Try Harder 2 Hardening the COREs

Shawn C

#whois

* Shawn C[a.k.a "citypw"]

* Day job at TYA infotech

    * Open source security consulting

* GNU/Linux security engineer

* Free/libre SW/FW/HW enthusaists

* Member of EFF/FSF/FSFE/RISC-V

* Patient Zer0 at HardenedLinux community(https://hardenedlinux.github.io/)

#whois2

* Persmule
* Day job at TYA infotech
    * Open source security consulting
* GNU/Linux engineer
* Free/libre SW/FW/HW enthusaists
* Firmware maintainer at HardenedLinux
* 0ld crew at BLUG(https://beijinglug.club/)

#cat /proc/agenda

* History: Ring 3

* Attacking the core

* Under the water

* Invincible devil

* Hope or delusion?

#Ring 3

* MAC/DAC/Sandboxing(seccomp)

* Baseline checks(STIG-4-Debian)

* Firewall/IDS/SOC

* etc

#We had a history with Ring 3

* Once upon a time, the stack was so "pure"...

* Stack/Heap layout
* Stack grows down (x86, MIPS)
* ESP points to the current top of the stack
* EBP points to the current function frame

```
High   +---------------------+
        |    Stack           |
        |(grow downward)|
        |---------------------|
        |                    |
        |---------------------|
        |  (grow upward)   |
        |      Heap          |
 Low   +---------------------+
```

#War at Ring 3

Stack overflow

Heap overflow

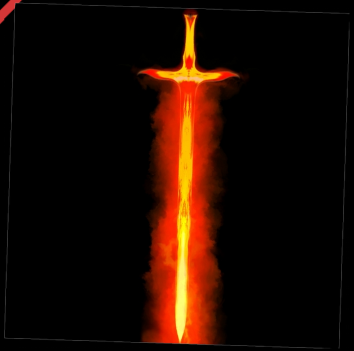
Integer overflow

Race condition

String formt

ret2libc/ROP

Overwrite ret/GOT/dtors



PaX ASLR/Vanilla ASLR + PIE

Stack cookie

PAGEEXEC/SEGEXEC/NX bit

FORTIFY SOURCE

RELRO

PAX_MPROTECT

Forward-edged CFI

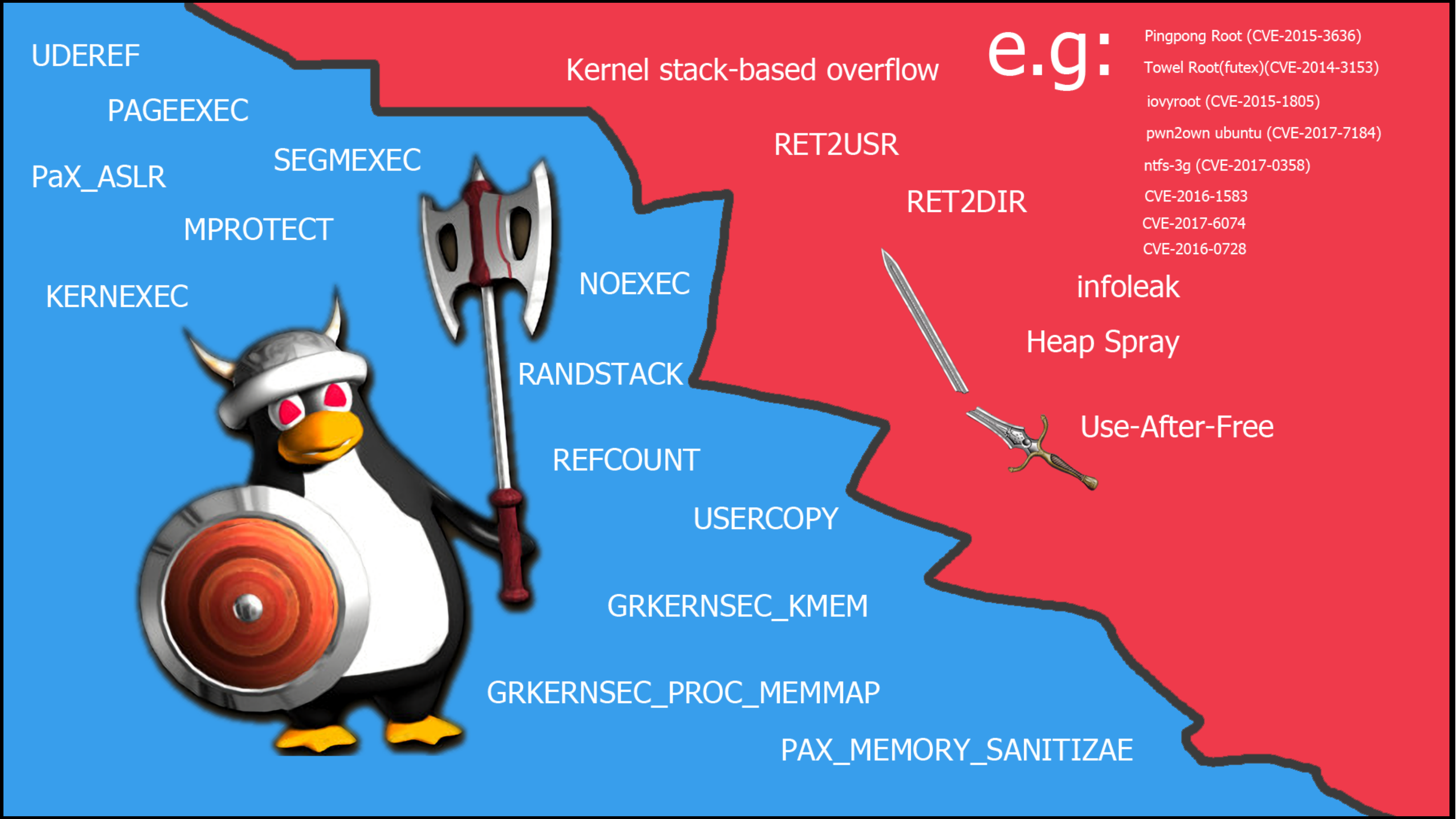
#End of story?

We got everything we need! Ok, this is it.
Thanks for coming. Bye, cruel world!

#Why attack the core?

