CS558 Network Security

Lecture 13: Breaking TLS1.2 (and older)

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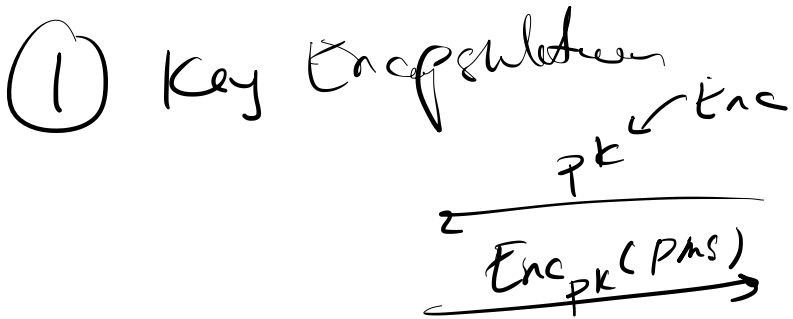
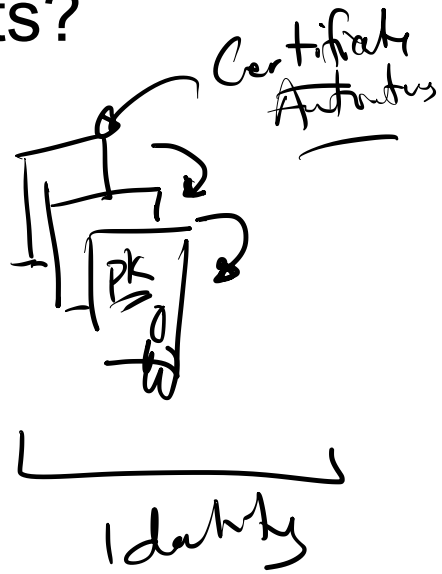
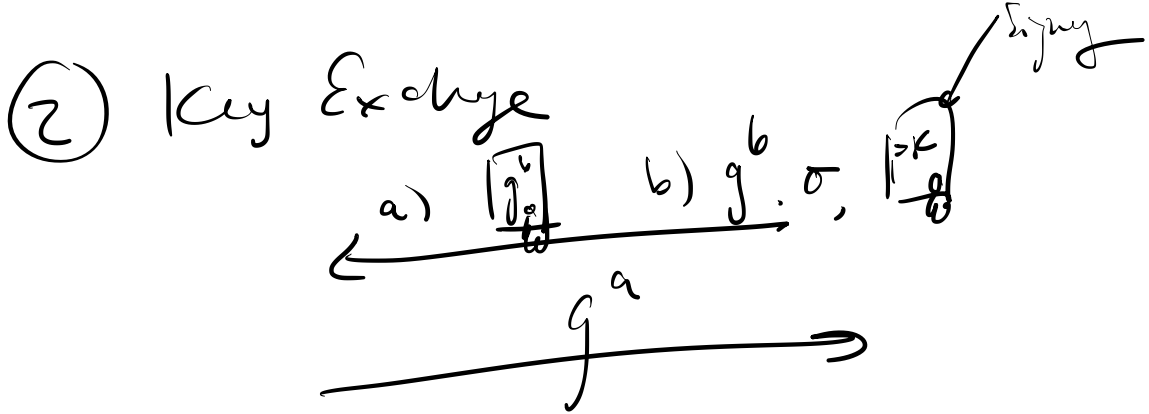
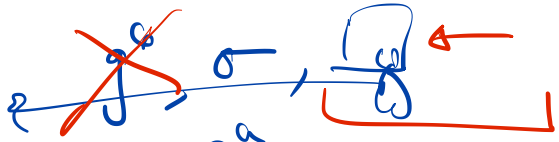
High Level Review -- What are the key parts?







