CLIP OS: Building a defense-in-depth OS with the Linux kernel and open source software

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Ready for IT

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About the ANSSI

- *Agence nationale de la sécurité des systèmes d'information*
- French authority in the area of cyberdefence, network and information security
- Provides its expertise and technical assistance to government departments and businesses and plays an enhanced role in supporting operators of vital importance.

CLIP OS project

CLIP OS?

- Linux distribution developed by the ANSSI
- Initially only available internally
- Now open source, mostly under the LGPL v2.1+
- Code and issue tracker hosted on GitHub[1][2]:
  - Version 4: available as reference and for upstream patch contribution
  - Version 5: currently developed version, alpha status, beta coming soon

[1] https://github.com/CLIPOS
[2] https://github.com/CLIPOS-Archive

CLIP OS?

Not yet another Linux distribution

- Not a generic/multi-purpose distribution

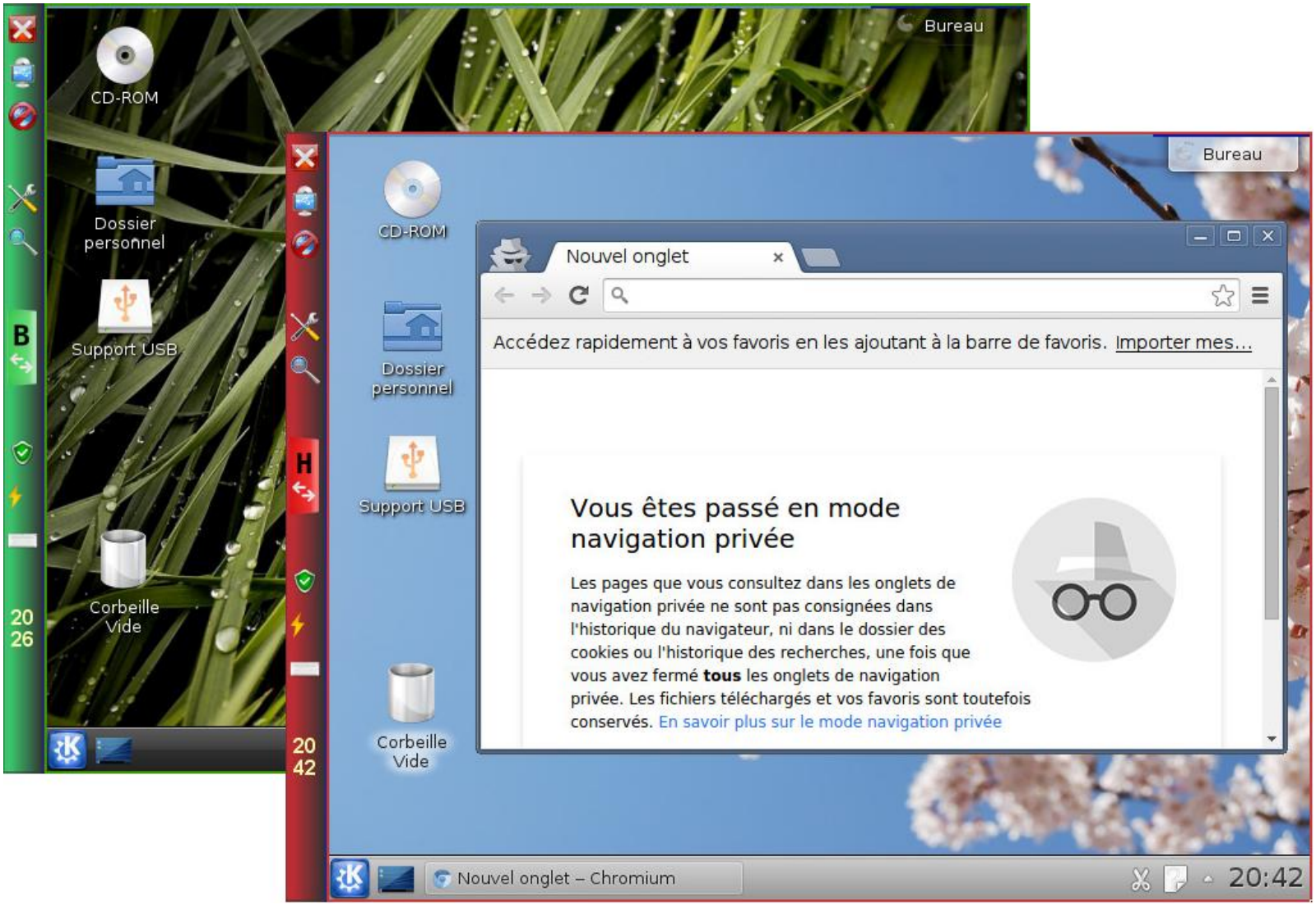
Targets three main use cases

- Office workstation
- Administration workstation
- IPsec gateway

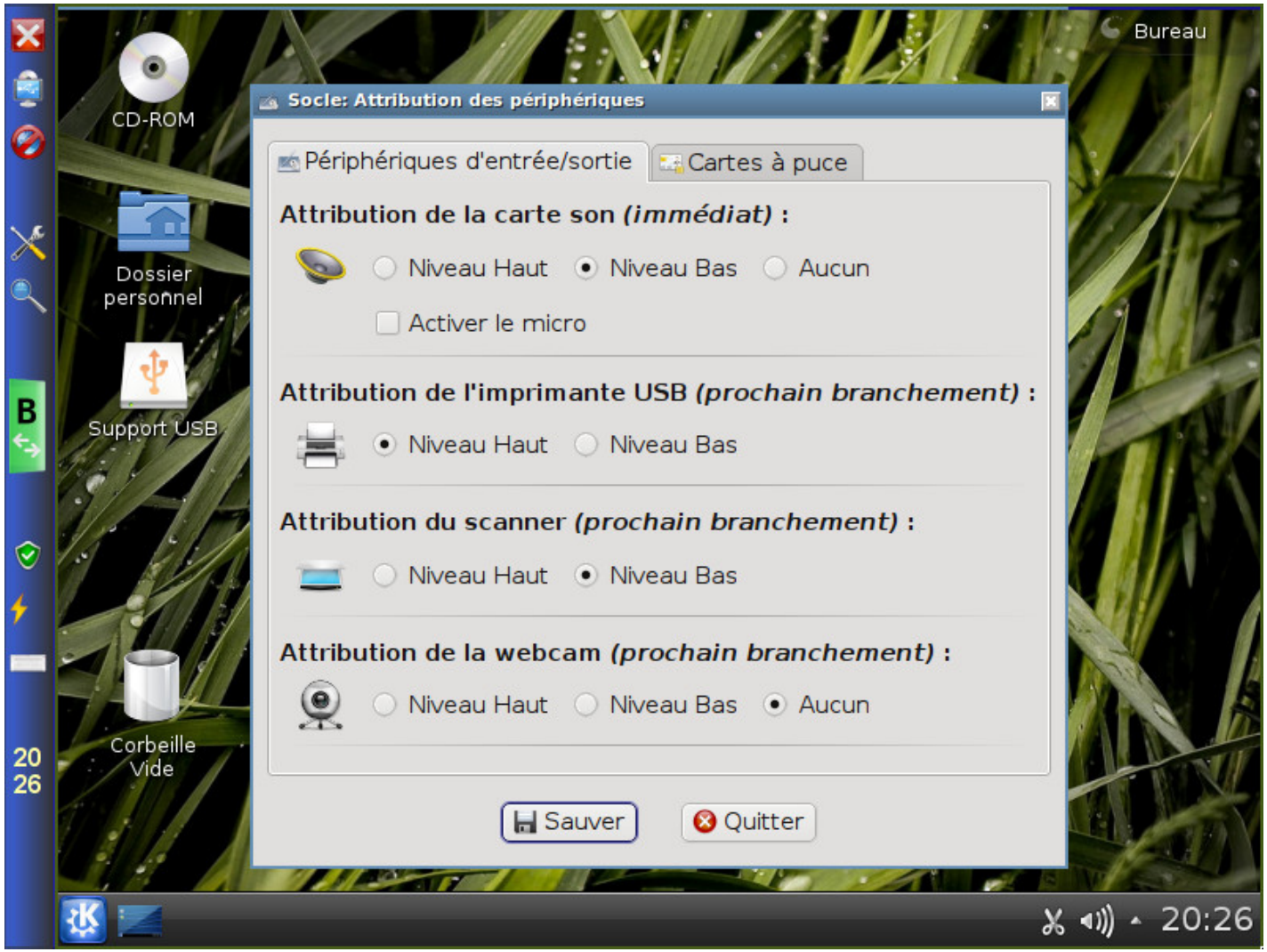
Hardened OS

- Based on Gentoo Hardened
- Hardened Linux kernel and confined services
- No interactive *root* account available:
  $\Rightarrow$ "Unprivileged" admin, audit and update roles
- Automatic updates using A/B partition model (similar to Android 7+)
- Multilevel security:
  - Provide two isolated user environments
  - Controlled interactions between isolated environments

