

Elaboration on Atomic Images and BlueBuild

with demo

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1 Demo Prerequisites

- GitHub account
- Ability to run VM

2 Explanation

2.1 General idea of Atomic Images

The concept of atomic images, also known as immutable images, refers to Linux distributions packaged similarly to container images. These images are often called "bootable containers." They allow for atomic updates to the distribution and programs in a single operation—hence the name "atomic"—while enabling layering of additional programs.

2.1.1 Reliability & Consistency

Atomic images prioritize reliability and consistency by mounting their root file system as read-only. This prevents "configuration drift" over time, as user changes that could lead to unpredictability are restricted.

2.1.2 Simplified Updates

Traditional update mechanisms risk leaving systems partially updated or broken if interruptions occur. Atomic images mitigate this through transactional updates, where changes take effect only upon successful completion and can be rolled back if needed. For instance, Fedora images using `rpm-ostree` perform automatic background updates.

2.1.3 Improved Security

Writable root file systems are significant attack vectors in Linux. Atomic images reduce this risk by employing a read-only root file system, making them less vulnerable to exploitation.

2.1.4 Container-Optimized Workflow

Linux systems were not traditionally optimized for containerized workloads. Atomic images address this gap by offering minimal, consistent base images designed for hosting containerized applications. Examples include Fedora CoreOS and Flatcar Container Linux.

2.1.5 Easy Reproducibility

Reproducing exact environments across systems is error-prone. Atomic images, akin to OCI and Docker images, use a layered approach, ensuring reliable and consistent setups across multiple systems. This enables large-scale operating system deployments. Paired with containerized applications, they create a fully reproducible stack.

2.1.6 Types and examples

- Minimal base images:
 - Fedora CoreOS
 - RHCOS (similar to CoreOS, but RHEL)
 - Fedora IoT
 - Flatcar Container Linux
 - Universal Blue uCore (based on Fedora CoreOS)
 - openSUSE MicroOS
- Atomic Desktops:
 - Fedora Silverblue (GNOME)
 - Fedora Kinoite (KDE Plasma)
 - Universal Blue Bluefin (based on Silverblue)
 - Universal Blue Aurora (based on Kinoite)
 - Universal Blue Bazzite (gaming orientated)

2.2 Projects

2.2.1 libostree

libostree (formerly OSTree) is a shared library and suite of command-line tools for committing and downloading bootable file system trees.

2.2.2 rpm-ostree

rpm-ostree integrates libostree with libdnf (the RPM package system). It powers Fedora/Red Hat images and derivatives like Universal Blue, enabling RPM package layering on base images.

Note: As of Fedora 41, focus has shifted to DNF5 and bootc. Features of rpm-ostree are gradually being migrated to DNF5.

2.2.3 Build Tools

Specific tools are required to build atomic images. Fedora uses coreos-assembler for CoreOS-style systems, while Universal Blue employs Red Hat's buildah to build OCI-compatible containers compatible with Docker and Kubernetes.

2.3 Custom Images

Linux is renowned for its customization capabilities, but sharing customizations is often cumbersome. Atomic images simplify this by encapsulating adjustments within the image itself. These adjustments can include style, kernel optimizations, drivers, and preinstalled applications.

2.3.1 Universal Blue

Universal Blue images are built on Fedora images, layering kernel optimizations and drivers (e.g., NVIDIA graphics drivers) on top. They offer a GitHub template for building custom images.

2.3.2 BlueBuild

BlueBuild simplifies the creation of custom Universal Blue images. It provides a workshop that sets up a GitHub repository to jump-start image creation. Future updates aim to enable programmatic image configuration.

2.3.3 Use cases

2.3.3.1 Application Deployment

Custom images streamline deployment by pre-configuring services, security, and compliance requirements. This approach reduces risks and accelerates product rollouts at scale.

2.3.3.2 Developer-Team environments

In teams where everyone uses Linux, a shared image can eliminate "works on my machine" issues by standardizing the development environment.

2.3.3.3 Education and Training environments

Pre-configured sandbox images provide students with secure, ready-to-use environments for practicing DevOps, security, or containerization, with minimal setup.

