From Manul to Kitten:

4 years of **AlmaLinux** development evolution

Andrew Lukoshko
AlmaLinux OS Lead Architect
FOSDEM 2025

AlmaLinux

Andrew Lukoshko

- 23 years of Linux experience
- 13 years of building RHEL based products
- 5 years in HPC
- 5 years in Enterprise
- 5 years in Cloud Provider

AlmaLinux OS Lead Architect from Day 1

AlmaLinux

🎉 On Feb 01, 2025, we celebrated 4 years since the release of the very first public release of AlmaLinux, **8.3 beta**, codenamed

Purple Manul

So this is how we started:

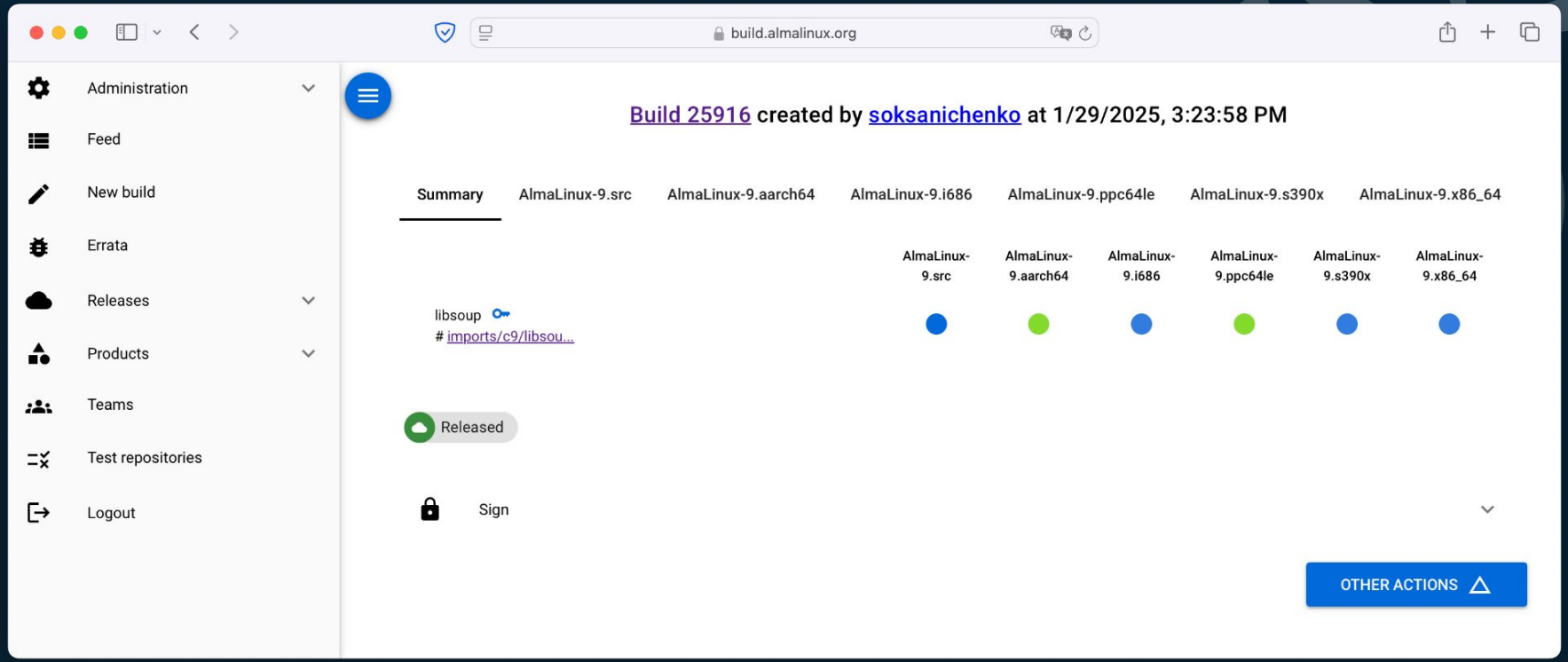
- Release took 55 days since Red Hat announced CentOS Linux 8 EOL
- Only 1 architecture was available - x86_64 (Intel/AMD)
- Exact RHEL clone
- No Secure Boot support
- No mirrors
- No Errata or OpenSCAP support (CentOS Linux never had them either)

AlmaLinux

Agenda

1. AlmaLinux Build System - our way to build RPM packages for 7 architectures
2. How we maintain dozens of images in easy and transparent way
3. How we unlocked major version upgrades in EL ecosystem
4. Why we decided to stop being RHEL clone
5. How we bring back support for 140+ devices disabled upstream
6. How we decided to support older CPUs than upstream does
7. Future of AlmaLinux

AlmaLinux Build System



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Build system components

AlmaLinux Build System core components:

1. **Web-Server** - https://github.com/AlmaLinux/albs-web-server
2. **Frontend** - https://github.com/AlmaLinux/albs-frontend
3. **Build Node** - https://github.com/AlmaLinux/albs-node
4. **Sign Node** - https://github.com/AlmaLinux/albs-sign-node
5. **Sign File** - https://github.com/AlmaLinux/albs-sign-file

AlmaLinux

What is Pulp?

Pulp is an open-source platform designed to manage repositories of software packages and to distribute content across large numbers of systems. It allows users to fetch software from various sources, organize it into repositories, and then make it available to a wide range of consumers. Pulp supports a variety of content types, including RPMs, Python packages, and more, through its plugin architecture.

Used by Red Hat Satellite/Katello and Fedora COPR.
And by AlmaLinux Build System.

