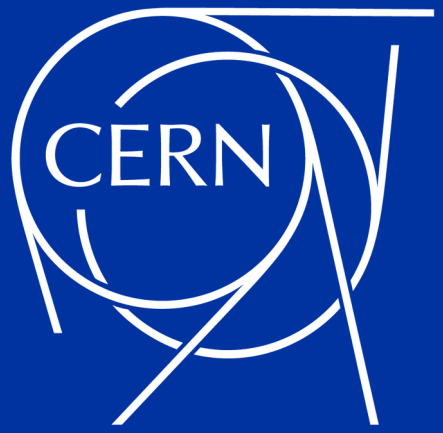


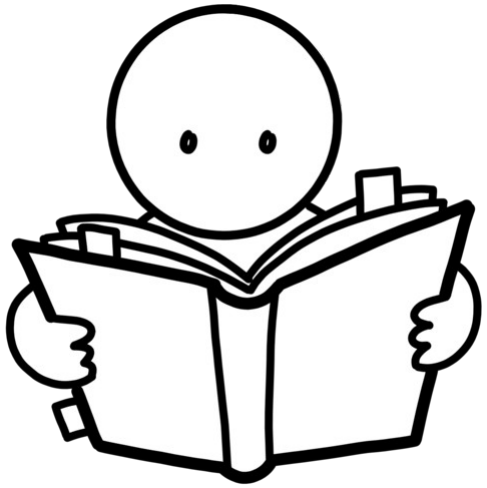
Front-End Computers Operating System A Common OS For IPC and SoC in ATS

Federico Vaga

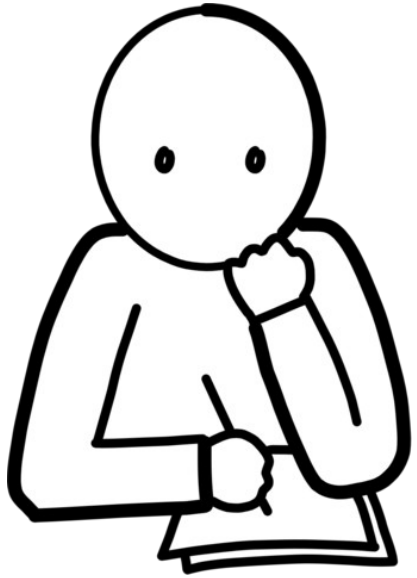
2023-10-06

Who am I?

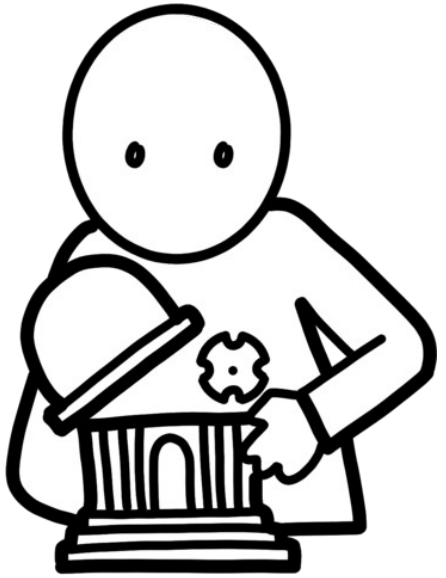
- **I work in CERN BE-CEM-EDL**
  - Beam department
  - Control Electronics and Mechatronics group
  - Electronic Design and Low level software section
- **I’m a Software Engineer, specialized in:**
  - Linux kernel development
  - Linux systems setup



Context
~ 5 min



Thinking
~ 10 min

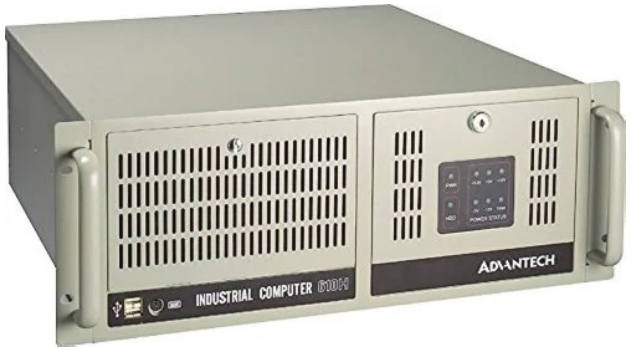


Doing
~ 5 min

History is a gallery of pictures in which there are many copies and few originals.

~ Alexis de Tocqueville

From 2008 To 2026



PowerPC

LYNXOS®

intel

5

intel

6

intel

7

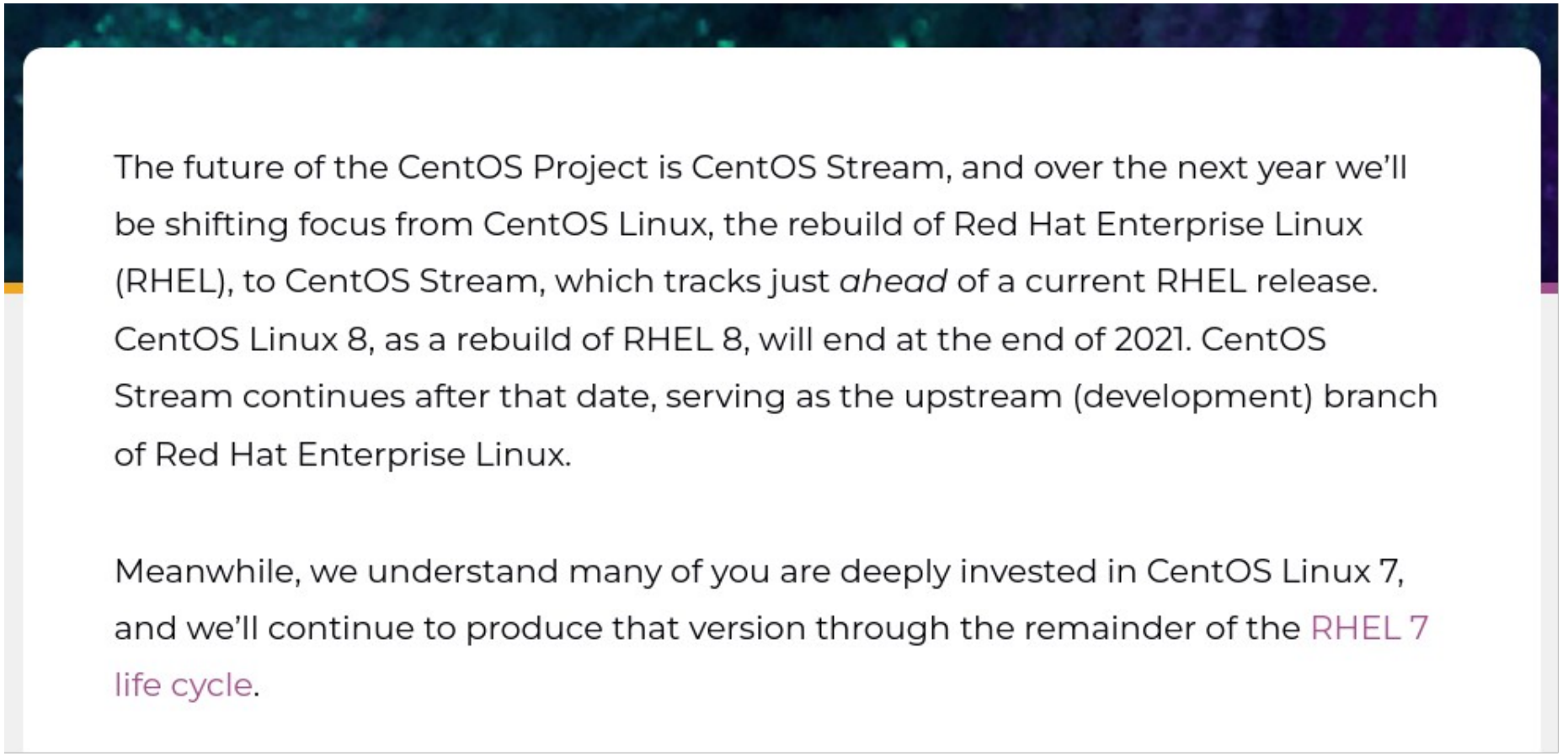
Scientific Linux

CentOS

2008 → 2024 (EOL) --→ 2026 (extension) - · - · - · - ·▶

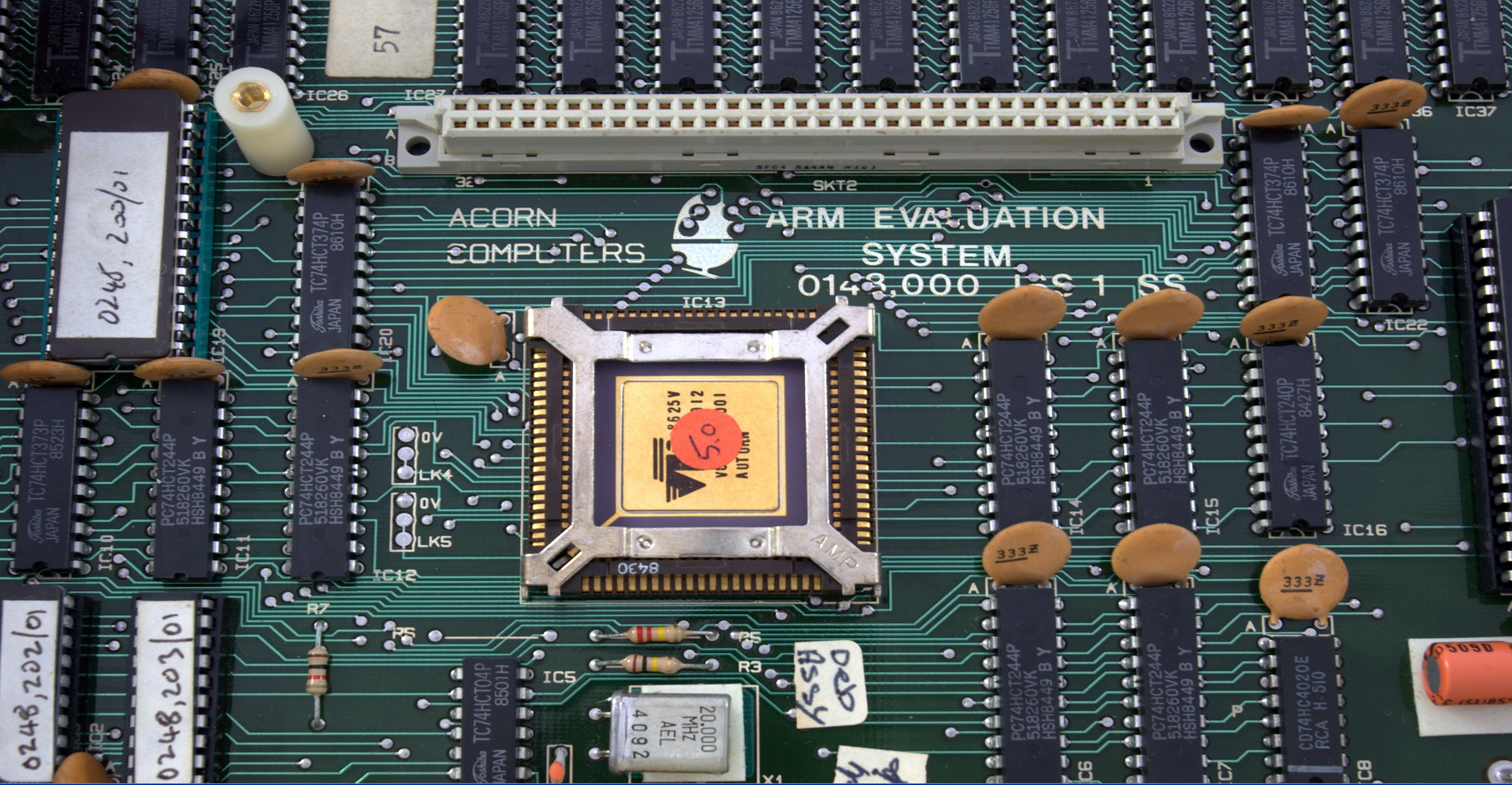
Red Hat Enterprise Linux Family Drama 2020 [1]

CentOS Project shifts focus to CentOS Stream

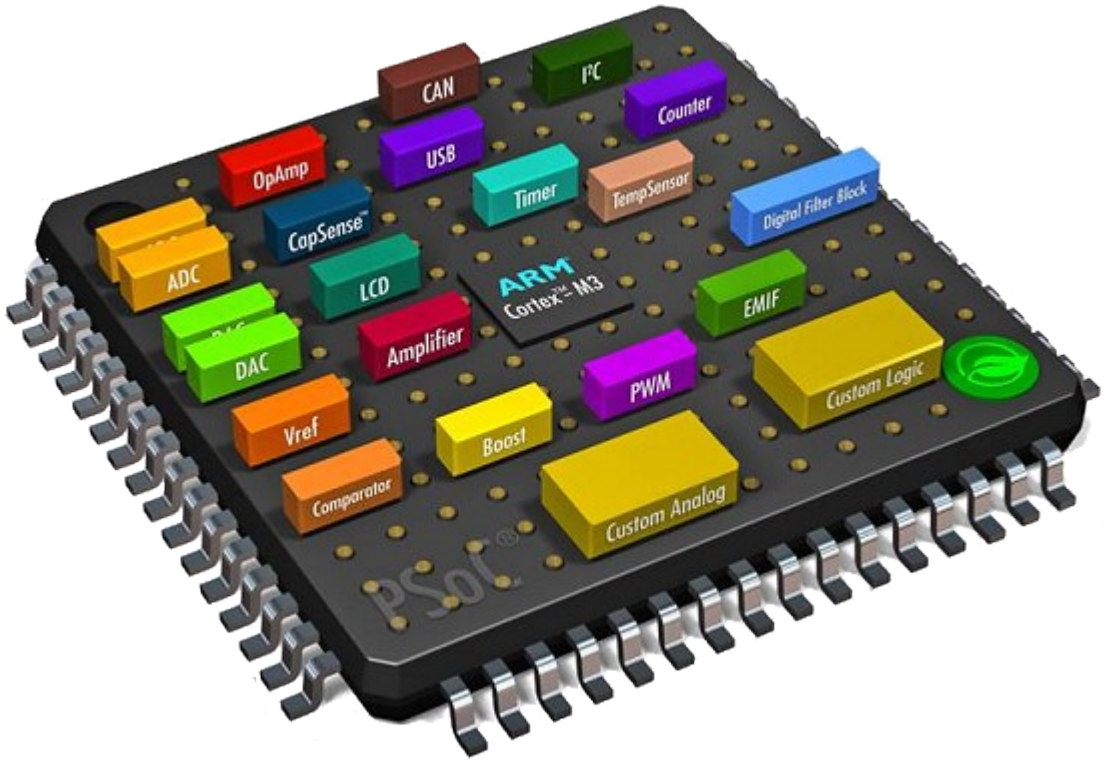


The future of the CentOS Project is CentOS Stream, and over the next year we'll be shifting focus from CentOS Linux, the rebuild of Red Hat Enterprise Linux (RHEL), to CentOS Stream, which tracks just *ahead* of a current RHEL release. CentOS Linux 8, as a rebuild of RHEL 8, will end at the end of 2021. CentOS Stream continues after that date, serving as the upstream (development) branch of Red Hat Enterprise Linux.

Meanwhile, we understand many of you are deeply invested in CentOS Linux 7, and we'll continue to produce that version through the remainder of the RHEL 7 life cycle.