TLS(1.2) in Detail



RFC 5246 TLS August 2008

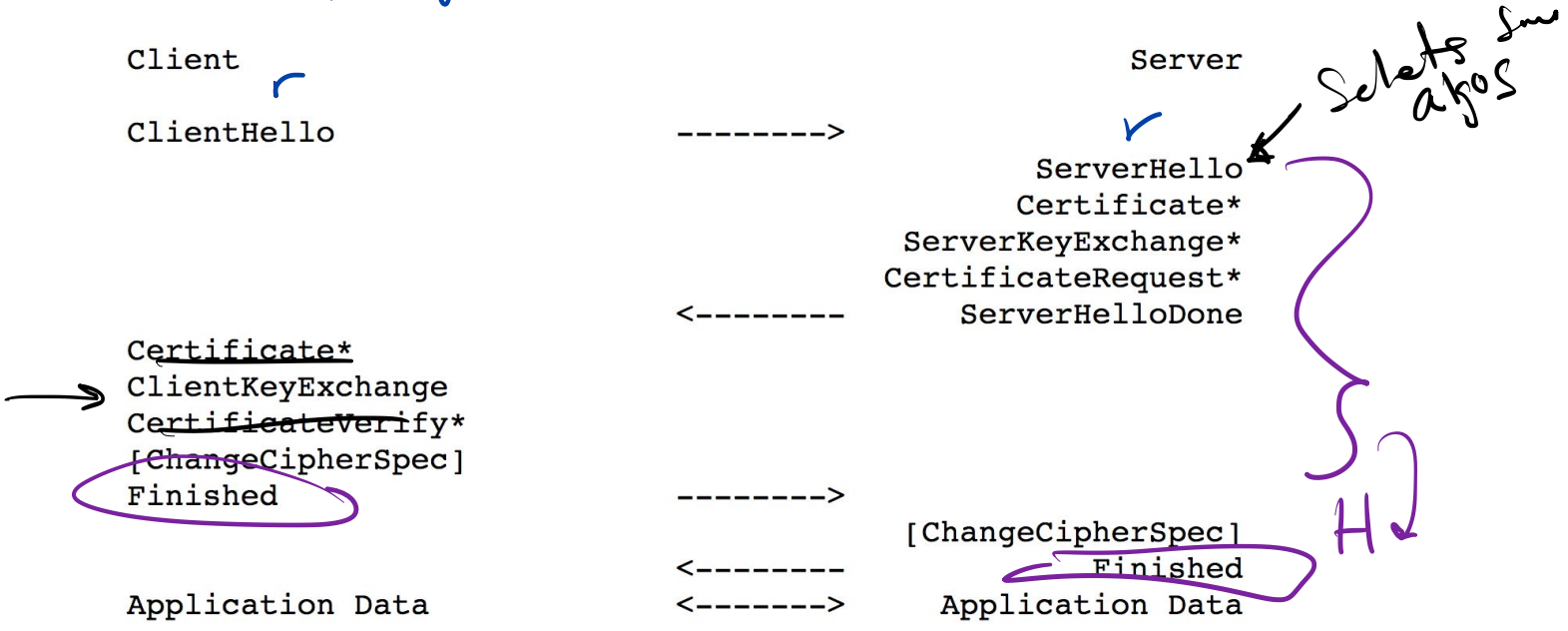


Figure 1. Message flow for a full handshake

Replay Attacks & Perfect Forward Secrecy

randomized transcripts from client and server

the ability to delete info

Emphemeral DH has PFS

Static DH + KEncap fail

Bleichenbacher's Attack (The Million Message Attack)

PKCS#1 v1.5

$m \longrightarrow c = m^e \bmod n$ (d)

