Software Defined Networks

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Agenda

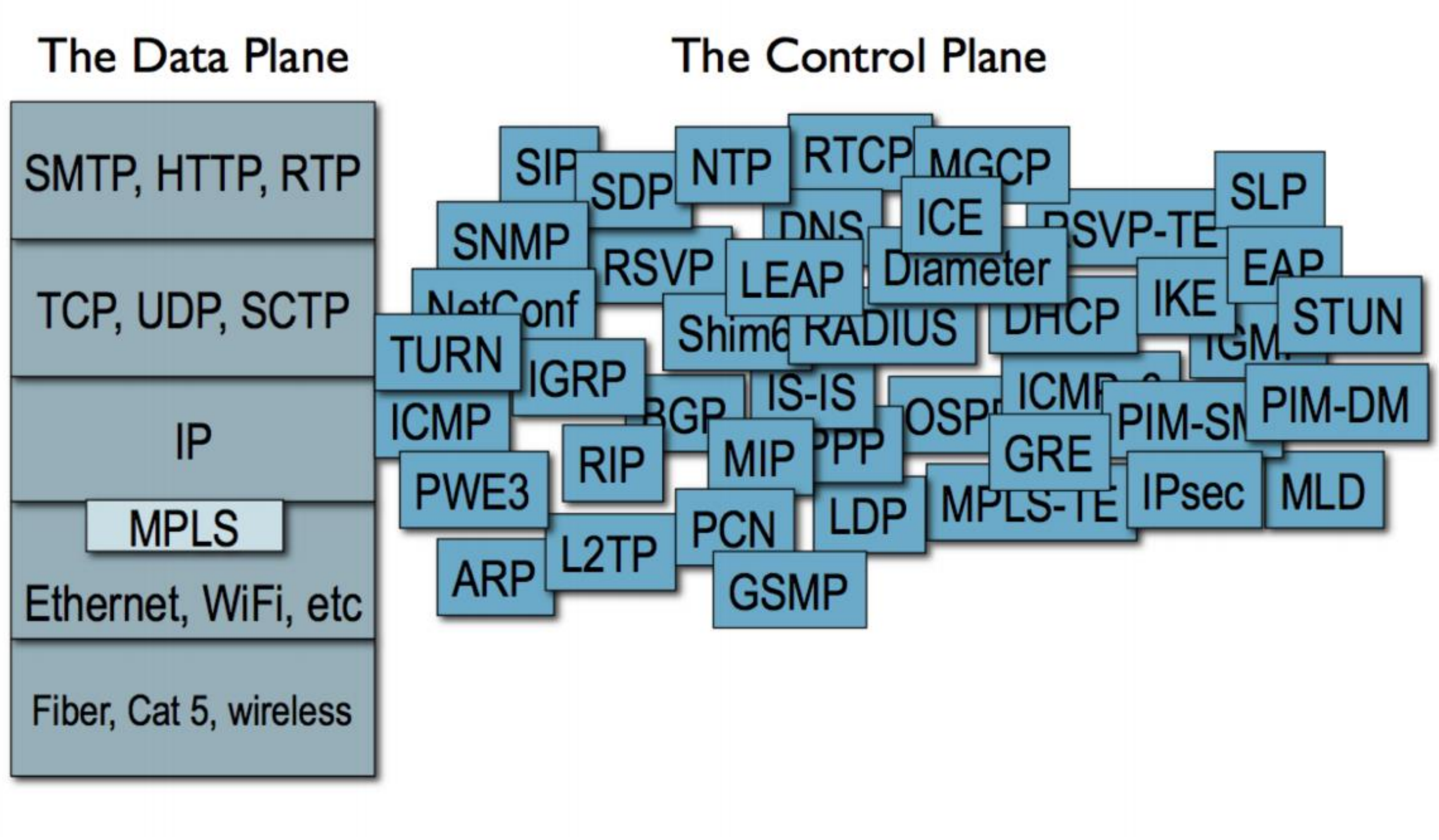
- » Brief history
- » SDN
- » OpenFlow
- » P4

Brief history

- Internet is a great success
  - Provides applications and services
  - Reliable (or unreliable) transport
  - Global best effort network
  - Local best effort networks
  - Physical transfer of bits
- Change and innovation only at the edge

