Application-aware Data Plane Processing in SDN

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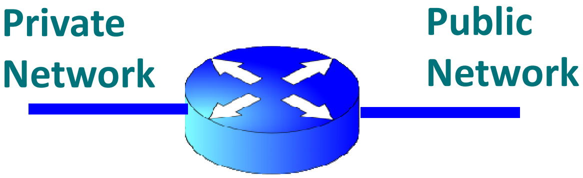
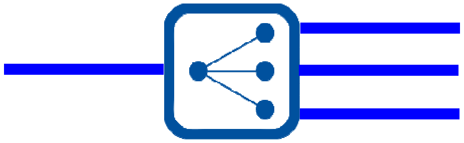
Motivating Examples

NAT



- IP & port rewrite
- Keep track of available public IP & port

Content based server selection



- Assign server IP based on URL
- Maintain flow state to support TCP splicing

Can we extend the SDN data path to directly support such network services ?

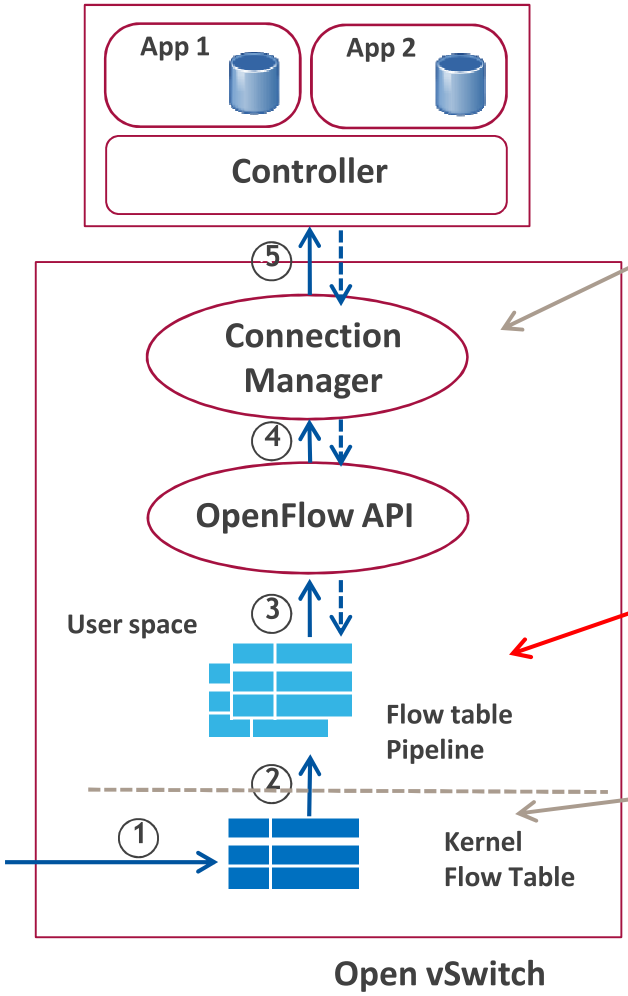
Application-aware data plane processing in SDN

Alternatives:

- Using middleboxes
  - More equipments to maintain
  - Extra hops (detour) in data path
  - Complexity of service chaining
- Using SDN controller to implement application processing logic
  - Switch-Controller delay cause slowdown in data path
  - Control plane not designed to handle every packet -> throughput bottleneck

Application-aware data plane processing:
One system for both routing and network services with **uniform central control** and **scale-out data plane**

Open vSwitch



Design Choice: Where to intercept the packet and implement application processing logic ?

