RUHR-UNIVERSITÄT BOCHUM

RUB

Systematization of Knowledge
Lessons Learned From SSL/TLS Attacks
20.08.2013

Horst Görtz Institute for IT-Security
Chair for Network and Data Security

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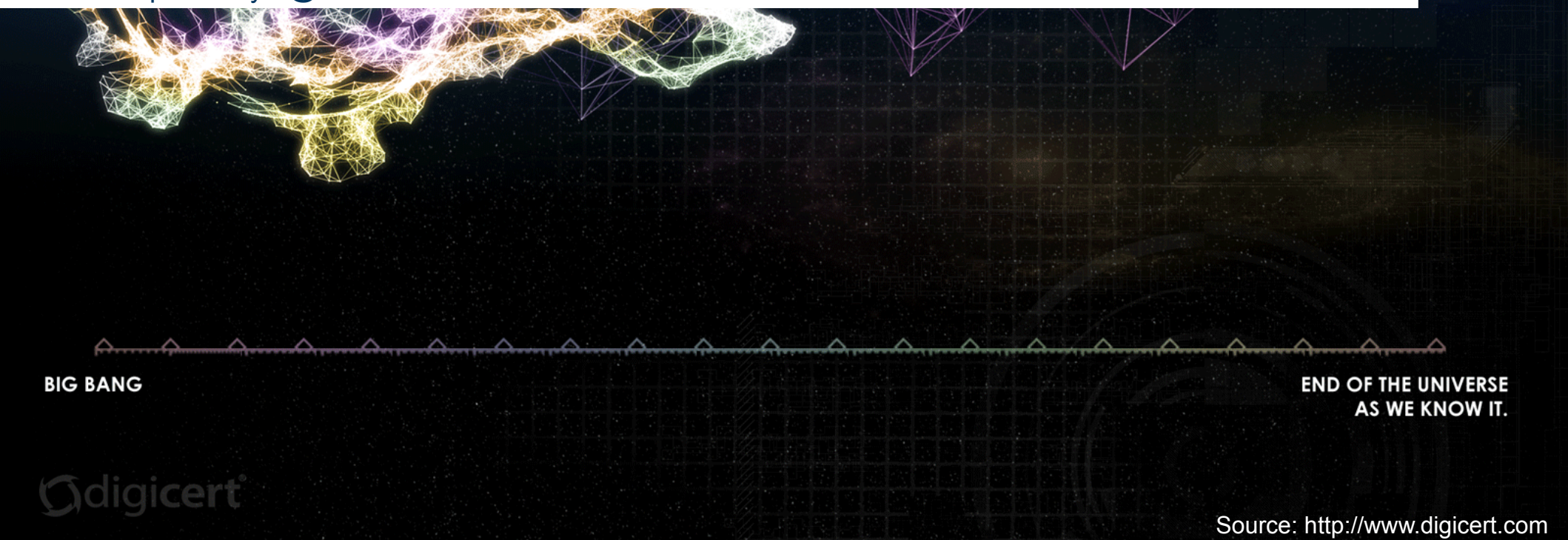
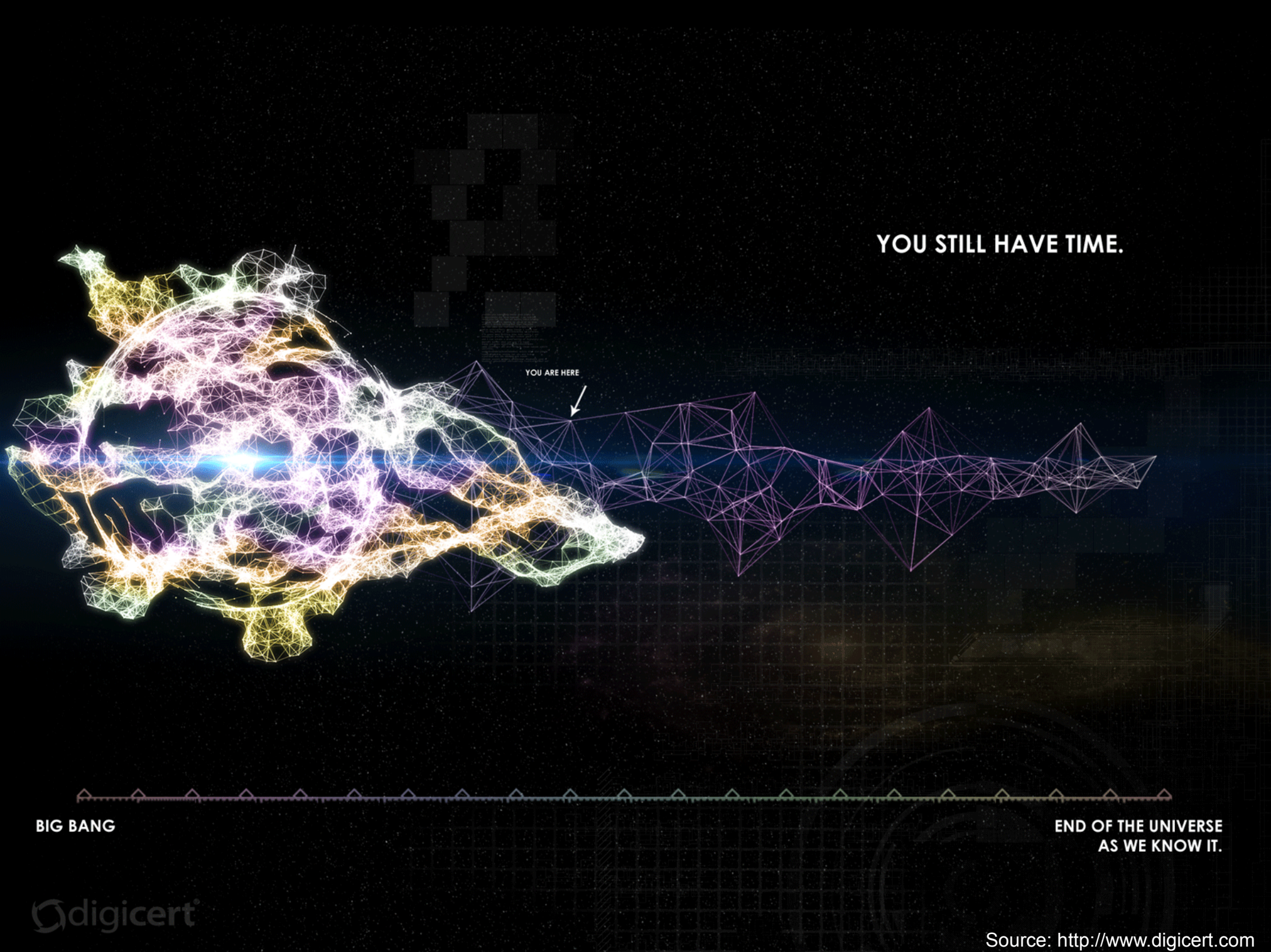