Brief history

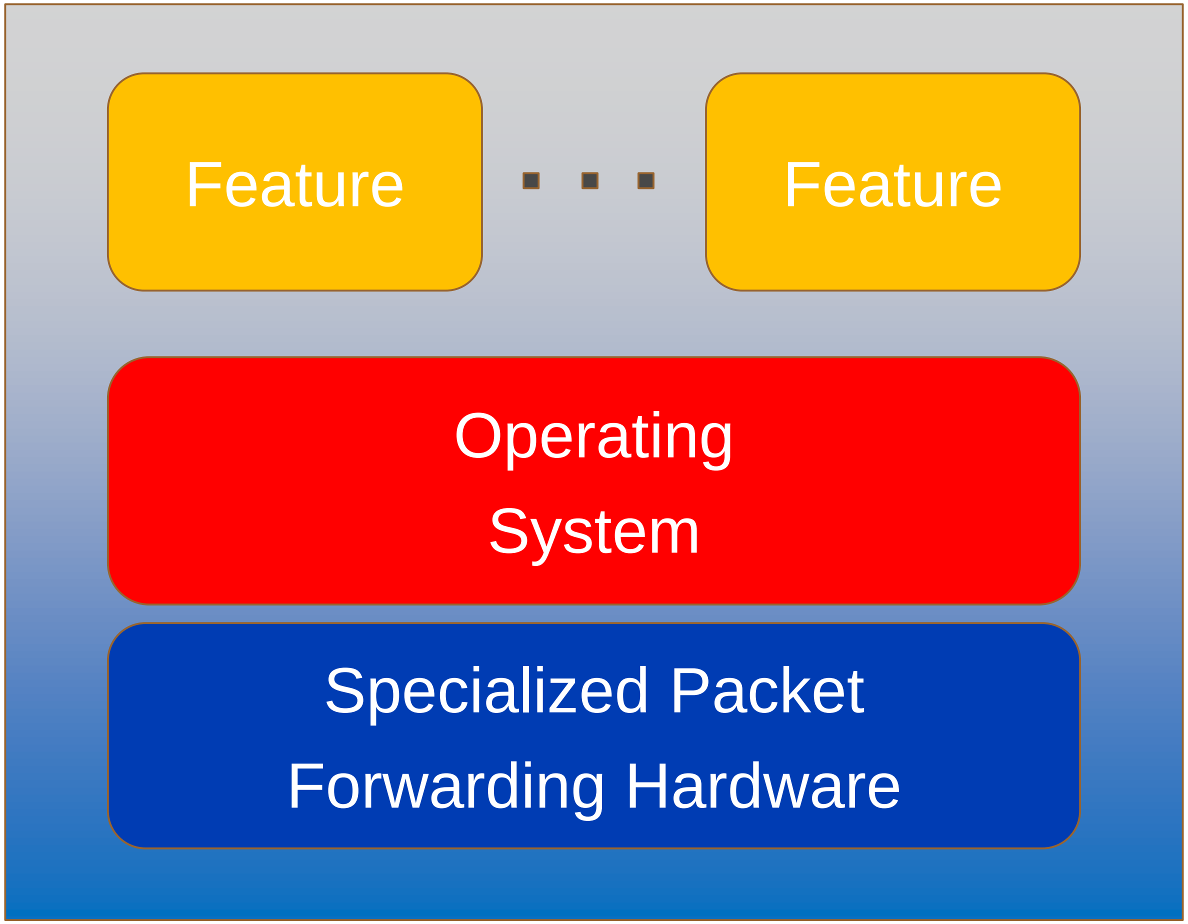
- Other IT fields (OS, DB, etc.):
  - Teach basic principles
  - Are easily managed
  - Continue to evolve
- Traditional networking:
  - Teach a lot of protocols
  - Difficult to manage
  - Evolves relatively slowly



