The meta-virtualization layer of OpenEmbedded

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WHEN IT MATTERS,
IT RUNS ON WIND RIVER.

Agenda

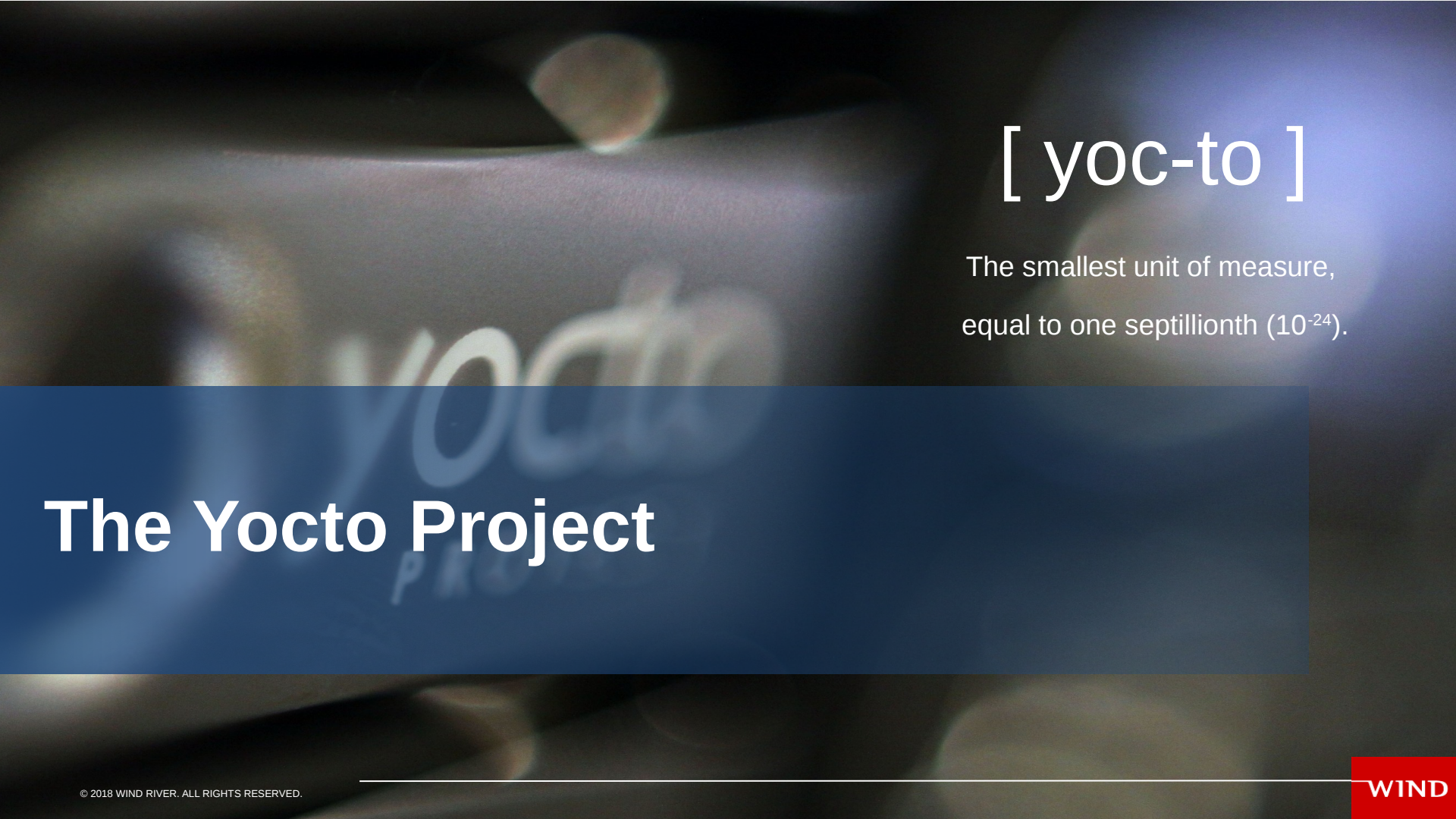
- Introduction
- Brief OpenEmbedded introduction / history
- How Wind River uses OE
- meta-virtualization
- OE + meta-virtualization + security
- Future / Questions

