DPDK DATA PLANE DEVELOPMENT KIT

THE LINUX FOUNDATION

Towards Low Latency Interrupt Mode DPDK

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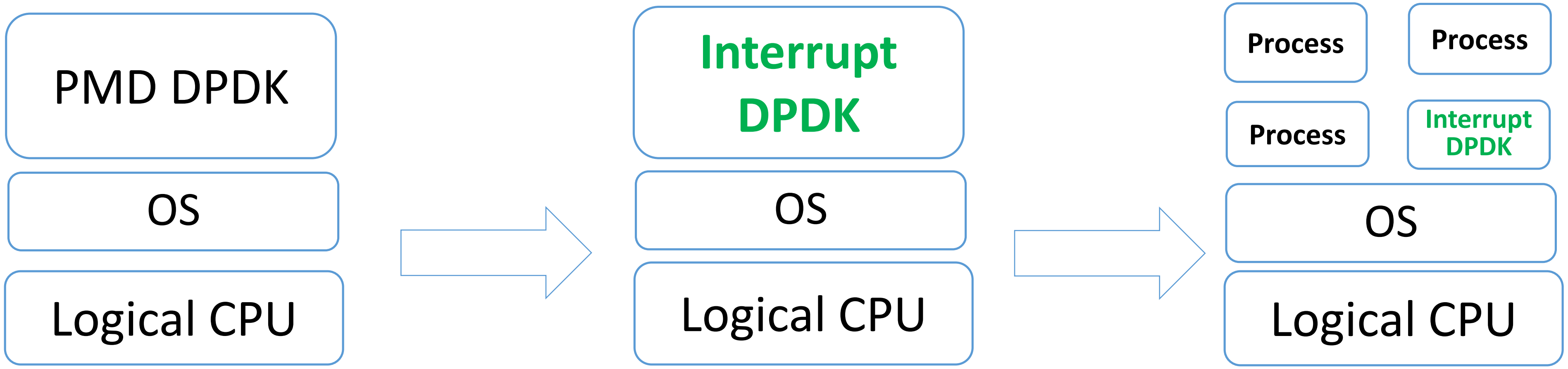
Agenda

- DPDK Working Mode Transition
- Problems and Optimizations
- Performance Evaluation
- Next Step Plan