Option 1: connection manager

- Pros: modular design
- Cons: redundant coding, slow
  - Unnecessary encap/decap
  - Redundant flow table

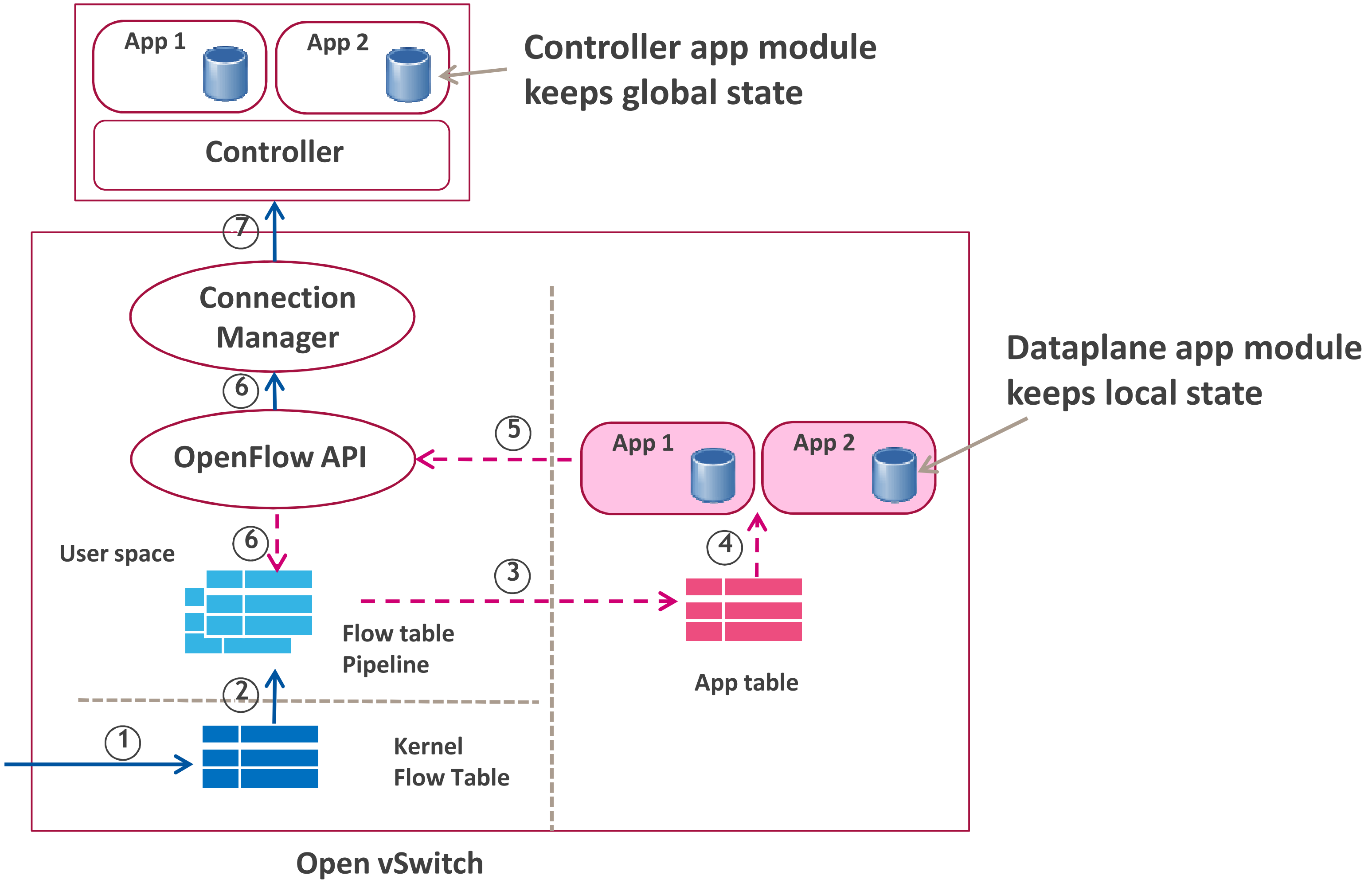
Option 3: user space flow table

- Good tradeoff between 1 & 2: easy implementation & reasonable performance

Option 2: kernel flow table

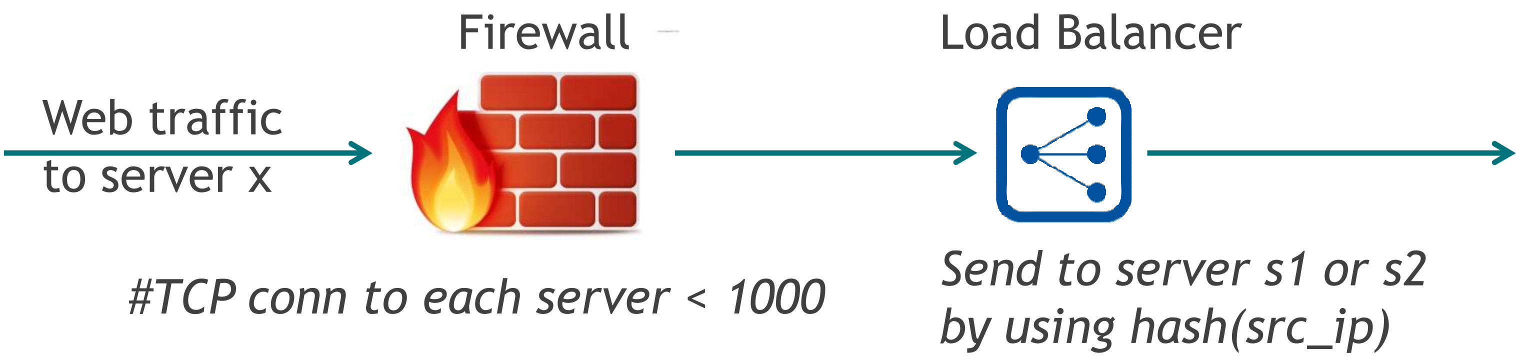
- Pros: best performance
- Cons: hard to implement

Application-aware Data Plane for Open vSwitch



Example: Firewall & Load Balancer

Required Policy:



