# Using CPU as a Traffic Co-processing Unit in Commodity Switches

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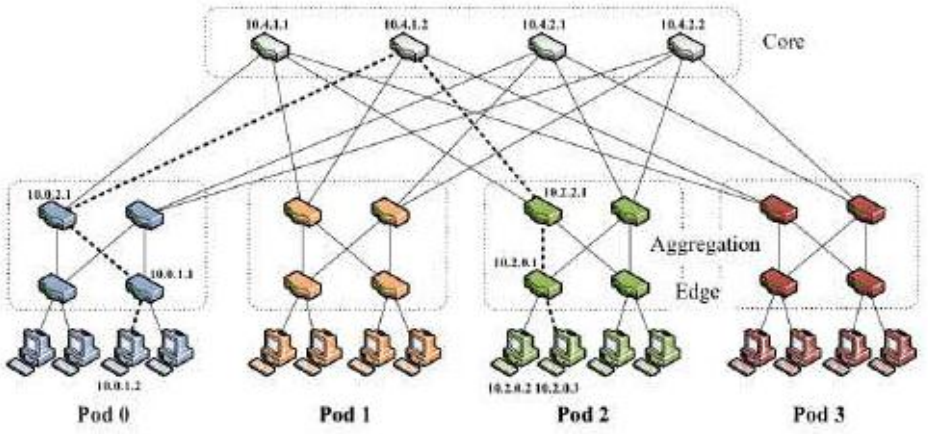
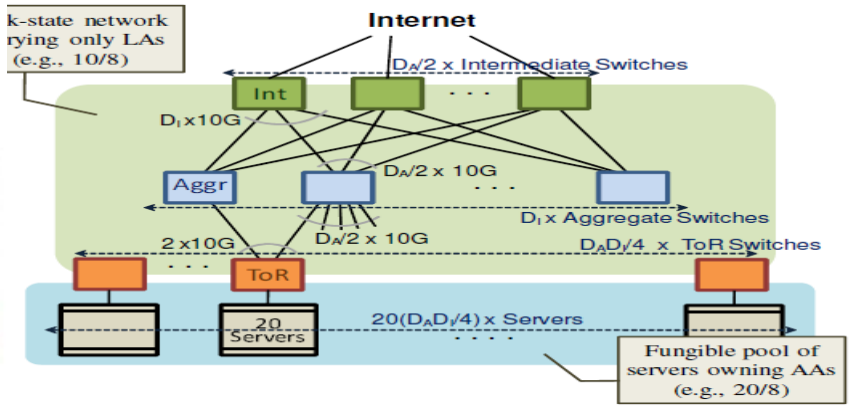
# Background

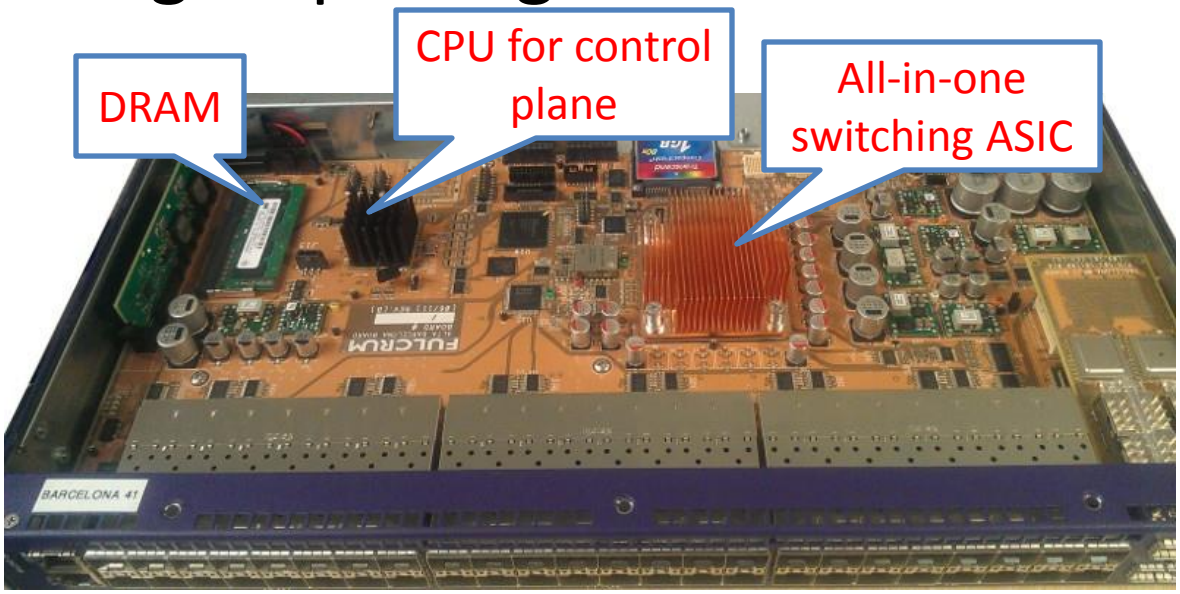
- Commodity switches are the basic building blocks in enterprise and data center networks
  - PortLand and VL2 build entire DCN with 1U commodity switches