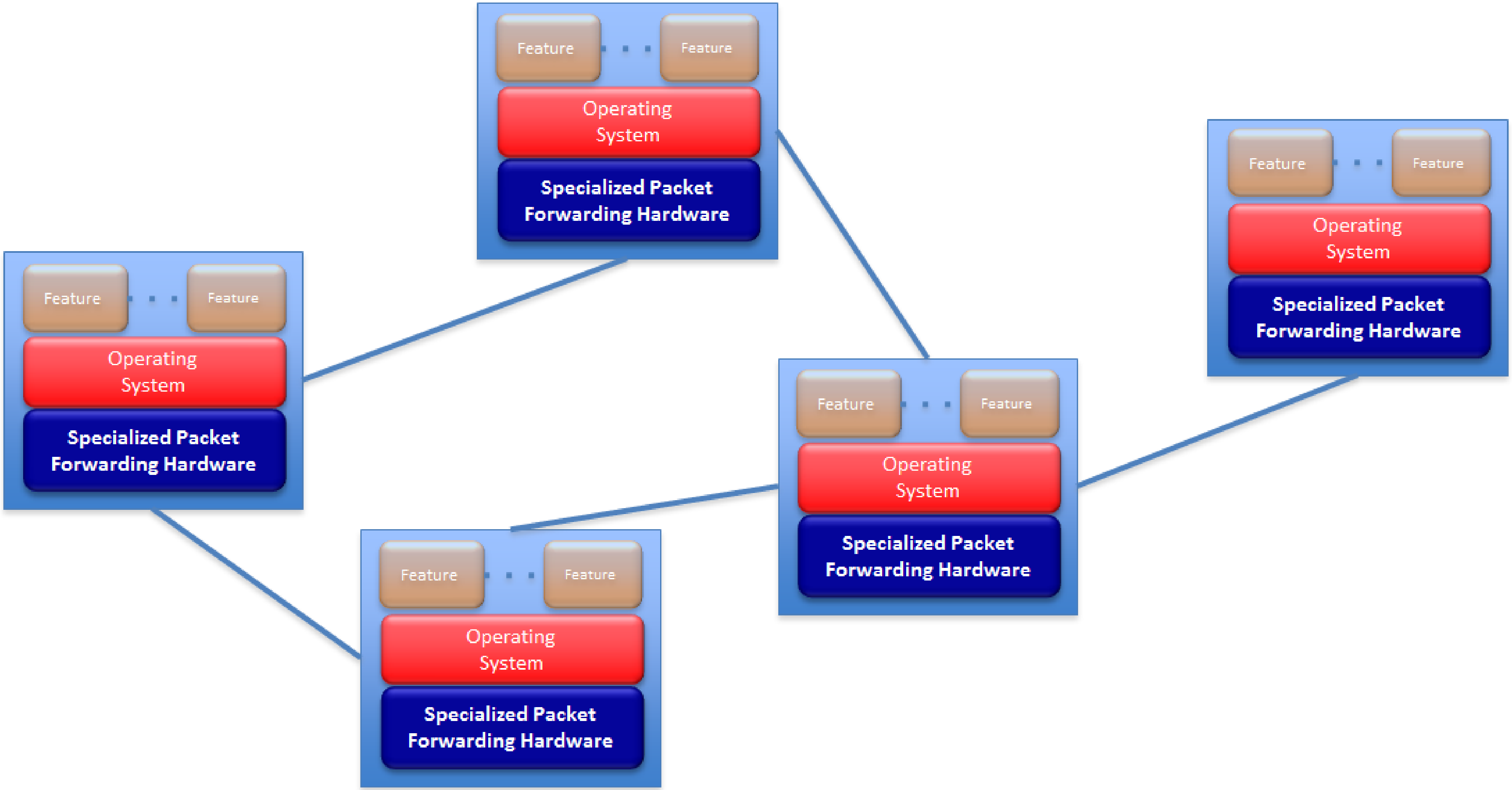
- Mark Handley. Re-thinking the control architecture of the internet.
- Keynote talk. REARCH. December 2009.

```
•interface Ethernet0/0.17
•encapsulation dot1Q 17
•ip address 125.1.17.7 255.255.255.0
•ip pim bsr-border
•ip pim sparse-mode
•!
•router ospf 1
•router-id 120.1.7.7
•redistribute bgp 700 subnets
•!
•router bgp 700
•neighbor 125.1.17.1 remote-as 100
•!
•address-family ipv4
•redistribute ospf 1 match internal external 1 external 2
•neighbor 125.1.17.1 activate
•!
•address-family ipv4 multicast
•network 125.1.79.0 mask 255.255.255.0
•redistribute ospf 1 match internal external 1 external 2
```