Firewall

Load Balancer

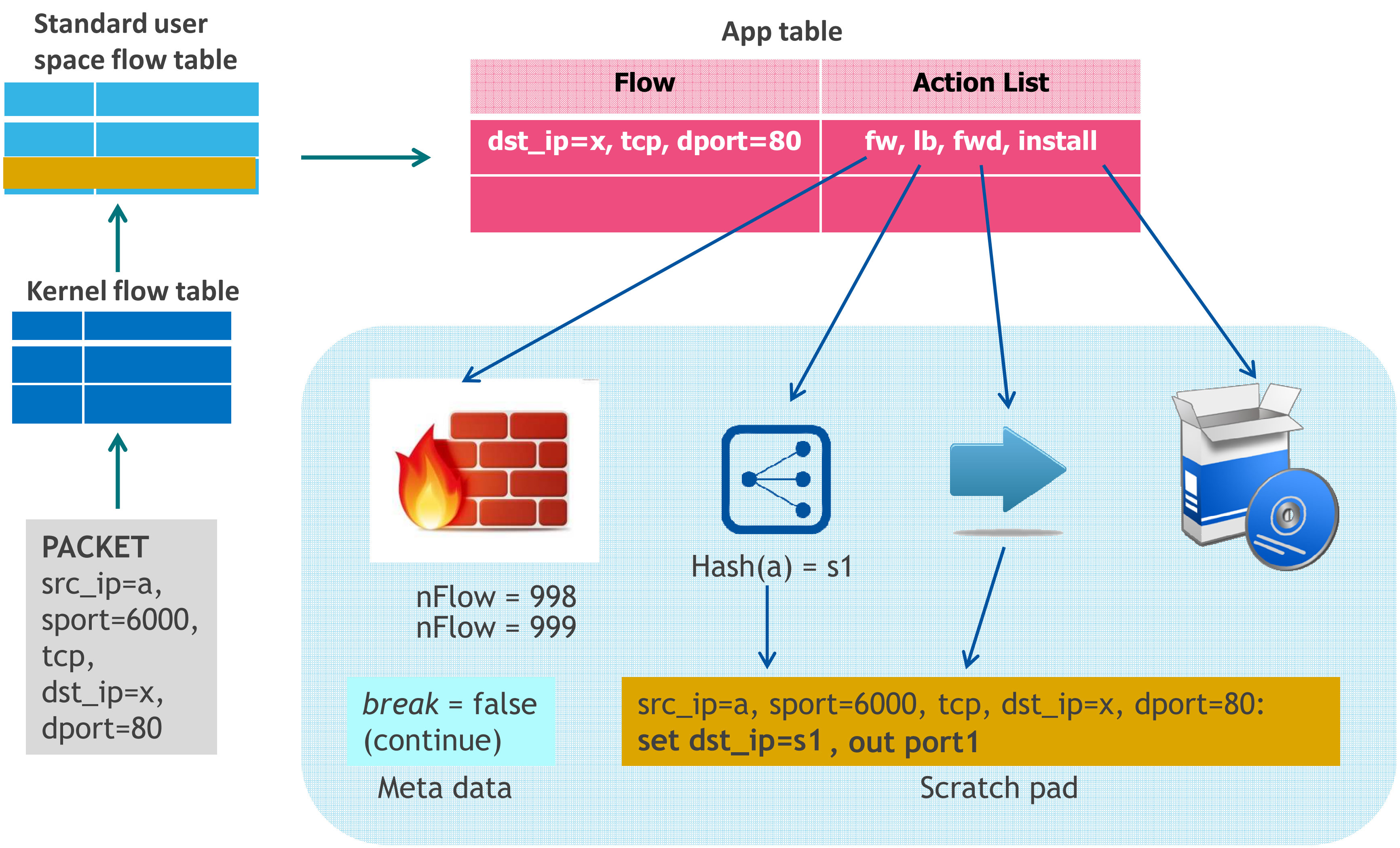
Web traffic to server x

#TCP conn to each server < 1000

Send to server s1 or s2 by using hash(src_ip)

App table rule: dst_ip=x, tcp, dport=80: fw, lb, fwd, install

Firewall & Load Balancer: Implementation