Working Model Transition

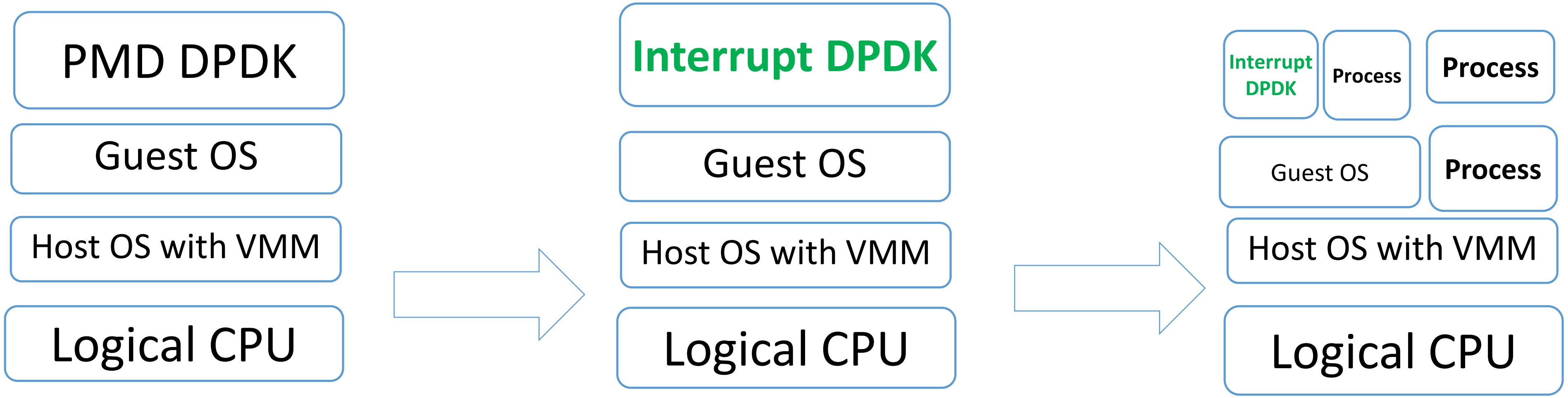


- Polling mode:
  - 100% CPU usage even without inbound packets

- Interrupt mode DPDK on a dedicated CPU:
  - Enter CPU idle state when no packet is received

- Interrupt mode DPDK sharing a CPU with other processes:
  - Run with the highest priority
  - Yield the CPU to other processes when no packet is received

Working Model Transition with Virtualization



- Polling mode:
  - 100% CPU usage even without inbound packets

- Interrupt mode DPDK inside a VM on a dedicated CPU:
  - Enter CPU idle state when no inbound packets

- Interrupt mode DPDK inside a VM sharing a CPU with other processes:
  - Run with the highest priority
  - Yield the CPU to other processes on the Host OS when no inbound packets
  - Possible to share the CPU with processes inside the VM, but not encouraged currently.

