PB173 Domain specific development: side-channel analysis

Seminar 3: continuation of the previous seminar “SPA Exercise and Acquisition/ChipWhisperer”

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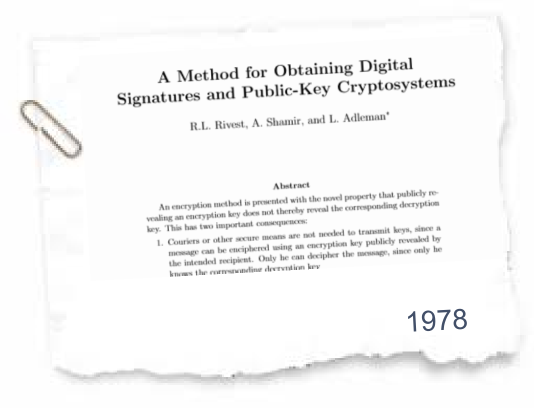
Solving Exercise: SPA on RSA

RSA

- Two primes p and q

- $N = pq$
- $\varphi(N) = (p-1)(q-1)$
- $e = 3, 5, 7, 17, 257, 65537 \rightarrow \gcd\big(e, \varphi(N)\big) = 1$
- $d = e^{-1} \bmod \varphi(N)$



A Method for Obtaining Digital Signatures and Public-Key Cryptosystems

R.L. Rivest, A. Shamir, and L. Adleman*

Abstract

An encryption method is presented with the novel property that publicly revealing an encryption key does not thereby reveal the corresponding decryption key. This has two important consequences:

1. Couriers or other secure means are not needed to transmit keys, since a message can be enciphered using an encryption key publicly revealed by the intended recipient. Only he can decipher the message, since only he knows the corresponding decryption key

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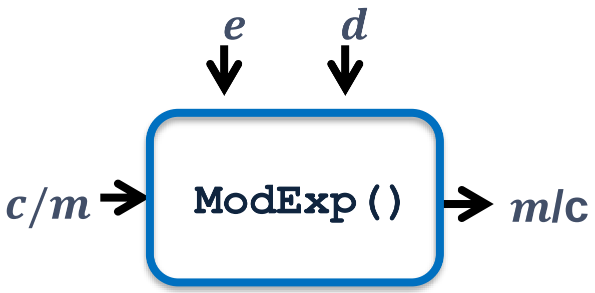
Modular Exponentiation:

- Encryption / Verification: $c = m^e \bmod N$
- Decryption / Signature: $m = c^d \bmod N$



RSA Exponentiation (1)

```
ModExp(c) {
        $A = 1$
        for ( $i = n-1$; $i \geq 0$; $i--$)
              $A = A^2 \bmod N$
              if ($d_i == 1$)
                    $A = A*c \bmod N$
              end if
        end for
        return $A = c^d \bmod N$
}
```

$d=(101)=5$

$A = 1$,

$d_2=1$

$A = A^2 \bmod N=1$

$A = A*c \bmod N=c$

$d_1=0$

$A = A^2 \bmod N=c^2$

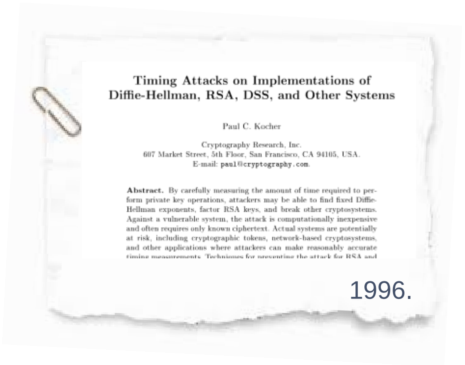
$d_0=1$

$A = A^2 \bmod N=c^4$

$A = A*c \bmod N=c^5$

Simple Power Analysis on RSA

```
ModExp(c) {
    A = 1
    for ( i = n-1; i≥0; i− −)
        A = A^2 mod N                S
        if (d_i = =1)
            A = A*c mod N            M
        end if
    end for
    return A = c^d mod N
}
```