# Background (cont')

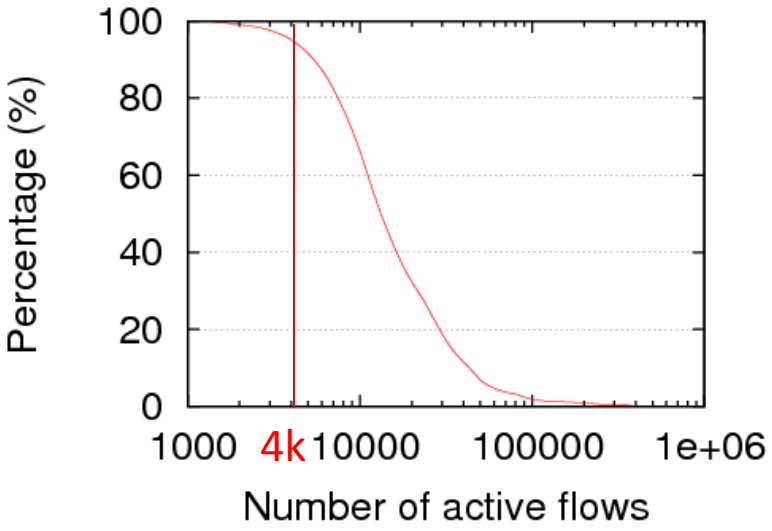
- Commodity switches now widely adopt single switching chip design




- Greatly simplifies switch design and lowers down the cost

# Limitation (I)

- Limited forwarding table size for flow-based forwarding schemes, e.g. Openflow
  - Openflow provides finest granularity for better security (Ethane), traffic load balancing (Hedera), Energy saving (ElasticTree)
  - 4k flow entries for most recent BRCM switching chip

