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

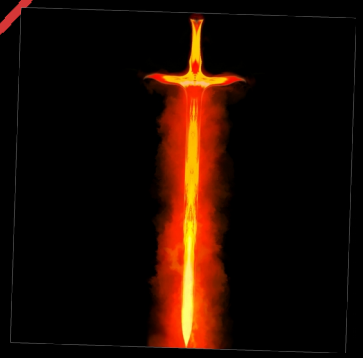
Integer overflow

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

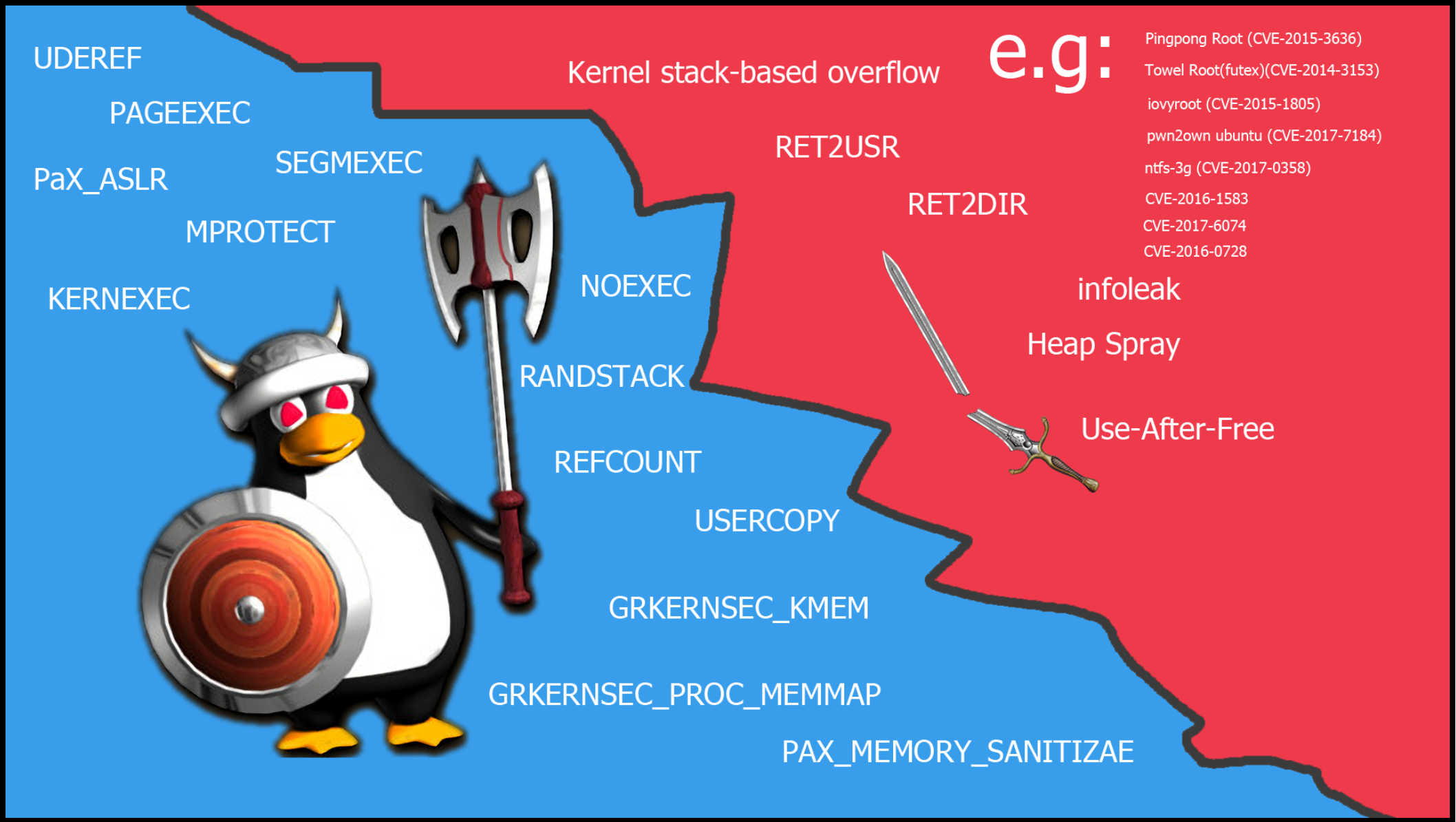
#End of story?

