LTD20-200
Heterogeneous Hardware-Accelerated OCI Containers & Secure OCI Containers

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Heterogenous HW Aware Containers

- **Goal**: Extend OCI specifications to support the utilization of more heterogeneous hardware capabilities within the containers ecosystem
  - Heterogeneous accelerator (FPGA, GPU, ...) deployment & access
  - Support for Cortex-R and Cortex-M co-processors
  - Kernel deployment (Xen hypervisor implementation as reference)

- **Motivation**: OCI is a quickly growing application packaging & deployment framework in cloud and edge targets. Simultaneously application performance growth is ever more dependent on mapping to heterogeneous platform targets. Therefore compute industry has a necessity to bridge this gap between container software ecosystem and increasingly domain-specific hardware architectures.
RunC + Heterogenous HW Access – “Startup”

OCI Image Spec Extensions:
- RESOURCE=DEVICE_DATA
- e.g. /amba/pr@01=/boot/bitstream
- e.g. 00:02.0=/lib/firmware/ipu3-fw.bin

Device Config

1. Container pre-start hook
   HWConfig(resource, bitstream)
   -> dev name & info

Container

1. Manifest with /amba/pr@0=bitstream

2. containerd
   containerd “shim”

3. start
   RunC [extra args] or config.json
   chroot

Container Orchestration Framework (e.g. Kubernetes)
RunC + Heterogenous HW Access – “Shutdown”

Container Orchestration Framework (e.g. Kubernetes)

Manifest with /amba/pr@0=bitstream

Device Config

containerd

containerd “shim”

RunC [extra args] or config.json

Container post-stop hook HWConfig(resource)

-> Free resources

Container

Heterogeneous HW Resource
Secure Containers w/ Xen

RunX:
- An OCI-compatible containers runtime under the LF-Edge umbrella
- Secure by default
- Micro-VMs optimized for constrained environments

Container Orchestration Framework (e.g. Kubernetes)

Container

containerd

containerd “shim”

RunX

xlc create

Linux

VM

Container

ramdisk

kernel

Xen
Secure Containers w/ Xen

OCI Image Spec Extensions:
- KERNEL
- RAMDISK
- DTB

Container Orchestration Framework (e.g. Kubernetes)

Tarball w/ kernel, ramdisk, & rootfs

containerd

containerd “shim”

RunX

1

xl create

Xen

Linux

VM

Container

Provided ramdisk

Provided kernel
Secure Containers w/ Xen

- Container Orchestration Framework (e.g. Kubernetes)
- RTOS packaged as a container
- containerd
- containerd “shim”
- RunX
- `xl create`

Diagram:
- VM
- RTOS
- Linux
- Xen
Secure Containers w/ Xen + Heterogenous HW

OCI Image Spec Extensions:
- RESOURCE = DEVICE_DATA
- KERNEL
- RAMDISK
- DTB

Container Orchestration Framework (e.g. Kubernetes)

Tarball w/ kernel, ramdisk, & rootfs

Device Config

containerd

containerd “shim”

RunX [extra args] or config.json

Linux

Xen

Provided ramdisk

Provided kernel

Heterogeneous HW Resource

VM
OCI Deployment of OpenAMP Resources

OCI Image Spec Extensions:
- RESOURCE=DEVICE_DATA
- e.g. /remoteproc0 = /boot/rpu0.elf

Container Orchestration Framework (e.g. Kubernetes)

Manifest with */pu/cpu@0=kernel

Device Config
1 containerd
2 containerd “shim”

Cortex-A

RemoteProc
Linux

Cortex-R and/or Cortex-M

Co-processor firmware
OCI Extension Topics

- **OCI image specification**
  - Key-value pairs for heterogenous accelerators
  - Key-value pairs for secure containers (RunX as reference implementation)
  - Device configuration data packaging within container image

- **OCI runtime specification**
  - Ensure containerd does not remove/filter relevant image spec data required for device configuration
  - Standardize container device configuration data passing between container & host
  - Standardize method for exporting of dynamic HW w/ container
Summary & Collaboration Request

● Xilinx development teams focused on implementing heterogeneous hardware container access architecture definition and prototyping. Requesting additional platform inputs, development collaboration, & OCI specification change advocates.

● Present collaborations underway with Project EVE within LF-Edge
  ○ Collaboration focused on proposed OCI changes
  ○ [https://wiki.lfedge.org/display/EVE/OCI+Image+Spec+for+VMs](https://wiki.lfedge.org/display/EVE/OCI+Image+Spec+for+VMs)
  ○ Collaboration with team at Zededa

● Proposal summary & collaboration request
  ○ Extend OCI specifications to support the utilization of more heterogeneous hardware capabilities within the containers ecosystem
    ■ Heterogeneous accelerator (FPGA, GPU, ...) deployment & access
    ■ OpenAMP integration for Cortex-R and Cortex-M co-processors
    ■ Kernel deployment (RunX as reference implementation)
  ○ Value is in having an integrated standards based infrastructure that can be used for deployment & orchestration of heterogeneous platform edge to cloud
  ○ If interested please contact Wes Skeffington ([wesley.skeffington@xilinx.com](mailto:wesley.skeffington@xilinx.com)) and Stefano Stabellini ([stefano.stabellini@xilinx.com](mailto:stefano.stabellini@xilinx.com))
Thank you

Accelerating deployment in the Arm Ecosystem