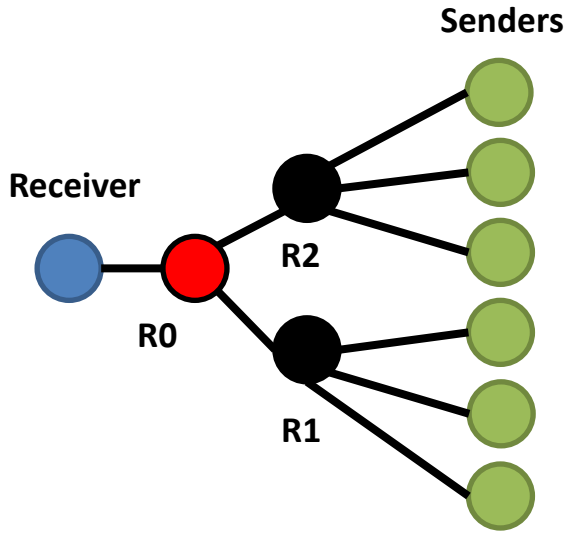


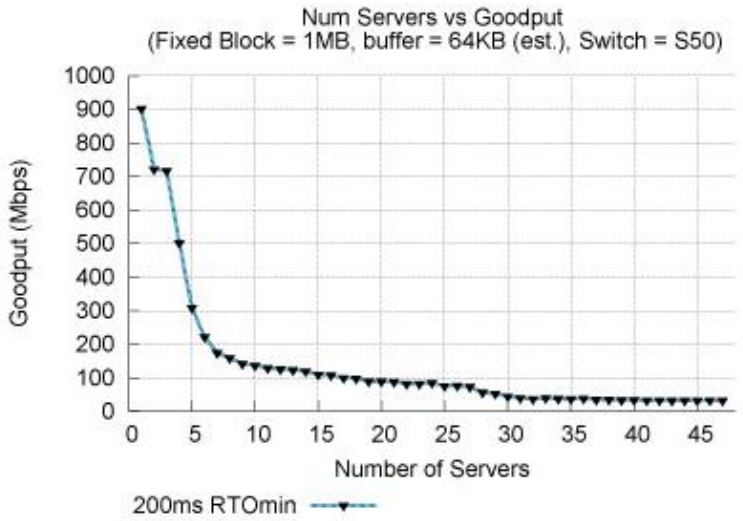

Data center for map-reduce style applications with 120 ToR and ~5k servers

# of active flows ≥ 4096 for 95%+ time

# Limitation (II)

- Shallow packet buffer for bursty traffic
  - Switching ASIC has only several MB buffer
  - Bursty traffic pattern, e.g. TCP incast, TCP flash crowds
  - Packet drops lead to degraded network performance