Multilevel from the end user point of view (v4)



Admin panel: devices assignment per level (v4)



Differences with Qubes OS

CLIP OS development began 5 years earlier than Qubes OS

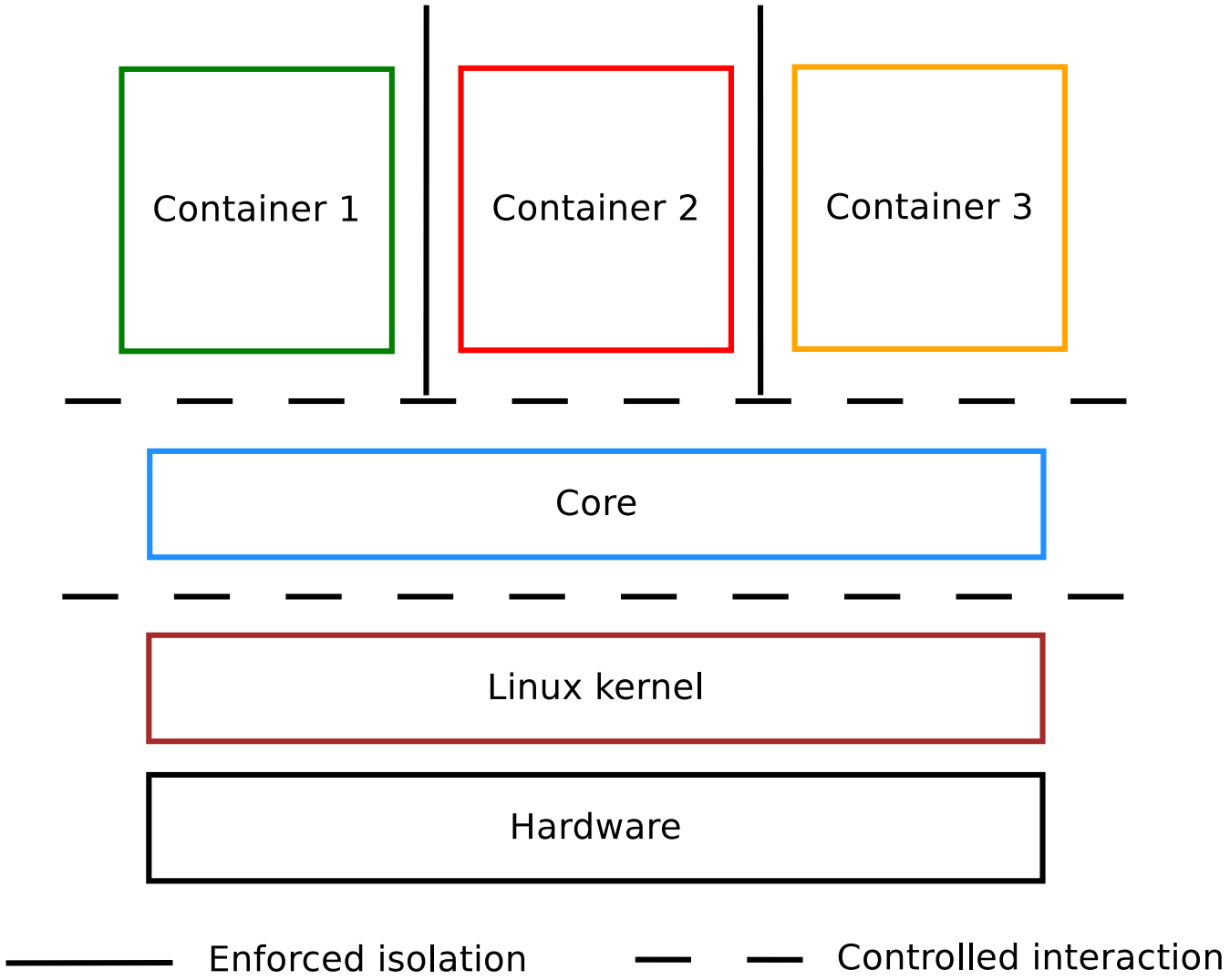
Main goals

- We target non-expert users
- Multilevel security model with two levels
- We favor a defense-in-depth approach

