Reactive and Proactive Standardisation of TLS

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Real World Crypto
11 January 2018

Motivation

Gmail by Google

citibank

improve efficiency

TLS 1.2
(and below)

weaknesses

TLS 1.3

post-deployment-analysis vs **analysis-prior-to-deployment**

Why?

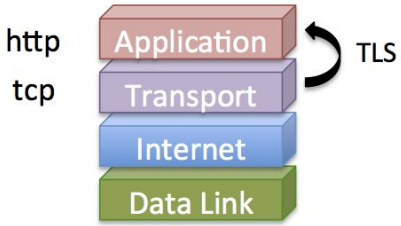
What can the security community learn? What standardisation model best fits critical protocols such as TLS?

NETSCAPE

SSL 2.0 (1995) → SSL 3.0 (1996)

IETF

TLS 1.0 (1999) → TLS 1.1 (2006) → TLS 1.2 (2008)



TLS 1.2
- 2-RTT
- static RSA/DH
- HS not encrypted

TLS 1.3
- 1-RTT
- 0-RTT
- ephemeral DH
- HS encrypted

IP, TLS, HTTP, ...

I E T F®

Security Area

... ...

TLS Working Group (WG)

TLS Request for Comments (RFCs)

TLS Mailing List

- Nov 26 2016
  - Re: [TLS] Certificate compression (a la QUIC) for TLS 1.3, *Victor Vasiliev*
  - Re: [TLS] Certificate compression (a la QUIC) for TLS 1.3, *Eric Rescorla*
  - [TLS] Certificate compression (a la QUIC) for TLS 1.3, *Alessandro Ghedini*

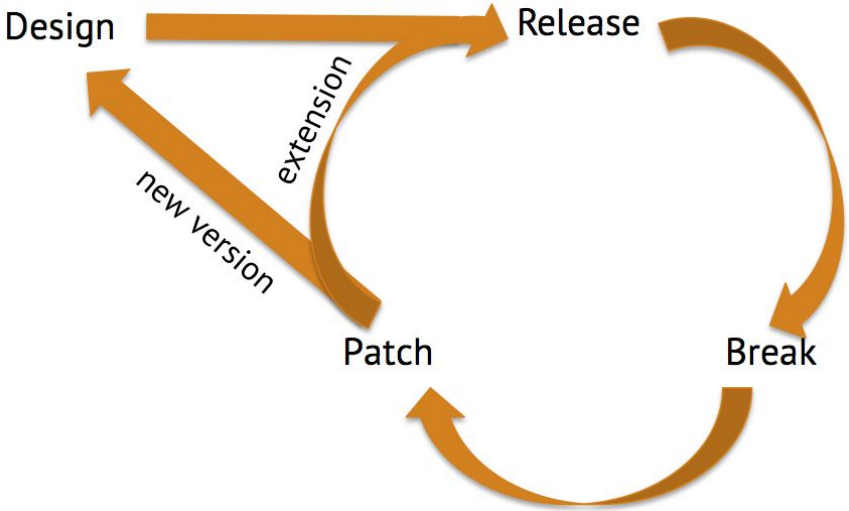
IETF Meetings

No formal membership!

Open model for standards development
- no barriers to entry
- no financial barriers to adoption

TLS 1.2 and below - Design, Release, Break, Patch

- Development followed a **reactive** standardisation process
- An attack → releasing a extension OR making the change in the next version of the standard



Countermeasure to BEAST
Long been known to be biased
Deprecated in 2015 → phased out sooner?

Affects TLS 1.0 → exploits chained-IV vulnerability, recover plaintext
Opened the floodgates → new techniques that **made attack practical**
TLS 1.1 removes this vulnerability BUT **implementations slow to react**, TLS 1.0 is still popular today!

Affects SSL 3.0 → PKCS#1 v1.5 padding oracle uncovers the pre-master secret
Briefly **addressed in TLS 1.0** → mechanism to remove the padding oracle
Re-enabled in many forms (Jager et. al, DROWN, ROBOT) → switch to PKCS#1 v2.1? No, **backwards compatibility**

Attack	Damage	Fix	Resurrected
Bleichenbacher	SSL 3.0, recover keys	Note in TLS 1.0 (1.1, 1.2)	Jager et al., DROWN, others
Vaudenay	TLS 1.0, recover plaintext	Addressed in TLS 1.1	Lucky Thirteen, POODLE (related)
Renegotiation	TLS 1.2 and below	Mandatory extension	Triple Handshake
BEAST	TLS 1.0, recovery plaintext	Addressed in TLS 1.1	Made practical with new techniques!
RC4	TLS 1.2 and below	Eventually deprecated	Old weakness