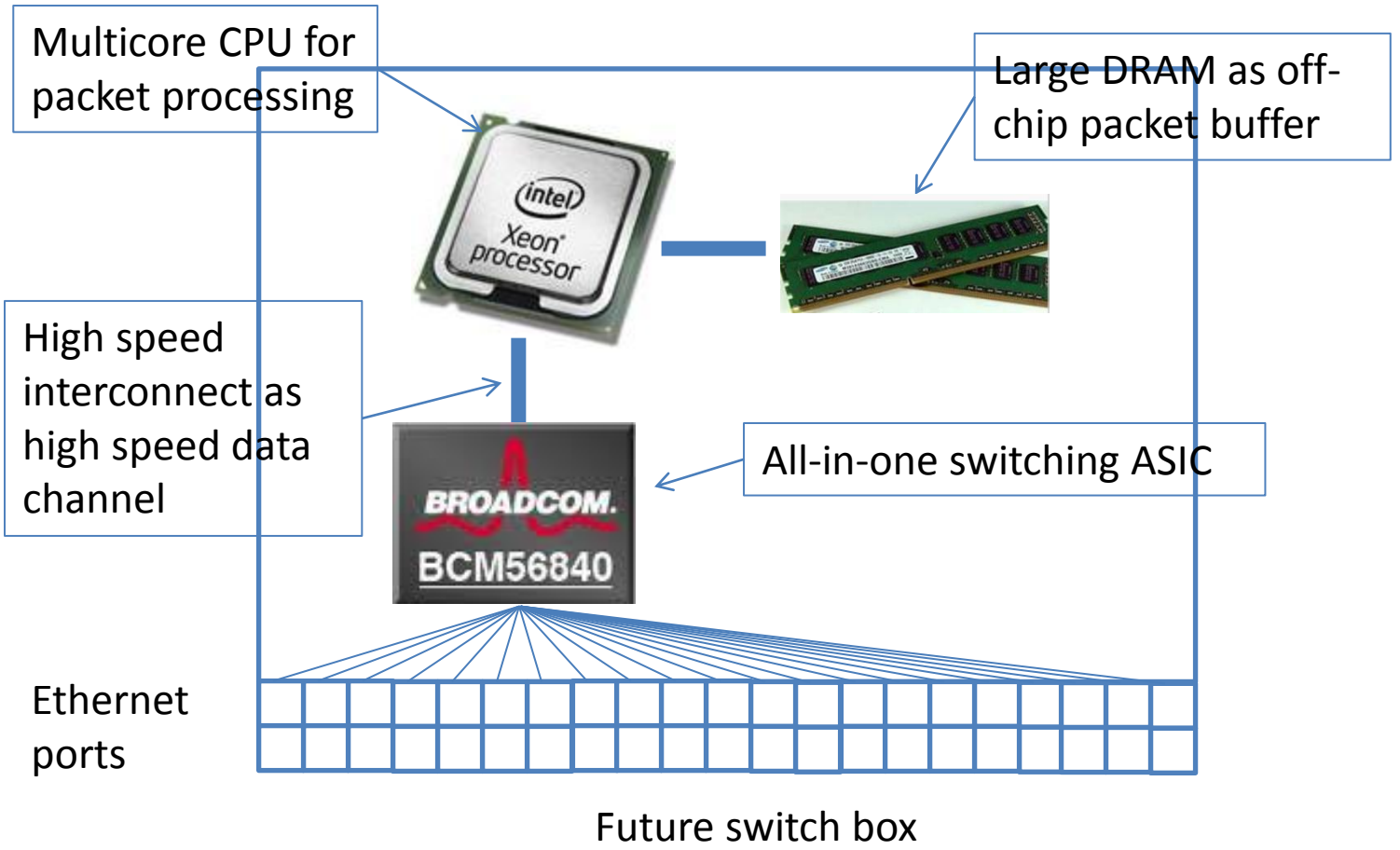


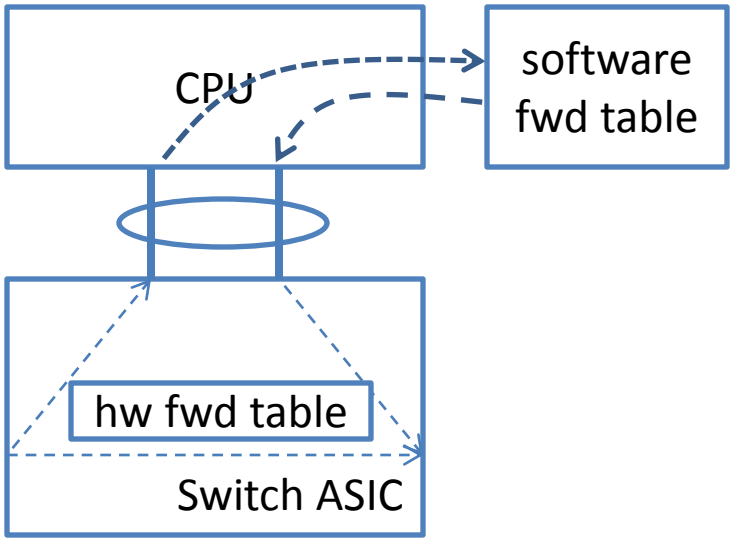
# Design Goals

- Large forwarding table
  - Support large forwarding table for forwarding schemes such as OpenFlow
- Deep packet buffer
  - Absorb temporary traffic bursts, e.g., TCP incast, TCP flash crowds