Standard user space flow table

Kernel flow table

PACKET
src_ip=a,
sport=6000,
tcp,
dst_ip=x,
dport=80

App table

Flow	Action List
dst_ip=x, tcp, dport=80	fw, lb, fwd, install

nFlow = 998
nFlow = 999

Hash(a) = s1

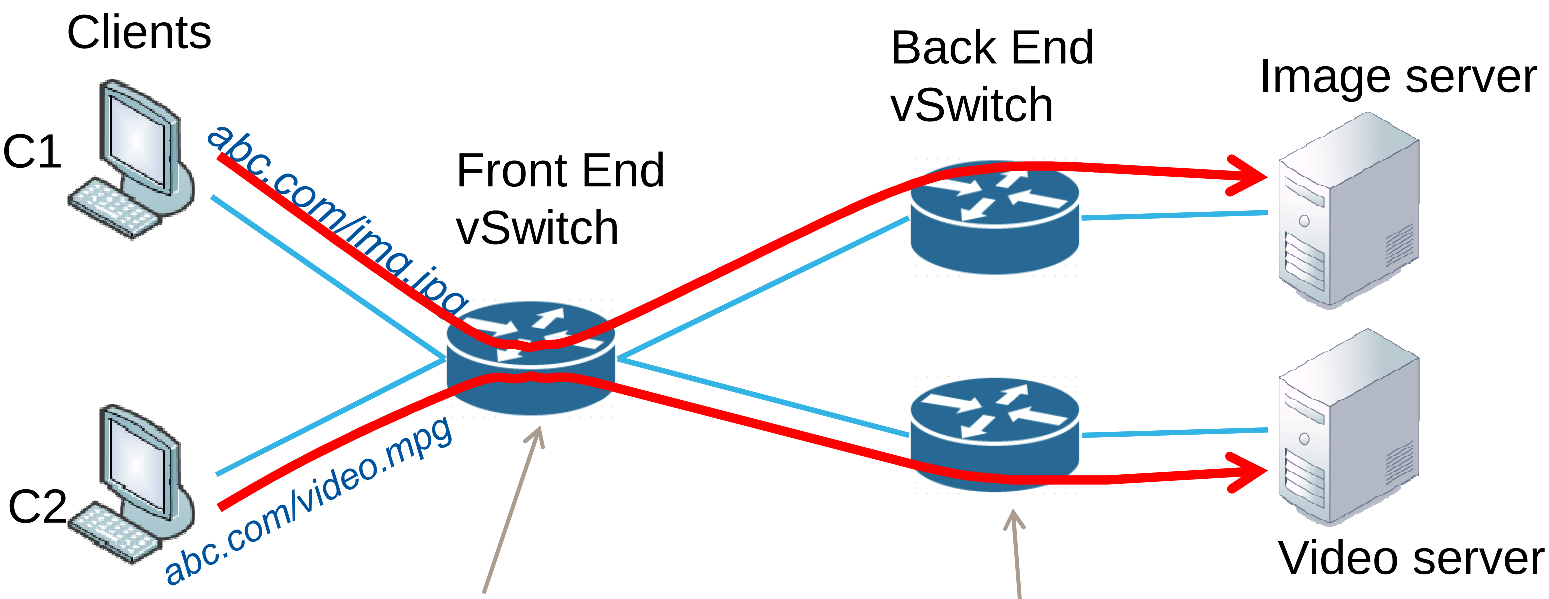
break = false
(continue)