* Linux kernel sucks in 2000s
    * One null-ptr deref can rule them all
* Still a cargo-cult security in 2017?
* Harder to exploit userspace programs

#Defend the core



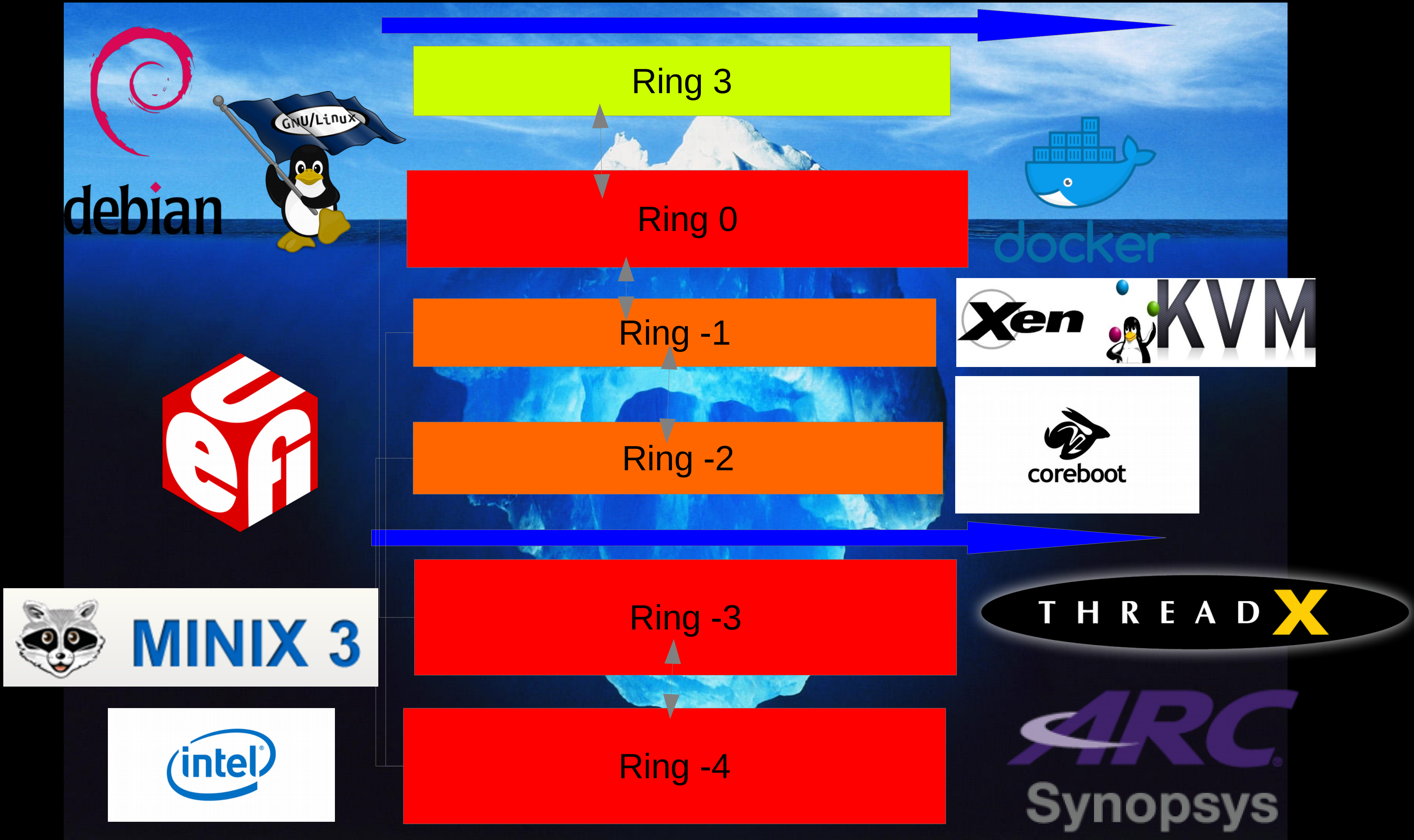
#Statistics – 2016/2017

Sources	CVEs	Public exploit works?
MITRE	245	1
Ubuntu security tracker	105	1

Only one public exploit work at PaX/Grsecurity in two yrs, and you can kill that one w/ situational hardening.

#Wait, which CORE exactly?

* RING 0 is **not** the CORE anymore



#Under the water

* VM guest escape

* Did all device drivers follow the best practice(let’s say IOMMU)?

* Old/new good/bad attacks on SMM

* Persistent attack chain

    * -1: Hijacking the kernel(perf impact?)

    * -2: Memory tricks

See the reference...

#Demo

What could possiblely go wrong with your “trusted” watcher? Don’t freaking out...

#Invincible devil

* Intel ME

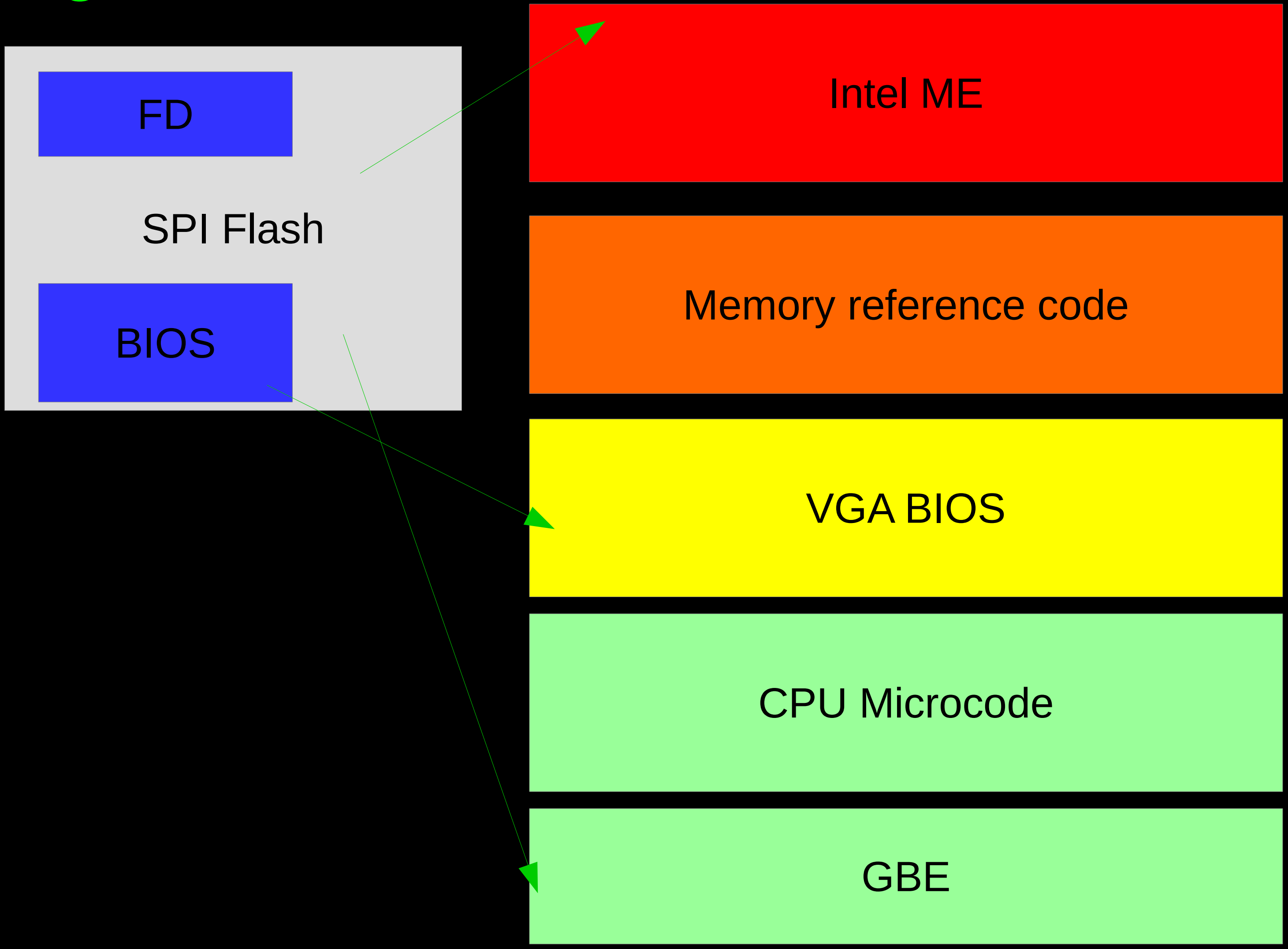
* A lot of ME "apps" based on it

* Changed a lot since v11

* Can’t be disabled until HAP/altmedisable bit disclosured that we know how BIGBRO does about Intel ME for their own defense

#From a libre FW's perspective

* Not good



#Hope or delusion?