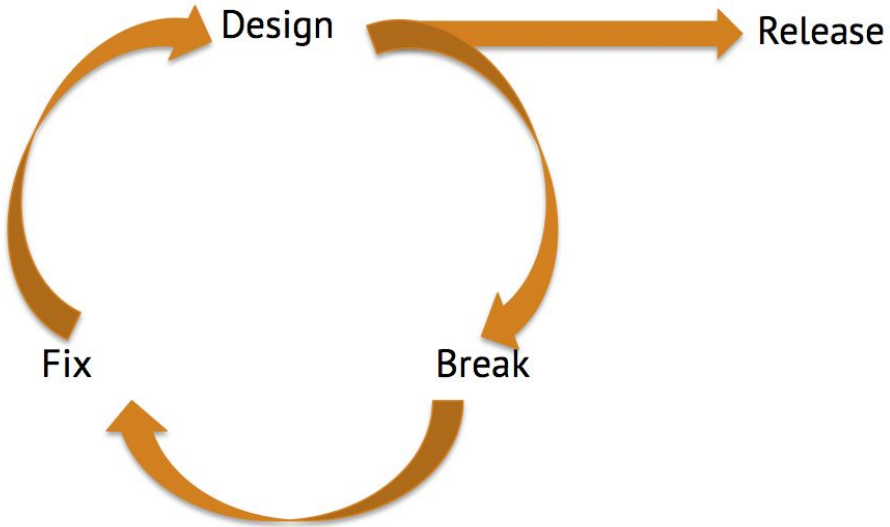
Contributing factors

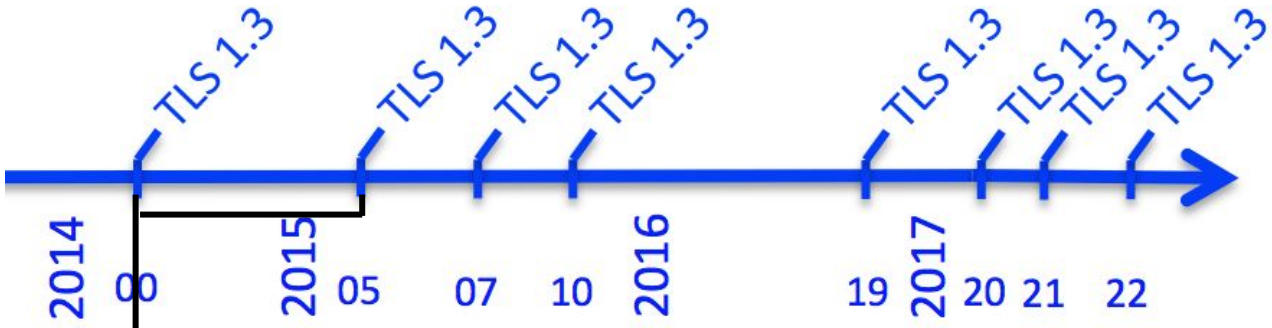
- Backwards compatibility, wide deployment of TLS and time lags in adopting new versions hinder meaningful change
- Analysis tools not yet fully developed before TLS 1.2 release
- Lack of interaction with the academic community - reward came from producing high profile attacks
- Incentive model leaves users vulnerable to attack and imposes a patch action

Is a more cautious approach warranted for critical protocols?

TLS 1.3 - Design, Break, Fix, Release

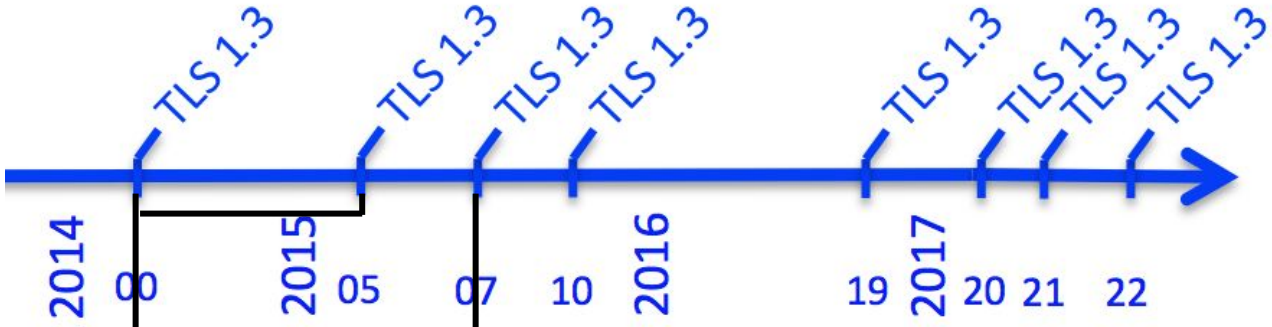
- Development has followed a **proactive** standardisation process
- Working closely with the academic community, multiple drafts have been developed prior to official release





Academic community starts to get heavily involved!

