DPDK

Berkeley Extensible Software Switch (BESS)

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BESS:
A Virtual Switch Tailored for NFV

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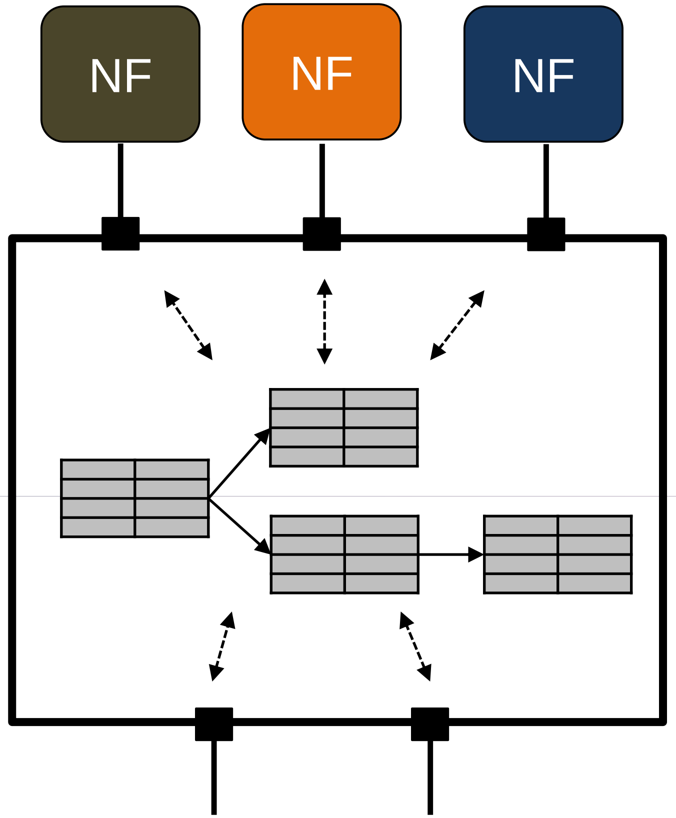
SPAN: Software Principle for Advanced Networking

http://span.cs.Berkeley.edu

Why Another Virtual Switch ?

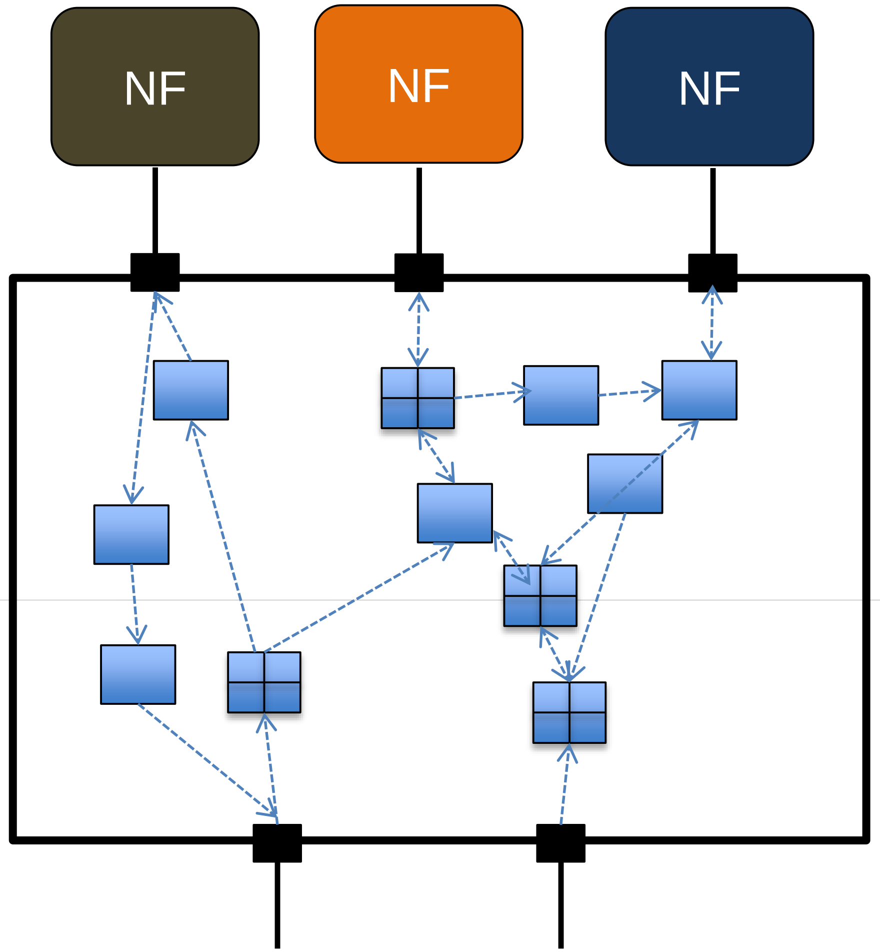
- Does Open vSwitch meet all the requirements for NFV?



1. Performance
   – OVS (~1Mpps) → OVS-DPDK (~15Mpps)
   – Vanilla DPDK (~59 Mpps/core)
   – Packet I/O is only half of the problem
2. Flexibility
   – Custom actions ?
   – Stateful packet processing ?
3. Extensibility
   – Must enable NFV controller evolution
   – Easily add support for new/niche protocols

Alternative Approach with BESS

- Modular pipeline as a dataflow graph
- Each module can run arbitrary code
  - Not limited by Match/Action semantics
  - Independently extensible & optimizable
- Everything is programmable, not just flow tables
- You pay only for what you use.
  - No performance cost for unused features



Berkeley Extensible Software Switch (BESS)

DPDK

- BESS is a programmable platform for vSwitch dataplane

- Clean-slate internal architecture with NFV in mind
  - Highly extensible & customizable
  - Readily deployable with backward compatibility
  - … all with extreme performance:
    - Sub-microsecond latency
    - Line-rate 40Gbps with min-sized packets on two cores
    - (> 2x faster than existing virtual switches)

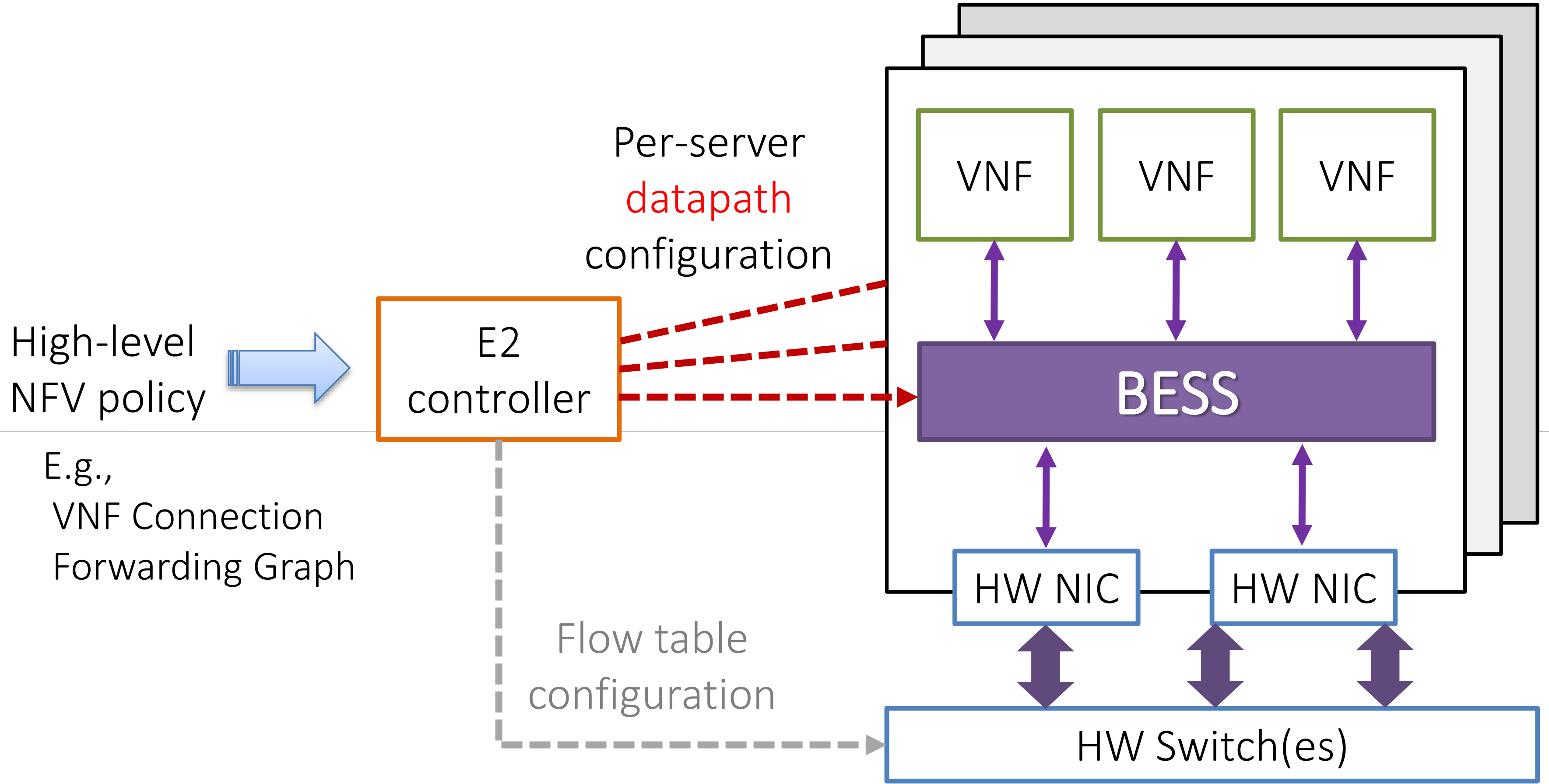
What can you Build on BESS ?

- NFV virtual switches

- Other possible usages:
  - Network virtualization for multi-tenant datacenters
  - Network functions (firewall, VPN, ADC, etc.)
  - Traditional L2/L3 switches
  - “Smart” NICs
  - ...

Our use Case: Elastic Edge (E2)

- E2 is a research prototype of our NFV platform
  - "E2: A Framework for NFV Applications", Palkar et al., In *ACM SOSP*, 2015



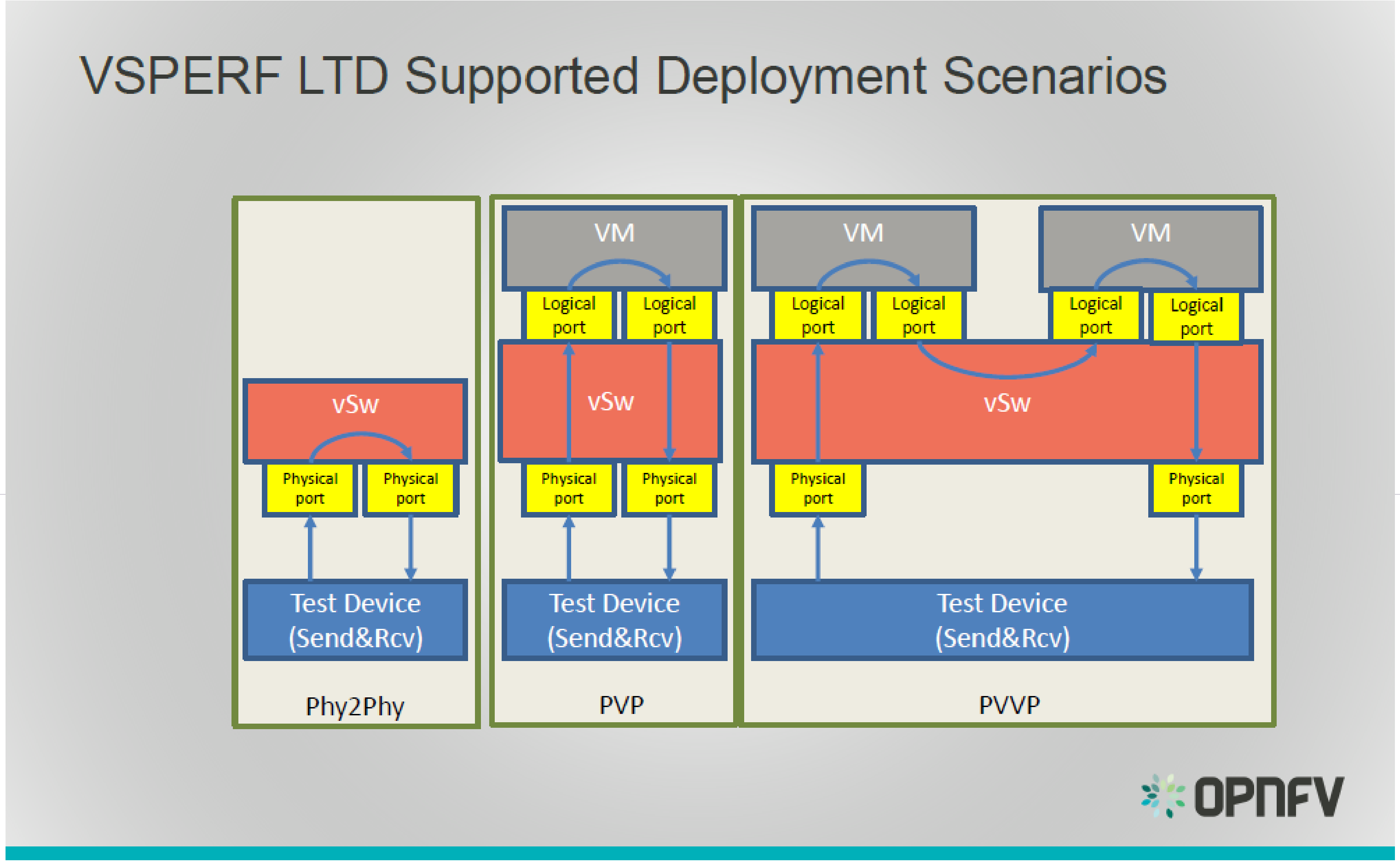
Performance – Minimum Framework Overhead