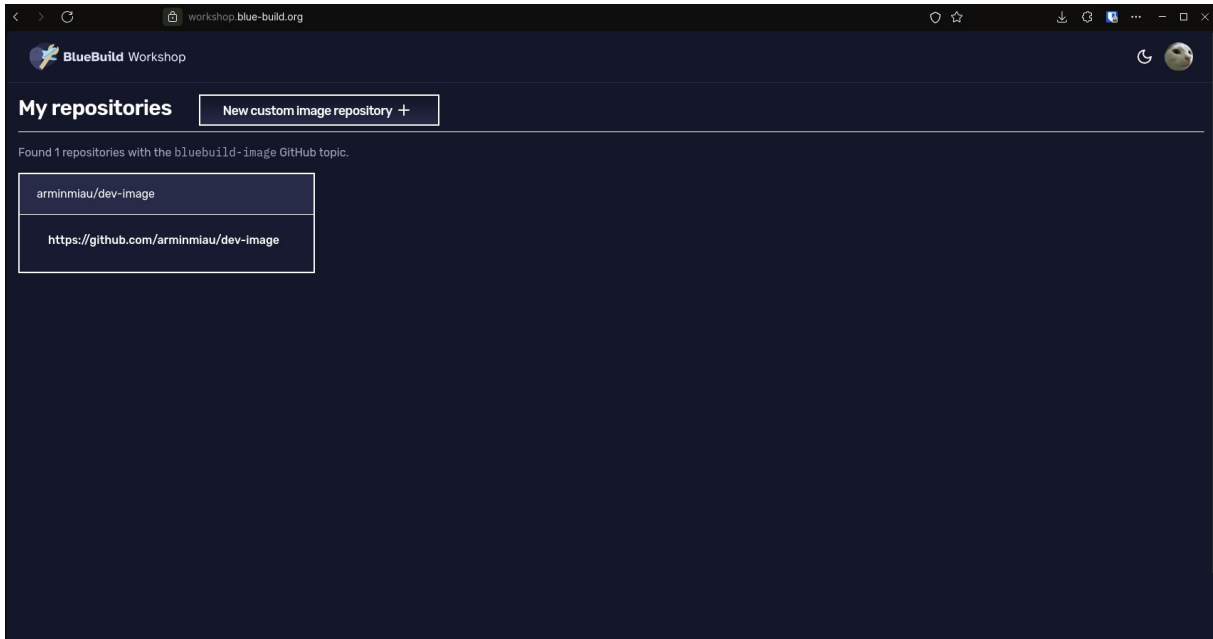
2.3.3.4 Experimentation and Learning

Atomic images offer a safe platform for testing different desktop environments, tools, and configurations. They allow users to experiment with Linux customizations and roll back changes as needed.

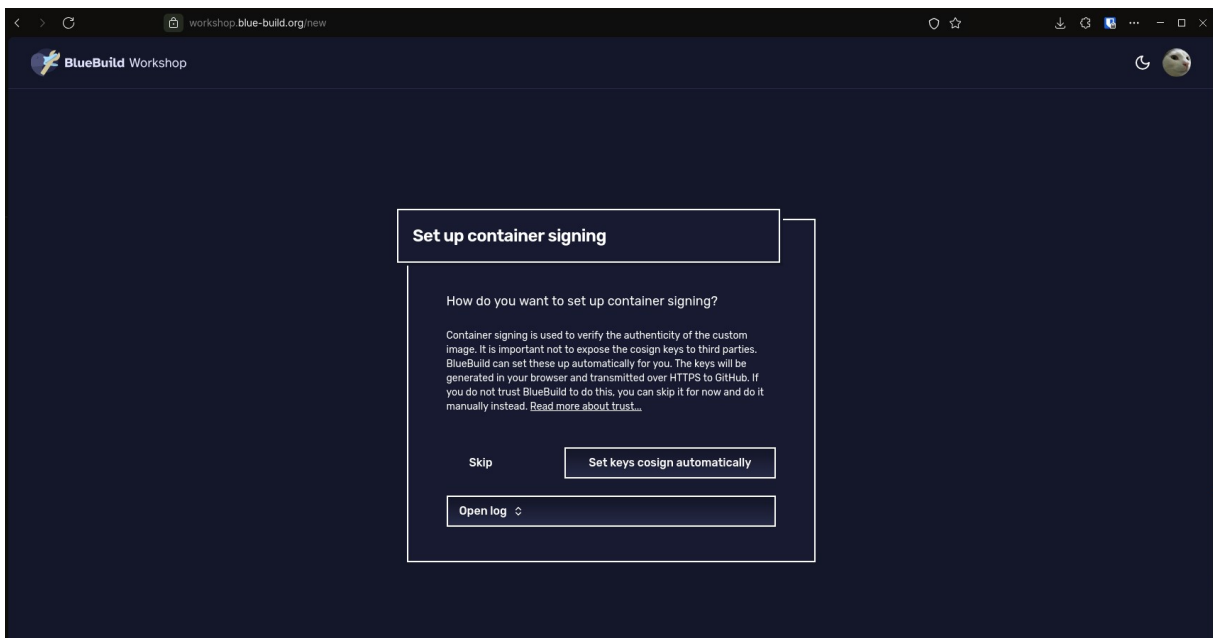
3 Demo

3.1 Setup

Head to <https://workshop.blue-build.org/> and login with GitHub. You'll need to authorize the application on the first time. Then click on "New custom Image repository +":



Name it something and in the next step click on "Set keys cosign automatically":



Once it's done open the repository and clone it.

Open recipe.yml in recipes. For this demo we'll choose aurora-dx with latest version.

```
# image will be published to ghcr.io/<user>/<name>
name: demo-image
# description will be included in the image's metadata
description: This is a demo image for my lightning talk.

# the base image to build on top of (FROM) and the version tag to use
base-image: ghcr.io/ubblue-os/aurora-dx
image-version: latest
```

Let's install .NET 8 as a layered rpm package and Rider as a Flatpak.

```
- type: rpm-ostree
  repos:
    # -
  install:
    - dotnet-sdk-8.0
  remove:
    # -

- type: default-flatpaks
  notify: true
  system:
    install:
      - com.jetbrains.Rider
  remove:
    # -
```