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



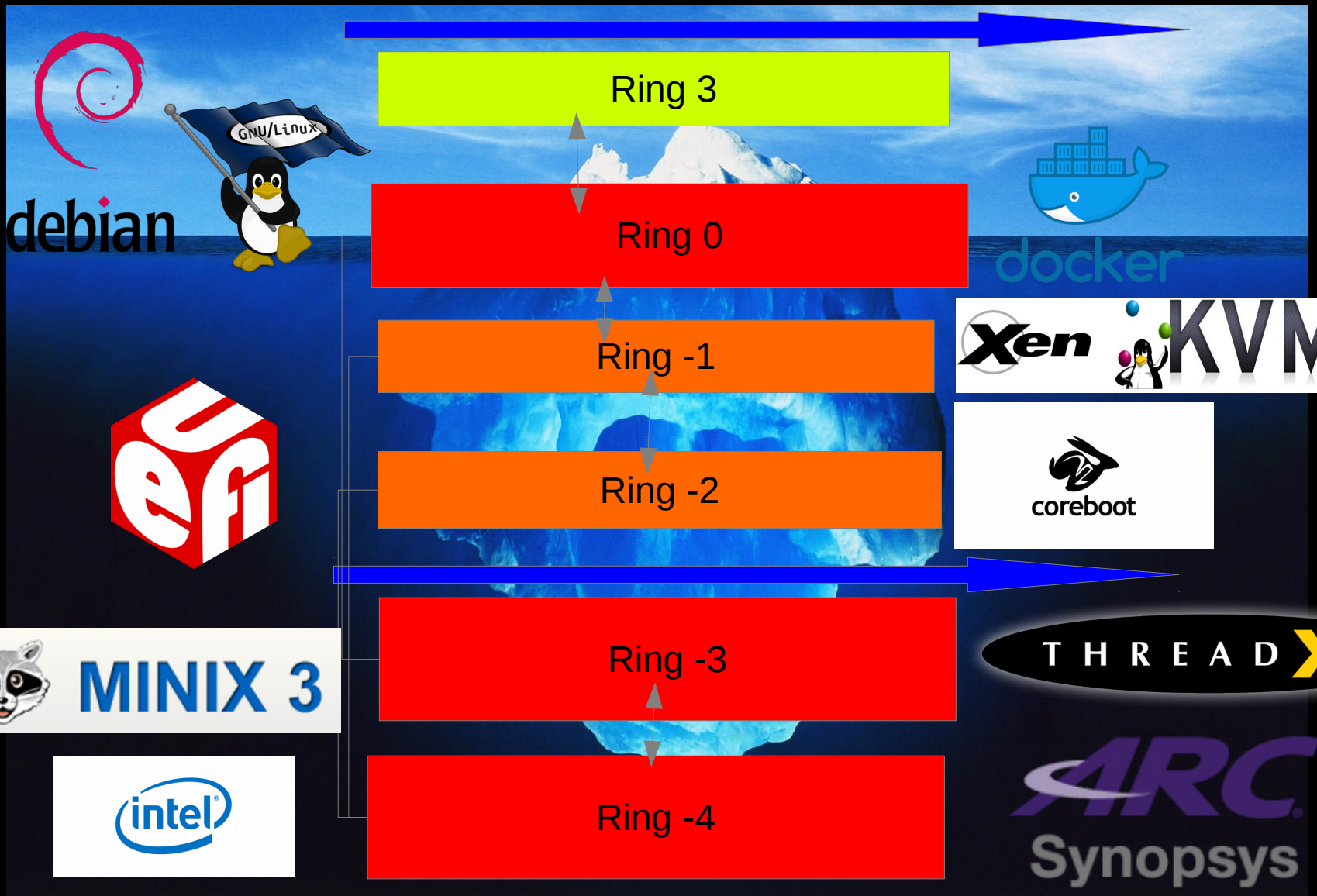
#Statistics – 2016/2017

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