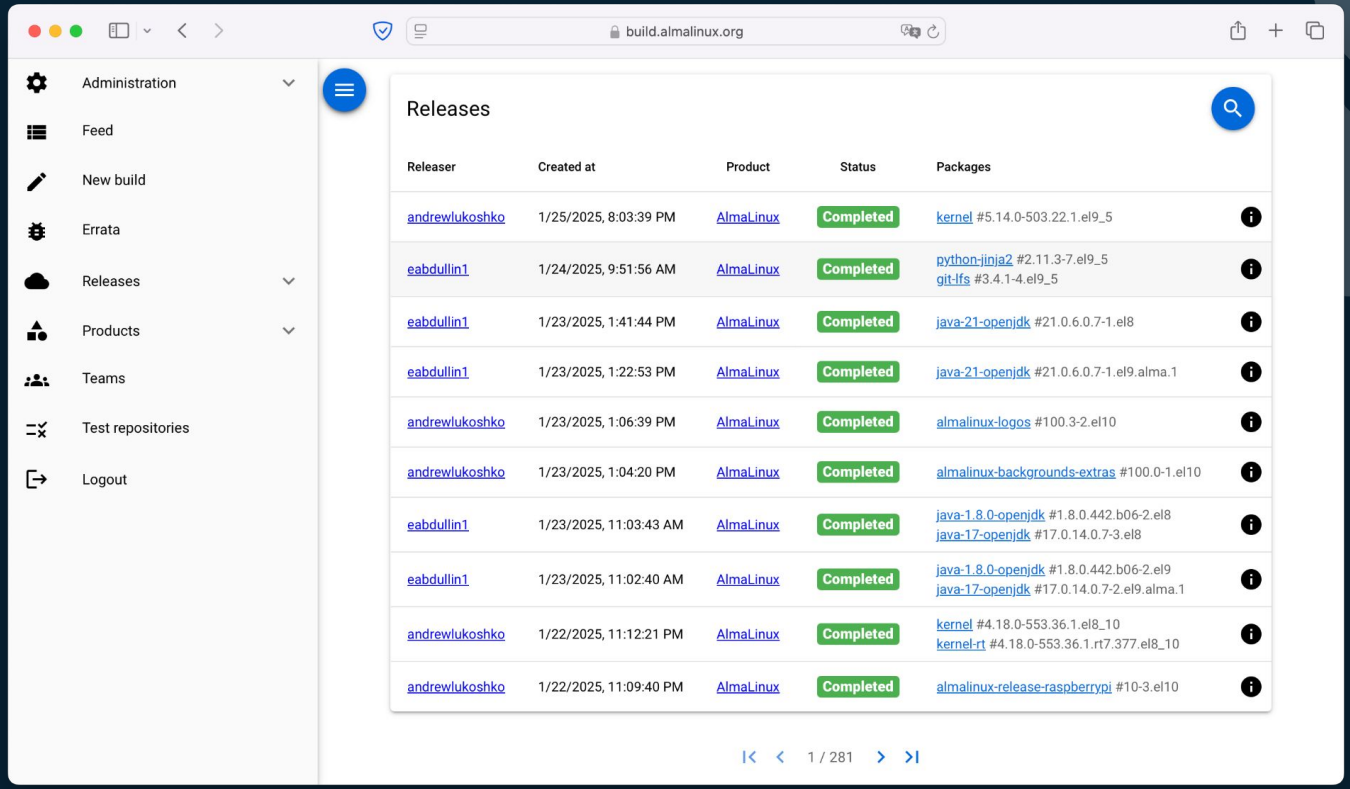
Why own build system?

Build System SIG members have 10+ years of experience in developing build system, so we just have own vision how we should do that.

AlmaLinux Build System can:

- Build RPM packages from any git repository or direct src.rpm URL for 7 architectures: x86_64, x86_64_v2, i686, aarch64, ppc64le, s390x, riscv64.
- Build DNF modules (necessary for AlmaLinux 8 and 9)
- Sign bootloader and kernel packages for Secure Boot (Intel and ARM)
- Release RPMs to internal Pulp repos and export them to filesystem
- Collect security advisories from Red Hat's public sources
- Create our own advisories (sometimes we fix CVEs too fast 😊)

How we release updates



pulp

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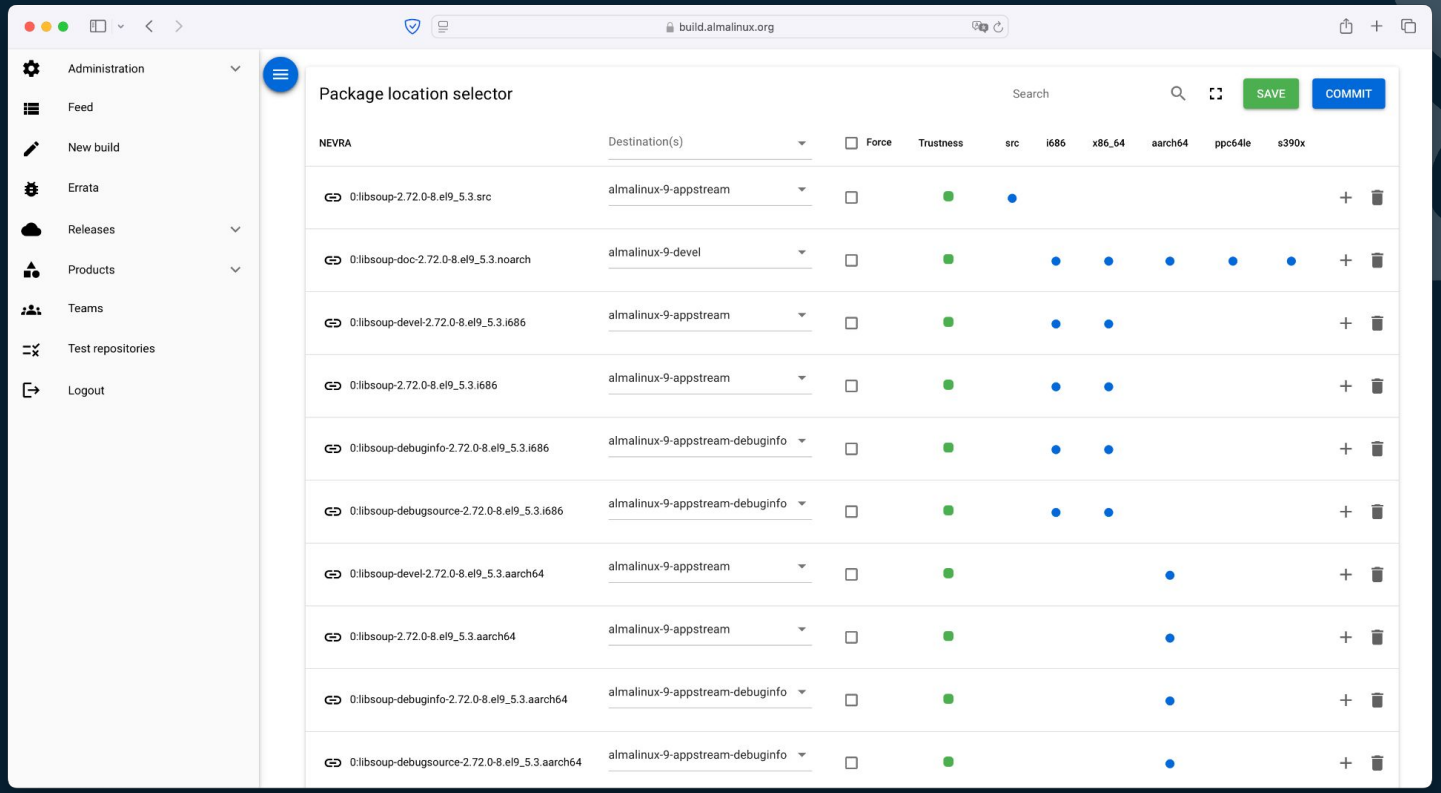
We don’t have to regenerate repositories after every package update

How we release updates



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Packages are released to repos according to their current placement in **AlmaLinux** and **CentOS Stream**

How we produce errata

Red Hat Security Data is publicly available under Creative Commons Attribution 4.0 International License

Data is available in several ways:

- Security Data API
- OVAL feed (deprecated)
- CSAF/VEX documents
- RSS feed

Data contains:

- Advisory id (RHSA-YYYY-NNNN)
- Description
- CVE and Red Hat bugzilla references
- Package names and versions

