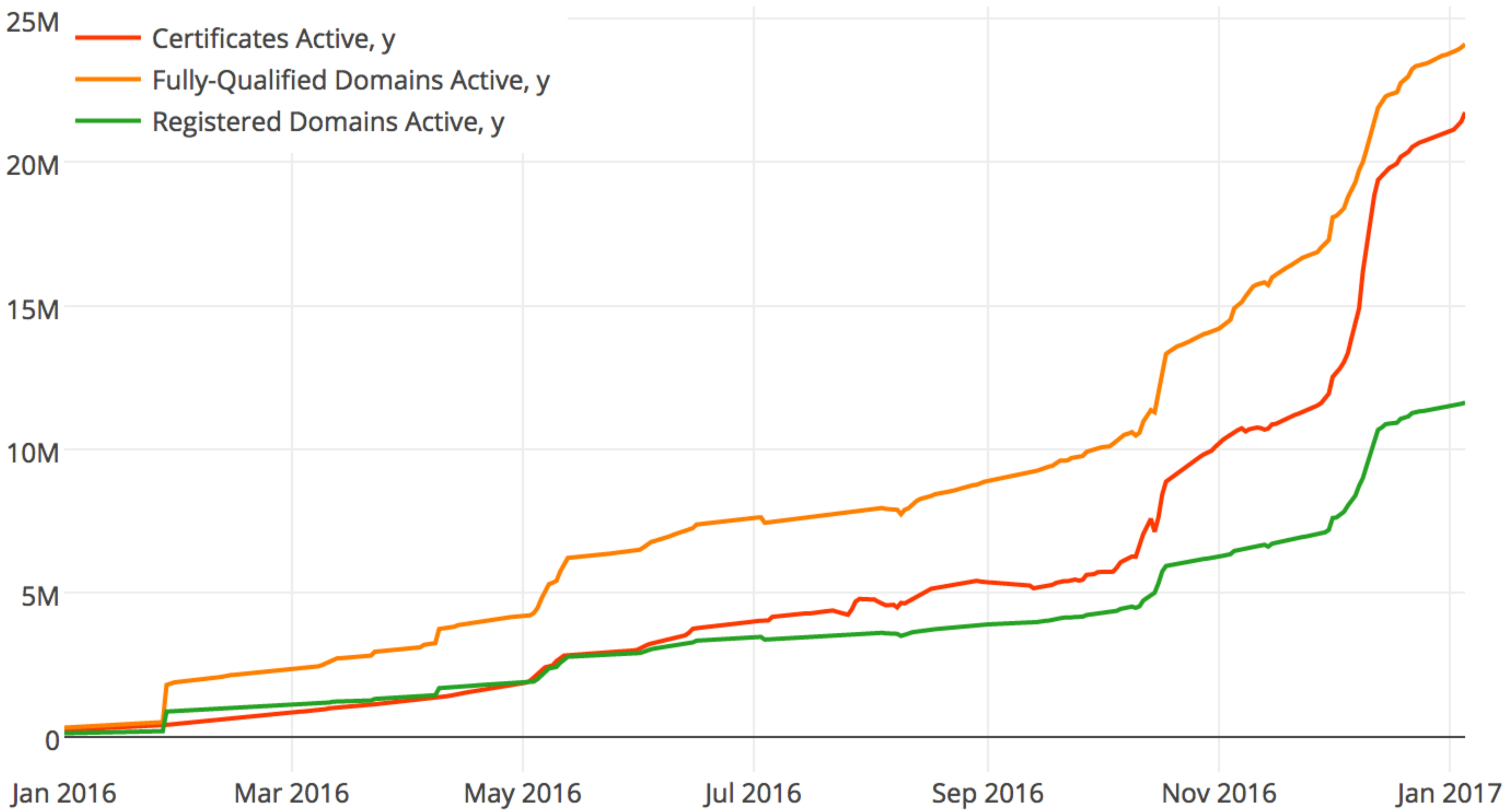
- Applications using PKI need to have a set of root CA public keys they “trust”
- Browsers have those – each with O(100) CAs in the list
- In/ex-clusion is highly political
  - https://cabforum.org/ is a venue for some of that politics
- Other applications and OSes handle this similarly

Some good news though...

- https://letsencrypt.org/ operating a free CA
  - Public beta since Dec 2015
- ACME protocol for automated certificate management
  - JSON based
  - https://tools.ietf.org/wg/acme/
- We'll see if it works this time;-)

Some good news though...

https://letsencrypt.org/stats/



Certificate Transparency (CT)

- There have been cases where CA's have been hacked or misbehave (later)
- CT is an attempt to improve the WebPKI (underlying https)
  - RFC6962 → https://tools.ietf.org/wg/trans/
- Idea: append-only public logs of all certificates issued to allow detection of mis-issuance
  - https://crt.sh/

Attribute certificates

- Kind of a PKI-wart
- Certificate-like thing which has attributes instead of a subjectPublicKey
- Treat as experimental if you ever hear about them
- Can be used for role-based access control etc.