* Some trade-off must be made

* Reproducible builds for PaX/Grsecurity

* Hardenedboot: Measured boot & verified boot

* Restricted ME via minimizing its fuctions

#Why PaX/Grsecurity matters

* Kill bug classes

* Kill exploit vectors

* Assumption: Let data center takes physical security into account

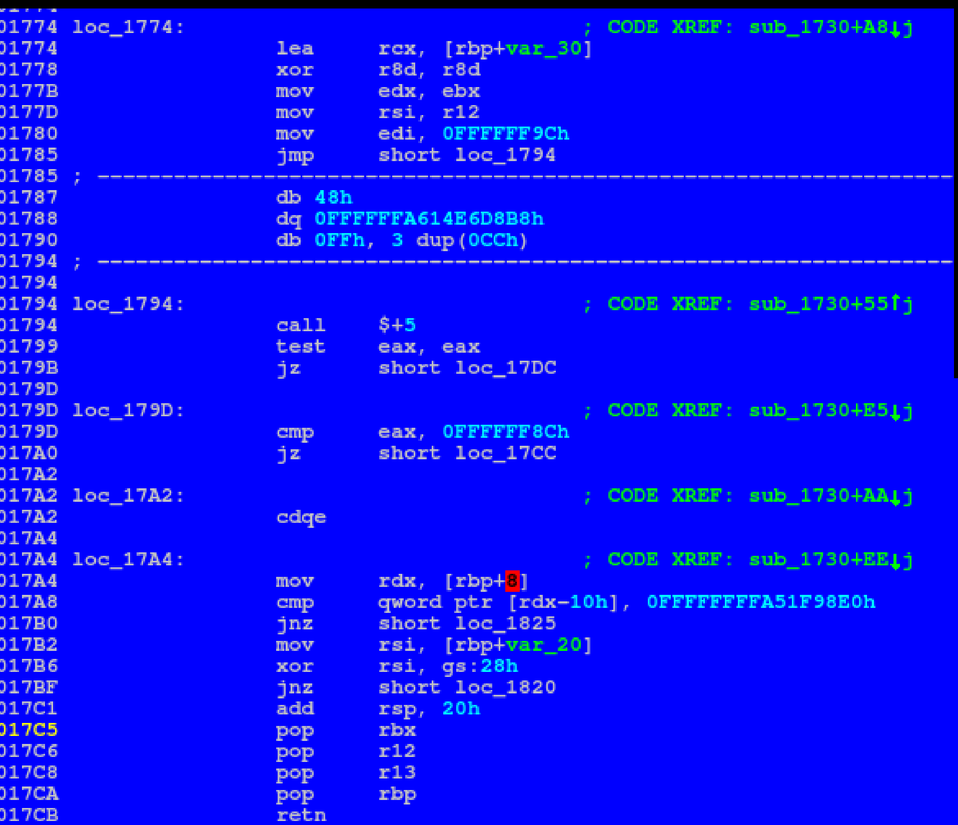
    * Kernel is still the path to the under water

    * Hardened guards kills the attack surfaces

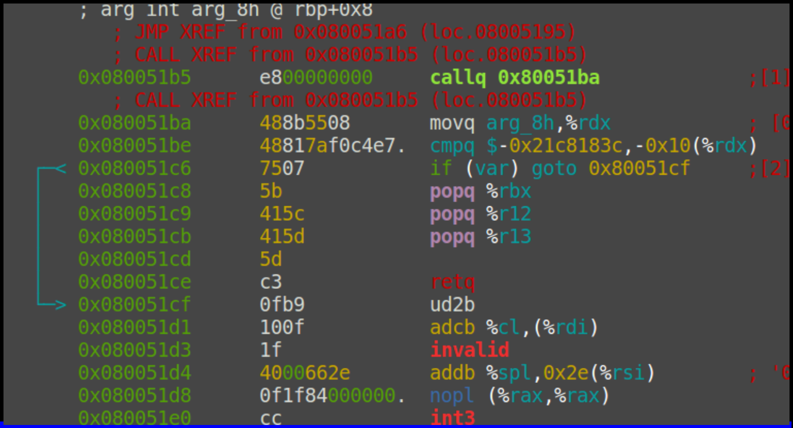
#New attack surfraces

* Why Side-channel/Fault injection should be considered in “Hardening the COREs” solution?

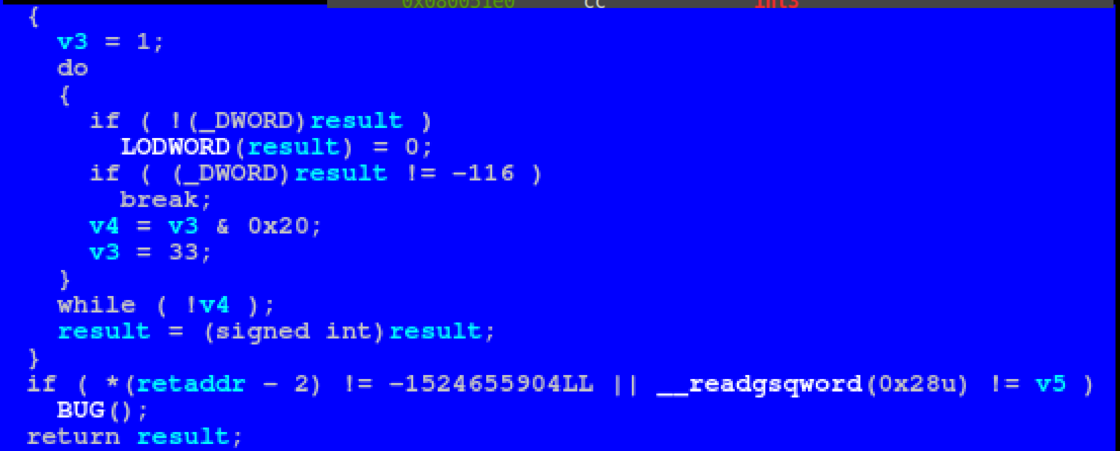
* S0rry, “Raising the bar” isn’t what PaX/Grsecurity does, it never was.



```
01774 loc_1774:                          ; CODE XREF: sub_1730+A8↓j
01774               lea     rcx, [rbp+var_30]
01778               xor     r8d, r8d
0177B               mov     edx, ebx
0177D               mov     rsi, r12
01780               mov     edi, 0FFFFFF9Ch
01785               jmp     short loc_1794
01785 ; ---------------------------------------------------------------------------
01787               db 48h
01788               dq 0FFFFFFA614E6D8B8h
01790               db 0FFh, 3 dup(0CCh)
01794 ; ---------------------------------------------------------------------------
01794
01794 loc_1794:                          ; CODE XREF: sub_1730+55↑j
01794               call    $+5
01799               test    eax, eax
0179B               jz      short loc_17DC
0179D
0179D loc_179D:                          ; CODE XREF: sub_1730+E5↓j
0179D               cmp     eax, 0FFFFFF8Ch
017A0               jz      short loc_17CC
017A2
017A2 loc_17A2:                          ; CODE XREF: sub_1730+AA↓j
017A2               cdqe
017A4
017A4 loc_17A4:                          ; CODE XREF: sub_1730+EE↓j
017A4               mov     rdx, [rbp+8]
017A8               cmp     qword ptr [rdx-10h], 0FFFFFFFFA51F98E0h
017B0               jnz     short loc_1825
017B2               mov     rsi, [rbp+var_20]
017B6               xor     rsi, gs:28h
017BF               jnz     short loc_1820
017C1               add     rsp, 20h
017C5               pop     rbx
017C6               pop     r12
017C8               pop     r13
017CA               pop     rbp
017CB               retn
```