Enterprise vs Embedded

- The world is not limited to enterprise vs embedded
  - It's really more a continuum, from the pre-defined to the fully customized
- Many users have requirements that are between those of the Enterprise Linux and Embedded Linux
  - Some enterprise like systems are source based
  - Some embedded like systems are based on preconfigured binaries
- One size does not fit all in the Linux ecosystem

OpenEmbedded

- OpenEmbedded
  - Includes a cross-compile build environment
  - User is required to configure and define their environment before compiling
  - Created a custom binary Linux distribution based on configuration
  - Output includes ‘packages’, like an enterprise OS, filesystem images, SDKs
- All software is downloaded from the original provider as source code
- Designed to be expanded/extended
- Commercial and Community support



The Yocto Project

[yoc-to]

The smallest unit of measure,

equal to one septillionth (10^{-24}).

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What is the Yocto Project?

- The Yocto Project is an Open Source project with a strong community
- It is based on a collection of embedded projects, tooling, and procedures
  - OpenEmbedded
  - Application Development
  - Quality Assurance testing
  - Commercial Ecosystem
- The Yocto Project is designed to provided an ecosystem to the Operating System developer.

It's not an embedded Linux distribution – it helps you creates the custom one for you

Who is the Yocto Project

- Founded under the Linux Foundation
- Members include numerous companies and projects spanning Silicon vendors, Board vendors, OSVs, ISVs, and end users
- Lead by Advisory Board and Technical Leadership
- Advisory board is responsible for ecosystem, marketing, etc.
- Technical Leadership is a meritocracy based group that leads various projects and makes technical contributions

Why was the Yocto Project started?

- The industry needed a common build system and core technology
  - Bitbake and OpenEmbedded build system
- A place for Commercial Interests to work together to avoid duplicating effort
  - Why should each company have a competing build system?
  - Why is each organization integrating the same components in different ways?
  - Why are we all duplicating effort, duplicating bugs, and duplicating solutions?
- *Less time spent on things which don't add value*
- *More time spent on things which do add value*

Comparisons …

Embedded Linux Requirements

- Goal:
  - Build upon the existing Linux ecosystem and goals
  - Build a complete, customized, Linux system for a specific device
  - Include Bootloaders, Linux Kernel, Root Filesystems
- Build from scratch from source
  - Reproducibility, IP compliance reasons, customization
- Use cross-compilation to build software
  - Often developer/build machine will be faster or more plentiful then target hardware
- Need a vibrant community
  - Documentation, support, training

Alternatives / Options

- OE / Yocto project
- Enterprise Linux
  - IoT variants
- Buildroot
- Roll-your-own

Enterprise Linux

- Easy entry level
- Often used for prototyping
- Customization or Support – not both
- Maintenance
- IoT focused systems
  - Project Atomic
  - Ubuntu Core
- Not cross-compiled
- Not source code based

Buildroot

- Allows simple entry into Embedded Linux
- Limited built in extension points
- No binary packages
- Most users end up having to create their own forks

Roll-your-own

- Enterprise based
- Silicon Vendor/Board Vendor SDK
- Completely custom

With the alternatives, why OpenEmbedded ?

- OE may not be right for all situations!
- PC like usage model? enterprise Linux or variants
- One-time use board bring up? OE might be too complex
- Foot-print, long-term maintenance, commercial ecosystem, IP, etc concerns?
  - OE/Yocto Project is probably what you want