# Assumptions for Commodity Switches

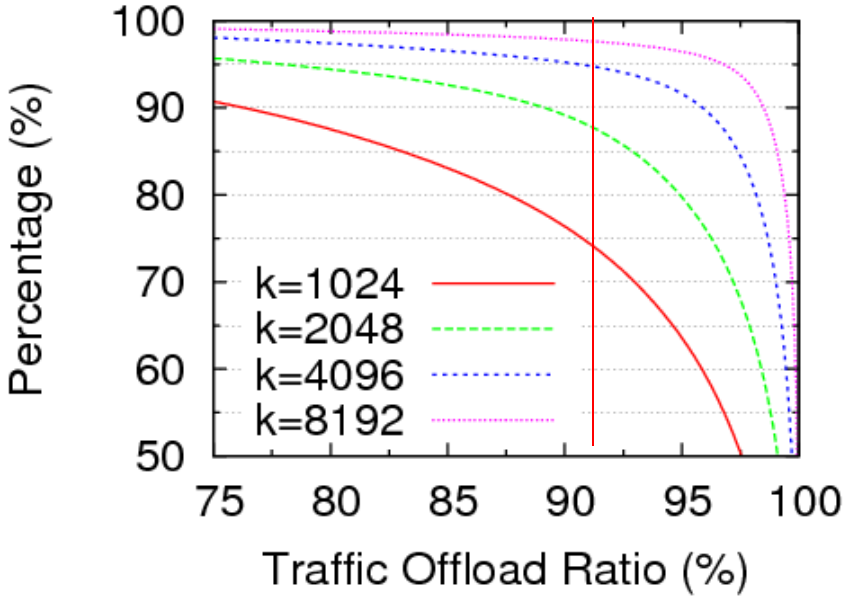


# Large forwarding table




- Complete forwarding table in software
- Partial forwarding table in hardware

# TraFfic Offloading Ratio (TFOR)

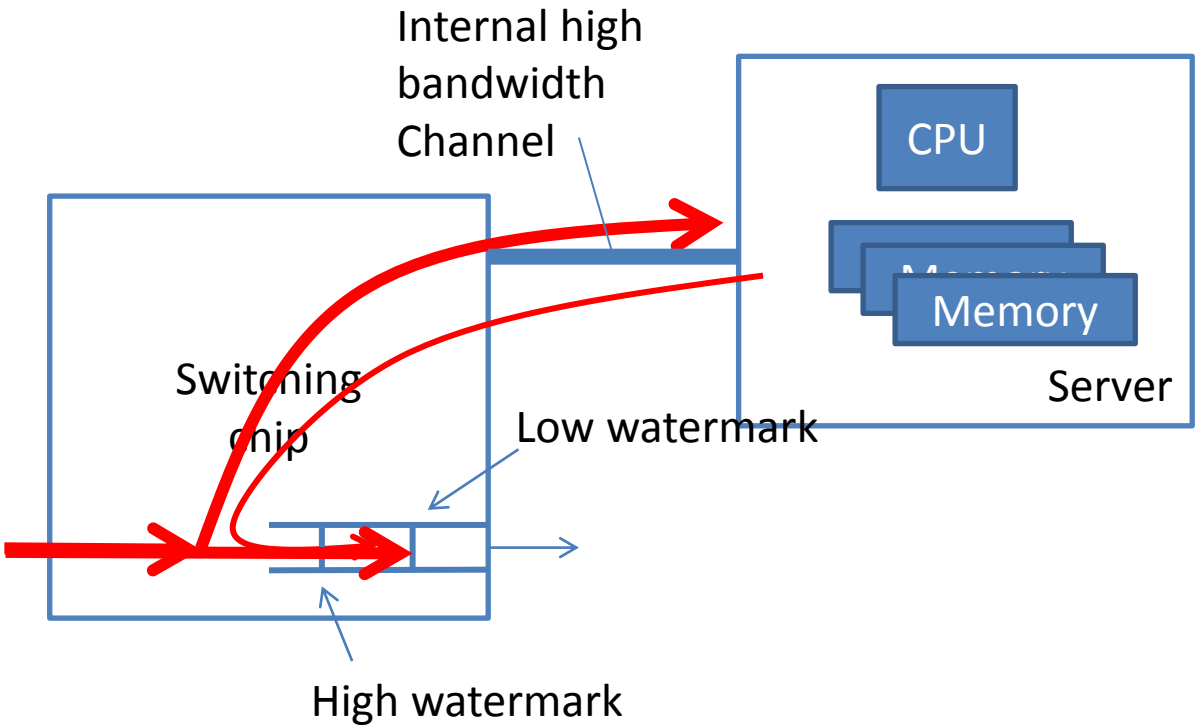



- TFOR: Traffic forwarded by HW v.s. all traffic
- Obtain TFOR: For every minute, get flow rates, sort the flows based on the rates, put *k* fastest flows in HW.
- TFOR ≥ 92% for 95%+ time when *k* = 4096