ACORN
COMPUTERS
ARM EVALUATION
SYSTEM
SKT2
IC13
IC12
IC16
IC22
IC5
R7
R3
LK4
LK5
0V
AMP
8430
20.000 MHz
AEL

The “New” Technology: System-On-Chip



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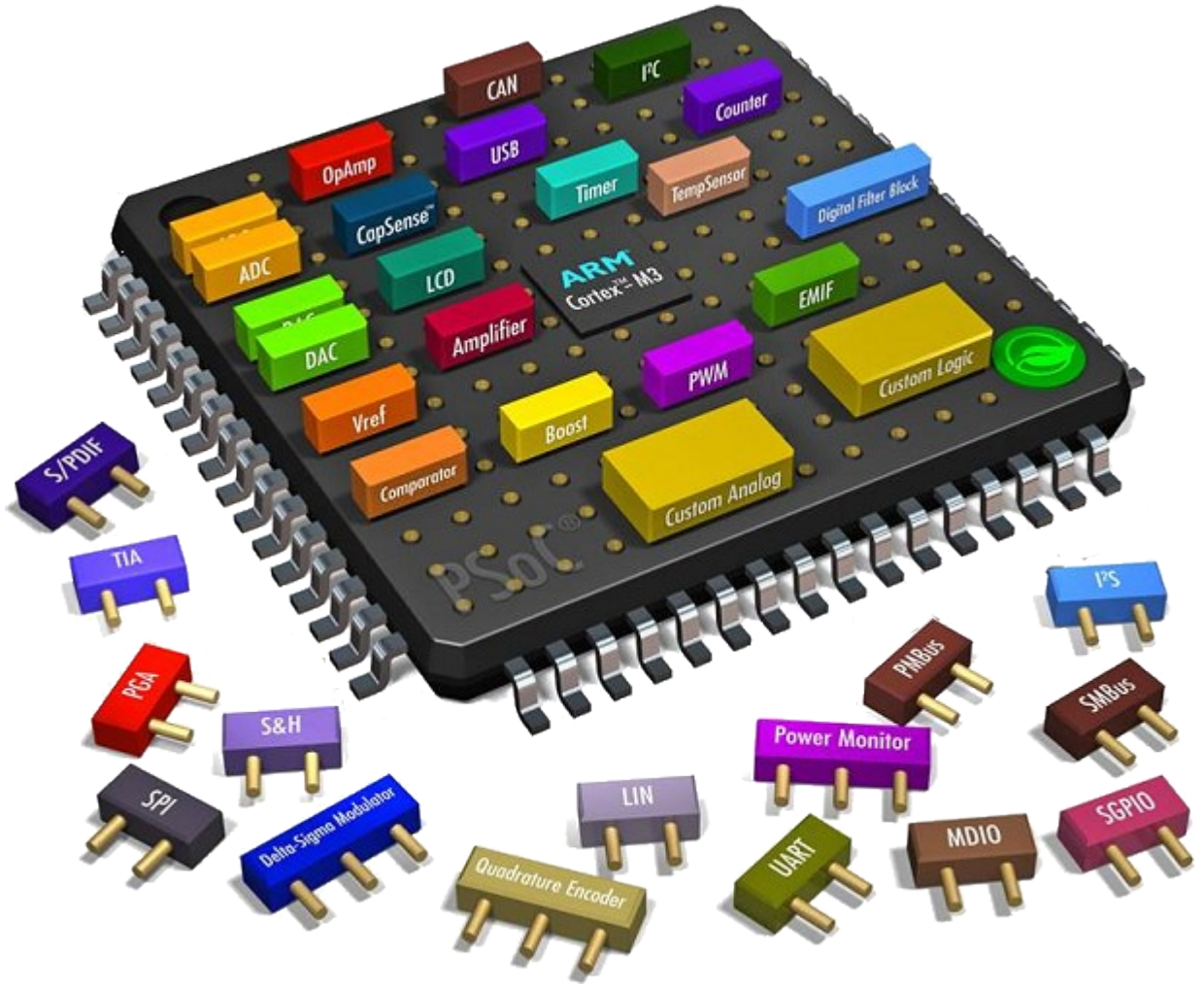
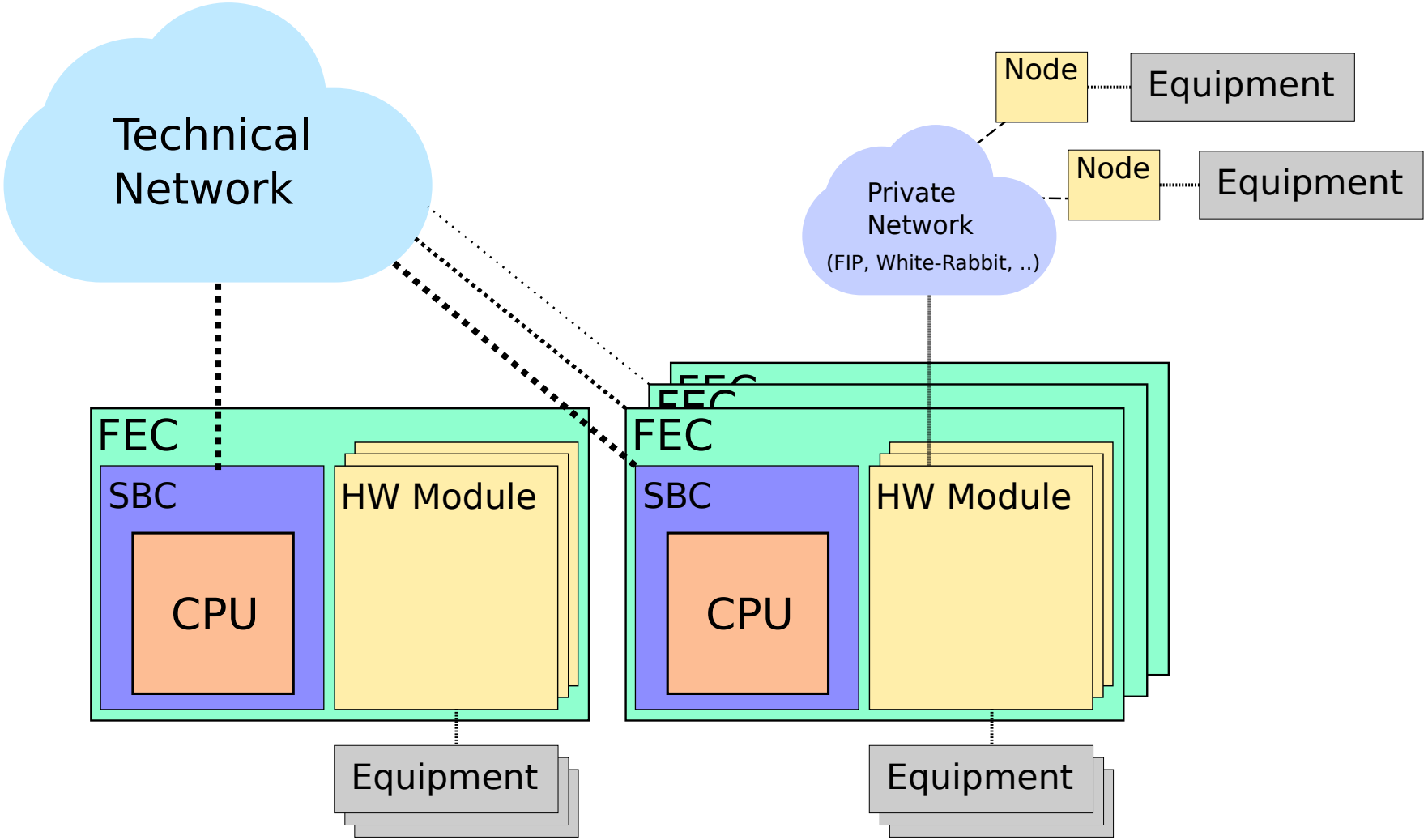


Front-End Computers (FEC): Overview



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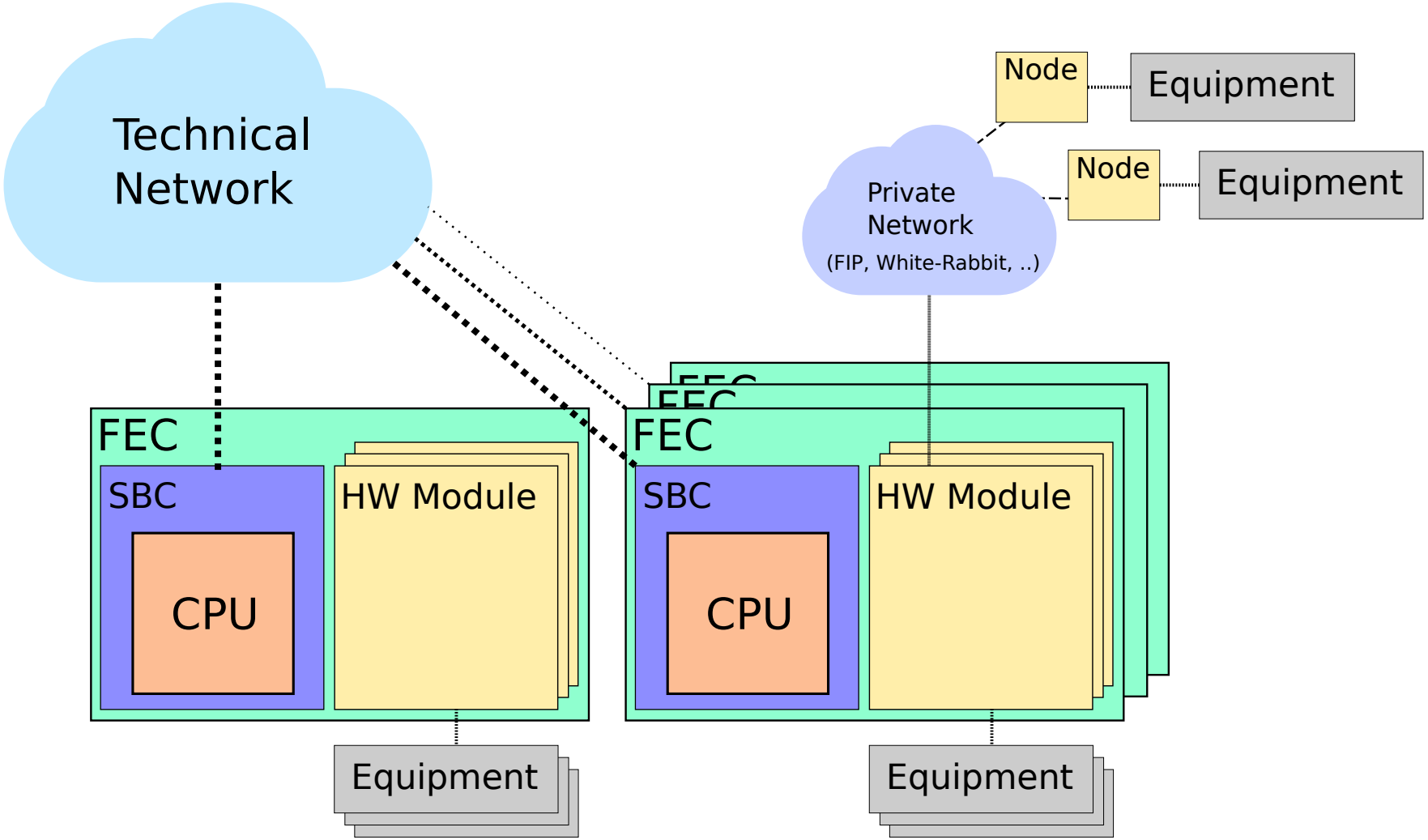

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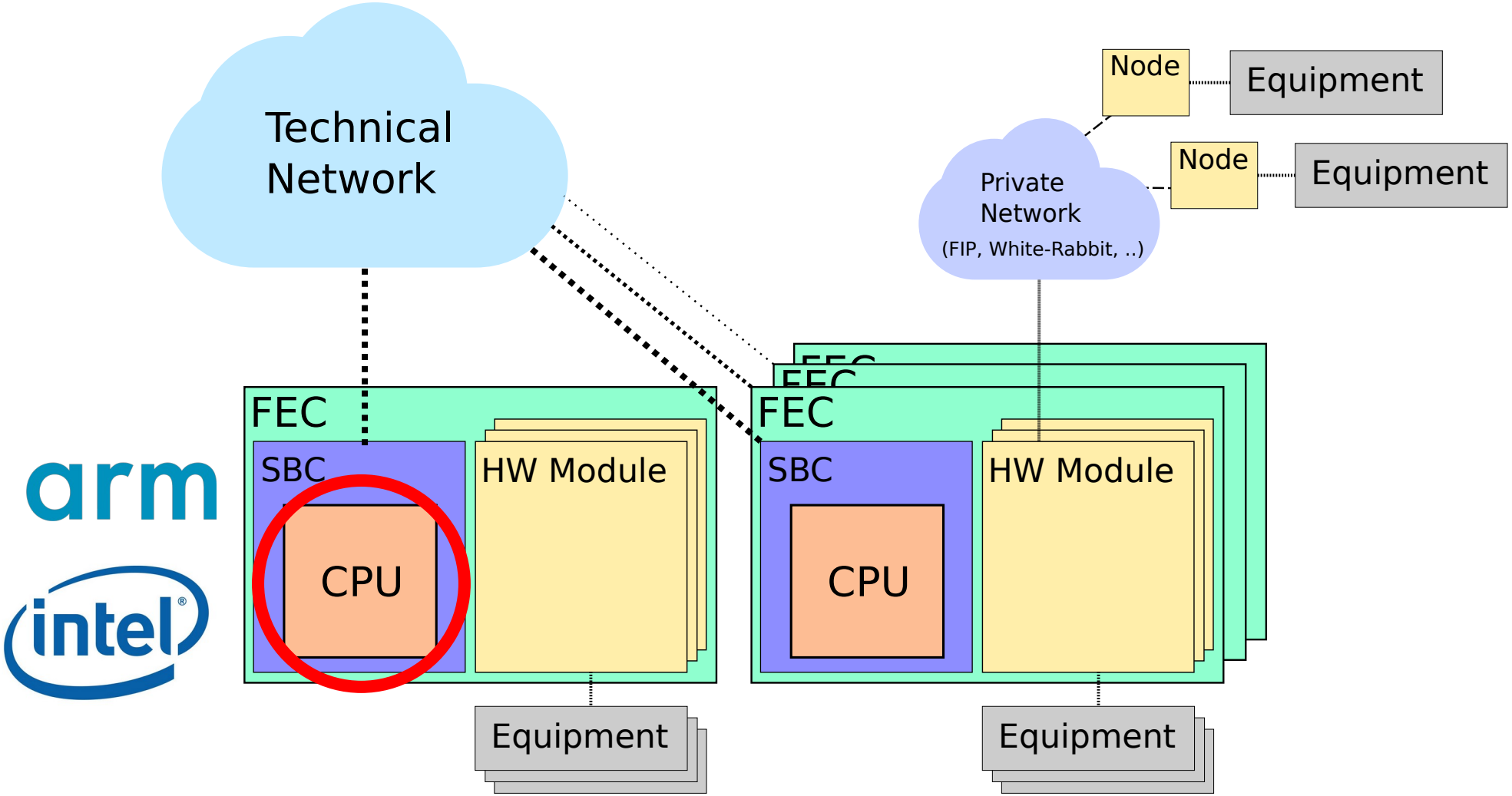

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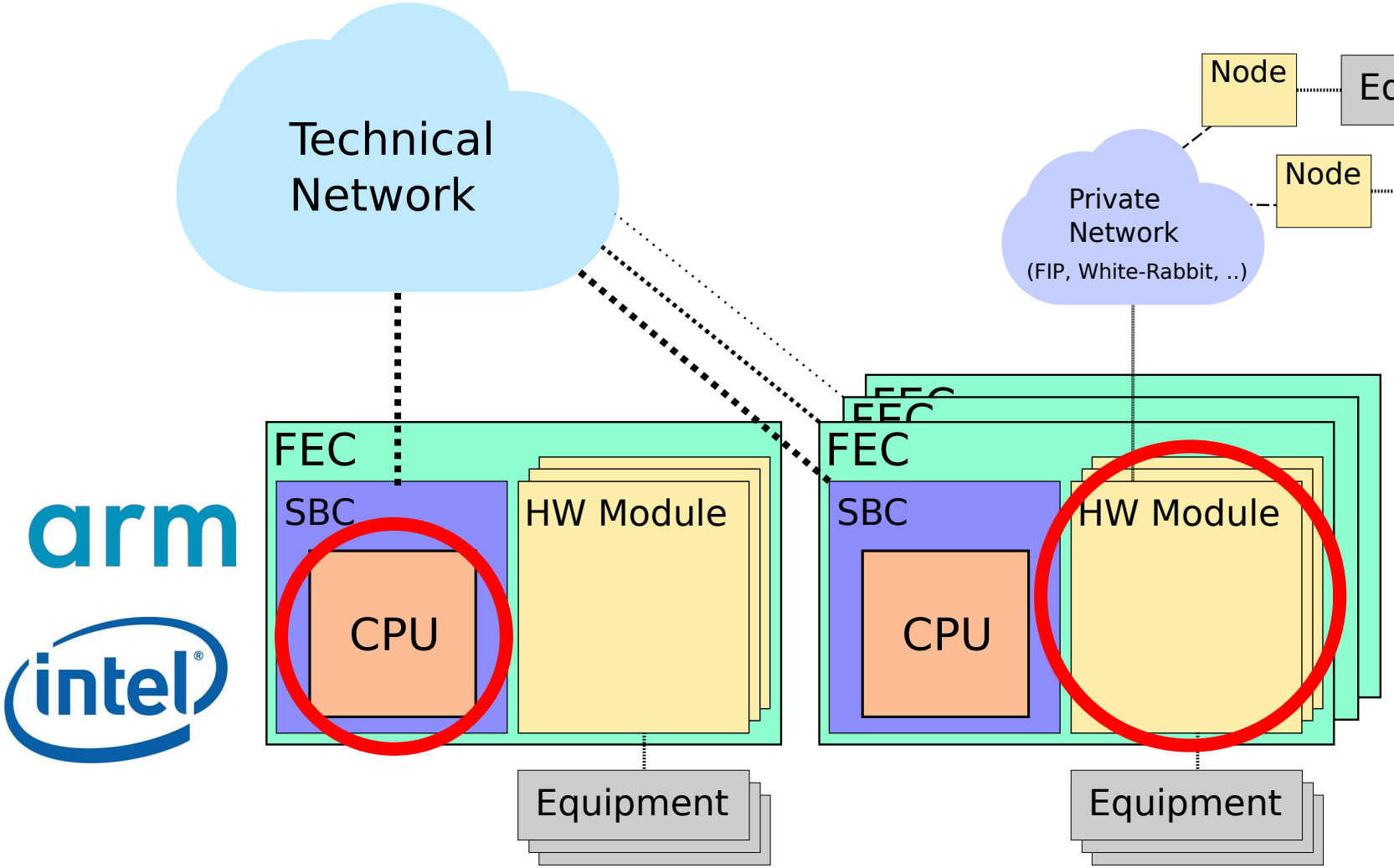
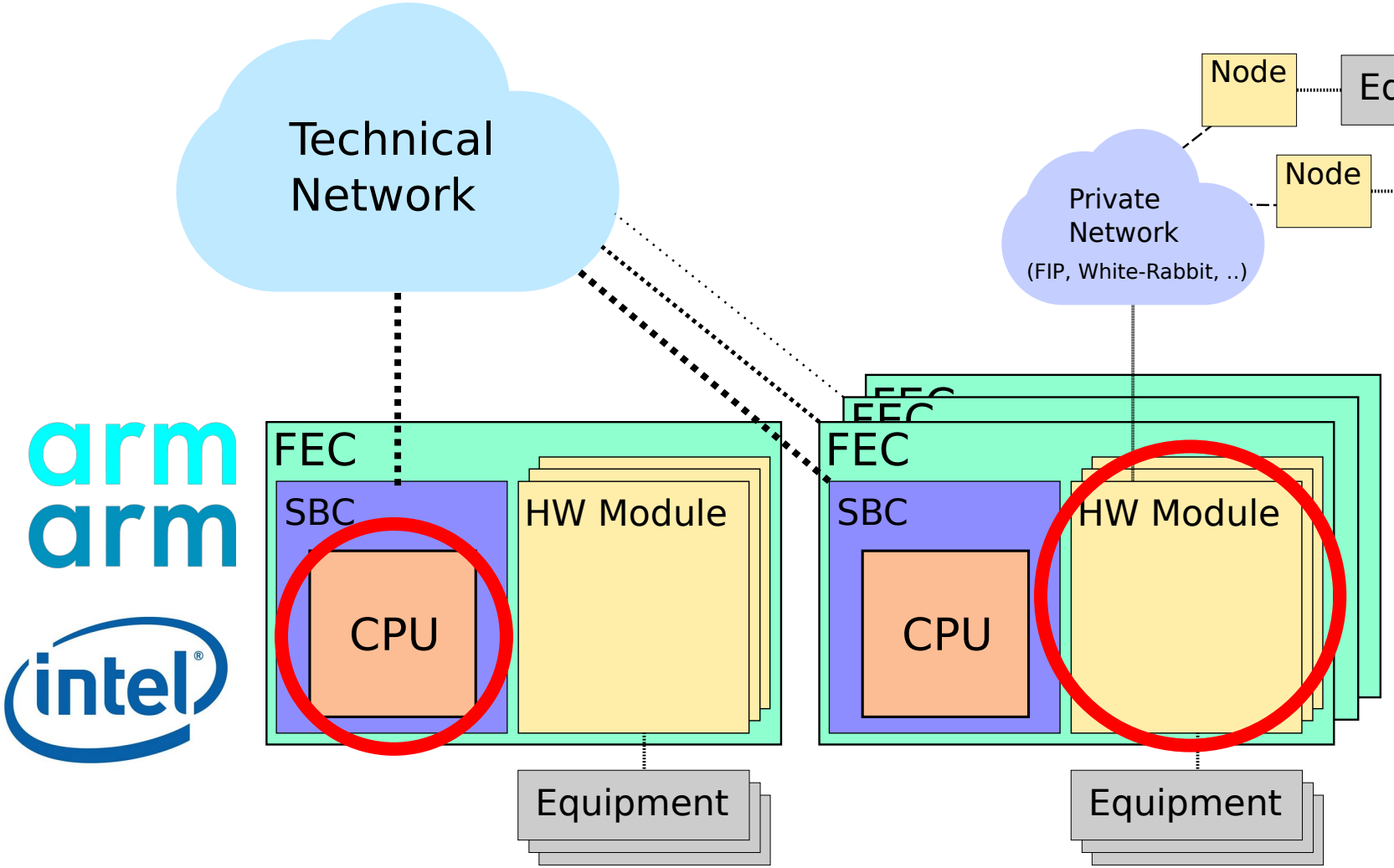