PKI Summary

- Mix of mature and new technology
  - Plenty of products/services and significant deployment experience
- Deployment and application integration problems exist
  - Can be overcome but expensive
- Still technology-of-choice for scalable key management
- Improvement is possible: e.g. ACME/CT

S/MIME

- There's a history here too!
  - PGP, PEM and MOSS
  - RSADSI's PKCS#7 based proposal
  - DKIM is a yet another development in this space
- Cryptographic Message Syntax (CMS) is the basis for S/MIME and other secure applications
- So S/MIME = CMS + Message-Specification + Certificate-specification

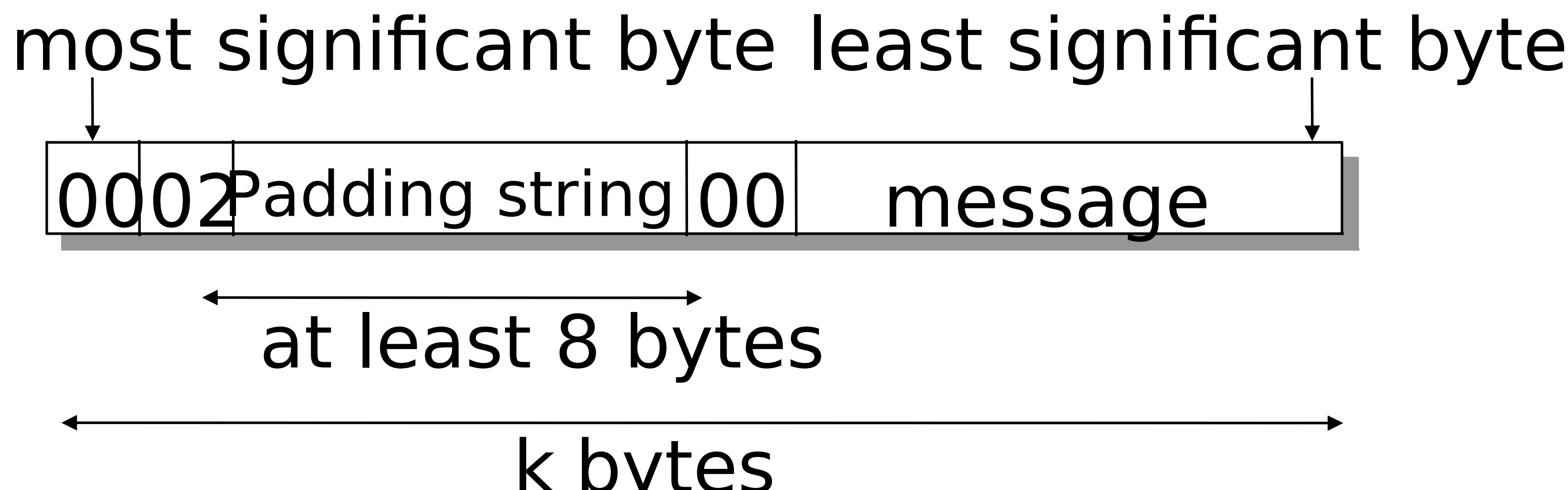
CMS

- How to MAC, sign and/or encrypt data in an ASN.1 oriented way
  - E.g. CMS defines:
    - SignedData
    - EnvelopedData
  - XML and JSON equivalents started from here
- Algorithms and options like in PKI
- Latest CMS specification: RFC 5652

PKCS#1 v1.5 Padding

RSA modulus: n=pq of length k bytes;

i.e. 256 ** (k-1) < n < 256 ** k



CMS SignedData (1)

```
SignedData ::= SEQUENCE {
 version CMSVersion,
 digestAlgorithms DigestAlgorithmIdentifiers,
 encapContentInfo EncapsulatedContentInfo,
 certificates [0] IMPLICIT CertificateSet
                              OPTIONAL,
 crls [1] IMPLICIT CertificateRevocationLists
                              OPTIONAL,
 signerInfos SignerInfos }
```

CMS SignedData (2)

```
SignerInfo ::= SEQUENCE {
 version CMSVersion,
 sid SignerIdentifier,
 digestAlgorithm DigestAlgorithmIdentifier,
 signedAttrs [0] IMPLICIT SignedAttributes OPTIONAL,
 signatureAlgorithm SignatureAlgorithmIdentifier,
 signature SignatureValue,
 unsignedAttrs [1] IMPLICIT UnsignedAttributes OPTIONAL }

SignerIdentifier ::= CHOICE {
 issuerAndSerialNumber IssuerAndSerialNumber,
 subjectKeyIdentifier [0] SubjectKeyIdentifier }

SignedAttributes ::= SET SIZE (1..MAX) OF Attribute
UnsignedAttributes ::= SET SIZE (1..MAX) OF Attribute
Attribute ::= SEQUENCE {
 attrType OBJECT IDENTIFIER,
 attrValues SET OF AttributeValue }
AttributeValue ::= ANY
SignatureValue ::= OCTET STRING
```

CMS Message Specification

- Latest specification is RFC 5751
- Tells you how to:
  - Start with a MIME message
  - Treat that as like plaintext the CMS way
  - Then take the resulting bytes and make them into a MIME message
- Note: LARGE messages exist
  - Have to handle BER as well as DER

CMS Certificate Specification

- Latest specification is rfc5750
- Tells you how to interface an s/mime mail user agent with a PKI
- Tells you how to interpret PKIX RFCs for secure mail purposes
  - E.g. How to include email addresses in certificates
- Model to be followed

CMS Deployment

- Most MUAs suport s/mime either built-in or as an option
  - There are also “plug-in” products
- And mostly then *can* work together
- But secure mail is not ubiquitous
  - Why?