# Flow Management

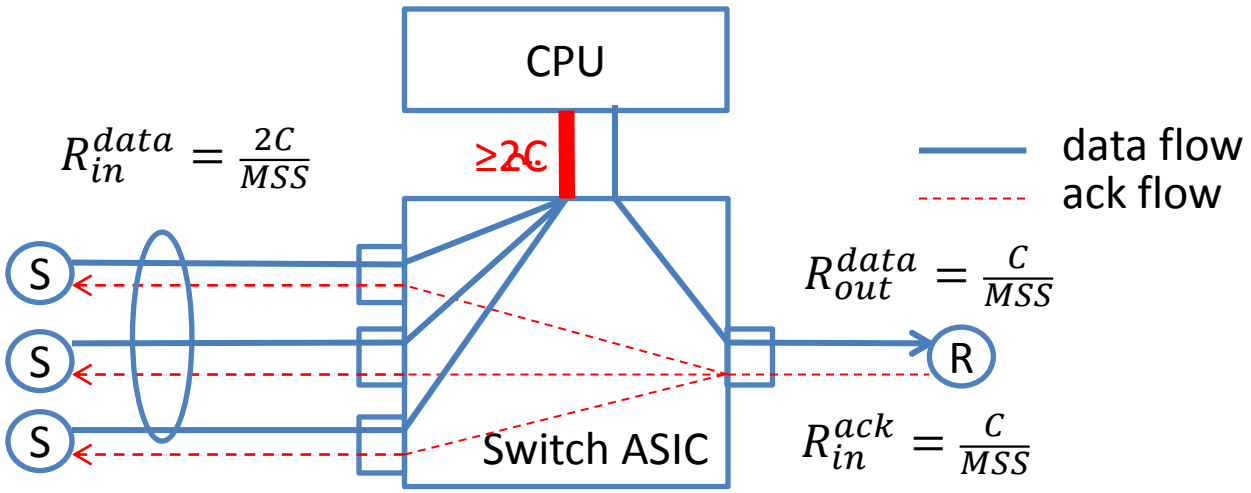
- *k* fastest flows are forwarded by hardware, rest are forwarded by software
- Assume one byte counter per flow in hardware
- Procedures
  - Count software-forwarded flow bytes, periodically read the counters from hardware
  - Rank flows based on their rates and determine *k* fastest flows
  - Offload fast flows to hardware and onload slow flows to software