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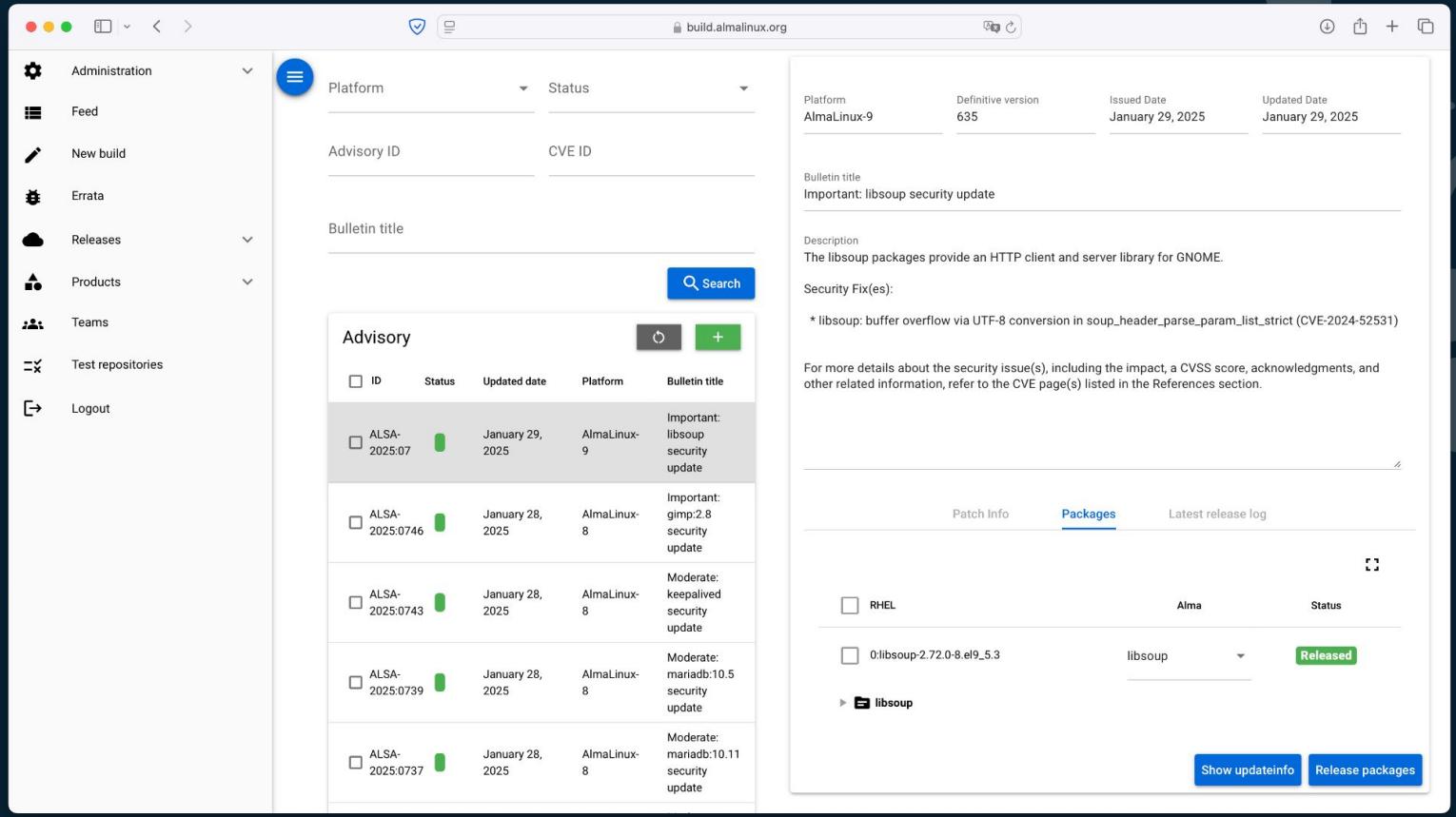
How we produce errata



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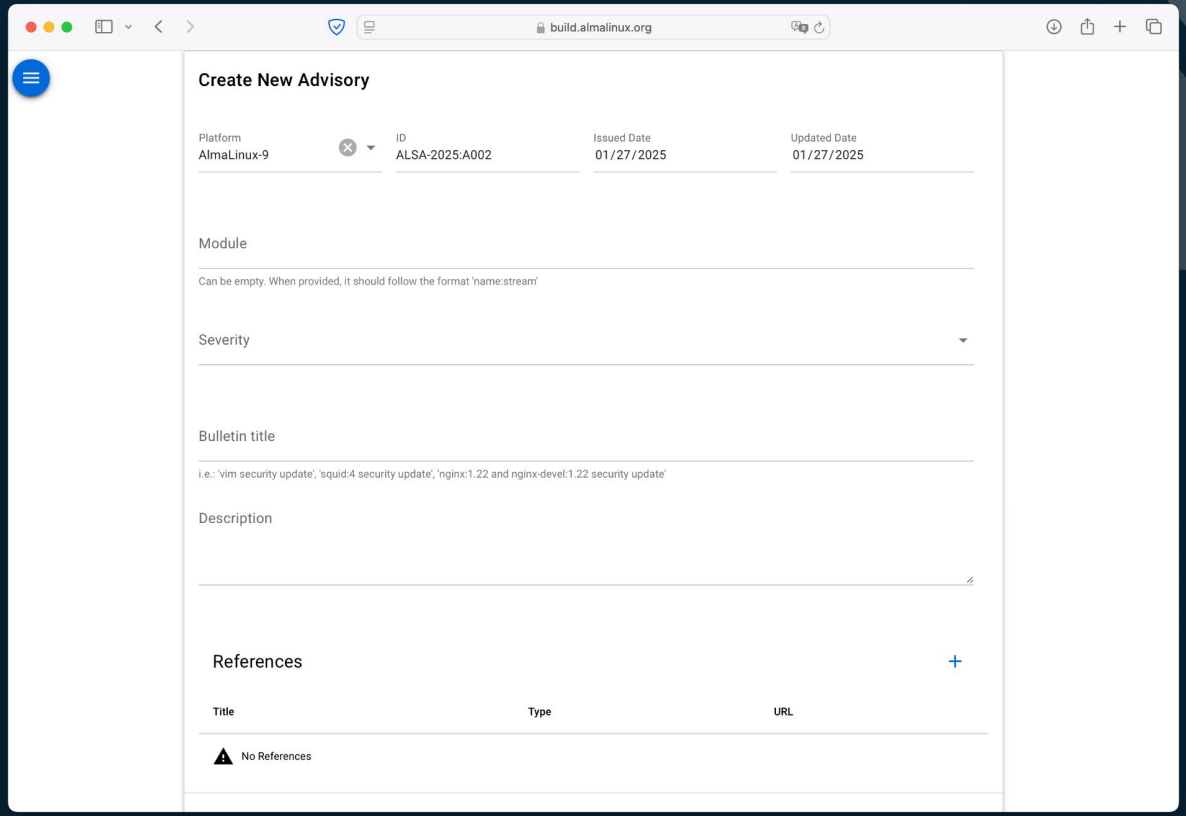
How we produce errata