Meta data

src_ip=a, sport=6000, tcp, dst_ip=x, dport=80:
set dst_ip=s1 , out port1

Scratch pad

Example 2: Content Aware Server Selection

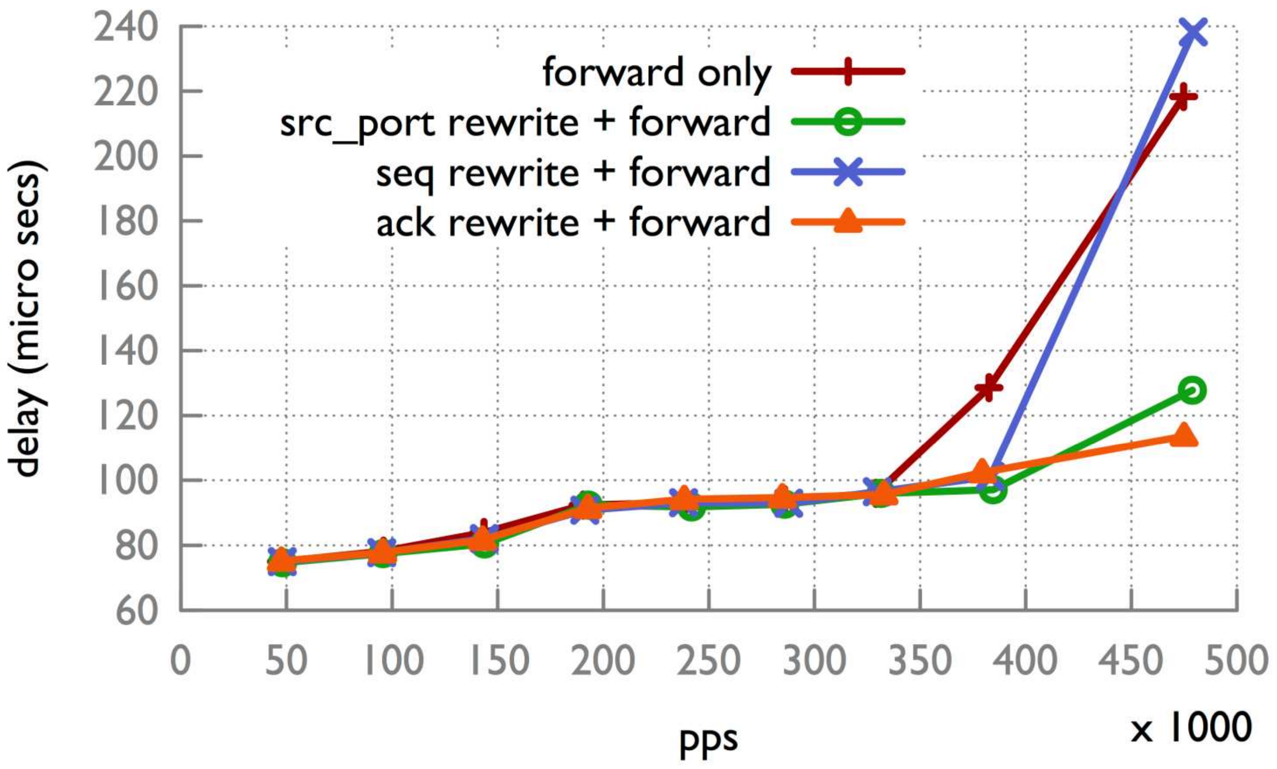


- 3-way TCP handshake with client
- Set server IP (DNAT)