Source: http://www.digicert.com



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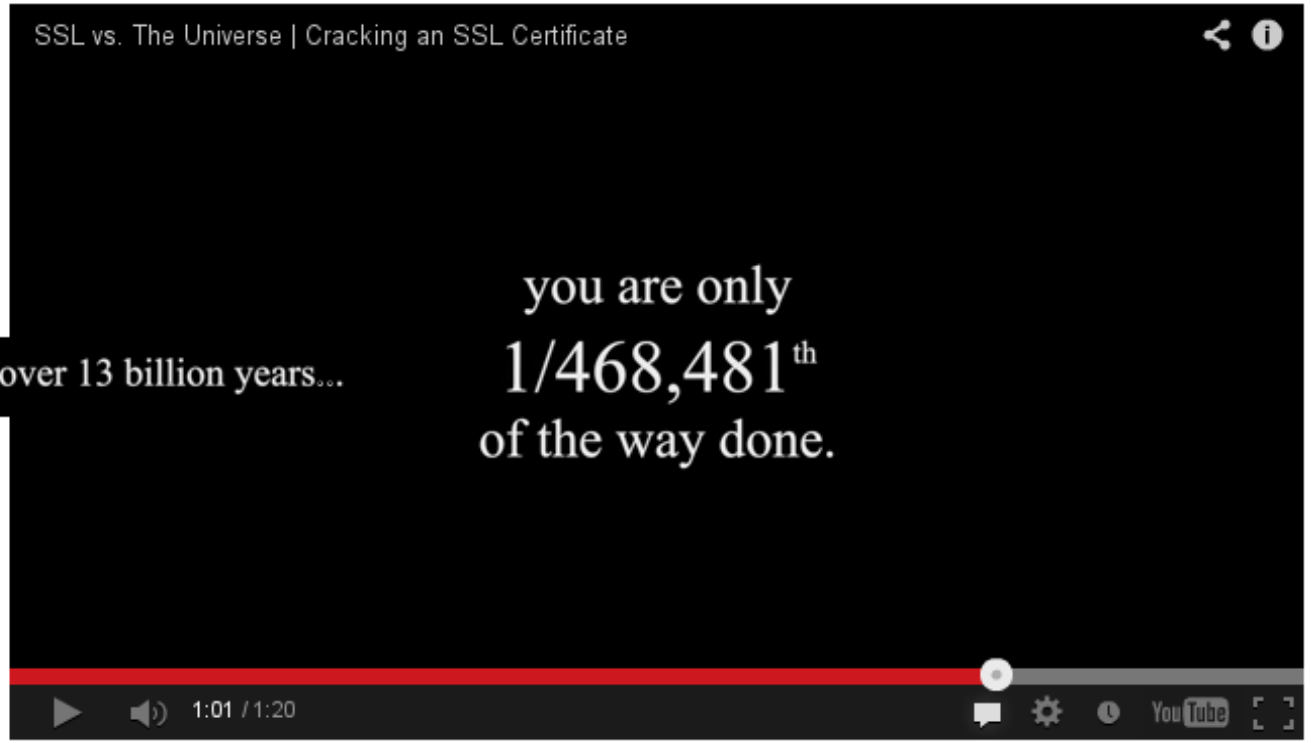
The Strength of an SSL Certificate

What Would it Take to Break a 2048 Bit SSL Certificate?



BIG BANG

END OF THE UNIVERSE
AS WE KNOW IT.

digicert

Source: http://www.digicert.com

What if we don't even need the private key?

Nearly 20 years of SSL/TLS

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Some key data

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- **5 official and 1 unpublished revision**
  - **SSL 2.0, SSL 3.0**
  - **TLS 1.0, TLS 1.1, TLS 1.2**
  - **SSL 1.0**

Nearly 20 years of SSL/TLS

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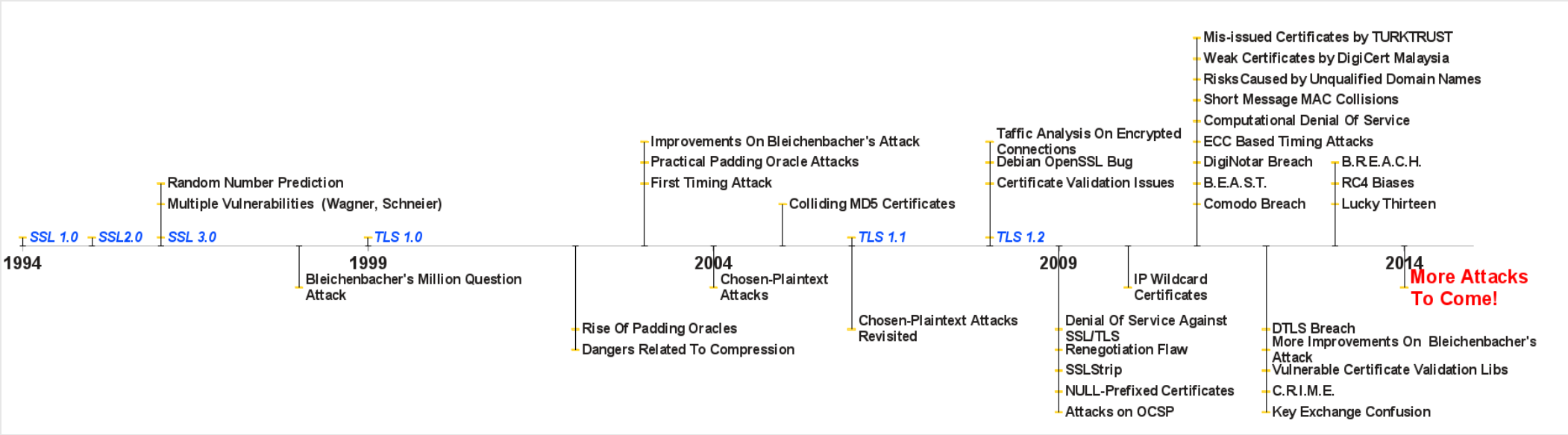
  - **SSL 1.0**
- **~ 39 theoretical and practical attacks so far**