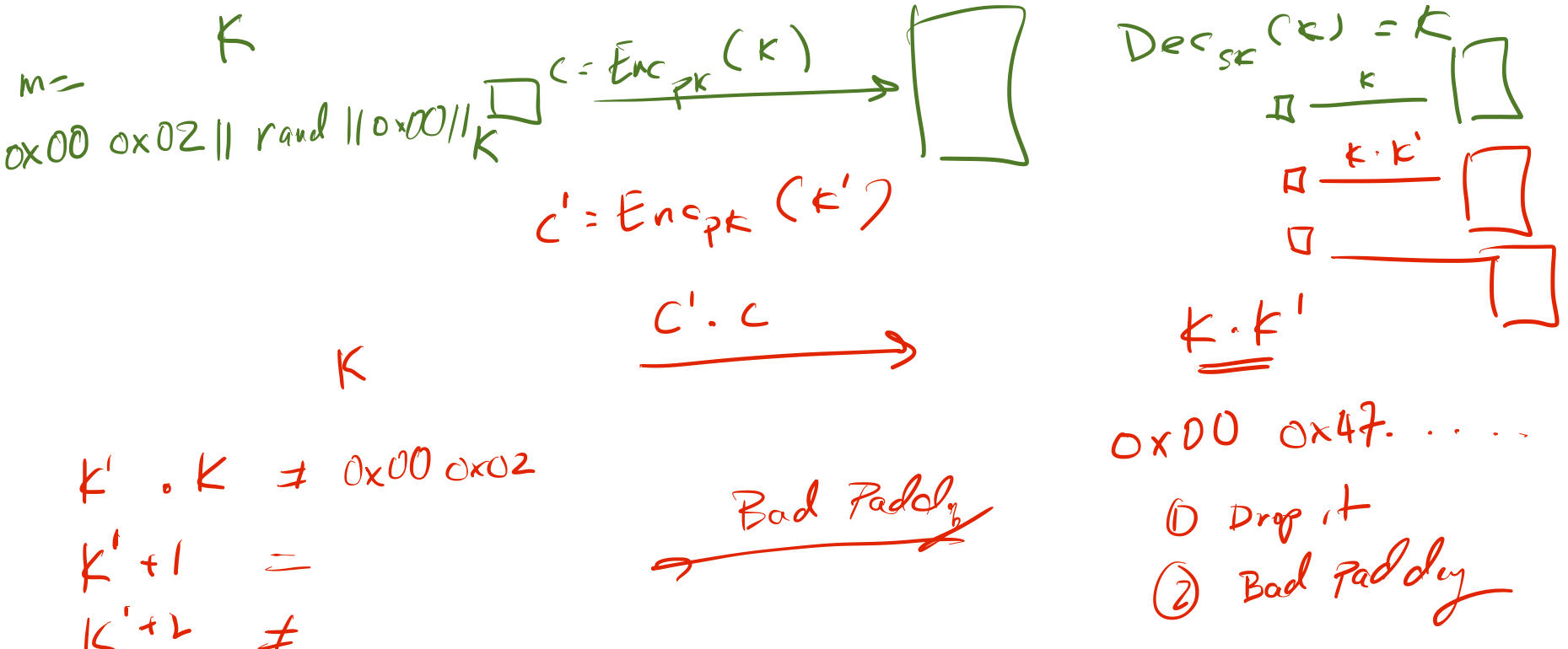
$d \equiv e^{-1} \bmod n$

$c^d = (m^e)^d = m^{ed} = m^1 \bmod n$

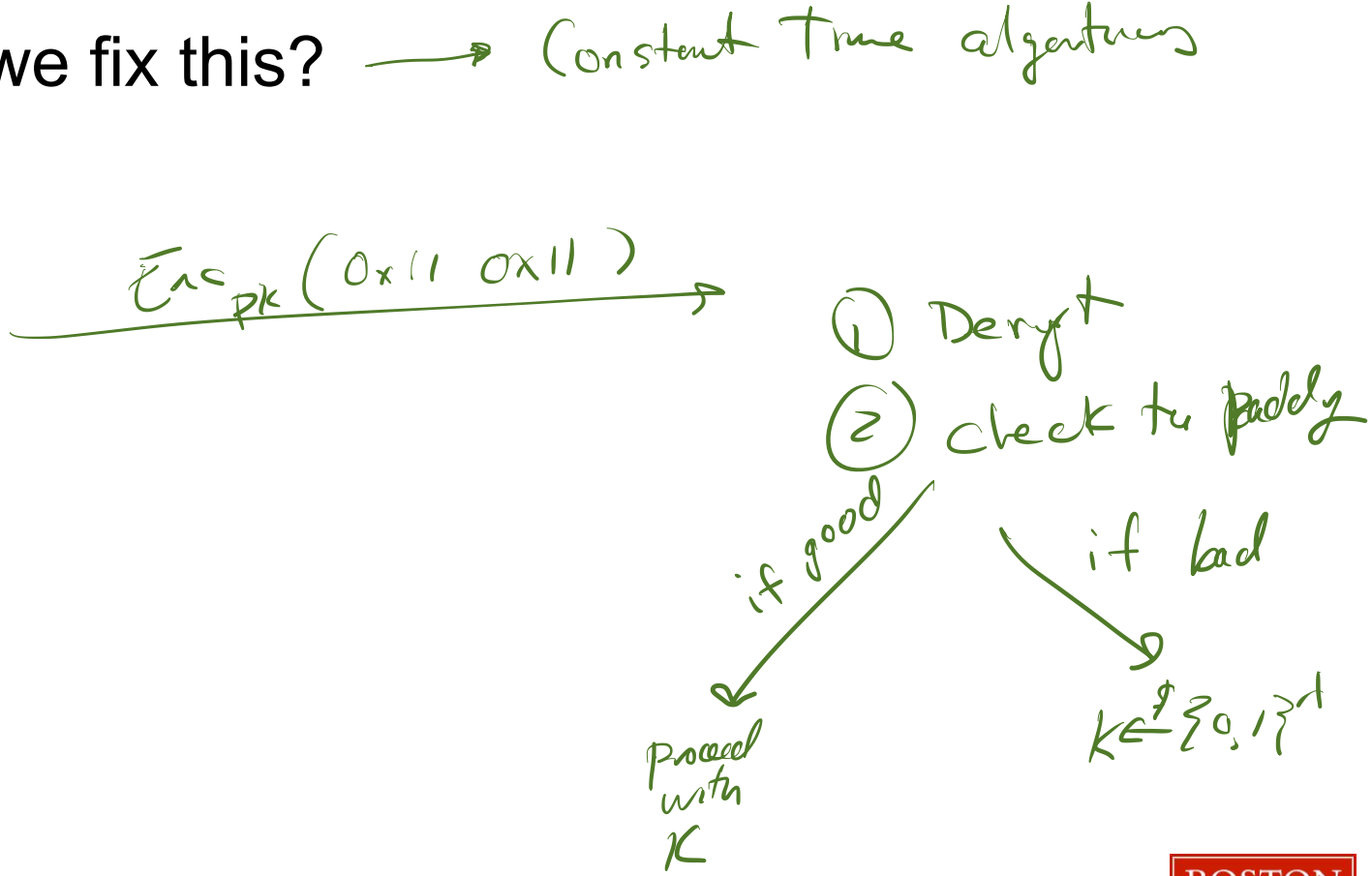