DPDK

- Packet buffer allocation/deallocation
  - ~10 CPU cycles per packet
- CPU scheduling
  - ~50 CPU cycles per round
  - Scales well with thousands of traffic classes
- Dynamic per-packet metadata attributes
  - Zero instruction overhead for access
  - Optimal CPU cache-line usage

Performance Evaluation

- OPNFV VSPERF usage models

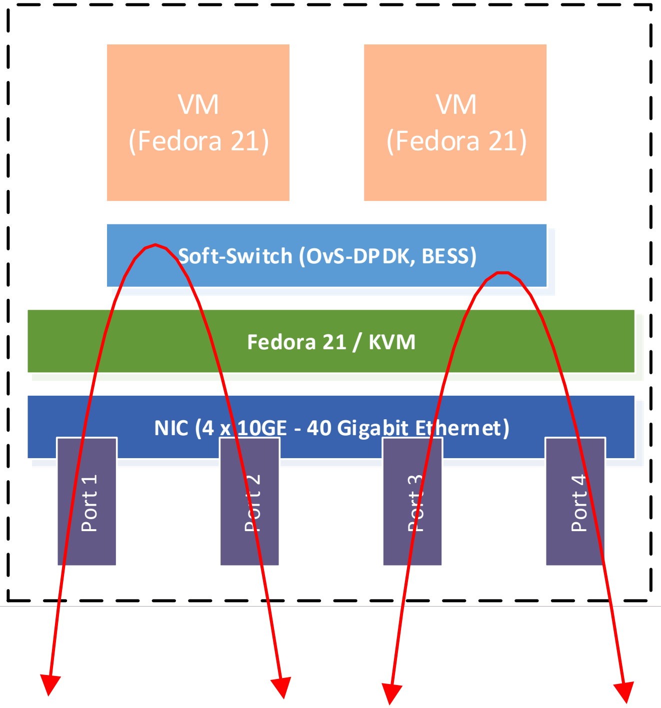


System Configuration

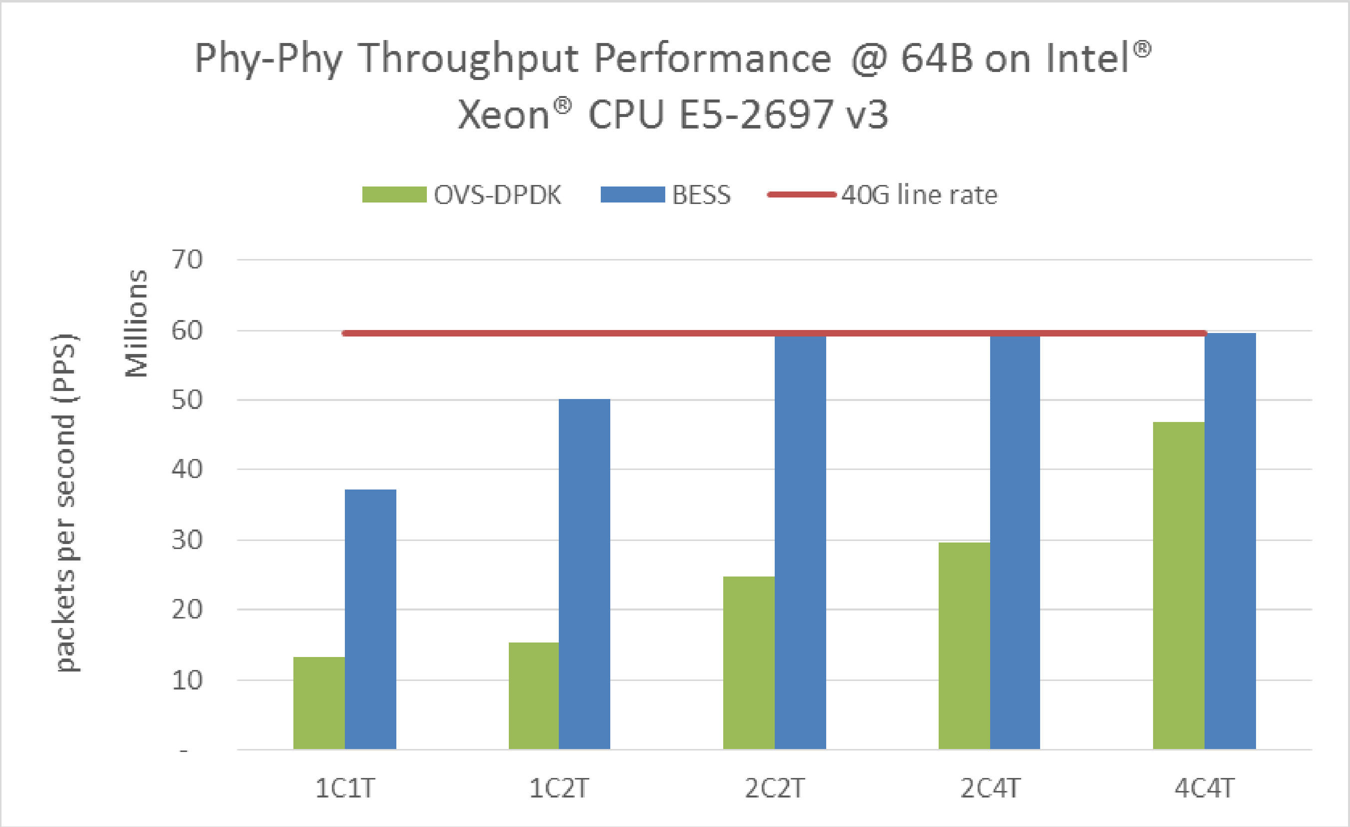
Hardware	
Platform	Wildcatpass S2600WT2
CPU	Intel(R) Xeon(R) CPU E5-2697 v3 @ 2.60GHz
Chipset	Intel® C610 series chipset (Wellsburg)
No of CPU	1
Cores per CPU	14 (HT Enabled. Total: 28)
LL CACHE	35840K
QPI/DMI	Auto
PCIe	Port3A and Port3C(x8)
MEMORY	Micron 16GB 1Rx4 PC4-2133MHz, 16GB per channel, 4 Channels, 64GB Total
NIC	2 x Intel® Ethernet X710-DA2 Adapter (Total: 4 Ports)
NIC Mbps	10000
BIOS	Version: SE5C610.86B.01.01.0008.021120151325 & Date: 02/11/2015

Software	
OS	Fedora 23
Kernel version	4.2.3-300.fc23.x86_64
Host Machine boot setting	Hugepage size = 1G ; No. of Hugepages = 16 Hugepage szie=2MB; No. of Hugepages = 2048 isolcpus=1-9,21-29
Software version	DPDK 16.07 BESS (Commit id: 940b2f114dcb9989b4fd2d3a24a4612454c21840)
Host settings	firewall, iptables, Selinux, network Manager disabled ip_forward = 0 set uncore frequency to the max ratio kill -9 dhclient rmmod ipmi_si ipmi_devintf ipmi_msghandler lpc_ich bridge sepci -s 00:03.0 184.l=1408 sepci -s 00:03.2 184.l=1408
IXIA TEST	RFC 2544 0% PACKET LOSS, 2 flows total/two ports
BIOS settings	P-state Disabled, C-State Disabled, HT ON and Turbo Boost Disabled
Fortville NIC FW Version	FW 4.33 API 1.2 NVM 04.04.02 eetrack 8000191c
IXIA TEST	RFC 2544 0% PACKET LOSS,4 total flows/4 ports

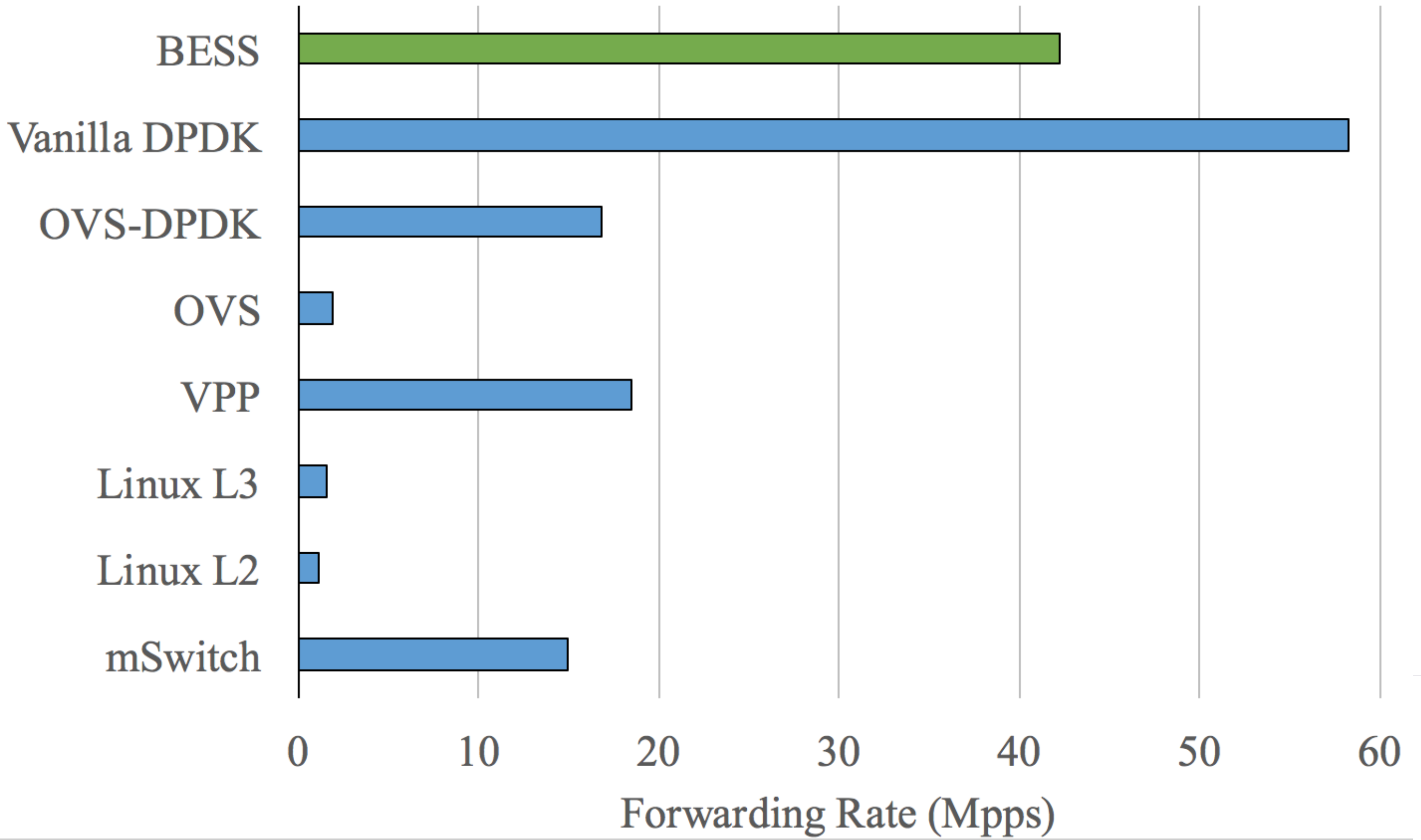
Phy-to-Phy Performance (1/2)



