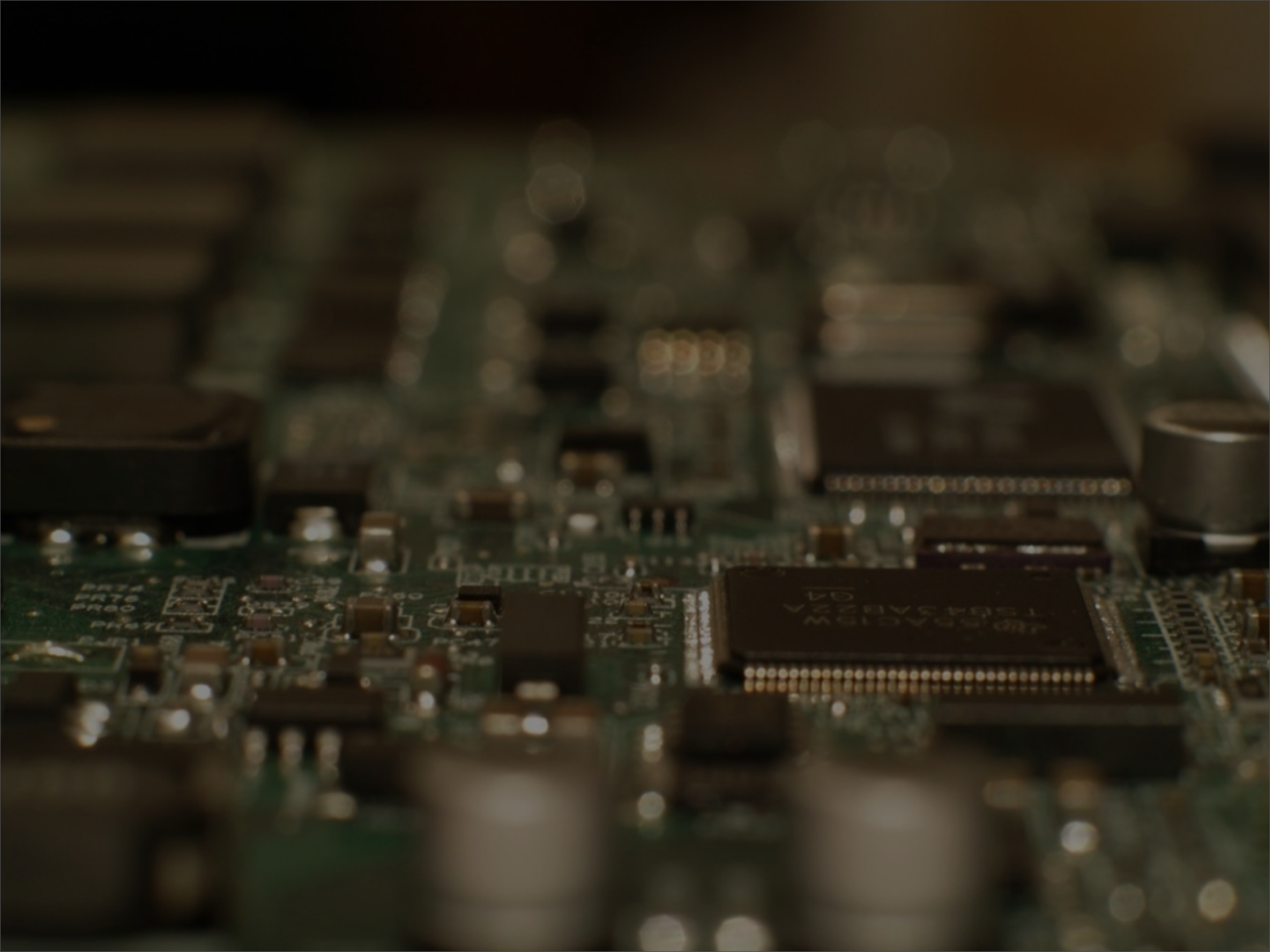

PR74
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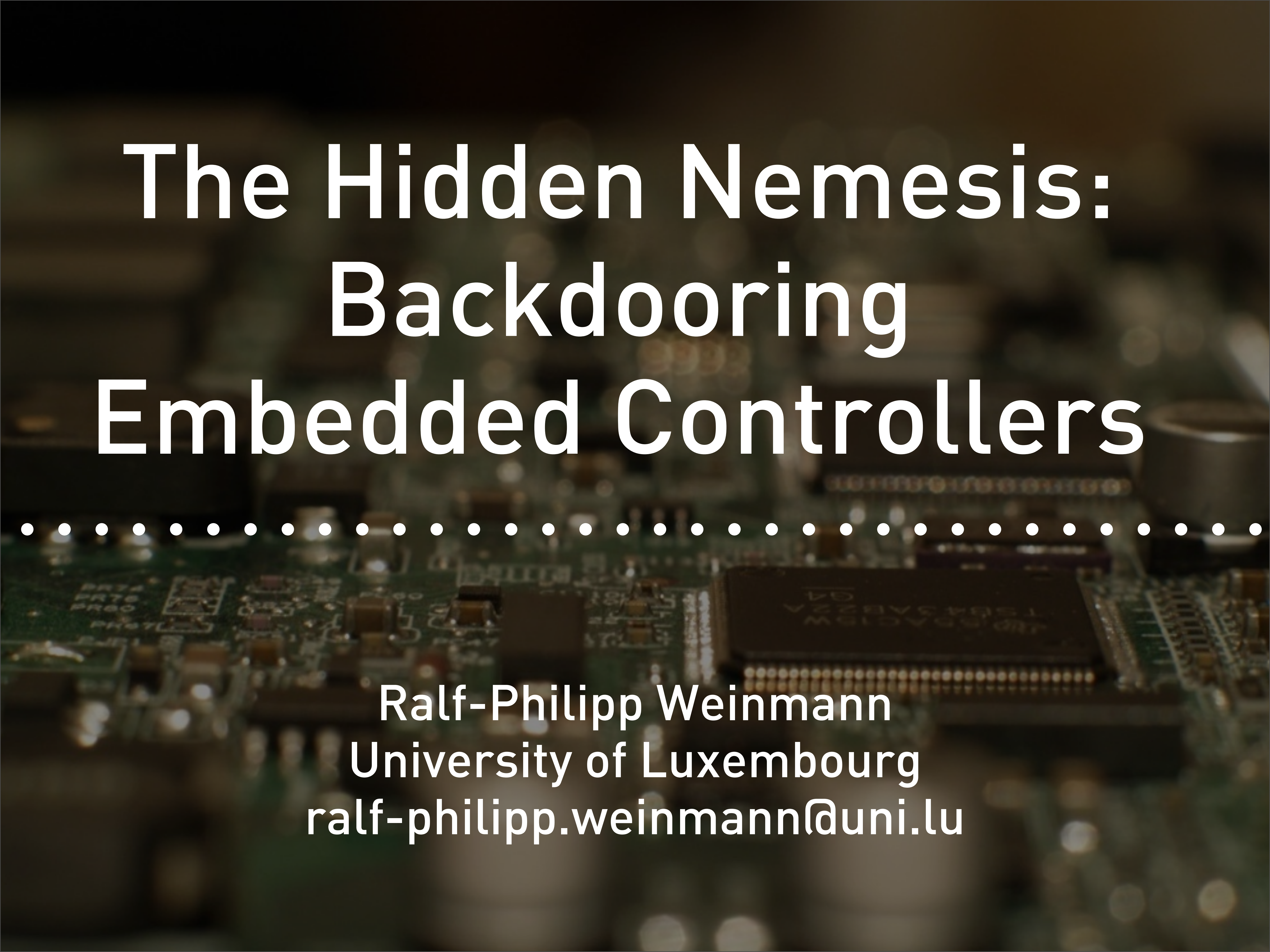

The Hidden Nemesis: Backdooring Embedded Controllers

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Targets.

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You can be one, too.

Assume I briefly have physical access your laptop.

#FAIL for you, I know.

Your laptop is reinstalled/reimaged frequently.

You are excellent at forensics.

You can disassemble and reassemble your laptop blindfolded and clean it like your M-16.

You have written backdoors/rootkits yourself.

How would I backdoor your box?