$c' = s^e \bmod n$

$c' \cdot c = m^e \cdot s^e = (m \cdot s)^e \bmod$

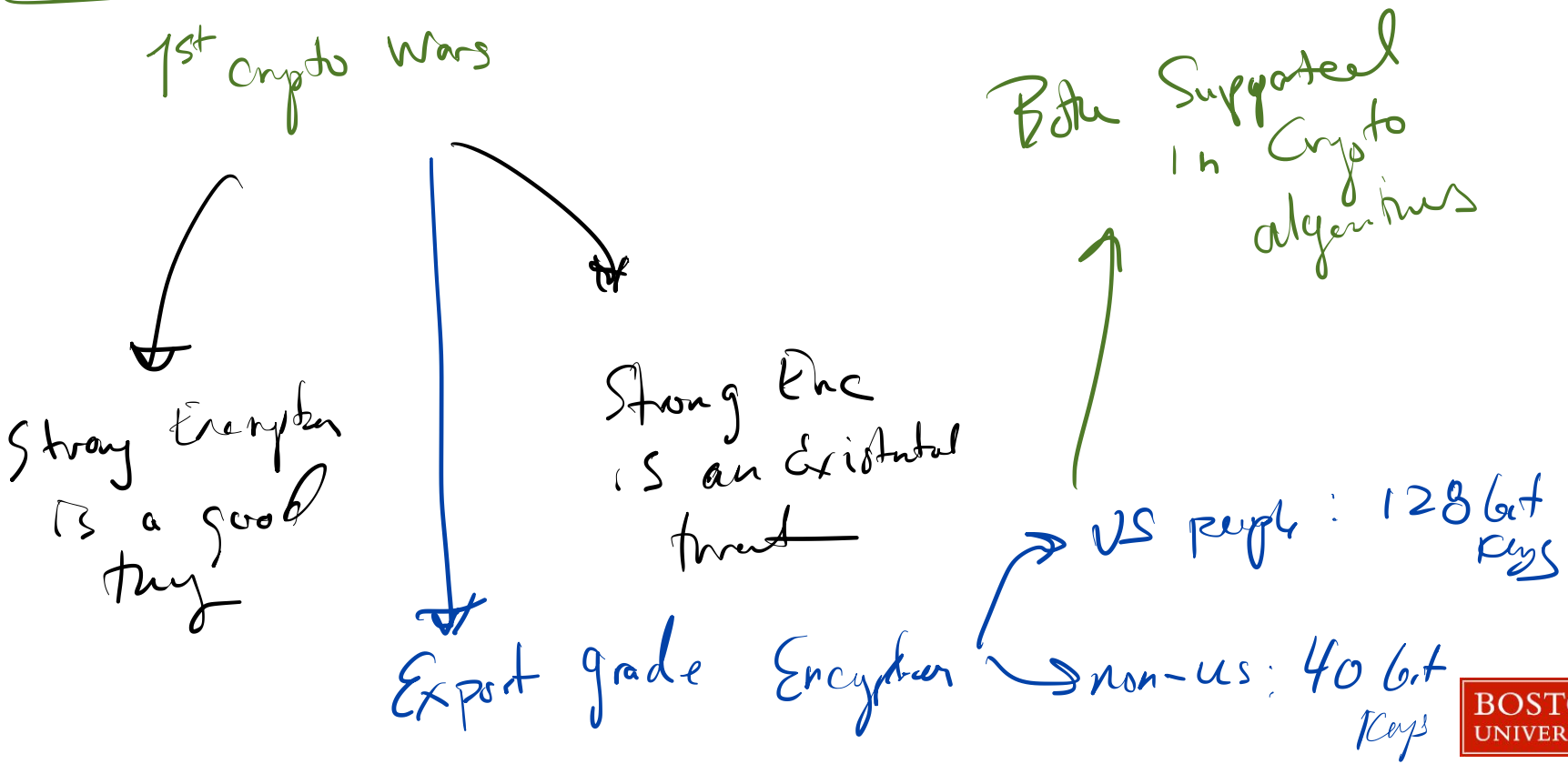
$Enc_{PK}(m) \cdot Enc_{PK}(s) = Enc_{PK}(m \cdot s)$