Technical point of view

- Hypervisor (Qubes OS) vs. supervisor isolation (CLIP OS)
- CLIP OS: Limited access rights and capabilities, even for administrators

General architecture overview



Project status (v5)

- First alpha release in September 2018
- Now close to beta release
- Current use-case: server & virtualization (no graphical user interface)

```
This is clipos-qemu.unknown_domain (Linux x86_64 5.0.14-clipos) 14:07:12

Hint: Num Lock on

clipos-qemu login: root
clipos-qemu ~ # lsblk
NAME                          MAJ:MIN RM  SIZE RO TYPE  MOUNTPOINT
vda                           254:0    0   20G  0 disk
|-vda1                        254:1    0  512M  0 part  /mnt/efiboot
`-vda2                        254:2    0 19.5G  0 part
  |-mainvg-core_5.0.0--alpha.1 253:0    0    4G  0 lvm
  | `-verity_core_5.0.0-alpha.1 253:3    0  177M  1 crypt /
  |-mainvg-core_state          253:1    0  512M  0 lvm
  | `-core_state_dif           253:4    0  474M  0 crypt
  |   `-core_state             253:5    0  474M  0 crypt /mnt/state
  `-mainvg-core_swap           253:2    0    1G  0 lvm
    `-swap                     253:6    0    1G  0 crypt [SWAP]
clipos-qemu ~ # uname -sr
Linux 5.0.14-clipos
clipos-qemu ~ # _
```

Security features

Goals

- High resistance to remote or local exploits
- Defense in depth: limit impact of successful exploits
- Limited options for attacker persistence

Currently available

- Minimal system and hardened applications
- Curated Linux kernel configuration and hardware profiles
- Confined services, user and roles
- No arbitrary code execution ($W \oplus X$) enforced system wide
- Full boot chain integrity with UEFI Secure Boot
- Password-less encrypted partitions with TPM 2.0 support
- Expected for beta: Automatic, atomic, in-background updates

Development and contribution

Development workflow:

- Install dependencies
- Retrieve sources
- Automated build steps
- Test in a QEMU virtual machine

See full documentation at `https://docs.clip-os.org`:

Conclusion

Open source project

- Sources: https://github.com/CLIPOS
- Bugs: https://github.com/CLIPOS/bugs
- Code review: https://review.clip-os.org

- Built to be reusable for other use cases
- Fell free to come and talk to us at the ANSSI stand!

Thanks!