- TCP handshake with server
- SNAT and TCP splicing for return traffic

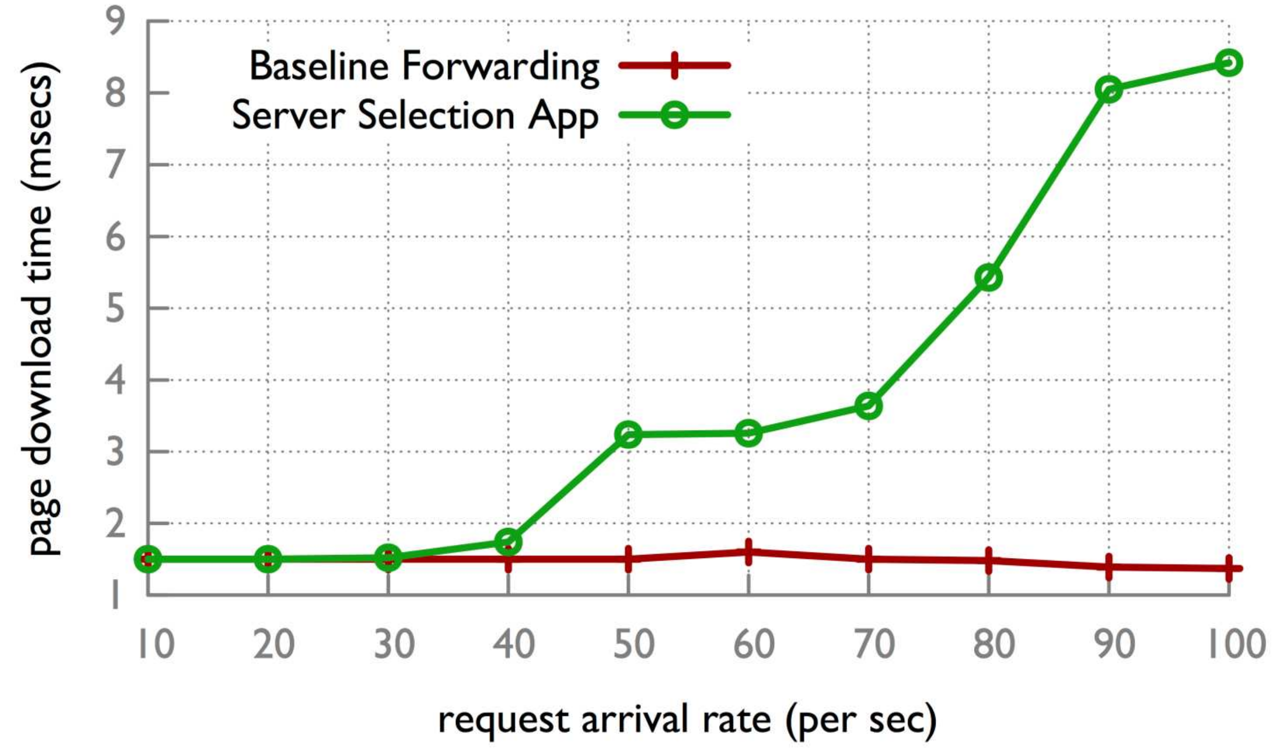
- Return traffic does not have to go through front-end vSwitch
- Both front-end & back-end vSwitches can be scaled out independently

