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\(^1\)
  - Version 4: available as reference and for upstream patch contribution
  - Version 5: currently developed version, alpha status, beta coming soon

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\(^1\) [https://github.com/CLIPOS](https://github.com/CLIPOS)

\(^2\) [https://github.com/CLIPOS-Archive](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:
  - "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

- Container 1
- Container 2
- Container 3

- Core
- Linux kernel
- Hardware

Enforced isolation  Controlled interaction
Project status (v5)

- First alpha release in September 2018
- Now close to beta release
- Current use-case: server & virtualization (no graphical user interface)
# 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
- Feel free to come and talk to us at the ANSSI stand!
Thanks!

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🌐 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: $W \oplus X$

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

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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.