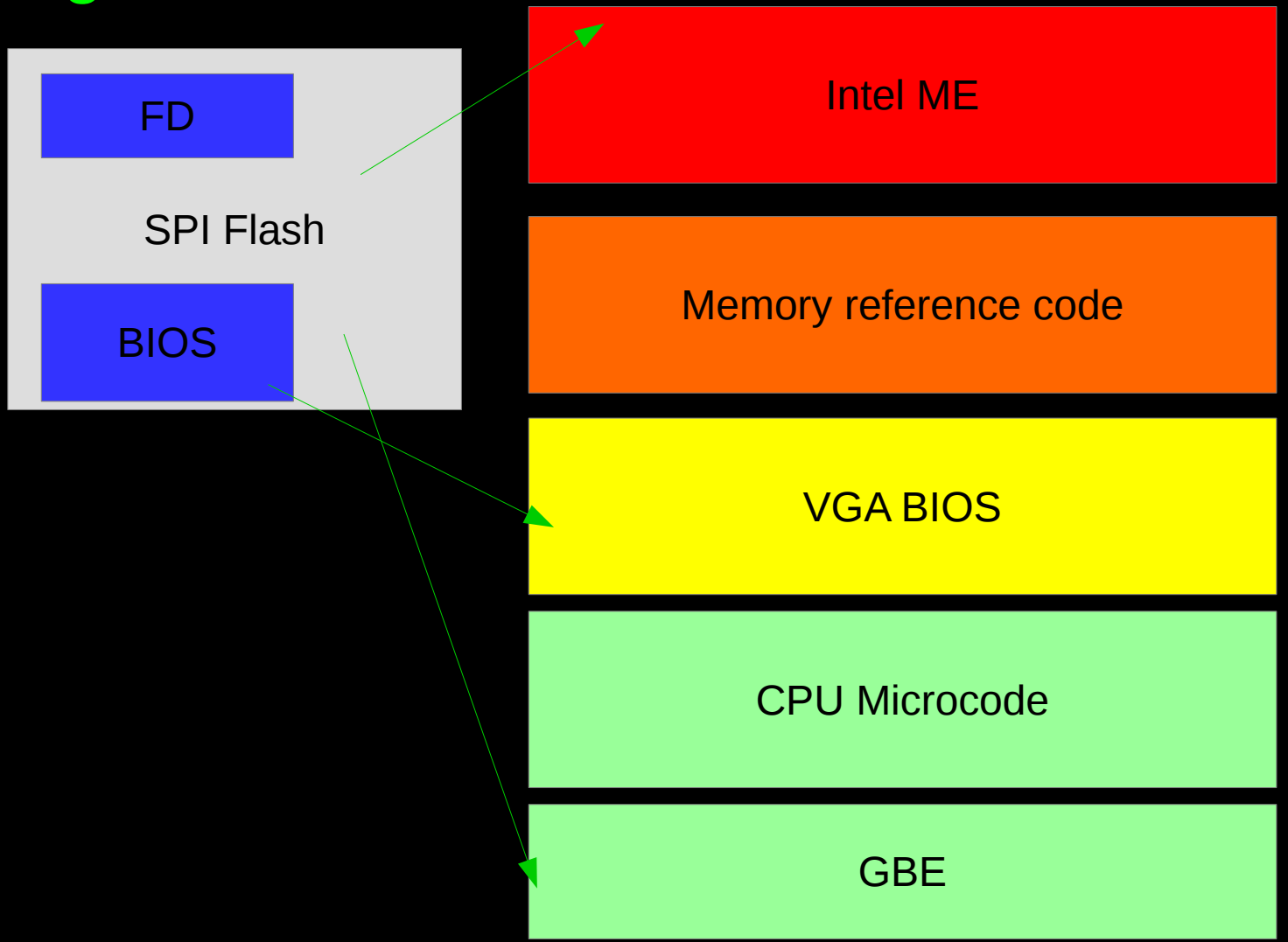
What could possiblely go wrong with your “trusted” watcher? Don’t freaking out...