Layers and the Ecosystem…

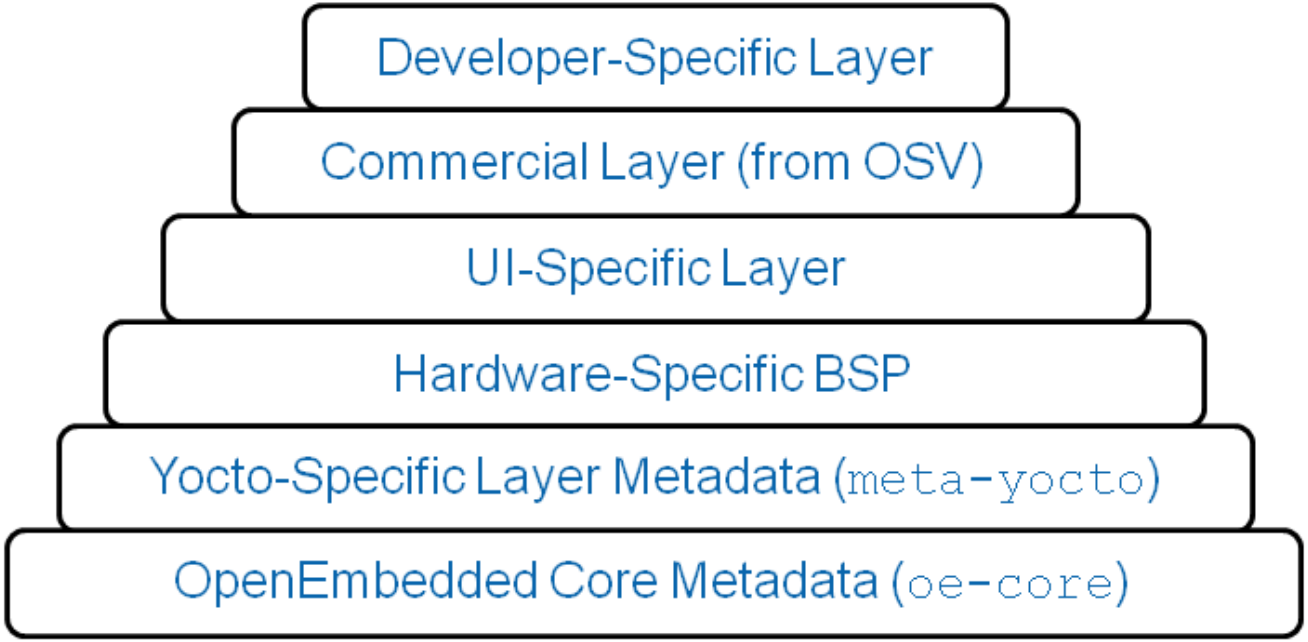
Layers

- Layers are a way to manage extensions, and customizations to the system
  - Layers can extend, add, replace or modify recipes
  - Layers can add or replace bbclass files
  - Layers can add or modify configuration settings
  - Layers are added via BBLAYERS variable in build/conf/bblayers.conf
- Best Practice: Layers should be grouped by functionality
  - Distribution configurations
  - BSP/Machine
  - Functional groups
  - Project/Product specific components

