



# Building operating systems optimized for containers, from IoT to desktops and servers



**Pass the SALT 2022**

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# Usual caveats and warnings

- This talk is about **community projects** (i.e. not a product)
- Thus reflects **my opinions**
- But I believe the goals are **shared**
- I'm a **contributor** to some of the projects mentioned
  - and some of the underlying technologies used



# Breaking News: Software has bugs (!)

- **Memory safety** issues, logic bugs
  - **Linux kernel** vulnerabilities
  - CVEs & **non** CVE fixes
  - etc.
- 
- Can't **find** them all, can't **fix** them all
  - Can't “just” **rewrite** everything in <good language>



# Well-known workarounds

- **Update** vulnerable software
- Focus on **bug classes** instead of single bugs
- Progressively introduce **better languages** in codebases
- **Defense in depth:**
  - Use **just** what you need
  - **Split** privileges
  - Put as much as possible into a **sandbox**



# Goal: Make workarounds usable

- Most users only use the **default** configuration
- Make the default behavior the **secure** option
  - No “secure configuration”
  - No “security focused” distribution
- Make updates a **non-event** and **enabled** by default
- Use a sandbox for **applications** by default





**How can we do this?**



# Limits of package centered systems

- Securing classic **package based** distributions is hard
- Requires **expert knowledge** and time to set up
- Can not provide **at the same time**:
  - lots of packages
  - secure by default packages
- Must select a **smaller** default set
  - Part of **attack surface reduction**



# Moving to image based distributions

- Provide a **curated set** of packages by default
- Every system is **the same** for a given version
- Makes **testing** and **reproducing** issues easier
- Updates are **atomic**
- But what do we **create** those images from?



# Taking a look at the Fedora Project



- Provides a **stable** and **up to date** software stack
- New release approximately every **six months**:
  - Mostly **security fixes** for stable releases
  - Major **new features** go into the next release
- **Upstream first** for patches and configuration changes



# ostree & rpm-ostree: Bridging the gap

- Hybrid image/package system with **atomic upgrades**
- Kind of like **Git** for your operating system
- Create “images” from **existing** packages
- Client side **package layering** and overrides:
  - Add, remove or replace packages **locally**
- Operations are **atomic, safe** and **easy to rollback**



# OS versioning and filesystem layout



- A **single identifier** for a given system version
  - Example: 36.20220605.3.0
- Uses **read-only** filesystem mounts:
  - Prevents accidents, basic attacks and **real vulnerabilities**
- **Clear distinction** between:
  - **/usr** □ distribution content (from packages)
  - **/etc** □ system configuration (defaults from packages)
  - **/var** □ all local system and user content





**Where is this happening?**



# rpm-ostree based Fedora variants



fedora  
**SILVERBLUE**



fedora  
**COREOS**



fedora  
**IoT**



fedora  
**KINOITE**

- Each variant is focused on a specific **use case**
- **Varying** degree of progress toward the stated goals



# Common ground for all variants

- Built **100%** from Fedora RPM packages
- System managed by **rpm-ostree**
- Most applications are run in **containers**:
  - **Podman** is included by default
- Enables **decoupling** applications and system updates



# Containers & security by default



- Confinement with **SELinux**:
  - **Confined** system services (targeted policy)
  - **Isolation** between containers and container ↔ host
  - Already **blocked** several real vulnerabilities in runc:
    - CVE-2019-5736: Latest container exploit (runc) can be blocked by SELinux
    - CVE-2021-30465: Mitigated by Default in OpenShift

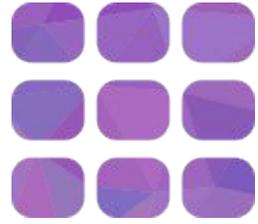




# What is Fedora IoT?



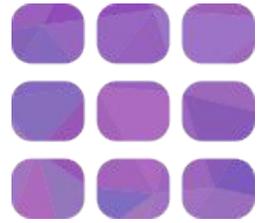
# Fedora IoT



- Focused on **IoT** use cases:
  - industrial gateways
  - smart cities
  - analytics with AI/ML
  - a project at home
- Management with **Ansible**



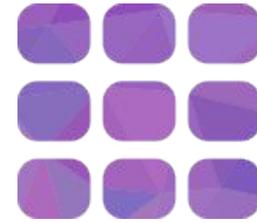
# Architectures and devices



- Support for **x86\_64**, **aarch64** and **ARMv7**:
  - Only supports devices with **UEFI support**
  - SoCs supported by Fedora (requires **SBBR/EBBR**)
  - ARMv7 support will end with [Fedora 37](#)
- Some **example devices** include:
  - NVIDIA Jetson Xavier series
  - Compulabs Fitlet2
  - Solid-run Honeycomb and Hummingboards
  - **Raspberry Pi** series of devices



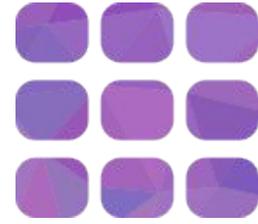
# Security for IoT & Edge devices



- Building on top of **TPM2** devices:
  - **Remote attestation** with [Keylime](#)
  - Pin disk encryption to **TPM PCRs** with [Clevis](#)
- Auto-updates are configurable:
  - Setup [Greenboot](#) to enable **automatic rollbacks**
- **On-boarding** with [Zezere](#):
  - Minimal touch on-boarding for a fleet of devices