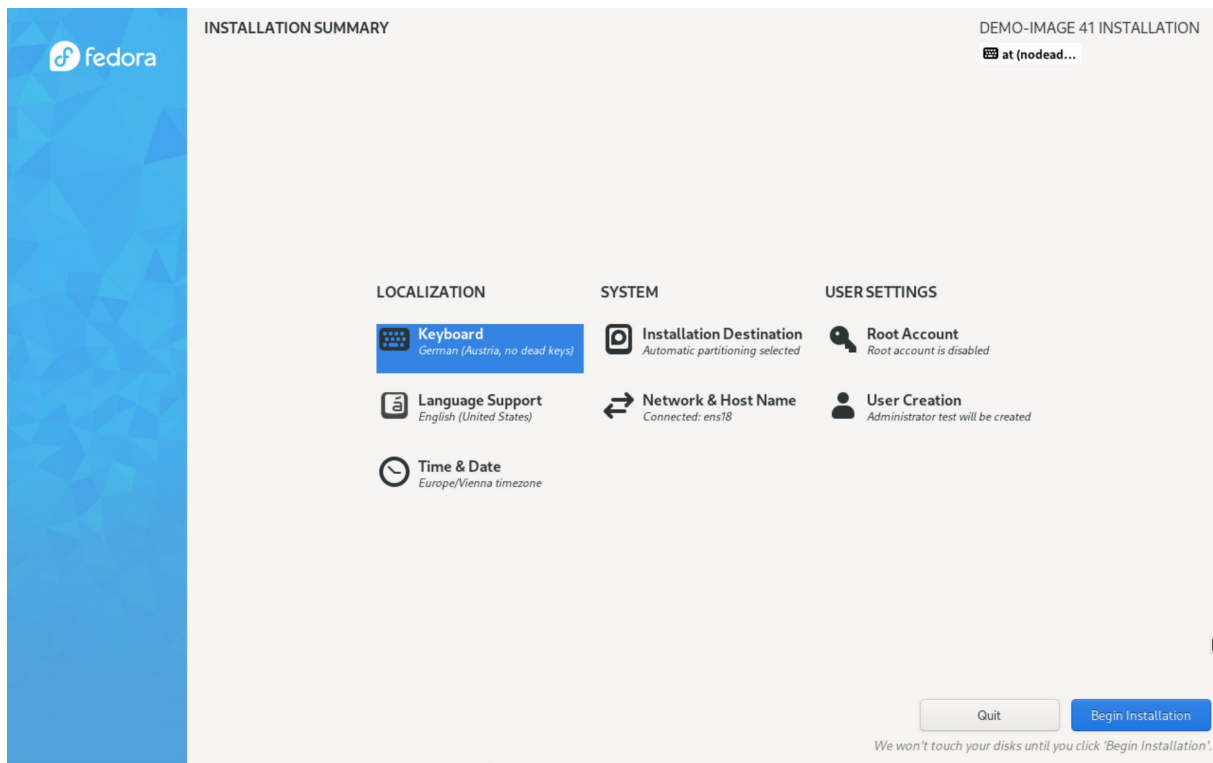
Add a ISO build job to the GitHub workflow (after bluebuild job in `.github/workflows/build.yaml`):

```
iso:
  name: Build ISO
  needs: bluebuild
  runs-on: ubuntu-latest
  permissions:
    contents: read
    packages: write
    id-token: write
  steps:
    - name: Build
      uses: jasonn3/build-container-installer@main
      id: build
      with:
        arch: x86_64
        image_name: demo-image
        image_repo: ghcr.io/arminmiao
        image_tag: latest
        version: 41
        variant: kinoite
        iso_name: demo-image-latest-x86_64.iso
    - name: Upload as artifact
      id: upload
      uses: actions/upload-artifact@v4
      with:
        name: ${{ steps.build.outputs.iso_name }}
        path: |
          ${{ steps.build.outputs.iso_path }}
          ${{ steps.build.outputs.iso_path }}-CHECKSUM
        if-no-files-found: error
        retention-days: 0
        compression-level: 0
```

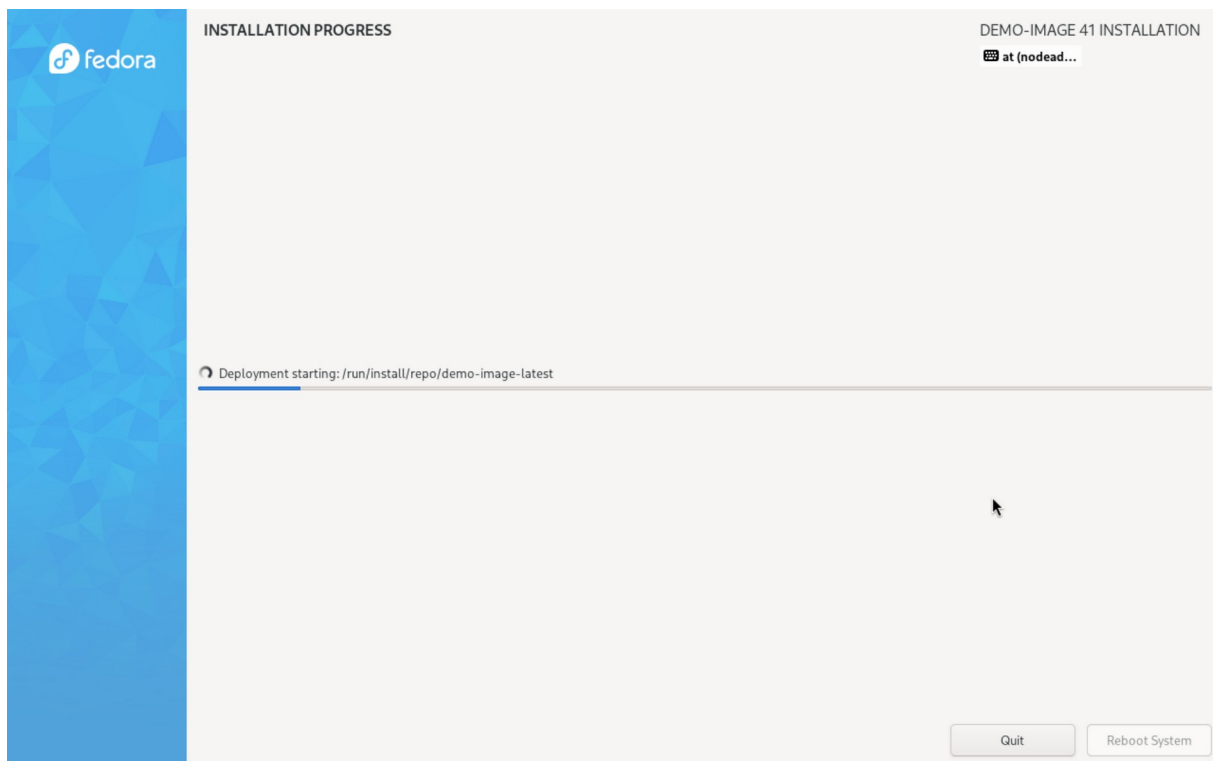
Commit and push the changes. The workflow will automatically build the new image and also an installation ISO. Once the ISO has been built you can test it out in a virtual machine.

