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New Security Features in TLS V1.3

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Agenda

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- TLS Overview
  - TLS Record Protocol
  - TLS Handshake Protocol
- History of TLS and SSL
- Some Recent Attacks on TLS
  - Heartbleed
  - POODLE
  - FREAK
- New Security Features in TLS v1.3
  - ECC-DHE
  - Galois-Counter Mode (GCM)

What is TLS?

- TLS = Transport Layer Security
- TLS provides a secure (encrypted, authenticated) tunnel on top of TCP between a client and a server
- Mostly used to secure http, transforming it to https
- Major enabler of electronic commerce
  - But can also be used to fulfill DSGVO requirements, e.g. when transferring sensitive data to third parties
- Trust-on-first-use (TOFU) protocol

TLS is growing in popularity

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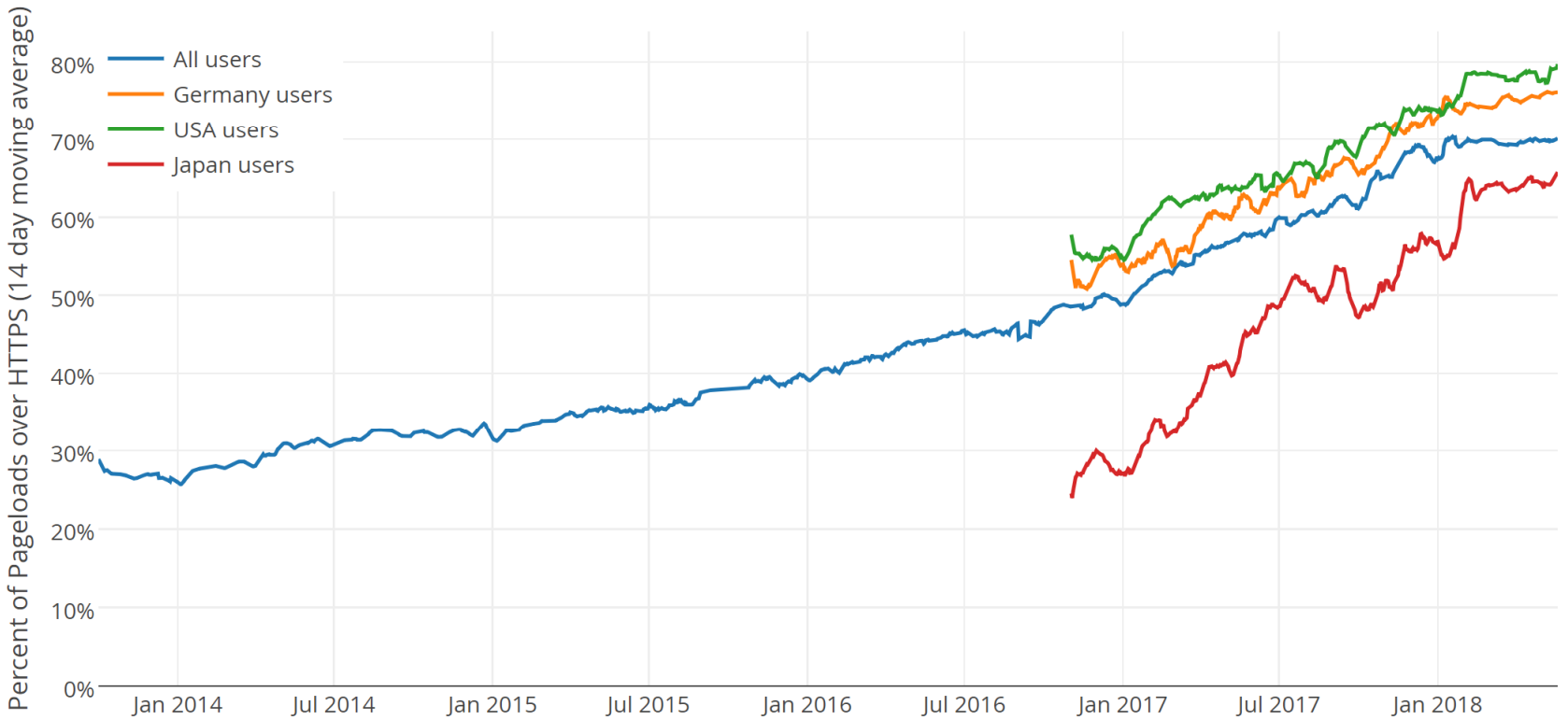
Percentage of Web Pages Loaded by Firefox Using HTTPS

(14-day moving average, source: Firefox Telemetry)



(source: letsencrypt.org)