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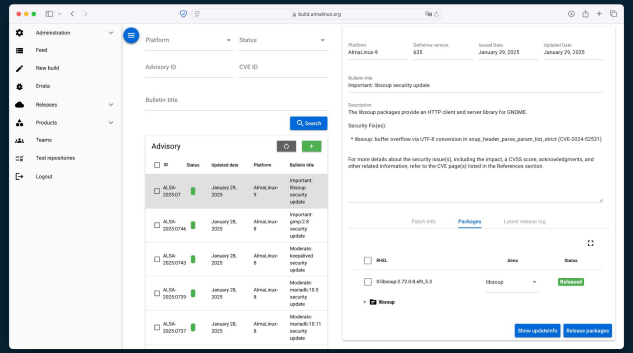
How we produce errata



Errata website

Mailing list

RSS feed

JSON feed

OVAL feed

updateinfo.xml

OSV database

AlmaLinux

How we build images

ISO Images

AlmaLinux supports 4 architectures:

- x86_64
- aarch64
- ppc64le
- s390x

Download ISO from mirrors

Cloud Images

AlmaLinux provides official images for cloud providers:

Amazon AWS
Generic Cloud
Google Cloud
Microsoft Azure
OpenNebula
Oracle Cloud Infrastructure

Container Images

AlmaLinux provides official OCI, Docker and UBI compatible images.

Get Docker Image
Get OCI Image from Quay.io
Get OCI Image from GitHub

Live Media

AlmaLinux builds Live Media images for GNOME, GNOME Mini, KDE, XFCE and MATE options.

Get Live Media Image

Vagrant Boxes

AlmaLinux provides official images for Vagrant:

- Libvirt
- VirtualBox
- Hyper-V
- VMWare
- Parallels

Get AlmaLinux on HCP Vagrant Registry

Incus and LXC

AlmaLinux images are available for Incus and LXC.

Get Incus and LXC Images

Raspberry Pi

AlmaLinux builds Raspberry Pi images, and also with GNOME desktop environment.

Get Raspberry Pi Image

WSL

Run the AlmaLinux terminal environment on Windows.

Get AlmaLinux for WSL

How we build images

ISO images:

Pungi tool is patched to build ISO images and repos without koji:
https://git.almalinux.org/almalinux/pungi
(this requires to have a local mirror of AlmaLinux repos we're building from)

Configuration files:
https://git.almalinux.org/almalinux/pungi-almalinux

Guide:
https://wiki.almalinux.org/development/building-almalinux-iso-locally

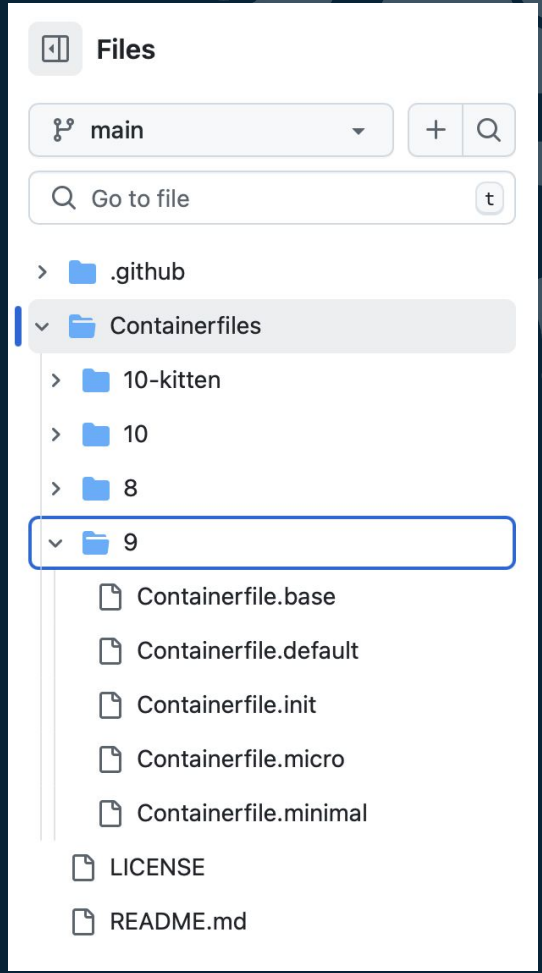
How we build images

Container images:

GitHub repo:
https://github.com/AlmaLinux/container-images

GitHub Actions pipeline is used to:

- Build containers for all supported architectures:
  - x86_64
  - aarch64
  - ppc64le
  - s390x
- Push to Docker Hub, Quay.io, GitHub Packages
- Create PR to Docker Hub Official Library



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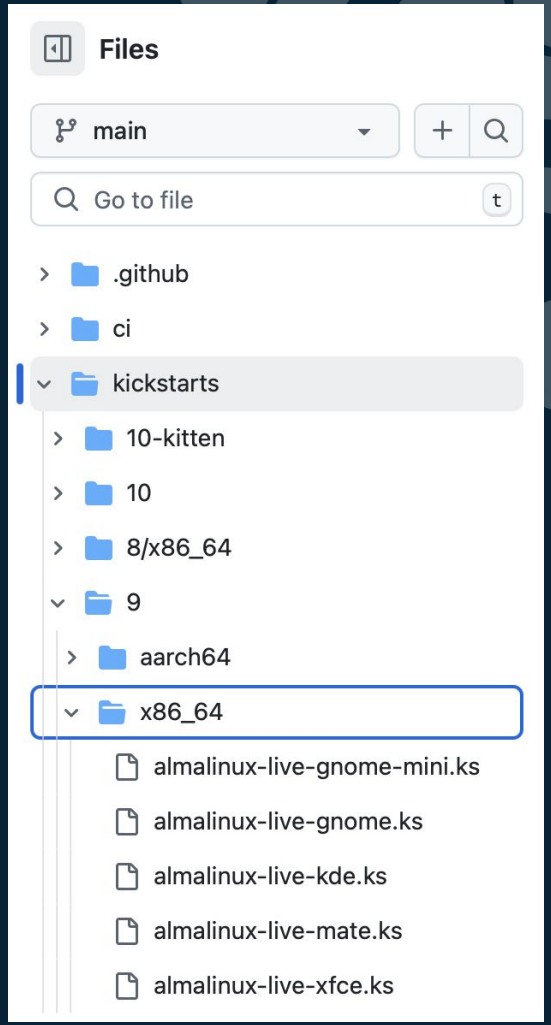
How we build images

Live Media images:

GitHub repo:
https://github.com/AlmaLinux/sig-livemedia

GitHub Actions pipeline is used to:

- Run AlmaLinux vagrant box
- Build for x86_64 and aarch64 with livemedia-creator
- Upload ISOs and logs to Amazon S3 bucket
- Notify in SIG/LiveMedia chat channel