3.2 Deployment

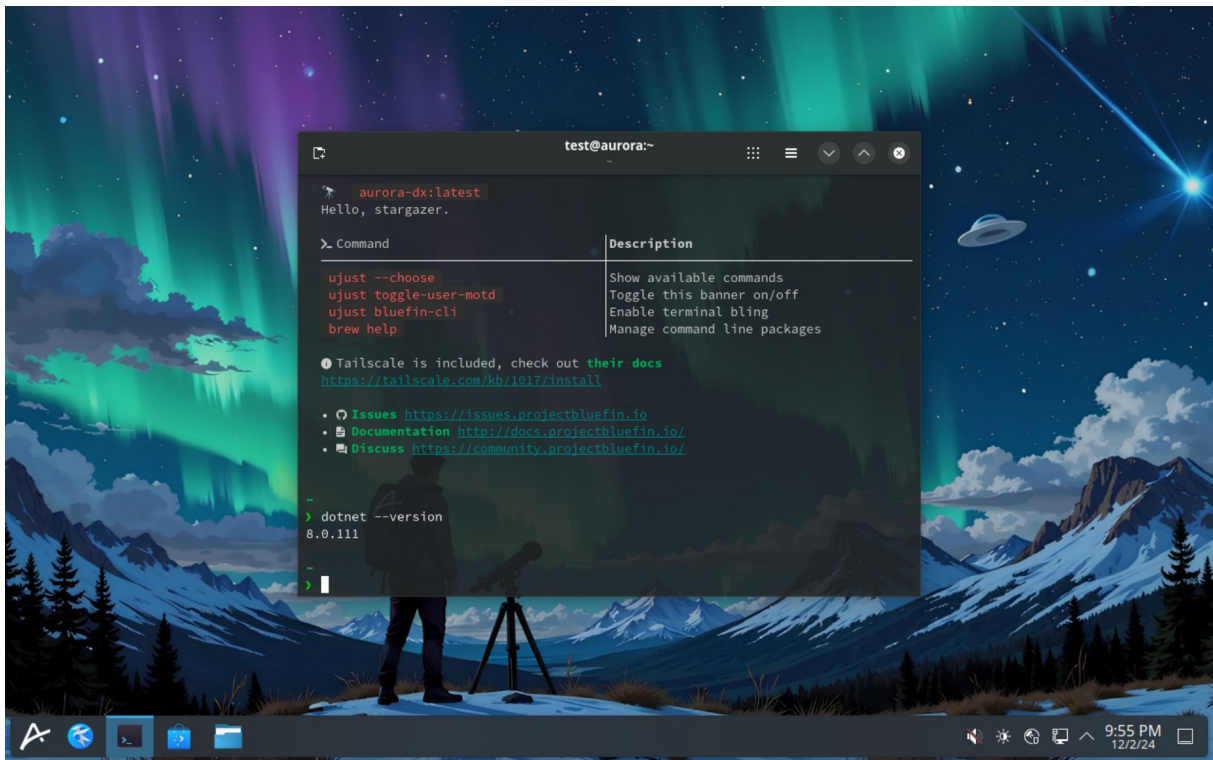
Due to the build and deploying process taking too long for the Lightning Talk, I have my virtual machine already prepared and this was the installation summary:



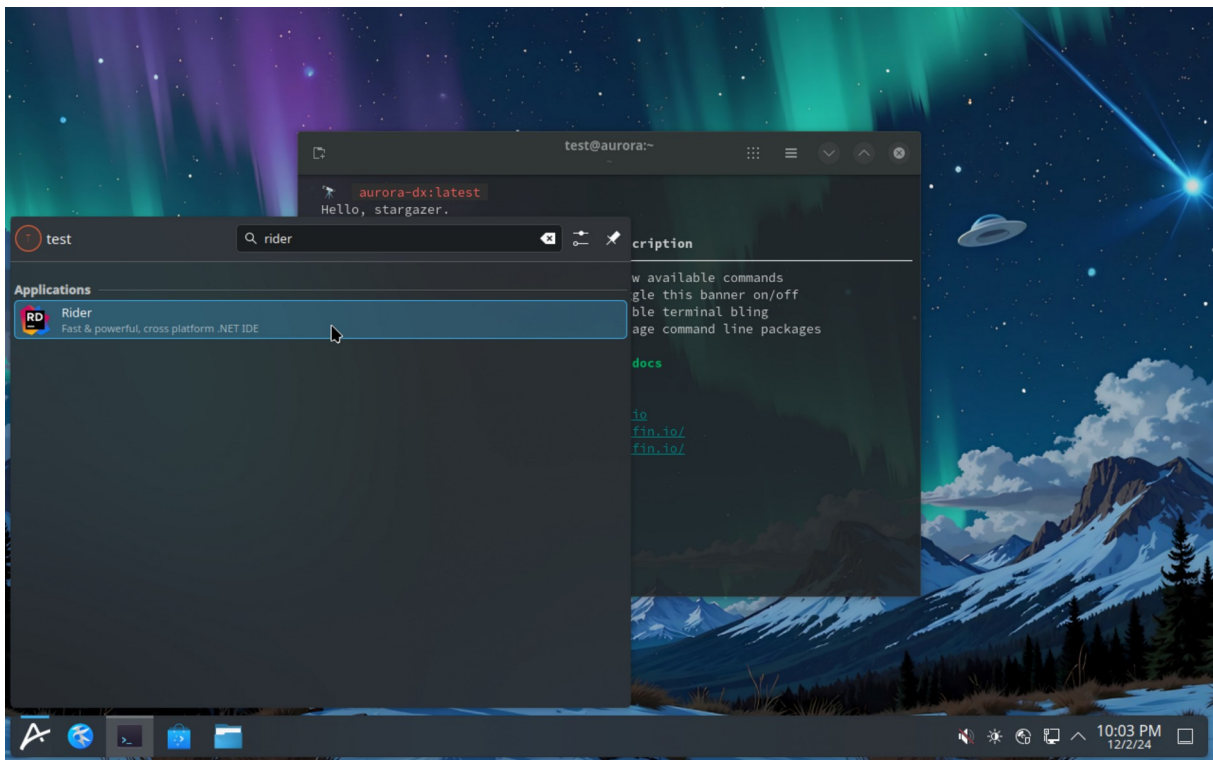
While installing you can see that it starts the deployment of the image:



After logging in we check the .NET version, which should be 8:

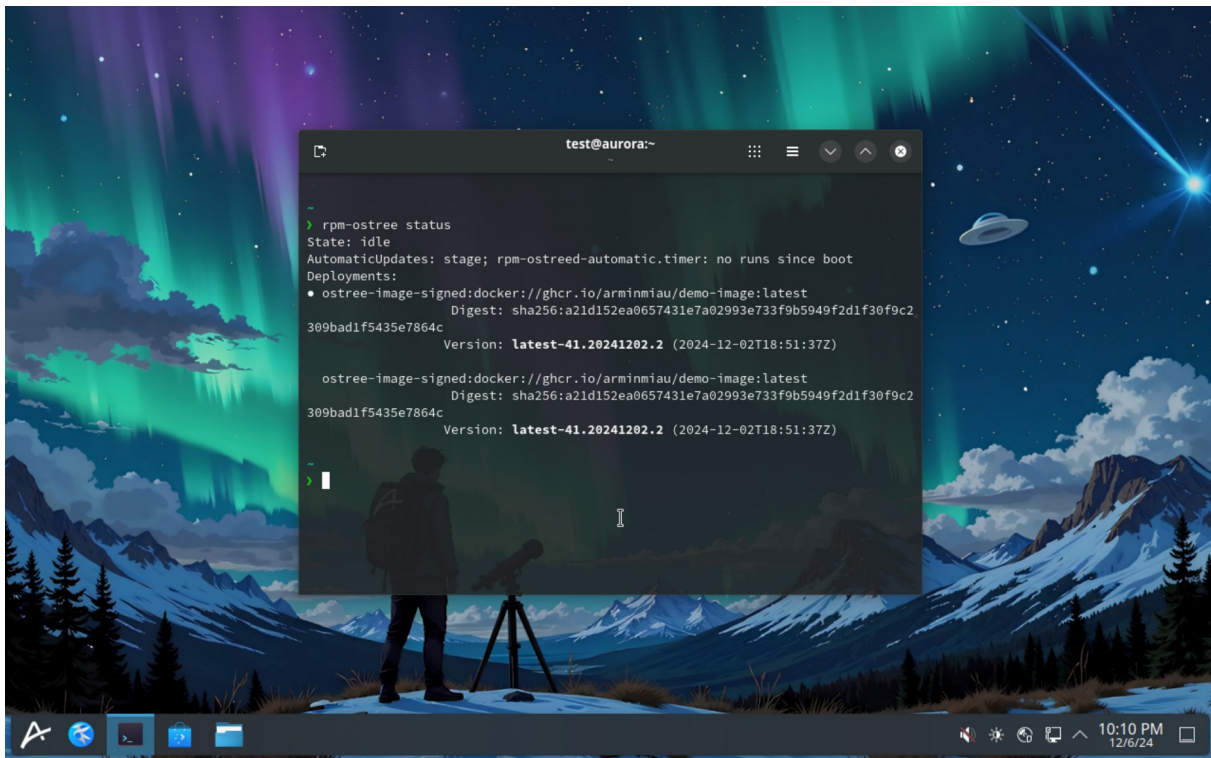


Then we can look for Rider, but at first login it will take a short time to appear as Flatpaks only get installed after first login, because they are sandboxed applications.