Reasons for Growing TLS Popularity

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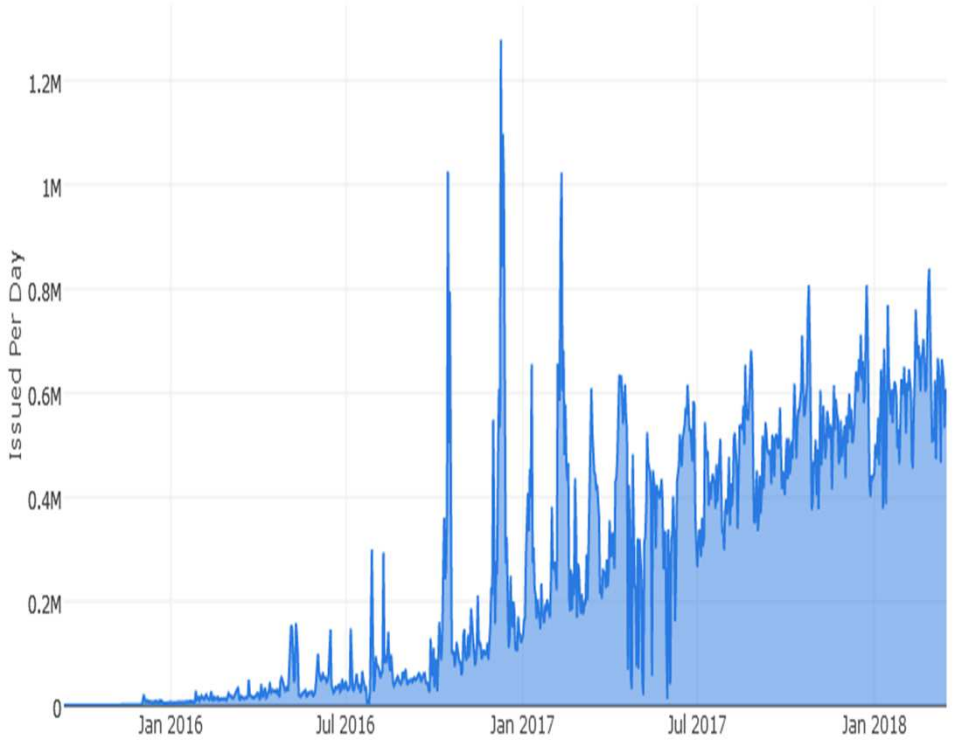
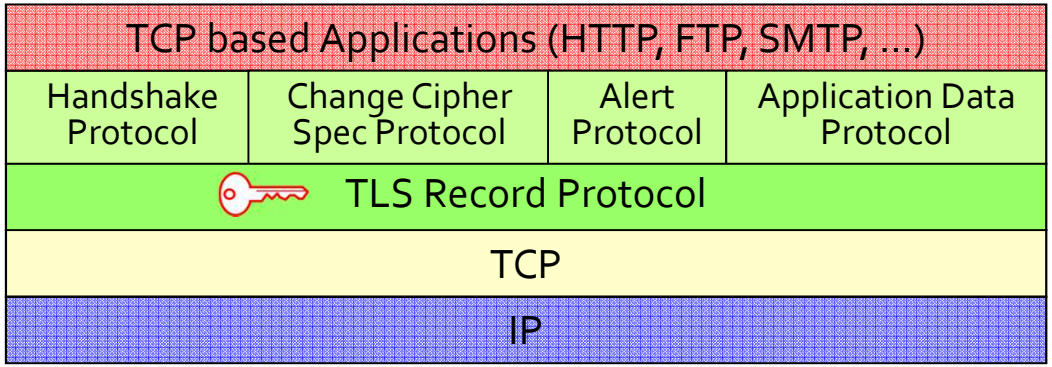
- Edward Snowden
- Google uses https support as ranking factor
- Easier access to certificates:
  - Let's Encrypt has issued more than 46 million active certificates by end of 2017



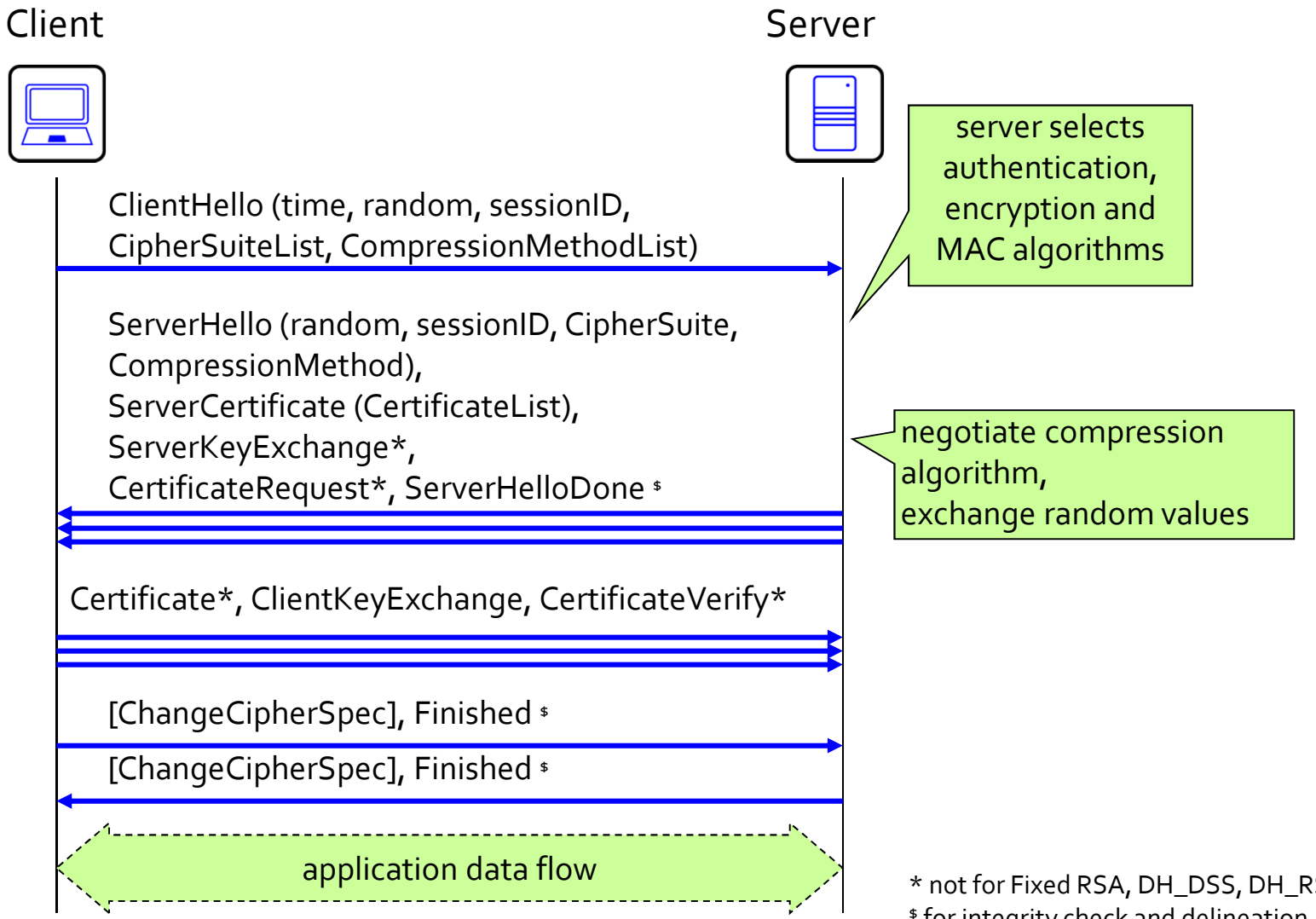
Number of Certificates Issued by Let's Encrypt Per Day (source: letsencrypt.org)

TLS Protocol Family Overview (Pre V1.3)