Custom

Front-End Computers (FEC): Overview



Custom

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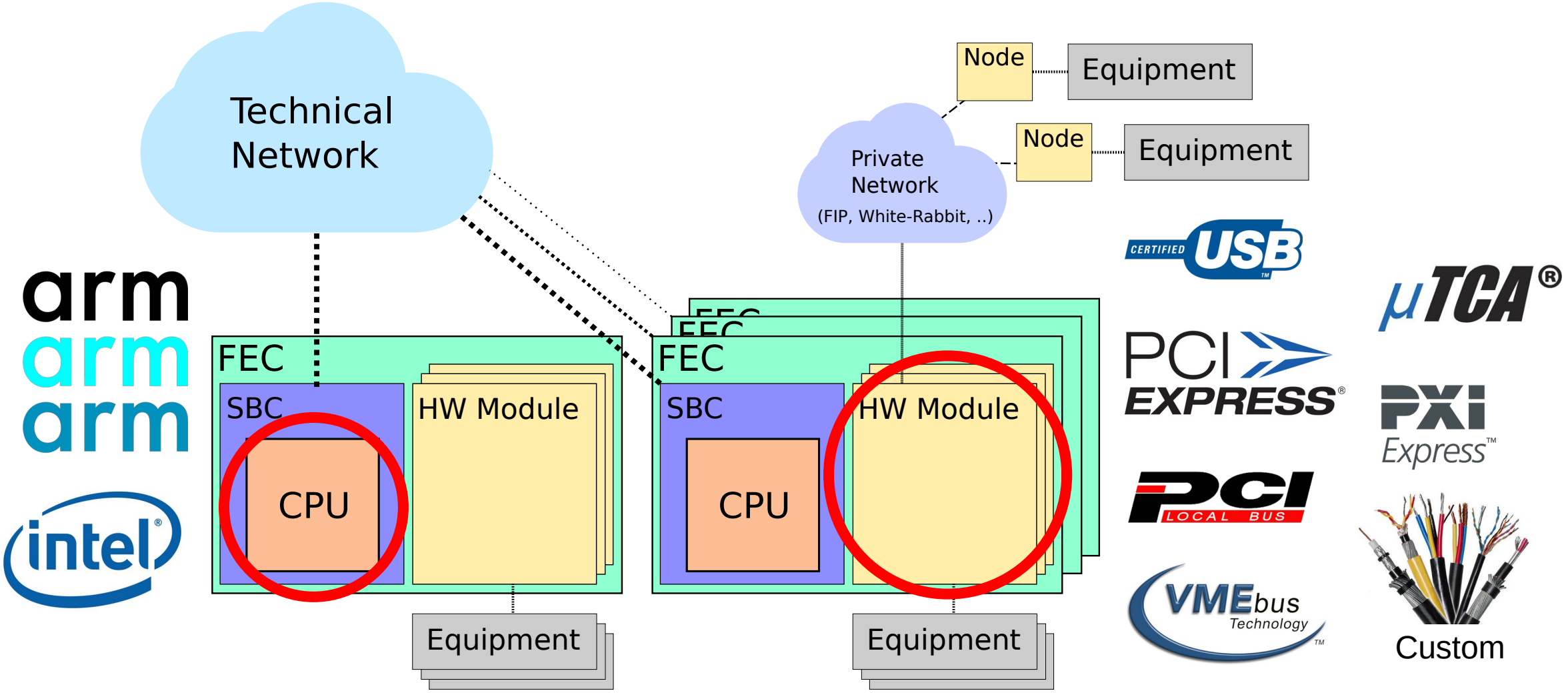

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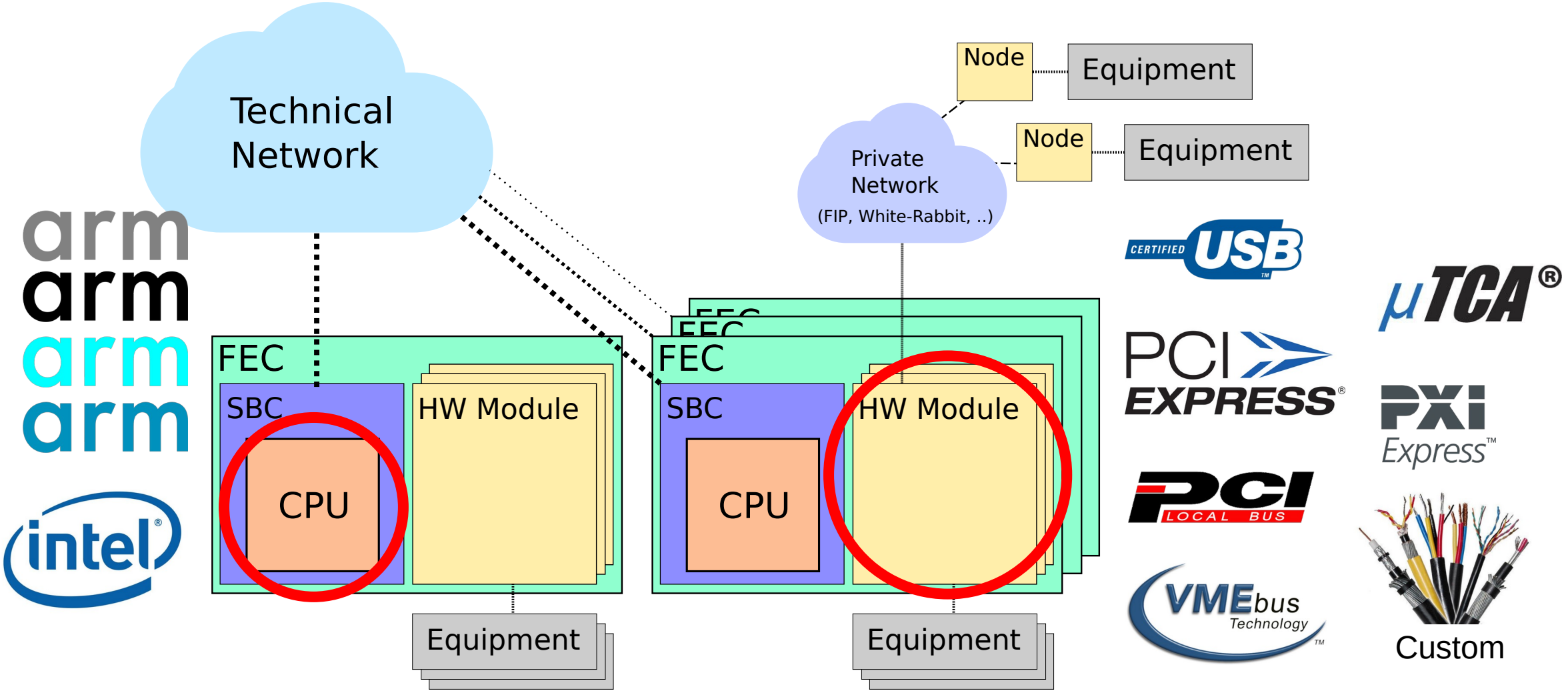
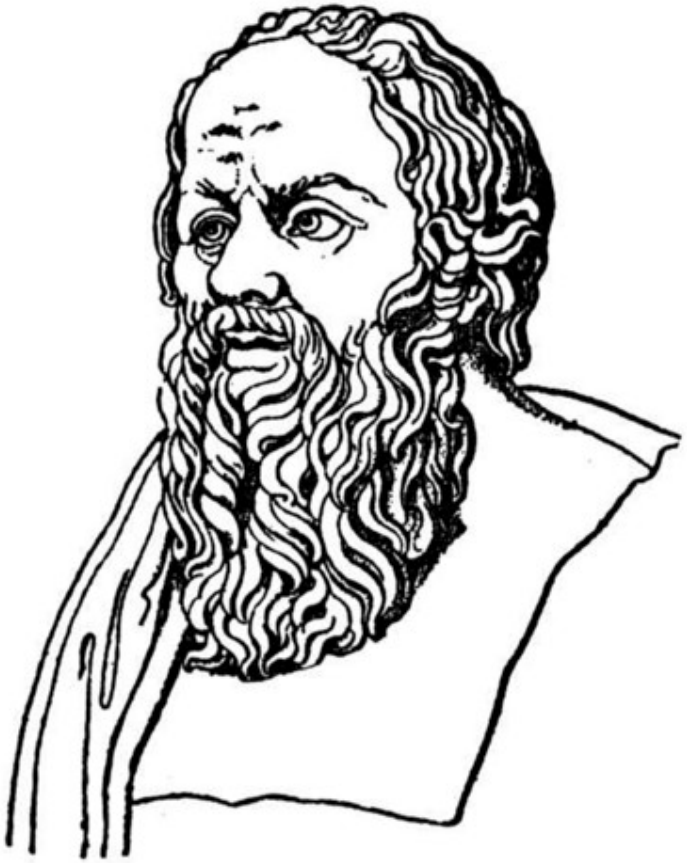


Open Questions In 2021

- **What to use after CentOS 7 On Front-End Computers?**
- **Can we reduce maintenance by running the same OS on SoC?**
- **How do we handle the need for different kernels?**
  - Different architectures
  - Different versions
  - Different configurations
- **Can we support more users with little additional effort?**
- **How hard is it to be ready for today “exotic” use cases?**

To know thyself is the beginning of wisdom.

~ Socrates

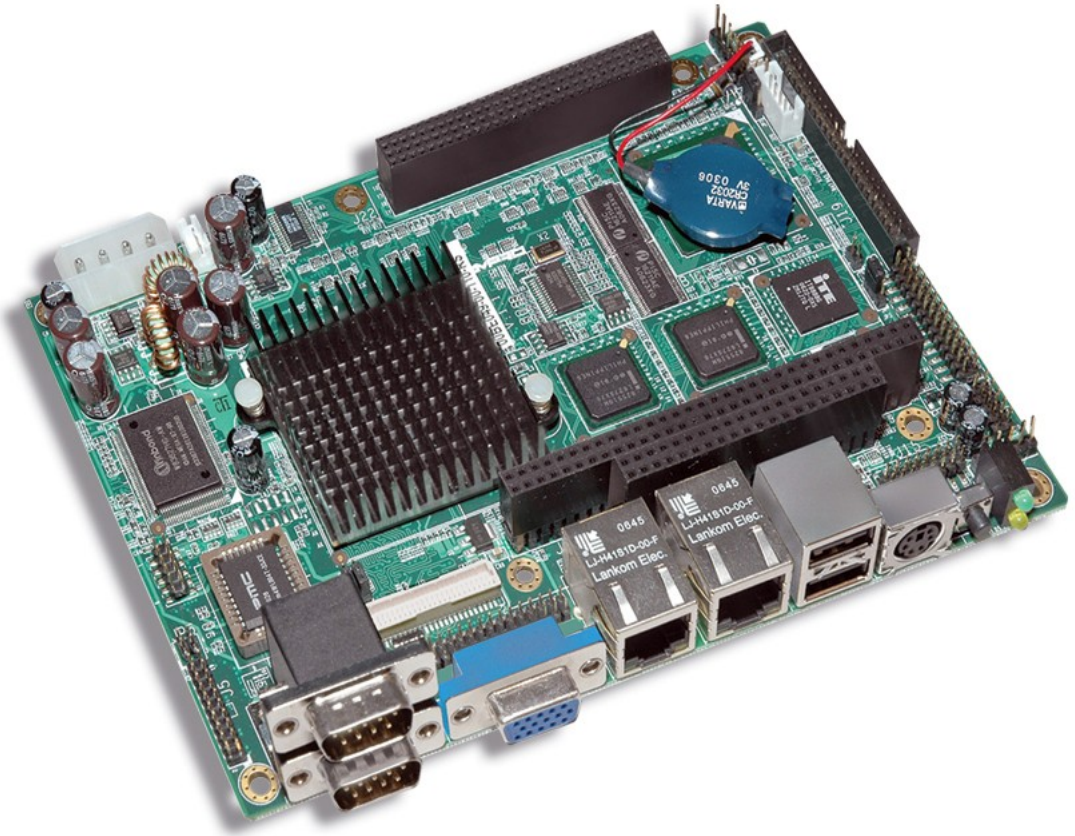


Definition

embedded system

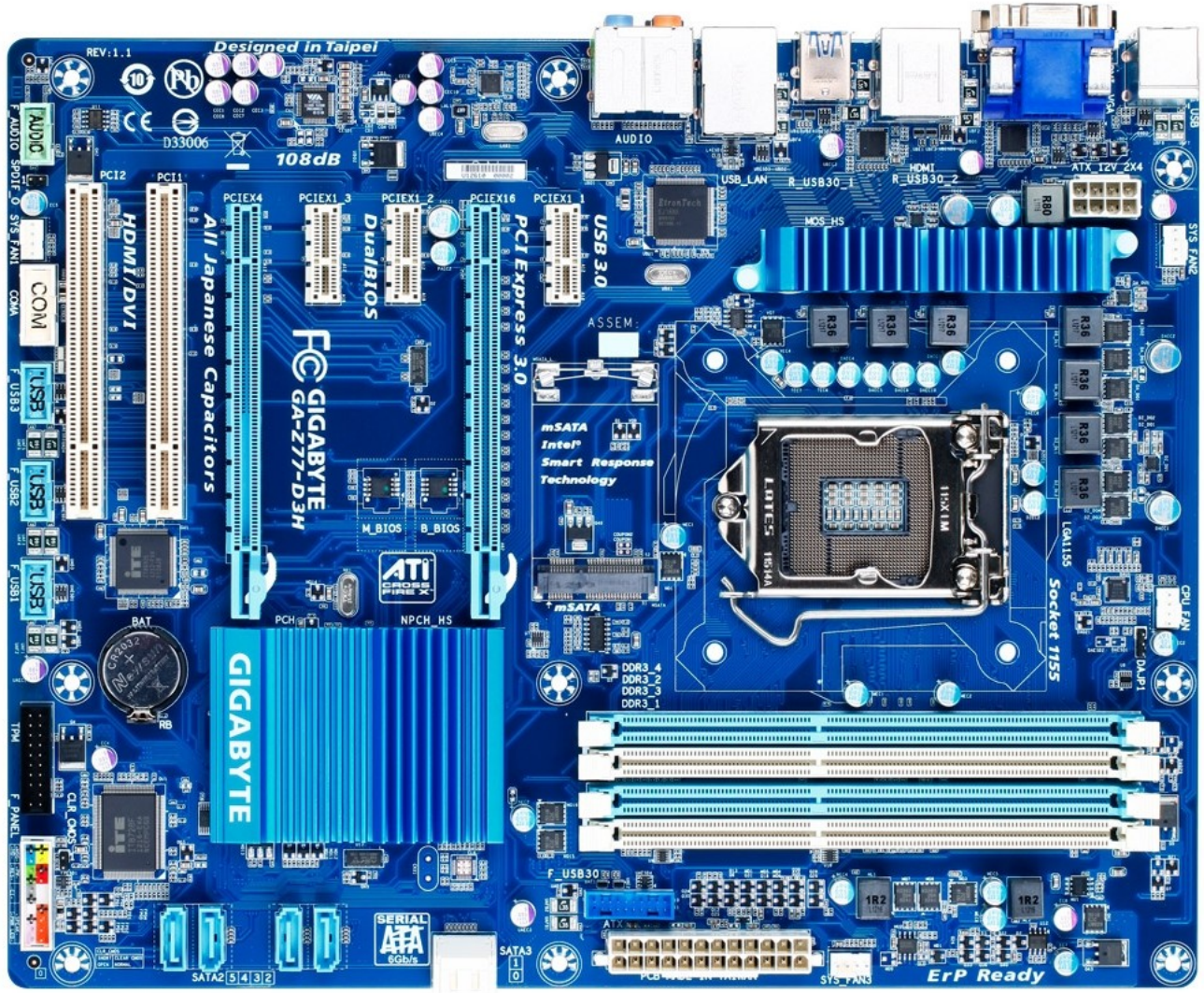
A combination of computer hardware and software, and perhaps additional mechanical or other parts, designed to perform a dedicated function. In some cases, embedded systems are part of a larger system or product.

Embedded Systems



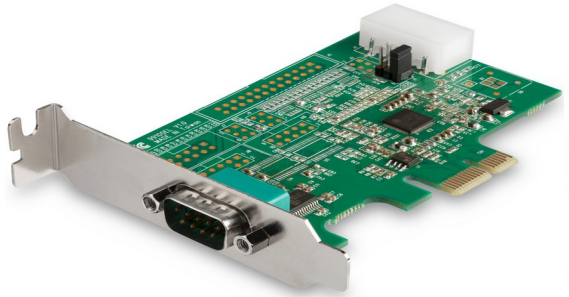
yocto PROJECT

~~Embedded Systems~~



Embedded Systems ?