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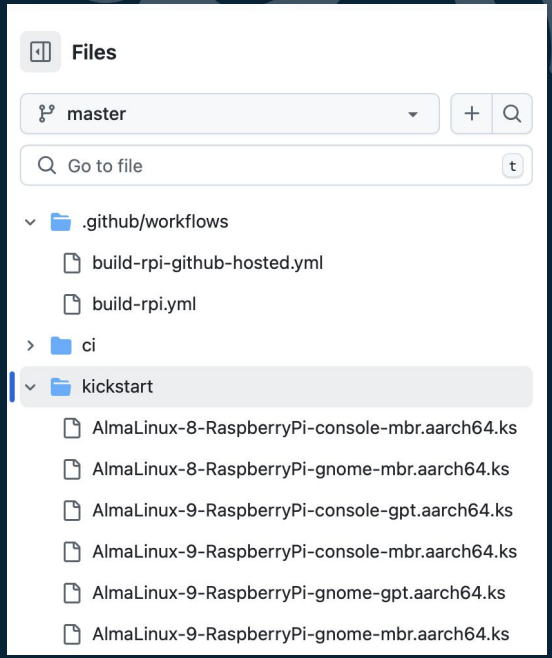
How we build images

Raspberry Pi images:

GitHub repo:
https://github.com/AlmaLinux/raspberry-pi

GitHub Actions pipeline is used to:

- Run AlmaLinux aarch64 container
- Build images with appliance-creator
- Upload images and logs to Amazon S3 bucket
- Notify in SIG/AltArch chat channel



How we build images

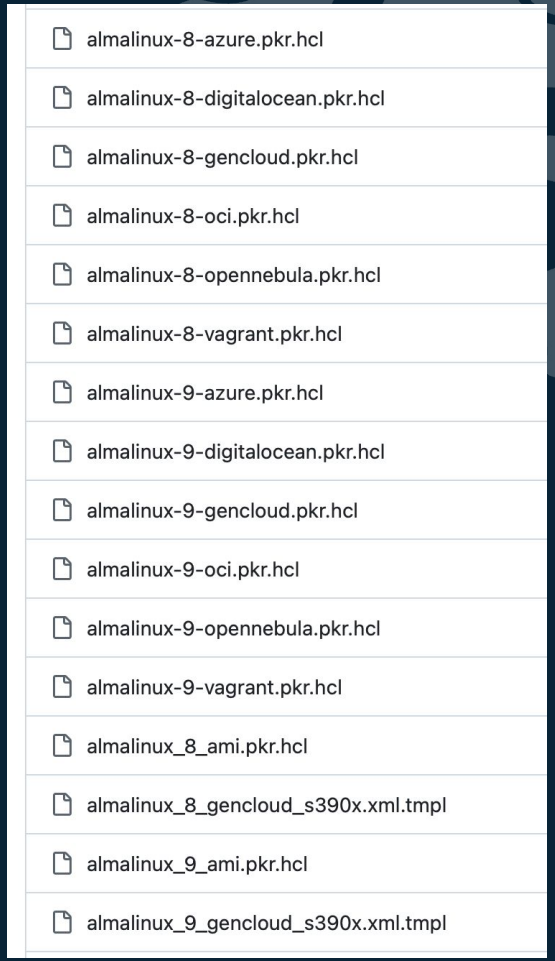
Cloud and Vagrant images:

GitHub repo:
https://github.com/AlmaLinux/cloud-images

We use Packer + Ansible to produce images for:

- OpenStack
- OpenNebula
- Azure
- AWS
- Oracle OCI
- Vagrant

You can contribute in automation!



AlmaLinux

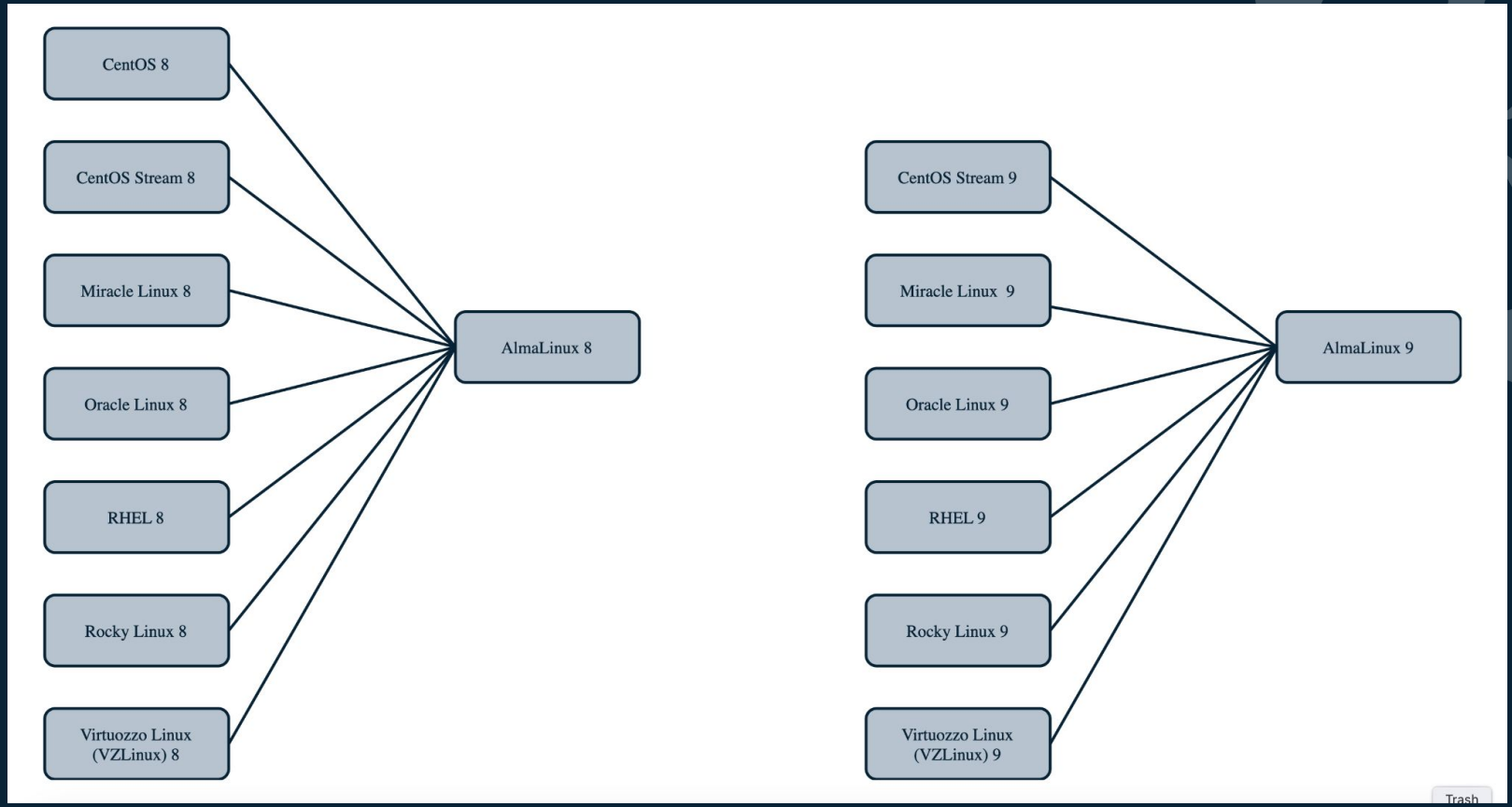
How to switch to AlmaLinux

We started our project with CentOS Linux 8 EOL in mind, so one of the first tools we developed was **almalinux-deploy**, a tool for online migration of already existing systems to AlmaLinux.