Traditional networking



Traditional networking


Feature
Feature
Operating System
Specialized Packet Forwarding Hardware
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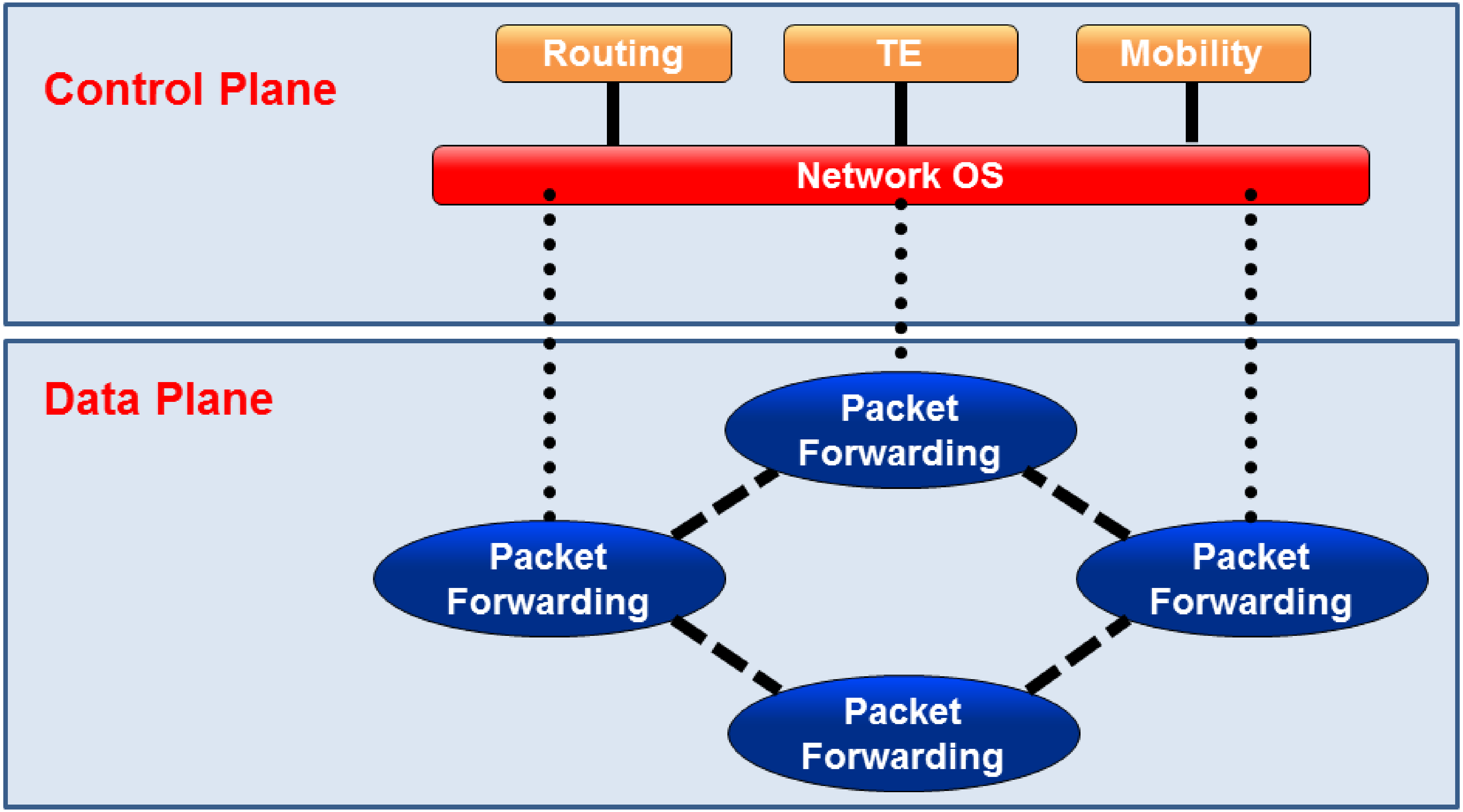
SDN