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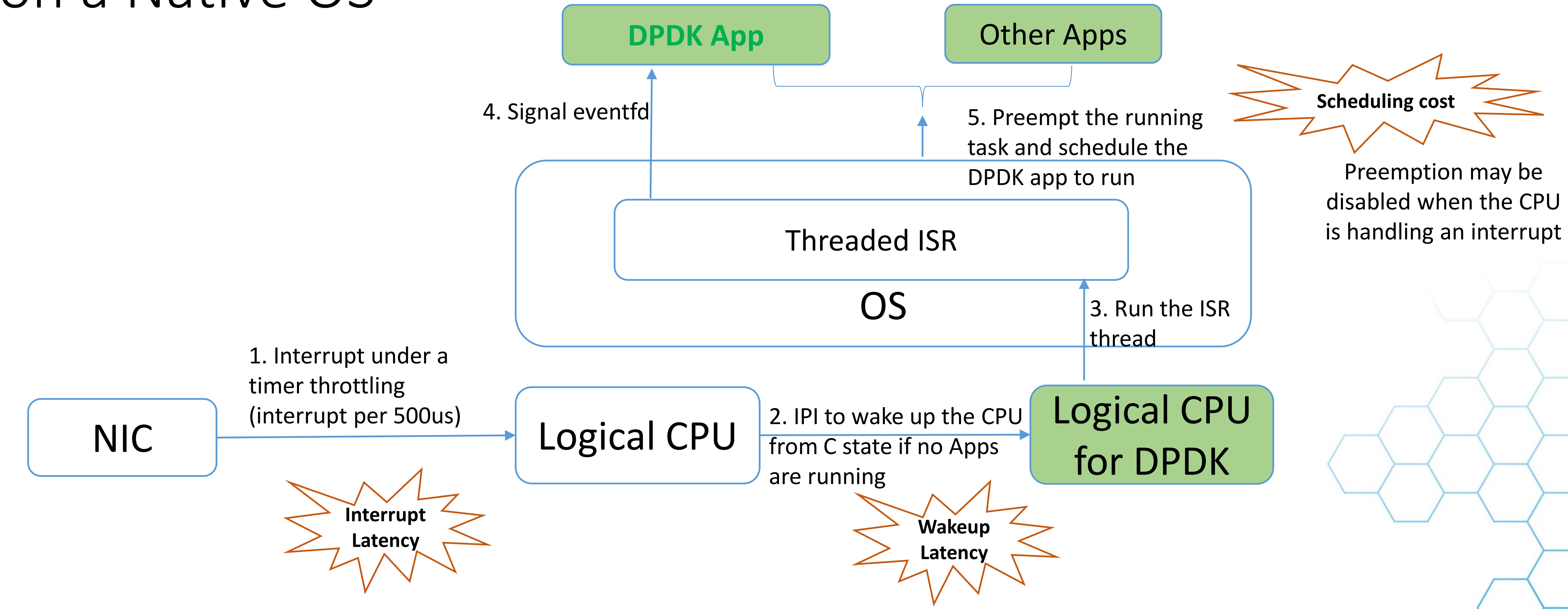
