# Side-channel Attacks & Data remanence

Magnus Almgren, Erland Jonsson

Subset from the syssec course repository by: Christian Platzer and Markus Kammerstetter (inetsec@seclab.tuwien.ac.at)

# Data remanence

- Often, the delete command does not really delete a file …
  - See discussion in course book[1]
  - Layers: OS – firmware in drive etc.
- Data remanence is
  - ”Residual information remaining on storage media after clearing. “

[1]Computer Security, Principles and Practice, 2nd edition, Stallings, Brown: p404—p407

# Side-channel attacks 1

- A **side channel attack** is any attack based on information gained from the ***physical implementation*** of an embedded system, for example a cryptosystem
- It normally requires **physical access** to the hardware
- A side-channel attack is an attack based on side-channel information, i.e. “extra” information that can be retrieved from the device.

# Side-channel attacks 2

- Types of side-channel attacks:
  - **Timing attack** – attacks based on measuring how much time various computations take to perform.
  - **Power monitoring attack** - attacks based on observing the varying power consumption by the hardware during computation
  - **Electromagnetic attacks** – based on observing electromagnetic emanation, cp. TEMPEST (Sw. RÖjande Strålning = RÖS)
  - **Acoustic cryptanalysis** - attacks which exploit the sound produced during a computation
  - **Differential fault analysis** - in which secrets are discovered by introducing faults in a computation.

# Timing Analysis



- We interact with the system and closely monitor the timing during operation

- For example, we might monitor the timing of a password check
  - Start timer when guessed password is sent to device
  - Stop timer when response (i.e. 'wrong password') is received
  - Compare time measurements for different guesses
  - See if we can draw a conclusion and determine the correct password

# A bad password check (1)



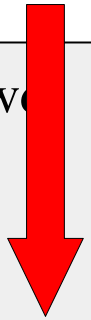
```
bool check_password(char *passwd)
{
for (int i=0; i<pass_len; i++)
{
        if (passwd[i] != stored_passwd[i])
                return false;
}

return true;
}
```

# A bad password check (2)



Terminates as soon a byte is wrong



```
bool check_password(char *passw
{
for (int i=0; i<pass_len; i++)
{
        if (passwd[i] != stored_passwd[i])
                return false;
}

return true;
}
```

Based on timing information, we can easily guess the password

# A better password check (1)



```
bool check_password(char *passwd)
{
int err=0;
for (int i=0; i<pass_len; i++)
{
        err |= passwd[i] ^ stored_passwd[i];
}

if (err != 0)
        return false;
return true;
}
```

# A better password check (2)



```
bool check_password(char *passwd)
{
int err=0;
for (int i=0; i<pass_len; i++)
{
        err |= passwd[i] ^ stored_passwd[i];
}

if (err != 0)
        return false;
return true;
}
```

Constant time

# Simple Power Analysis (1)

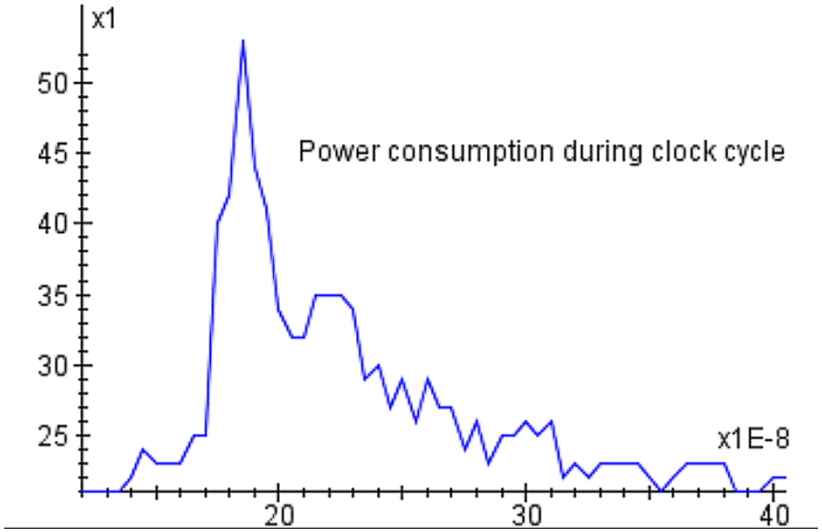


- The power consumption of a processor depends on the instruction executed
- We closely monitor the power consumption during clock cycles (i.e. time domain)
- For a given instruction, the power consumption also depends on the data processed

# Simple Power Analysis (2)



- Example:



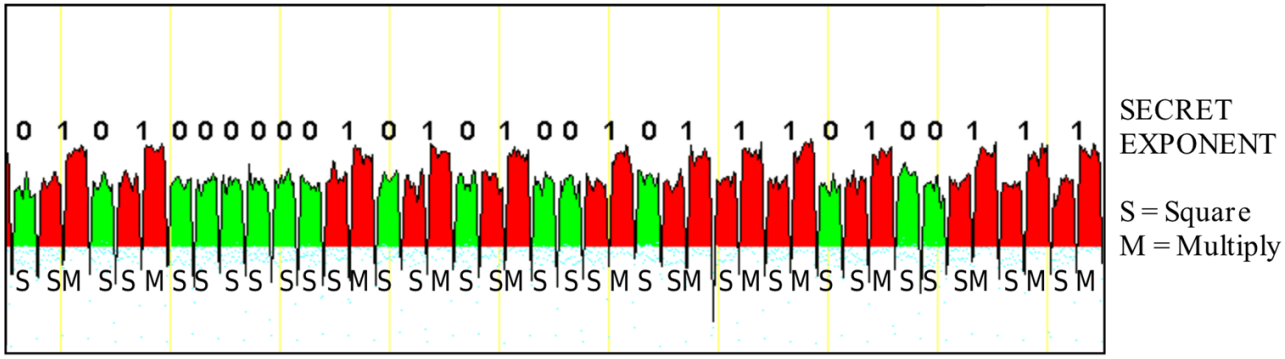

Source: riscure.com

- By analyzing the power consumption, it might be possible to determine the *instruction* and *data*

# Vulnerable RSA exponentiation



- Example:




Source: 'Protecting FPGAs from Power Analysis', Cryptography Research Inc.

- Using SPA, we can complete recover the RSA secret key in this case !

- Drawback: We need a good S/N ratio for SPA to work, can be increased through averaging over multiple measurements