GitHub Repository:
https://github.com/AlmaLinux/almalinux-deploy

Migration guide:
https://wiki.almalinux.org/documentation/migration-guide.html

How to switch to AlmaLinux



AlmaLinux

How we unlocked major version upgrades in EL ecosystem

In 2021 we started the ELevate project:
https://almalinux.org/elevate/

It unlocks upgrades to next major versions which is unsupported in RHEL derivatives, and has become especially popular after CentOS Linux 7 EOL.

Based on Red Hat's Leapp framework:
https://github.com/oamg/leapp
https://github.com/oamg/leapp-repository

ELevate is developed in a distribution agnostic way and is built as a tool for the whole ecosystem, not just AlmaLinux!

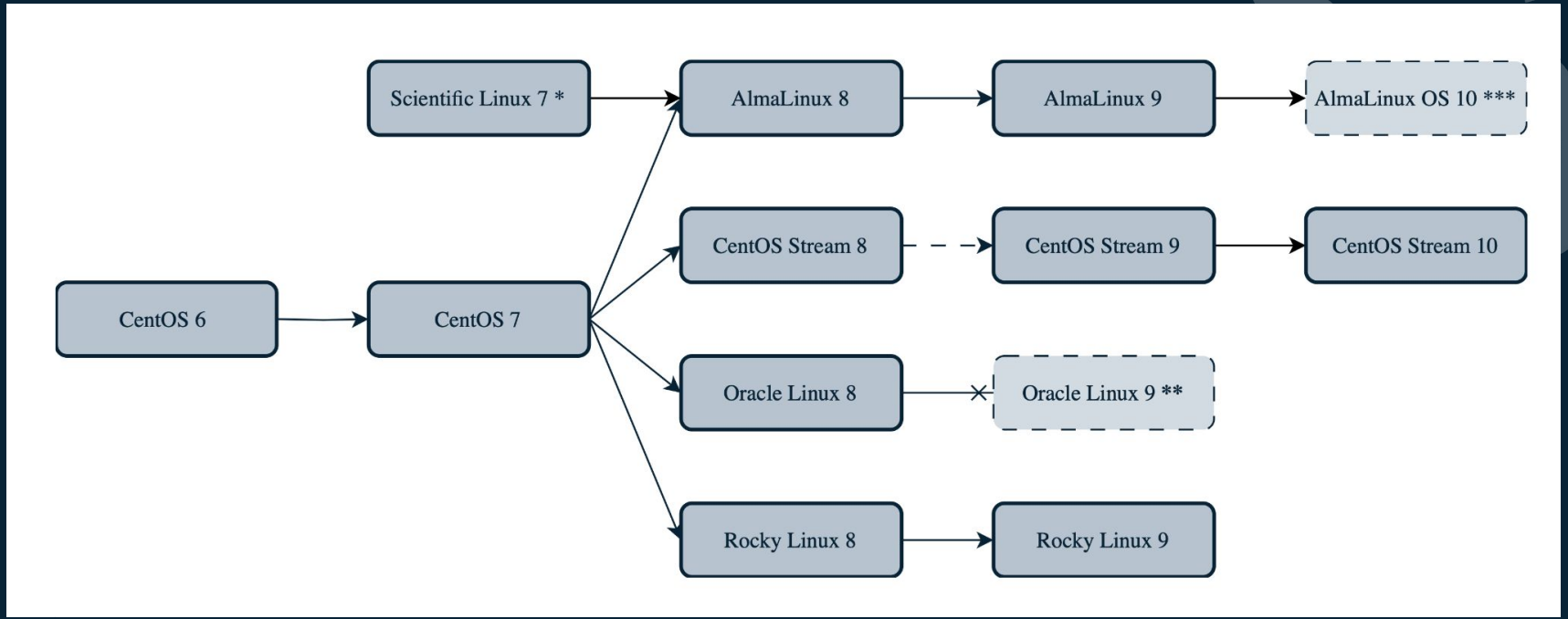
How we unlocked major version upgrades in EL ecosystem

We maintain soft fork of https://github.com/oamg/leapp-repository repo to add the following features:

- Support for non-RHEL distributions
- Support for popular 3rd party repositories like:
  - EPEL (!)
  - Docker CE
  - MariaDB
  - Microsoft Linux Package Repositories
  - nginx
  - PostgreSQL
  - Imunify
  - KernelCare

How we unlocked major version upgrades in EL ecosystem

Supported operating systems:



How we unlocked major version upgrades in EL ecosystem

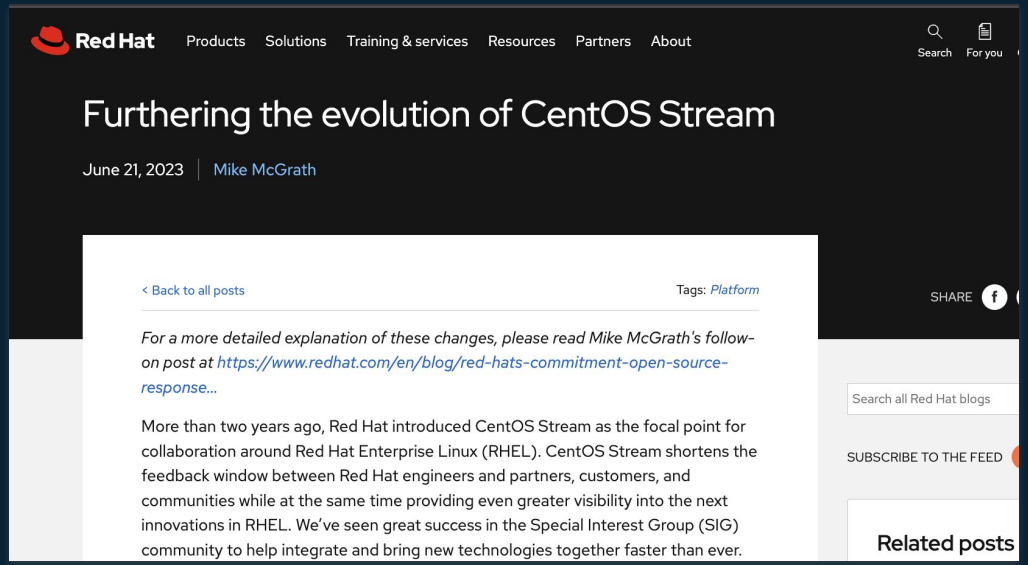
How to contribute to ELevate?