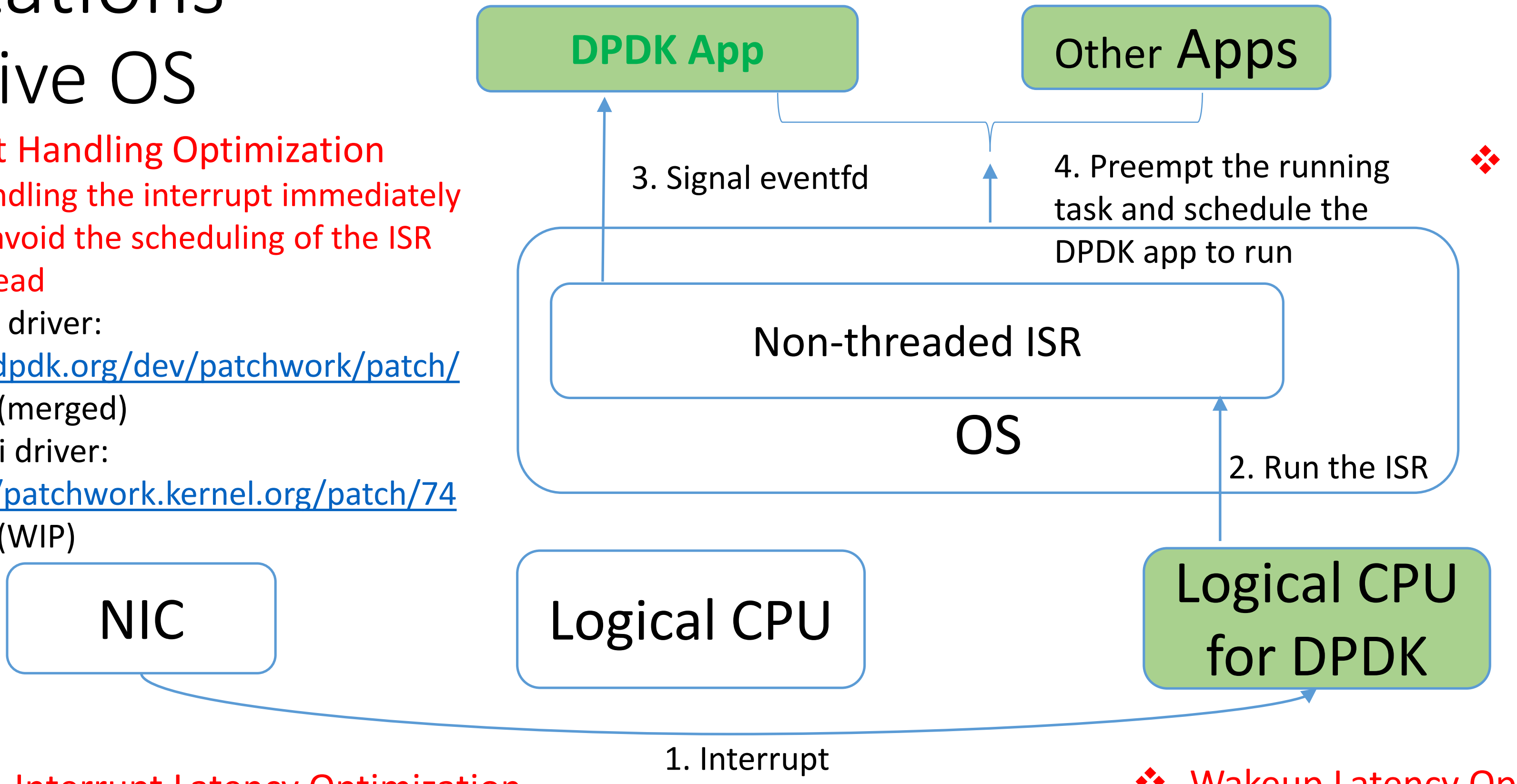
Performance Issues on a Native OS