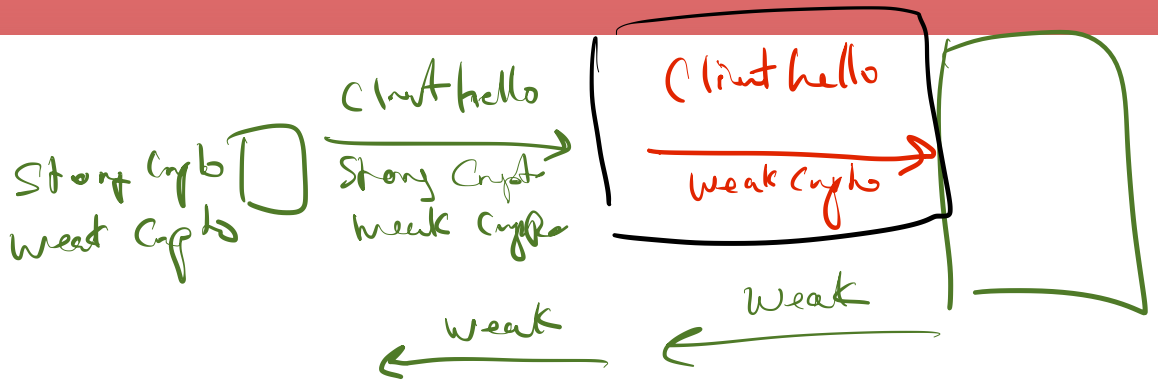


How should we fix this?



Downgrade Attacks





40 9 6

RSA - 2048

RSA - 512

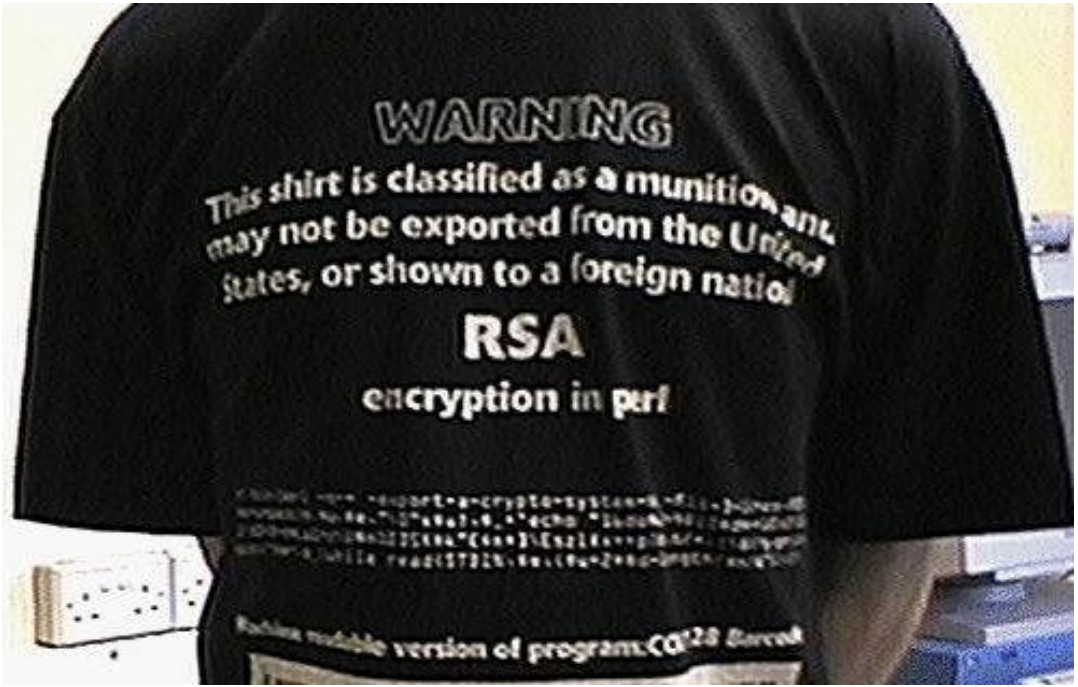
Problem :