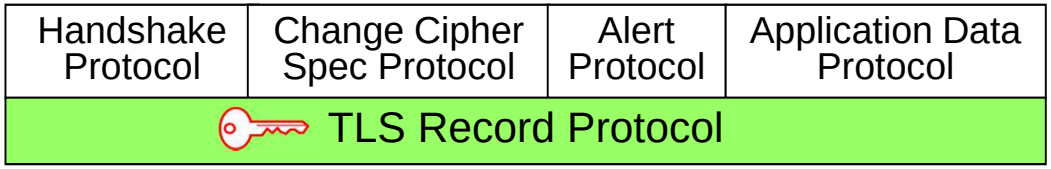
- Handshake Protocol:
  - Client and Server agree on algorithms (Cipher Suites) and keys
  - Server and optional Client authentication based on digital certificates
- Record Protocol
  - Symmetric End-to-End encryption
  - Integrity Protection via symmetric MACs

TLS Handshake Overview (Pre V1.3)

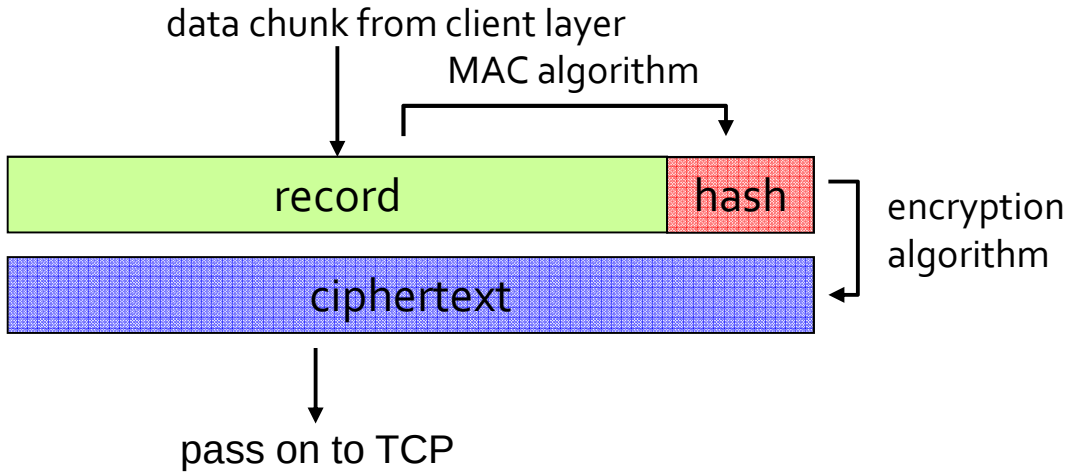


* not for Fixed RSA, DH_DSS, DH_RSA
$ for integrity check and delineation

TLS Record Protocol Overview (Pre V1.2)



- tasks
  - › fragmentation
  - › compression (optional)
  - › Integrity protection and confidentiality
  - › MAC-then-Encrypt:
    - › First, key dependent MAC computation
    - › Then encryption



History of SSL and TLS Overview

~~1994: SSL v1.0~~

March 1995: SSL v2.0

Nov 1995: SSL v3.0

→

1999: TLS v1.0

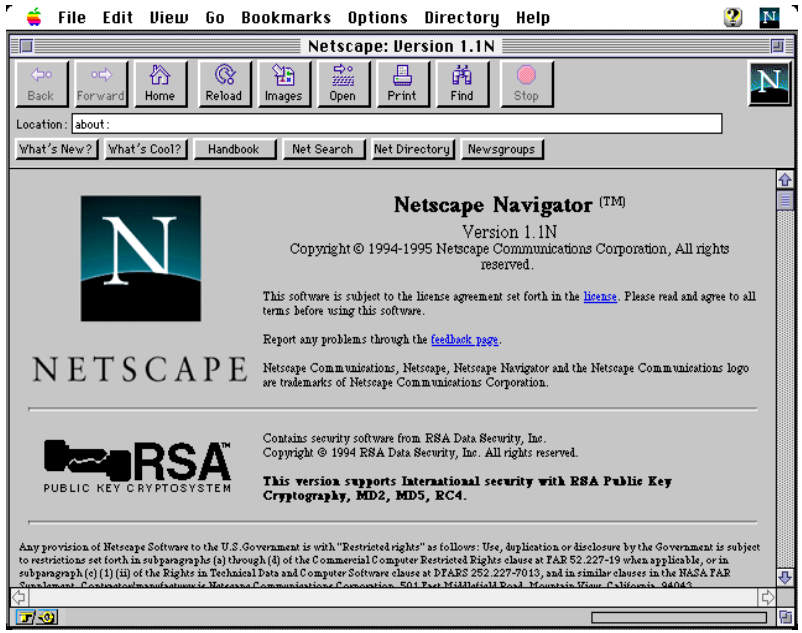
2006: TLS v1.1

2008: TLS v1.2

March 2018: TLS v1.3 Draft submitted to IESG for publication

Detailed History of SSL and TLS

- Until 1994: Netscapes develops SSL. Version 1.0 has serious security issues and is never published
- March 1995: SSL V2.0 shipped in Netscape Navigator V1.1
  - Has unprotected Handshake Messages
- November 1995: SSL V3.0
- January 1999: IETF publishes TLS V1.0 (almost identical to SSL V3.0)
- April 2006: TLS V1.1 addresses the BEAST Attack (but nobody notices)
- August 2008: TLS V1.2 introduces authenticated encryption (AEAD)
- February 2014: Firefox 27 supports TLS V1.2
- October 2014: POODLE Attack on TLS V1.2
- February 2016: Work on TLS V1.3 starts
- The Payment Card Industry Security Standards Council sets 30th June 2018 as deadline for disabling SSLv3.0 / TLS v1.0