Layers

LEGO is a trademark of the LEGO Group

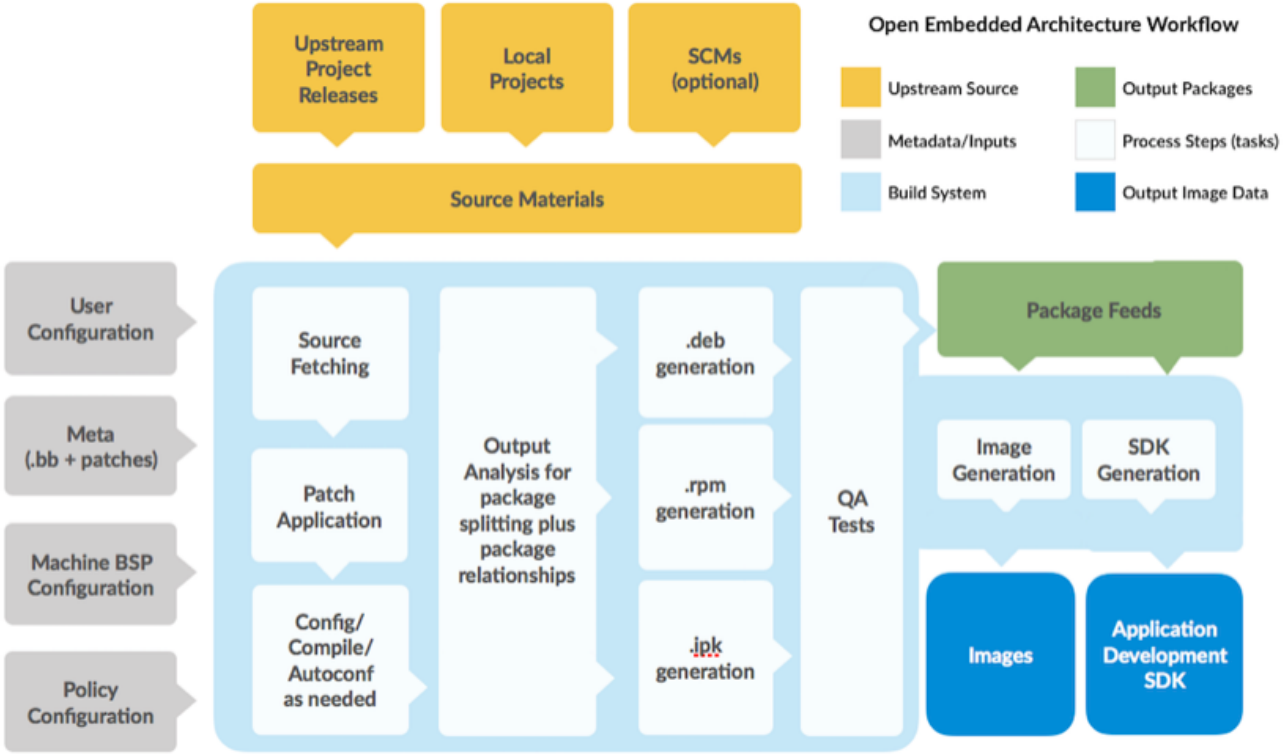
Layers



Ecosystem

- The ecosystem is formed by the collection of layers and projects
  - Broad and active
  - Content of layers is a work in progress
- Various levels of maintenance and ‘quality’
  - Yocto project compatibility and layer index
  - Tools to support layers and recipe creation/maintenance
- If you have layers: test for compatibility and publish!

Build System Workflow



How (and why) is Wind River using the Yocto Project?

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What about commercial Linux?

- Prior to the Yocto Project, there were many commercial Linux products
  - Each was incompatible with the others, even if they shared a common core
- In many ways each commercial vendor had created their own ‘Roll-your-own’ system and tried to share the costs among their customers
- This lead to many limited ecosystems:
  - Limited ISV support
  - Limited semiconductor support
  - Limited BSP support
- Vendor lock-in was a problem for customers

Innovation / Differentiation

- Linux is now a commodity operating system
- Nobody is going to buy a new kernel
- People will pay for service, new development, features, etc.

Software Lifecycle Management

- Open source software lifecycle is short
  - New versions are released constantly, but not on any fixed cycle
  - Days, weeks, months or years
  - Old versions are often abandoned as soon as new versions are released
- Commercial product lifecycles vary
  - Developed in 6 months, only sold for 6 months
  - Developed for 6 months and sold for years…
  - Developed over years and sold for years…
- It is Wind River's job to help the customer manage the commercial lifecycle vs the fast changing open source lifecycles

Software Integration

- Roll-your-own or the Yocto Project?
- It’s easy to do something once…
- It’s not to bad to do it twice…
- But supporting something for a long time takes process, planning and expertise
- Carrying costs, including maintenance, updates, etc add up quickly!
- Continuous Integration of the Yocto Project

What that looks like …

- Core product
  - Closely based on OE core
  - Selected / curated layers
  - github / community editions
  - CI/CD stream
- WR BSPs
- Vertical specific ‘products’ (distros)
  - WR core + additional layers and configuration
  - Networking, industrial
  - Technology horizontals: virtualization /containers, security ..

meta-virtualization overview

- From openhub:
  - has had 773 commits made by 104 contributors
  - with a very well-commented source code
  - has a well established, mature codebase
  - maintained by a very large development team
  - starting with its first commit in June, 2012
- Current maintainer(s): Bruce Ashfield (Wind River)
- Contributors: OSVs (Wind River, Mentor, Monta Vista, Enea, ...), distros, individual users

meta-virtualization goals

- Goals:
  - Single point of integration for virtualization technologies
    - VMs and containers
    - Core technology + support software
    - Many audiences: Bleeding edge and established tech
    - Well tested and stable
    - Baseline for creating OE derived virtualization solutions
- Recipes migrate over time