Timing Attacks on Implementations of
Diffie-Hellman, RSA, DSS, and Other Systems

Paul C. Kocher

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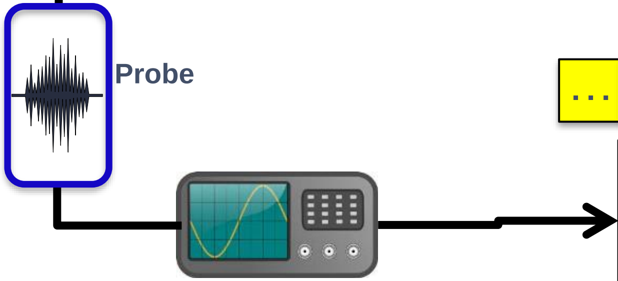
Abstract. By carefully measuring the amount of time required to perform private key operations, attackers may be able to find fixed Diffie-Hellman exponents, factor RSA keys, and break other cryptosystems. Against a vulnerable system, the attack is computationally inexpensive and often requires only known ciphertext. Actual systems are potentially at risk, including cryptographic tokens, network-based cryptosystems, and other applications where attackers can make reasonably accurate timing measurements. Techniques for preventing the attack for RSA and

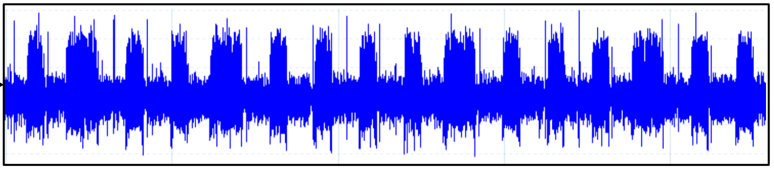
1996.

"By carefully measuring the *amount of time* required to perform private key operations, attackers may be able to find […] RSA keys."

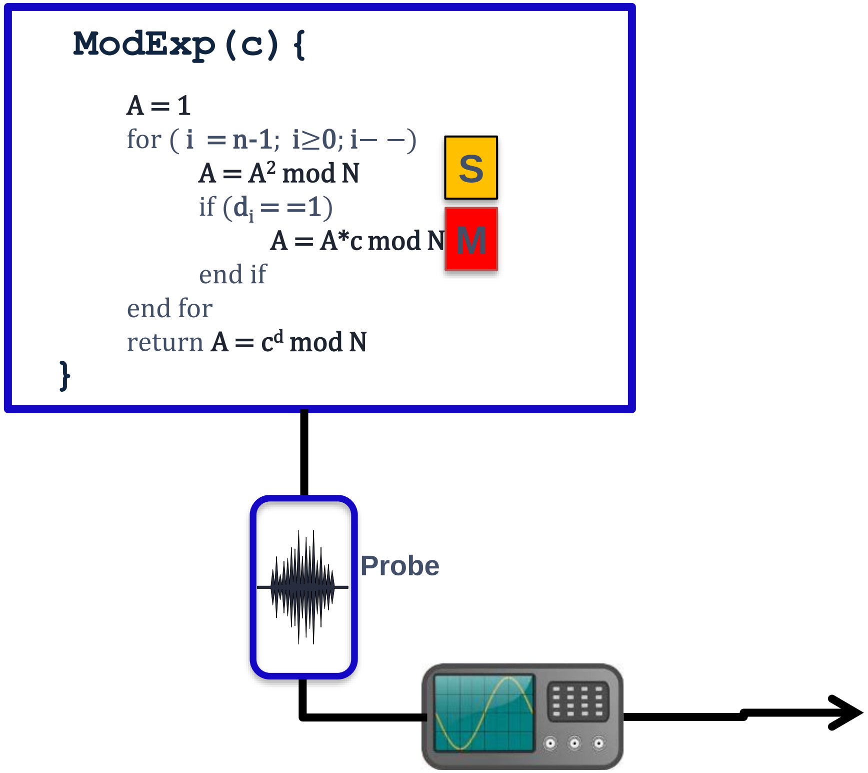


1	0		1	0	0	0		1	0	0		1	0

… S M S S M S S S S M S S S M S S …



Simple Power Analysis on RSA



```
ModExp(c) {
    $A = 1$
    for ( $i = n-1;\ i \geq 0;\ i- -$ )
        $A = A^2 \bmod N$
        if ($d_i = = 1$)
            $A = A*c \bmod N$
        end if
    end for
    return $A = c^d \bmod N$
}
```

This SPA matching does not always need to look this way!
One pattern might correspond multiple operations etc.