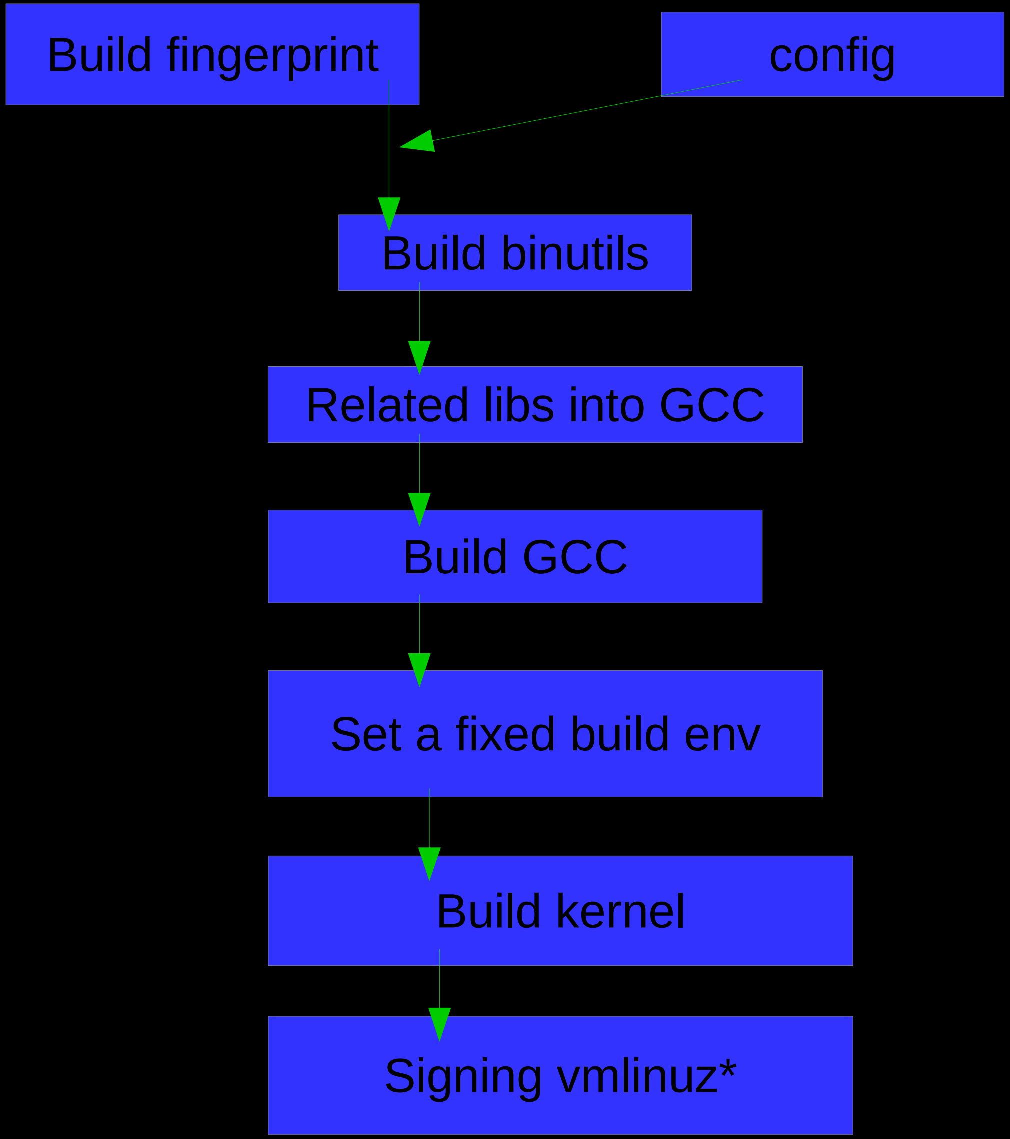


```
        ; arg int arg_8h @ rbp+0x8
           ; JMP XREF from 0x080051a6 (loc.08005195)
           ; CALL XREF from 0x080051b5 (loc.080051b5)
        0x080051b5      e800000000      callq 0x80051ba         ;[1]
           ; CALL XREF from 0x080051b5 (loc.080051b5)
        0x080051ba      488b5508        movq arg_8h,%rdx        ; [
        0x080051be      48817af0c4e7.   cmpq $-0x21c8183c,-0x10(%rdx)
     ┌─< 0x080051c6      7507            if (var) goto 0x80051cf ;[2]
     │  0x080051c8      5b              popq %rbx
     │  0x080051c9      415c            popq %r12
     │  0x080051cb      415d            popq %r13
     │  0x080051cd      5d
     │  0x080051ce      c3              retq
     └─> 0x080051cf      0fb9            ud2b
        0x080051d1      100f            adcb %cl,(%rdi)
        0x080051d3      1f              invalid
        0x080051d4      4000662e        addb %spl,0x2e(%rsi)    ; '
        0x080051d8      0f1f84000000.   nopl (%rax,%rax)
        0x080051e0      cc              int3
```