Source: Irene Liew, Anbu Murugesan – Intel Network Packet Group

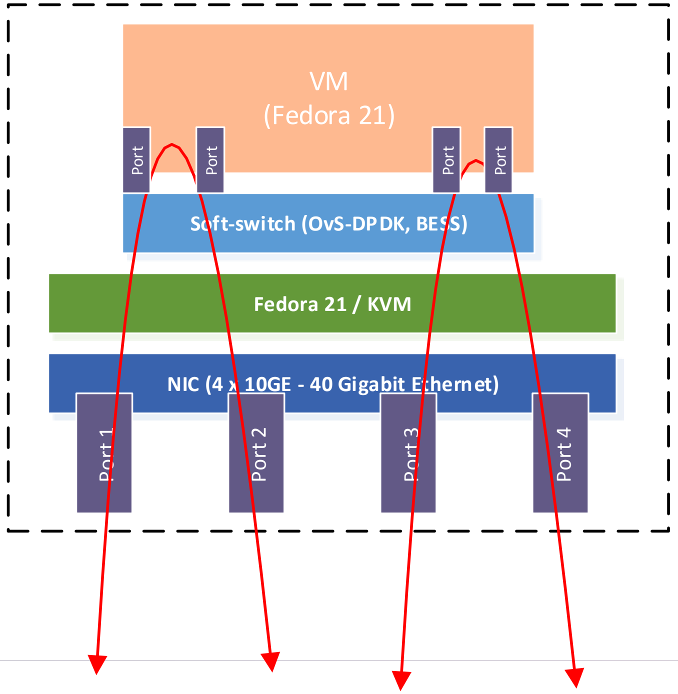


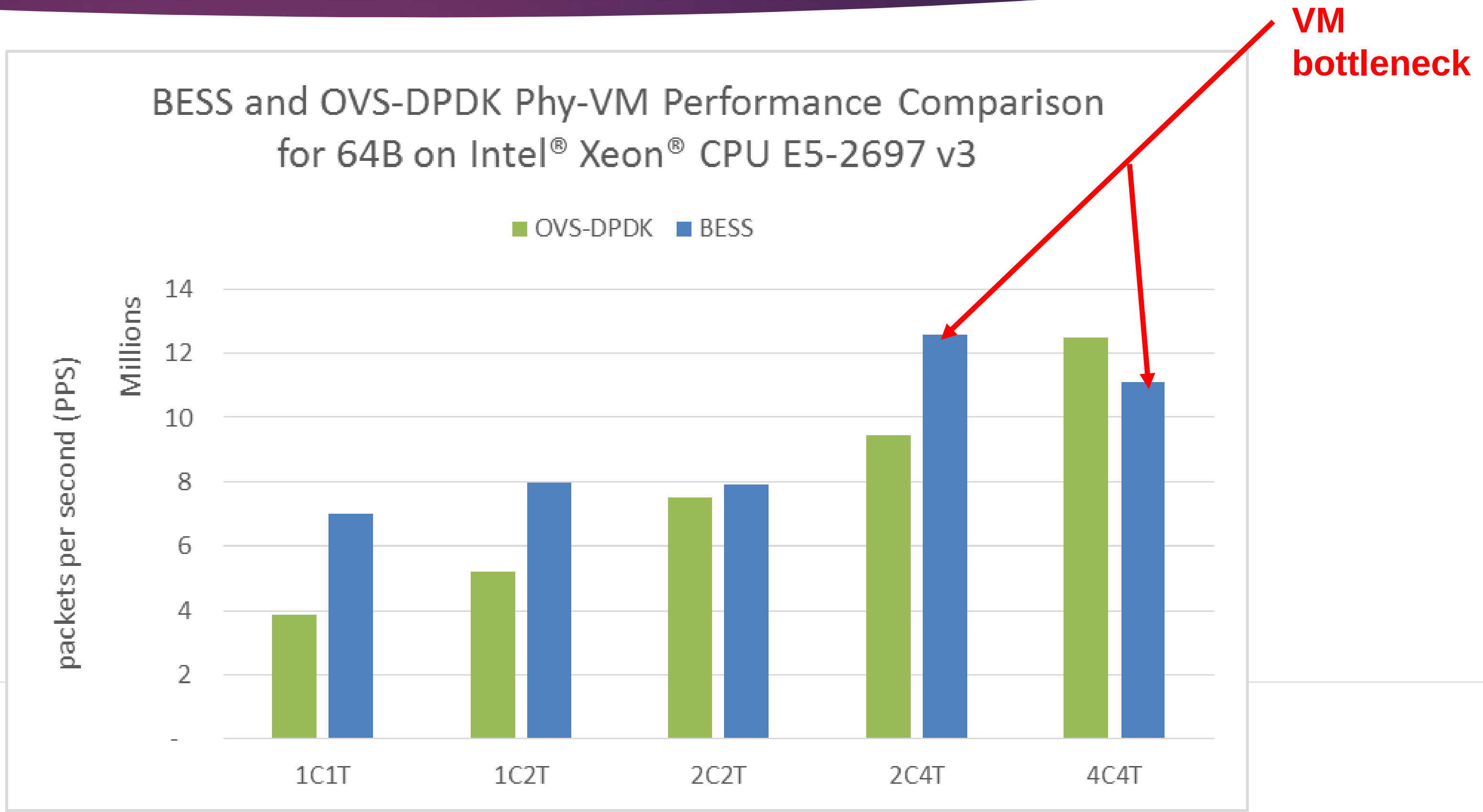
Phy-to-Phy Performance (2/2)



Data sources:
- BESS, Vanilla DPDK, VPP: measured on a 2.6GHz Xeon E5-2650 v2 machine
- OVS, Linux L2/L3: Emmerich et al. “Performance Characteristics of Virtual Switching”, CloudNet 2014
- OVS-DPDK: Intel ONP 2.1 Performance Test Report
- mSwitch: (link bottlenecked w/ large batch sizes @ 3.2GHz) Honda et al. “mSwitch: A Highly-Scalable, Modular Software Switch”, SOSR 2015