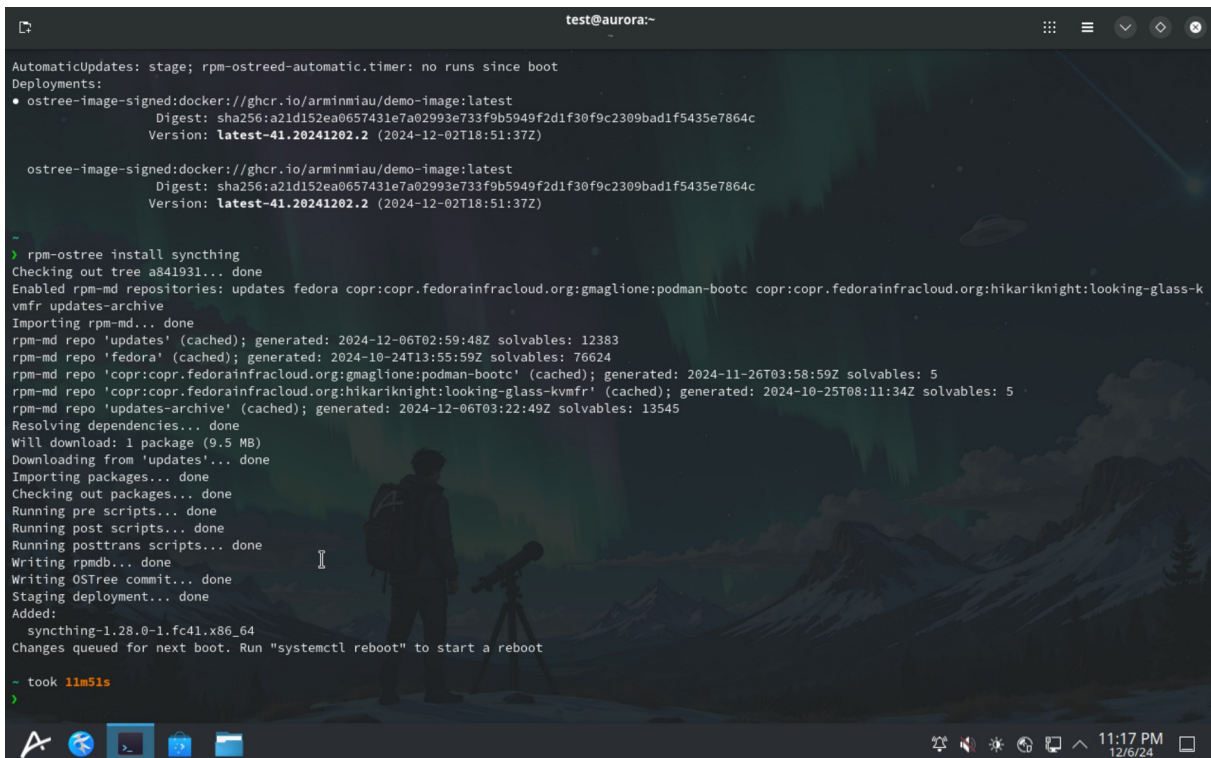
3.3 Layering and live-apply example

With `rpm-ostree status` we get a brief overview of the deployment status.

A terminal window titled 'test@aurora:~' is open over a desktop background of a snowy mountain landscape with a person looking through a telescope. The terminal displays the output of the 'rpm-ostree status' command. The output shows the system is in an 'idle' state, with automatic updates staged. It lists two deployments, both pointing to the 'latest' image with a specific digest and version 'latest-41.20241202.2' from 2024-12-02T18:51:37Z.

```
test@aurora:~  
-  
> rpm-ostree status  
State: idle  
AutomaticUpdates: stage; rpm-ostreed-automatic.timer: no runs since boot  
Deployments:  
• ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
  Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
  Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
  
  ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
  Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
  Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
-  
>
```

To layer a package we can use `rpm-ostree install <package>`. Let's install `syncthing`:

A terminal window titled 'test@aurora:~' shows the output of the 'rpm-ostree install syncthing' command. The output details the process of checking out the tree, enabling repositories, importing packages, resolving dependencies, downloading the package (9.5 MB), and staging the deployment. It concludes with the package 'syncthing-1.28.0-1.fc41.x86_64' being added and a message to run 'systemctl reboot' to start a reboot.

```
test@aurora:~  
AutomaticUpdates: stage; rpm-ostreed-automatic.timer: no runs since boot  
Deployments:  
• ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
  Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
  Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
  
  ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
  Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
  Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
-  
> rpm-ostree install syncthing  
Checking out tree a841931... done  
Enabled rpm-md repositories: updates fedora copr:copr.fedorainfracloud.org:gmaglione:podman-bootc copr:copr.fedorainfracloud.org:hikariknight:looking-glass-kvmfr updates-archive  
Importing rpm-md... done  
rpm-md repo 'updates' (cached); generated: 2024-12-06T02:59:48Z solvables: 12383  
rpm-md repo 'fedora' (cached); generated: 2024-10-24T13:55:59Z solvables: 76624  
rpm-md repo 'copr:copr.fedorainfracloud.org:gmaglione:podman-bootc' (cached); generated: 2024-11-26T03:58:59Z solvables: 5  
rpm-md repo 'copr:copr.fedorainfracloud.org:hikariknight:looking-glass-kvmfr' (cached); generated: 2024-10-25T08:11:34Z solvables: 5  
rpm-md repo 'updates-archive' (cached); generated: 2024-12-06T03:22:49Z solvables: 13545  
Resolving dependencies... done  
Will download: 1 package (9.5 MB)  
Downloading from 'updates'... done  
Importing packages... done  
Checking out packages... done  
Running pre scripts... done  
Running post scripts... done  
Running posttrans scripts... done  
Writing rpmdb... done  
Writing OSTree commit... done  
Staging deployment... done  
Added:  
  syncthing-1.28.0-1.fc41.x86_64  
Changes queued for next boot. Run "systemctl reboot" to start a reboot  
- took 11m51s  
>
```

At the end the command will say: "Changes queued for next boot".