e2e email security barriers

- Designs pre-date web user agent which changes trust model (where's the private key kept? Needs new infrastructure)
- Needs all major email service providers (yahoo, hotmail, gmail) to deploy the same thing which also needs to be implemented by all major user agent developers (microsoft, mozilla, apple, google)
- Public key retrieval needs to be fixed (doable if the above done, but a killer if not done), likely with some new PKI (doable but who's gonna pay?)
- Mail headers need to be protected as users don't get that S/MIME and PGP only protect body and not e.g. Subject, From (new enveloping protocol needed, can be done but kludgy)
- We need to unify S/MIME and PGP or pick one or we'll lose interop (it's ok if the other soldiers on for some niches)
- Users don't care much, so it has to be entirely transparent for them (needs significant UI work, co-ordinated across MUAs and significant web-UAs)

Transport Layer Security (TLS)

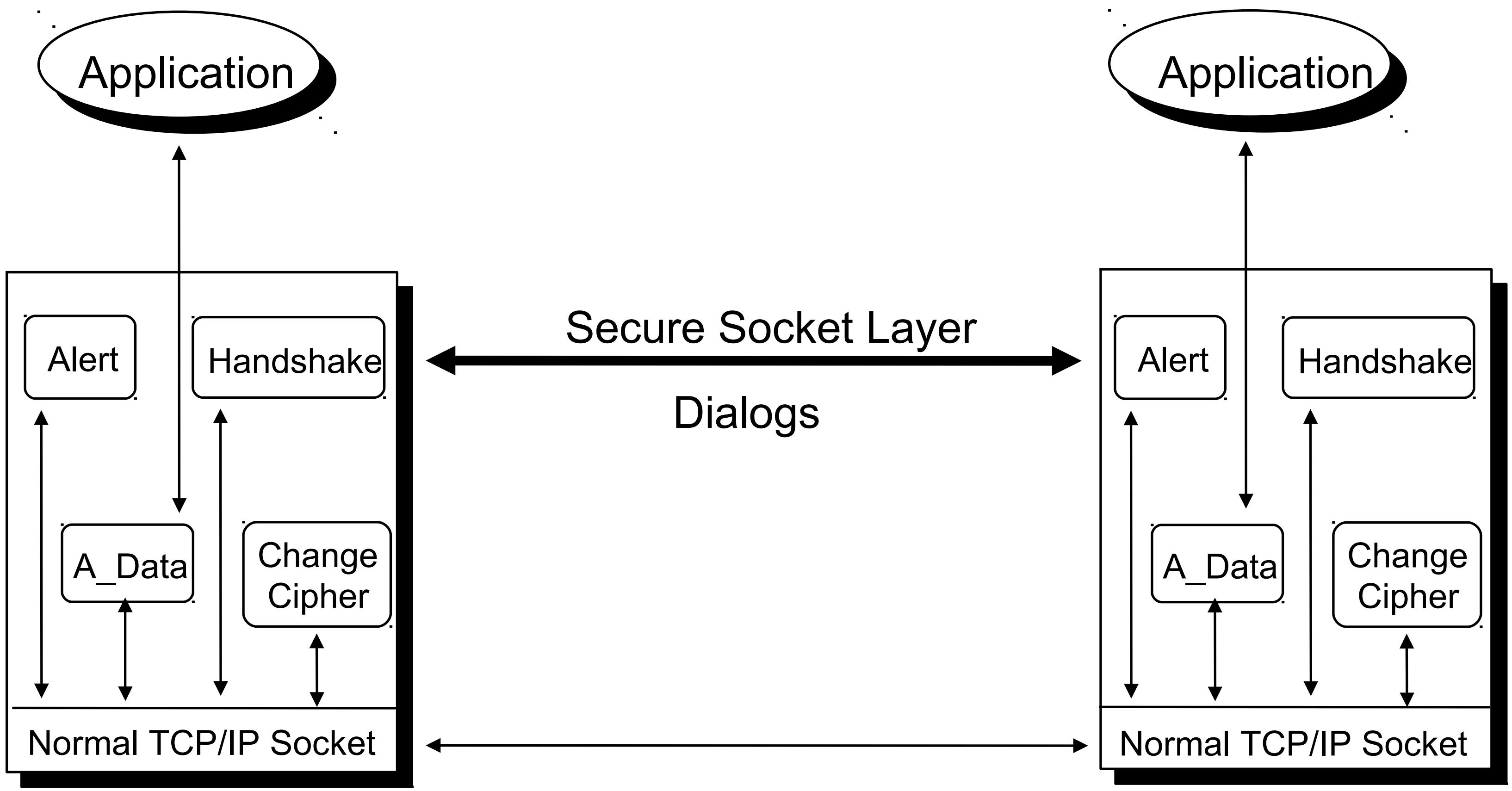
- Secure Sockets Layer (SSL): General Purpose Network Security Protocol proposed by Netscape in 1994.
- Designed to work with any application that uses sockets to communicate e.g., ftp, http, nntp, telnet...
  - Platform independent, application independent negotiations
- SSL standardised as Transport Layer Security (TLS)
  - Latest is TLS1.2: RFC 5246
  - Oddly: RFC6101 is SSL3.0!