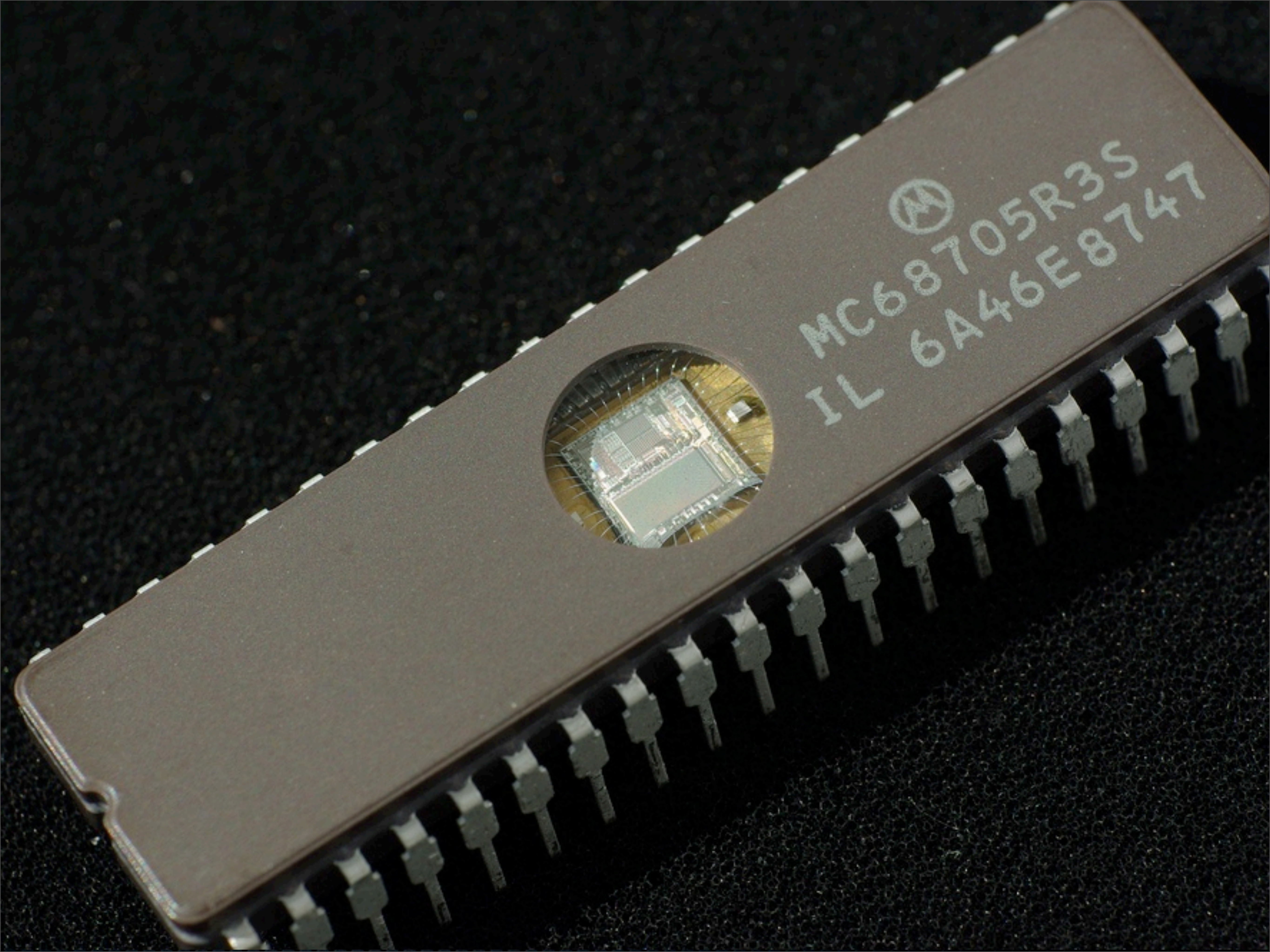
Backdoors in laptops

- State of the art:
  - Hardware (e.g. keylogger: modified keyboard)
  - Software (usually hooks into operating system's keyboard handler)
  - BIOS (see CORE's talk), ACPI (Heasman)
- What about firmware of other devices?
  - Network card? Graphics card? HDD? AMT?
  - Anything else?