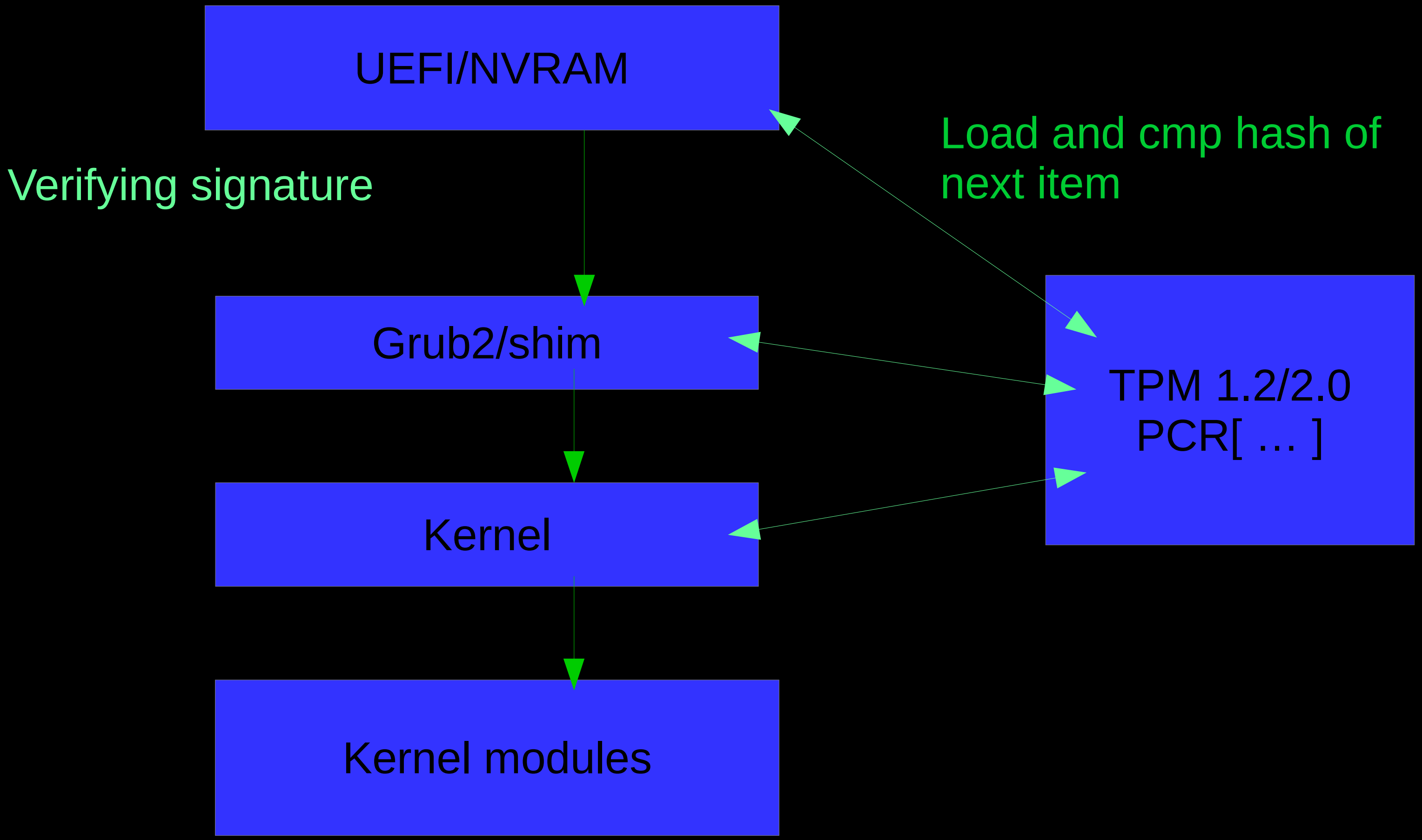


```
{
  v3 = 1;
  do
  {
    if ( !(_DWORD)result )
      LODWORD(result) = 0;
    if ( (_DWORD)result != -116 )
      break;
    v4 = v3 & 0x20;
    v3 = 33;
  }
  while ( !v4 );
  result = (signed int)result;
}
if ( *(retaddr - 2) != -1524655904LL || __readgsqword(0x28u) != v5 )
  BUG();
return result;
```

#Reproducible builds for PaX/Grsecurity



#Hardened Boot

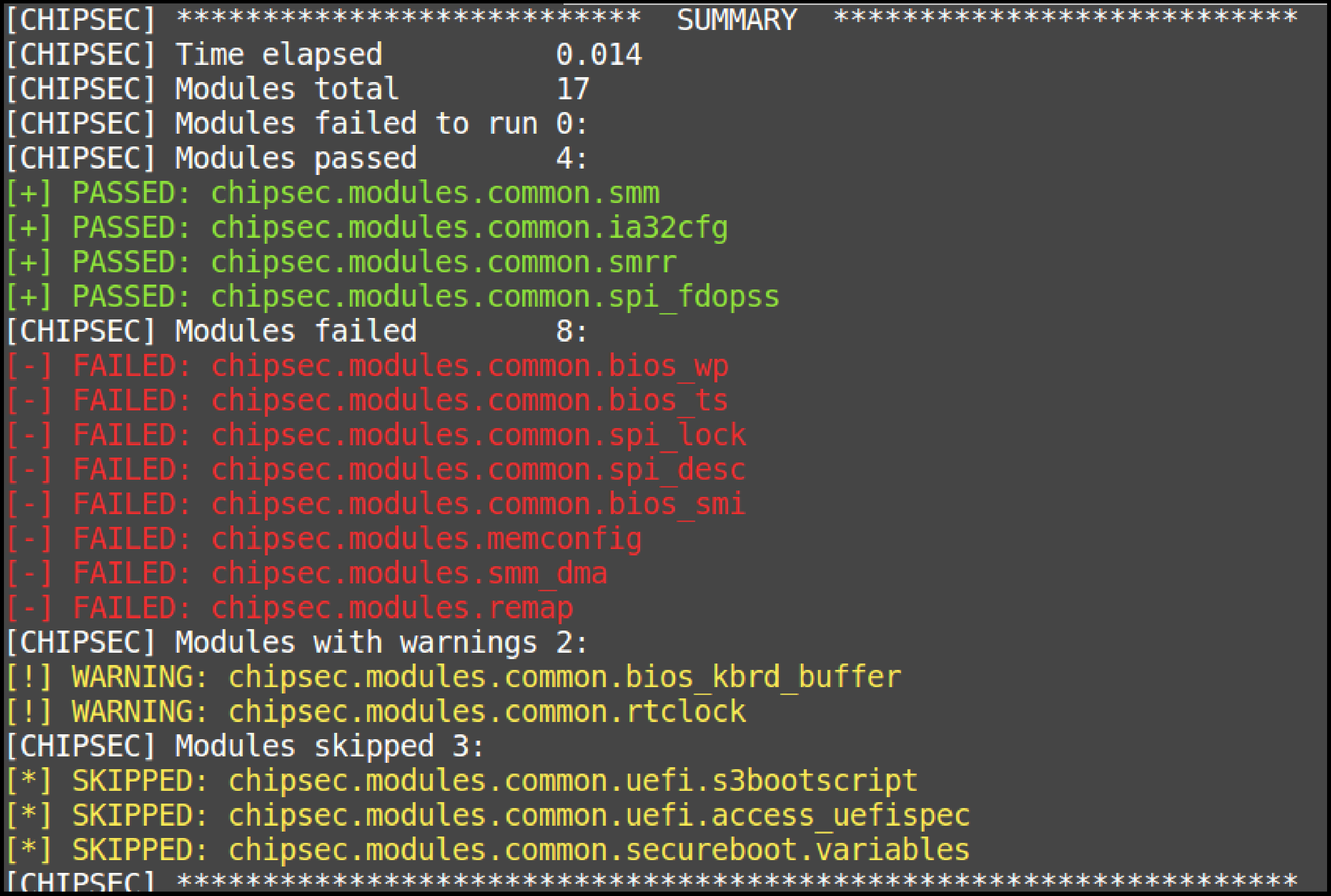


#Free/libre solution?

