The Little Hypervisor for IoT

Anthony Xu
Intel Open Source Technology Center
Agenda

- What’s ACRN
- Architecture
- Q&A
What is ACRN?

ACRN* is a flexible, lightweight reference hypervisor, built with real-time and safety-criticality in mind, optimized to streamline embedded development through an open source platform.
ACRN Features

- Small Footprint
- Built for IoT
- Adaptability
- Built for Real-Time
- Safety Criticality
- Truly Open Source
ACRN HV Share Mode

VM_Exit Dispatcher

HyperCall Handler
- VM lifecycle Manager
  - EPT Manager
    - PCI PT Manager
    - Virtual INT Manager
- Other VM_Exit Handler
- UART Driver
  - Timer Manager
    - Notification Manager
  - UART Emulator
    - PIC Emulator
      - EPT violation Handler
      - Other VM_Exit Handler
      - Instruction Decoder
      - IOAPIC Emulator
        - Convert INT to Guest
      - LAPIC Emulator
        - Inject INT to Guest
      - Console Manager
        - Forward IO request to SOS
      - Forward IO to Guest

PIO Handler

Interrupt Handling
- IRQ Handler
- Timer Manager
- Notification Manager
- UART Emulator
- PIC Emulator
- EPT violation Handler
- Other VM_Exit Handler
ACRN Partition Mode

VM1
- USER
- KERNEL
- Native Device Driver

VM2
- USER
- KERNEL
- Native Device Driver

ACRN Hypervisor
- VMX
- VT-d
- EPT
- vPCI bus
- vHost Bridge
- vMPTable
- vLAPIC/vMSI

Device

Virtual Resource

Physical Resource

VMX NON-ROOT OPERATION

VMX ROOT OPERATION
We didn’t see any performance improvement in partition mode 😞

After investigation, we think similar performance is reasonable. Because same technologies are used in both modes.
We noticed there are a lot of LAPIC related VM_Exits

Can we pass through LAPIC?

Yes
Guest Interrupt Delivery

LAPIC owned by HV

- VM
- USER
- KERNEL
- IDT

External interrupt

- External Interrupt VM_EXIT
- IRQ handler
- Inject Interrupt
- IDT

HV

- Interrupt is enabled in HV
- External Interrupt VM_EXIT is enabled

LAPIC owned by VM

- VM
- USER
- KERNEL
- IDT

External interrupt

- External Interrupt VM_EXIT
- HV

- Interrupt is disabled in HV
- External Interrupt VM_EXIT is disabled
ACRN HV Partition Mode w/ LAPIC PT

VM Exit Dispatcher

- HyperCall Handler
- IRQ Handler
- PIO Handler
- EPT violation Handler
- Other VM Exit Handler

- VM lifecycle Manager
- EPT Manager
- PCI PT Manager
- Virtual INT Manager

- Timer Manager
- Notification Manager
- PIC Emulator
- RTC Emulator
- Forward IO request to SOS

- UART Emulator
- IOAPIC Emulator
- LAPIC Emulator

- Instruction Decoder
- Inject INT to Guest
- PCI bus Emulator
- Console Manager

- IOMMU Driver
- IOAPIC Driver
- LAPIC Driver
- UART Driver

Software Module
Hardware Driver
For Debug
New module
Not Used
Not Used For LAPIC PT
Performance

- Coffee Lake desktop
- C/P state is disabled
- 2CPU, 8G mem for both native and VM
- Integrated 1Gbps NIC card
- Netperf TCP latency test

![Graphs showing latency comparison between Native and Partition Mode with and without LAPIC PT]
Security issue!
VM might send IPI to other VMs.

1. Make sure Guest OS doesn’t do that.

2. Enable x2APIC, only intercept/emulate Guest IPI operation.
ACRN Hybrid Mode

Privileged VM

- Privileged VM
  - USER
  - KERNEL
  - Native Device Driver

Service OS VM

- Service OS VM
  - USER
  - KERNEL
  - Native Device Driver
  - VM Manager
  - ACRN Device Model (Mediators)

UOS

- UOS
  - USER
  - KERNEL

ACRN Hypervisor

- VMX
- VT-d
- EPT
- VM API
- Virtio API
- Trusty API
- VMX ROOT OPERATION
- vMPTable
- vPICI
- vPIC/vLAPIC/vIOAPIC/vMSI
- vHost Bridge
- Device
## Footprint

<table>
<thead>
<tr>
<th>Mode</th>
<th>Hypervisor</th>
<th>Device Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACRN Share Mode</td>
<td>28k</td>
<td>39k</td>
</tr>
<tr>
<td>ACRN Partition Mode</td>
<td>15k</td>
<td>0</td>
</tr>
<tr>
<td>ACRN Partition Mode w/ LAPIC PT</td>
<td>11k</td>
<td>0</td>
</tr>
<tr>
<td>ACRN Hybrid Mode</td>
<td>29k</td>
<td>39k</td>
</tr>
</tbody>
</table>
Call to Action

Join us!

If you support the ACRN project and feel that this is the right thing for the embedded ecosystem, join us in moving this project forward together as a community member. We need code contributors, users, and project direction influencers!

Contribute code!

Make a difference to the project by committing code, help us become a better project. Project code merged in the past 6 months allows you to become a voting member of the Technical Steering Committee.

GitHub: https://github.com/projectacrn

All Contributions Matter

• In open source projects a contribution can be anything which helps the project to accomplish its mission. Examples of Contributions beyond just code include:

  • Financial Assistance, Requirements Gathering, Documentation, Testing, Bug Reporting

Join the ACRN Community Today!
https://projectacrn.org
Q&A

Any Questions?
ACRN Sessions at OSS NA

ACRN Technical Overview
ACRN Hypervisor for Embedded IoT

Speaker:
Anthony Xu
ACRN Architect

Wednesday August 29, 2018
3:00pm – 3:40pm
Room 114/115

ACRN BOF Session
The Little Hypervisor for IoT Development

Moderator:
Jeffrey Osier-Mixon
ACRN Community Manager

Wednesday August 29, 2018
5:40pm – 6:20pm
Room 109

ACRN Demo
THANK YOU