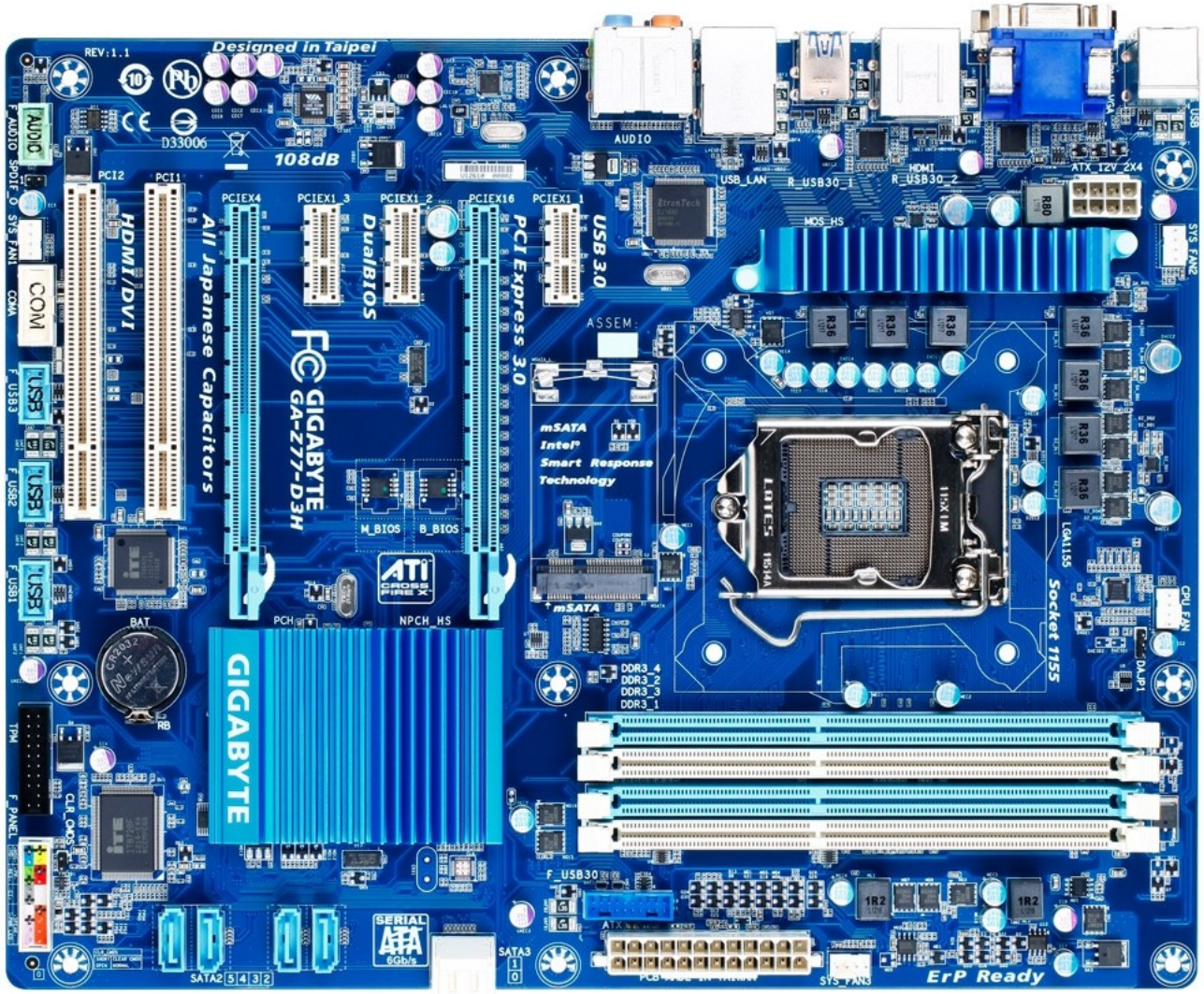
CAN Bus



Serial Bus

Digital IO

Custom Card

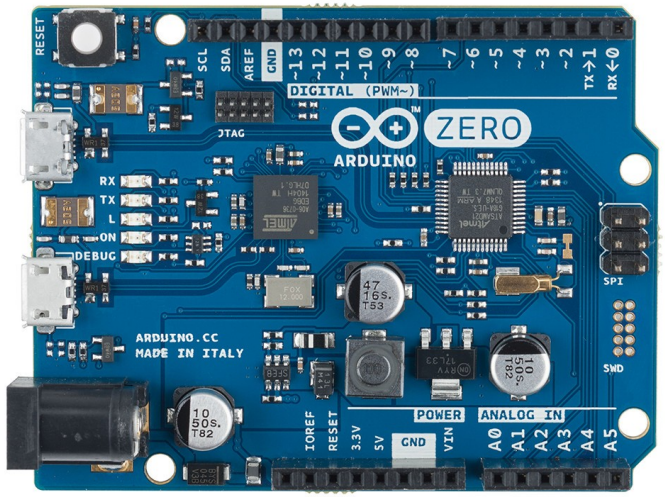


Embedded Systems !

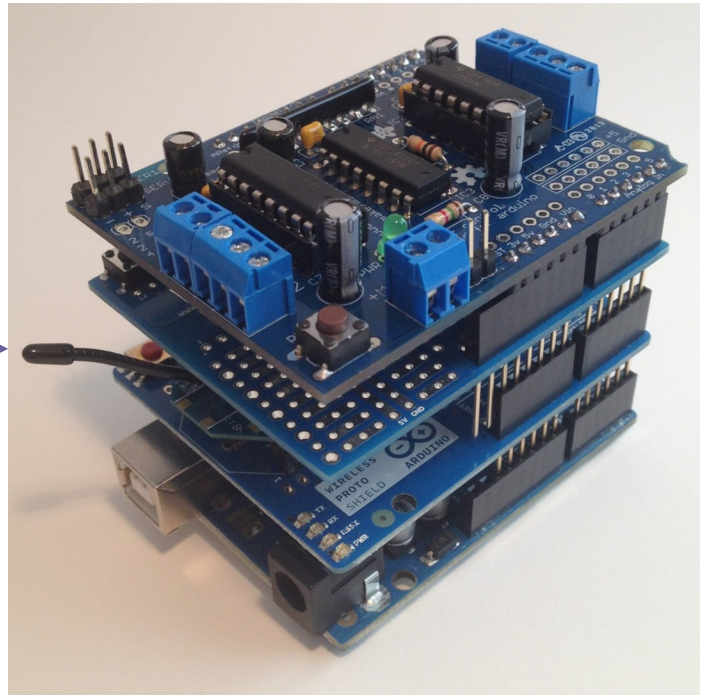
General Purpose platforms

Embedded System

Embedded Systems: An Arduino Analogy

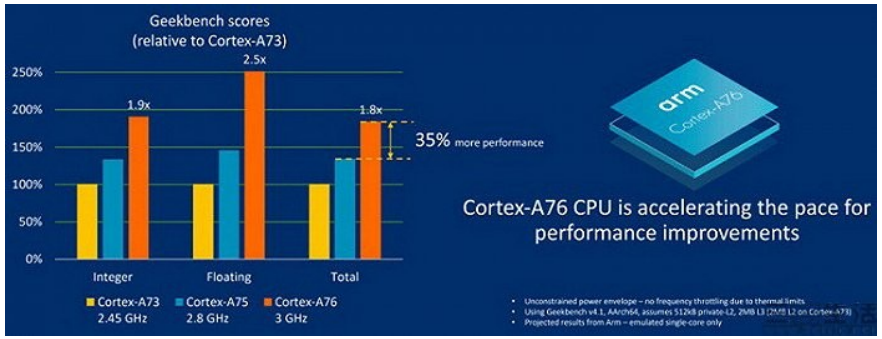


General Purpose platform

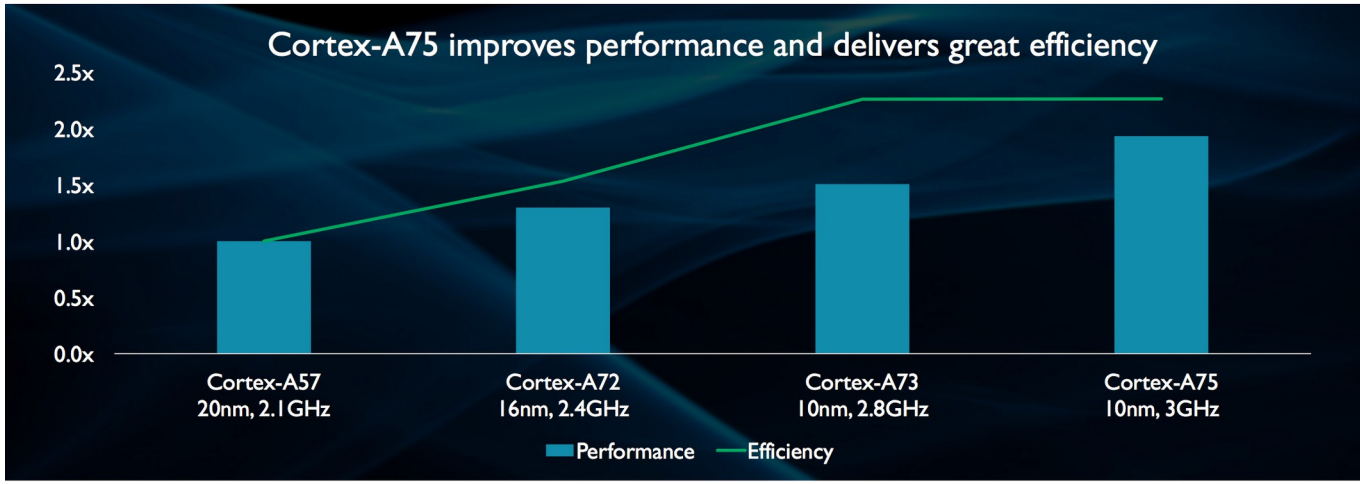


Embedded System

ARM Based SoC Getting More Powerful



Cortex-A75: High performance, leading efficiency



Performance and efficiency per-core, at-speed using target process node

ARM

Industrial-PC Or SoC Based systems Are Embedded Systems

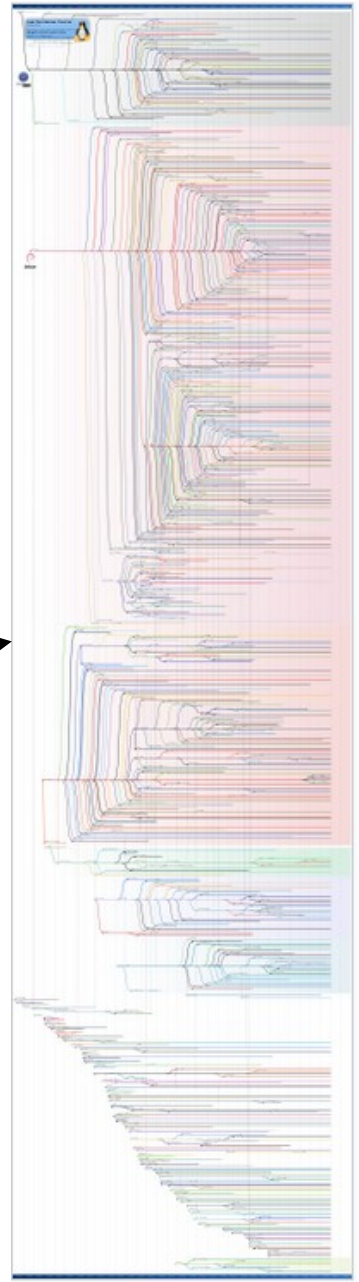
Industrial-PC and our selection of System-on-Chip comply with our performance requirement

Implement A Common OS Solution For Powerful Embedded Systems In ATS

Linux Distributions Panorama

DistroWatch.com
Put the fun back into computing. Use Linux, BSD.

Wikimedia picture



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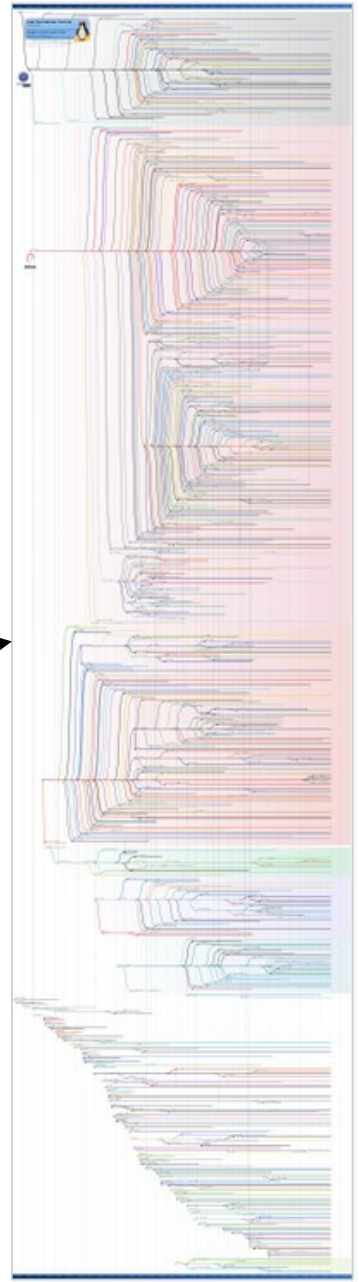

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- **On top of Linux, they distribute open-source software**
  - Technically speaking any Linux distribution would do
  - Each software follows its own governance and development life-cycle
  - May add patches

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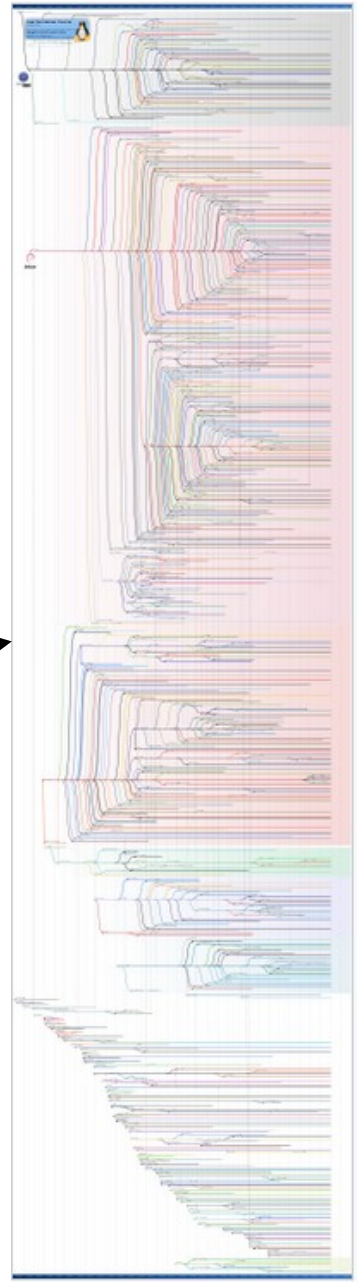

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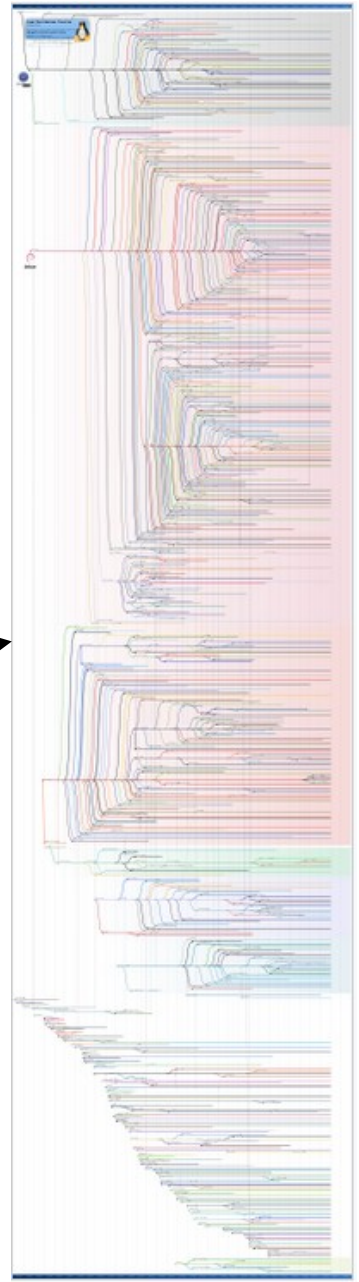

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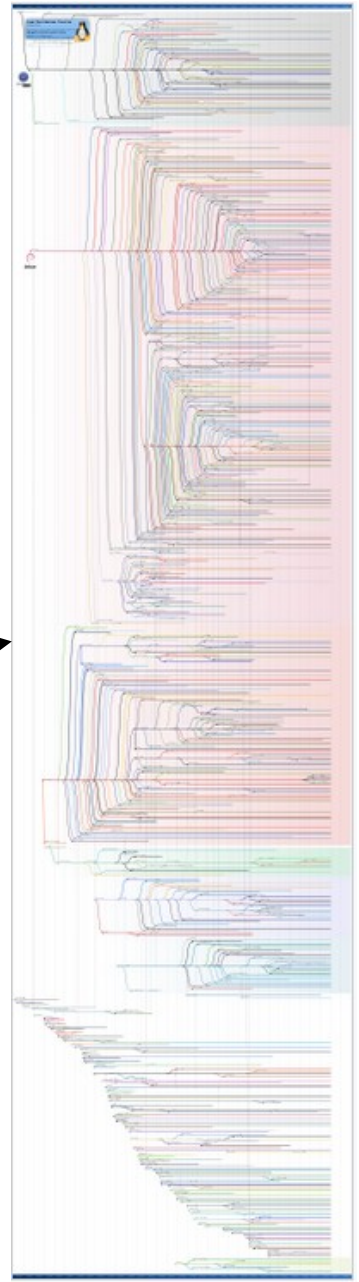

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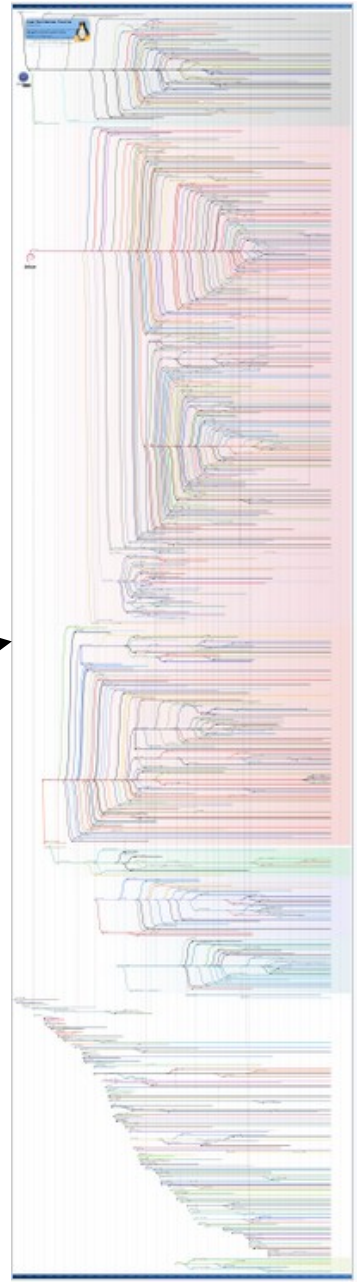

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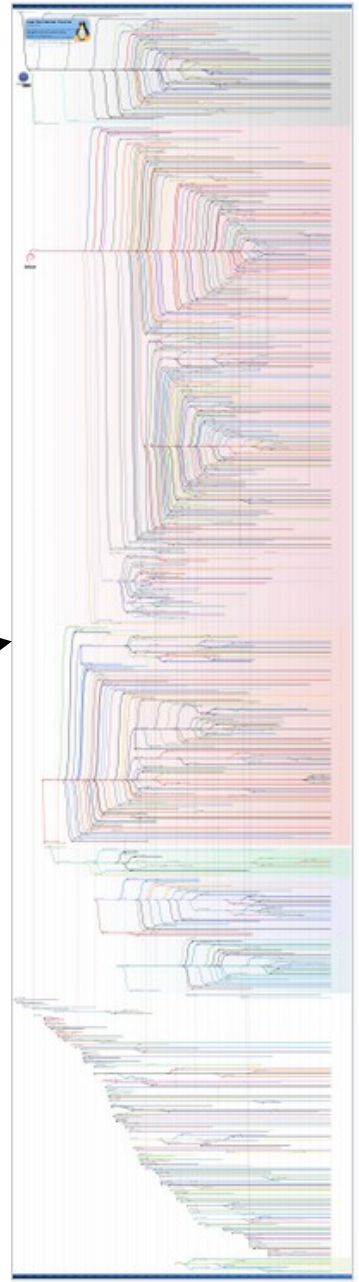

Does this matter?