Timeline


SSL 1.0
SSL2.0
SSL 3.0
TLS 1.0
TLS 1.1
TLS 1.2
1994
1999
2004
2009
2014
Random Number Prediction
Multiple Vulnerabilities (Wagner, Schneier)
Bleichenbacher's Million Question Attack
Improvements On Bleichenbacher's Attack
Practical Padding Oracle Attacks
First Timing Attack
Rise Of Padding Oracles
Dangers Related To Compression
Colliding MD5 Certificates
Chosen-Plaintext Attacks
Chosen-Plaintext Attacks Revisited
Taffic Analysis On Encrypted Connections
Debian OpenSSL Bug
Certificate Validation Issues
Denial Of Service Against SSL/TLS
Renegotiation Flaw
SSLStrip
NULL-Prefixed Certificates
Attacks on OCSP
IP Wildcard Certificates
Mis-issued Certificates by TURKTRUST
Weak Certificates by DigiCert Malaysia
Risks Caused by Unqualified Domain Names
Short Message MAC Collisions
Computational Denial Of Service
ECC Based Timing Attacks
DigiNotar Breach
B.E.A.S.T.
Comodo Breach
DTLS Breach
More Improvements On Bleichenbacher's Attack
Vulnerable Certificate Validation Libs
C.R.I.M.E.
Key Exchange Confusion
B.R.E.A.C.H.
RC4 Biases
Lucky Thirteen
More Attacks To Come!

Contribution

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- **Collected attacks on SSL/TLS**

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- **Analyzed all attacks**

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- Analyzed all attacks
- Categorized each attack
- Identified the root cause of the vulnerabilities for each attack
- Concluded Lessons Learned for each attack
- Created a Guideline for Protocol Designers and Implementers

Attack Patterns

Abnormalities during the analysis of attacks

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  3. **Attacks on the PKI**

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  1. **Attacks on the Handshake Protocol**
  2. **Attacks on the Record Layer**
  3. **Attacks on the PKI**
  4. **Various other Attacks**

Attacks on the Handshake Protocol
Details

- **Main goal: Influence Handshake Phase**

Attacks on the Handshake Protocol
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  - **A**
  - **R**
  - **I**
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  - **E**

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  - **Interfere messages or message parts**
  - **Systematically analyze communication**
  - **E**

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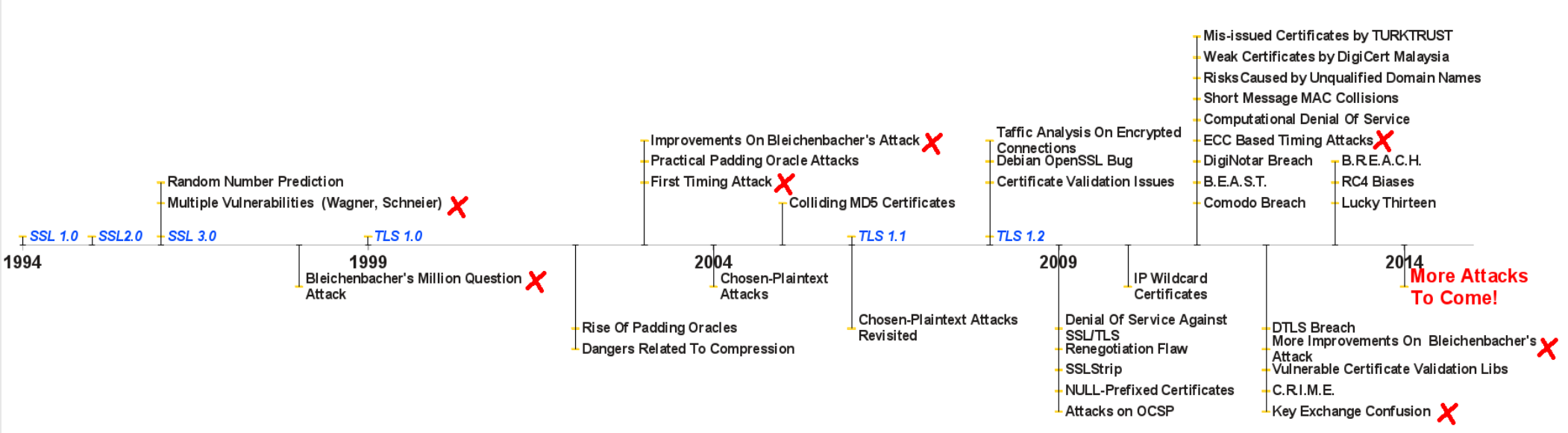
Details