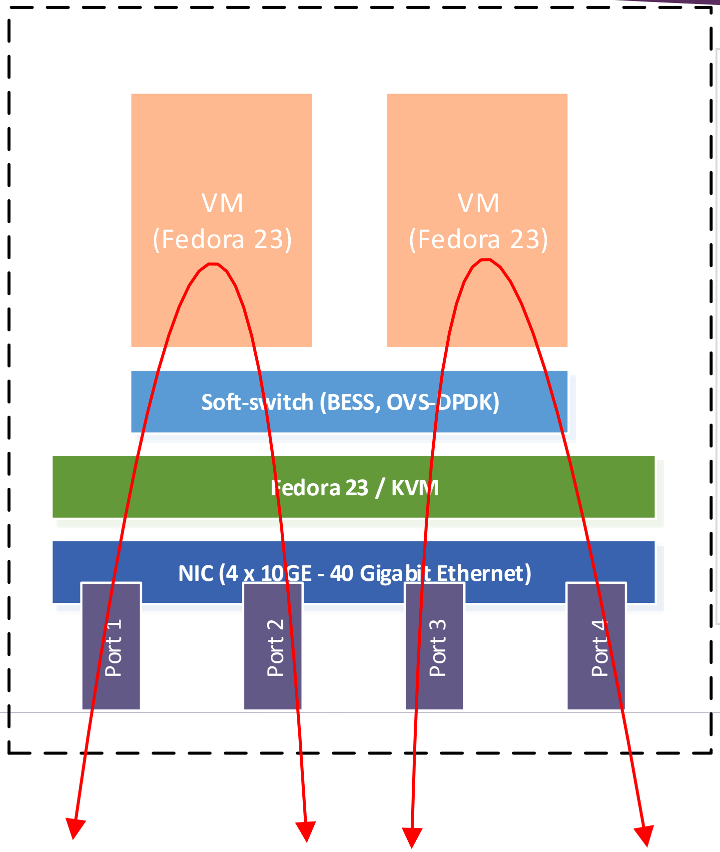
Phy-NF-Phy Performance

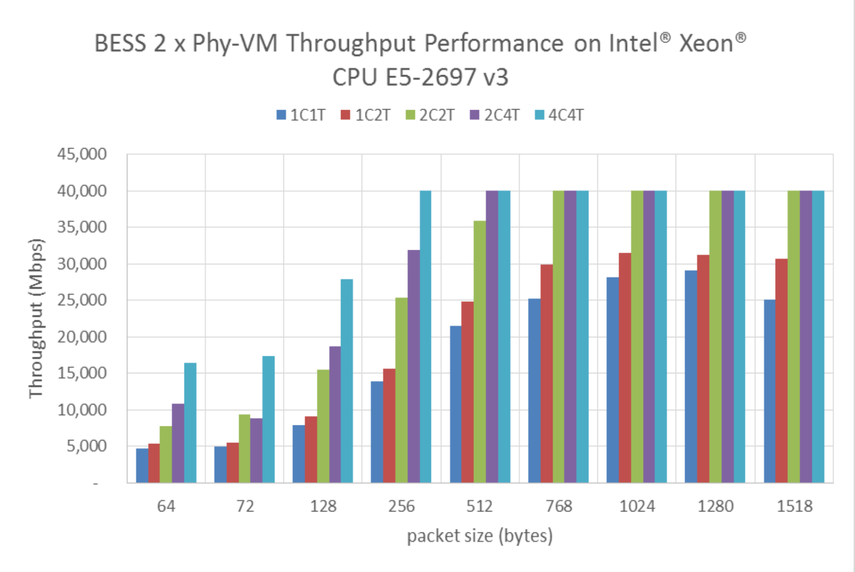


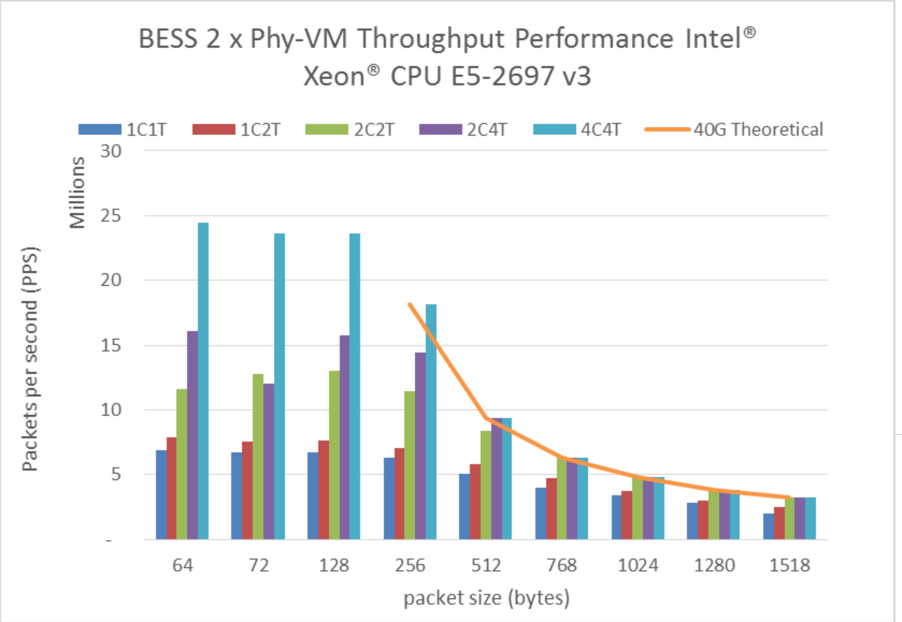


Source: Irene Liew, Anbu Murugesan – Intel Network Packet Group

2 x Phy-NF-Phy Performance



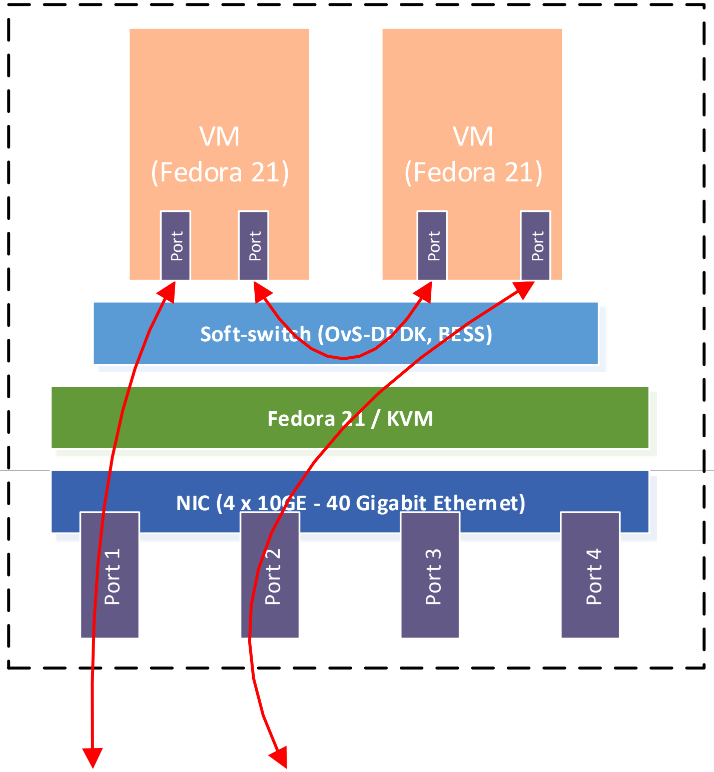


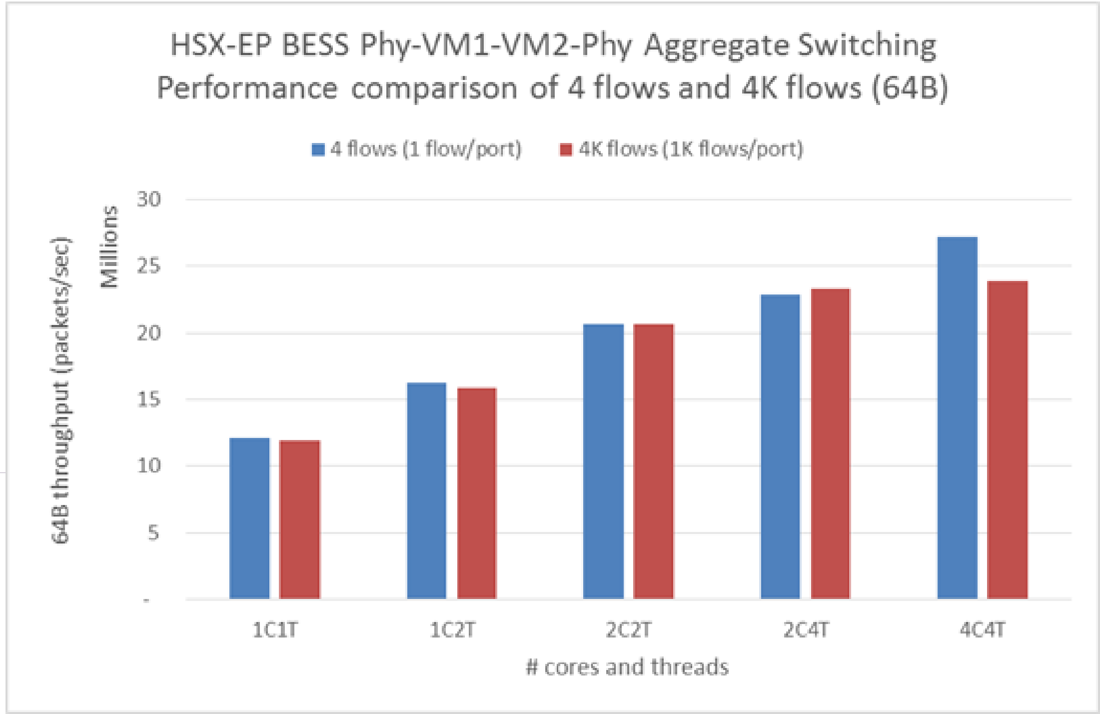


Source: Irene Liew, Anbarasan Murugesan – Intel NPG Architecture

Phy-NF-NF-Phy Performance

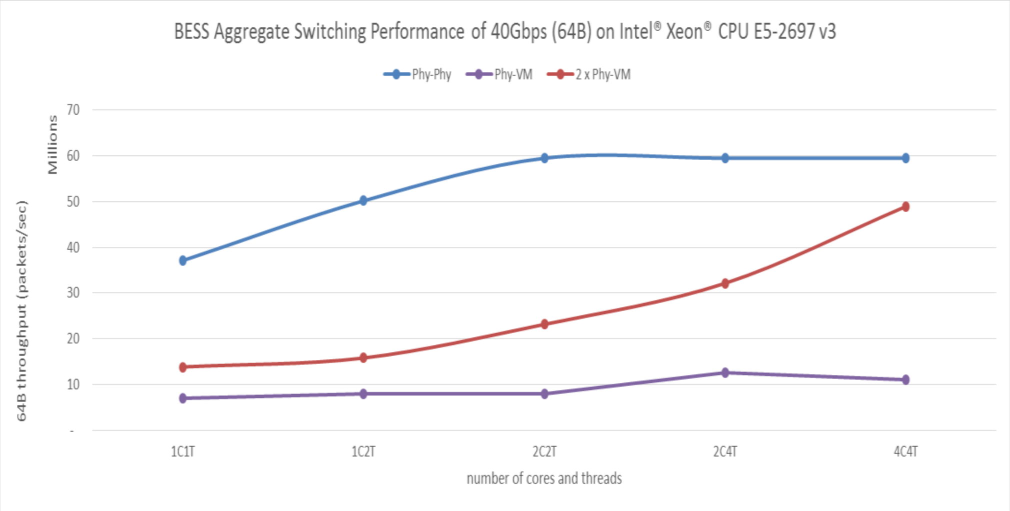
- BESS outperforms OVS-DPDK by a factor of 4-5x*

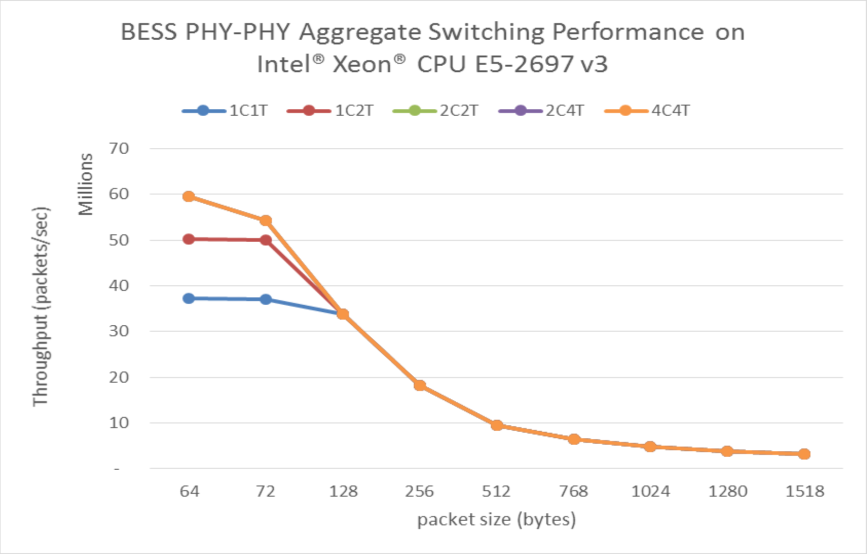


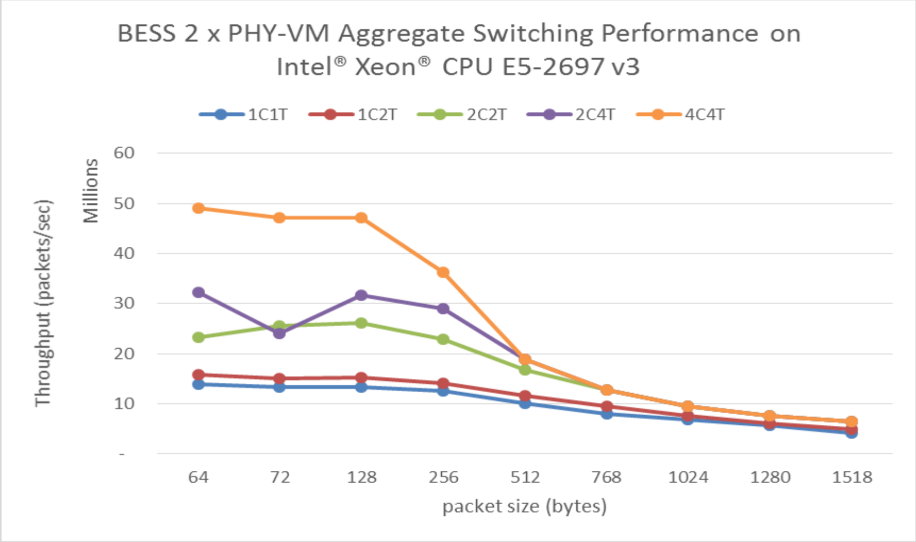


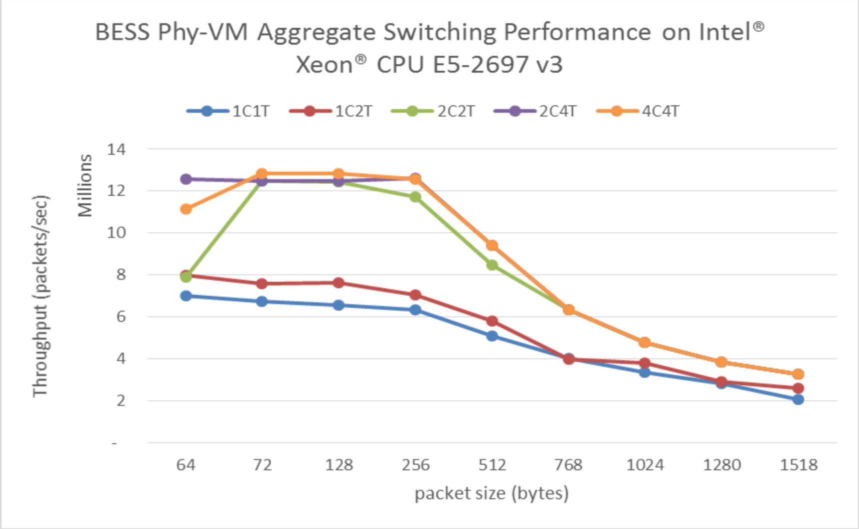
* Source: Intel ONP 2.1 Performance Test Report

Multi-Core / Thread Scalability









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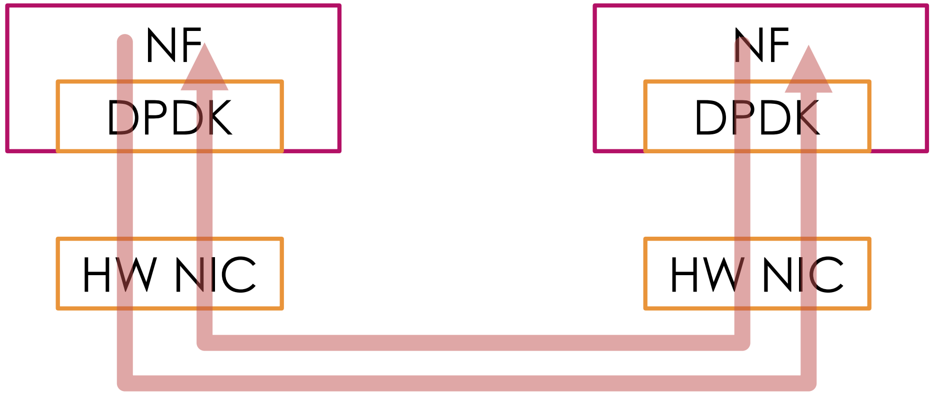
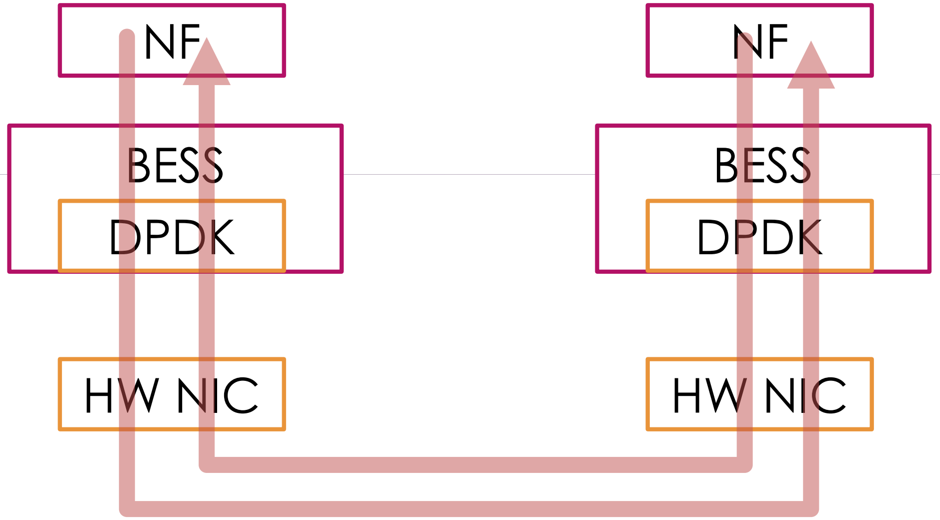
Round-Trip Latency



