Timing attacks

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Minerva attack can recover private keys from smart cards, cryptographic libraries

Older Athena IDProtect smart cards are impacted, along with the WolfSSL, MatrixSSL, Crypto++, Oracle SunEC, and Libgcrypt crypto libraries.

By Catalin Cimpanu for Zero Day | October 3, 2019 -- 12:54 GMT (13:54 BST) | Topic: Security

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TPM-FAIL lets attackers steal private keys from TPMs. Attacks take from minutes to a few hours.

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mehr...

ELLIPTISCHE KURVEN

Minerva-Angriff zielt auf zertifizierte Krypto-Chips

Forscher konnten zeigen, wie sie mit einem Timing-Angriff die privaten Schlüssel von Signaturen mit elliptischen Kurven auslesen konnten. Verwundbar sind Chips, deren Sicherheit eigentlich zertifiziert wurde.

4. Oktober 2019, 13:41 Uhr, Hanno Böck

s Hollar, Wikimedia Commons)

Golem article

Timing attacks are not a new phenomenon

Password recovery if server compares letter by letter:

Try `AAA`,

Timing attacks are not a new phenomenon

Password recovery if server compares letter by letter:

Try `AAA`, `BBB`,

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Password recovery if server compares letter by letter:

Try `AAA`, `BBB`, `CCC`, ..., `III` takes slightly longer to fail.
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Try `IAA`, `IBB`, `ICC`, ..., `IKK` takes slightly longer to fail.
Try `IKA`, `IKB`, `IKC`, ..., `IKV` takes slightly longer to fail.

⋮

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Password recovery if server compares letter by letter:

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Try `IAA`, `IBB`, `ICC`, ..., `IKK` takes slightly longer to fail.
Try `IKA`, `IKB`, `IKC`, ..., `IKV` takes slightly longer to fail.

⋮

Password is `IKVROCKS`.

1974: Exploit developed by Alan Bell for TENEX operating system.

Exponentiation with secret exponent (RSA, DH)

Compute c^d given c and d.

```
n = 1000001
d = 12473
c = 41241
l = d.nbits()
D = d.bits()
m = c
for i in range(l-2,-1,-1):
  m = m^2 % n
  if D[i] == 1:
    m = m * c % n
print(m)
```

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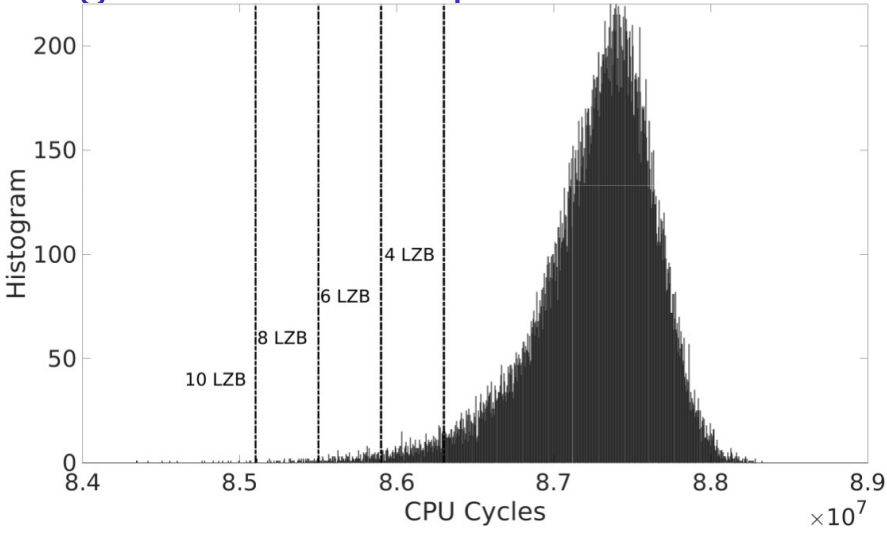
Timings of scalar multiplication on NIST P-256



(Picture from TPM-Fail)

Other exponentiation methods

- The timing variation depends strongly on the length of the scalar/exponent.
- Very sparse or very dense scalars will be miscategorized.
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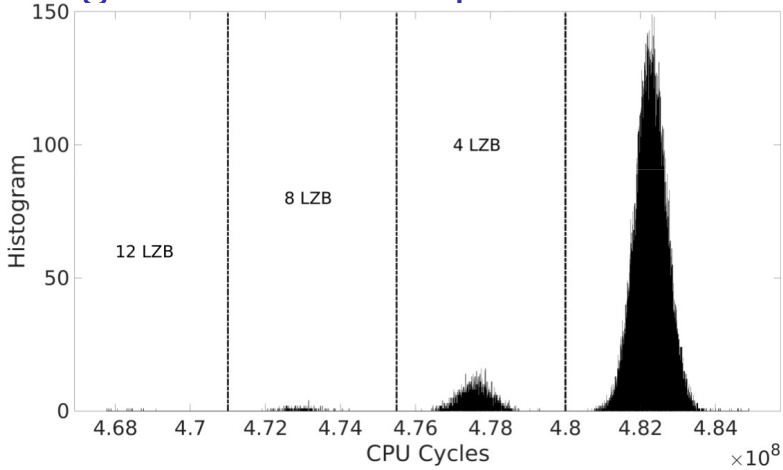
  Precompute c, c^2, and c^3.

$$c^{14019} = \left(\left(\left(\left(\left(\left(c^3\right)^4 \cdot c\right)^4 \cdot c^2\right)^4 \cdot c^3\right)^4\right)^4\right)^4 \cdot c^3.$$

  Same number of squarings, 4 instead of 7 multiplications.

Timings of scalar multiplication on NIST P-256



Larger windows reduce the variability through branching but accentuate the length.

(Picture from TPM-Fail)

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  - TPM–Fail: TPM meets Timing and Lattice Attacks
    Daniel Moghimi, Berk Sunar, Thomas Eisenbarth, Nadia Heninger
    https://tpm.fail/
  - Minerva attack
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  With just a small bias in the nonces (one-time scalars) the secret signing key leaks.
- Lots of libraries, smart cards, and TPMs affected.
- Even worse: hyperthreading attacks, cache-timing attacks, etc. give more fine-grained timing information $\Rightarrow$ more exploits.

Constant-time exponentiation

```
n = 1000001
d = 12473
c = 41241
l = n.nbits()
D = d.digits(2,padto = l)
m = 1 # so initial squarings don't matter
for i in range(l-1,-1,-1): # fixed-length loop
  m = m^2 % n
  h = m * c % n
  m = (1 - D[i]) * m + D[i] * h # selection by arithmetic
print(m)
```

This costs 1 multiplication per bit, so as slow as worst case.

Interplay with elliptic-curve formulas

- We can translate this to scalar multiplication on elliptic curves: Initialize with the neutral element, for every bit compute a doubling and an addition.
- Formulas for addition on Weierstrass curves have exceptions for adding ∞, so initialization at ∞ does not work.
- Edwards curves have a complete addition law, **easy** to double or add the neutral element $(0, 1)$.
- The Montgomery ladder has a similar data flow, but the costs per bit of the scalar are **less** than one addition plus one doubling for Montgomery curves.

For more see https://ecchacks.cr.yp.to.