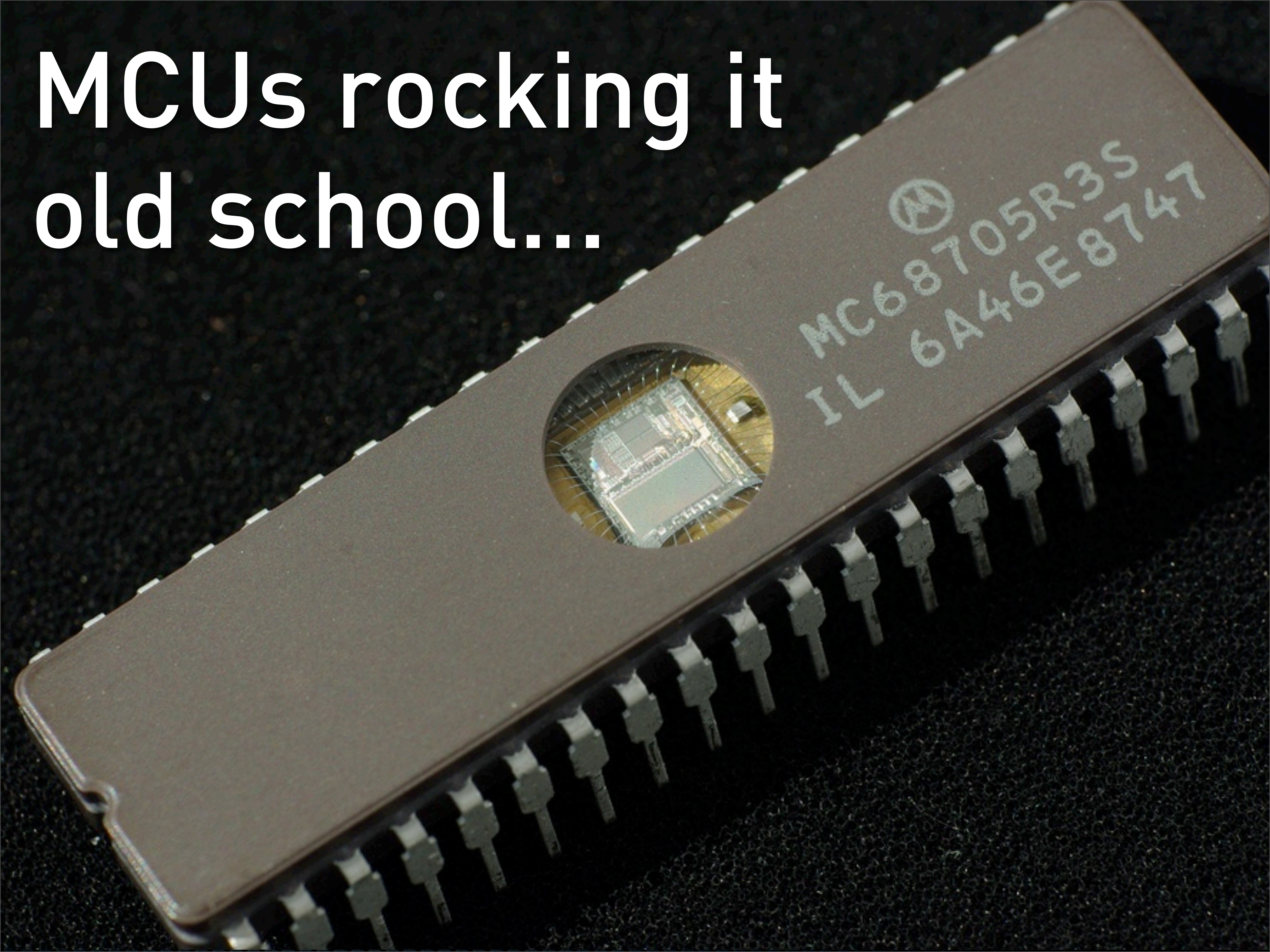
That’s what this talk is about!