(1) Existence of old ciphers

(2) Backwards Compatibility

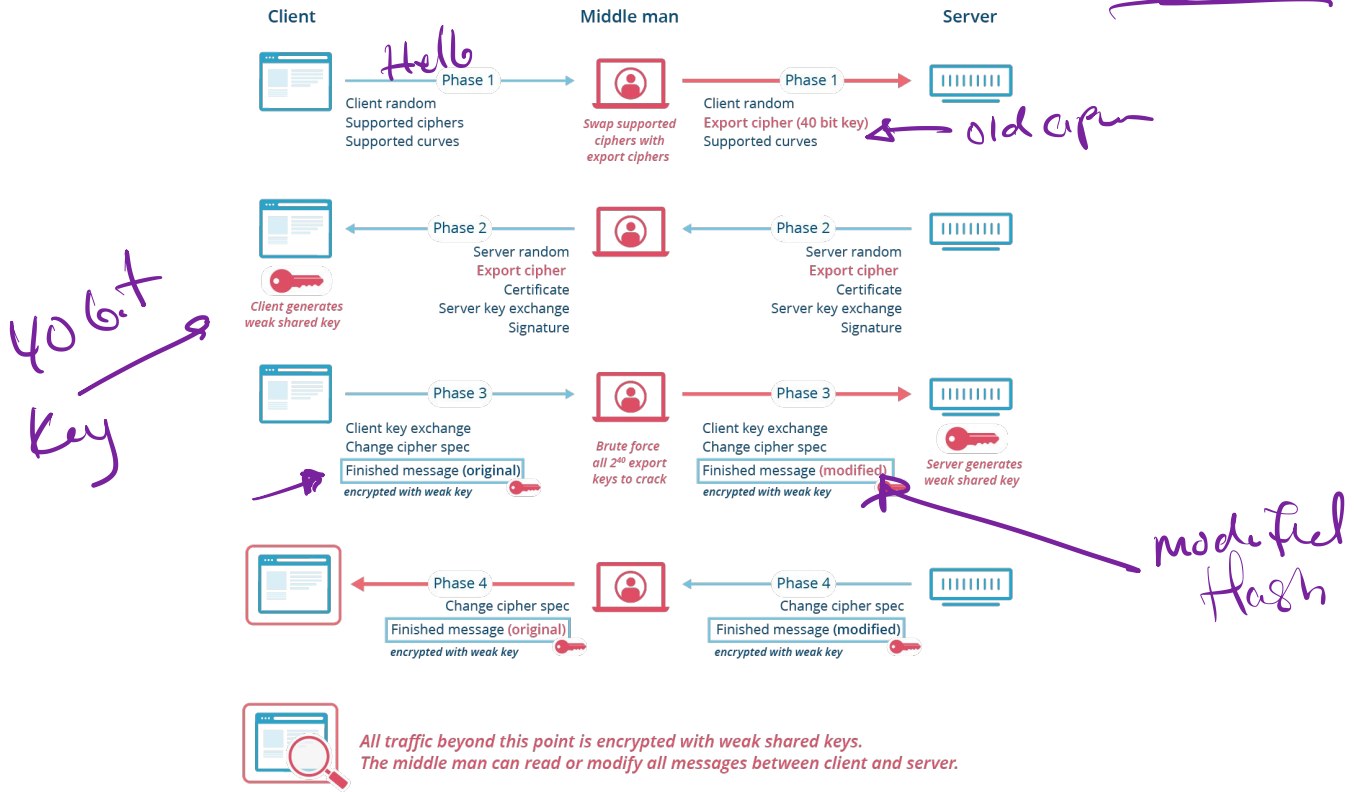
TLS_RSA_WITH_NULL_SHA256	NULL-SHA256
TLS_RSA_WITH_AES_128_CBC_SHA256	AES128-SHA256
TLS_RSA_WITH_AES_256_CBC_SHA256	AES256-SHA256
TLS_RSA_WITH_AES_128_GCM_SHA256	AES128-GCM-SHA256
TLS_RSA_WITH_AES_256_GCM_SHA384	AES256-GCM-SHA384
TLS_DH_RSA_WITH_AES_128_CBC_SHA256	DH-RSA-AES128-SHA256
TLS_DH_RSA_WITH_AES_256_CBC_SHA256	DH-RSA-AES256-SHA256
TLS_DH_RSA_WITH_AES_128_GCM_SHA256	DH-RSA-AES128-GCM-SHA256
TLS_DH_RSA_WITH_AES_256_GCM_SHA384	DH-RSA-AES256-GCM-SHA384
TLS_DH_DSS_WITH_AES_128_CBC_SHA256	DH-DSS-AES128-SHA256
TLS_DH_DSS_WITH_AES_256_CBC_SHA256	DH-DSS-AES256-SHA256
TLS_DH_DSS_WITH_AES_128_GCM_SHA256	DH-DSS-AES128-GCM-SHA256
TLS_DH_DSS_WITH_AES_256_GCM_SHA384	DH-DSS-AES256-GCM-SHA384
TLS_DHE_RSA_WITH_AES_128_CBC_SHA256	DHE-RSA-AES128-SHA256
TLS_DHE_RSA_WITH_AES_256_CBC_SHA256	DHE-RSA-AES256-SHA256
TLS_DHE_RSA_WITH_AES_128_GCM_SHA256	DHE-RSA-AES128-GCM-SHA256
TLS_DHE_RSA_WITH_AES_256_GCM_SHA384	DHE-RSA-AES256-GCM-SHA384
TLS_DHE_DSS_WITH_AES_128_CBC_SHA256	DHE-DSS-AES128-SHA256
TLS_DHE_DSS_WITH_AES_256_CBC_SHA256	DHE-DSS-AES256-SHA256
TLS_DHE_DSS_WITH_AES_128_GCM_SHA256	DHE-DSS-AES128-GCM-SHA256
TLS_DHE_DSS_WITH_AES_256_GCM_SHA384	DHE-DSS-AES256-GCM-SHA384
TLS_ECDH_RSA_WITH_AES_128_CBC_SHA256	ECDH-RSA-AES128-SHA256
TLS_ECDH_RSA_WITH_AES_256_CBC_SHA384	ECDH-RSA-AES256-SHA384
TLS_ECDH_RSA_WITH_AES_128_GCM_SHA256	ECDH-RSA-AES128-GCM-SHA256
TLS_ECDH_RSA_WITH_AES_256_GCM_SHA384	ECDH-RSA-AES256-GCM-SHA384
TLS_ECDH_ECDSA_WITH_AES_128_CBC_SHA256	ECDH-ECDSA-AES128-SHA256
TLS_ECDH_ECDSA_WITH_AES_256_CBC_SHA384	ECDH-ECDSA-AES256-SHA384
TLS_ECDH_ECDSA_WITH_AES_128_GCM_SHA256	ECDH-ECDSA-AES128-GCM-SHA256
TLS_ECDH_ECDSA_WITH_AES_256_GCM_SHA384	ECDH-ECDSA-AES256-GCM-SHA384
TLS_ECDHE_RSA_WITH_AES_128_CBC_SHA256	ECDHE-RSA-AES128-SHA256
TLS_ECDHE_RSA_WITH_AES_256_CBC_SHA384	ECDHE-RSA-AES256-SHA384
TLS_ECDHE_RSA_WITH_AES_128_GCM_SHA256	ECDHE-RSA-AES128-GCM-SHA256
TLS_ECDHE_RSA_WITH_AES_256_GCM_SHA384	ECDHE-RSA-AES256-GCM-SHA384
TLS_ECDHE_ECDSA_WITH_AES_128_CBC_SHA256	ECDHE-ECDSA-AES128-SHA256
TLS_ECDHE_ECDSA_WITH_AES_256_CBC_SHA384	ECDHE-ECDSA-AES256-SHA384
TLS_ECDHE_ECDSA_WITH_AES_128_GCM_SHA256	ECDHE-ECDSA-AES128-GCM-SHA256
TLS_ECDHE_ECDSA_WITH_AES_256_GCM_SHA384	ECDHE-ECDSA-AES256-GCM-SHA384
TLS_DH_anon_WITH_AES_128_CBC_SHA256	ADH-AES128-SHA256
TLS_DH_anon_WITH_AES_256_CBC_SHA256	ADH-AES256-SHA256
TLS_DH_anon_WITH_AES_128_GCM_SHA256	ADH-AES128-GCM-SHA256
TLS_DH_anon_WITH_AES_256_GCM_SHA384	ADH-AES256-GCM-SHA384