- **Main goal: Influence Handshake Phase**
  - **Alter messages or message parts**
  - **Replay communication or parts of it**
  - **Interfere messages or message parts**
  - **Systematically analyze communication**
  - **Establish own Cryptographic Primitives**

Attacks on the Handshake Protocol
Details



Attacks on the Record Layer
Details

- **Main goal: Violate Confidentiality or Integrity**

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  - **B**
  - **A**
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Attacks on the Record Layer
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- **Main goal: Violate Confidentiality or Integrity**
  - **Break Encryption**
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Attacks on the Record Layer
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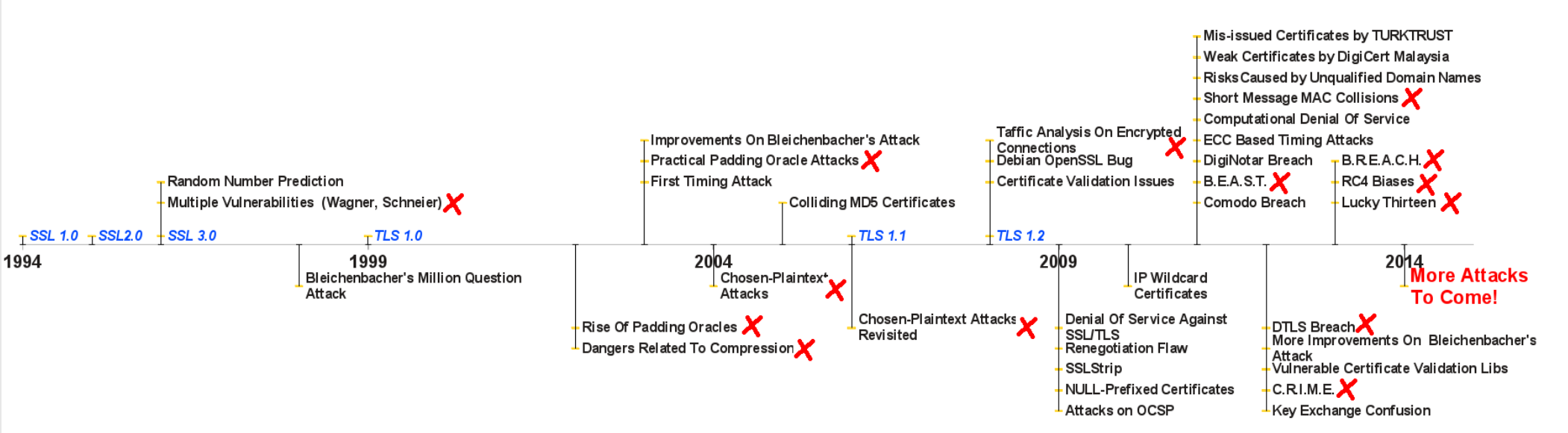
- **Main goal: Violate Confidentiality or Integrity**
  - **Break Encryption**
  - **Analyze Encrypted Traffic**
  - **T**

Attacks on the Record Layer
Details

- **Main goal: Violate Confidentiality or Integrity**
  - **Break Encryption**
  - **Analyze Encrypted Traffic**
  - **Tamper with MAC**