Embedded controller

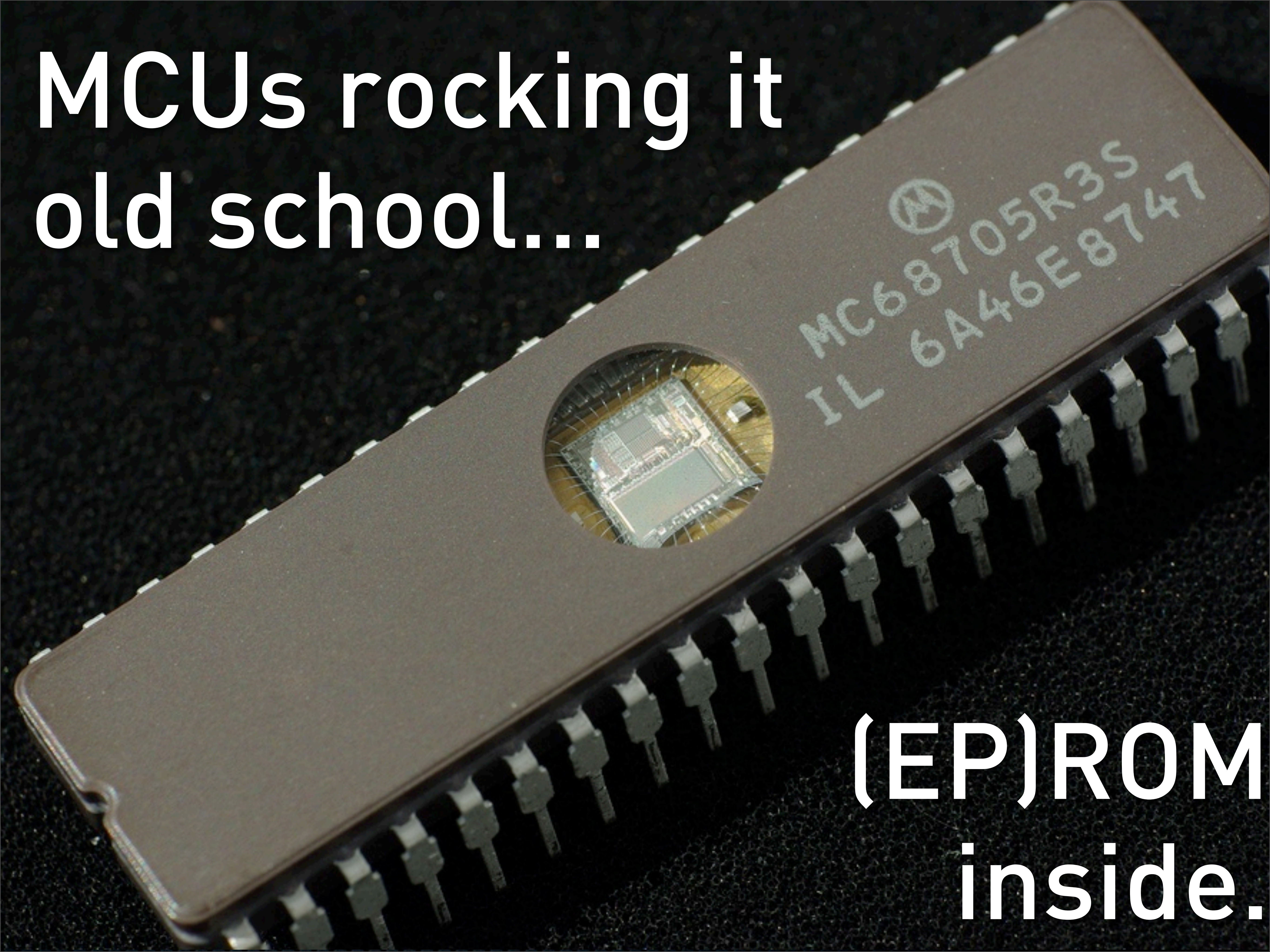
- Microcontroller in (almost?) every PC laptop
  - MacBooks have SMC instead
    keyboard is connected through USB
- 8- or 16-bit MCU, Renases widespread in ThinkPads
- Controls sensors and actuators:
  temperature, battery, fans, brightness, LEDs
- Also responsible for hotkeys (e.g. enable VGA out, brightness control etc.)
- Hence: needs access to stream of key presses


MC68705R3S
IL 6A46E8747

MCUs rocking it old school...