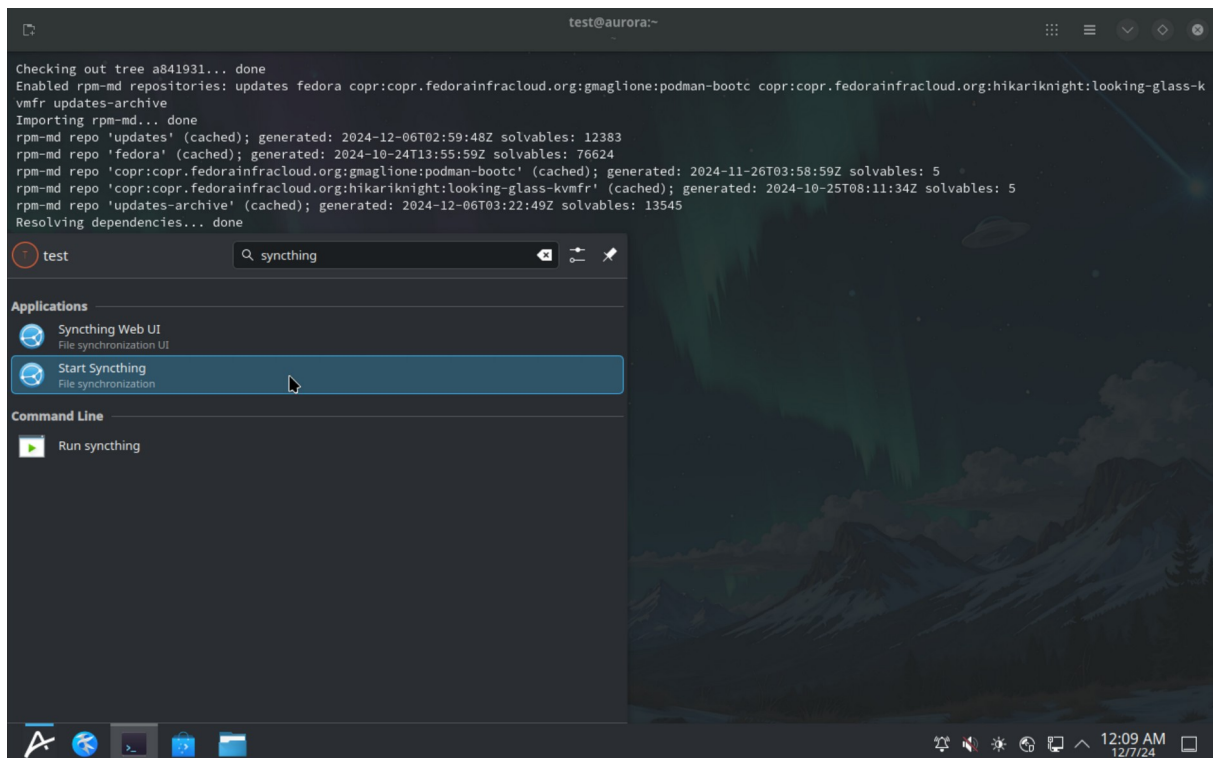
If we look at rpm-ostree status again, we see that the new change hasn't been deployed yet.

```
test@aurora:~  
rpm-md repo 'copr:copr.fedorainfracloud.org:hikariknight:looking-glass-kvmfr' (cached); generated: 2024-10-25T08:11:34Z solvables: 5  
rpm-md repo 'updates-archive' (cached); generated: 2024-12-06T03:22:49Z solvables: 13545  
Resolving dependencies... done  
Will download: 1 package (9.5 MB)  
Downloading from 'updates'... done  
Importing packages... done  
Checking out packages... done  
Running pre scripts... done  
Running post scripts... done  
Running posttrans scripts... done  
Writing rpmdb... done  
Writing OSTree commit... done  
Staging deployment... done  
Added:  
  syncthing-1.28.0-1.fc41.x86_64  
Changes queued for next boot. Run "systemctl reboot" to start a reboot  
  
~ took 11m51s  
> rpm-ostree status  
State: idle  
AutomaticUpdates: stage; rpm-ostreed-automatic.timer: no runs since boot  
Deployments:  
  ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
    Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
    Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
    Diff: 1 added  
    LayeredPackages: syncthing  
  
  • ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
    Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
    Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
  
  ostree-image-signed:docker://ghcr.io/arminmiao/demo-image:latest  
    Digest: sha256:a21d152ea0657431e7a02993e733f9b5949f2d1f30f9c2309bad1f5435e7864c  
    Version: latest-41.20241202.2 (2024-12-02T18:51:37Z)  
  
~  
> |
```