RTT: 8.22us



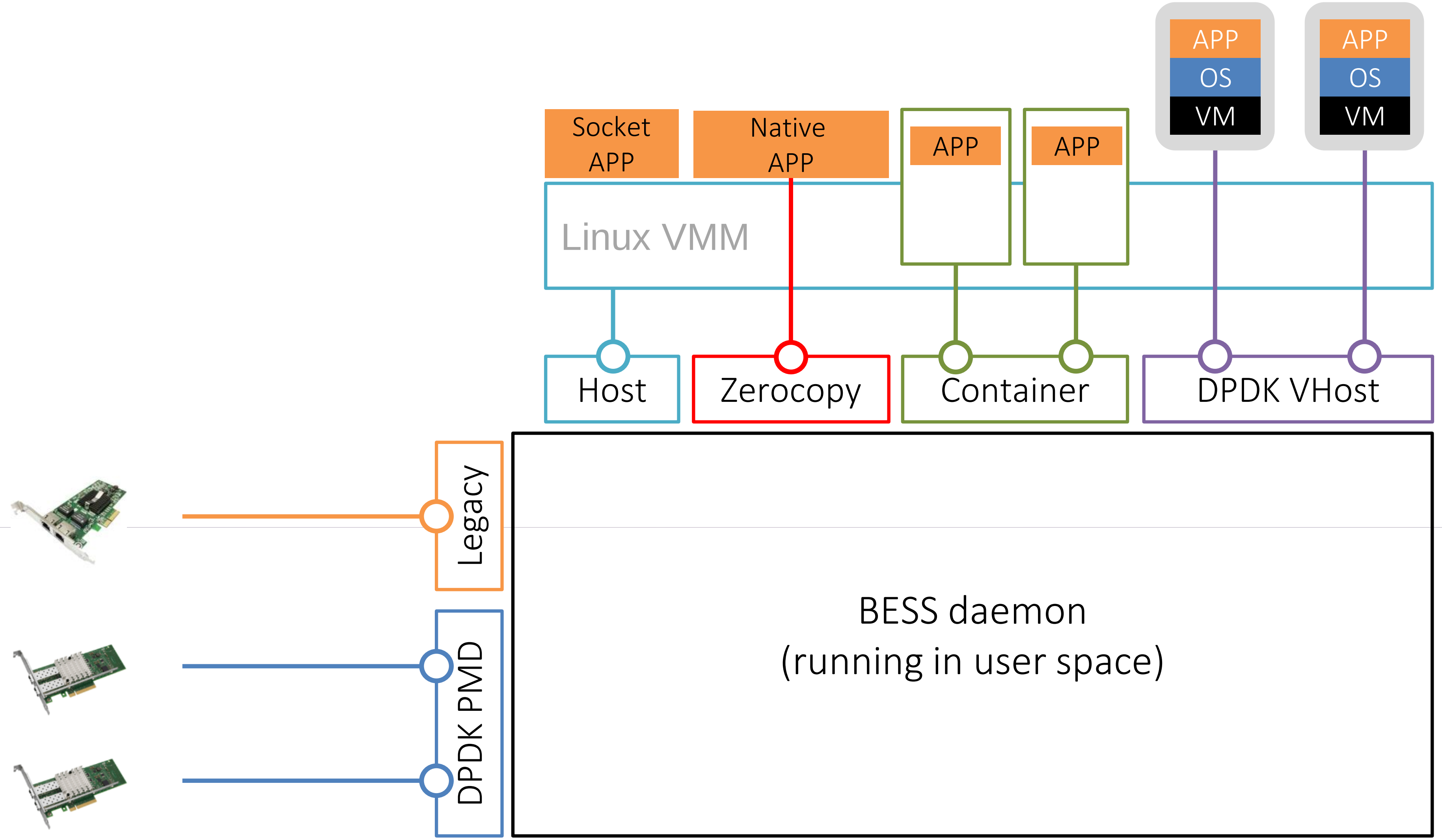
RTT: 8.82us

- Increase of 0.60us (0.15us per BESS traverse)

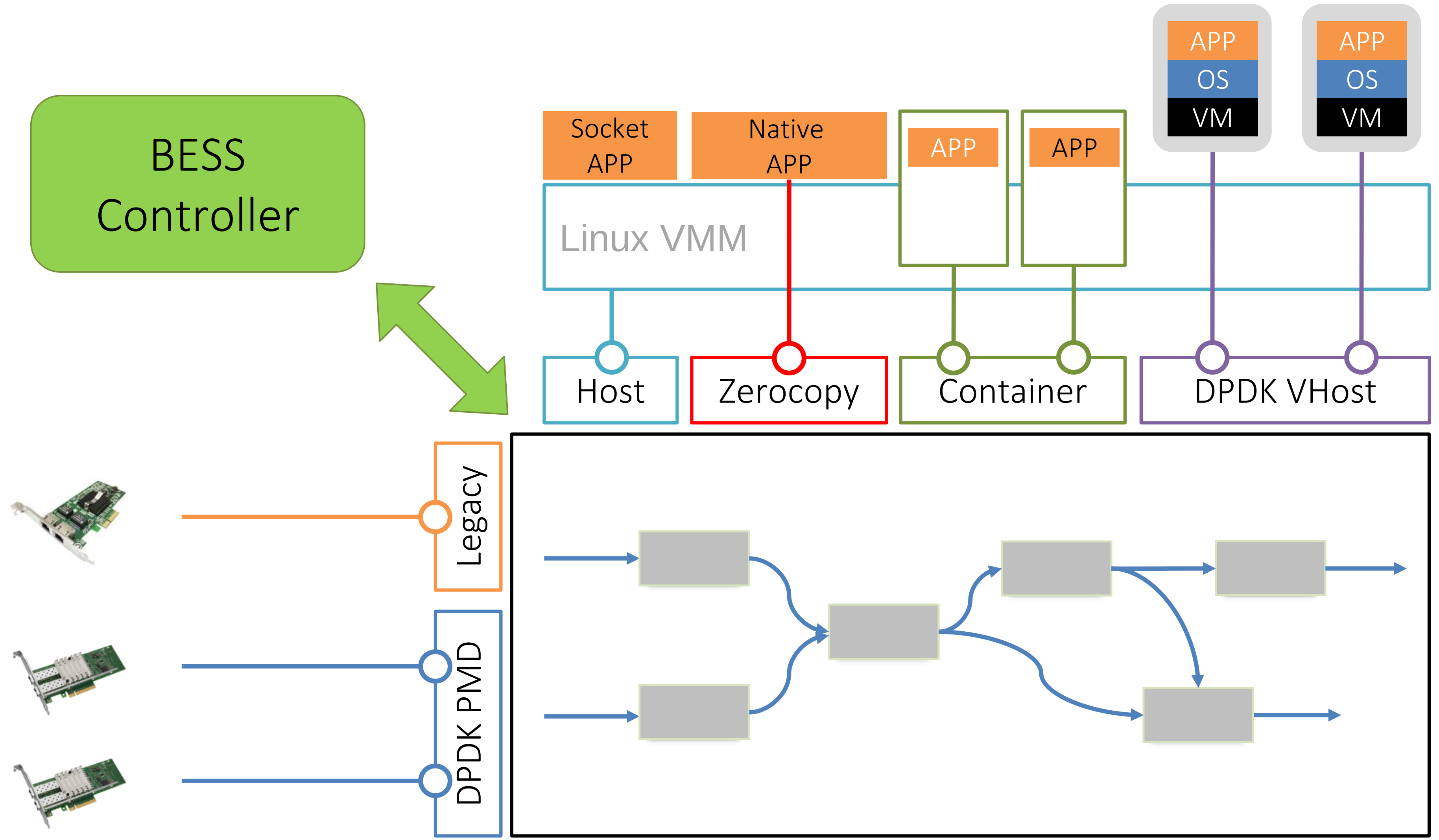
BESS Architecture Overview (1/3)

BESS daemon
(running in user space)

BESS Architecture Overview (2/3)

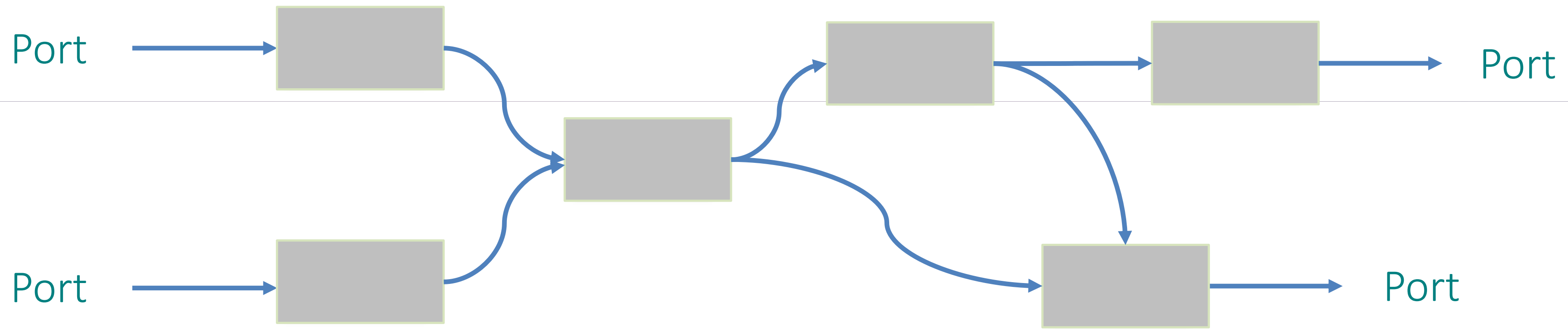


BESS Architecture Overview (3/3)



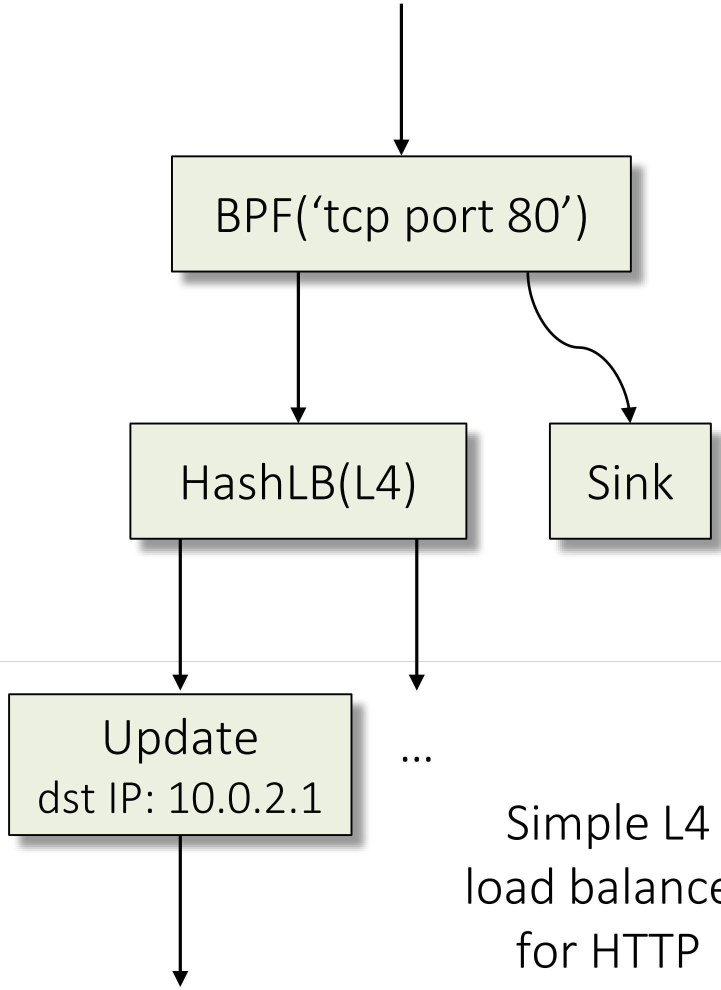
Modular Datapath Pipeline

- External ports are interconnected with “modules” in a dataflow graph (like the Click modular router).
  – You can compose modules to implement your own datapath.
  – Developing a new module is easy.



