

Wanna TEMPEST your computer?

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TLS-SEC

March 12, 2018



TLS-SEC

Toulouse
Hacking
Convention

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"Projet long" context

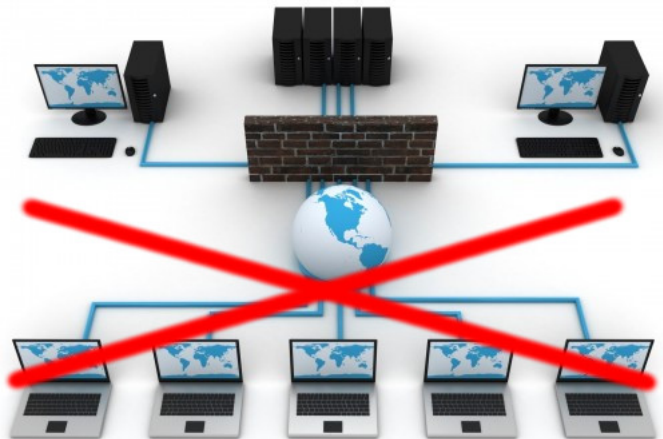
THC 2018 Challenge

- Prepare tutorial challenge
- Work based on *GSMem: Data Exfiltration from Air-Gapped Computers over GSM Frequencies* (24th USENIX Security Symposium)
- "Challenge" : data exfiltration from an air-gapped computer
- "Tutorial" : guide the challenger step-by-step
- Main idea : follow how we succeed to reproduce a part of the paper

Air-gapped networks



Air-gapped networks



Electromagnetic emanations

Emanations

- Each electronic device has emanations
- Could be optical, electronical, acoustical, mecanical or electromagnetical
- Focus on electromagnetic emanations

TEMPEST

- Name given by NSA for standards protecting against electromagnetic emanations
- Context : EMSEC, surbpart of COMSEC

Challenge context

Goal

Get a password stored on the air-gapped computer

Problem

Air-gapped computer \Rightarrow no possibility to gain access and/or exfiltrate data via network

Solution

Use electromagnetic emanations to create a covert channel and exfiltrate data

Technical environment

Devices

- 1 air-gapped computer (attacked computer)
- 1 standard computer (attacker's computer)

Tools

- Spectrum analyzer
- Software-defined radio : USRP/RTL-SDR
- Antennas
- Softwares : URH/GNURadio

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Transmission without specific component

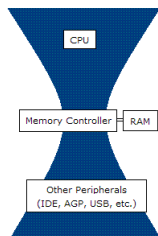
Our target (remind)

Use electromagnetic emanations to create a covert channel and exfiltrate data

Problems

- Computer's electromagnetic emanations \rightarrow low amplitude
- Amplitude increase \Rightarrow circuit tension increase

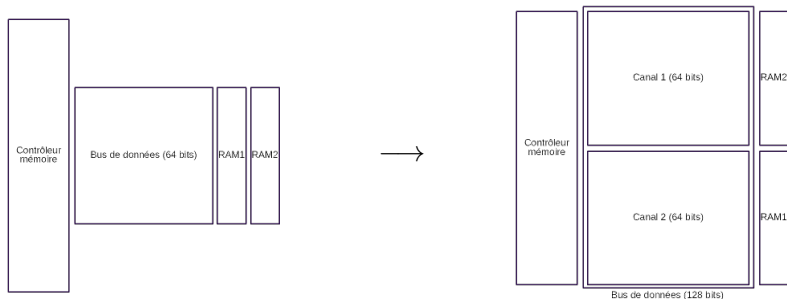
Problem bypass : Multi-channel memory architectures



Memory access

- Memory controller → bottleneck
- Intel/AMD → Multi-channel memory architectures
- Increase data bus size :
 - Double channel \Rightarrow 128 bits
 - Triple channel \Rightarrow 192 bits
 - Quadruple channel \Rightarrow 256 bits

Problem bypass : Multi-channel memory architectures

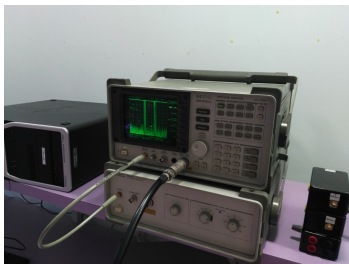


Consequence using Multi-channel memory

- More electrons in movement at the same time
- Significant electromagnetic emanations created
- \Rightarrow Emanations could be used to create covert channel

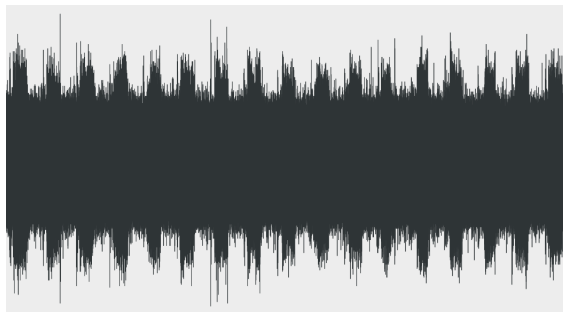
Problem bypass : Multi-channel memory architectures

Application



- Be sure to bypass CPU optimizations
- Use of MOVNTDQ instruction on `xmm` registers
- Emanations highlight :
 - Find emission frequency : spectrum analyzer
 - Watch signal : USRP/RTL-SDR + URH

Problem bypass : Multi-channel memory architectures



Modulation

- Modulation = information coding process
- Binary Amplitude-Shift Keying (B-ASK) modulation :
 - bit 0 \leftrightarrow normal emission level
 - bit 1 \leftrightarrow average emission level when multi-channel memory is used

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Test

test

- test

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The Malware

Idea

- Same skeleton than the Transmission section
- 1bit/s to reduce error rate

What is transmitted ?

- The message : a file in argument
- End of File
- A pattern to localize the message : 11111111
- All of this in an infinite loop

The Reception

In GNU Radio

- Start the malware before the acquisition to avoid a bug in the first bit transmitted
- Wait around 2 minutes

Conversion of the GRC file into our flag

- Localize a first pattern
- Extract bytes from this pattern until the next one
- Convert extracted bytes into ASCII and print it

The Reception

```
void extract_msg(FILE * fic, char * msg, char * pattern)
{
    char chaine[TAILLE_MAX],
        tmp1[TAILLE_MAX],
        *tmp2,
        tmp3[TAILLE_MAX]="",
        *tmp4,
        bin[TAILLE_MAX]="";

    while (fgets(chaine, TAILLE_MAX, fic) != NULL)
    {
        memset (tmp1, 0, sizeof (tmp1));
        strncpy(tmp1, chaine+10, 55);
        rem_space(tmp1);
        strcat(bin, tmp1);
    }
    tmp2 = strstr(bin, pattern);
    strcpy(tmp3, tmp2+strlen(pattern));
    tmp4 = strstr(tmp3, pattern);
    strncpy(msg, tmp3, tmp4-tmp3);
}
```

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Researchers work

- Better equipment
- Signal processing optimization
- Reception until 30m

Limits

- Very limited flow rate to prevent error
- Can be improve with a frequency modulation (attack USBee)

Countermeasures

- Faraday cage
- Zonal approach
- Antivirus