#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?

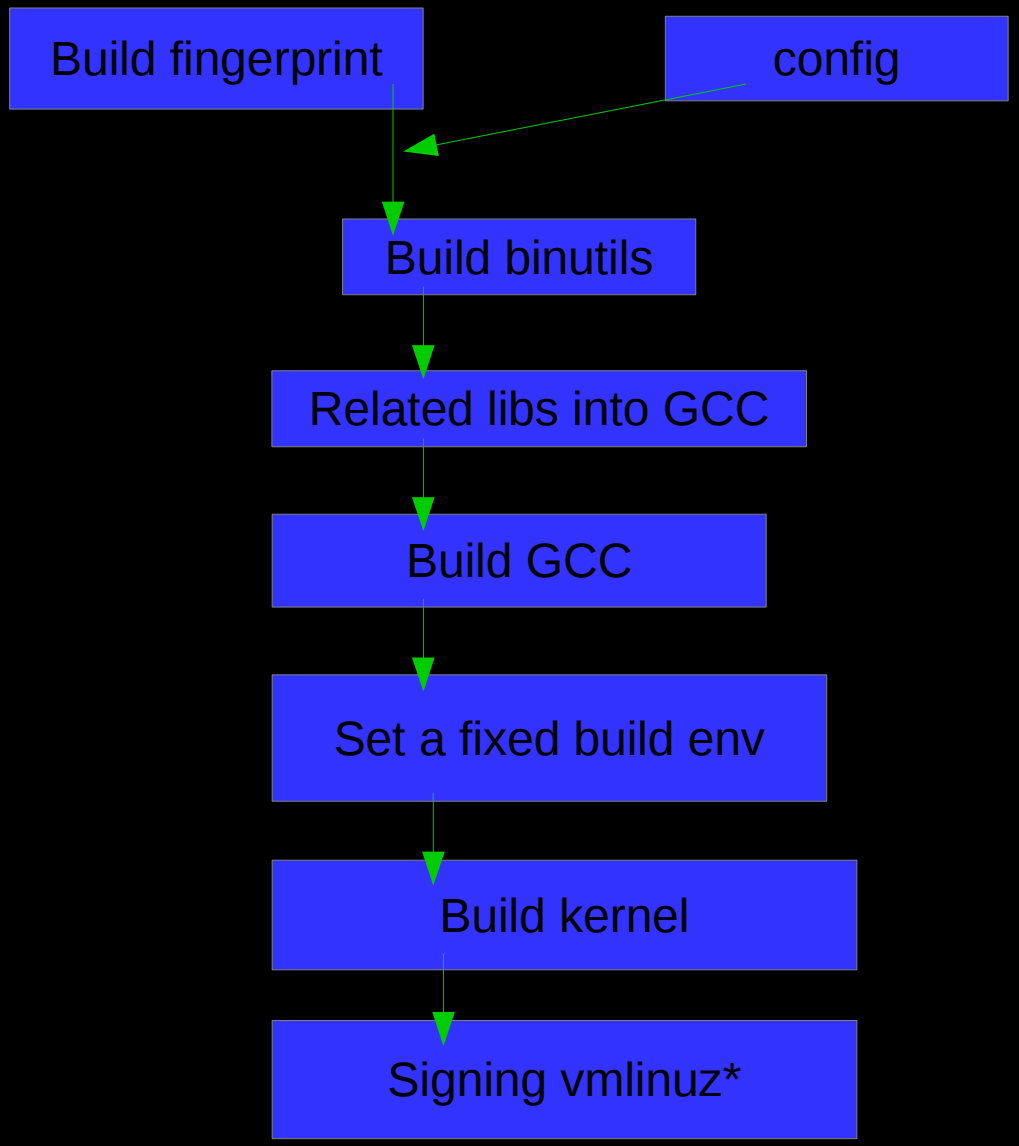
* S0rry, “Raising the bar” isn’t what PaX/Grsecurity does, it never was.