Removal of mechanisms that aid attacks → compression, renegotiation, MEE
Analysed by Dowling et al. and Kohlweiss et al. → provides valuable feedback to WG on design



WG draws inspiration from secure designs and acknowledges the research community's concerns!

Becomes highly influenced by **OPTLS** (Krawczyk and Wee)
Designed with TLS modes in mind
Uses secure primitives

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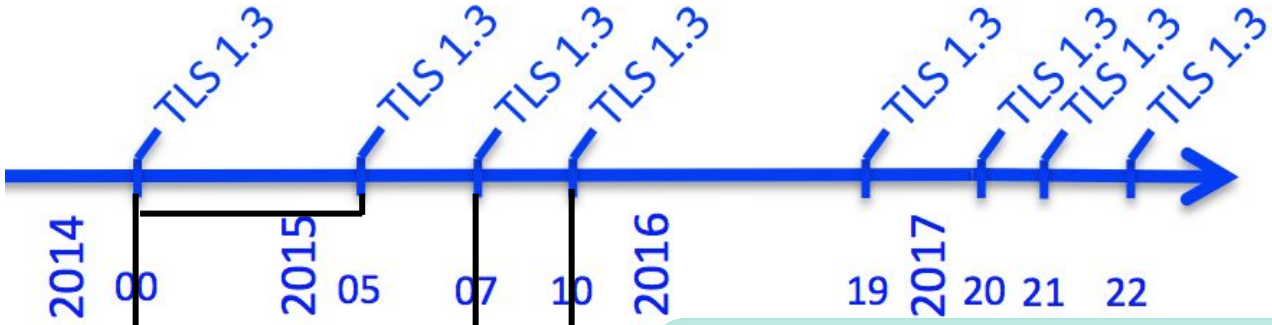

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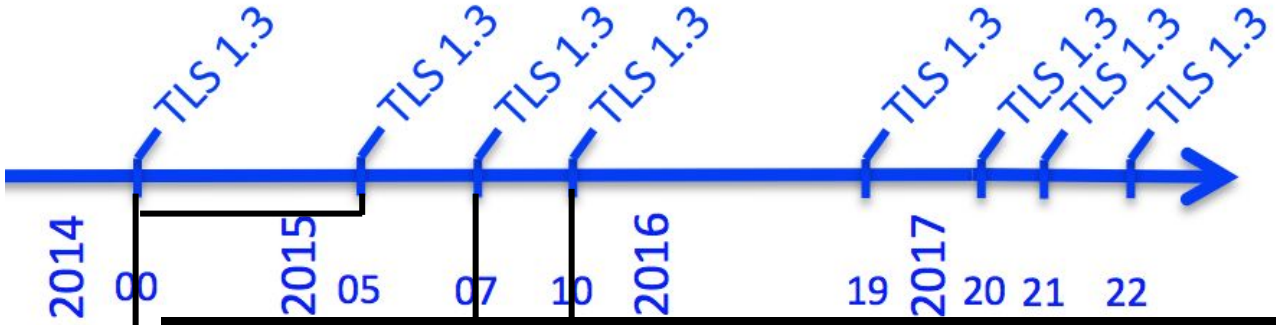

"Thanks for posting this. It's great to see people doing real formal analysis of the TLS 1.3 draft; this is really helpful in guiding the design."

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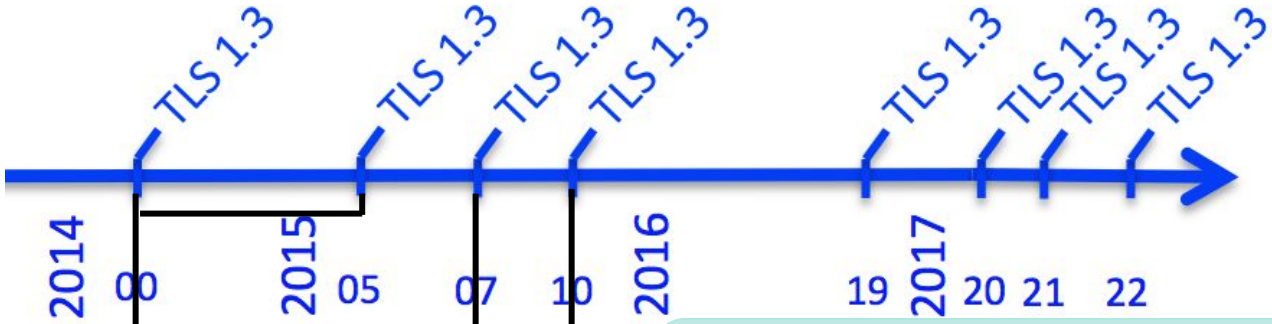

Much more analysis after `draft 10`...