Linux Distributions Panorama

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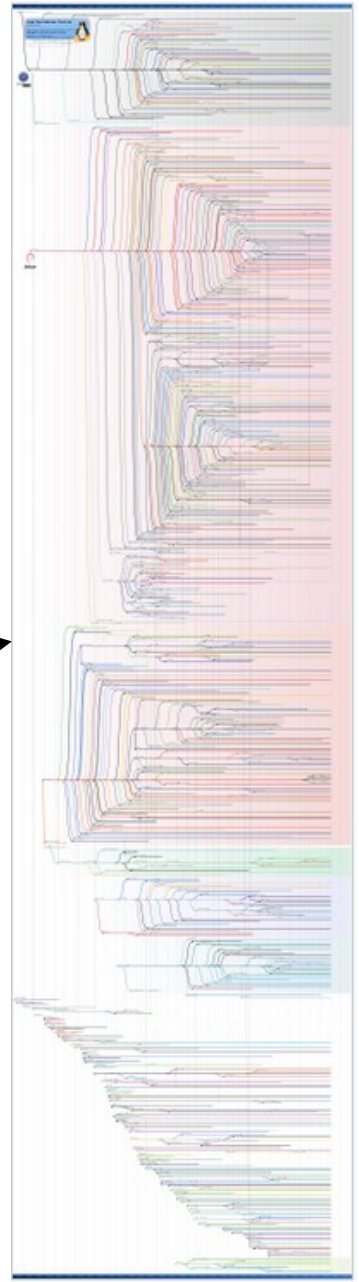

Does this matter? YES!

It Matters Because It Affects:

- governance priorities;
- community or company size;
- software availability, version, building, and configuration;
- supported architectures;
- the development life-cycle;
- the upgrade policy;
- the delivered support level;
- its maintenance;
- its long-term existence.


Cloud
Computing


BuildRoot
Making Embedded Linux Easy
CIVIL
INFRASTRUCTURE
PLATFORM
Cloud
Computing
yocto
PROJECT
Red Hat
Enterprise Linux
debian
GNU/Linux


PCSPECIALIST
XFX
PCSPECIALIST
PCSPECIALIST


PCSPECIALIST
XFX
COOLER MASTER


BuildRoot
Making Embedded Linux Easy
CIVIL INFRASTRUCTURE PLATFORM
yocto PROJECT
debian
GNU/Linux
Red Hat Enterprise Linux
SteamOS


Windows 11
CIVIL INFRASTRUCTURE PLATFORM
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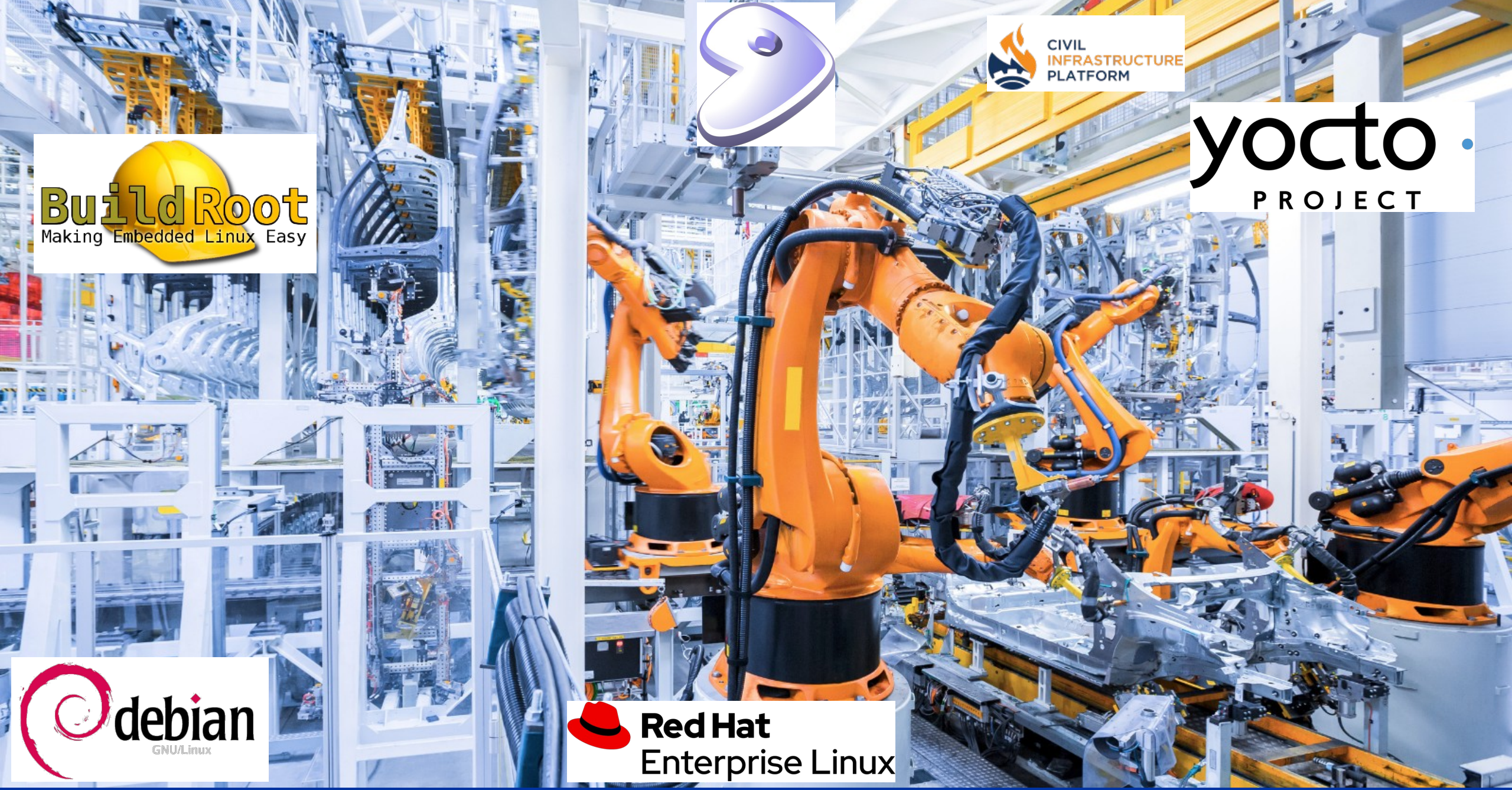
BuildRoot
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debian
GNU/Linux
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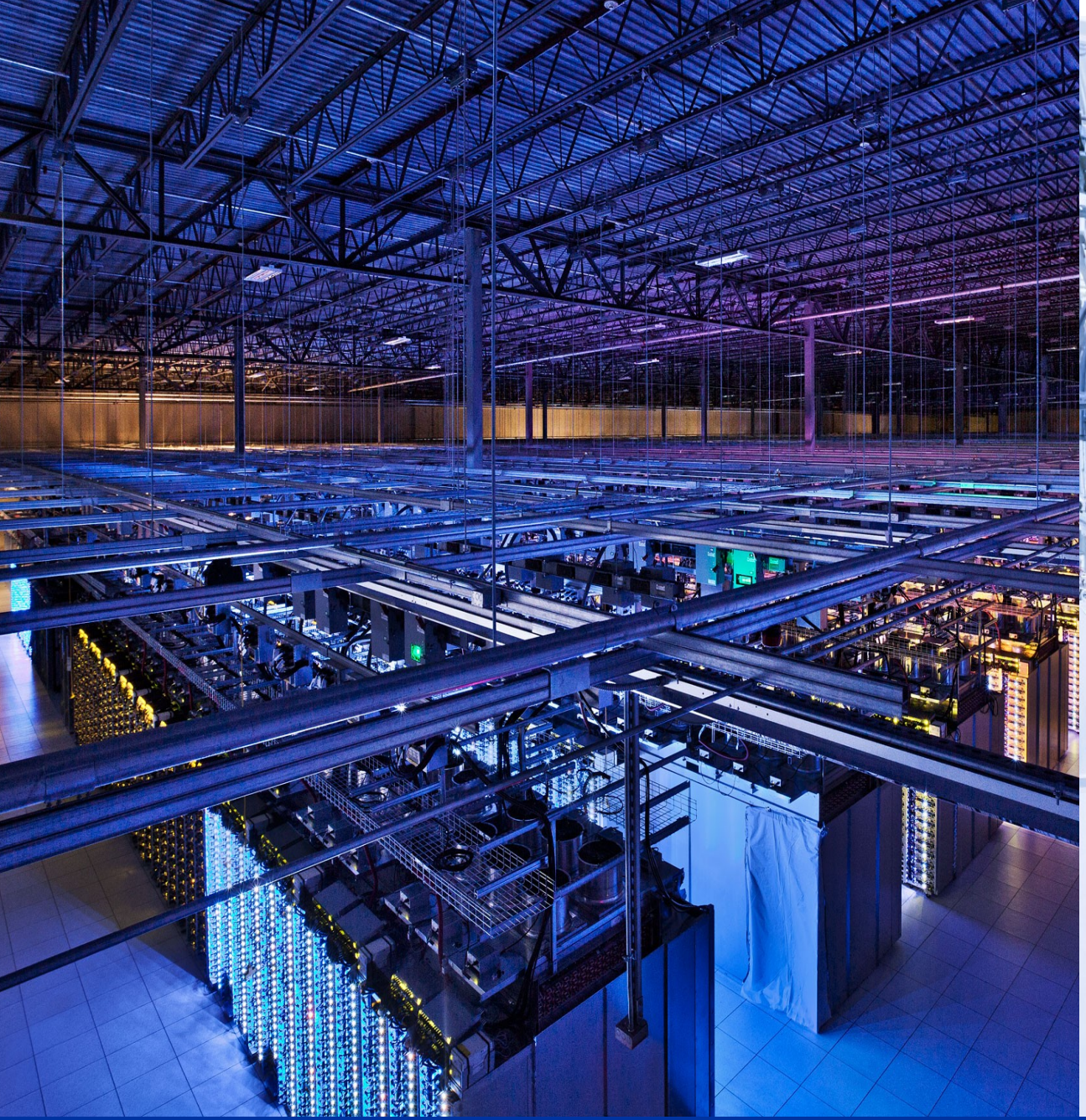

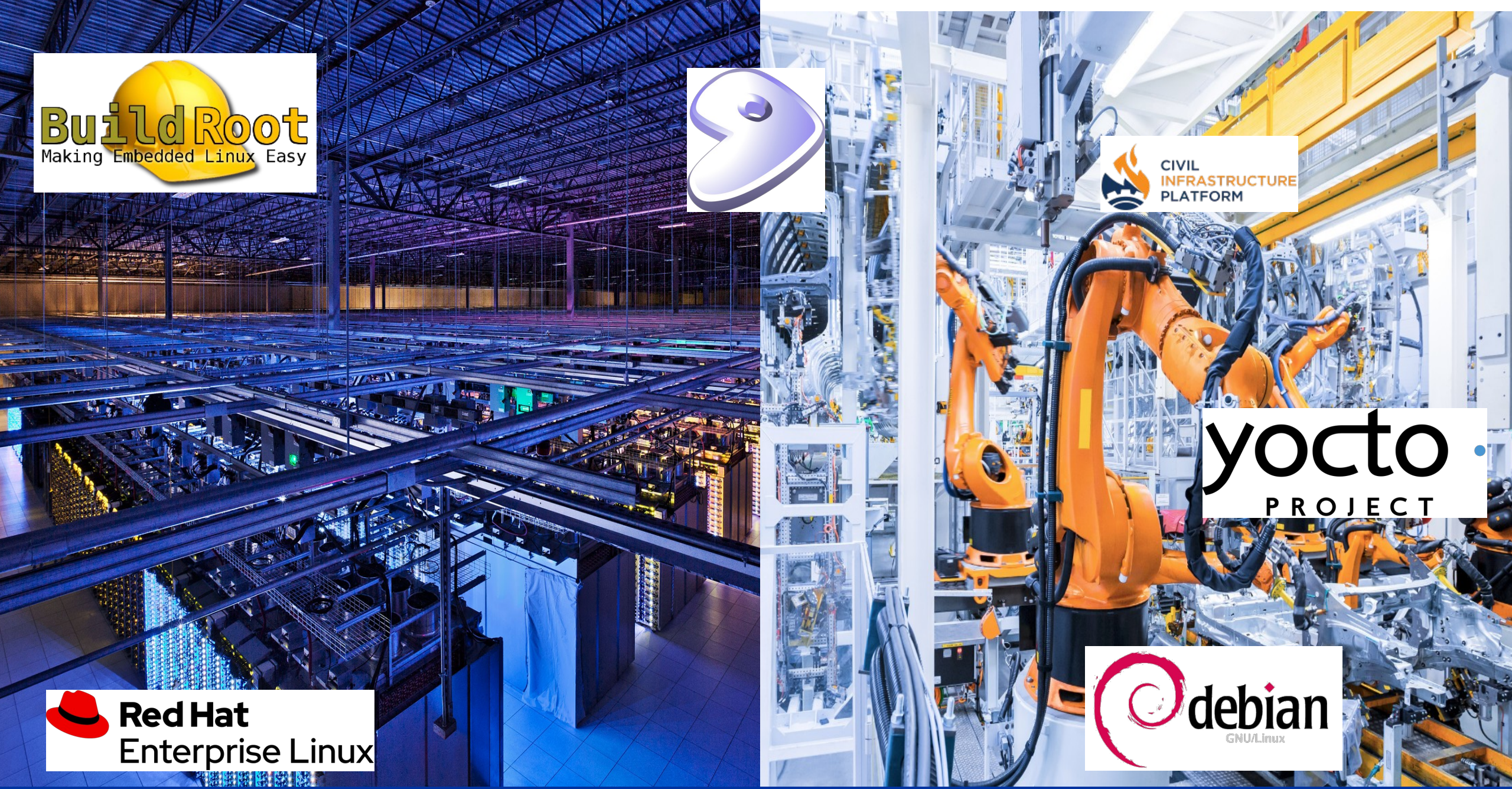
Build Root
Making Embedded Linux Easy
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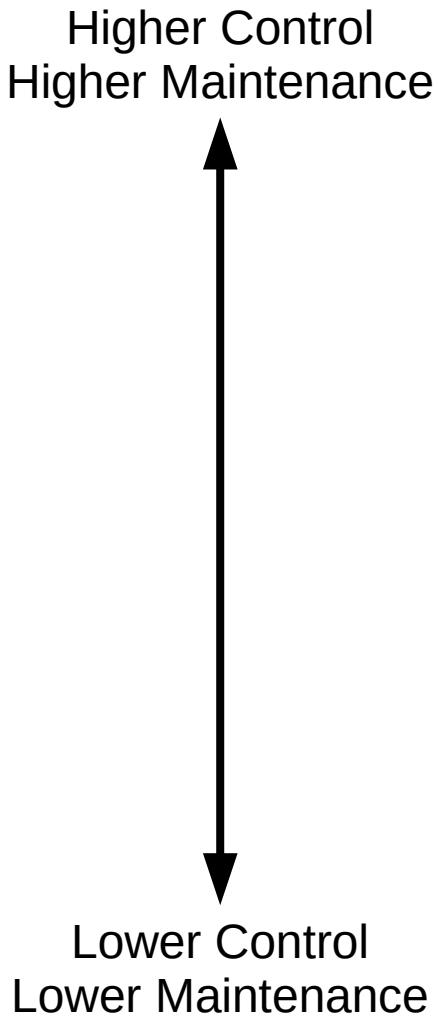
INFRASTRUCTURE
PLATFORM
yocto
PROJECT
Red Hat
Enterprise Linux
debian
GNU/Linux

Our Operating Systems Options

2022

Our Operating Systems Options



Our Operating Systems Options

Higher Control
Higher Maintenance

Lower Control
Lower Maintenance

Our Operating Systems Options

Higher Control
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Lower Control
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Our Operating Systems Options

Higher Control
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Lower Control
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linux from scratch

yocto PROJECT

PTX DIST

BuildRoot
Making Embedded Linux Easy

debian GNU/Linux

archlinux

SUSE

Red Hat Enterprise Linux

AlmaLinux

ubuntu

Our Operating Systems Options

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CIVIL INFRASTRUCTURE PLATFORM

archlinux

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ubuntu

Our Operating Systems Options

Higher Control
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linux from scratch

yocto PROJECT

PTX DIST

BuildRoot
Making Embedded Linux Easy

The control we need - The maintenance we can afford

CIVIL INFRASTRUCTURE PLATFORM

archlinux

debian GNU/Linux

SUSE

Red Hat Enterprise Linux

AlmaLinux

ubuntu

Our Operating Systems Options

Higher Control
Higher Maintenance

Lower Control
Lower Maintenance

The best fit

Why Two Linux Distributions?