https://www.openssl.org/docs/man1.0.2/man1/ciphers.html


WARNING
This shirt is classified as a munition and
may not be exported from the United
States, or shown to a foreign nation
RSA
encryption in perl

Downgrade Attack (FREAK)

(+Logjam Attack)



CLOUDFLARE

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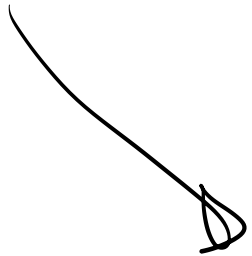
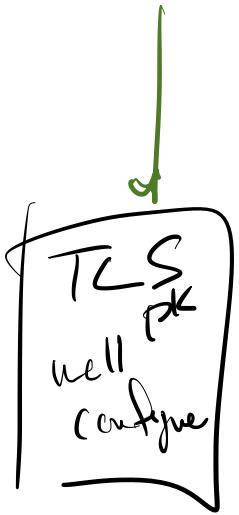
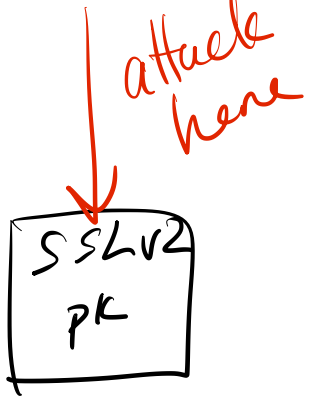
DROWN and ROBOT

