2550 Intro to cybersecurity

L19 (part 2): Cold Boot attack

abhi shelat/Ran Cohen

Lest We Remember:
Cold Boot Attacks on Encryption Keys

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Usenix 2008

Protecting data in stolen computers

- Basic protection: password-based login (OS level)
- Attacker can:
  - – remove the hard drive
  - – plug it into its computer
  - – reboot

LOG-IN
Username:
Password:

Stolen computer

Attacker’s computer

Protecting data in stolen computers

- Basic protection: password-based login (OS level)
- Industry best practice: disk encryption

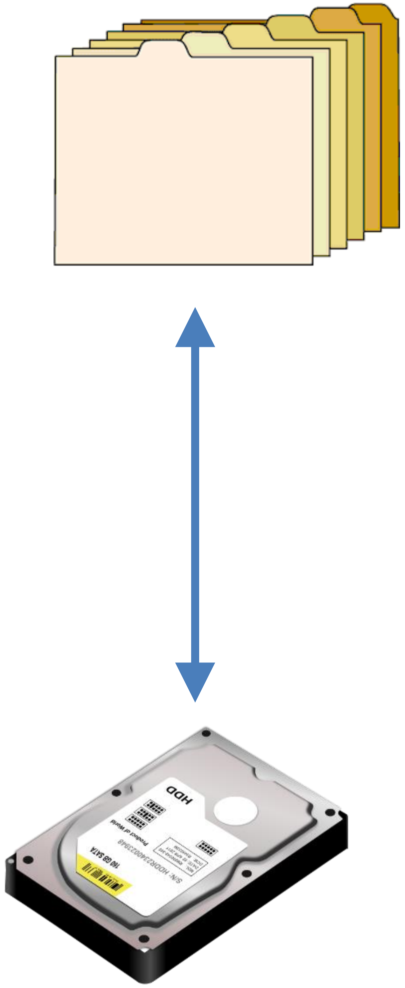
Stolen computer

Attacker’s computer

Disk Encryption Solutions

FileVault (Apple OS/X)