- **It enforces software portability**
  - Everything must work on different Linux environments
- **It reduces the Total Cost of Ownership (TCO)**
  - It reduces the exit costs and prevents lock-in
- **It is relatively cheap to *maintain* both solutions**
  - After a first investment in portability, it is easy to maintain
- **It allows us to have an exit strategy**
  - We can always easily move to the second distribution if needed
- **We will never support two distributions at the same time**
  - Only one distribution will be officially supported (primary)
  - The second distribution will be our exit strategy (secondary)

2022|3

CentOS Stream

AlmaLinux

Plan A: RHEL Family

Align To CERN Recommendation

Profit from existent infrastructure, expertise and services

Services and expertise

Infrastructure

OS

2022|3

CentOS Stream

AlmaLinux

Plan A: RHEL Family

Align To CERN Recommendation

Profit from existent infrastructure, expertise and services

(Plan B: Debian)

Services and expertise

Infrastructure

OS

Red Hat Enterprise Linux Family Drama 2022/3 [2] (for us)

9

`-march=x86_64-v2`

~ 50% of our systems are incompatible

10

`-march=x86_64-v3`

~ 65% of our systems are incompatible

The cost of these compiler flags have been estimated in more than 5 MCHF in material budget and staff

The probability of a successful replacement during 2026H1 has been estimated to be very low

x86_64 ABI versioning

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~~**Plan A: RHEL Family**~~

Plan B: Debian

x86_64 ABI versioning

debian

2023

Plan B: Debian

No hardware incompatibilities

And software flexibility

Services and expertise

Infrastructure

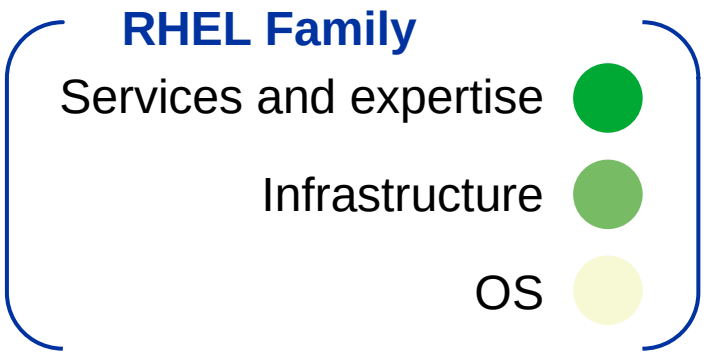
OS

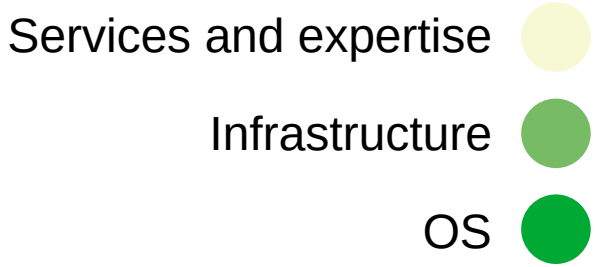
debian

Plan B: Debian

No hardware incompatibilities

And software flexibility





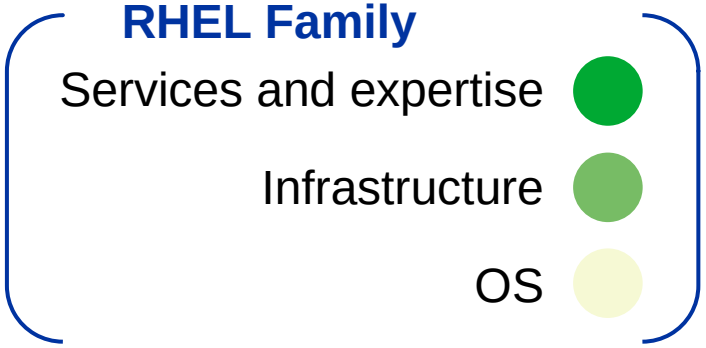
debian

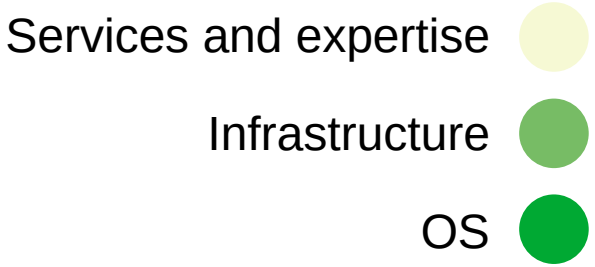
Plan B: Debian

No hardware incompatibilities

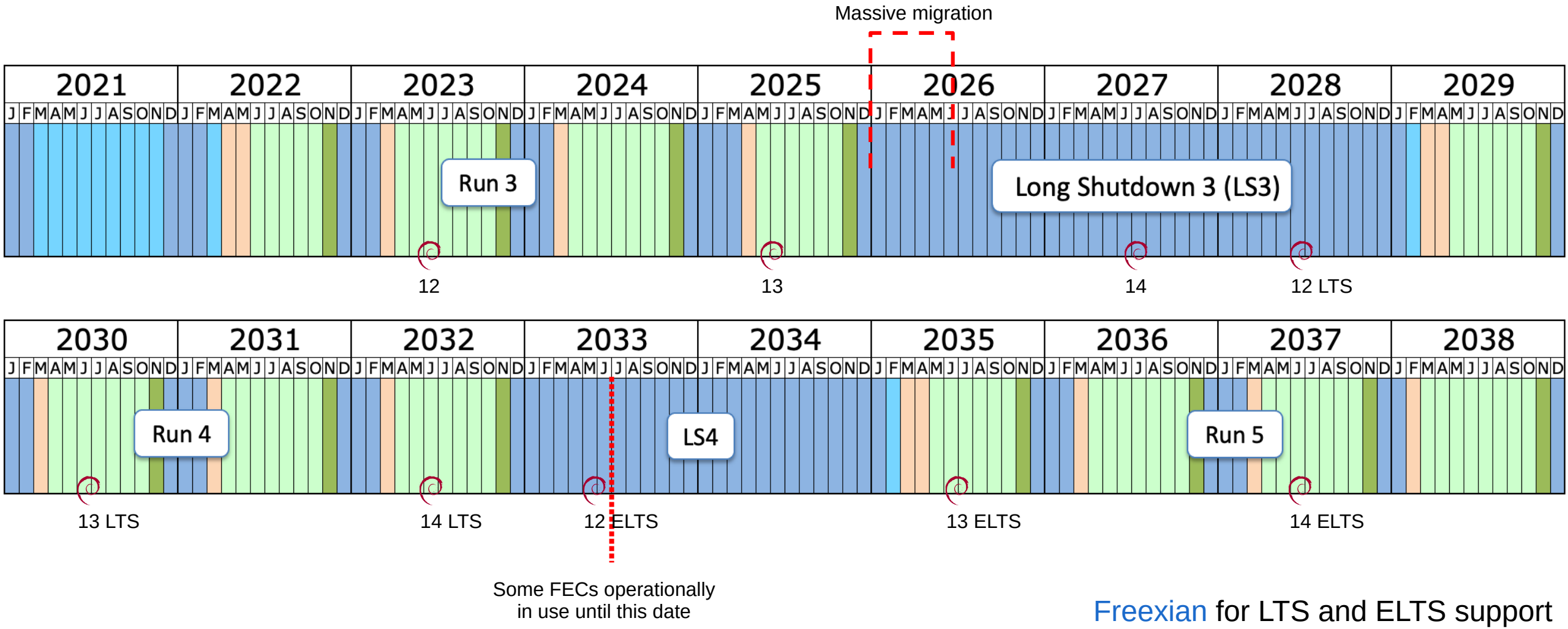
And software flexibility

(Plan C: We do not have one, yet)





LHC And Debian Schedule



Freexian for LTS and ELTS support

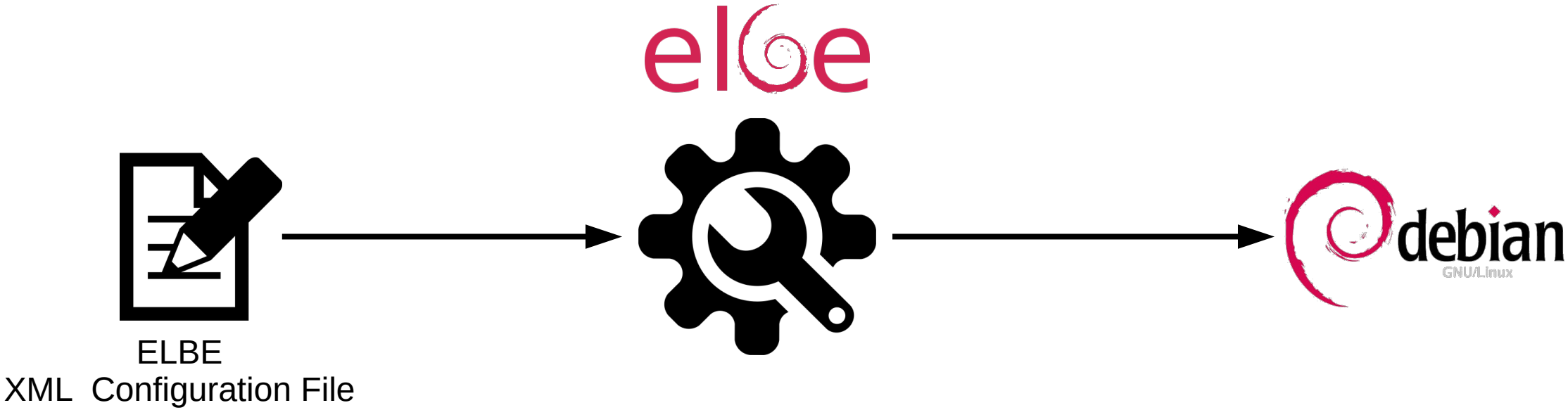
Start by doing what's necessary; then do what's possible; and suddenly you are doing the impossible.

~ Francis of Assisi

Start by doing what's necessary; then do what's possible; and suddenly you are doing the impossible.

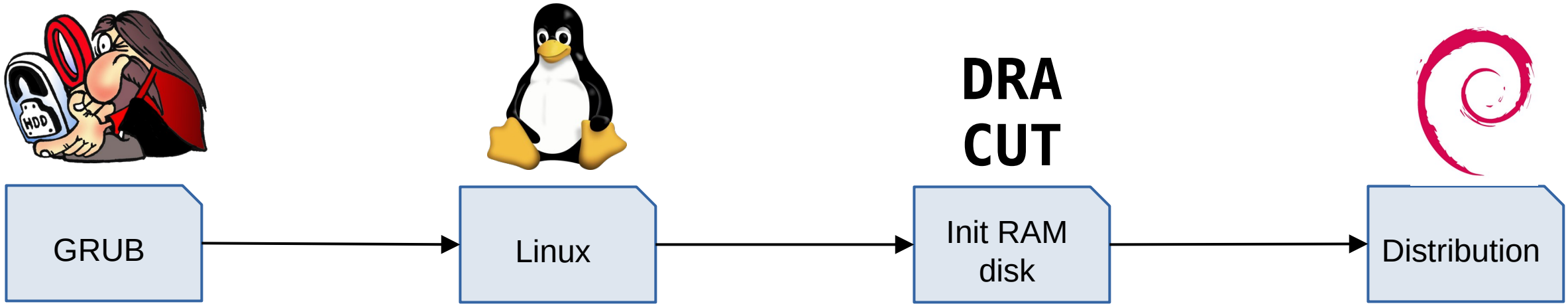
~ Francis of Assisi

Building Processes



elbe-rfs.org debian.org

Booting Sequence

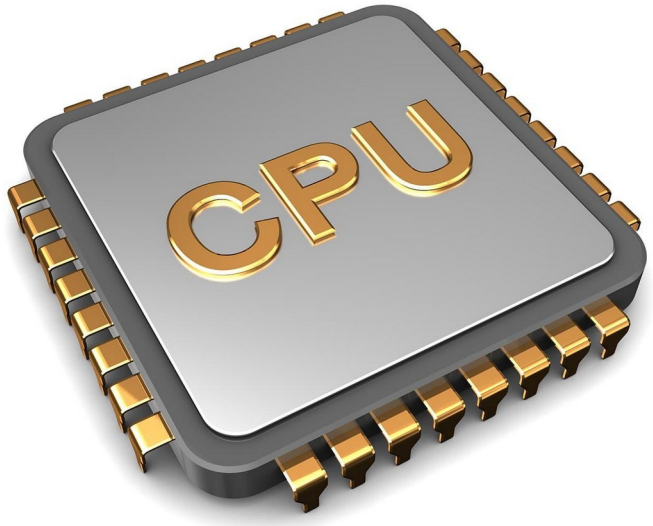


www.gnu.org/software/grub

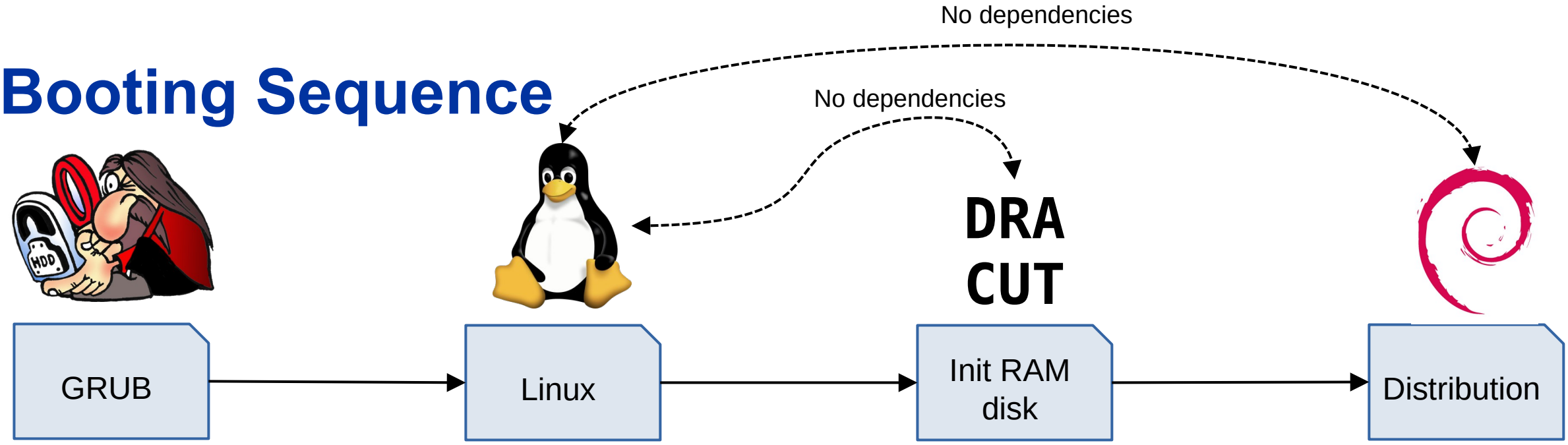
www.kernel.org

github.com/dracutdevs/dracut

www.debian.org



Booting Sequence



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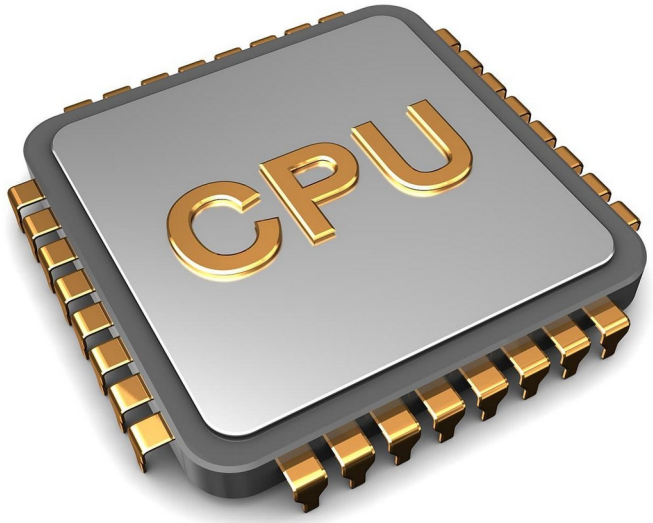
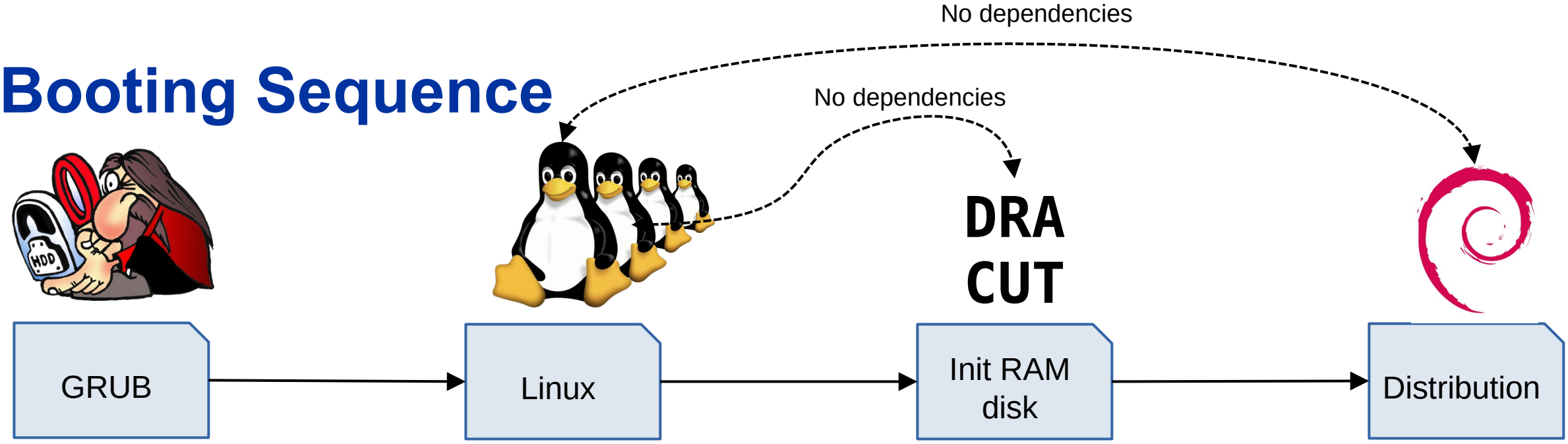