```
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
```

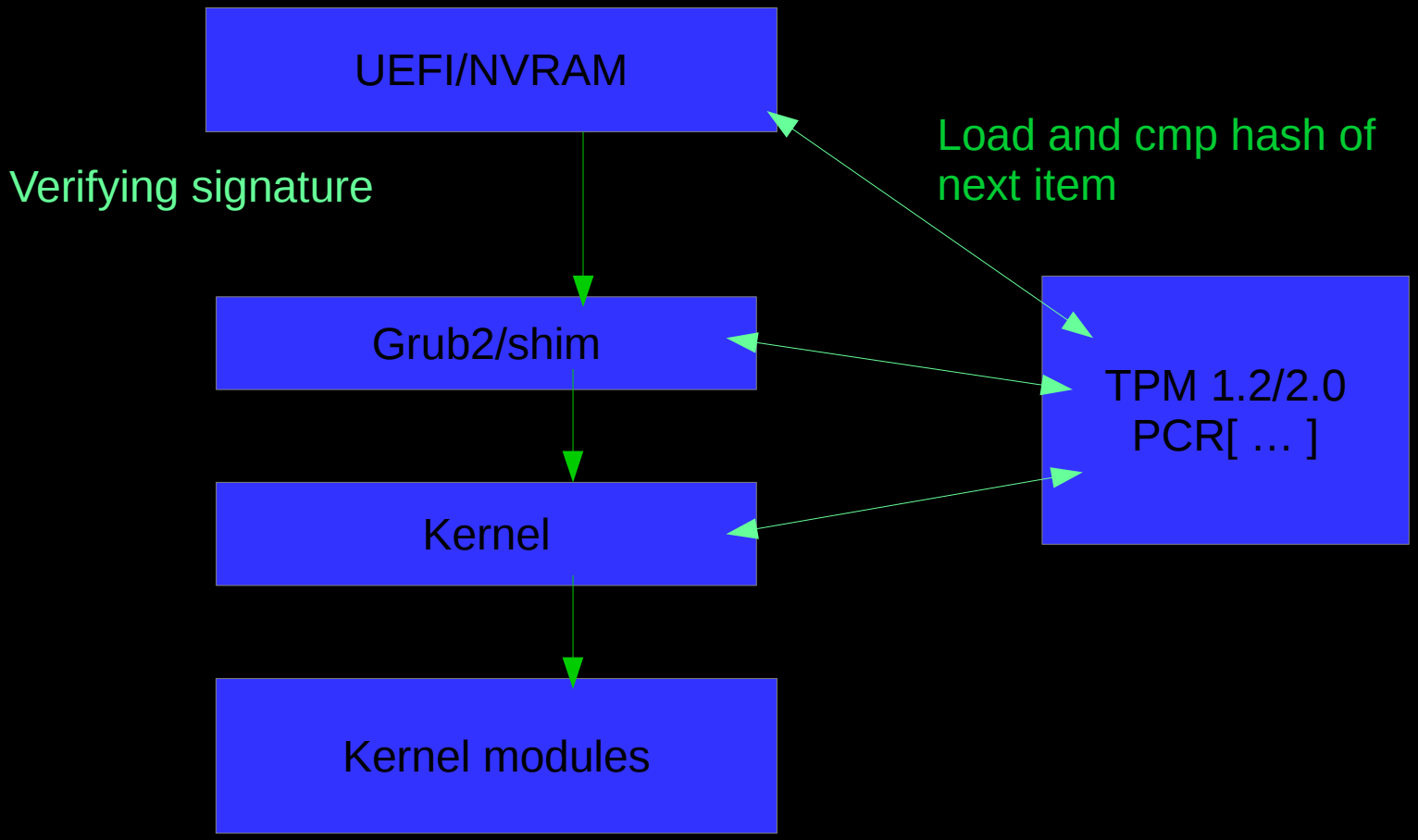
```
; arg int arg_8h @ rbp+0x8
   ; JMP XREF from 0x080051a6 (loc.08005195)
   ; CALL XREF from 0x080051b5 (loc.080051b5)
0x080051b5      e800000000      callq 0x80051ba                 ;[1]
   ; CALL XREF from 0x080051b5 (loc.080051b5)
0x080051ba      488b5508        movq arg_8h,%rdx                ; [0
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)            ; '0
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?