Recent Attacks on TLS

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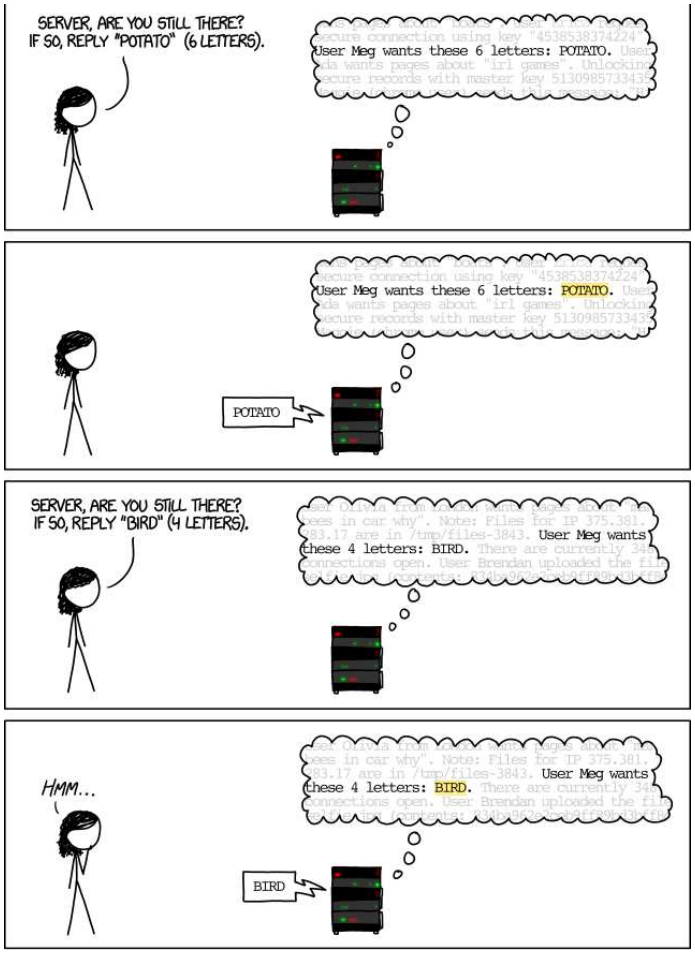
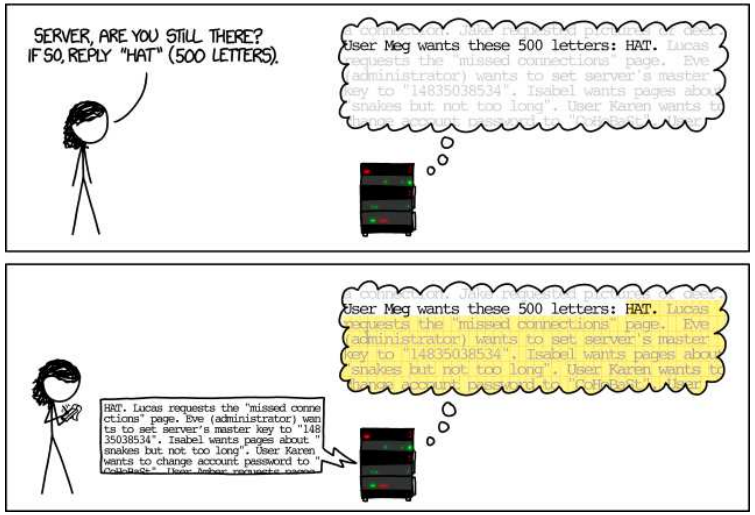
- Cryptographic Attacks:
  - December 2008: MD5 Considered Harmful
  - August 2012: Microsoft starts blocking RSA Keys weaker than 1024 bits
  - March 2013: RC4 dead
  - January 2016: SHA-1 Certificates no longer allowed to be issued
- Implementation Bug:
  - April 2014: Heartbleed Attack
- Protocol Attacks:
  - September 2011: BEAST Attack against TLS v1.0 publicly noticed
  - October 2014: POODLE Attack on TLS V1.2
  - March 2015: FREAK Attack

Heartbleed Attack



https://xkcd.com/1354/



- Buggy Heartbeat code published March 2012 (OpenSSL V1.0.1)
- Heartbleed Attack discovered April 2014

The POODLE Attack of 2014

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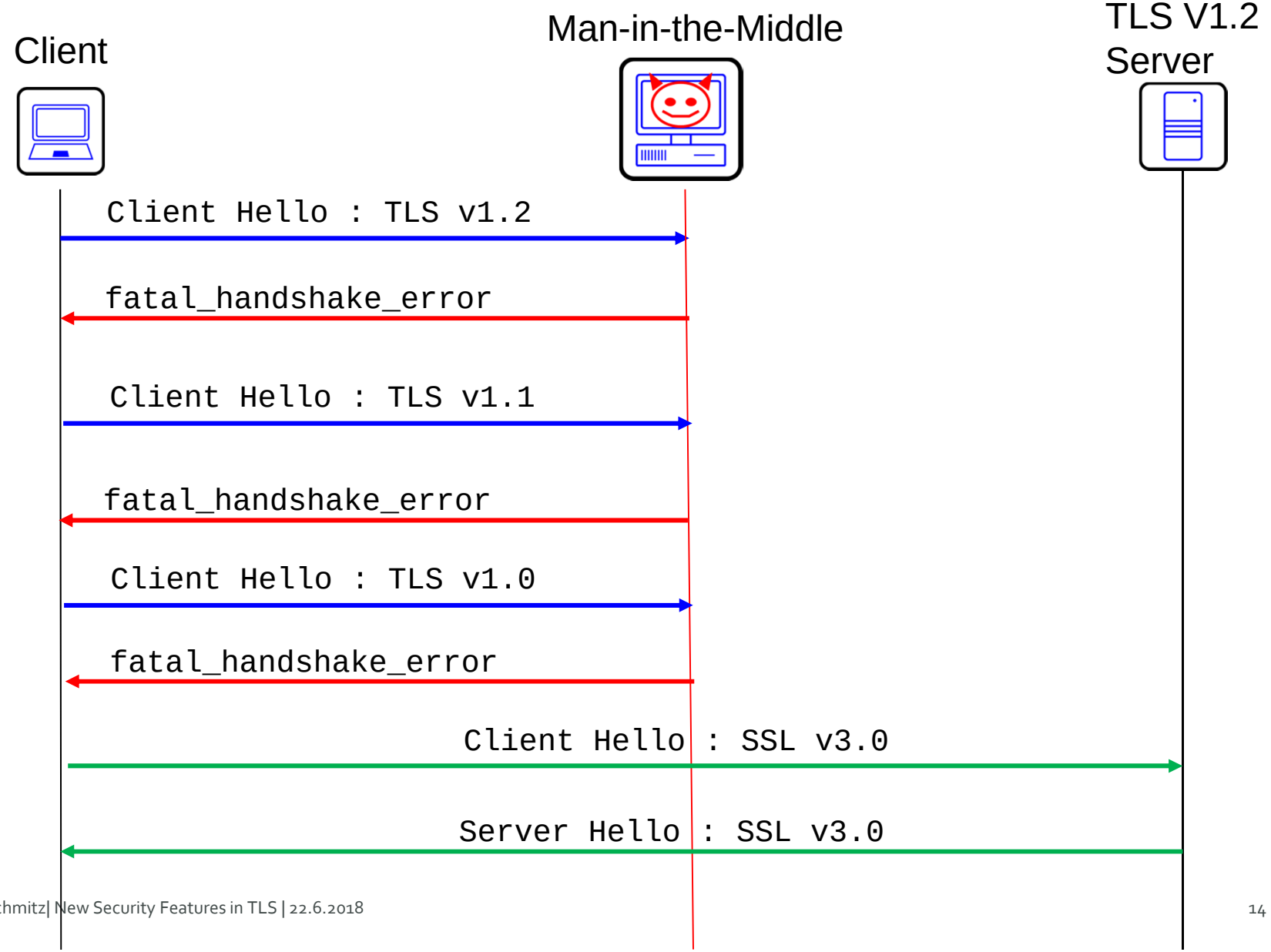
- Padding Oracle On Downgraded Legacy Encryption
- Possible because:
  - Downgrade Dance to SSL v3.0
  - SSL v3.0 uses CBC-Mode to encrypt and allows arbitrary padding
  - MAC-then-Encrypt order of operations when forming the records leaves padding data unprotected by MAC