TLS - services provided

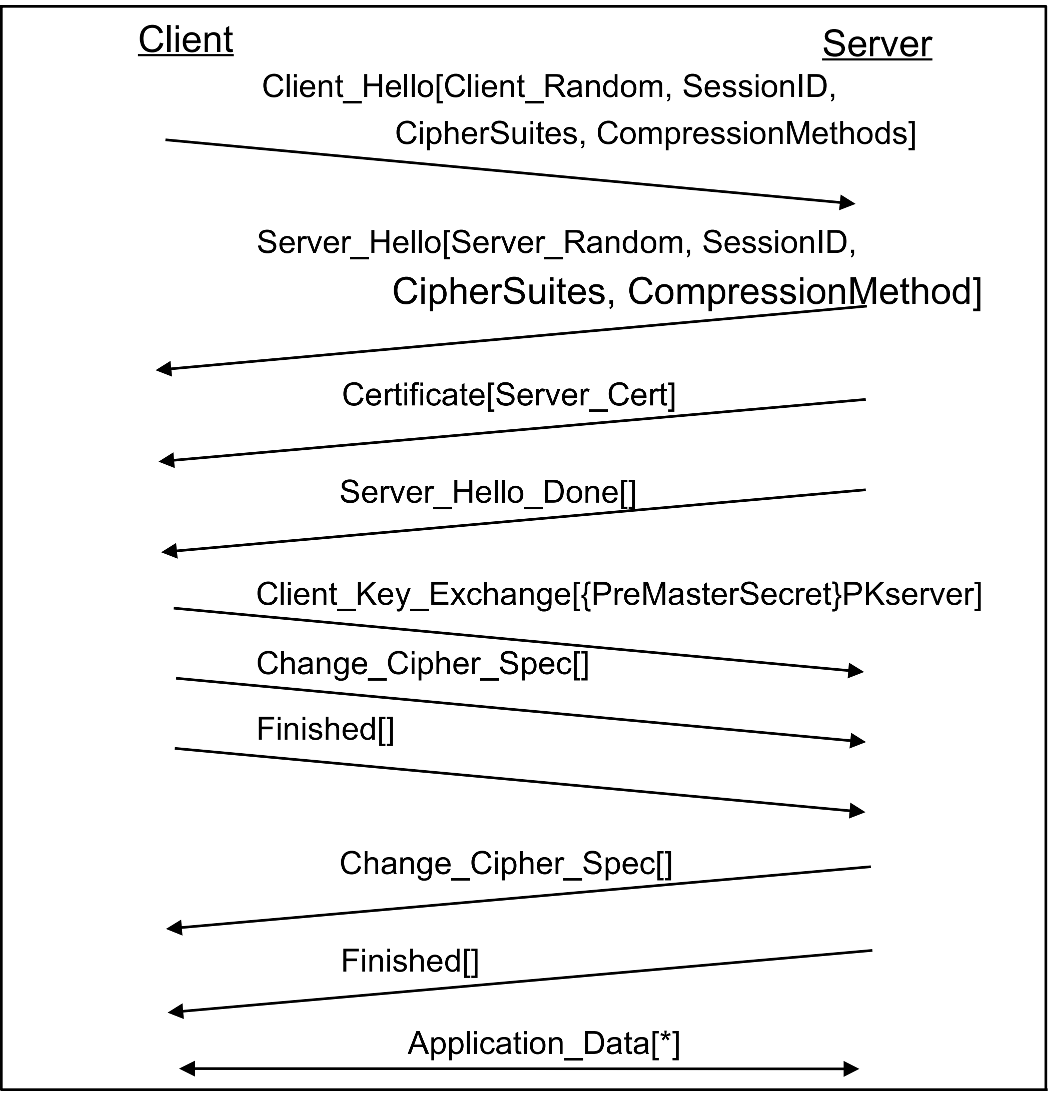
- Server Authentication - Buyer can believe they are dealing with a bona fide merchant
  - (Optional) Client authentication
  - Digital certificates (X.509)
- Message Encryption - Buyer can send credit card details across the network without fear of interception
  - Also message integrity and freshness
- Relatively transparent to the user and application developer