Building Modules

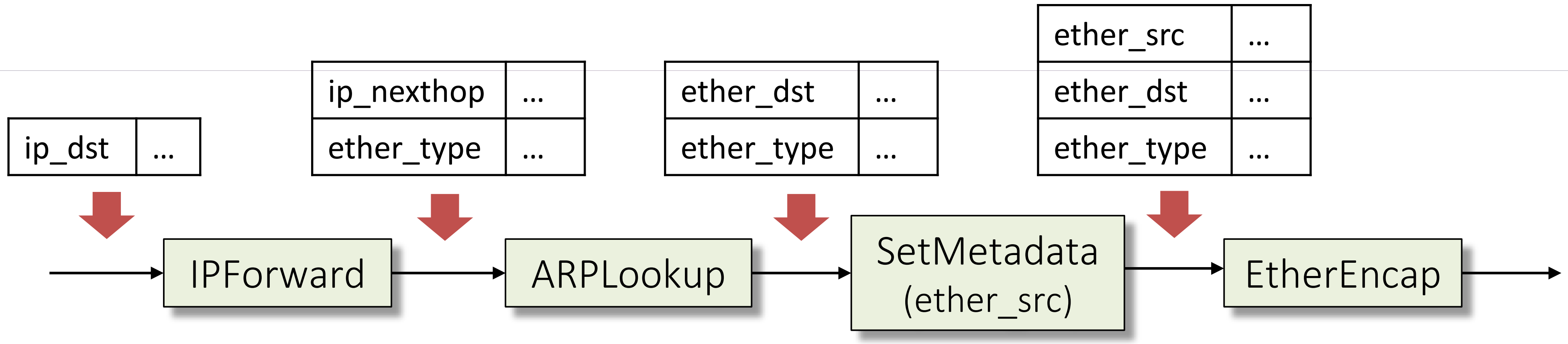
- BPF filter
- Exact match table
- Wildcard match table
- Load balancer
- Encapsulation / decapsulation
- L2 forward
- IP Lookup
- 802.1q / 802.1ad
- Metadata
- …



Simple L4
load balancer
for HTTP

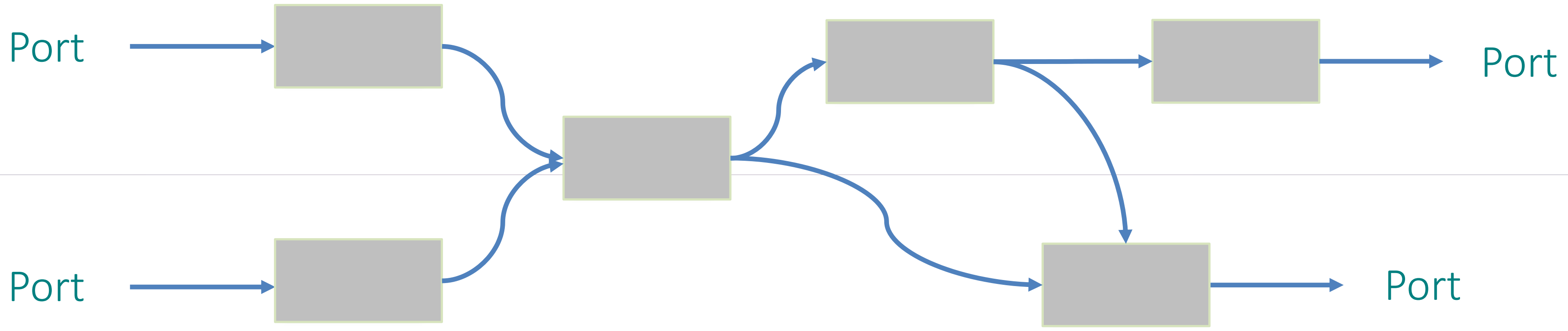
Dynamic Packet Medatada

- Modules can tag metadata attributes to packets
  - Dynamic key-value table for each packet
  - 0-instruction access overhead, as compared to static “C struct”
  - Optimal usage of memory (cf. metadata bloat in Linux sk_buff)
  - Enables more decoupled and coherent design of modules



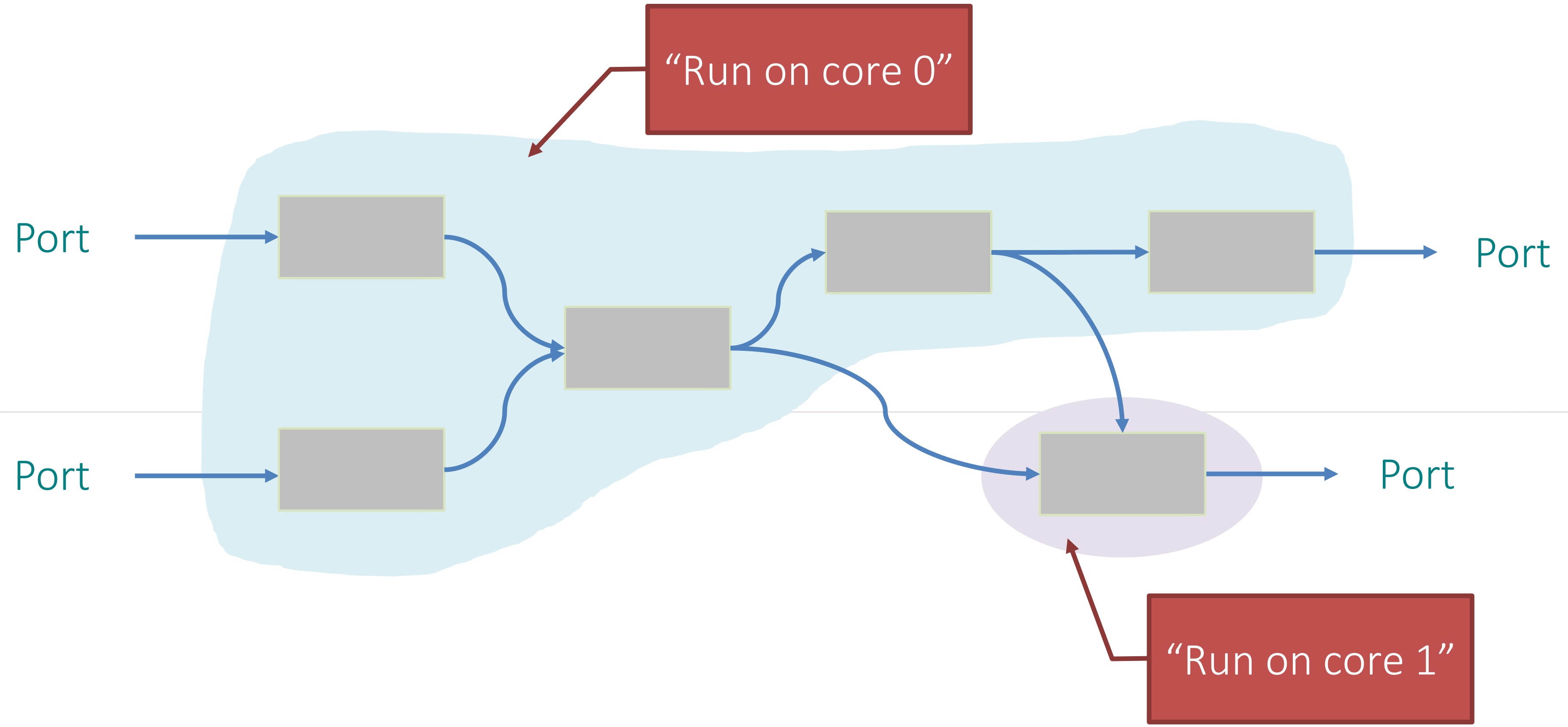
Resource-Aware CPU Scheduler (1/5)

- BESS allows flexible scheduling policies for the data path
  - In terms of CPU utilization and bandwidth. Examples:



Resource-Aware CPU Scheduler (2/5)

- BESS allows flexible scheduling policies for the data path.
  - In terms of CPU utilization and bandwidth. Examples:



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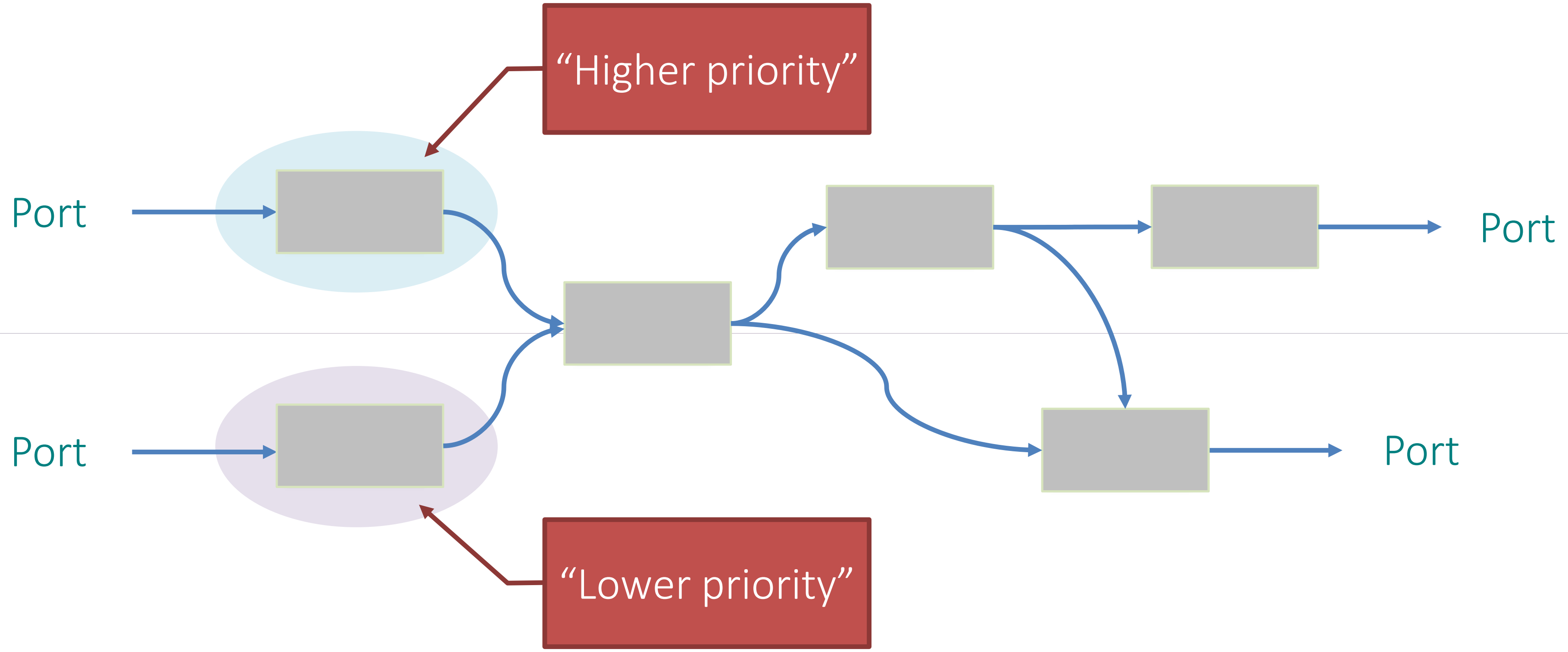
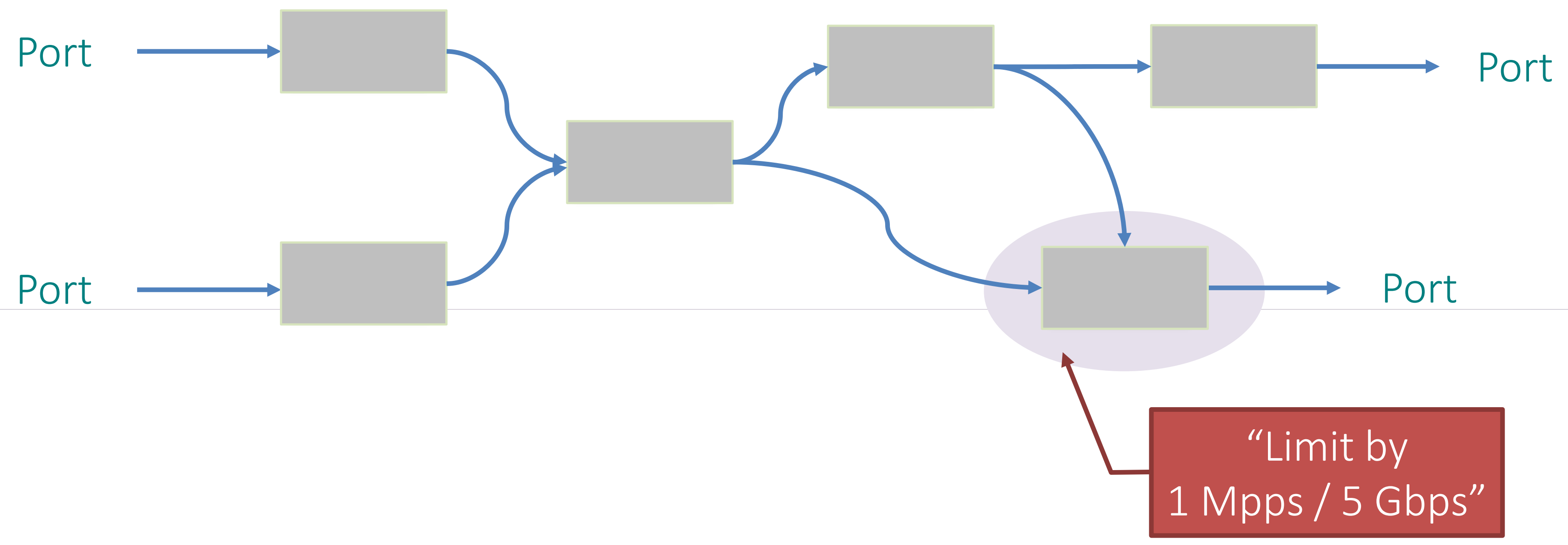