The Downgrade Dance



The FREAK Attack of 2015

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- Factoring RSA_Export Keys
- Some TLS V1.2 servers still support RSA_Export cipher suites with 512 bit key length (although explicitly deprecated in TLSv1.1)
- A Man-in-the-Middle can trick a client *C* into accepting a weak RSA public key by manipulating the `ClientHello` message
- Attacker factorizes weak RSA key either on the fly or before the attack happens

Reasons for Insecure TLS Configurations

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- Main problem: The „Legacy Bloat“:
  - Co-Existence of many versions and ciphersuites which are still supported for backward compatability
  - Administrators tend to sacrifice security for maximum backwards compatibility
- Two quotes from expert security auditors:
  - *„Backward Compatibility is the major showstopper regarding proper TLS configurations.*“
  - Admins are *„afraid of using crypto*“, fearing that strong crypto might lead to incompatibilities.

New Security Features in TLS V1.3

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Cited from draft-ietf-tls-tls13-28:

> The list of supported symmetric algorithms has been pruned of all algorithms that are considered legacy. Those that remain all use Authenticated Encryption with Associated Data (AEAD) algorithms.

> Static RSA and Diffie-Hellman cipher suites have been removed; all public-key based key exchange mechanisms now provide forward secrecy.

New Security Features in TLS V1.3: No Insecure Algorithm Options

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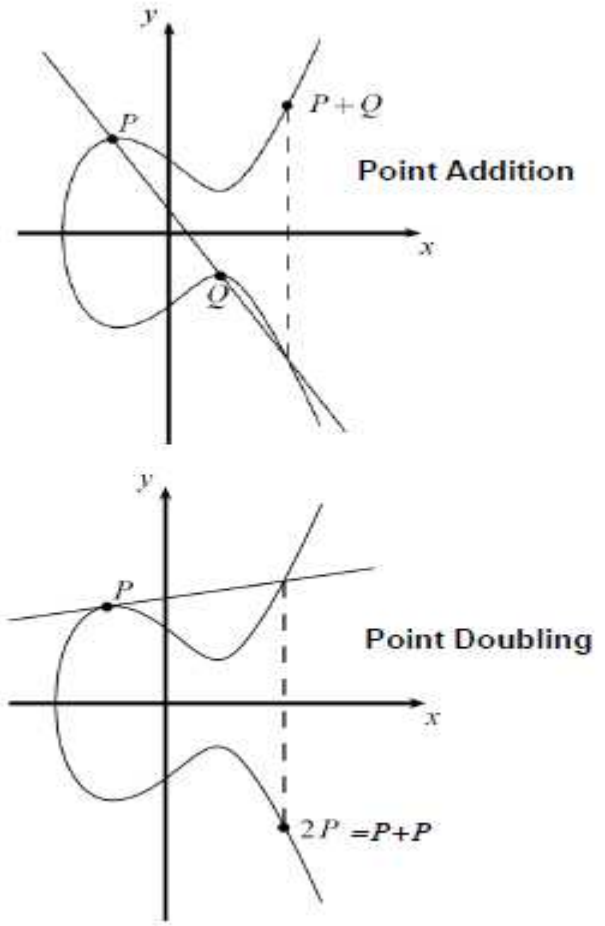
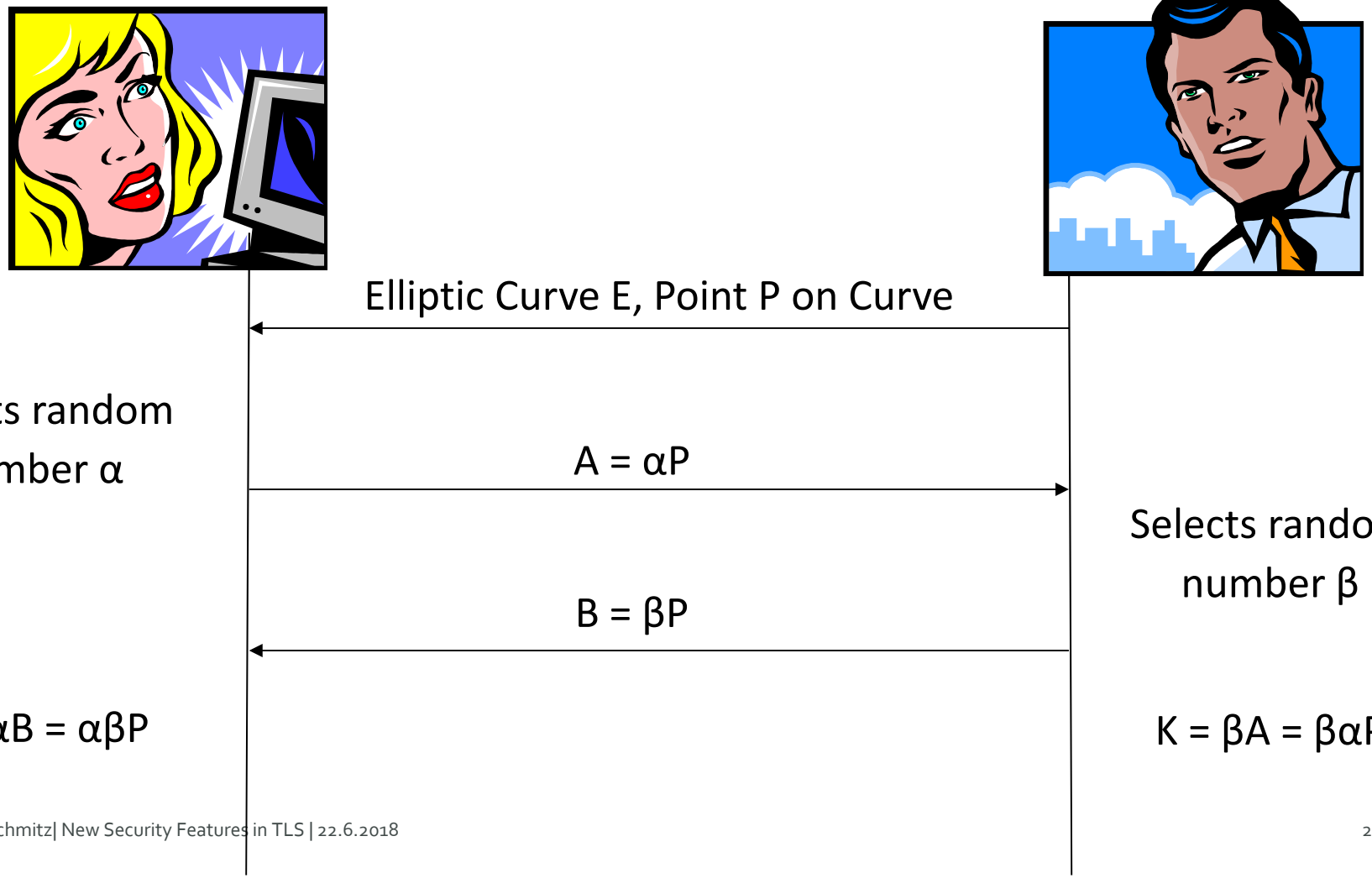
- Get rid of all insecure algorithm options:
  - No export ciphers
  - No RC4
  - No MD5, No SHA-1
  - Use SHA-256
- No Key Exchange via Static RSA or DH Keys
  - Promote Forward Secrecy through ephemeral public keys
  - Three Basic Key Exchange Modes:
    - (EC)DHE
    - (EC)DHE with Pre-Shared Key (PSK)
    - PSK
- Mandatory Authenticated Encryption
  - Use Galois Counter Mode (GCM)