* Coreboot/FSP
* Libreboot
* Situational hardening
  * Old good machines for critical assets
  * Newer machines for generic purposes
  * Security needs some trade-off if performance is necessary: NERF/LinuxBoot
* Reference model for custom firmware
* Long-term plan: coreboot for RISC-V?

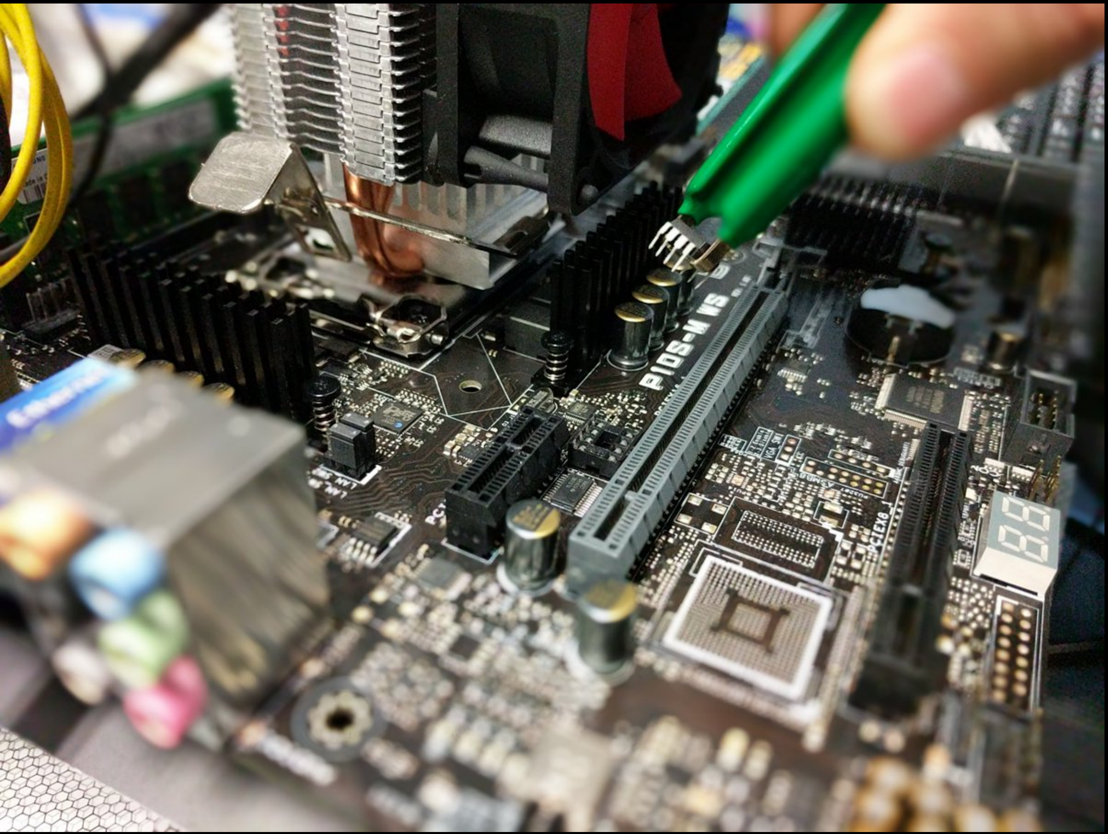
#Open == auditable

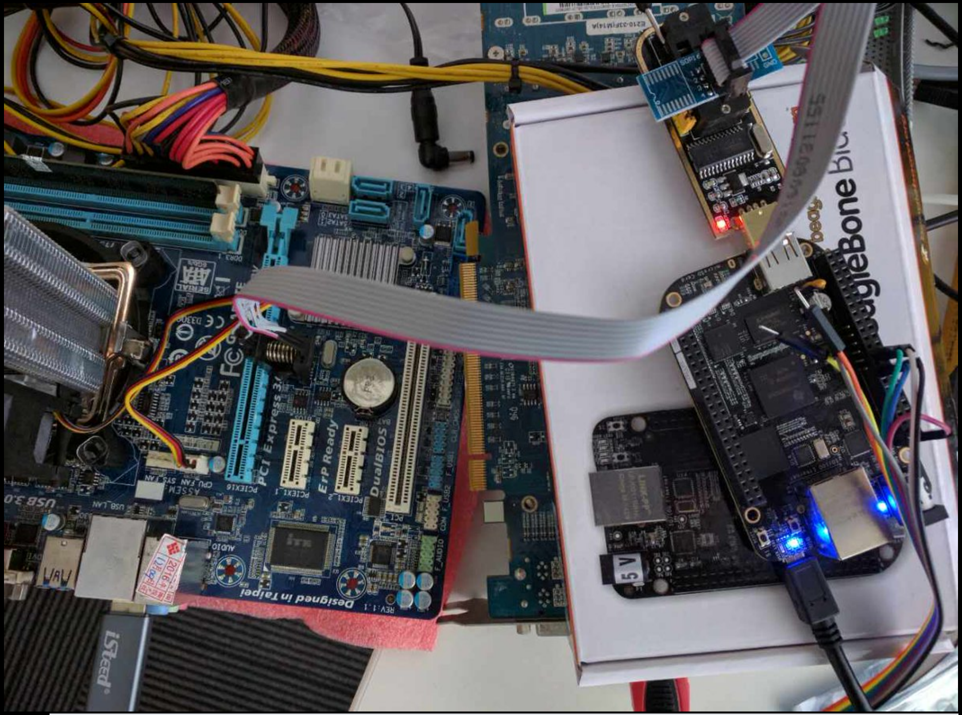
* open != secure, a-random-coreboot-machine:



```
[CHIPSEC] ***************************  SUMMARY  ***************************
[CHIPSEC] Time elapsed          0.014
[CHIPSEC] Modules total         17
[CHIPSEC] Modules failed to run 0:
[CHIPSEC] Modules passed        4:
[+] PASSED: chipsec.modules.common.smm
[+] PASSED: chipsec.modules.common.ia32cfg
[+] PASSED: chipsec.modules.common.smrr
[+] PASSED: chipsec.modules.common.spi_fdopss
[CHIPSEC] Modules failed        8:
[-] FAILED: chipsec.modules.common.bios_wp
[-] FAILED: chipsec.modules.common.bios_ts
[-] FAILED: chipsec.modules.common.spi_lock
[-] FAILED: chipsec.modules.common.spi_desc
[-] FAILED: chipsec.modules.common.bios_smi
[-] FAILED: chipsec.modules.memconfig
[-] FAILED: chipsec.modules.smm_dma
[-] FAILED: chipsec.modules.remap
[CHIPSEC] Modules with warnings 2:
[!] WARNING: chipsec.modules.common.bios_kbrd_buffer
[!] WARNING: chipsec.modules.common.rtclock
[CHIPSEC] Modules skipped 3:
[*] SKIPPED: chipsec.modules.common.uefi.s3bootscript
[*] SKIPPED: chipsec.modules.common.uefi.access_uefispec
[*] SKIPPED: chipsec.modules.common.secureboot.variables
[CHIPSEC] *****************************************************************
```