meta-virtualization components

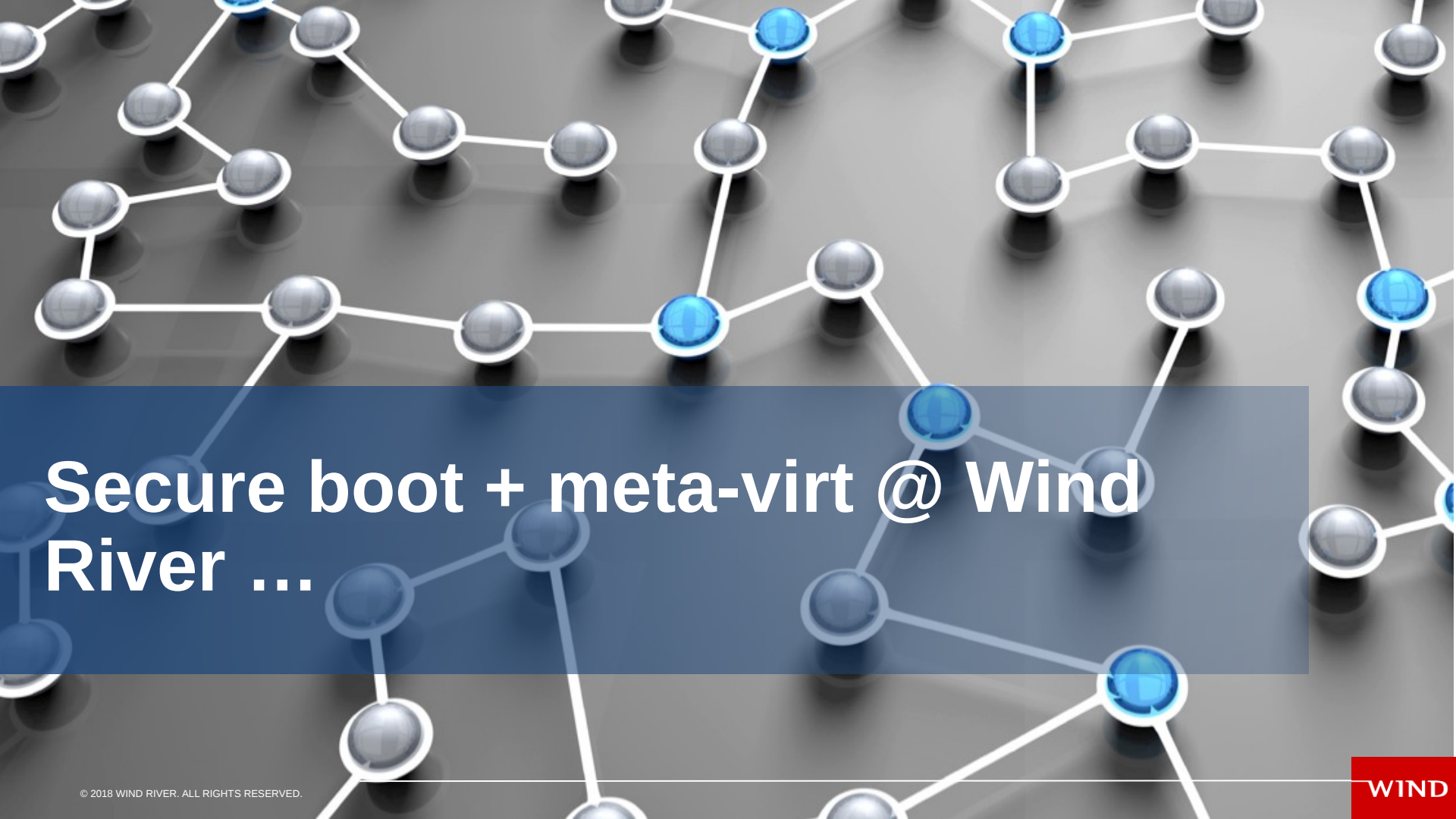
- Technology
  - virtualization: guests/hosts, containers, management, utilities / support, configuration(s): images, kernel
- ~98 recipes (some are variants)
  - recipes-containers: Kubernetes, runc, docker/moby, OCI, LXC, containerd
  - recipes-core: system init, runv
  - recipes-devtools: support recipes for core/containers
  - recipes-extended: libvirt, hyperstart, kvmtool, image definitions, dev86 ..
  - recipes-kernel: configuration fragments to support VMs/Container features
  - recipes-networking: CNI, OpenVSwitch, netns

meta-virtualization use cases

- Virtualization: Xen / KVM
  - Small, secure, etc
- Containers: docker, LXC, runc, moby
  - Lightweight, micro-services, serverless, etc
  - Standards based: OCI
- VMs and container co-existence
  - Single image, nested, runv …
- Management and control
  - CLI: libvirt
  - Orchestration: kubernetes, CNI, etc

How Wind River uses meta-virtualization

- Core hypervisor support
  - realtime + security variants
- Containers
  - Core container support: docker, lxc, runc
  - Container OS: OverC