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- “TLS Ready or Not?” (TRON 1.0) workshop in February 2016
  - showcased work by the academic community - computational analyses, symbolic analyses, implementations
  - brought the WG and the research community together
  - definition of properties - late in the game?
  - followed up by the less formal TRON 2.0

Huge amount of back and forth between the WG and the research community.

What's changed?

Available Tools

Protocol analysis tools have matured since TLS 1.2

- primitives (HKDF, AEAD)
- modelling key exchange (ACCE, multi-stage KE)
- program verification (miTLS)
- automated tools (Tamarin, ProVerif)

Post-2008 a design-break-fix-release cycle can thrive!

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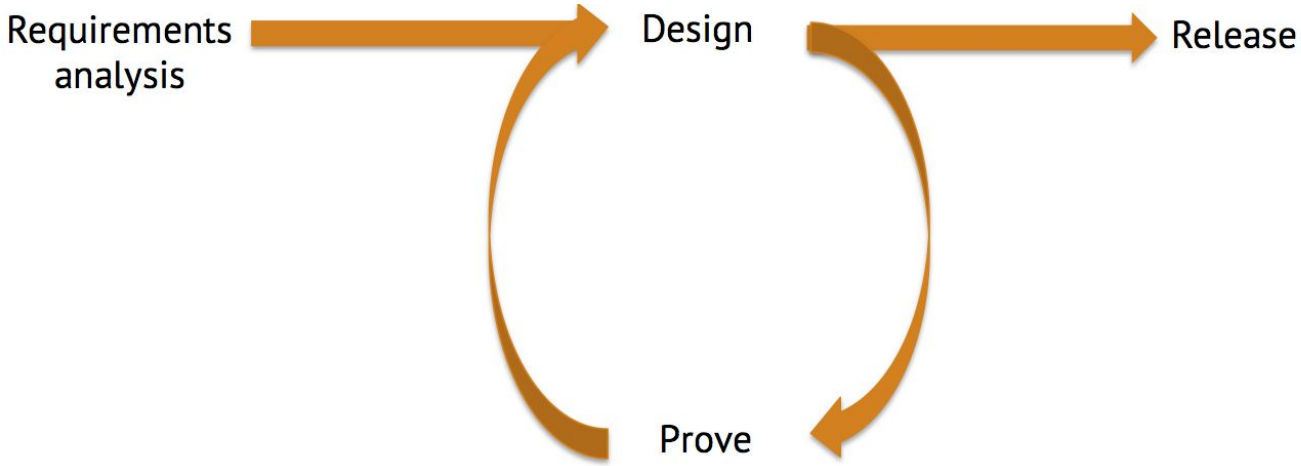
Impact and Incentives

- WG uses secure primitives and responds to research community's needs, easing analysis
- research community appreciates the complexity of the protocol and use cases
- many top-tier publications prior to official release

Implementers and researchers seem to understand each other better.

Can we do *even* better?

- Many cooks in the kitchen brings conflict
- Rapidly moving target! Analyses become easily outdated
- TRON 1.0 - full set of requirements missing



Beyond TLS 1.3

- Is this newer, collaborative process unique to TLS?
- How does this process compare to ISO, NIST?
- What's best for critical protocols such as TLS?

vs

vs

	IETF (TLS 1.3)	ISO	NIST (SHA-3)
Model	Open	Closed	Open competition
Organisation	WGs	WGs	Teams
Membership	Individuals	National Bodies	N/A
Contributions	Many-to-one	Many-to-one	One-to-one
Cost	Free	$ 175	Free
Analysis	Prior-to-deployment	Post-deployment (sometimes pre)	Prior-to-deployment

protocol

primitives

Closing remarks

- Move from design-release-break-patch to design-break-fix-release enabled by better tools and greater engagement of the academic community
- Newer process allows for preemptive decision making and hopefully produces a stronger protocol, requiring less patching
- Perhaps requirements analysis-design-prove-release process would have been better
- Competition model as employed by NIST potentially suits TLS