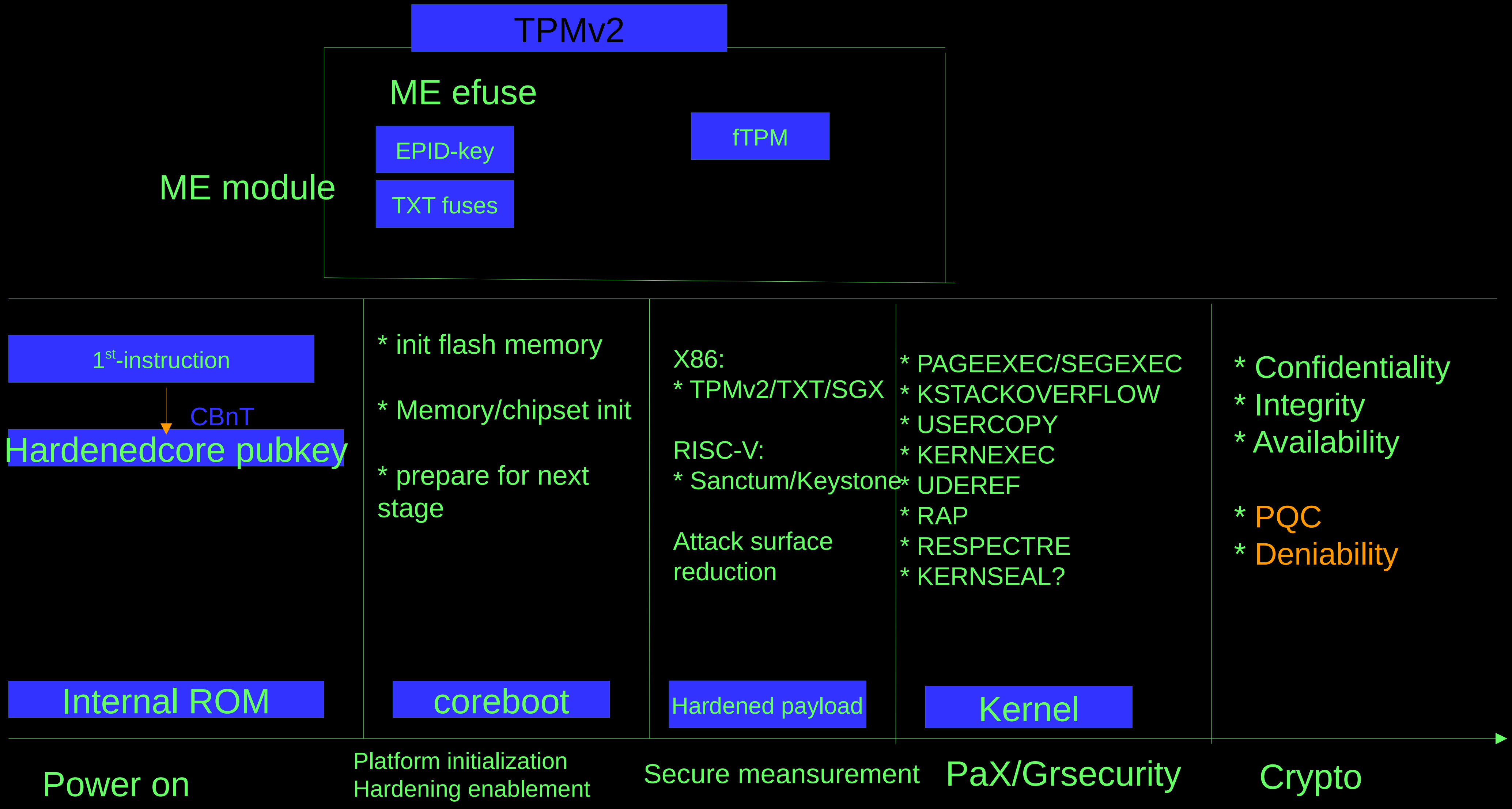
#Neutralizing ME



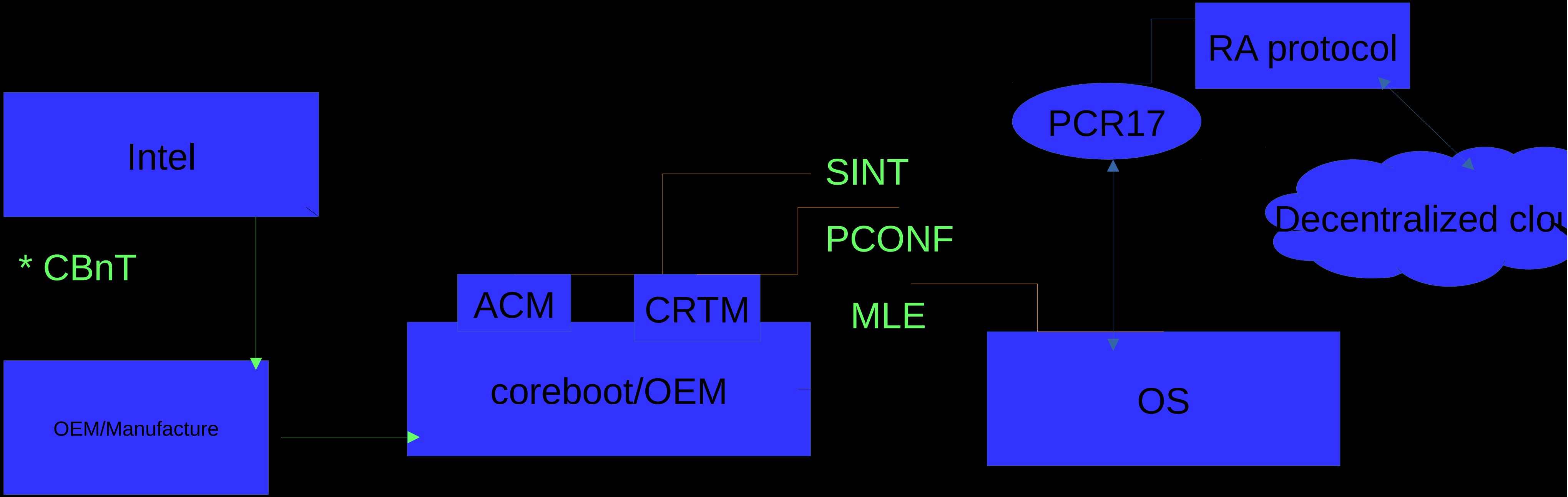


Mainboard	CPU	Tested BIOS
GA-B75M-D3H	SandyBridge	OEM/Coreboot
GA-B75M-D3V	IvyBridge	OEM/Coreboot
Lenovo T420	IvyBridge	OEM/Coreboot
Lenovo X220/X220i	SandyBridge	OEM/Coreboot
Lenovo X230	IvyBridge	OEM/Coreboot
Chromebook XE550C22	IvyBridge	OEM/Coreboot
ASUS P10S-M WS	Skylake	OEM

Core of the decentralized cloud?