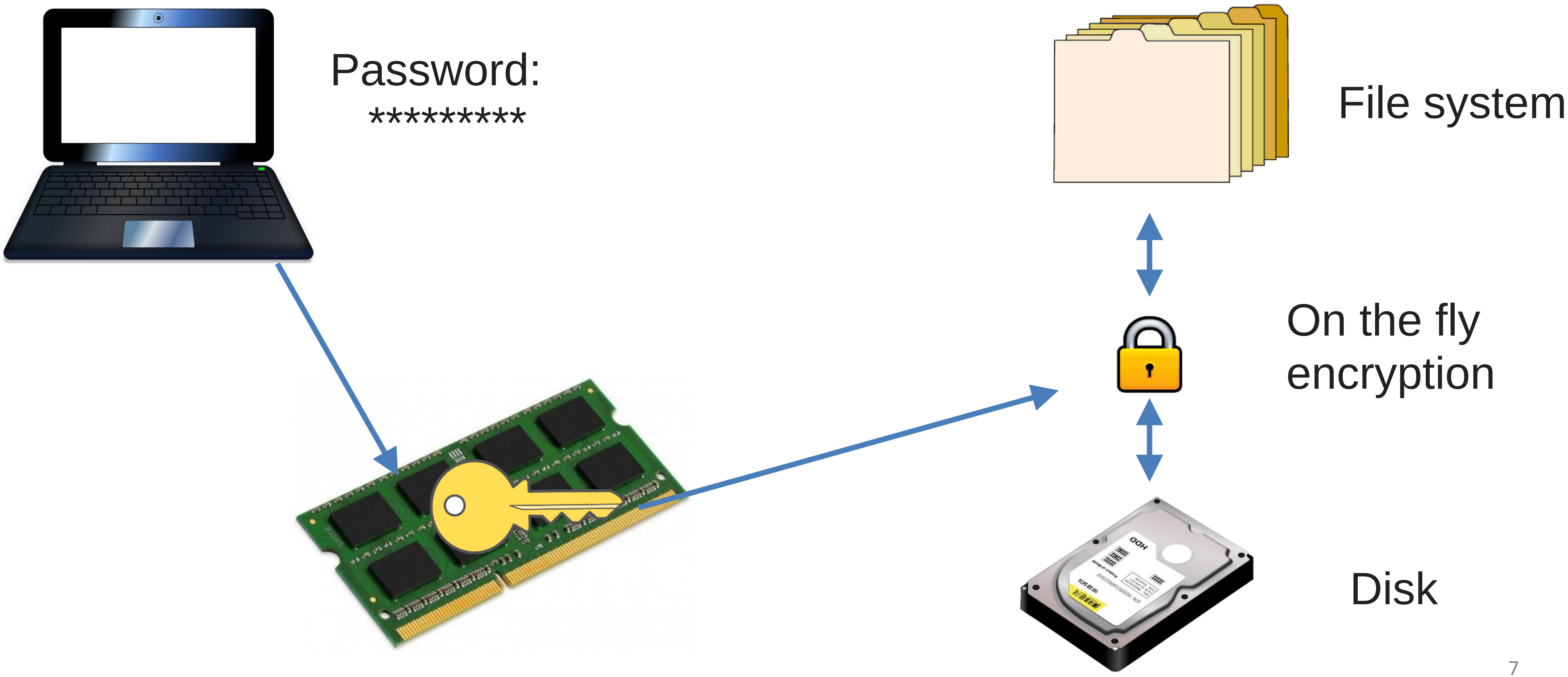
Full Disk Encryption



File system

Disk

Full Disk Encryption



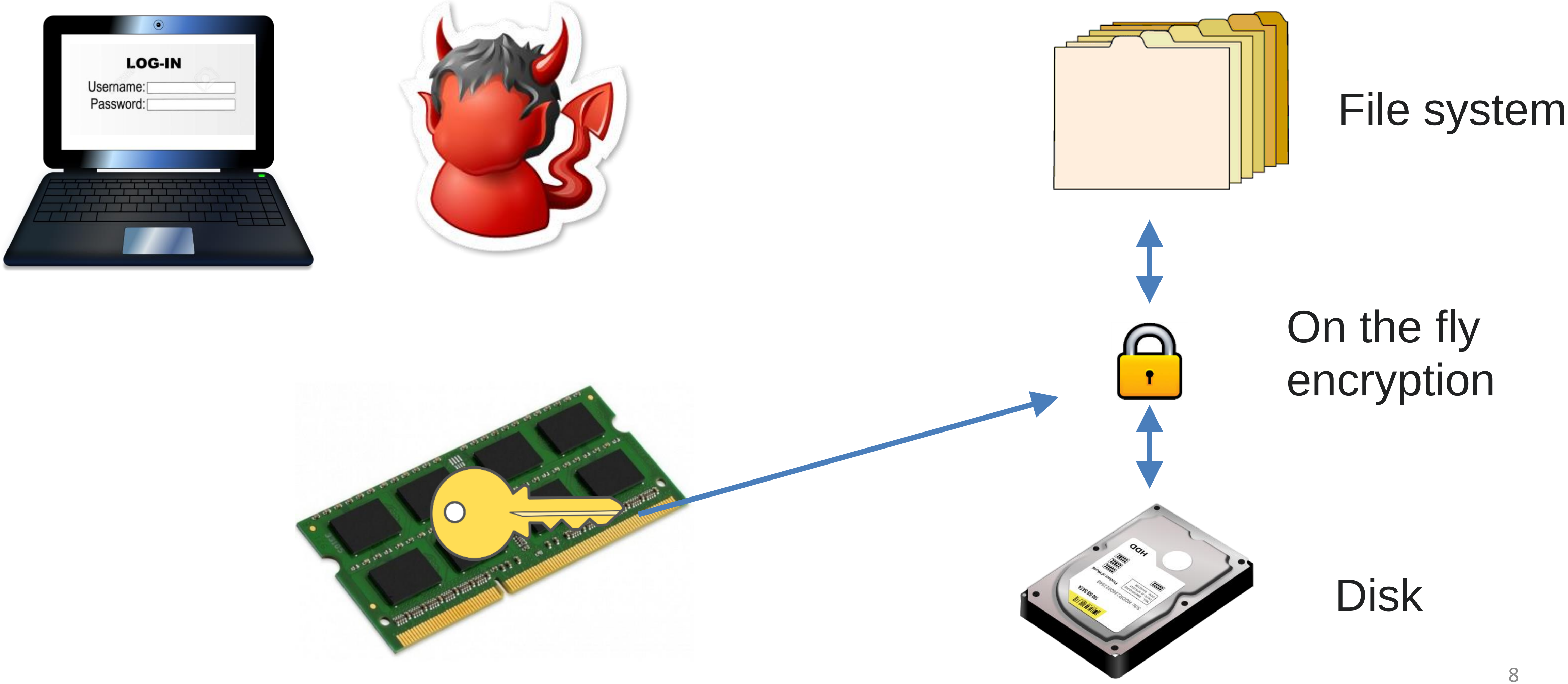
Password:
****

File system

On the fly
encryption

Disk

Full Disk Encryption



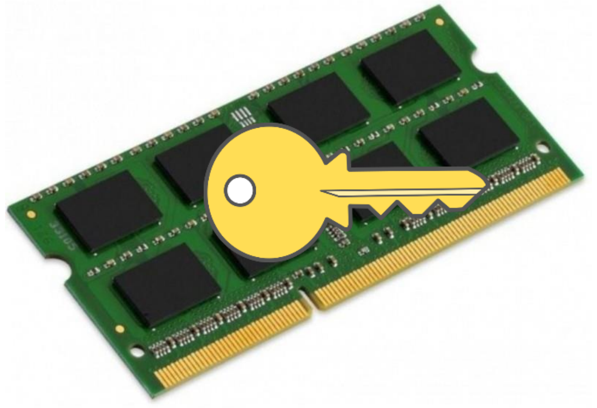
File system