DPDK App
Other Apps
4. Signal eventfd
5. Preempt the running task and schedule the DPDK app to run
Scheduling cost
Preemption may be disabled when the CPU is handling an interrupt
Threaded ISR
OS
3. Run the ISR thread
1. Interrupt under a timer throttling (interrupt per 500us)
NIC
Logical CPU
2. IPI to wake up the CPU from C state if no Apps are running
Logical CPU for DPDK
Interrupt Latency
Wakeup Latency

Optimizations on a Native OS

- Interrupt Handling Optimization
  - Handling the interrupt immediately to avoid the scheduling of the ISR thread

  igb_uio driver: http://dpdk.org/dev/patchwork/patch/19855/(merged)
  vfio_pci driver: https://patchwork.kernel.org/patch/7493081/(WIP)



- Scheduling Optimization
  - RT Linux is helpful to reduce the scheduling delay

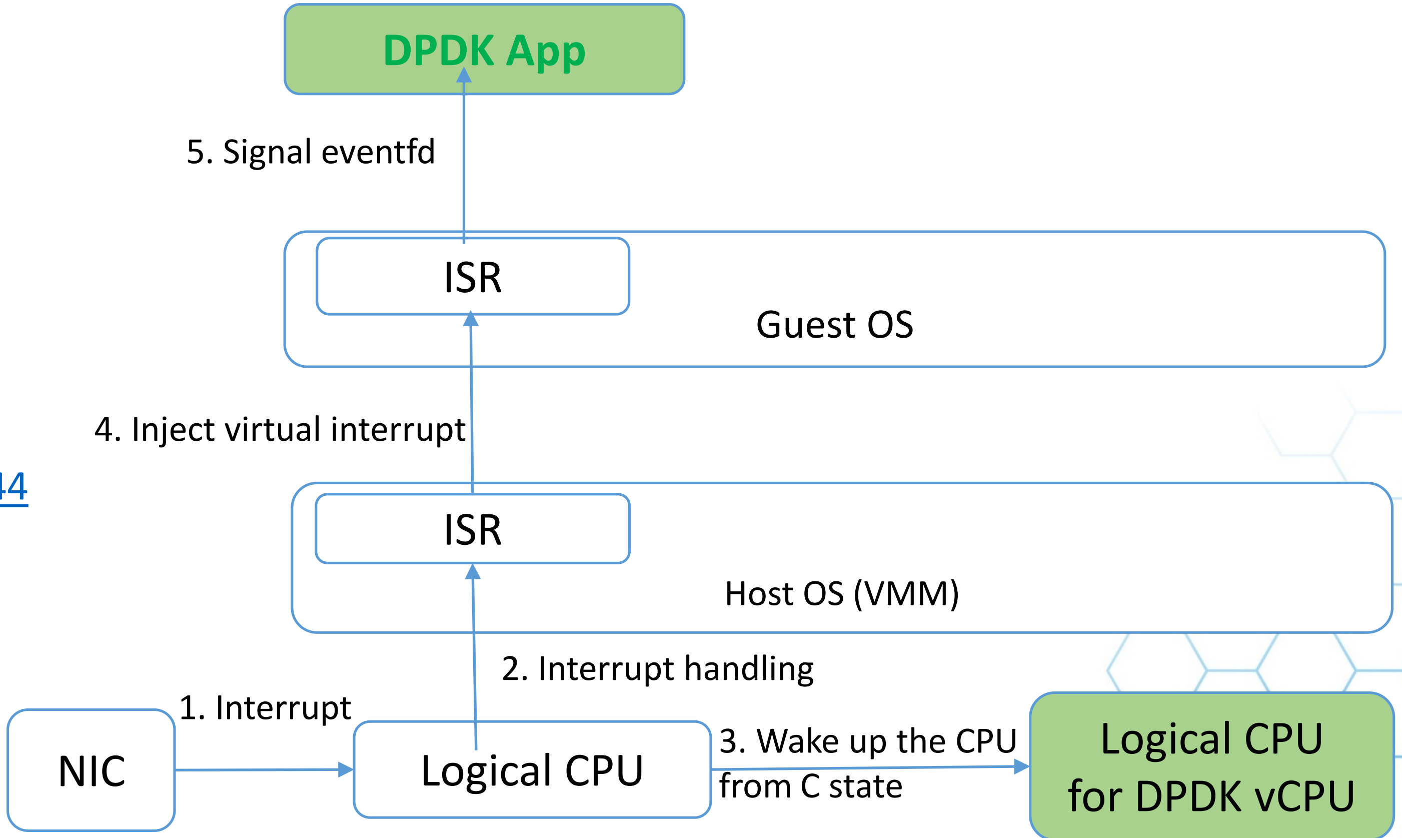
- Interrupt Latency Optimization
  - Interrupt affinity setup to avoid one IPI. It will be good if the affinity can be set in the DPDK library.
  - Remove the timer throttling to get interrupts in time. http://dpdk.org/dev/patchwork/patch/19856/ (WIP)