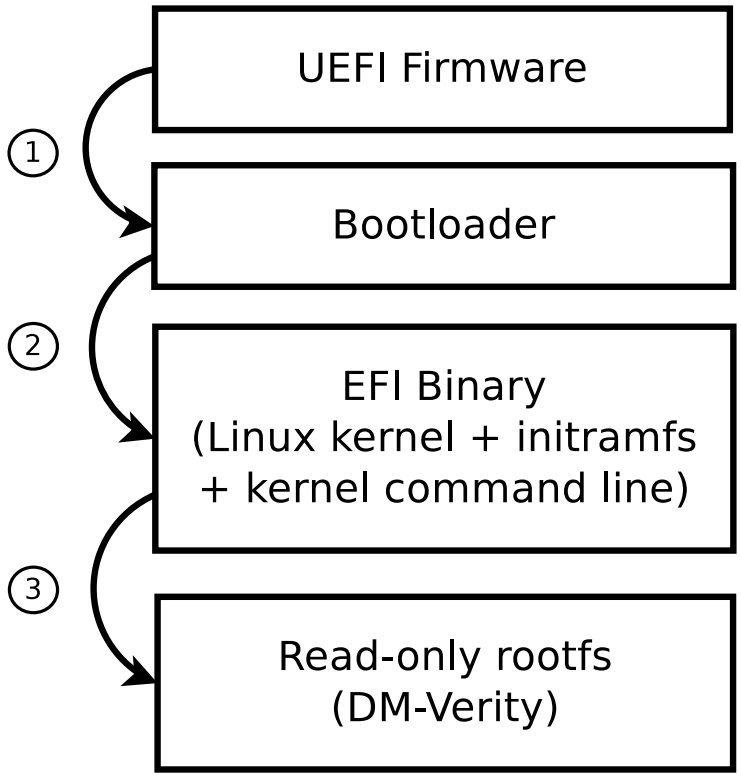
✉ clipos@ssi.gouv.fr

- Website: clip-os.org
- Docs: docs.clip-os.org
- Sources: github.com/CLIPOS
- Bugs: github.com/CLIPOS/bugs

Full boot chain integrity guarantee

Guarantee full system integrity even in the event of a system compromise

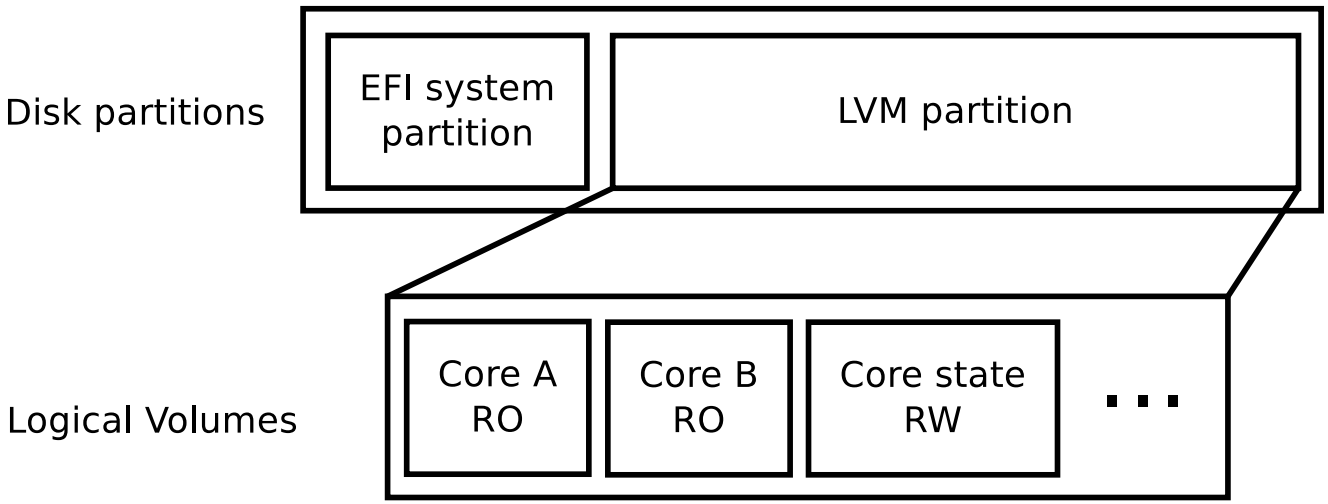
- Will only boot if the system's integrity can be cryptographically verified
- Based on UEFI Secure Boot feature:
  - Signed bootloader, initramfs, Linux kernel and its command line
  - Read-only system partition (Squashfs) protected by DM-Verity (with forward error correction)
  - Custom keys (i.e. not signed by Microsoft, requires enrollment in hardware)



No arbitrary code execution: W ⊕ X

Defense in depth and difficulty for an attacker to persist post compromission

- Strict split between:
  - Read Only: system executables, configuration and data (DM-Verity)
  - Read Write: runtime configuration, logs, user and application data (DM-Crypt+DM-Integrity)