ECDHE

- Elliptic Curve Diffie-Hellman Ephemeral:
  - Use Diffie-Hellman over Elliptic Curves for Key Exchange
  - Use a fresh DH Keypair for each session to provide *forward secrecy*
- DH Keypairs are authenticated by a long-lived keypair or PSK
- If this keypair is lost, only future connections are endangered



Diffie – Hellman Key Exchange over Elliptic Curves



Elliptic Curve
Diffie-Hellman Key Exchange Toy Example

- Public Parameters:

$$E : y^2 = x^3 + x + 1 \bmod 97$$

$$P = (95, 66)$$

- Alice's Secret Key:

$$\alpha = 16$$

- Alice sends to Bob:

$$A = \alpha P = (82, 54)$$

- Bob's Secret Key:

$$\beta = 94$$

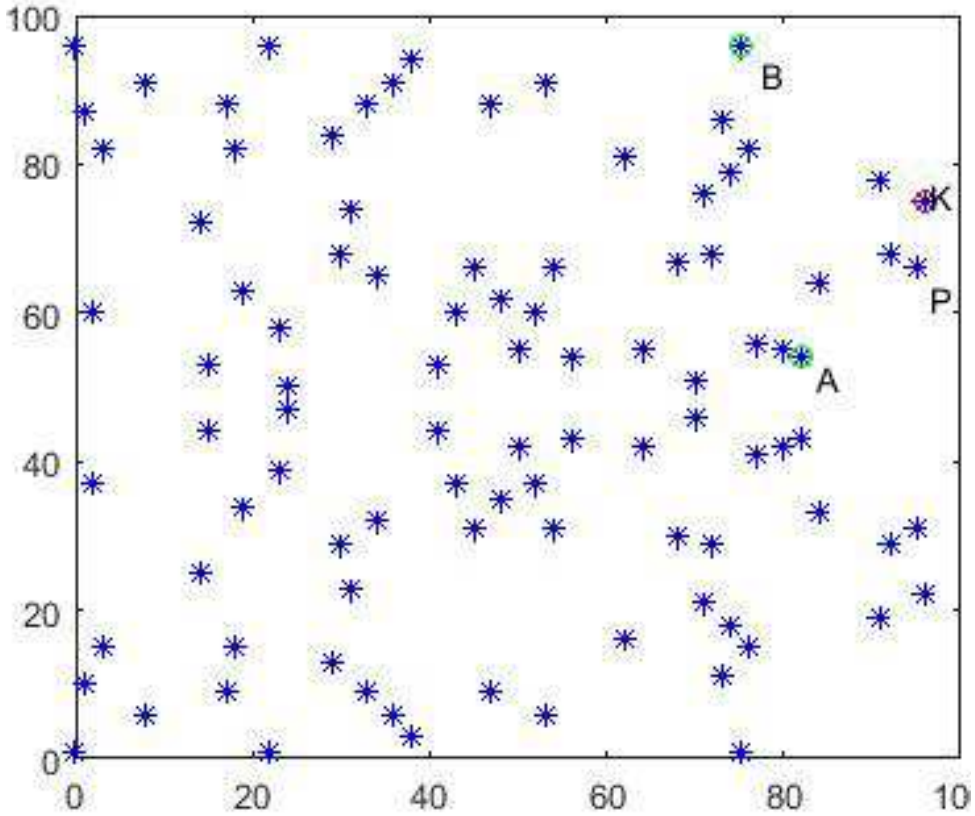
- Bob sends to Alice:

$$B = \beta P = (75, 96)$$

- Alice computes:

$$K_{Alice} = \alpha B = (96, 75)$$

- Bob computes: $K_{Bob} = \beta A = (96, 75)$



Elliptic Curve Crypto Security Level in Bits

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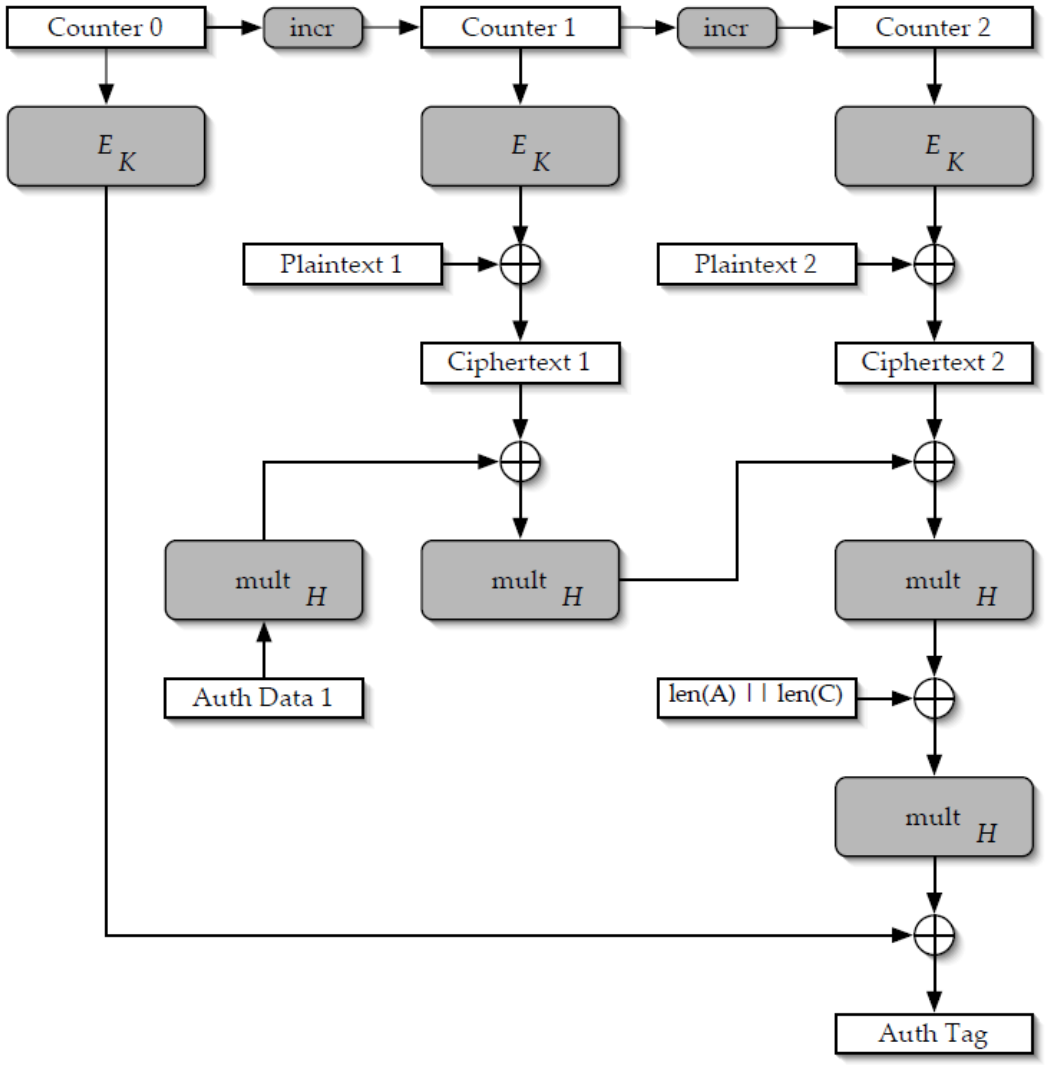
Symmetric Key	RSA Key	ECDH Key
80	1024	160
112	2048	224
128	3072	256
192	7936	384
256	15360	512

Authenticated Encryption: The Galois Counter Mode (GCM)