# Deep Packet Buffer



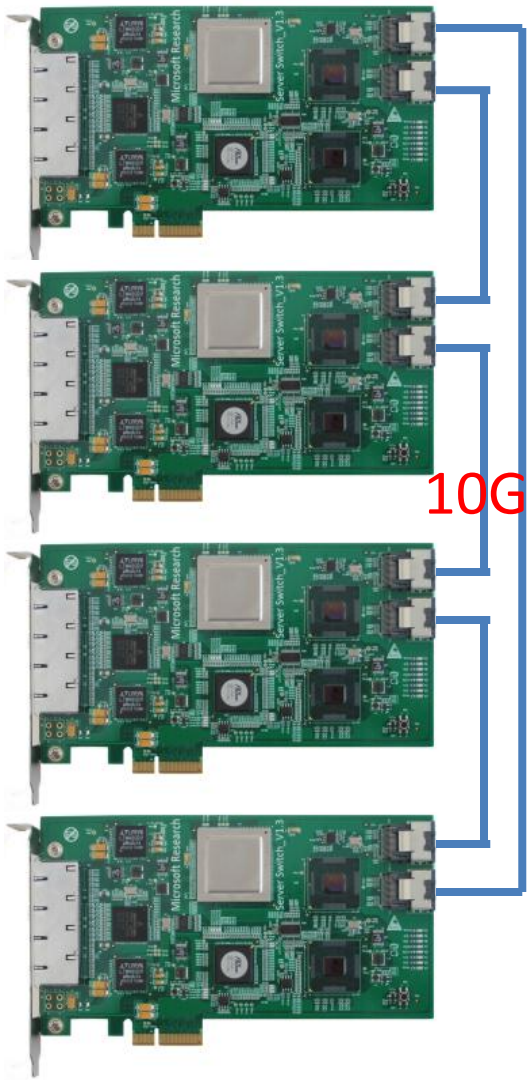

- Phase 1: Traffic redirection
- Phase 2: Cancel redirection

# Internal bandwidth Needed



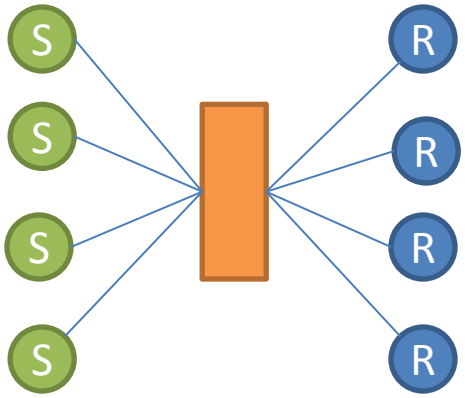

- Receiver: delayed ack disabled
- Senders: TCP slow start
- No packet drops when internal bandwidth is larger than 2C.

# Prototype




- A 16xGE port switch using 4 ServerSwitch cards
- HP z800 workstation
  - 8 CPU cores
  - 48GB DRAM
- Kernel code for packet forwarding
- User space code for switch ASIC management

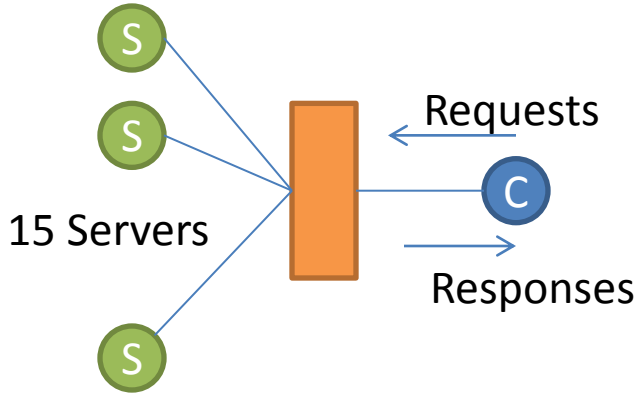
# Large Forwarding Table



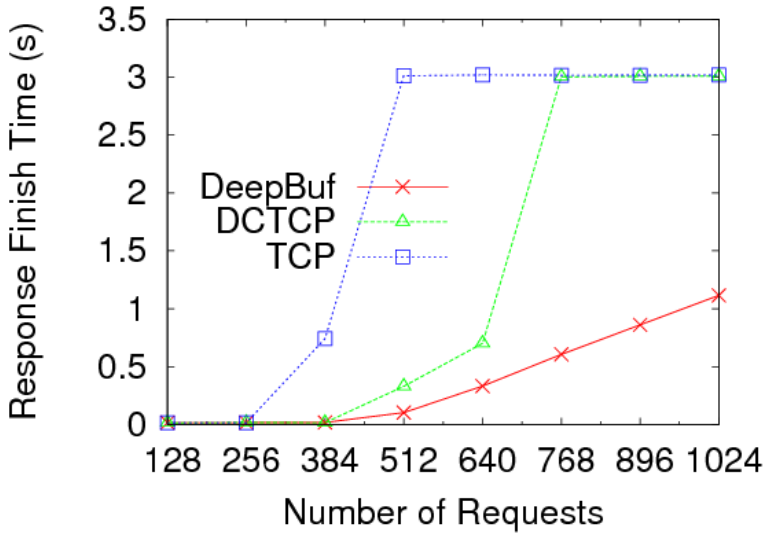

- 10 min synthesized traffic using flow size distribution from DCN measurements
- 1,792 HW flow entries

| Interval ratio | Total bytes (GB) | # of active flows | TFOR |
|---|---|---|---|
| 1x | 33.6 | 10,644 | 96.1% |
| 1/10x | 336 | 106,544 | 90.5% |

# Deep Packet Buffer




TCP Flash Crowds last for 1 second




| 1024 Requests | SYN/ACK timeout | Data timeout | Fast Recovery | Packet drops |
|---|---|---|---|---|
| TCP | 109 | 180 | 690 | 15962 |
| DCTCP | 23 | 395 | 173 | 3302 |
| DeepBuf | 0 | 0 | 0 | 0 |

# Conclusions

- Two major limitations of current commodity switches
  - Limited forwarding table for Openflow
  - Shallow packet buffer for bursty traffic pattern
- Use CPU as traffic co-processor to address these two limitations

# QUESTIONS?