# Upcoming: Secure on-boarding



- **FIDO Device Onboarding (FDO):**
  - Zero touch **secure provisioning** for IoT
  - Based on **FIDO specification**
  - Easily on-board a large number of devices
- Implemented entirely in **Rust** (client & server):
  - <https://github.com/fedora-iot/fido-device-onboard-rs>
- Planned for **Fedora 37**





# What is Fedora CoreOS?

# Fedora CoreOS



- Successor to two **container-first** OSes:
  - CoreOS Inc's Container Linux
  - Fedora Atomic Host (from Project Atomic)
- **Incorporates ideas** from both:
  - Provisioning stack & cloud native expertise (CL)
  - Fedora foundation, update stack & SELinux (FAH)
- Focused on **single node** and **clusters** use cases

# Philosophy



- **Automatic updates** by default
  - No interaction for administrators
- **Automated provisioning**
  - All nodes start from **same starting point**
  - Use Ignition to provision a node on **first boot**
- **Immutable infrastructure**
  - **Automate** deployment and system configuration
  - Update configs and **re-provision** to apply changes

# Platforms and architectures



- Available for a plethora of **cloud/virt platforms**:
  - Alibaba, AWS, Azure, Azure Stack, DigitalOcean, Exoscale, GCP, IBM Cloud, OpenStack, Nutanix, Vultr, VirtualBox, VMware, QEMU/KVM
  - Directly launchable on AWS & GCP
- Several options for **Bare Metal**:
  - Live ISO, PXE (network) boot, 512b/4K native disk images
- Support for **x86\_64**, **aarch64** and **s390x**

# Reducing the OS footprint



- First step in security hardening: **reducing** attack surface
  - Less software to **track** for security and bug fixes
- Only **essential** system services and administration tools
- Two **container runtimes**: podman & moby-engine
- Only includes Bash: no Python, etc.

# Building with safer languages



- Using **memory safe languages** for most of Fedora CoreOS specific additions:
  - **Go:** Butane, Ignition, toolbox, container engines (podman & moby-engine)
  - **Rust:** Afterburn, Zincati, coreos-installer, bootupd, rpm-ostree (in progress), Cinnati

# Fedora CoreOS examples



- **Single node** Matrix server:
  - <https://github.com/travier/fedora-coreos-matrix>
- **Nomad** cluster:
  - <https://github.com/travier/fedora-coreos-nomad>
- **Kubernetes** cluster with **OKD**:
  - <https://www.okd.io/installation/>



# What are Fedora Silverblue & Kinoite?



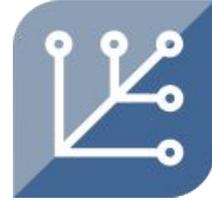
# Fedora Silverblue & Fedora Kinoite

- **Desktop** variants with **Wayland** and **Pipewire**
- Fedora **Silverblue**:
  - Featuring the **GNOME** desktop
  - Following the work on Fedora Workstation
- Fedora **Kinoite**:
  - Featuring the **KDE Plasma** desktop
  - Following the work on the KDE Spin



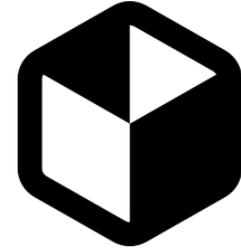
# Easy desktop experience for users

- **rpm-ostree** makes system updates a non-event
  - Prepared in the background
  - Applied on reboot
  - Instant rollback when facing issues
- Work in progress in GNOME Software and Plasma Discover to make them **easier to manage**
- End goal is to make them **“transparent”**



# More sandboxed applications

- Applications shipped as **Flatpaks**
  - Installation and updates **independent** of system operations
- More and more applications use **Portals**
  - Thus using a **strong sandbox**
  - X.org deprecation will remove the biggest hole in the sandbox
- Major applications **providers**:
  - **Fedora** (FOSS only)
  - **Flathub** (mixed FOSS and proprietary)



# Development in and with containers

- Use containers to create **mutable environments** that are independent of the system
- Install any package, development tools, IDEs, etc.
- **Not a security boundary**: a lot is shared with the host
- **toolbox**: Currently Fedora focused but other distributions are planned
- **Distrobox**: Works with most Linux distributions



**DISTROBOX**





# Future security improvements



# Future work: Runtime integrity for ostree

- **rpm-ostree** checks integrity at update time
- Then relies on **filesystem** or **block device** integrity
- Work in progress: **composefs**
  - new “virtual” filesystem
  - modeled around ostree repo format
  - based on **fs-verity**
  - enables “**at access time**” integrity checks

# Future work: Boot attestation

- Integrate **Keylime** (in Rust) into other variants (already in IoT):
  - **remote boot attestation** for server use cases
  - **local boot attestation** for desktops (see also [tmptotp](#))
- Improving the user experience with **TPM pinned encryption**:
  - Make [Clevis](#) (and Tang) easier for desktops
  - Installer changes and user story for **recovery**

# Get involved!

- Fedora IoT: <https://getfedora.org/iot/>
- Fedora CoreOS: <https://getfedora.org/coreos>
- Fedora Silverblue: <https://silverblue.fedoraproject.org/>
- Fedora Kinoite: <https://kinoite.fedoraproject.org/>



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