↳ SSLv2
Brute force keys

↳ Bleichenbacher



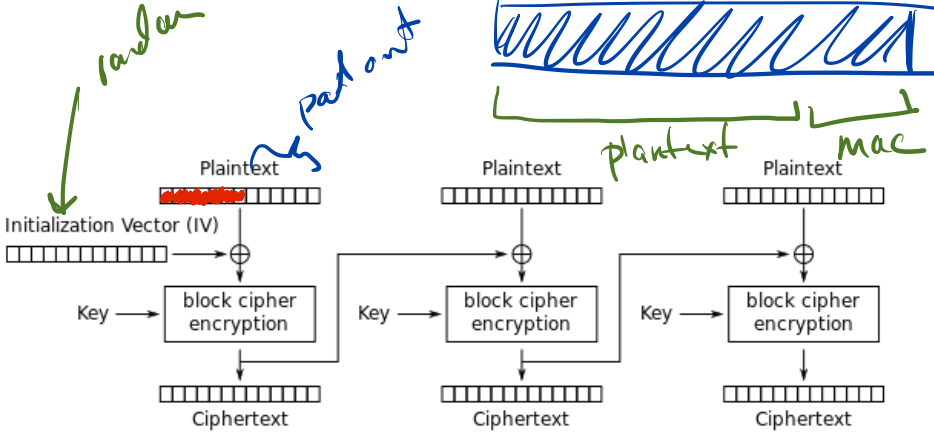




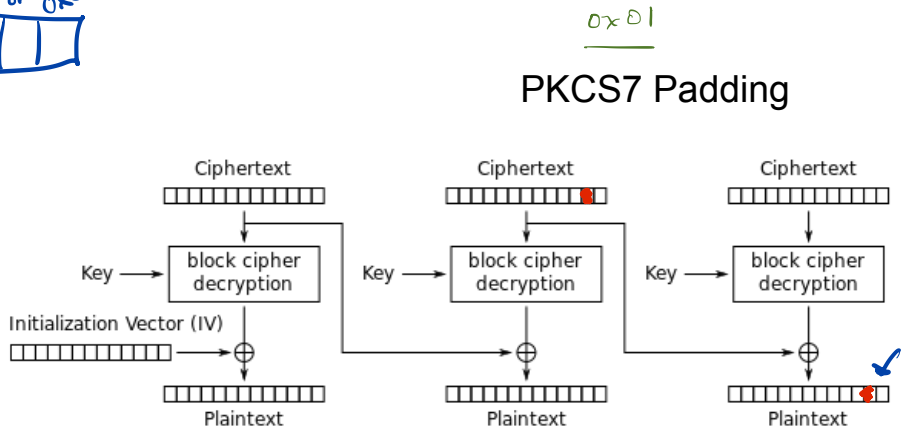
How should we fix this?

Break backwards compatibility

Padding Oracles in Symmetric Key Land (BEAST)

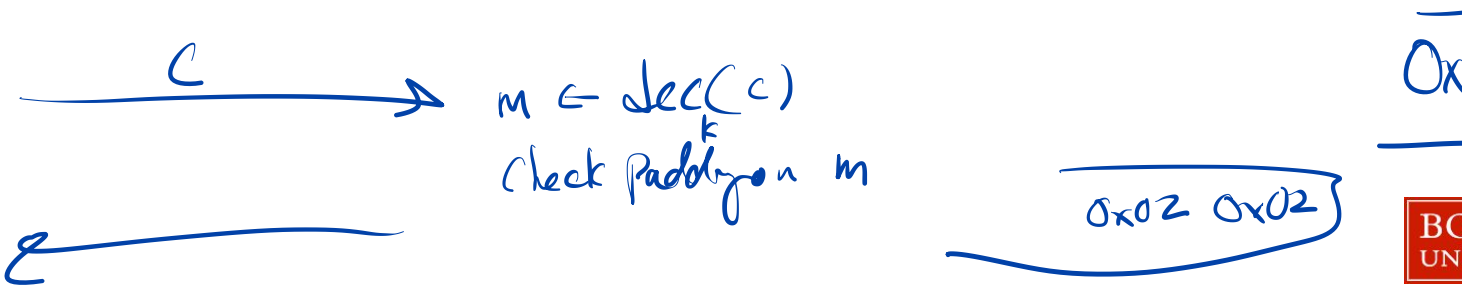


Cipher Block Chaining (CBC) mode encryption



Cipher Block Chaining (CBC) mode decryption

PKCS7 Padding



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TLS 1.2

MAC+Enc

TLS 1.3

Enc + MAC

X - A = 0x01

→ 0x01 - (0x07 + 0xFF)

0x08

How should we fix this?