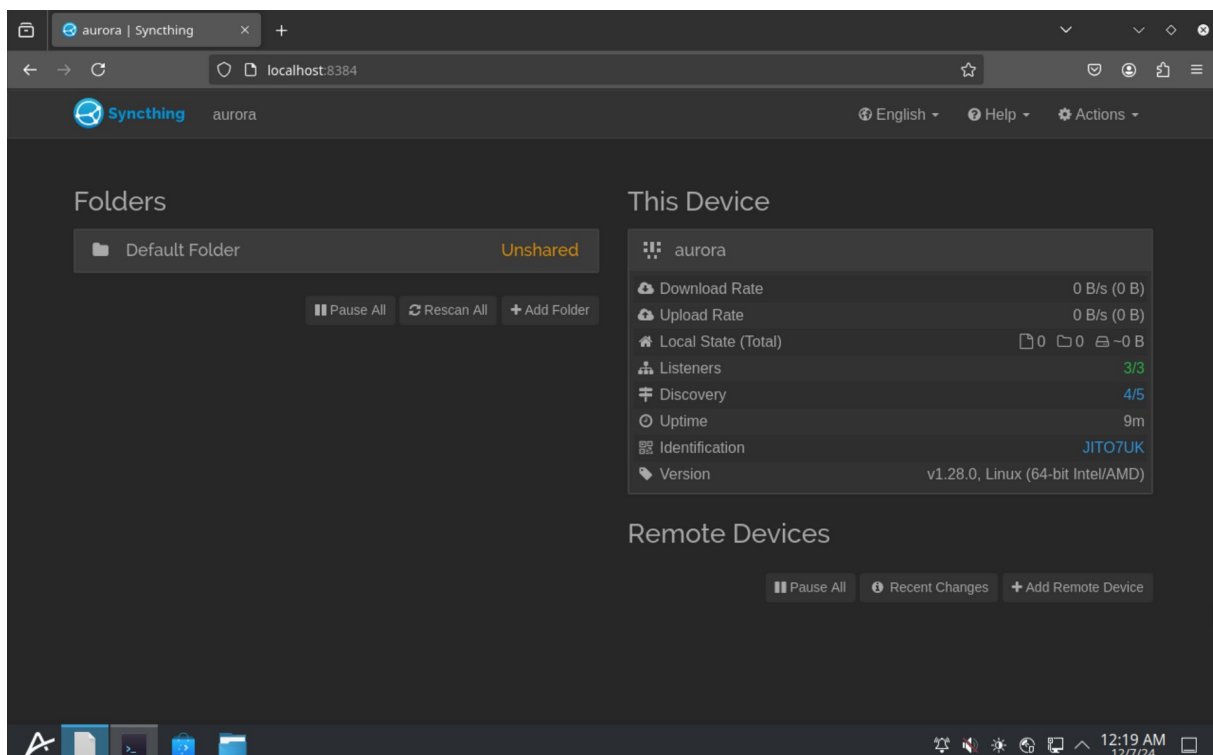
We can trigger a live deploy using `sudo rpm-ostree apply-live`. (Which might not always work, in my testing it only worked after layering one package and rebooting before adding syncthing and applying live.)

```
test@aurora:~  
Checking out tree a841931... done  
Enabled rpm-md repositories: updates fedora copr:copr.fedorainfracloud.org:gmaglione:podman-bootc copr:copr.fedorainfracloud.org:hikariknight:looking-glass-kvmfr updates-archive  
Importing rpm-md... done  
rpm-md repo 'updates' (cached); generated: 2024-12-06T02:59:48Z solvables: 12383  
rpm-md repo 'fedora' (cached); generated: 2024-10-24T13:55:59Z solvables: 76624  
rpm-md repo 'copr:copr.fedorainfracloud.org:gmaglione:podman-bootc' (cached); generated: 2024-11-26T03:58:59Z solvables: 5  
rpm-md repo 'copr:copr.fedorainfracloud.org:hikariknight:looking-glass-kvmfr' (cached); generated: 2024-10-25T08:11:34Z solvables: 5  
rpm-md repo 'updates-archive' (cached); generated: 2024-12-06T03:22:49Z solvables: 13545  
Resolving dependencies... done  
Will download: 1 package (9.5 MB)  
Downloading from 'updates'... done  
Importing packages... done  
Checking out packages... done  
Running pre scripts... done  
Running post scripts... done  
Running posttrans scripts... done  
Writing rpmdb... done  
Writing OSTree commit... done  
Staging deployment... done  
Freed: 148.3 MB (pkgcache branches: 0)  
Added:  
  syncthing-1.28.0-1.fc41.x86_64  
Changes queued for next boot. Run "systemctl reboot" to start a reboot  
  
~ took 10m51s  
> sudo rpm-ostree apply-live  
[sudo] password for test:  
Computing /etc diff to preserve... done  
Updating /usr... done  
Updating /etc... done  
Running systemd-tmpfiles for /run and /var... done  
Added:  
  syncthing-1.28.0-1.fc41.x86_64  
Successfully updated running filesystem tree.  
  
~ took 8s  
> |
```

Once done we can start syncthing (the background process of it):



When the syncthing daemon has started we can look at the web ui.



4 Links

If you want to research more yourself here are some sources:

<https://ostreedev.github.io/ostree/>

<https://coreos.github.io/rpm-ostree/>

<https://coreos.github.io/coreos-assembler/>

https://fedoraproject.org/wiki/Initiatives/Fedora_bootc

<https://fedoraproject.org/wiki/Changes/OstreeNativeContainer>

<https://fedoraproject.org/wiki/Changes/DNFAndBootcInImageModeFedora>

<https://fedoraproject.org/coreos/>

<https://universal-blue.org/>