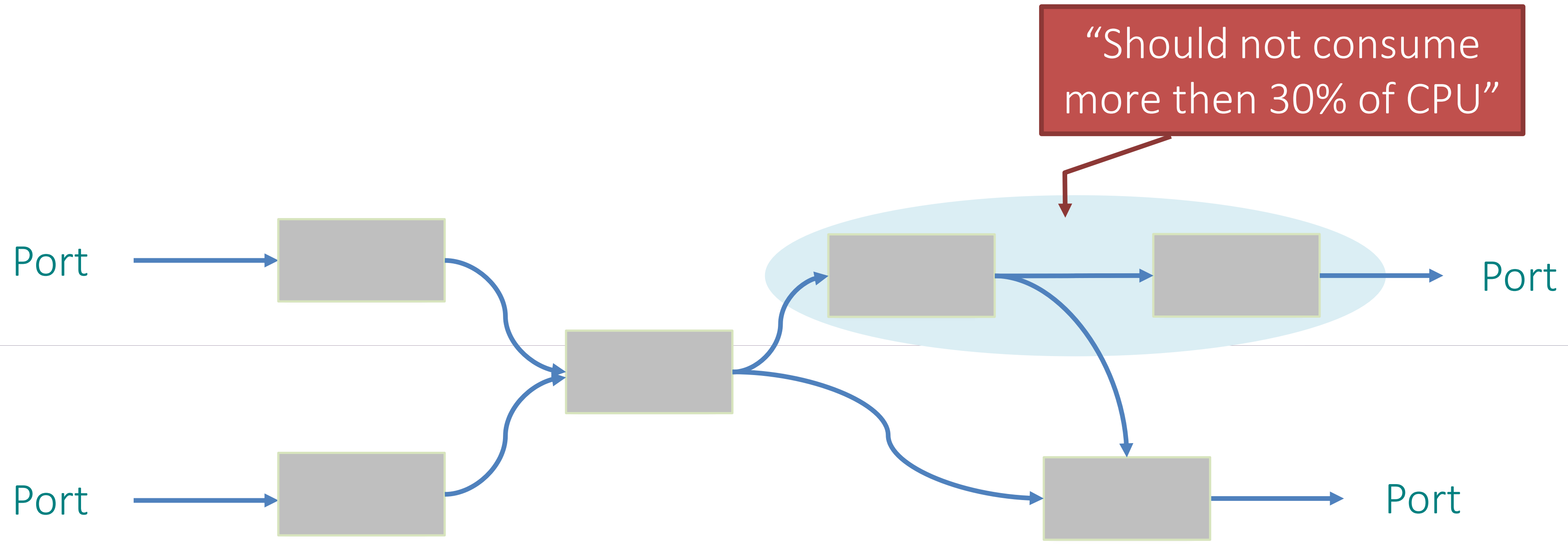
Resource-Aware CPU Scheduler (4/5)

- BESS allows flexible scheduling policies for the data path.
  - In terms of CPU utilization and bandwidth. Examples:

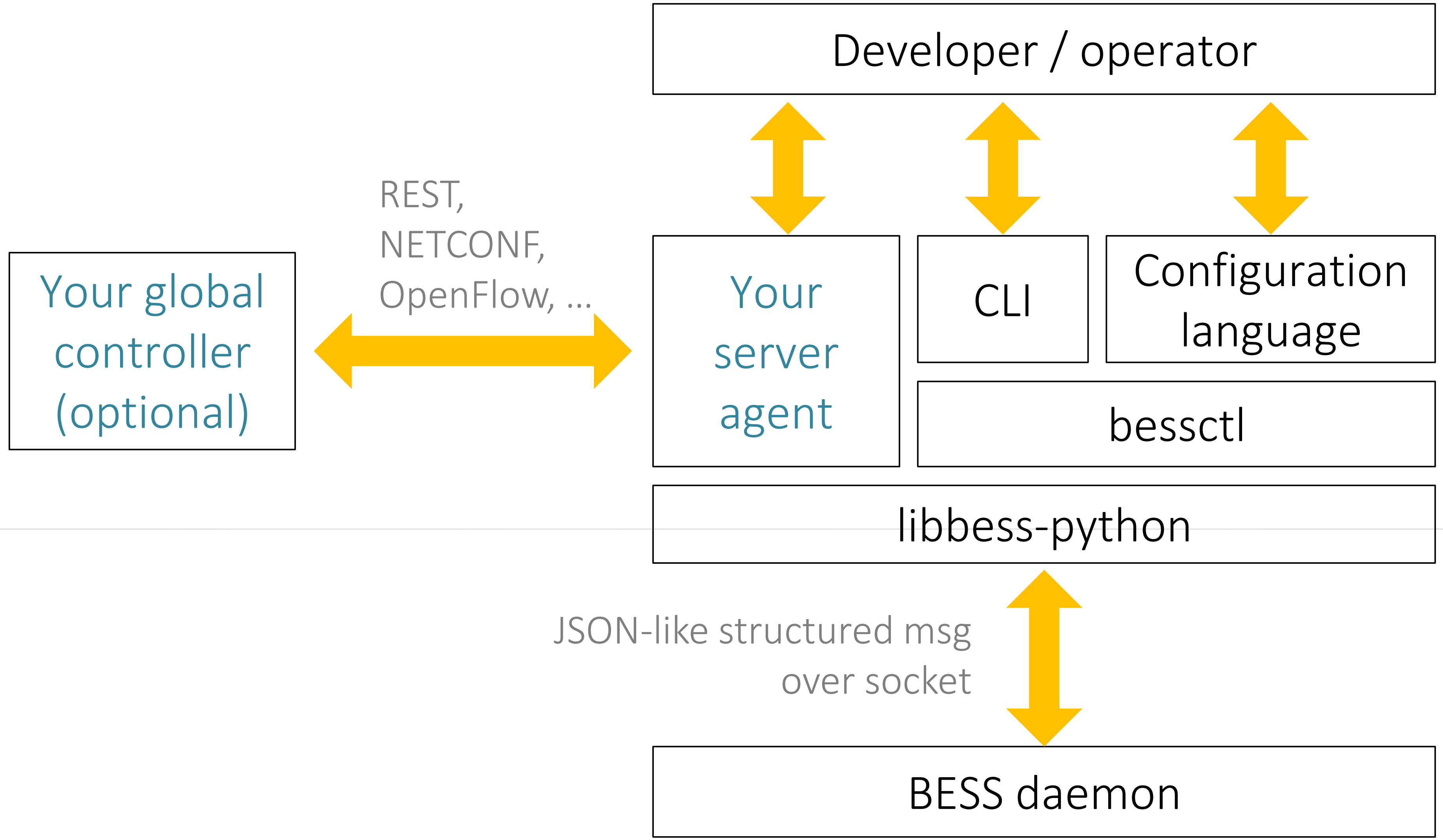


Resource-Aware CPU Scheduler (5/5)

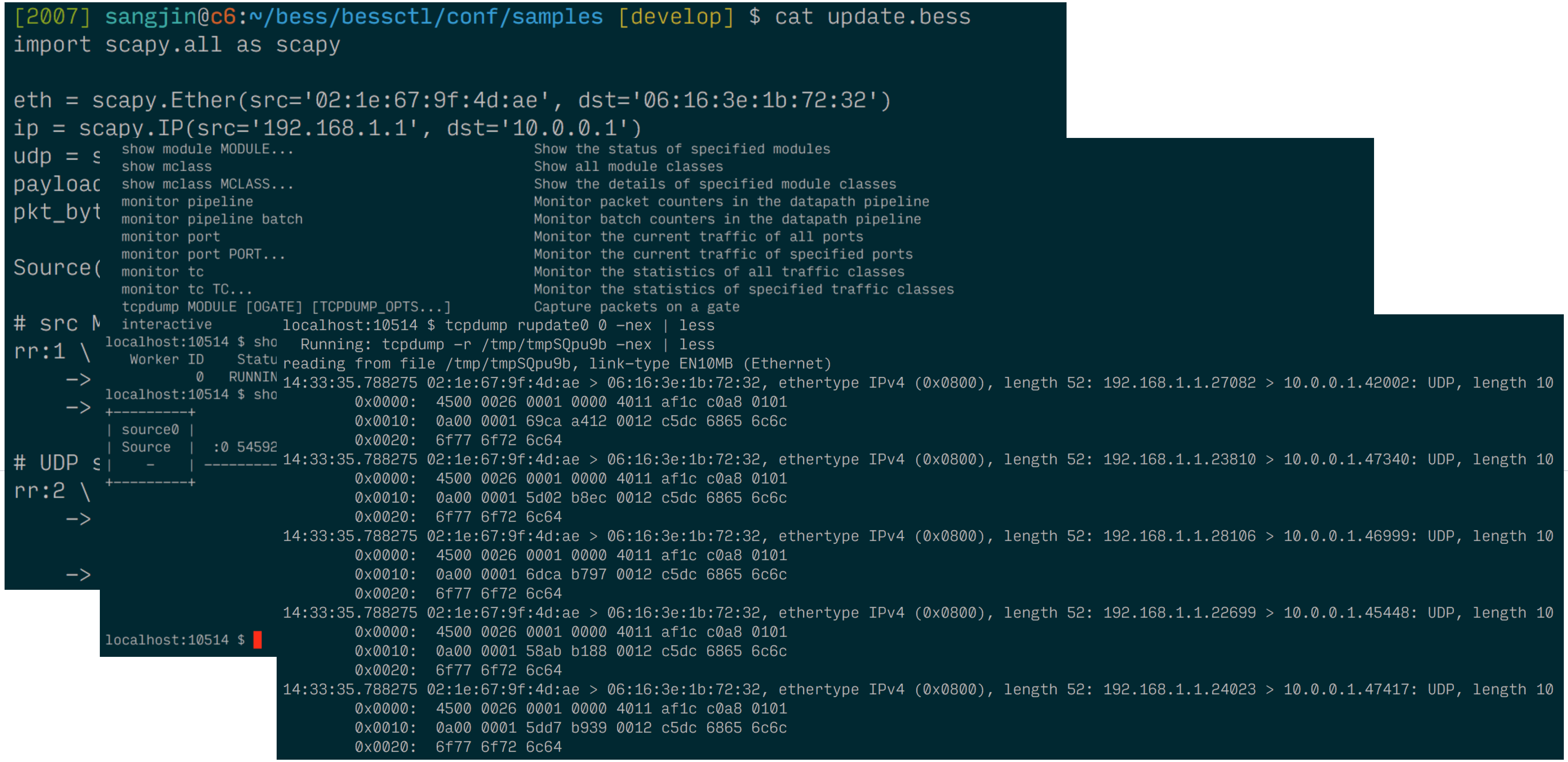
- BESS allows flexible scheduling policies for the data path.
  - In terms of CPU utilization and bandwidth. Examples:



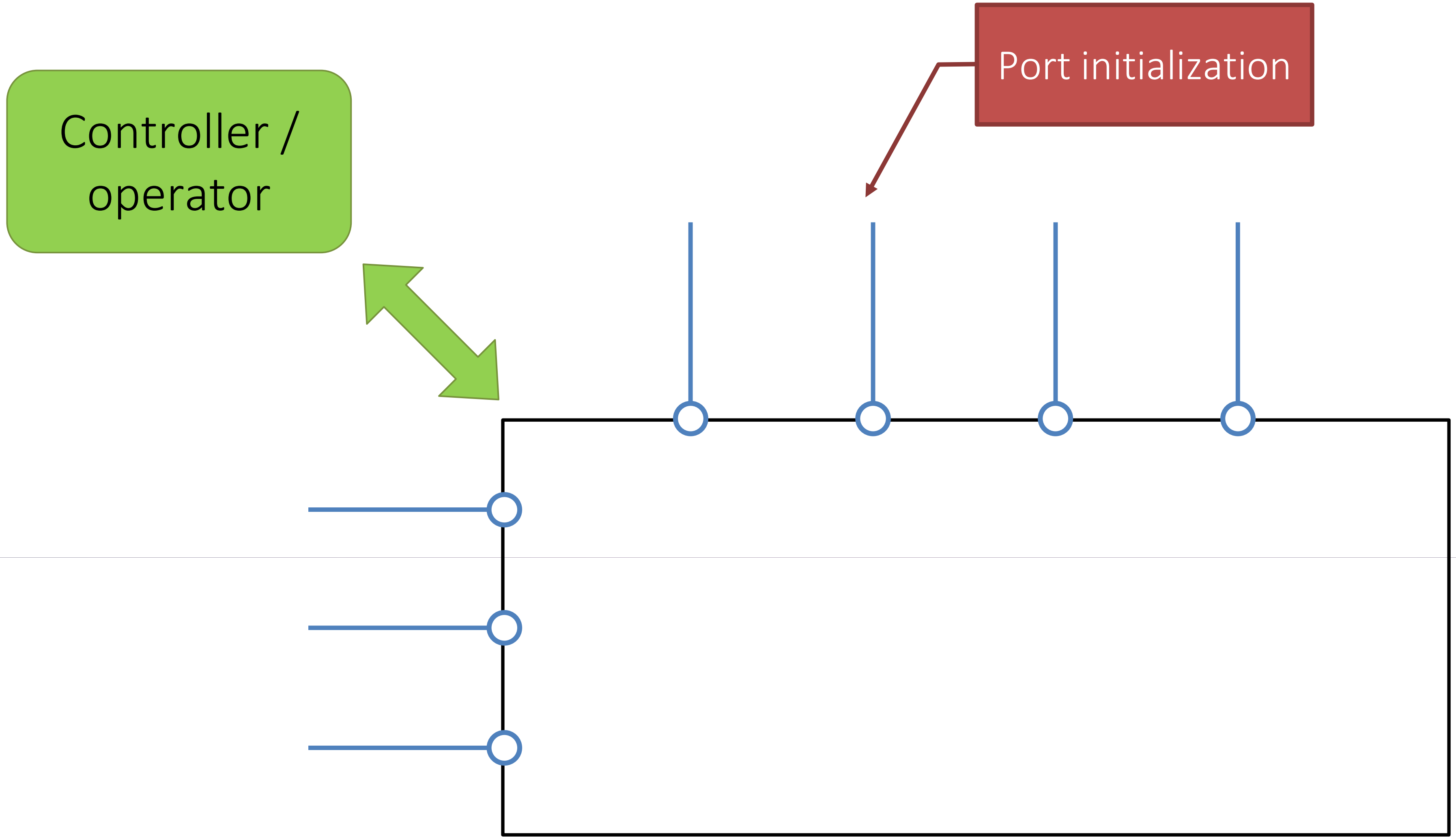
BESS Control Interface (1/5)



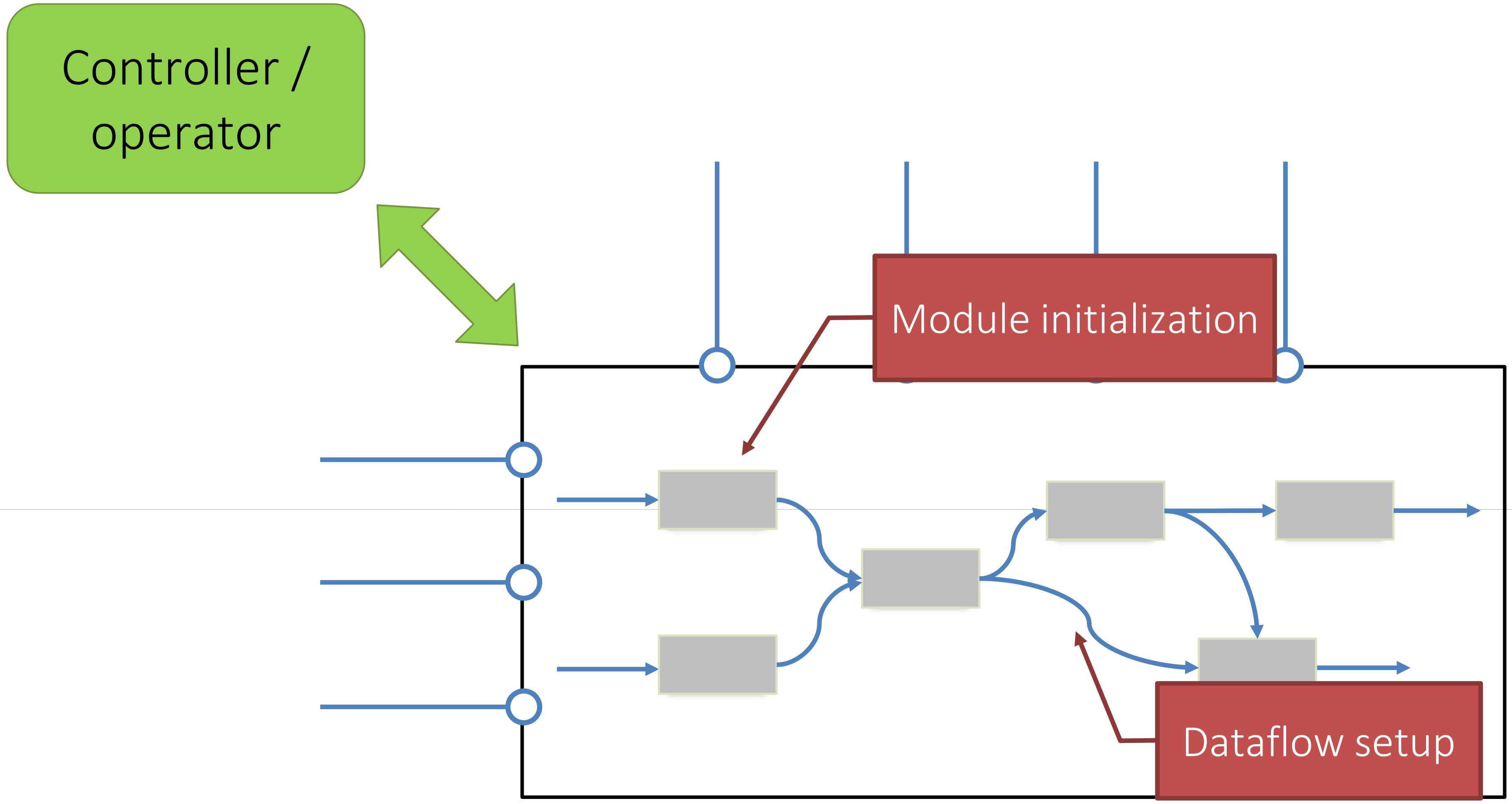
BESS Control Interface (2/5)



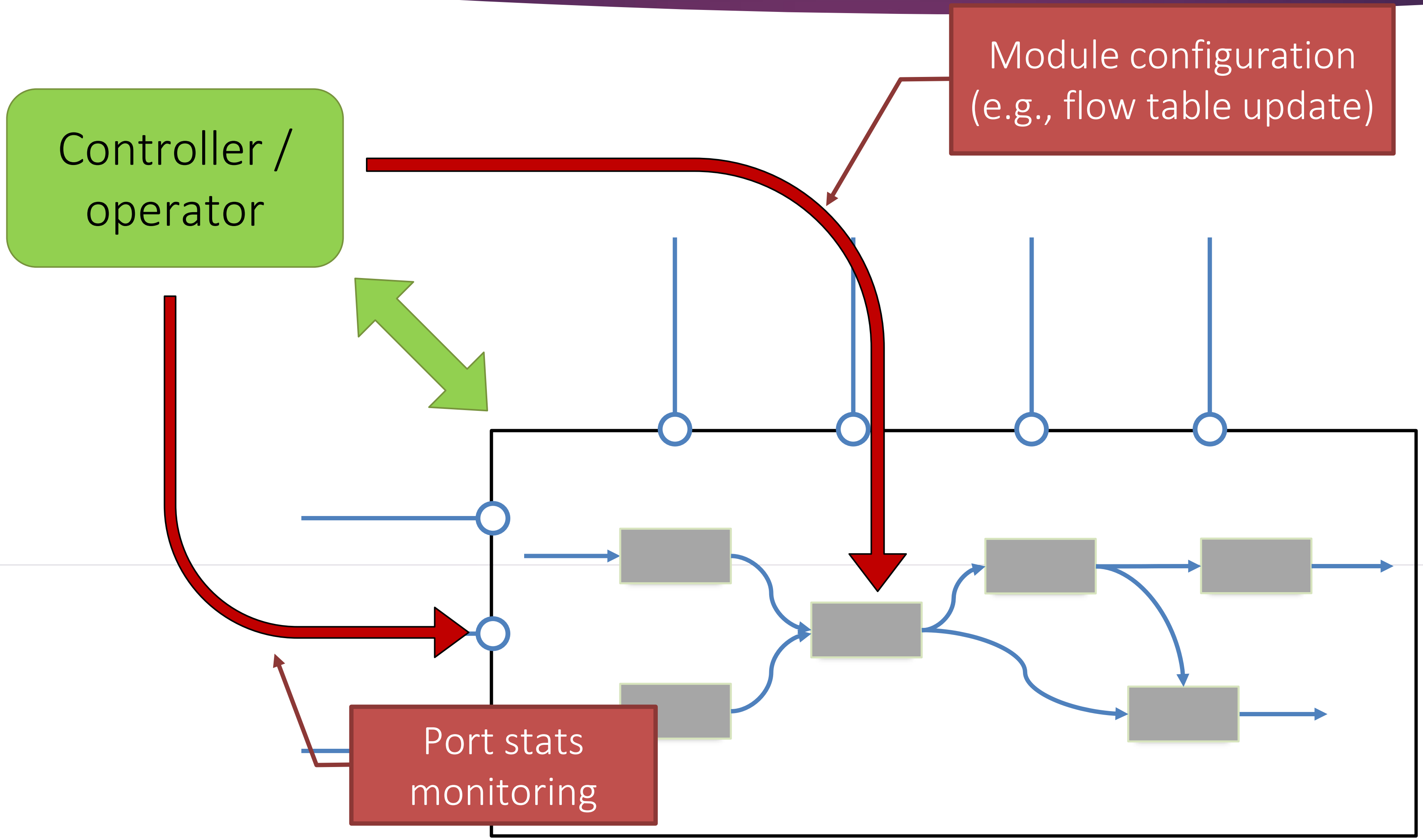
BESS Control Interface (3/5)



BESS Control Interface (4/5)



BESS Control Interface (5/5)



Summary

- BESS is an ideal vSwitch platform for NFV
  - High performance
    - Sub-microsecond latency/jitter
    - Small packet 40Gbps throughput with only 1-2 cores
  - Full flexibility and extensibility

- Available on GitHub: https://github.com/netsys/bess
  - Under BSD3 License
  - ~34k lines in C and Python, supporting
    - Linux 3.x / 4.x (x86_64), DPDK 16.04
    - QEMU/KVM virtual machines, Docker/LXC containers

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Questions?

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