New Security Features in TLS V1.3: Protocol Modifications

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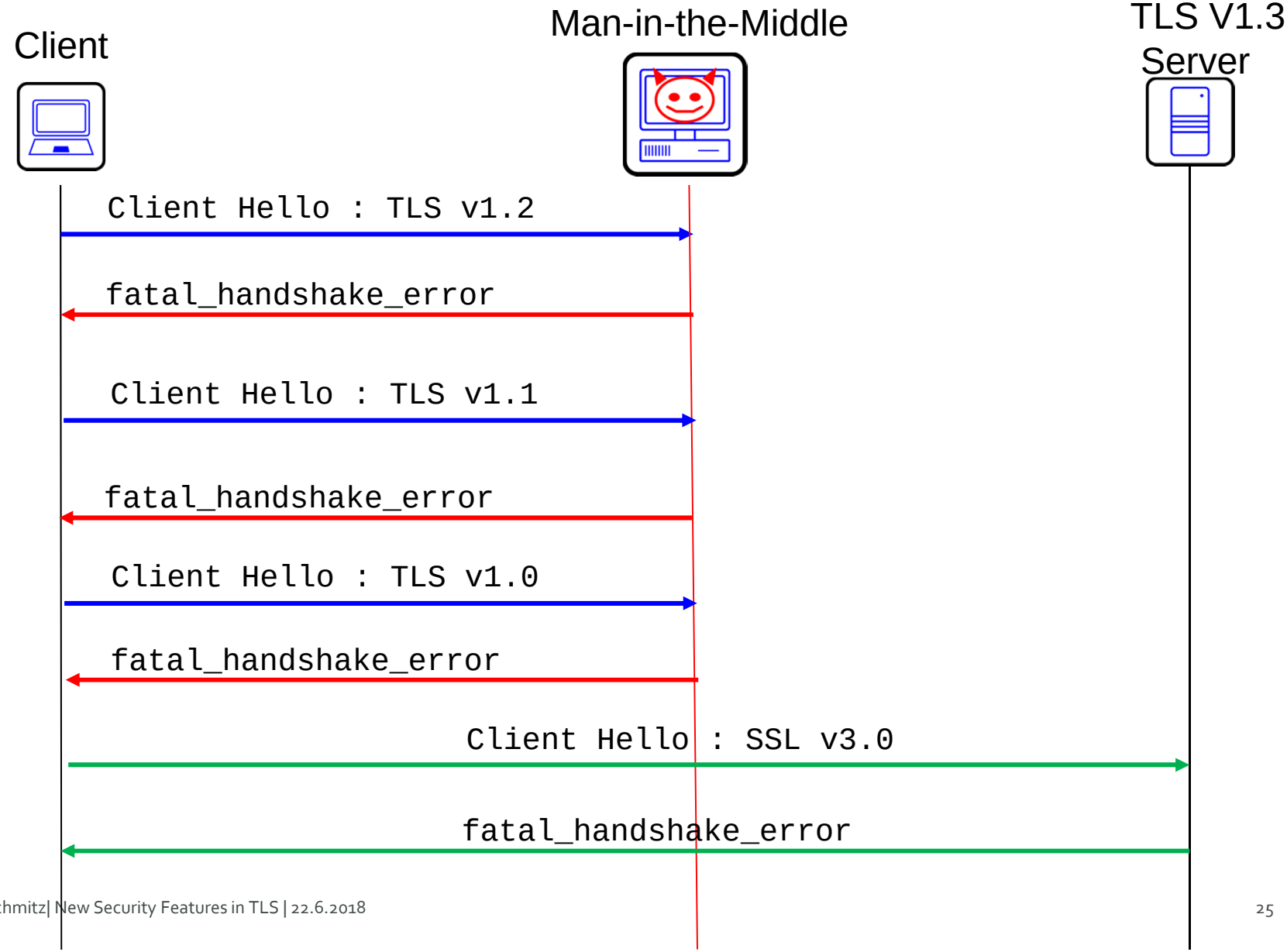
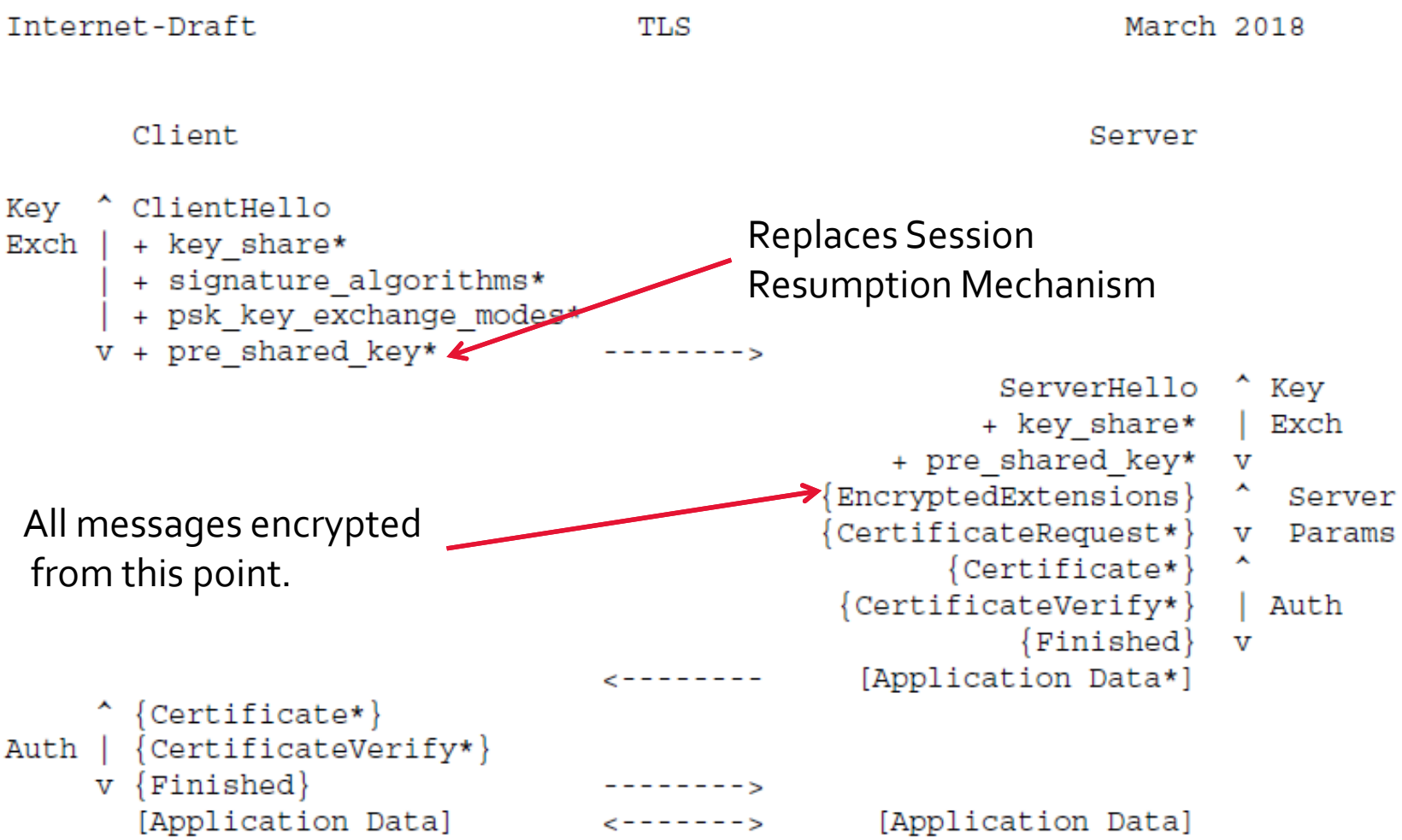
- All handshake messages after the ServerHello are now encrypted.
- SSL negotiation is prohibited
- Downgrade attempts are signalized by servers
  - If negotiating TLS 1.2 or lower, TLS 1.3 servers MUST set the last seven bytes of their random value to the bytes: 44 4F 57 4E 47 52 44 (ASCII for DOWNGRD)
  - `ServerKeyExchange` Messages include a signature over random values
  - TLS 1.3 clients receiving a `ServerHello` indicating TLS 1.2 or below MUST check that the last seven bytes are not equal to these values.

Sorry, No Downgrade Dance with TLS V1.3



TLS V1.3 Handshake Overview



References

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- FREAK:
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  https://tools.ietf.org/pdf/draft-ietf-tls-tls13-28.pdf

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Thank You for Your Attention!