Components of the TLS Protocol

- TLS broken into 4 interrelated sub-protocols

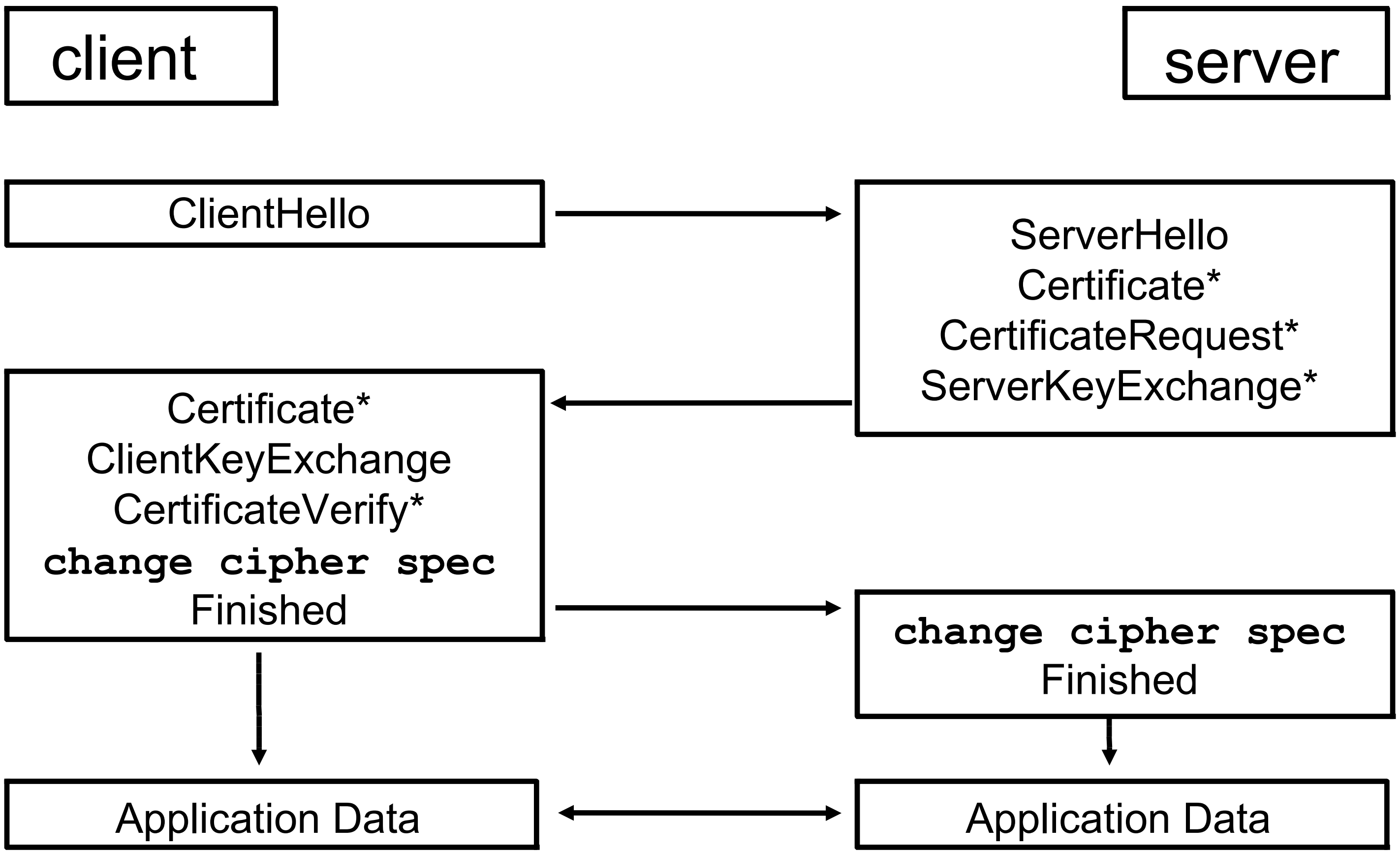


The Handshake Protocol



- Negotiate Compression Method and Cipher Suite
- Swap random quantities
- Client obtains server certificate path
- Client invents PreMasterSecret (48 bytes) and securely sends it to the server
- Keys Calculated by both
- Finished message using new algorithms
- Data send in A_Data Units

Handshake Protocol
summary



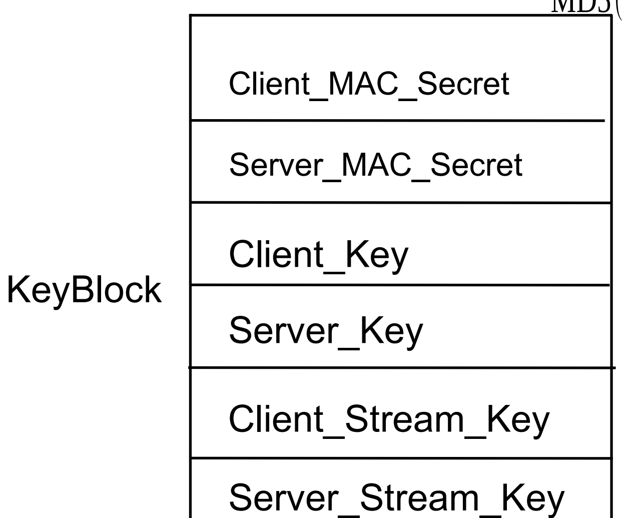
* Indicates optional or situation dependent messages that are not always sent

Computing the Keys from the Pre-MasterSecret

- First compute MasterSecret
- MasterSecret = f(PreMasterSecret, Client.Random, Server.Random)