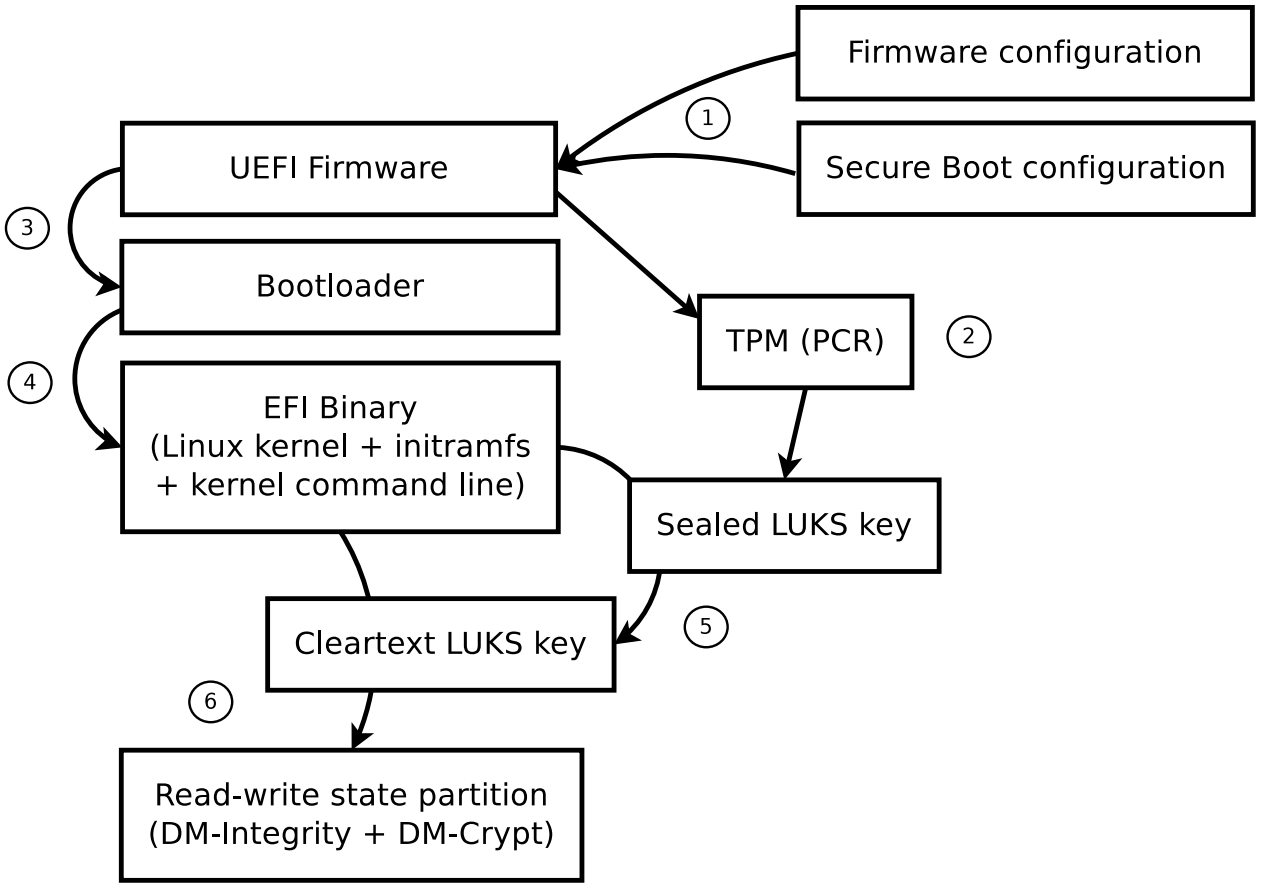


- Interpreter support (Bash, Python, etc.) currently in progress upstream[3]

[3] See the talk at Kernel Recipes 2018, Paris (https://clip-os.org/en/talks)

Password-less encrypted partitions

- Automatic secret sealing & unsealing with a TPM 2.0
- Based on boot chain integrity measurements



Hardened Linux kernel and curated hardware profiles

Hardened Linux kernel

- Based on latest upstream stable kernel
- Includes hardening patches: lockdown, linux-hardened, stackleak
- Security focused build configuration (KCONFIG)
- Security focused runtime configuration (sysctl)

Curated hardware profiles

- Per hardware profile selection of firmware and kernel modules
- Currently available hardware profiles (easily extended):
  - QEMU/KVM virtual machine
  - Lenovo X260

Roadmap: Beta

Completed

- "Unprivileged" admin, audit and update roles
- SSH server (for audit, admin and debug)

In progress

- Client for automatic updates:
  - Unattended, in background, updates (i.e. effective on reboot)
  - User controlled rollback at boot time
- Confined IPsec client
- Basic network (DHCP, static IP) and firewall (static rules) support

Roadmap: 5.0 stable

- Confined user environments (GUI)
- Multilevel support (Vserver-like LSM)
- Automated installation using PXE
- etc.