MCUs rocking it old school...



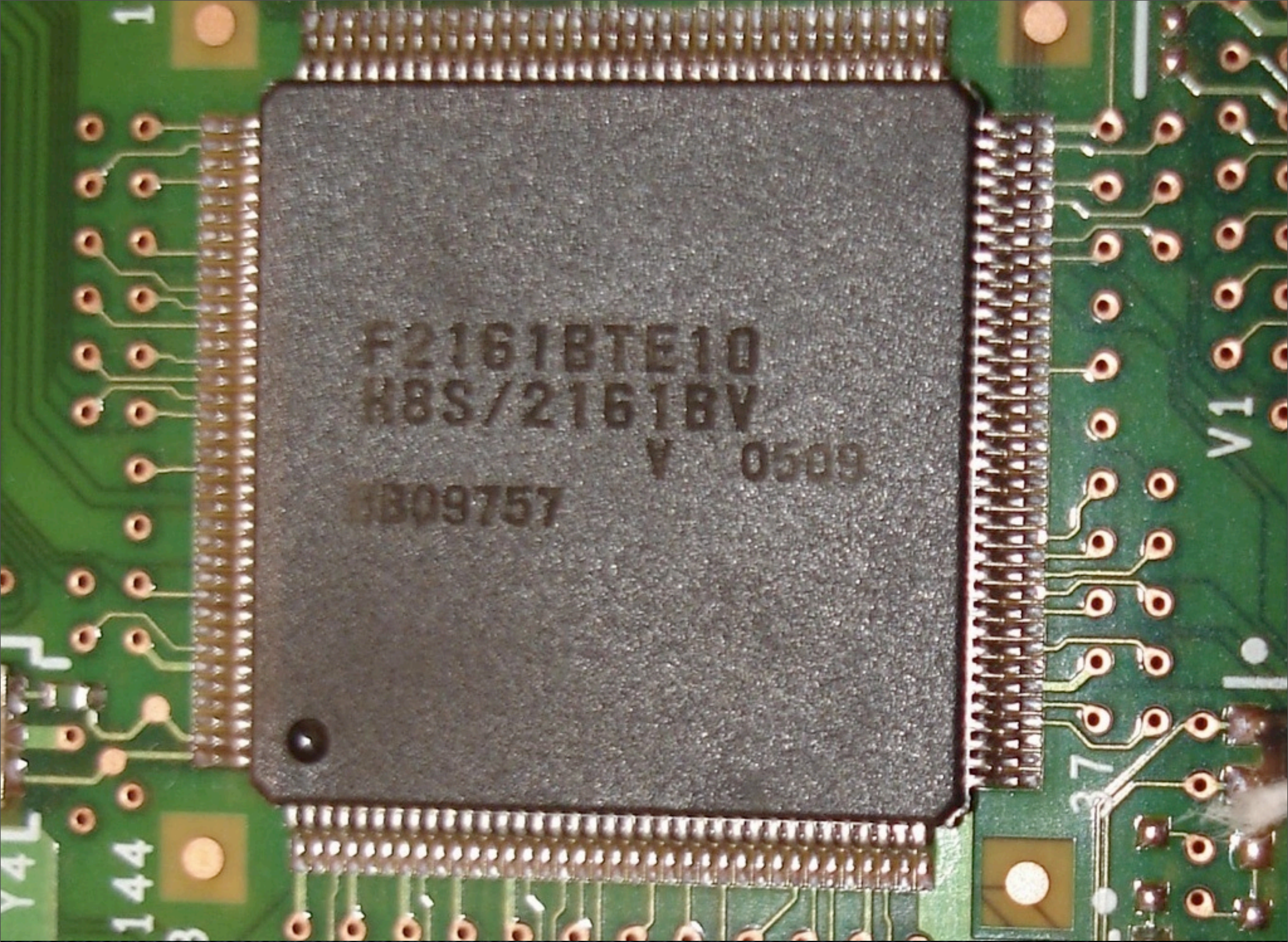
(EP)ROM inside.