On the fly encryption

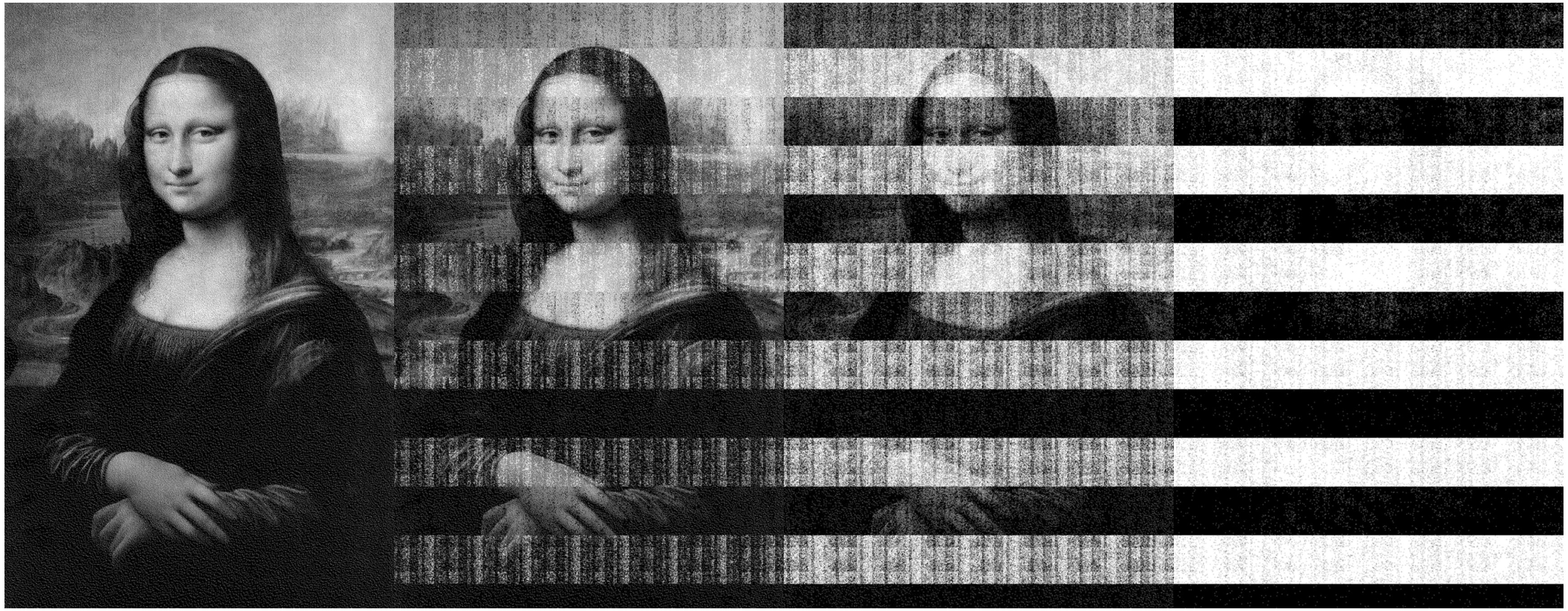
Disk

Common attack scenario

- Assumptions 1: secure encryption
- Assumptions 2: OS protects the key in RAM
- Attacker may try to reboot and intercept before OS loads
- Assumptions 3: RAM is volatile, key will be lost