RSA Exponentiation (2)

```
ModExp(c) {
        $A = c$
        $j=-1$
        for ( $i = n-1$; $i \geq 0$; $i--$)
              if ($d_i$ ==1):
                    $j = i$
                    break
              end if
        if $j==-1$:
              return 1
        end if
        …
        …
        for ( $i = j-1$; $i \geq 0$; $i--$)
              $A = A^2 \bmod N$
              if ($d_i$ = =1):
                    $A = A*c \bmod N$
              end if
        end for
        return $A = c^d \bmod N$
}
```

$d=(0101)=5$

$j\text{-}1 = 1$

$A = c$

$d_1=0$

$A = A^2 \bmod N=c^2$

$d_0=1$

$A = A^2 \bmod N=c^4$

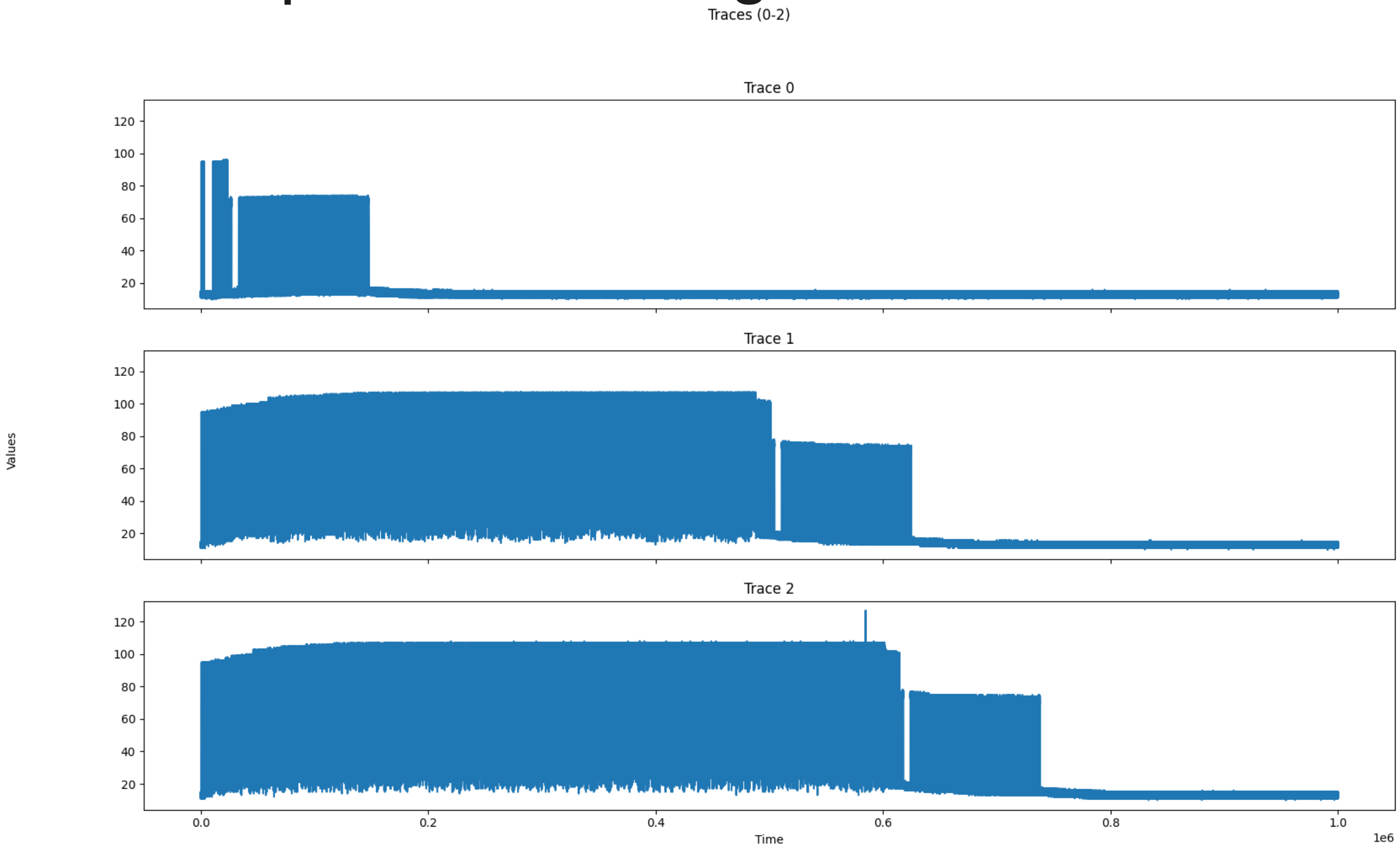
$A = A*c \bmod N=c^5$

Excercise

- RSA_unprotected.trs
- visualize.py
  - python3
  - Install matplotlib (e.g., pip)
  - Install trsfile (available on pip)
  - Feel free to modify the code and ask me questions about that.
- Three different traces
  - Tell me first 20 most significant bits of each exponent.
- Take your time, good luck!
  - I will give some hints during the exercise ☺