GitHub repository with Leapp soft fork:
https://github.com/AlmaLinux/leapp-repository

GitHub repository with OS and 3rd party repos configuration:
https://github.com/AlmaLinux/leapp-data

Contribution guide:
https://wiki.almalinux.org/elevate/Contribution-guide.html

How we now build AlmaLinux from various sources



Red Hat stopped uploading sources to CentOS git since June 21, 2023

Downloading Red Hat sources to use them for your product is
Red Hat Subscription Agreement violation!

AlmaLinux

How we now build AlmaLinux from various sources

AlmaLinux

Getting sources legally

Red Hat Universal Base Image (UBI)

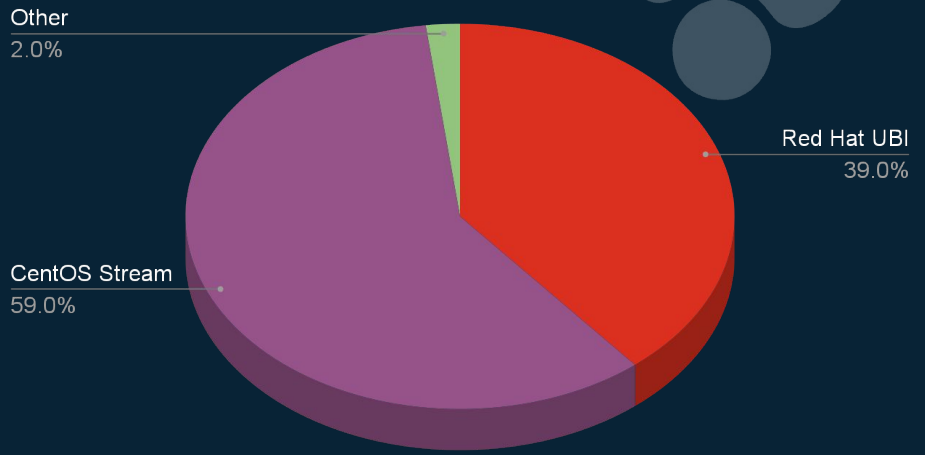
https://cdn-ubi.redhat.com/content/public/ubi/dist/

- RHEL sources in public, updated daily
- Limited set of packages

CentOS Stream

https://gitlab.com/redhat/centos-stream/rpms/

- Future RHEL packages
- We pick only specific package versions
- Not all packages are the same as RHEL



AlmaLinux

Why is it great not to be a RHEL clone?

- AlmaLinux team can release bugfixes requested by our community without waiting for RHEL updates. Moreover, we send fixes to CentOS Stream ourselves!

- AlmaLinux team can fix vulnerabilities earlier than Red Hat. As a distribution vendor we're subscribed to **distros@vs.openwall.org** mailing list and can obtain info about vulnerabilities and fixes much earlier they become available for public, so we can independently prepare and release updates same day.

- AlmaLinux derivatives can request to include some changes specific to them to avoid maintaining the package fork, but only if such changes don't affect AlmaLinux users.

- AlmaLinux can include device drivers that were removed from RHEL for non-technical reasons.

Why is it great not to be a RHEL clone? Bugfixes

Mark Wielaard, **bzip2** developer, contacted us on Nov 12 and informed us that recent AlmaLinux 8 security update for CVE-2019-12900 breaks upstream **bzip2** data integrity tests so basically updated **bzip2** may fail on some archives. He recommended us to apply additional upstream patch to fix this behaviour.

AlmaLinux update for **bzip2** was released Nov 15. Also we informed Red Hat about this issue and sent pull requests to CentOS Stream 8 and 9:

https://issues.redhat.com/browse/RHEL-67824

https://gitlab.com/redhat/centos-stream/rpms/bzip2/-/merge_requests/7
https://gitlab.com/redhat/centos-stream/rpms/bzip2/-/merge_requests/8

RHEL8 got this fix January 28, 2025

Why is it great not to be a RHEL clone? Security

On July 24, 2023 AMD published CVE-2023-20593 “**Zenbleed**” vulnerability. We immediately started intensive public testing for **linux-firmware** package update and published it to AlmaLinux 8 and 9 repos on July 27. Same security update for RHEL 8 and 9 was released September 12 and 19 respectively.

On July 01, 2024 high severity **openssh** vulnerability CVE-2024-6387 “**regreSSHion**” was published. Thanks to **distros@vs.openwall.org** mailing list we knew about this vulnerability several days earlier than it became public. So we was able to build and test the fix internally in advance and just release it to AlmaLinux repos same day the vulnerability was published. Red Hat released this fix 2 days later.

Why is it great not to be a RHEL clone? Derivatives

We're very satisfied when other organizations decide to use AlmaLinux as foundation for their software or even hardware projects. And we're here to help them with that.

The most popular AlmaLinux derivative is CloudLinux, operating system for hosting industry, which is based on AlmaLinux since version 8.5 and uses AlmaLinux public mirrors infrastructure.

They decided to rebase on AlmaLinux to not duplicate efforts in rebuilding upstream packages but better focus on their own packages set that makes CloudLinux unique.

For example, to reduce this packages set they contributed CloudLinux support to AlmaLinux's **cloud-init** package. So AlmaLinux team applies patch for both AlmaLinux and CloudLinux support to reduce amount of packages for derivative to maintain.

How we support additional hardware

CentOS 7 EOL happened June 30, 2024 and since 2023 many users started upgrading to AlmaLinux 8 and have found that many of their storage and network devices are not supported anymore and basically don't work because upstream decided to drop support to hardware they considering outdated.

We decided to bring this removed devices support back to kernel, it's **more than 140 devices** covered by the following drivers:

- **aacraid** - Dell PERC2, 2/Si, 3/Si, 3/Di, Adaptec Advanced Raid Products, HP NetRAID-4M, IBM ServeRAID & ICP SCSI
- **be2iscsi** - Emulex OneConnectOpen-iSCSI for BladeEngine 2 and 3 adapters
- **be2net** - Emulex BladeEngine 2 and 3 adapters
- **hpsa** - HP Smart Array Controller
- **lpfc** - Emulex LightPulse Fibre Channel SCSI
- **megaraid_sas** - Broadcom MegaRAID SAS
- **mlx4_core** - Mellanox Gen2 and ConnectX-2 adapters
- **mpt3sas** - LSI MPT Fusion SAS 3.0
- **mptsas** - Fusion MPT SAS Host
- **qla2xxx** - QLogic Fibre Channel HBA
- **qla4xxx** - QLogic iSCSI HBA

The ELRepo Project

AlmaLinux

How we support additional hardware

Global patch to move all “disabled” pci ids to “unmaintained” list:
0001-Enable-all-disabled-pci-devices-by-moving-to-unmaint.patch

Per-driver patches:
0002-Bring-back-deprecated-pci-ids-to-mptsas-mptspi-drive.patch
0003-Bring-back-deprecated-pci-ids-to-hpsa-driver.patch
0004-Bring-back-deprecated-pci-ids-to-qla2xxx-driver.patch
0005-Bring-back-deprecated-pci-ids-to-lpfc-driver.patch
0006-Bring-back-deprecated-pci-ids-to-qla4xxx-driver.patch
0007-Bring-back-deprecated-pci-ids-to-be2iscsi-driver.patch

https://git.almalinux.org/rpms/kernel

The ELRepo Project

AlmaLinux

How to become even more special?