- SDN defining features:
  - Separate control plane from data plane
  - (Logically) Centralized control of data plane devices

SDN


Control Plane
Routing
TE
Mobility
Network OS
Data Plane
Packet Forwarding
Packet Forwarding
Packet Forwarding
Packet Forwarding

SDN

- Separate control plane
  - Abstract view of network
  - Simplify interface for controlling program
  - Make networking innovation easier

Data (forwarding) plane

- Packet processing and forwarding
- Fast and “simple” hardware implementation
- Software implementation for VMs directly in server
- Standard interface (API) to data plane
- Simple set of operations over packet

Control plane

- High level processing and routing decisions
- VERY complex
- Slow(er) and “intelligent” software implementation
- Provide unified network abstraction for applications
- Simplified network management
- Greater network flexibility

Management plane

- Configuration and management
- Network tuning

- Traffic engineering, device provisioning, …

OpenFlow

- Standardized and maintained by Open Networking Foundation
- Developed for experiments and prototyping on production network - slicing
- Current OF switch specification v1.5.1 (important v1.0 and v1.3)

OpenFlow

- Enables the network to react to topology, application or user changes in real-time
- Early commercial adoption in data centres
- (Sometimes) Misunderstood to be the only SDN solution

OpenFlow

- » OpenFlow Channel
- » Message types

- » Matches
- » Actions

OpenFlow

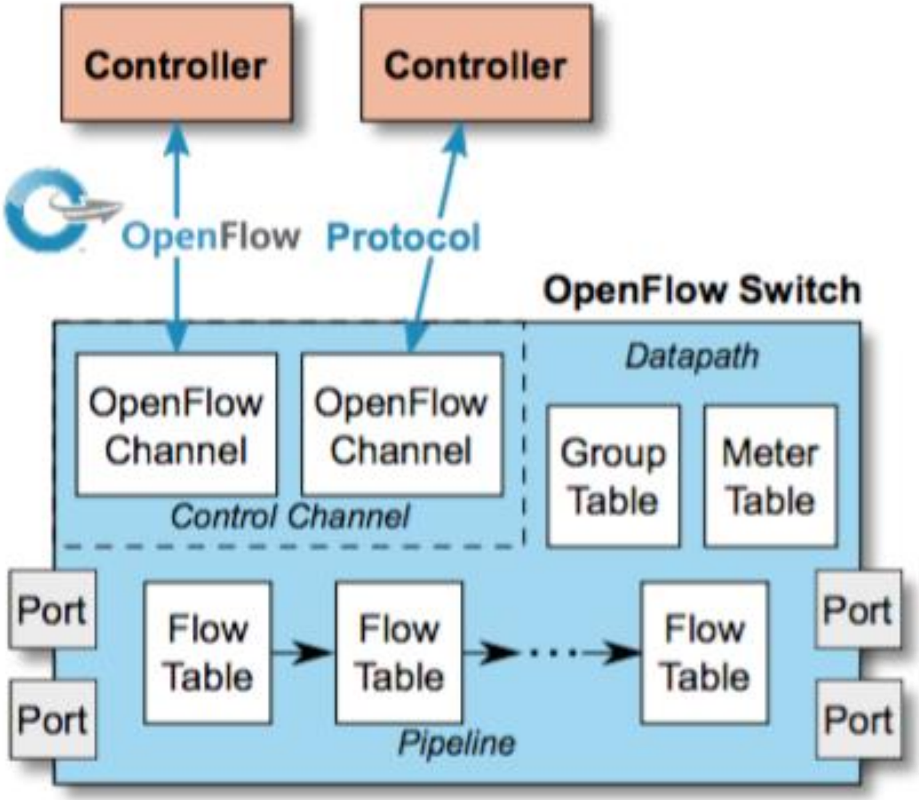


Figure 1: Main components of an OpenFlow switch.