Decay After Cutting Power



5 secs 30 secs 60 secs 5 mins

Capturing Residual Data

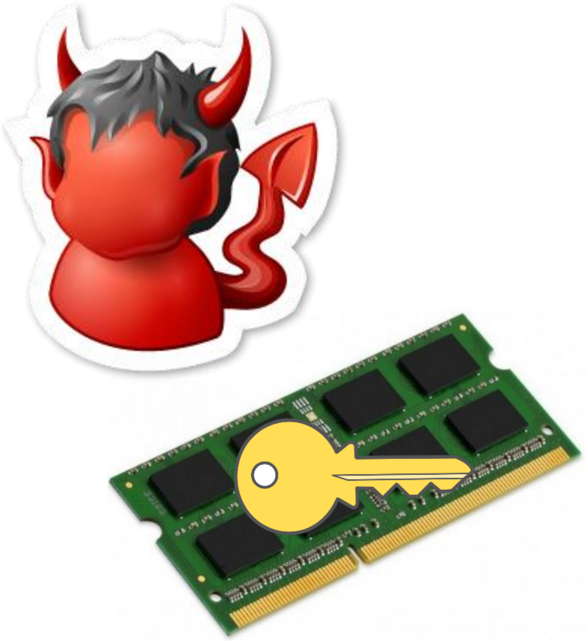
- After disconnecting power large part of RAM remain for a short time
- **Complication:** booting full OS overwrites large areas of RAM
- **Solution:** boot a small low-level program to dump out memory contents
  - PXE (Preboot eXecution Environment) dump (9 KB)
  - EFI (Extensible Firmware Interface) dump (10 KB)
  - USB dump (22 KB)

Basic Cold Boot Attack

Computer locked, disk encrypted, key in RAM

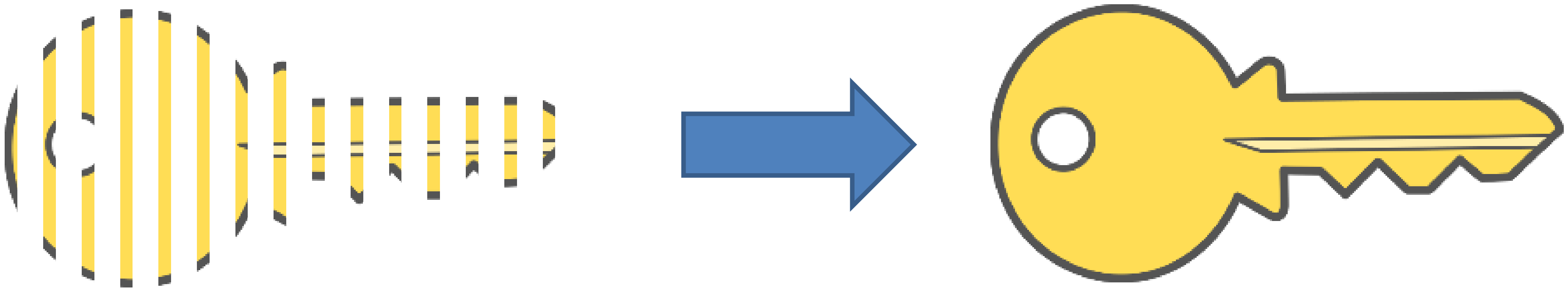
- Attacker can:
  - – Plug USB with memory dumping software
  - – Disconnect and reconnect the battery
  - – Analyze memory dump and extract key
  - – Decrypt the disk

Stolen computer



Recovering the key

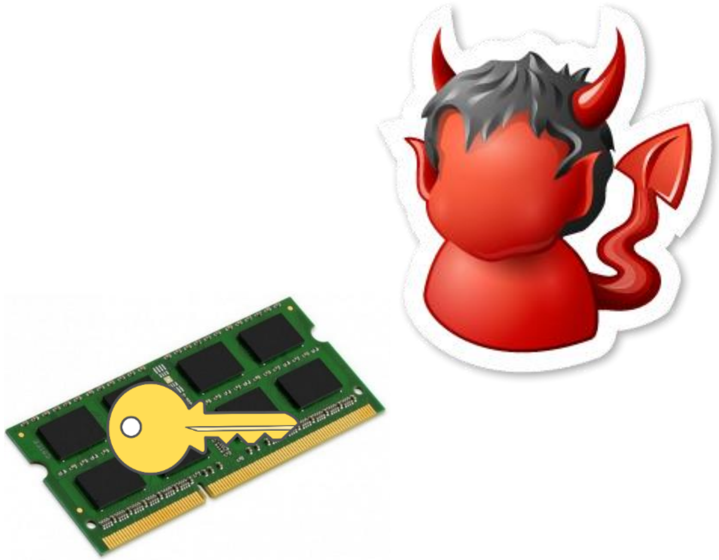
- The attack doesn’t recover the whole key
- For some encryption schemes this is sufficient to recover the key, e.g., AES and RSA
- Opened a new line of research “leakage-resilient cryptography”



What if BIOS Clears RAM?