Experimentation: TCP splicing



- TCP sequence number rewriting implemented in kernel space
- Very good performance: same as native OVS kernel actions

Experimentation: Server Selection



- Server selection action implemented in user space
- Performance can be significantly improved by using the new multi-threaded OVS daemon implementation (on-going work)

Conclusions and Future Work

- A first step towards enabling application-aware SDN data plane
- Overall, extending software switches like Open vSwitch to support network service applications is a promising direction
- Kernel to user space copying is still a performance barrier
  - Careful design choices to trade-off between ease of implementation and performance
  - Current design doesn't suite applications that require processing *every packet*
- Future work
  - Take advantage of muti-threaded OVS daemon in recent versions
  - Make the apps "pluggable"
  - DPDK

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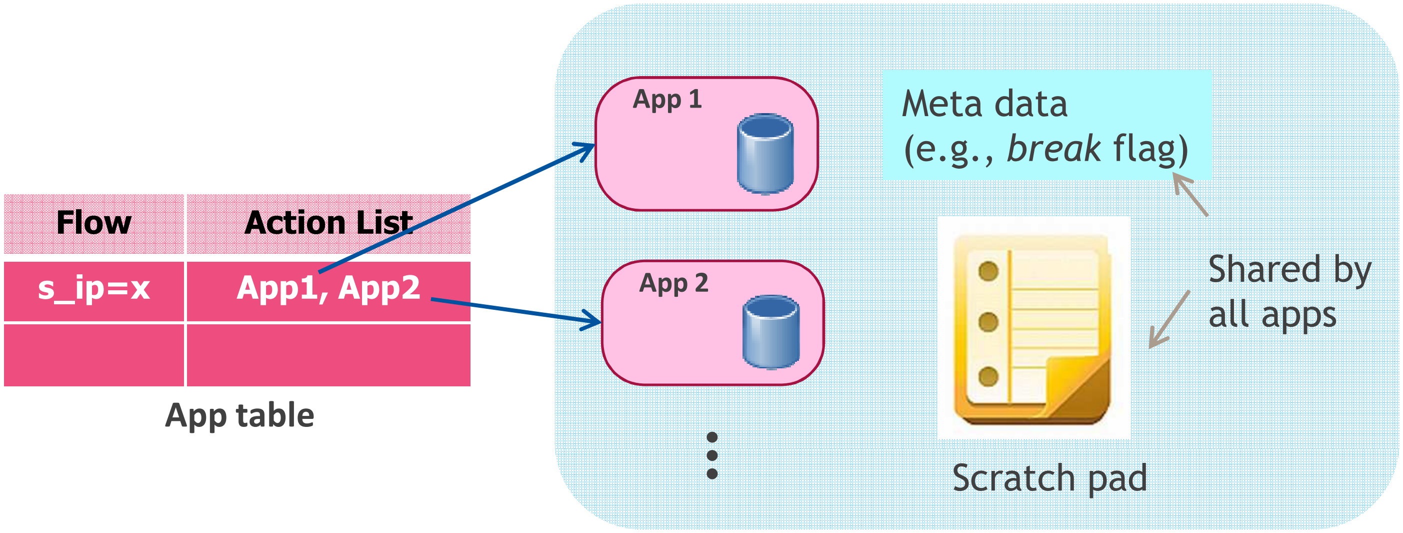
Design Details: App Table, App Actions, App Chaining



Flow	Action List
s_ip=x	App1, App2

App table

- App actions implemented as *vendor actions*, only run in user space
  - Determine actions for current packet
  - Modify local app state
  - Generate/modify rule set to be installed in standard flow table
  - Remove flows from standard flow table
  - Generate packet out
  - Send Packet_In, Flow_Removed, or app update vendor msg to controller

  … by calling Openflow API module