- Wakeup Latency Optimization
  - Limit the maximum C state via the kernel booting parameter

Performance Issues on a VM

- Latency as described for the native environment, plus the extra latency from the virtualization layer
  - The ISR on the guest kernel
  - Host/Guest context switch for interrupt injection
- Potential bugs on the VMM layer may cause longer latency
  - https://www.spinics.net/lists/kvm/msg144469.html

Further optimizations to the VMM layer are in our next step plan



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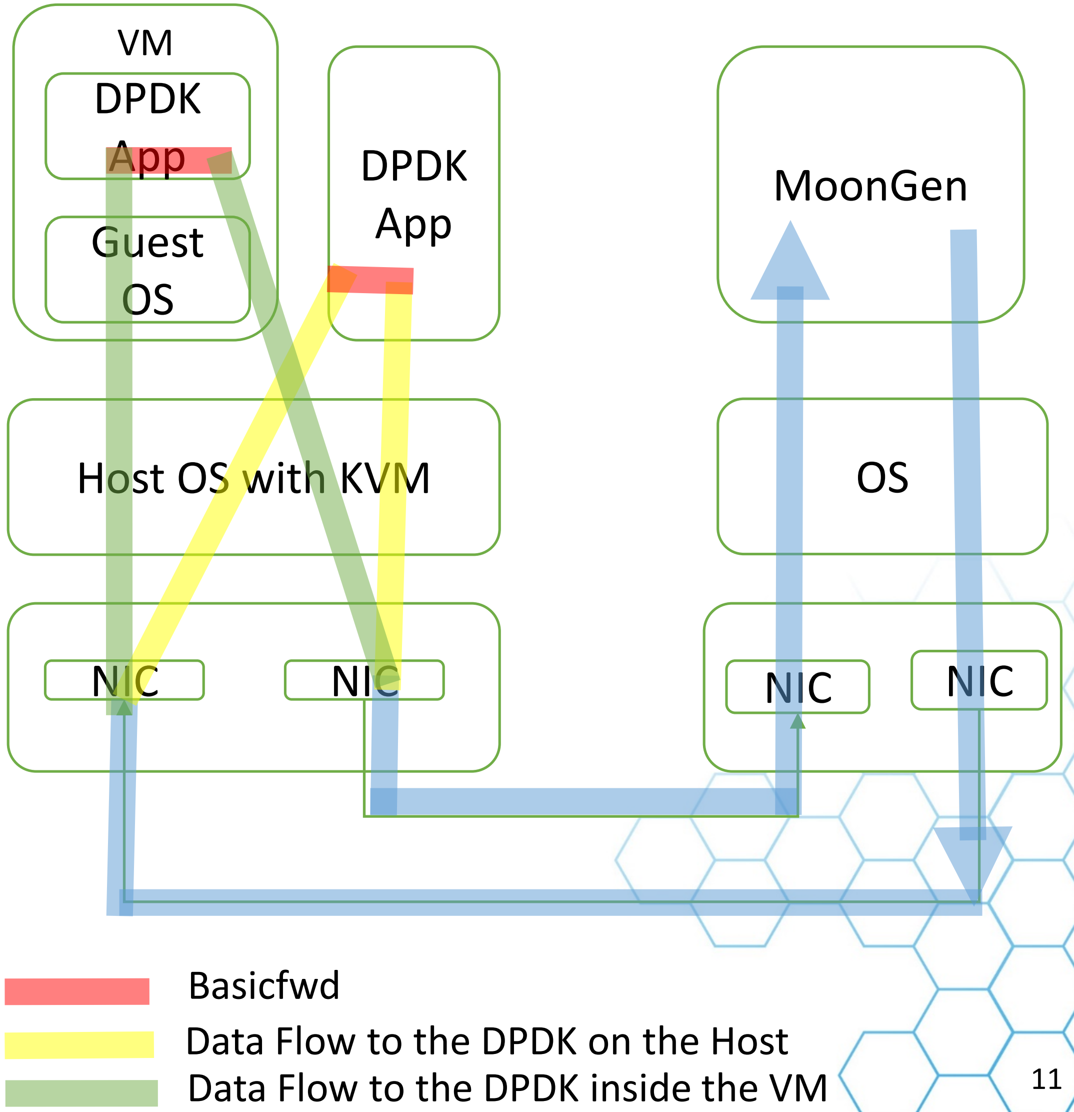
Test Environment

- Host
  - CPU: Intel XeonE5-2699 v3 @ 2.30GHz
  - OS: KVM4NFV D release (RT Kernel 4.4)
  - NIC: Intel Ethernet Controller X540-AT2, 10Gbs
- Guest
  - vCPUs bound to isolated pCPUs
  - OS: same as host
- Test applications
  - DPDK basicfwd
    - Modified based on DPDK l3fwd-power example
    - Sleep if no packets for more than 300 us
- Packet generator (MoonGen)
  - 1 packet every 350 us



VM

DPDK App

Guest OS

DPDK App

MoonGen

Host OS with KVM

OS

NIC

NIC

NIC

NIC

🟥 Basicfwd

🟨 Data Flow to the DPDK on the Host

🟩 Data Flow to the DPDK inside the VM

CPU Idle Optimization –Current Situation

Max Cstate	C0	C1	C3	C6
Interrupt mode Basicfwd Latency (us)	14	14.9	60.9	87.7
C State Exit Latency *	0	2	33	133

* Output from “cpupower idle-info” on Intel XeonE5-2699 v3 @ 2.30GHz

Latency Improvement

Latency	Minimum (µs)	Average (µs)	Maximum (µs)
Interrupt mode Basicfwd (Host, before optimization)	19	105	418
Interrupt mode Basicfwd (Host, after optimization)	9	14	21
Interrupt mode Basicfwd (in-VM, before optimization)	9	112	7210
Interrupt mode Basicfwd (in-VM, after optimization)	9	20	35

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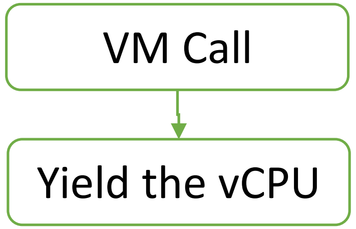
Optimizations to DPDK inside the VM