Reach the limits?



* e-fuses
* CBnT: BACMs + SINT for servers
* ME/SPS modules
* RoT

* u-code verify the signature of BACM
* TXT/tboot: SINT
* TPMv2 policy
* CoT

* Hardening based on PaX/Grsecurity
* PCR17

Hardening level and compliance

Level	Type	Security Hardening Profile
Critical	Physical machine	Situational hardening for Firmware/Kernel + Enclave + Remote attestation + Harbian audit Level 2
	Virtual machine	Situational hardening for kernel + Hypervisor-based Remote attestation + Harbian audit Level 2 + Optional(firmware mirror integrity verification)
Important	Physical machine	Standard hardening for Firmware + Situational hardening for kernel + Enclave + Remote attestation + Harbian audit Level 1
	Virtual machine	Situational hardening for kernel + Hypervisor-based Remote attestation + Harbian audit Level 1
Normal	Physical machine	Harbian audit Level 1 + Optional(Enclave + Remote attestation)
	Virtual machine	Harbian audit Level 1 + Optional(Enclave + Remote attestation)

#Extra notes;-)

* Neutralized ME affected remote attestation via SGX?

* Think harder about your situational hardening solution before ask OEM write your pk

* You don’t need Intel Bootguard if the data center could take care of physical security

* Big clouds(AWS/Google/Facebook/BAT3H/etc) should do the situational hardening for their core infrastructure. Otherwise it might become someone else’s computer;-)

* Masters of Pwn killed by PaX/Grsecurity

#Are we done?

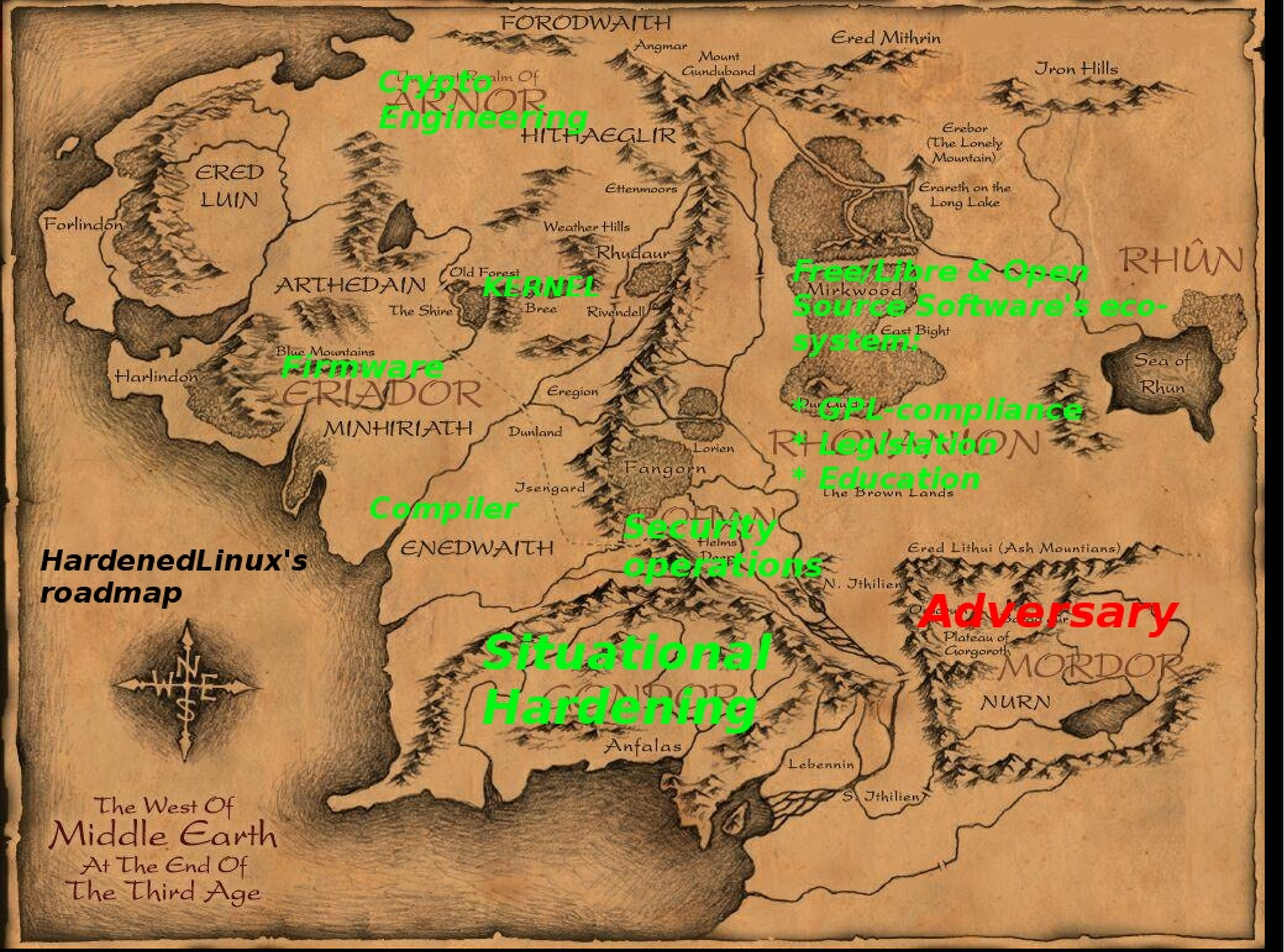
* Or just another starting point?

* Know your enemy(from Ring 3/0/-1/-2/-3/-4)

* Risk assessment for important production/assets

    * Known bug classes/exploit vectors

HardenedLinux's roadmap



Reference

* PaX/Grsecurity:

https://grsecurity.net/

* Coreboot:

http://coreboot.org/

* Linux kernel mitigation checklist:

https://hardenedlinux.github.io/system-security/2016/12/13/kernel_mitigation_checklist.html

* Ring 0: Linux kernel vulnerablity & exploitation & silent fixes

https://github.com/hardenedlinux/grsecurity-101-tutorials/blob/master/kernel_vuln_exp.md

* Virtualization security:

https://github.com/hardenedlinux/grsecurity-101-tutorials/blob/master/virt_security.md

Reference

* Firmware security:

https://github.com/hardenedlinux/firmware-anatomy/blob/master/hack_ME/firmware_security.md

* Reproducible builds for PaX/Grsecurity

https://github.com/hardenedlinux/grsecurity-reproducible-build

* Hardened Boot:

https://github.com/hardenedlinux/Debian-GNU-Linux-Profiles/tree/master/docs/hardened_boot

* Neutralized ME with coreboot stuff

https://github.com/hardenedlinux/hardenedlinux_profiles/tree/master/coreboot

* Intel ME’s info:

https://github.com/hardenedlinux/firmware-anatomy/blob/master/hack_ME/me_info.md

QA

Thanks