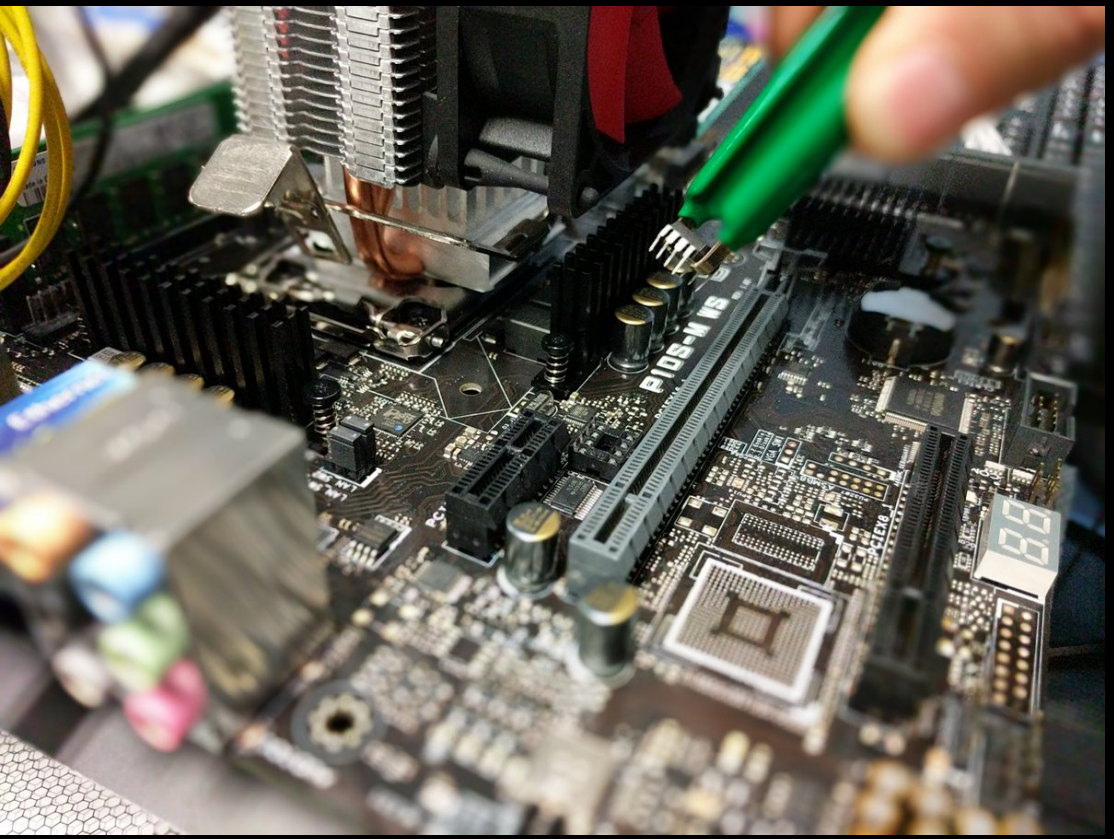
* Coreboot/FSP
* Libreboot
* Situational hardening
  * Old good machines for critical assets
  * Newer machines for generic purposes
  * Security needs some trade-off if performance is necessary: NERF/LinuxBoot
* Reference model for custom firmware
* Long-term plan: coreboot for RISC-V?