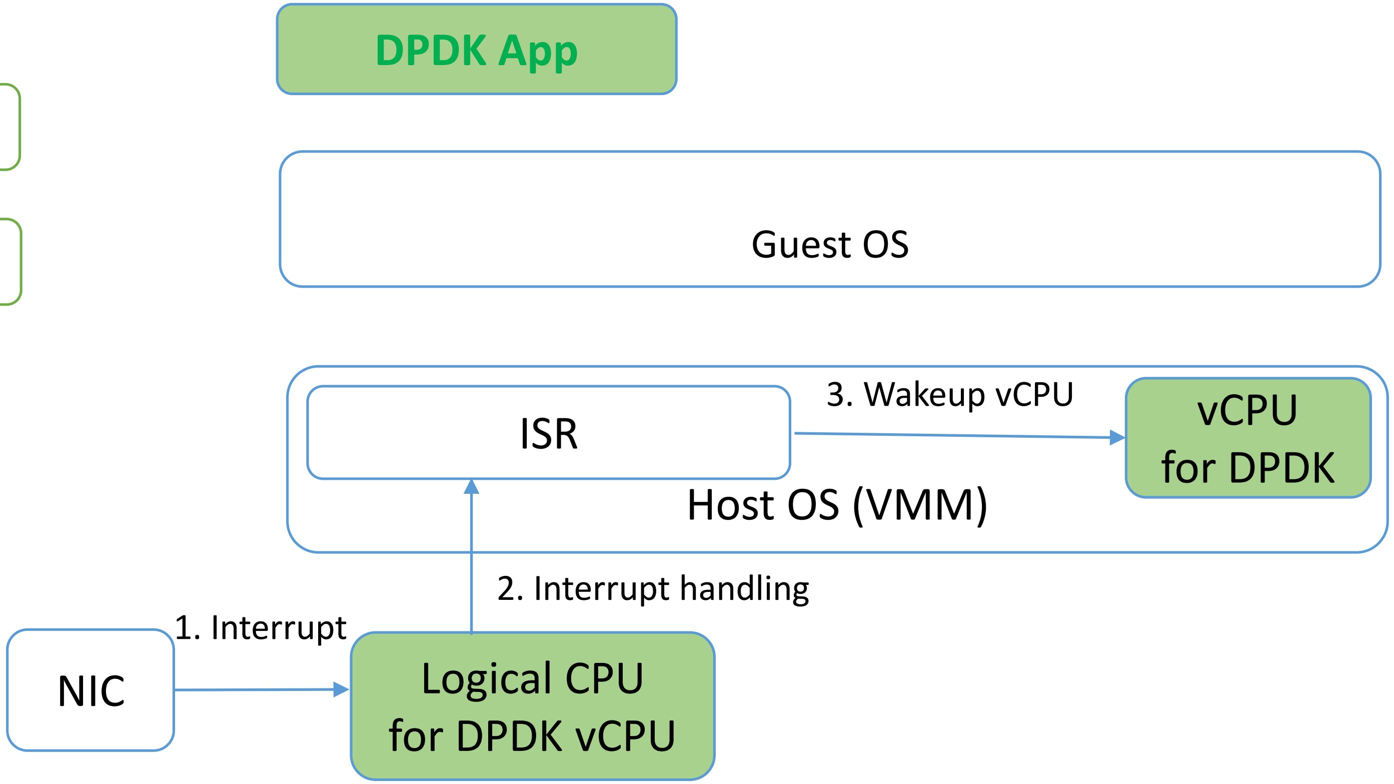
When no packets come:



VM Call

Yield the vCPU

When packets come:



DPDK App

Guest OS

ISR

3. Wakeup vCPU

vCPU for DPDK

Host OS (VMM)

2. Interrupt handling

1. Interrupt

NIC

Logical CPU for DPDK vCPU

- DPDK App starts to run once the vCPU is woken up by the Host ISR
- No need to inject virtual interrupts
- No need to signal eventfd inside the VM

End of Presentation

Thank you!