Booting Sequence



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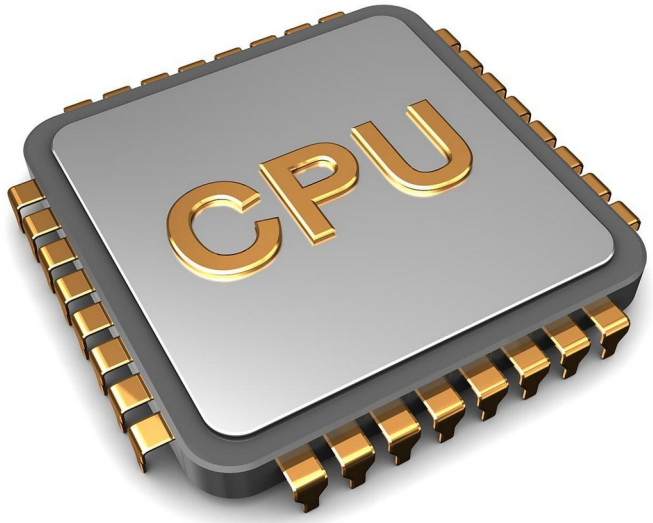
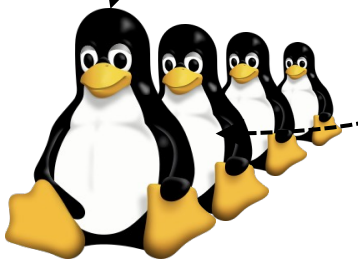


Booting Sequence



No dependencies

No dependencies

DRA
CUT

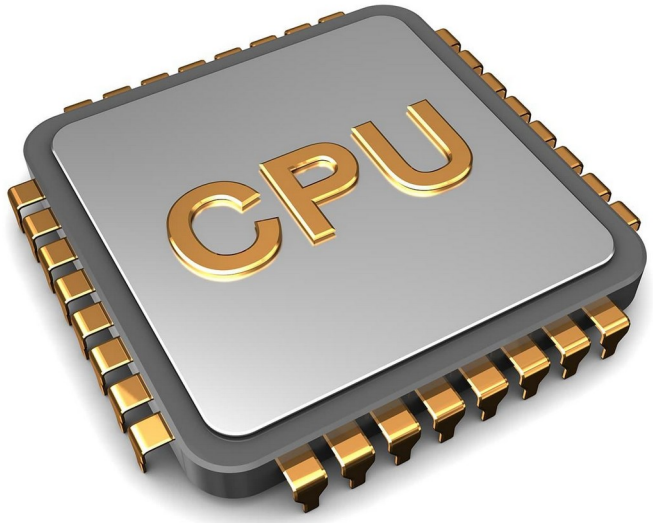
GRUB → Linux → Init RAM disk → Distribution

www.gnu.org/software/grub

www.kernel.org

github.com/dracutdevs/dracut

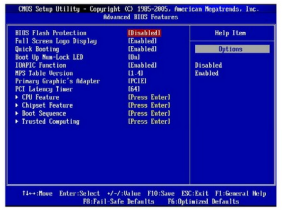
www.debian.org



Projects References

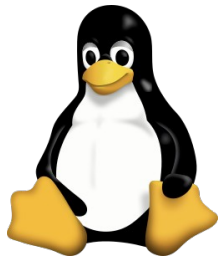
	Project	Reference	Architectures	Binary Distribution
Bootloader	fec-bootloader	GRUB (2.12)	x86_64 aarch64	Gitlab Registry
Linux	fec-os-kernel	Linux Stable (5.10.x)	x86_64 aarch64 (Zynq UltraScale+)	Gitlab Registry
Init Ramdisk	fec-os-initramfs	Dracut (057)	x86_64 aarch64	Gitlab Registry
Distribution	fec-os-distribution	Debian (12)	x86_64 aarch64	Gitlab Registry

Network RAM Booting: Industrial PC



BIOS
EFI Firmware

GRUB

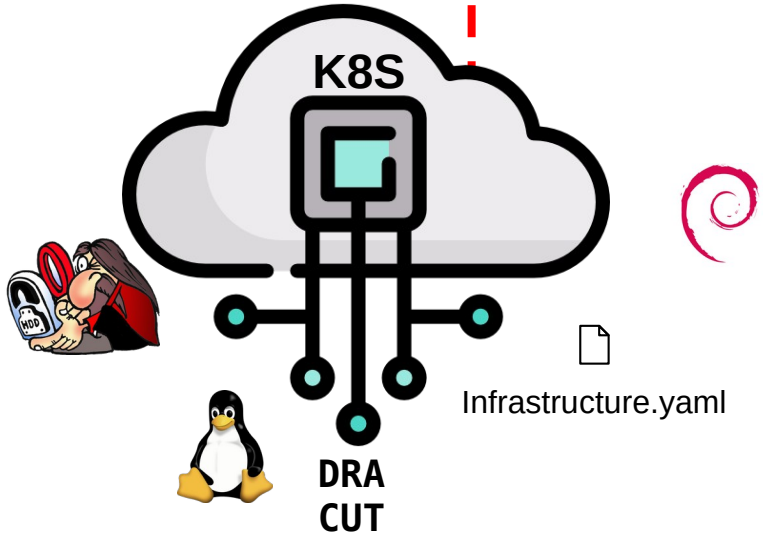


Linux

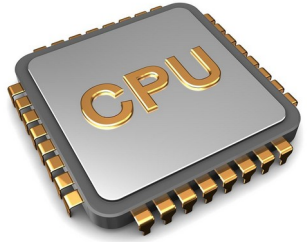
DRA
CUT

Init RAM
disk

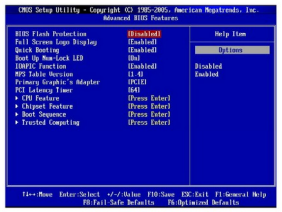
Distribution



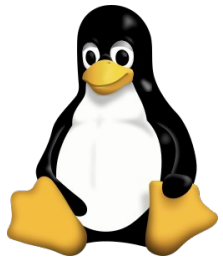
Infrastructure.yaml



Network RAM [illegible]g. Industrial PC



Using SMBIOS, I detect and build the Linux command line



DRA
CUT

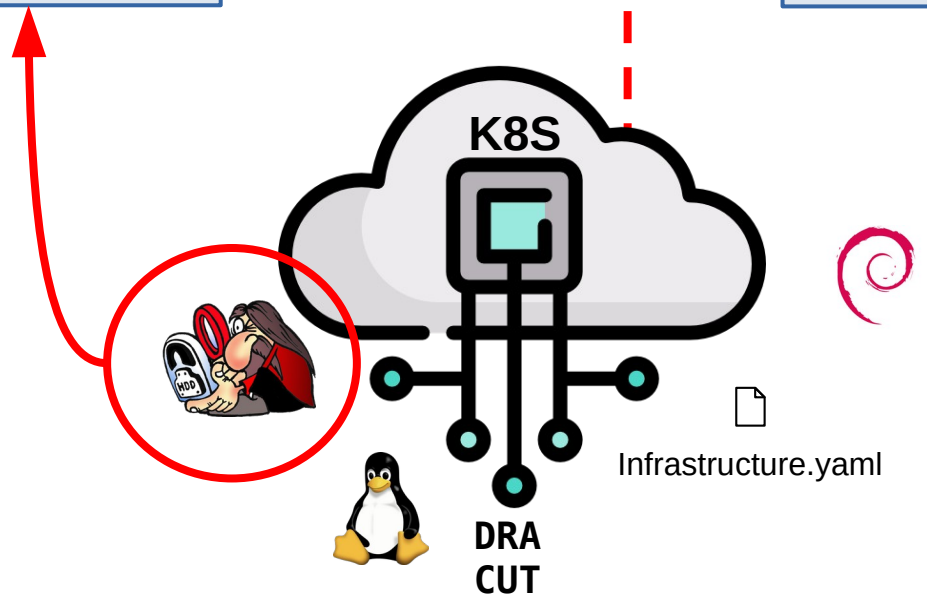
BIOS
EFI Firmware

GRUB

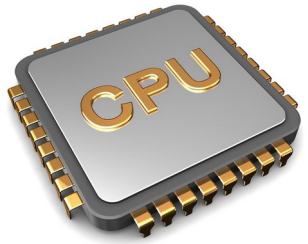
Linux

Init RAM
disk

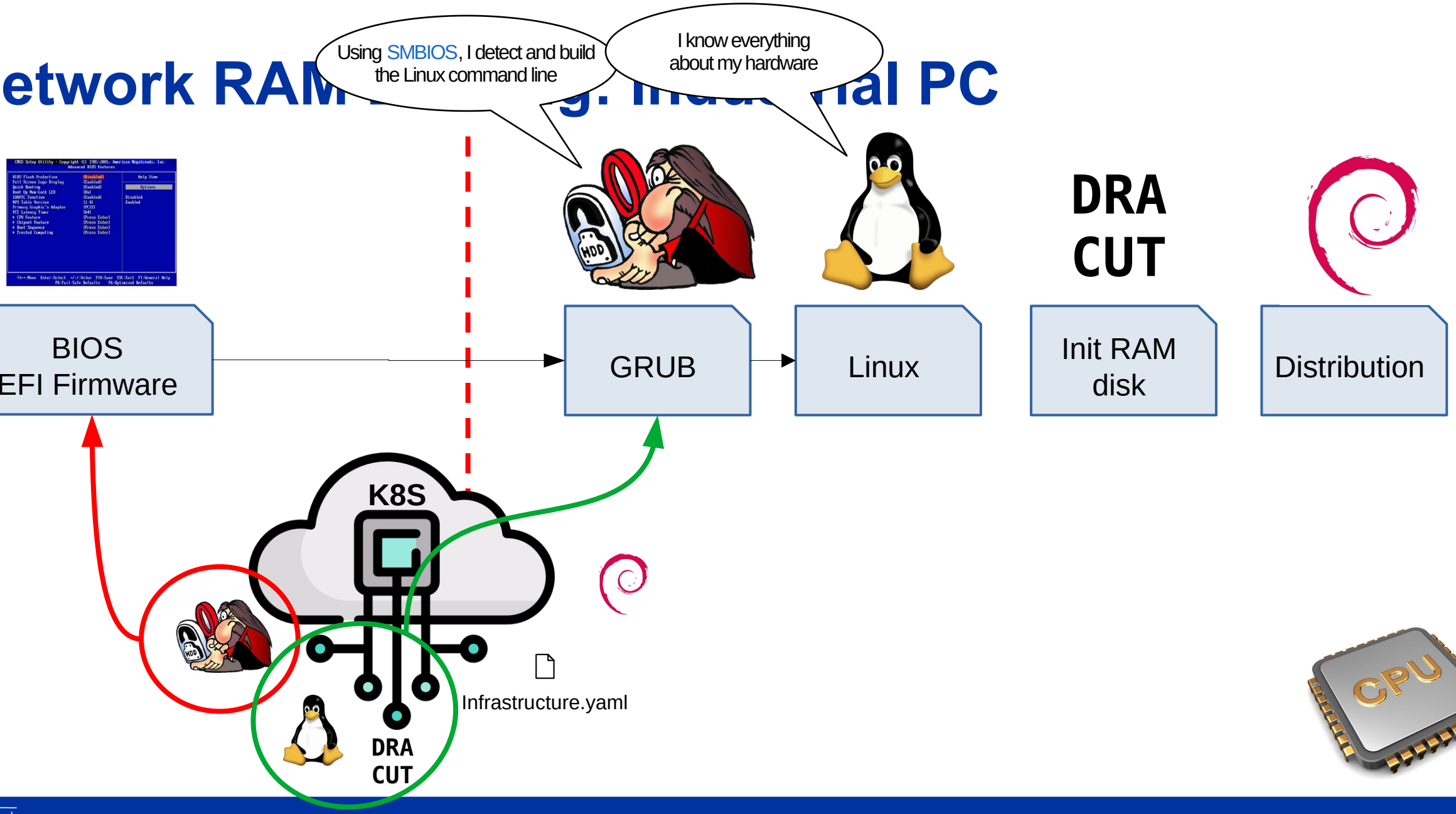
Distribution



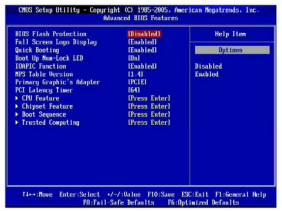
Infrastructure.yaml



Network RAM [illegible] PC

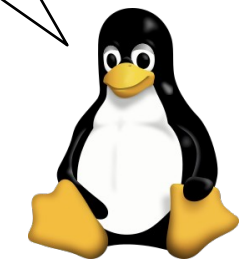


Network RAM [illegible]g. Industrial PC



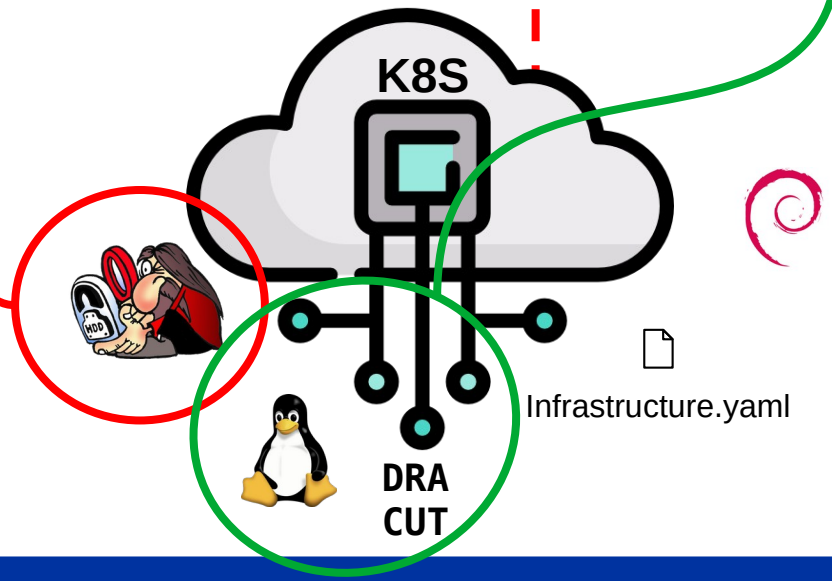
Using SMBIOS, I detect and build the Linux command line

I know everything about my hardware

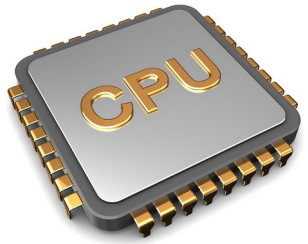


DRA CUT

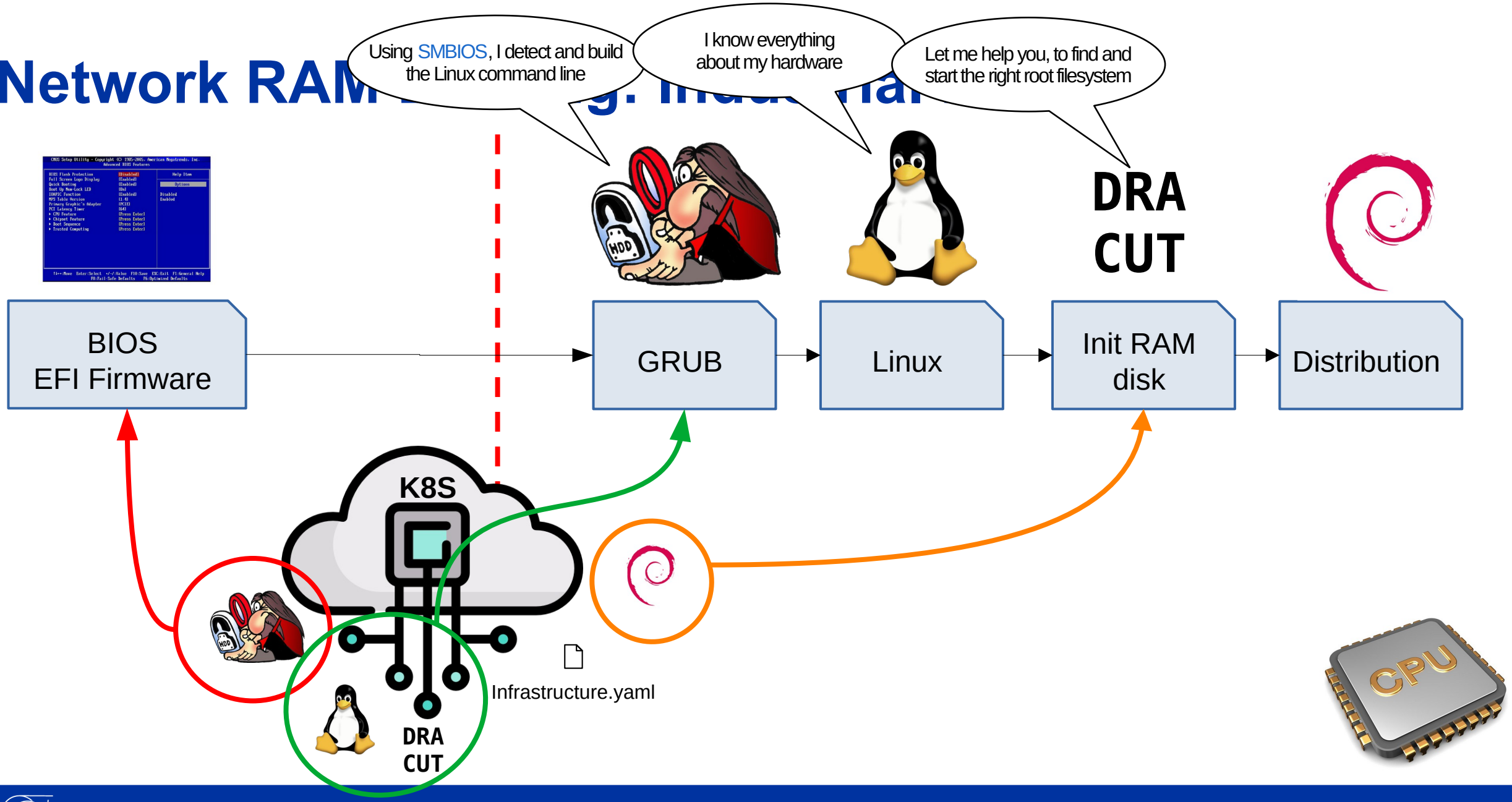
BIOS EFI Firmware → GRUB → Linux → Init RAM disk → Distribution