Attacks on the Record Layer
Details



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- **Main goal: Influence, Compromise or Trick PKI**
  - **Recover or Break Private Keys**
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  - **H**

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Details

- **Main goal: Influence, Compromise or Trick PKI**
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- **Main goal: Influence, Compromise or Trick PKI**
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- **Main goal: Influence, Compromise or Trick PKI**
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  - **Compute Colliding Certificates**
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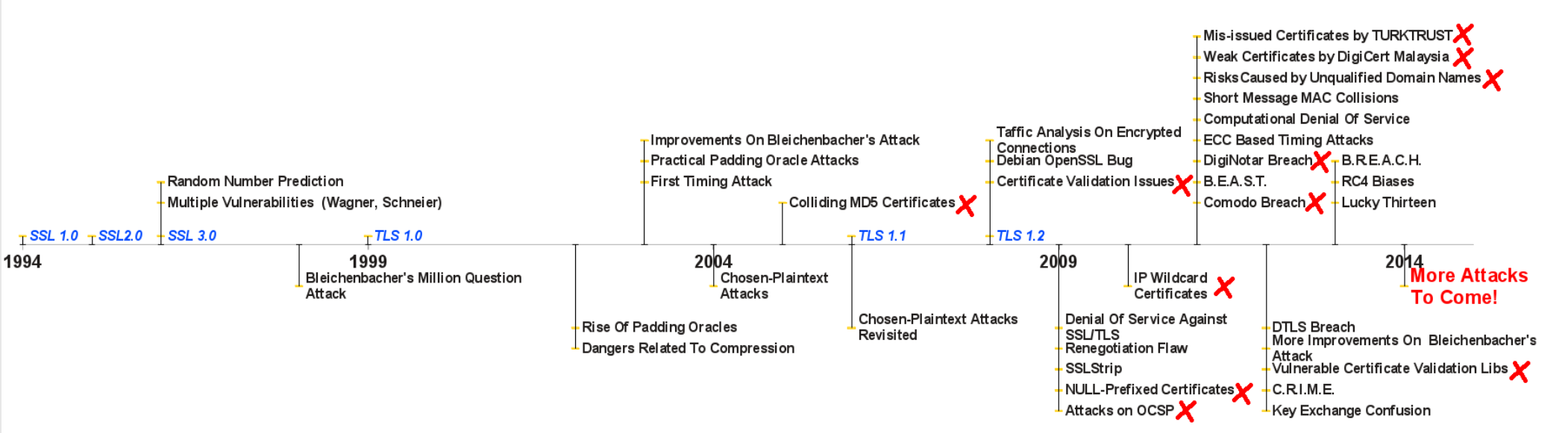
  - **Trick Certificate Validation**
  - **Compute Colliding Certificates**
  - **Hack or Trick Certification Authorities**

Attacks on the PKI
Details



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  - **Smuggle Data into Running Connections**
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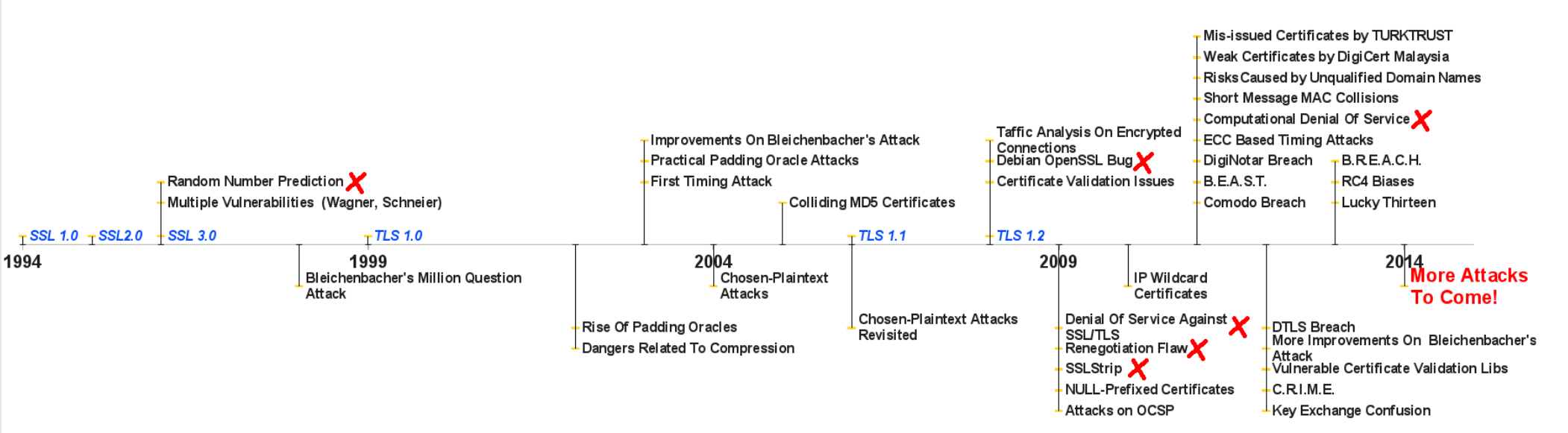
Details