Secure boot + meta-virt @ Wind River …

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Secure boot requirements

- As little as possible is BSP specific
  - leverage hardware when possible
  - Avoid one-offs
- Multiple layers of security
- key management
- Multi-architecture

Wind River Linux Security

Security technology

- Security policy
  - SE Linux MLS/MCS
  - Login and remote access
- Access controls
- Memory protection
- PKI
- Secure & measured boot
- Linux IMA
- TPM 1.2 and TrouSerS
- TPM 2.0 and TPM2-TSS

UEFI, TXT

PTT

- SCAP (OpenSCAP)
- FIPS OpenSSL

AES-NI, QAT

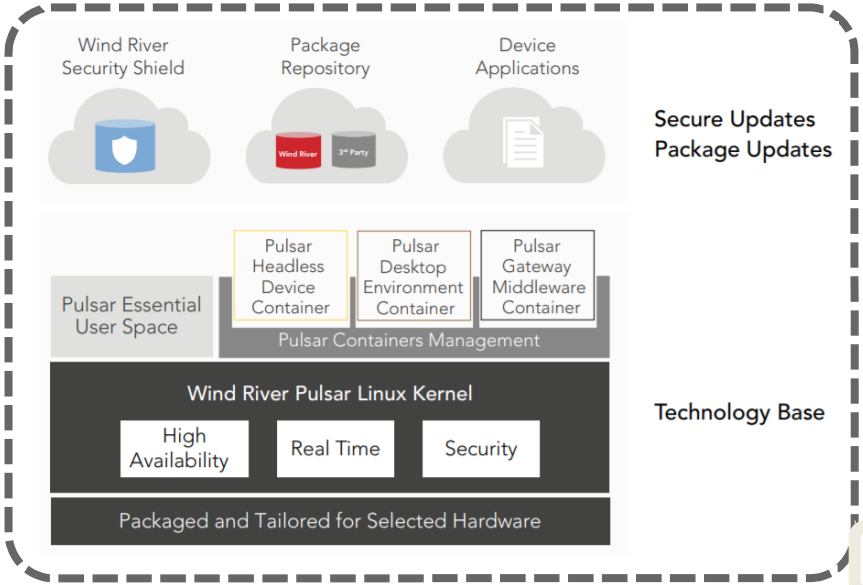
- Remote attestation
- File system integrity monitoring
- Backup/restore

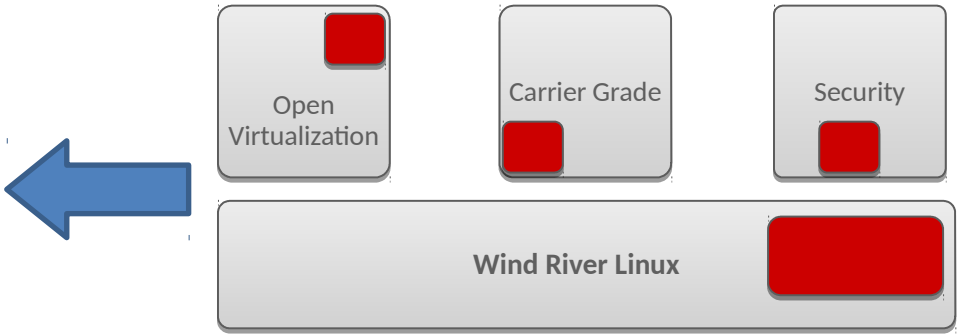
Virtualization technology

- Least privilege/privilege controls
- Access controls
- Resource utilization protection
- Memory protection

VTx/VTd

OverC / WRL Security Reference Image





- Wind River Linux secure kernel
- Secure Boot — **UEFI, TXT**
- Linux IMA
- Secure backup/restore
- SELinux

PTT

- TPM 2.0 and TPM2-TSS
- IPsec/L2TP/PPTP VPN
- Storage encryption — **AES-NI, QAT**
- Secure update
- OpenSCAP configuration guidance

What’s next ?…

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What the future may hold …

- New technology in meta-virtualizion
  - Hypervisors (ACRN ...)
  - container / sandbox techniques (gvisor? pouch? kata containers)
- Improved system level use cases / tests, not just buckets of packages
  - security 'toolkit' / core components
  - See Richard Purdie's 2.6 planning email
- Update mechanisms (OTA or not), reference binary feeds
- Developer experience
- More … we need help!