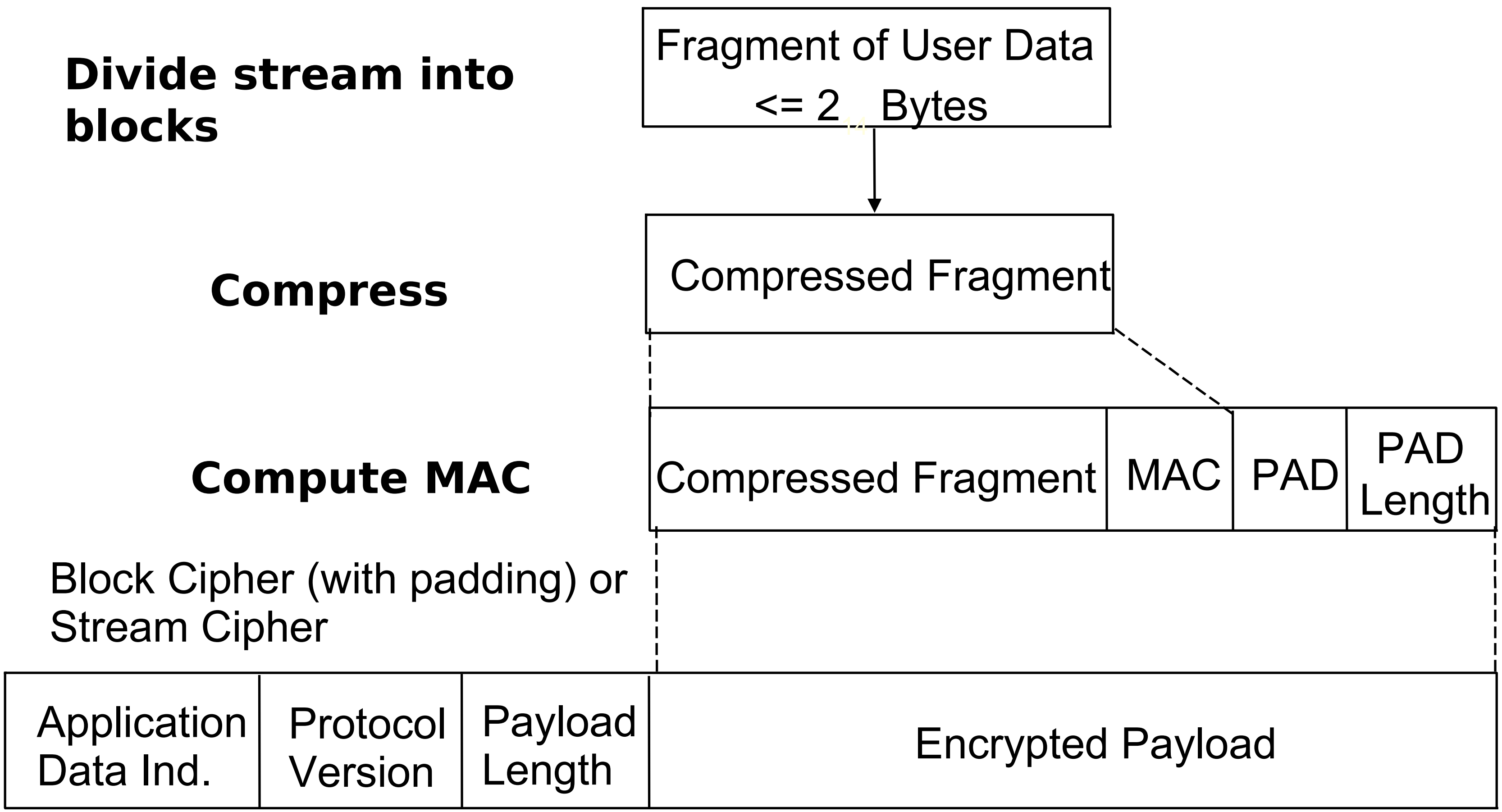
- MasterSecret Used to prime key-generator
- KeyBlock = f(MasterSecret, Client.Random, Server.Random)

$$
\begin{aligned}
KeyBlock = {} & MD5(MasterSecret + SHA('A' + MasterSecret + ServerHello.Random + ClientHello.Random)) + \\
& MD5(MasterSecret + SHA('BB' + MasterSecret + ServerHello.Random + ClientHello.Random)) + \\
& MD5(MasterSecret + SHA('CCC' + MasterSecret + Server.Hello.Random + ClientHello.Random)) + [\ldots]
\end{aligned}
$$



Partition key-stream into individual quantities

Applying the Keys to Application Data (Record Layer)



Ciphersuites

- SSL/TLS supports various cryptographic options
  - Digest algorithms, key transport, ...
- Design decision was to represent all choices made in a single value
  - Ciphersuite – a 16 bit number
  - TLS_RSA_WITH_3DES_EDE_CBC_SHA
- Interesting consequences...

A TLS Handshake Visualisation

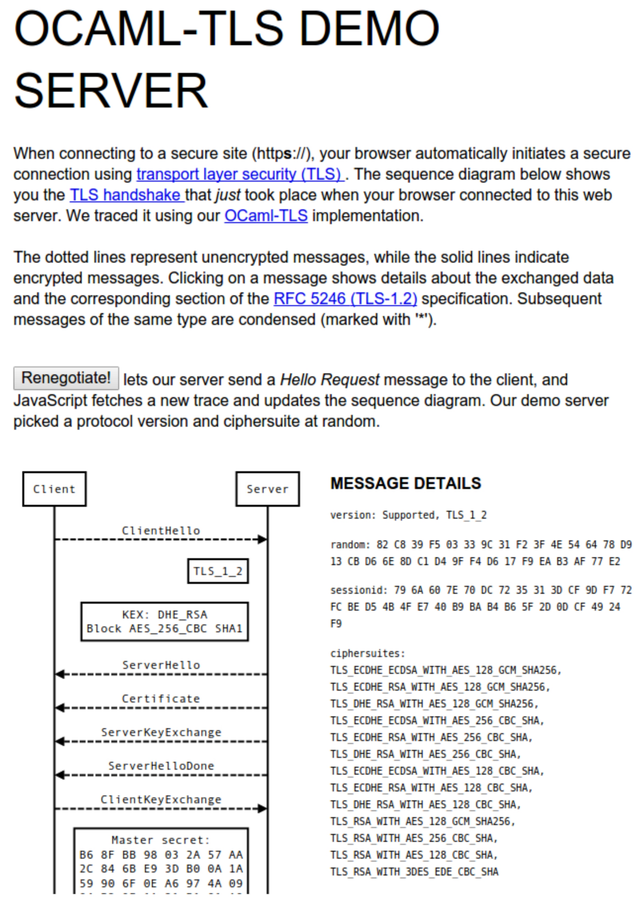
https://tls.openmirage.org/

Shows the messages you exchange with that server and references bits of text from RF 5246.