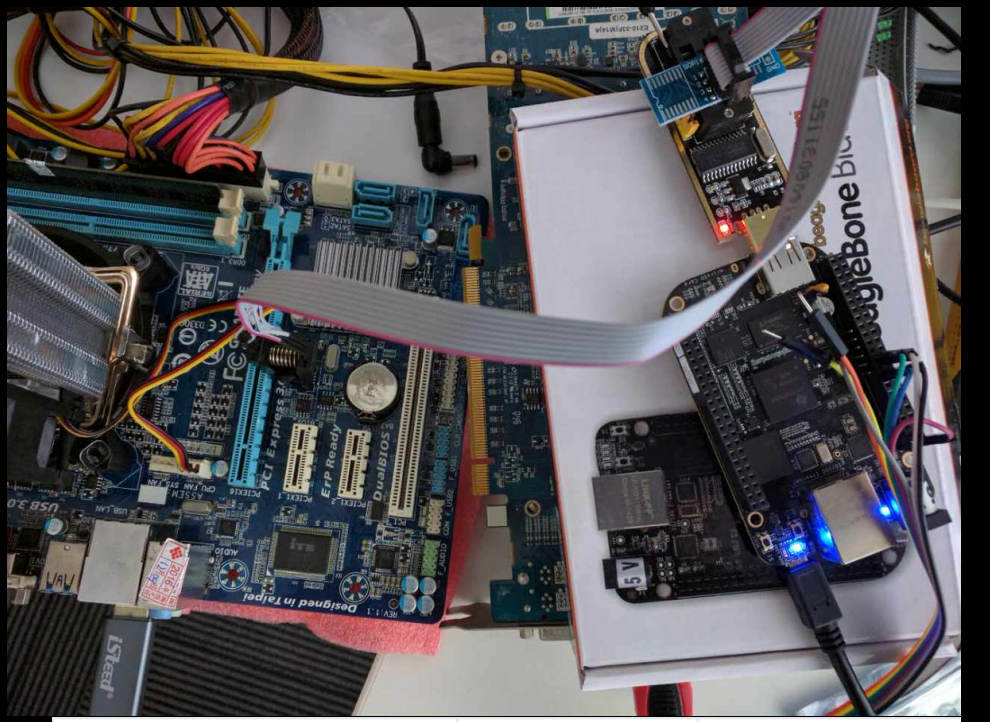
#Open == auditable

* 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

#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
Crypto Engineering
Firmware
Compiler
Security operations
Situational Hardening
KERNEL
Free/Libre & Open Source Software's eco-system:
+ GPL-compliance
+ Legislation
+ Education
Adversary
The West Of Middle Earth At The End Of The Third Age
FORODWAITH
Angmar
Mount Gunduband
Ered Mithrin
Iron Hills
ARNOR
HITHAEGLIR
ERED LUIN
Forlindon
Ettenmoors
Weather Hills
Rhudaur
Erebor (The Lonely Mountain)
Erareth on the Long Lake
ARTHEDAIN
Old Forest
The Shire
Bree
Rivendell
Mirkwood
East Bight
RHÛN
Sea of Rhun
Blue Mountains
Harlindon
ERIADOR
Eregion
MINHIRIATH
Dunland
Lorien
Fangorn
Isengard
The Brown Lands
ENEDWAITH
Helms
Ered Lithui (Ash Mountians)
N. Ithilien
Plateau of Gorgoroth
MORDOR
NURN
Anfalas
Lebennin
S. Ithilien

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