OpenFlow

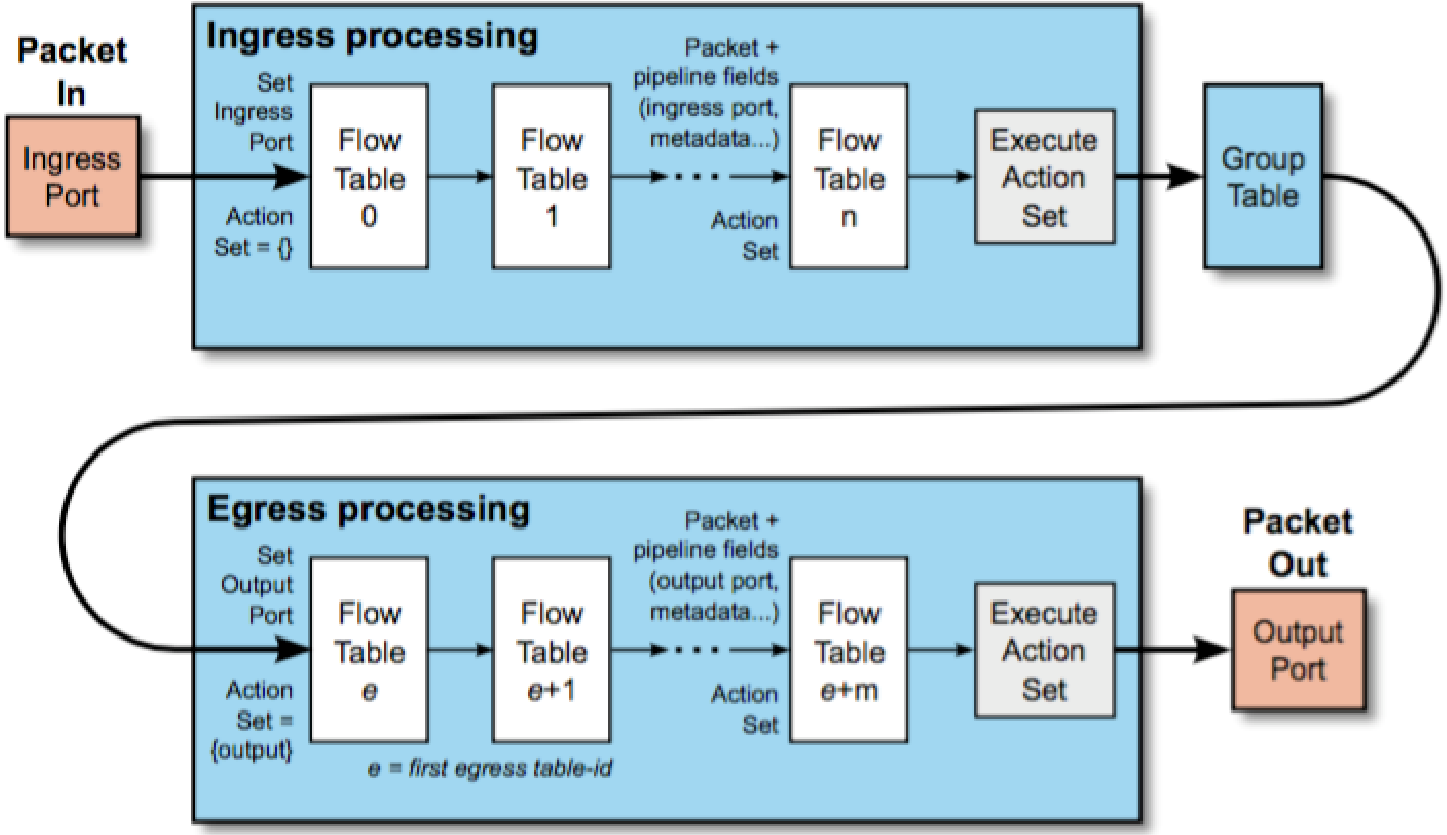


Figure 2: Packet flow through the processing pipeline.