Some common ECs

- ENE: KB8910, KB926C/D, KB3310, KB3700 etc. as well as SMSC
  - 8051 based, 8-bit MCU
- ITE (usually includes Super I/O controller): IT8500, IT8502E, IT8516, IT8301 etc.
  - 8052 core, 8-bit MCU
- Nuvoton
  - CR16 core and others 8051 core
- Fujitsu: MB90378, 16-bit core

ThinkPad ECs

- Renases H8S, clocked at 10Mhz
- Powered when laptop has power
  (laptop may be turned off)
- BIOS and EC code can be flashed over LAN
  (disable this BIOS option if you own a ThinkPad!)
- Prior work on reversing them (benign, for fixing bugs)
- IDA Pro Advanced has support for the H8S


F2161BTE10
H8S/2161BV
V 0509
B09757
V1
37
144
Y4
1

Prior work

- Commented disassemblies available for T43
- Pins/data lines identified
  - keyboard scan matrix
  - LEDs/ThinkLight
  - fan control
- Some patches available to fix annoyances

Source-equivalent !

http://ec.gnost.info/ec–18s.7z

```
; Source Equivalent for ThinkPad Embedded Controller Firmware


; H8S/2161BV Pin Assignments
; 32..25 PE  -> keyboard scan matrix outputs
; 50..43 PF  -> keyboard scan matrix outputs
; 58..51 PG  <- keyboard scan matrix inputs
;    108 P13 -> BJT -> ThinkLight LED
;      3 P44 -> BJT -> IGFET -> fan motor
;     80 P62 <- BJT <- fan tachometer signal
[...]
; Type 1R: T40/p; T41/p; T42/p; R50/p; R51 1829..1831, 1836
[...]
; Type 1Y: T43/p 2668..2669, 0x2678..2679, 0x2686..2687
[...]
; Type 70: T43 1871..1876; R52 0x1858..1863, 0x1958
[...]
; Type 76: R52 1846..1850, 1870
[...]
; Type 1V: R50e, R51 2883, 0x2887..2889, 0x2894..2895   ; not supported
```

THE
BACK DOOR

The PROMIS backdoor folklore

- Promis often was sold together with a computer
- Anyone remember Inslaw?
- Inventor of Prosecutor's Management Information System, a people-tracking software
- Lots of legal fights about this software
- Pirated, backdoored versions allegedly sold by CIA and/or Mossad to foreign governments

More on PROMIS

- PROMIS and computer (e.g. a Prime) were sold as bundle
- Hardware of computer was backdoored, allegedly contained two chips
  - storage chip ("Elbit") [using "ambient electricity"]
  - communication chip, using spread-spectrum modulation to periodically transmit entire contents of database and/or keystroke buffer ["Petrie" chip]
- Let's do it without the additional hardware!

Backdoor Capabilities

- For ThinkPads (only tested on X60s at the moment)
- Can record and exfiltrate keystroke data
- Assuming compression rate of 5:1 and 64KBytes scratch space → 300k keystrokes in ring buffer
- Data exfiltration
  - Can communicate with host CPU through ACPI or temperature readings
  - Get fancy: Modulate LEDs (Blinkenlights!) for optical and EM modulation!

Alternatives: JitterBugs

- Idea and first PoC by Shah, Molina and Blaze [Usenix Security 2006]
- Covert timing channel to leak key strokes
- PoC is bump-in-the-wire hardware implementation
- firmware approach already suggested by authors
- Assumes bursted keyboard activity
- Uses inter-packet delays for a 1-bit channel

Demo

Defense

- EC firmware: not write-only, can dump it as well
- Build repository of known good versions and publish fingerprints (SHA-256)
- Ongoing project: http://coderpunks.org/ecdumper
- First release will be for ThinkPads only
- Contributions (for other models) welcome!

Outlook

- Want to cover more vendors/models
- Look into other devices with reflashable firmware:
    - BIOS/ACPI yesterday, ECs now, vPro/AMT next?
- Defense:
    - Build tools to fingerprint more laptop firmware
    - Make sure firmware is signed & verified
- Fundamental discussion on trust placed in firmware necessary