- Can the attacker move the memory to its own computer where BIOS doesn’t clear RAM?
- Naively that would take too much time
- Solution: cool the memory card

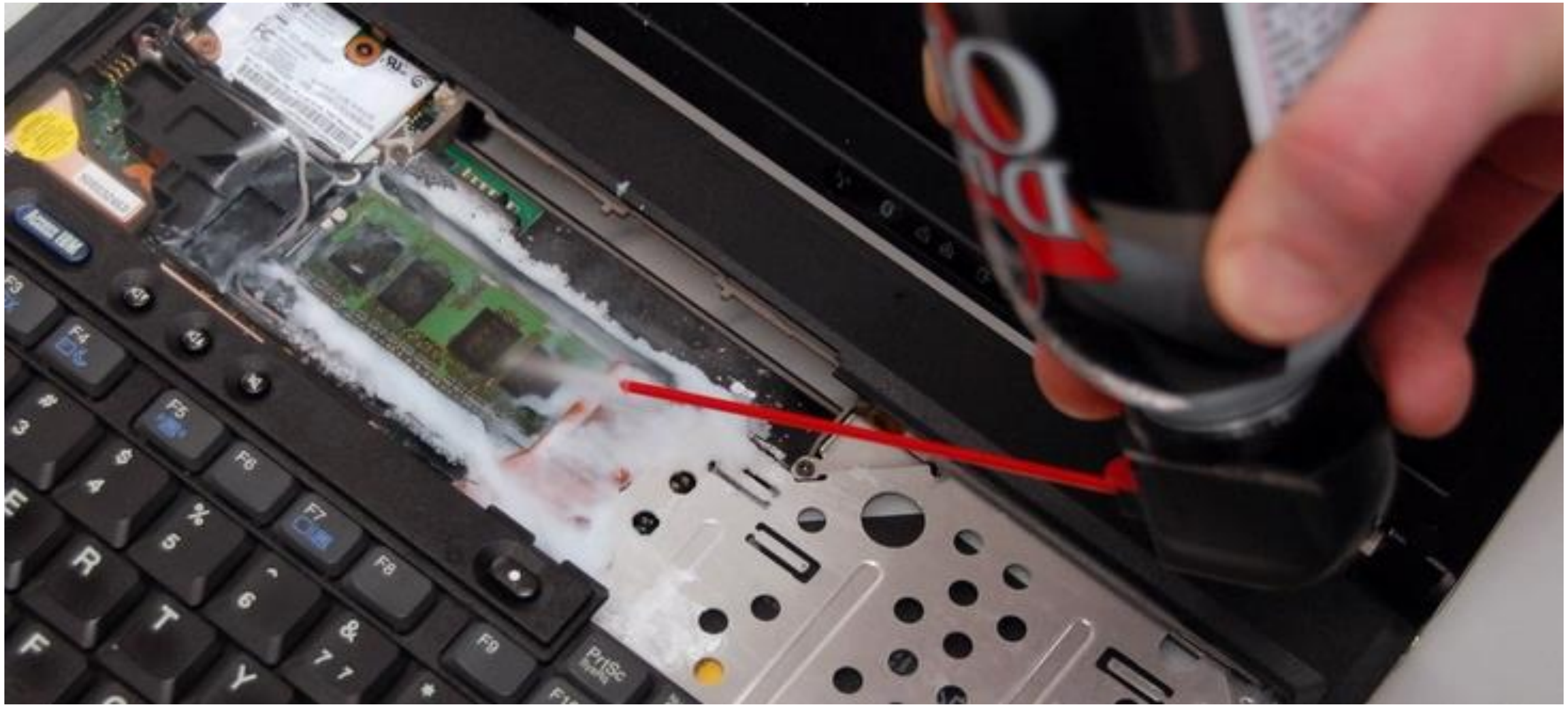
Stolen computer



Attacker’s computer

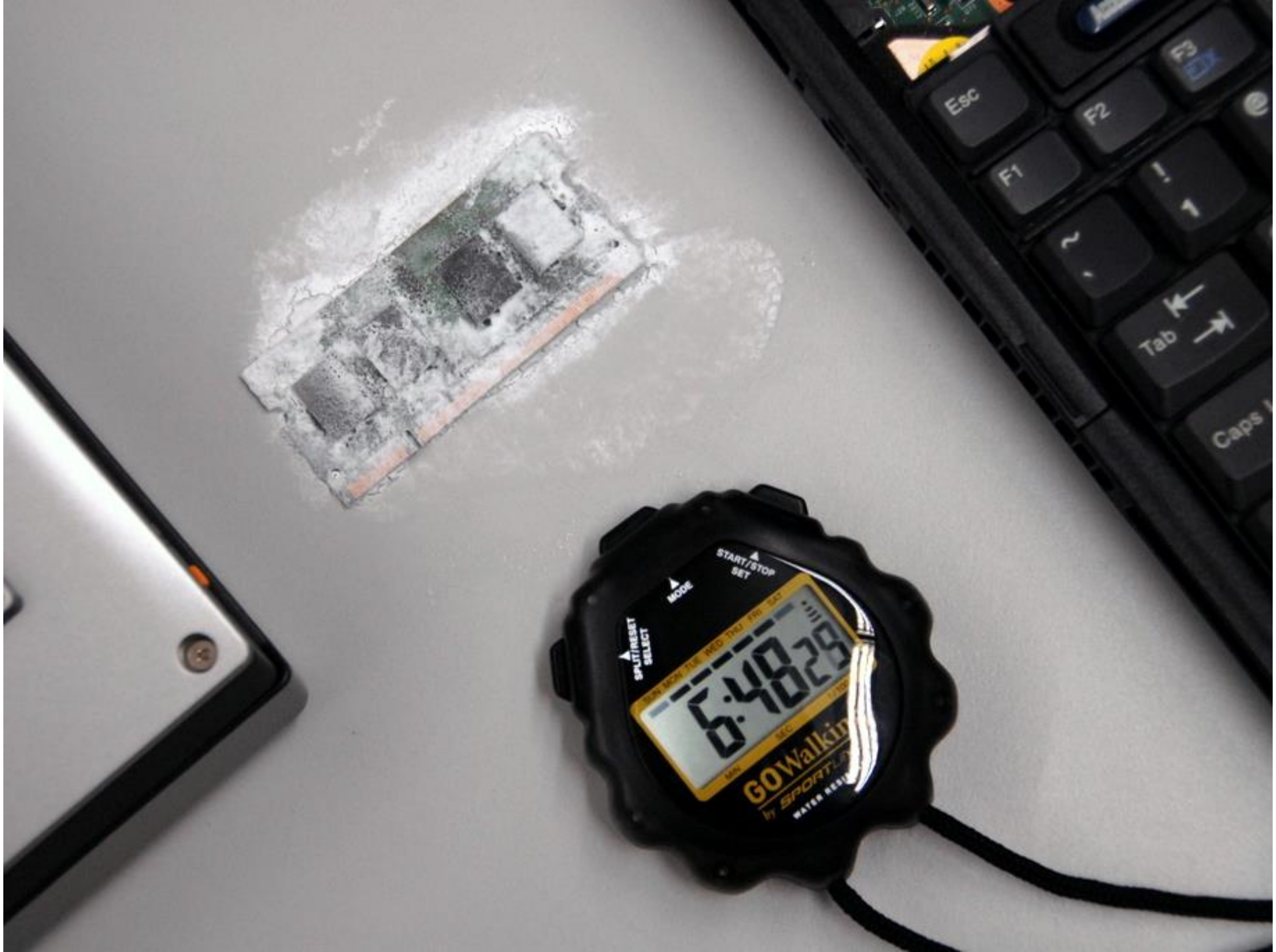
Slowing Decay by Cooling

Spray with upside-down multipurpose duster



-50°C

< 0.2% decay after **1 minute**


START/STOP
SET
MODE
SPLIT/RESET
SELECT
SUN MON TUE WED THU FRI SAT
6:48 29
MIN
SEC
GOWalkin
by SPORTLI
WATER RESIS
Esc
F1
F2
F3
Tab
Caps

Even Cooler

Liquid nitrogen -196°C

< 0.17% decay after **1 hour**

Not necessary in practice