- **Main goal: Predict, Disturb, Inject, Disable**
  - **Guess Random Numbers**
  - **Affect Reliability**
  - **Smuggle Data into Running Connections**
  - **Prevent Traffic Encryption (disable SSL/TLS)**

Various Other Attacks
Details



Finally...

… I tried to put the keywords in a meaningful context

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unfortunately without success

Lessons Learned 1/2

… what can we conclude?

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1. **Theoretical attacks can turn into practice**

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3. **Reliable cryptographic primitives are important**
4. **Processes must leak as little information as possible**
5. **Specifications have to be implemented without own improvements**
6. **Critical parts in specifications and source code have to be highlighted**

Lessons Learned 2/2

… what can we conclude?

7. **Specifications have to verbose, unambiguous and technically detailed**

Lessons Learned 2/2

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8. **Details on requirements and preconditions are necessary**

Lessons Learned 2/2

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9. **Data has to be protected**

Lessons Learned 2/2

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10. **The interplay between different layers must be part of the security analysis**

Lessons Learned 2/2

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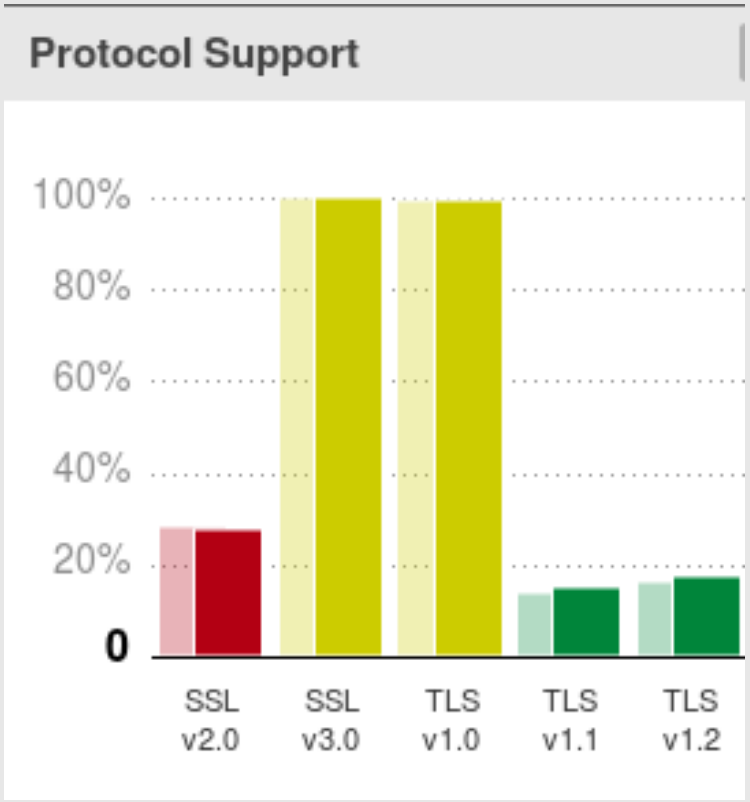
11. **Flexibility mostly means additional risks**
12. **Always be careful and alarmed**



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