If you allow JS, you can click the arrows.

Nice!

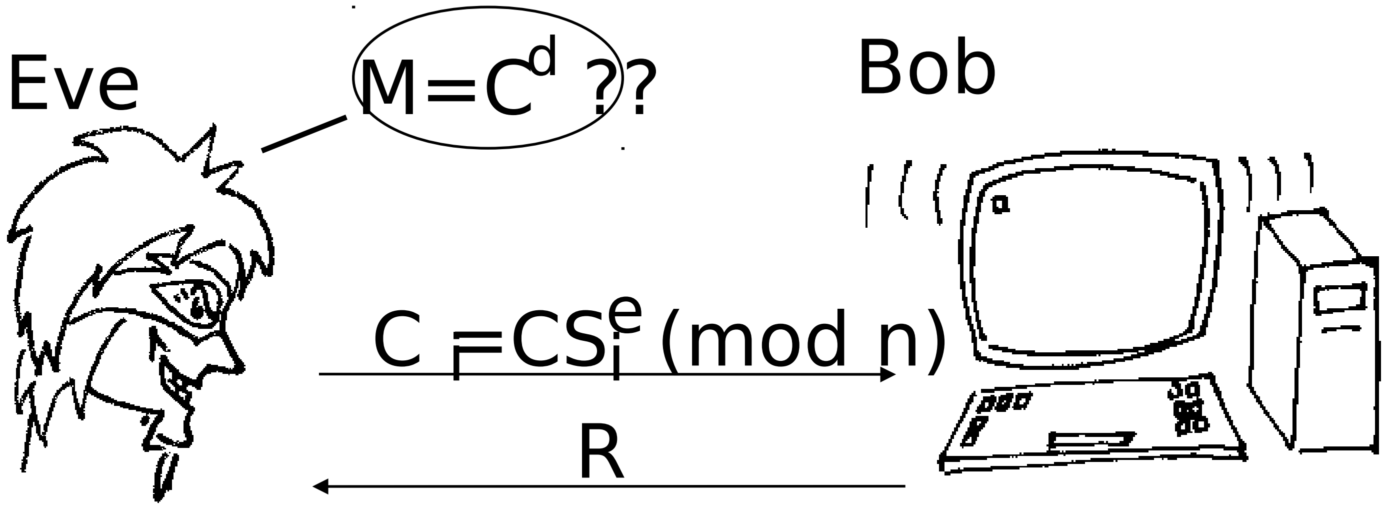
2017 update: site sadly seems a bit broken now



Bleichenbacher

- “Materials” section has a full paper & ppt
  - If you **completely** understand the attack, you're doing very well!
- Basis
  - PKCS#1 v1.5 padding adds formatting to the data
  - If I have an “oracle” that'll attempt decryption and tell me when the recovered plaintext has the PKCS#1 v1.5 padding then I gain knowledge
- This happened with TLS!
  - “Million message” attack

How the attack works: Overview



If a message C_i is PKCS conforming then

$$2*256**(k-2) \quad -1 < MS < 3*256**(k-2)$$

- This is an adaptive chosen-ciphertext attack
- RFC3218 describes the attack and ways to avoid it.

Deployment of TLS

- Mid '90's: Used in Netscape Commerce Server
  - International “Step-up” encryption: Strong crypto for international banks, with special Verisign certificate
  - Built into Communicator 4.0 and later
- Now: Basically everywhere, Standard part of Web browsers, servers and development platofrms (PHP, python etc.)
  - secure online trading, banking, commerce...
- Certificates being issued by a variety of Trusted Third Parties (TTP)
  - VeriSign, Cybertrust/Baltimore OMNIRoot

Recent TLS Developments

- TLS WG no longer in maintenance mode as work on TLS 1.3 nearing completion (more on that later)
- Datagram TLS (DTLS) for use with connectionless applications (e.g. RTP) is RFC 6347

Recent(ish) TLS-relevant Stuff

- IETF dane WG: http://tools.ietf.org/wg/dane

  TLSA RR: hashes of keys in DNS (4 options)

    - Requires DNSSEC
    - Provide additional assurance that the right key is being used for TLS, or avoids use of CAs
- IETF websec WG:
    - Key-pinning in HTTP (HPKP): RFC 7469
    - Strict Transport Security (HSTS): RFC 6797
- OSCP Stapling (RFCs 6066, 6961)

IP Security (Ipsec)

- Took sooooo loooooong and produced such a complex outome that they have a 2011 document roadmap (rfc6071).
- Start with rfc 4301, the security architecture
- Main moving parts: AH (RFC 4302), ESP (RFC 4303), and IKEv2 (RFC 5996)
    - AH mostly deprecated
    - IKE -> IKEv2 due to IKE/ISAKMP/... complexity, do NOT bother with IKEv1
- So, we'll only look at ESP & IKEv2

Ipsec overview

- “Security Architecture” rfc4301
  - Key exchange, data encryption and data integrity mechanisms at the IP layer
- Optional as part of an IPv4 stack
  - Mandatory to implement as part of IPv6 stacks
- Tunnel/Transport modes
  - VPNs using tunnel mode common
- Security policy DB
  - How to handle (un)protected packets