OpenFlow

```
sh ovs-ofctl dump-flows s1
 cookie=0x8e67bd412a95a3fb, duration=5662.610s, table=0,
n_packets=61, n_bytes=20971, idle_age=5083,
priority=4,in_port=2,dl_vlan=1 actions=strip_vlan,NORMAL

 cookie=0x8e67bd412a95a3fb, duration=5679.407s, table=0, n_packets=3,
n_bytes=258, idle_age=5662, priority=2,in_port=2 actions=drop

 cookie=0x8e67bd412a95a3fb, duration=5679.641s, table=0,
n_packets=7779256, n_bytes=30272629666, idle_age=1, priority=0
actions=flood
```

OpenFlow match

```
sh ovs-ofctl dump-flows s1
```

```
 cookie=0x8e67bd412a95a3fb, duration=5662.610s, table=0,
n_packets=61, n_bytes=20971, idle_age=5083,
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OpenFlow action

```
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actions=flood
```

OpenFlow

- Disadvantages
  - Protocol is too complex
  - Getting more complex
  - Incomplete implementations

P4

- P4: programming protocol-independent packet processors
- https://dl.acm.org/citation.cfm?id=2656890

P4

- Goals:
  - Reconfigurability
  - Protocol independence
  - Target independence

P4

- P4 program configures forwarding behavior
- Express serial dependencies
- P4 compiler translates into a target-specific representation
- OF can still be used to install and query rules once forwarding model is defined

P4

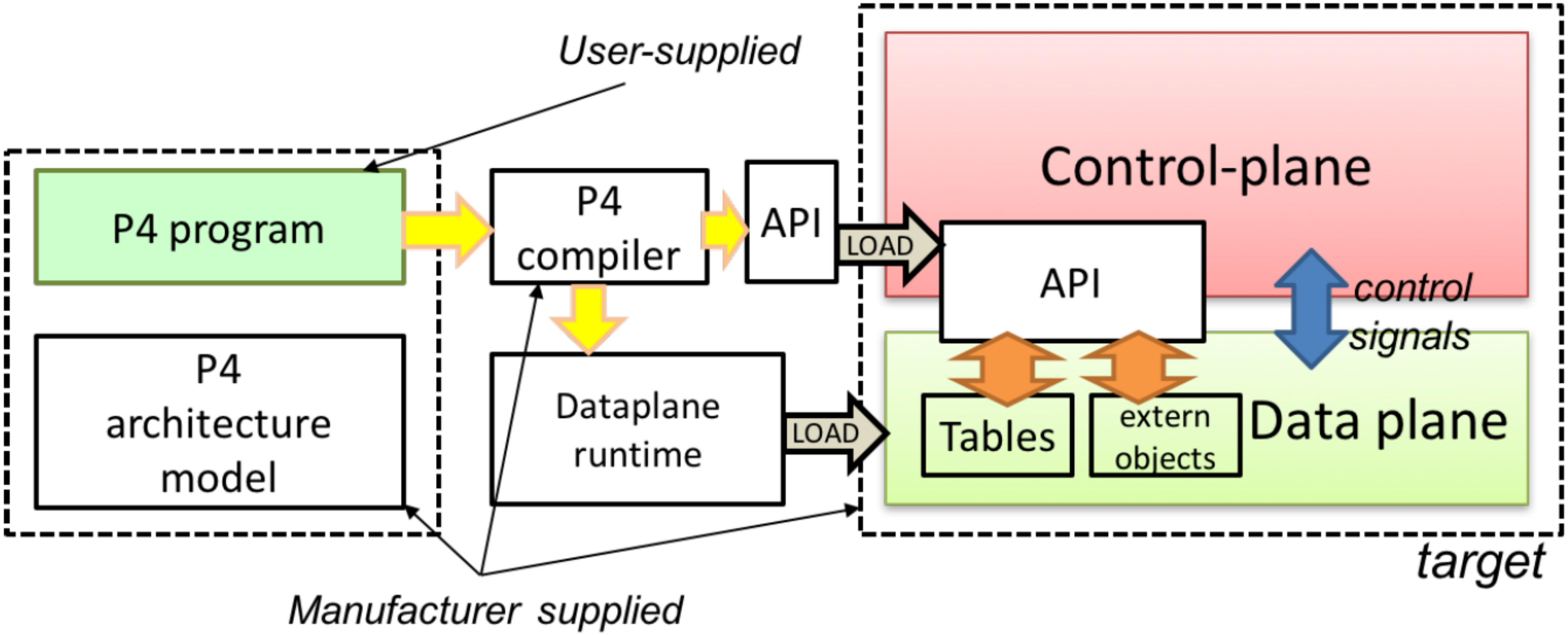

Figure 2. Programming a target with P4.

P4

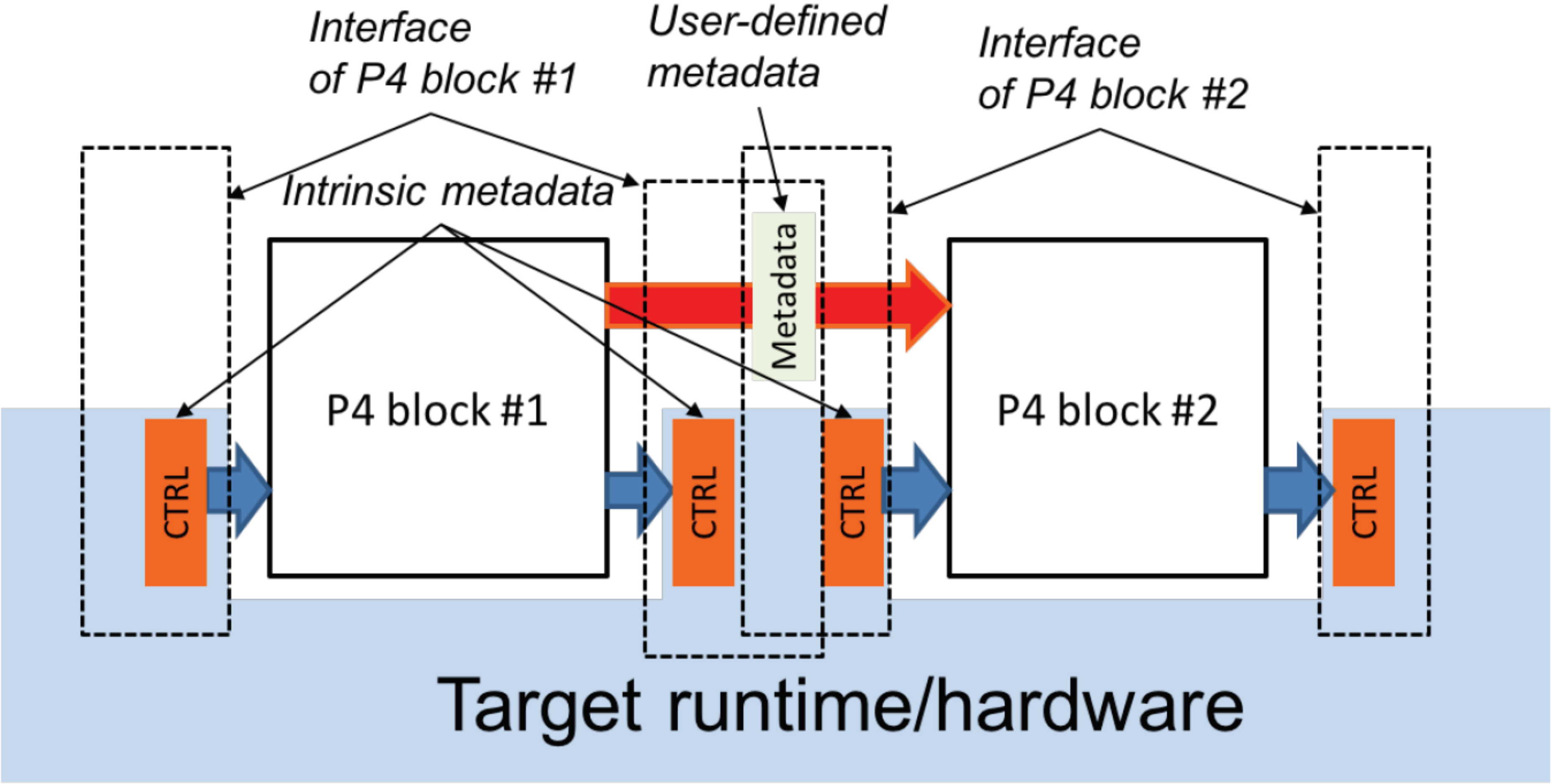

Figure 4. P4 program interfaces.

https://www.opennetworking.org/

https://p4.org/

Nick McKeown, Jennifer Rexford Changhoon Kim and Laurent Vanbever lectures