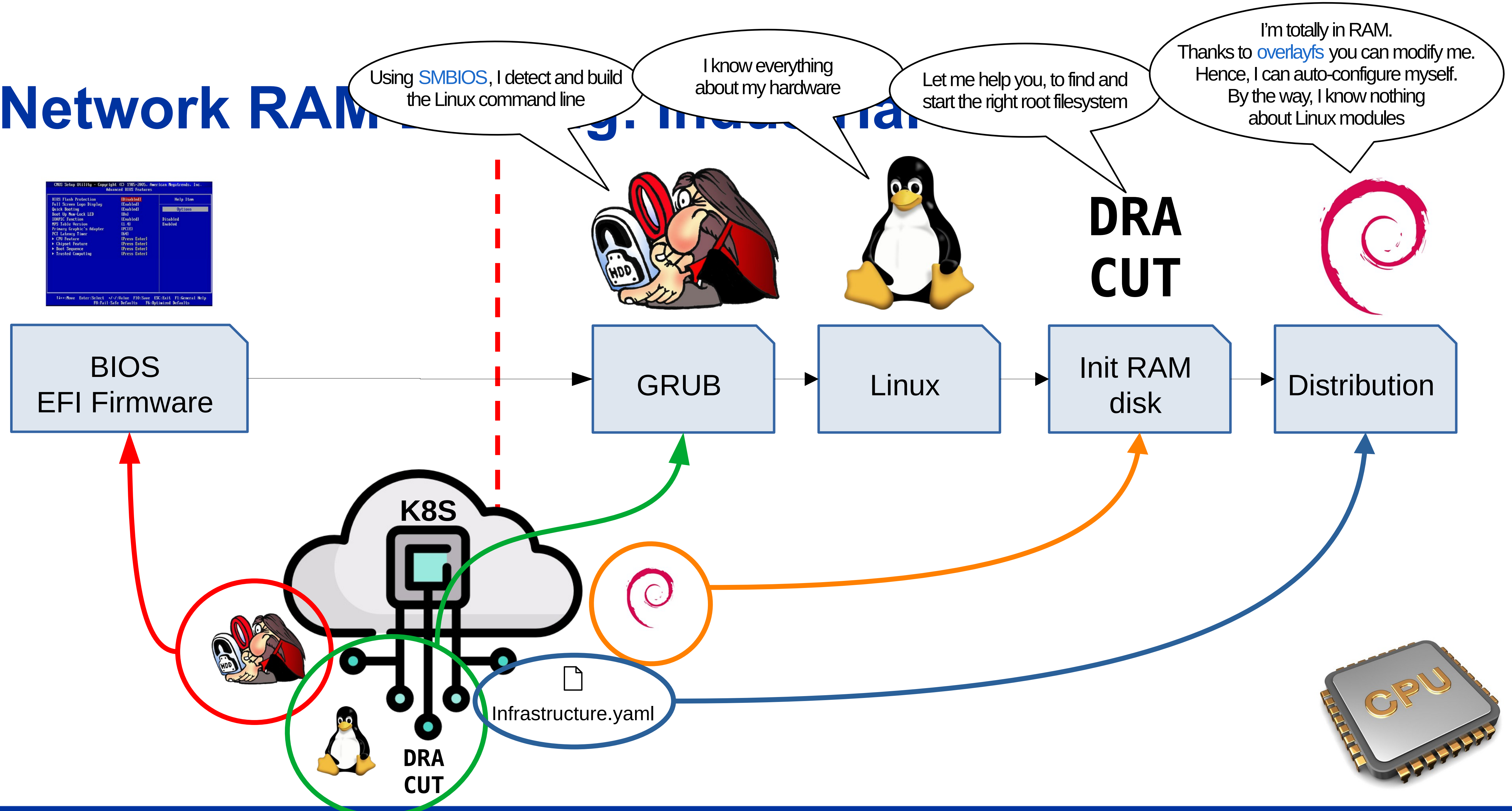
Infrastructure.yaml



Network RAM [illegible]g: Infra[illegible]

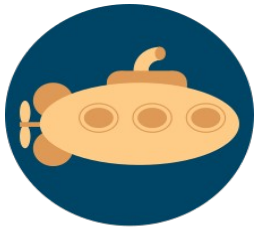


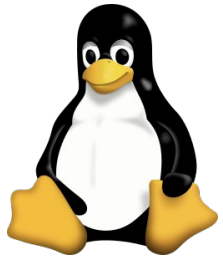
Network RAM



Using SMBIOS, I detect and build the Linux command line
I know everything about my hardware
Let me help you, to find and start the right root filesystem
I'm totally in RAM.
Thanks to overlayfs you can modify me.
Hence, I can auto-configure myself.
By the way, I know nothing about Linux modules
DRACUT
BIOS
EFI Firmware
GRUB
Linux
Init RAM disk
Distribution
K8S
DRACUT
Infrastructure.yaml
CPU

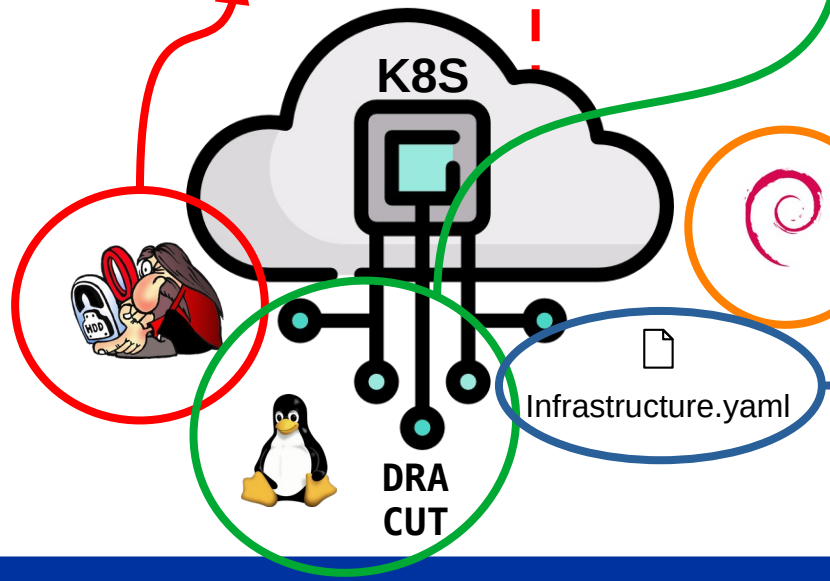
Network RAM Booting: System-on-Chip

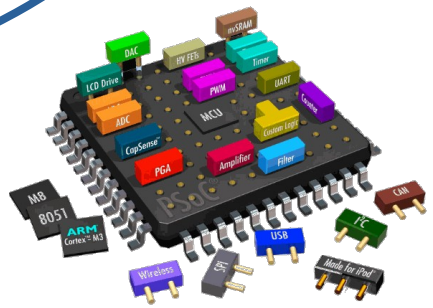




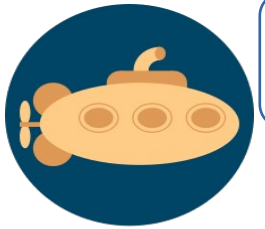
DRA
CUT

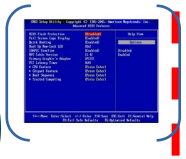
FSBL and friends → U-Boot → GRUB → Linux → Init RAM disk → Distribution

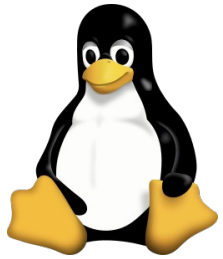




Network RAM Booting: System-on-Chip

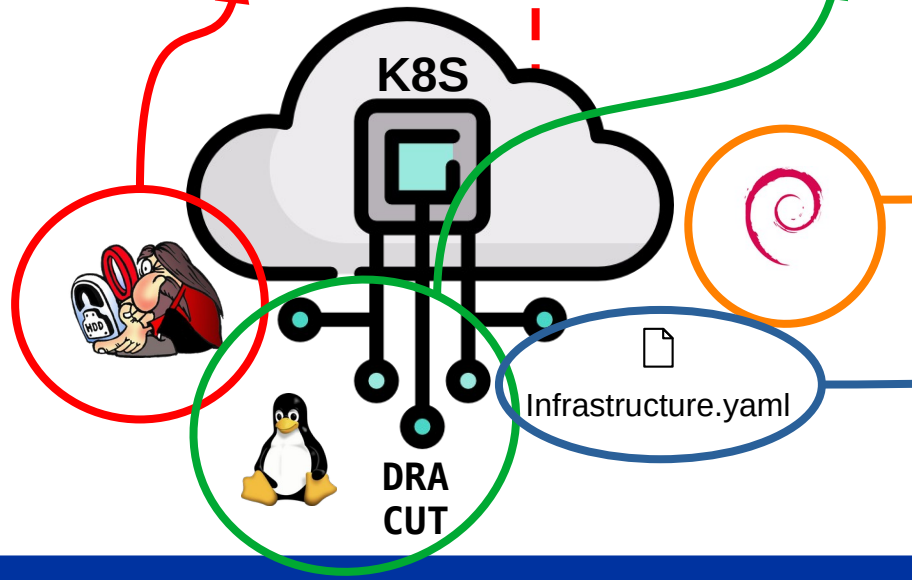


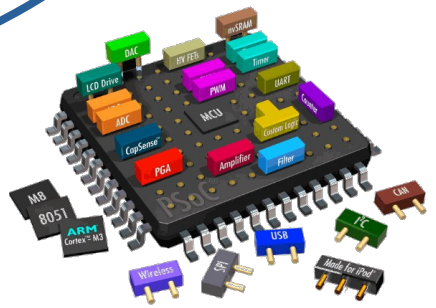




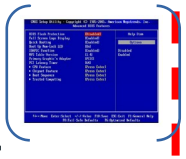
DRA
CUT

FSBL and friends → U-Boot → GRUB → Linux → Init RAM disk → Distribution

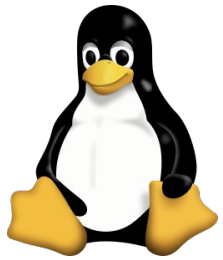




Network RAM Booting: System-on-Chip

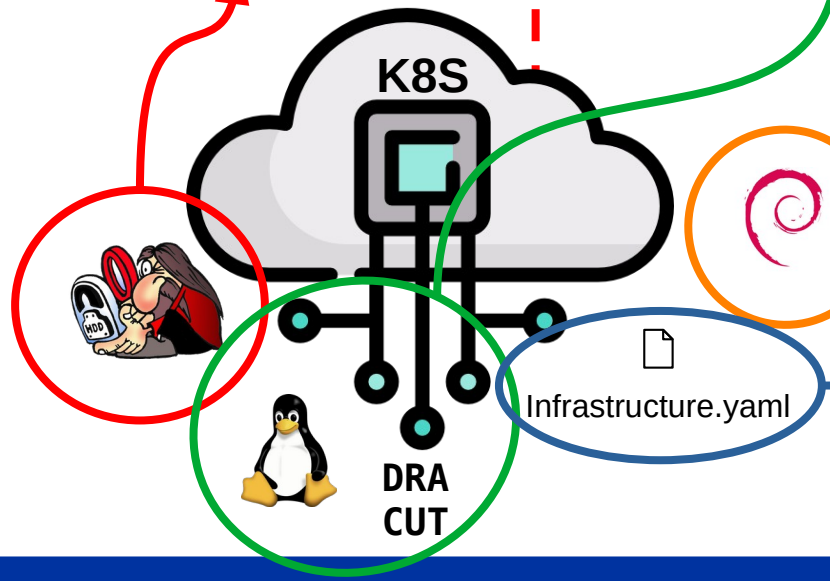


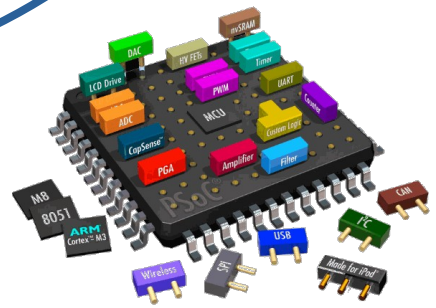
BAREBOX



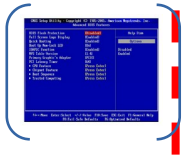
DRA CUT

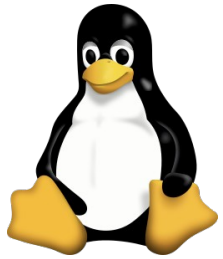
FSBL and friends → Barebox → GRUB → Linux → Init RAM disk → Distribution





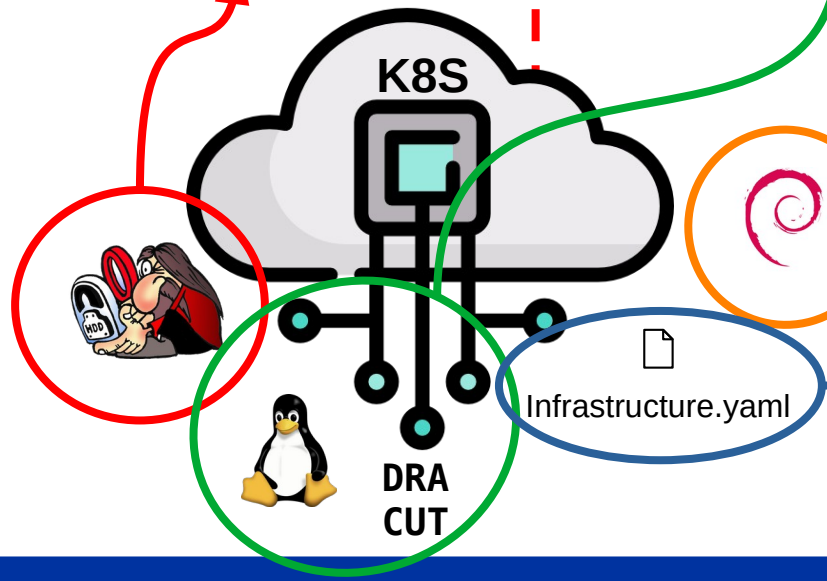
Network RAM Booting: System-on-Chip

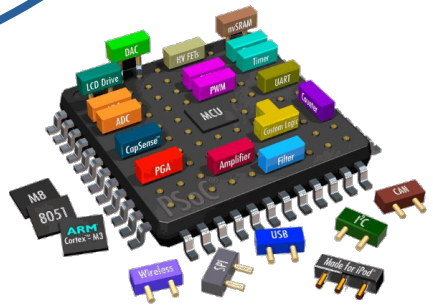




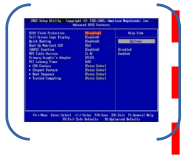
DRA
CUT

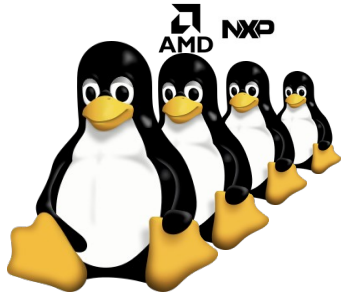
FSBL and friends → coreboot → GRUB → Linux → Init RAM disk → Distribution





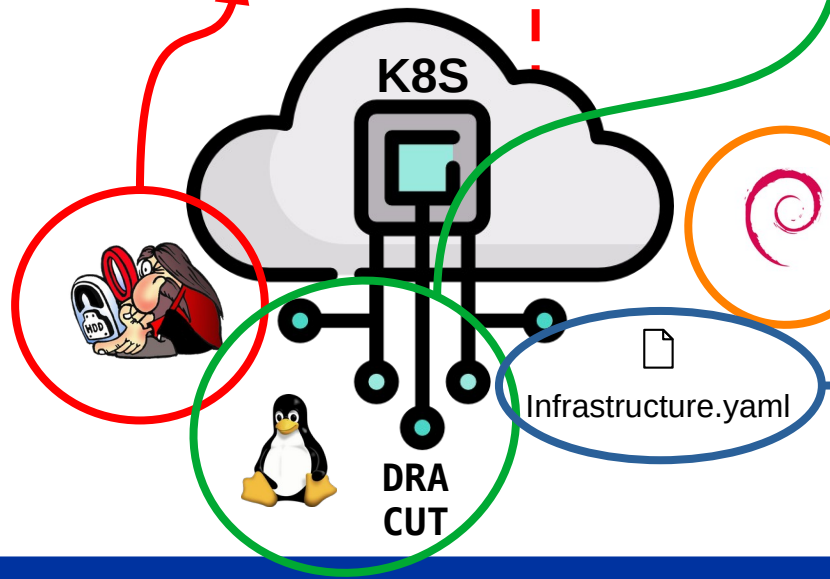
Network RAM Booting: System-on-Chip

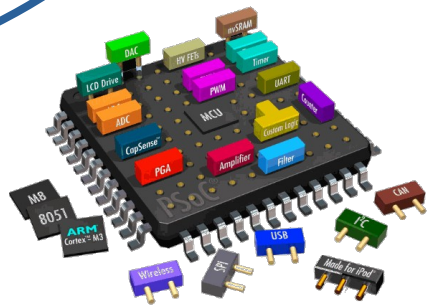




DRA
CUT

FSBL and friends → coreboot → GRUB → Linux → Init RAM disk → Distribution





Every pleasure is most valued when it is coming to an end.

~ Lucio Anneo Seneca