ESP – Encapsulated Security Payload

```
0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ----
|               Security Parameters Index (SPI)                 | ^Auth.
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |Cov-
|                      Sequence Number                          | |erage
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ | ----
|                    Payload Data* (variable)                   | |   ^
~                                                               ~ |   |
|                                                               | |Conf.
+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |Cov-
|               |     Padding (0-255 bytes)                     | |erage*
+-+-+-+-+-+-+-+-+               +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ |   |
|                               |  Pad Length   | Next Header   | v   v
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+ ------
|                 Authentication Data (variable)                |
~                                                               ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

ESP terms

- Specification: rfc4303
- SPI selects amongst different
  - Algorithms; Keys; etc.
  - SPI (+ dest. IP) = Security Association (SA)
- Seq# for anti-replay
  - Never cycles (new SA needed)
- Next header specifies payload protocol
- SA's are directional
  - So we use different keys between Alice and Bob as compared to between Bob and Alice

ESP – some features

- ESP allows some basic level of traffic hiding
  - Padding (up to 255 bytes) to disguise data length
  - Tunnel mode between gateways
- Data expansion
  - About +19 bytes per packet, possibly worse
  - Can be serious (telnet)

IKE - Internet Key Exchange

- IKEv1 (rfc2409) is a mess of:
  - ISAKMP (rfc2408)
  - OAKLEY (rfc2412) and SKEME (not an rfc)
  - DOI (rfc2407)
- IKEv2 (RFC 7296) is a single document that's much better
  - But is 142 pages long;-(
- Wasn't that simple!

IKEv2 (1)

- Provides protocol
  - Mutually authenticate
  - Exchange keys
- Based on:
  - D-H and
  - Pre-shared secrets or RSA

IKEv2 (2)

- Establishes an IKE-SA and one (or more) CHILD-SA
- Generally requires 4 or 6 messages
  - IKE_SA_INIT (req/rep)
  - IKE_AUTH (req/rep)
  - CREATE_CHILD_SA (req/rep)

IKEv2 Phase1
IKE_SA_INIT & IKE_AUTH

```
Initiator                                        Responder
-----------                                      ---------
HDR, SAi1, KEi, Ni   -->

          <--    HDR, SAr1, KEr, Nr, [CERTREQ]

HDR, SK {IDi, [CERT,] [CERTREQ,] [IDr,]
 AUTH, SAi2, TSi, TSr}     -->

          <--    HDR, SK {IDr, [CERT,] AUTH,
                              SAr2, TSi, TSr}
```

IKEv2 Phase2 CREATE_CHILD_SA

```
Initiator                                    Responder
-----------                                  ---------
HDR, SK {SA, Ni,[Kei],[TSi,Tsr]} -->

           <-- HDR, SK {SA, Nr,[Ker],[Tsi, TSr]}
```

Some IKEv2 Features

- Not IKEv1!
- Uses ESP to protect things
- Misc:
  - PFS, NAT-capable, Traffic Selectors, Liveness checks, Cookies
- Still a bit clunky though!
  - E.g. Compression (rfc2393), ESP and then AH nested SAs

IPsec summary

- Tunnel mode widely used for VPNs and works just fine
  - Transport mode hardly used at all
- IKE interop today isn't perfect (with certs), but is ok
  - Some vendor-specific stuff, e.g. For RADIUS/legacy auth
- Deployment issues:
  - Windows, NAT, Firewall, ECN, Opportunistic Keying, APIs
  - IKEv2 work aims to address a bunch (but not all!) of these

Kerberos

- Originally developed as part of MIT project athena
  - RFC4120 (but RFC1510 may be easier)
- Designed for many users working with few(-ish) servers
  - Largely symmetric key (shared secret) based
- Based around clients interacting with a Key Distribution Centre (KDC) aka:
  - Authentication server (AS)
  - Ticket Granting Server (TGS)

Kerberos

- Uses ASN.1 again! (sort-of)
- Latest spec: RFC 4120
- Typical use:
  - Client sends AS_REQ to KDC gets AS_REP containing TGT
  - Client sends TGS_REQ to KDC (includes TGT) and gets TGS_REP (including Ticket)
  - Client sends KRB_SAFE to server including Ticket

A Ticket

```
Ticket ::= [APPLICATION 1] SEQUENCE {
tkt-vno [0] INTEGER (5),
realm [1] Realm,
sname [2] PrincipalName,
enc-part [3] EncryptedData -- EncTicketPart }

-- Encrypted part of ticket

EncTicketPart ::= [APPLICATION 3] SEQUENCE {
flags [0] TicketFlags,
key [1] EncryptionKey,
crealm [2] Realm,
cname [3] PrincipalName,
transited [4] TransitedEncoding,
authtime [5] KerberosTime,
starttime [6] KerberosTime OPTIONAL,
endtime [7] KerberosTime,
renew-till [8] KerberosTime OPTIONAL,
caddr [9] HostAddresses OPTIONAL,
authorization-data [10]
         AuthorizationData OPTIONAL }
```

Kerberos Things to Note

- Loose clock sync. Required
- Kerberos realm is like but not the same as a DNS domain
- Inter-realm and public key based operation defined but not used that often
- Used in Windows NT security and later (KDC is part of ActiveDirectory)
- Various authorization data extension have been done over the years
- AS_REQ can contain dictionary attackable password or something better (usually the former;-()

Mix'n'match

- PKI vs. Shared-secret vs. Trusted public keys
- TLS vs IPsec vs S/MIME vs CMS
- When should you pick which?