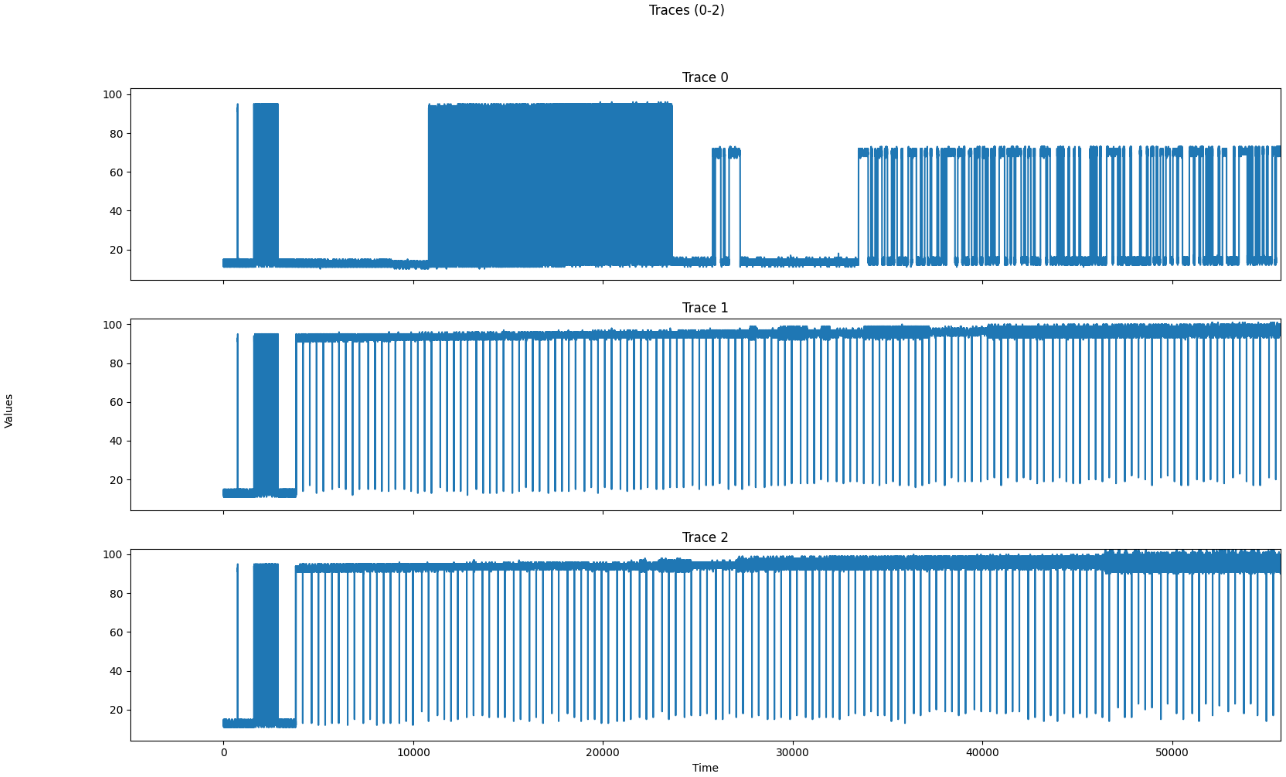
Exercise

- SPA with operation leakage



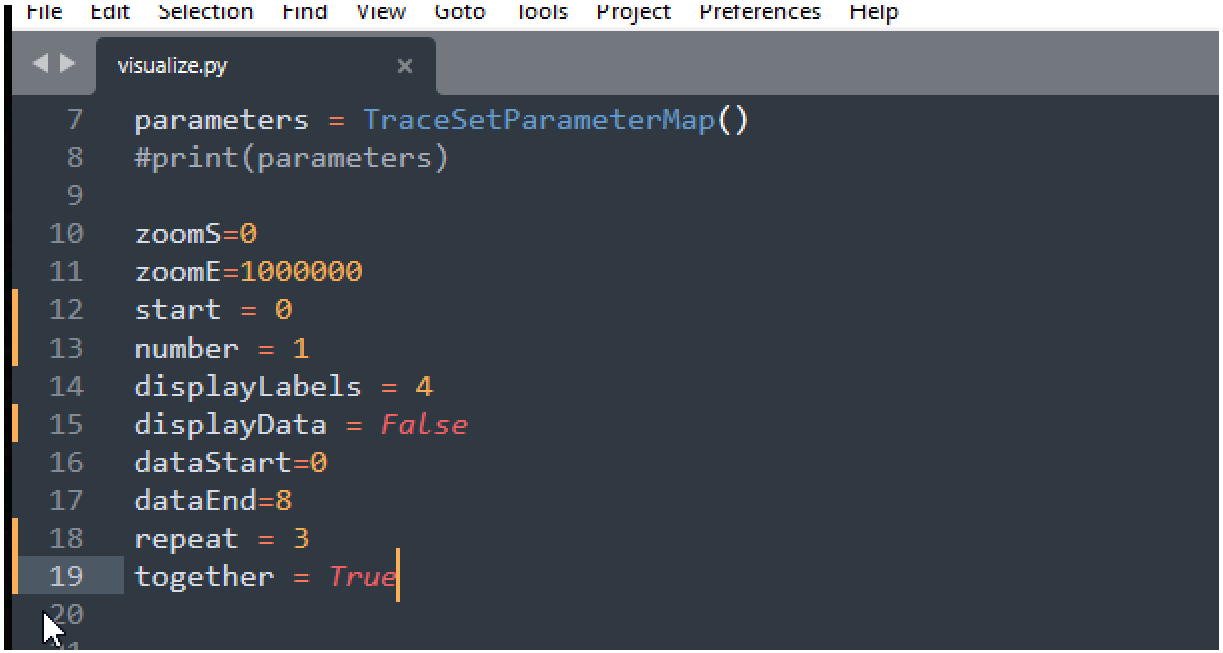
Exercise

- Try to zoom in and find the RSA exponentiation and then get the exponent!



Exercise

- How the visualization script works?



```
parameters = TraceSetParameterMap()
#print(parameters)

zoomS=0
zoomE=1000000
start = 0
number = 1
displayLabels = 4
displayData = False
dataStart=0
dataEnd=8
repeat = 3
together = True
```

Solution?

- Anyone?
- First trace?
- Second trace?
- Third trace?

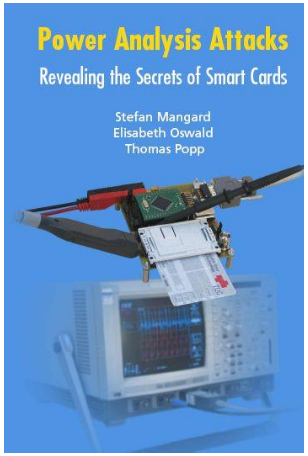
Finishing Acquisition / Chip Whisperer presentation

Homework

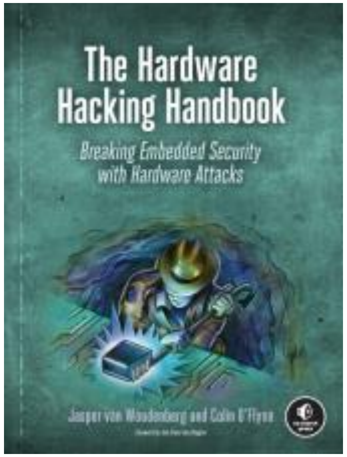
- TODOs before the next seminar:
  - Try to capture side-channel traces
  - Compute input / output correlation
  - Try differential power analysis
- On the next seminar – division of topics
- And in parallel we will also work on Chip Whisperer.

Reading

- For interested people
- Side-Channel Analysis – blue book:
  - http://dpabook.iaik.tugraz.at/
  - The books is available at the uni.
  - Look online



- The Hardware Hacking Handbook:
  - https://nostarch.com/hardwarehacking
  - I have an epub version.


The Hardware Hacking Handbook
Breaking Embedded Security with Hardware Attacks
Jasper van Woudenberg and Colin O'Flynn

Questions