Our experience of the last 1.5 years shows that the new path we've chosen is successful. We're able to reliably maintain 100% ABI compatibility with RHEL using legal only sources and even can bring minor improvements to our users.

But what about major changes? How to bring them? How to make community test them? How to prepare our infrastructure for next major AlmaLinux version?

The answer is...

How to become even more special?

Our experience of the last 1.5 years shows that the new path we've chosen is successful. We're able to reliably maintain 100% ABI compatibility with RHEL using legal only sources and even can bring minor improvements to our users.

But what about major changes? How to bring them? How to make community test them? How to prepare our infrastructure for next major AlmaLinux version?

The answer is...

AlmaLinux Kitten

How to become even more special?

- No minor versions
- Based on CentOS Stream 10 sources
- Supported for at least 5 years
- Foundation for AlmaLinux 10 Beta
- Will allow to get AlmaLinux 10 updates earlier

Since Day 1 has the following changes compared CentOS Stream:

- Compiled with **Frame Pointers enabled** to improve profiling and debugging
- **Secure Boot** is supported for both Intel and ARM
- **SPICE** protocol support for virtualization environments (dropped since RHEL9)
- **KVM** virtualization support on **IBM Power** platform (dropped since RHEL9)
- Even more devices supported that were dropped from RHEL
- Has additional **x86_64_v2** architecture option to support older Intel/AMD CPUs (since 2008)
- ~~Firefox and Thunderbird are included~~

How to add x86_64_v2 (_v3,_v4) architecture to EL?

RPM supports x86_64 levels as architectures since 4.19.0

But it’s still necessary to patch:

- dnf
- libdnf
- efi-rpm-macros
- libsolv
- lorax
- pesign
- python-productmd
- ...

For full packages list with v2 patches applied go to:
https://wiki.almalinux.org/development/Modified-packages.html

How to add x86_64_v2 (_v3,_v4) architecture to EL?

RPM supports x86_64 levels as architectures since 4.19.0

Surprisingly, we still need to patch RPM as well because of this:

```
%ifarch x86_64
# some genius code
%endif
```

```
%ifarch %{x86_64}
# some genius code
%endif
```

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So we treat x86_64_v2 as x86_64 in architecture checks now

What's next?

Plans for 2025:

- AlmaLinux 10 stable release in May
- AlmaLinux 10 for RISC-V
- EPEL 10 for x86_64_v2 (https://github.com/AlmaLinux/ALESCo/pull/2)
- Automation, automation, automation
- Improve contributor experience

No drama, just Linux.

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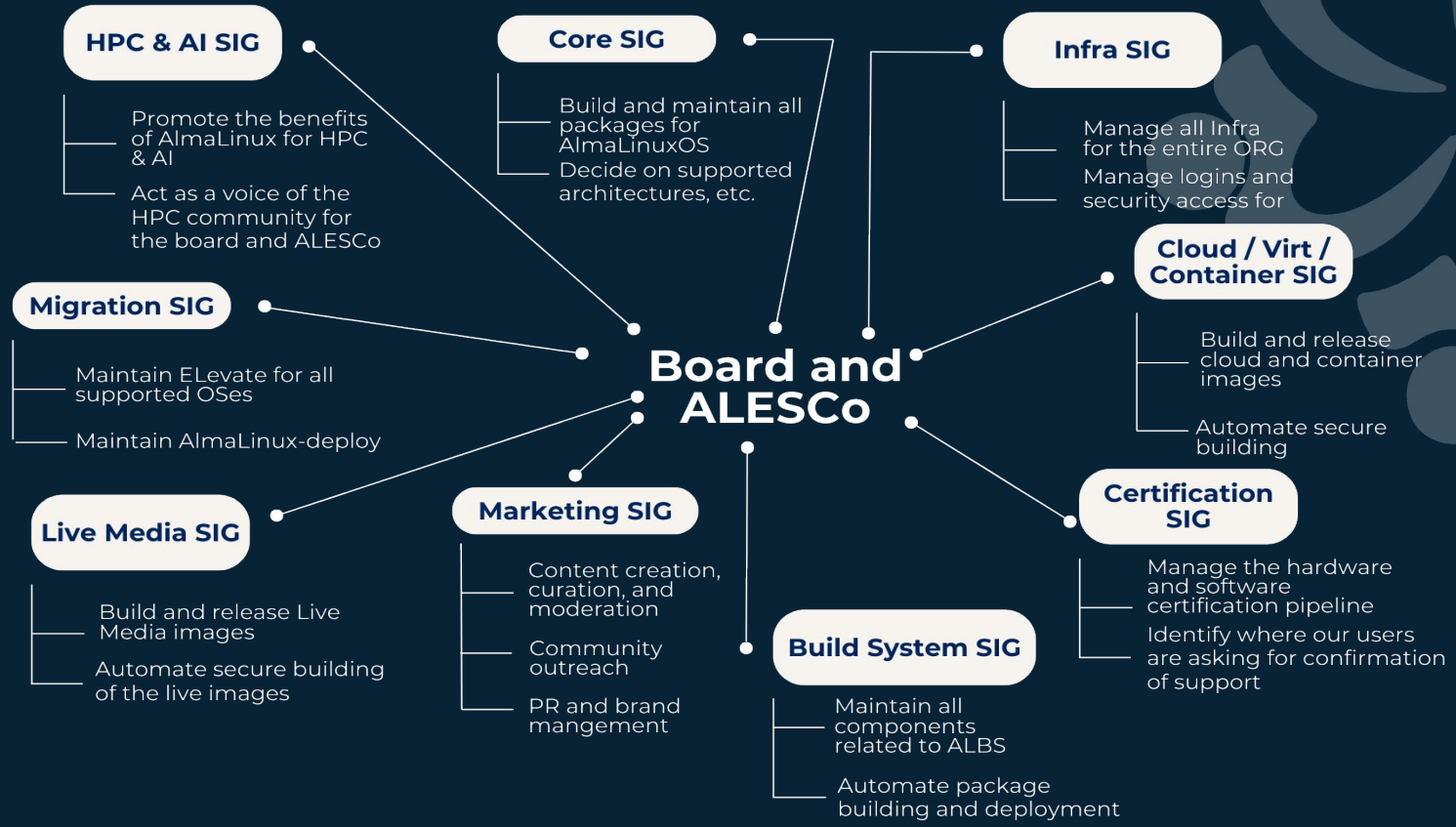
AlmaLinux Special Interest Groups (SIGs)



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https://wiki.almalinux.org/sigs/

Thank you!
Q&A time!

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