OpenFlow - the key standard of Software-Defined Networks

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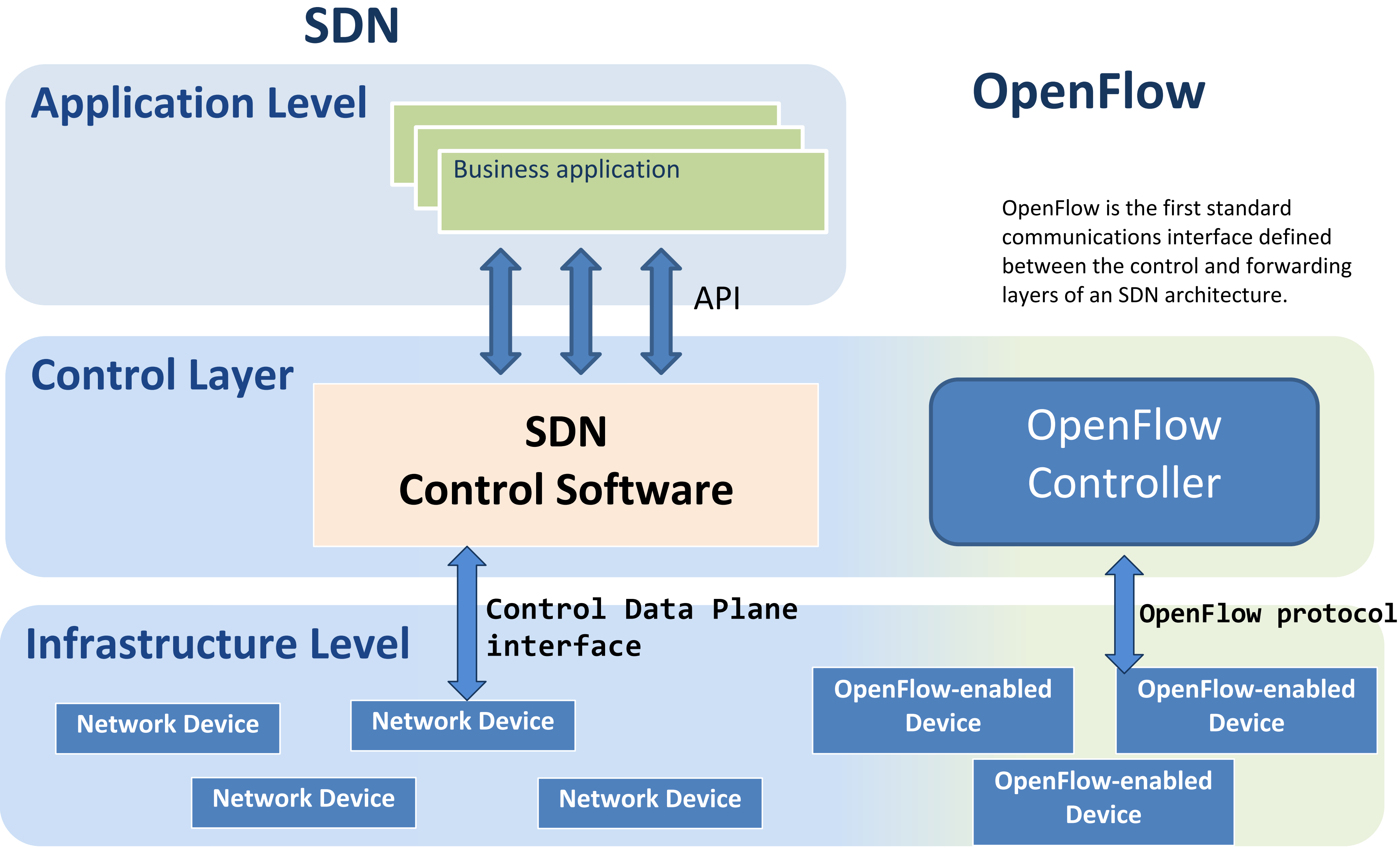
Software-defined network

The Need for a New Network Architecture	Limitations of Current Networking Technologies
• Changing traffic patterns • The rise of cloud services • “Big data” means more bandwidth • The “consumerization of IT”	• Complexity that leads to stasis • Inconsistent policies • Inability to scale • Vendor dependency

The key idea of SDN

Network control is decoupled from forwarding and is directly programmable.

OpenFlow and Software-Defined Network



SDN

OpenFlow

Application Level

Business application

API

Control Layer

SDN
Control Software

OpenFlow
Controller

Infrastructure Level

Control Data Plane
interface

OpenFlow protocol

Network Device

Network Device

Network Device

Network Device

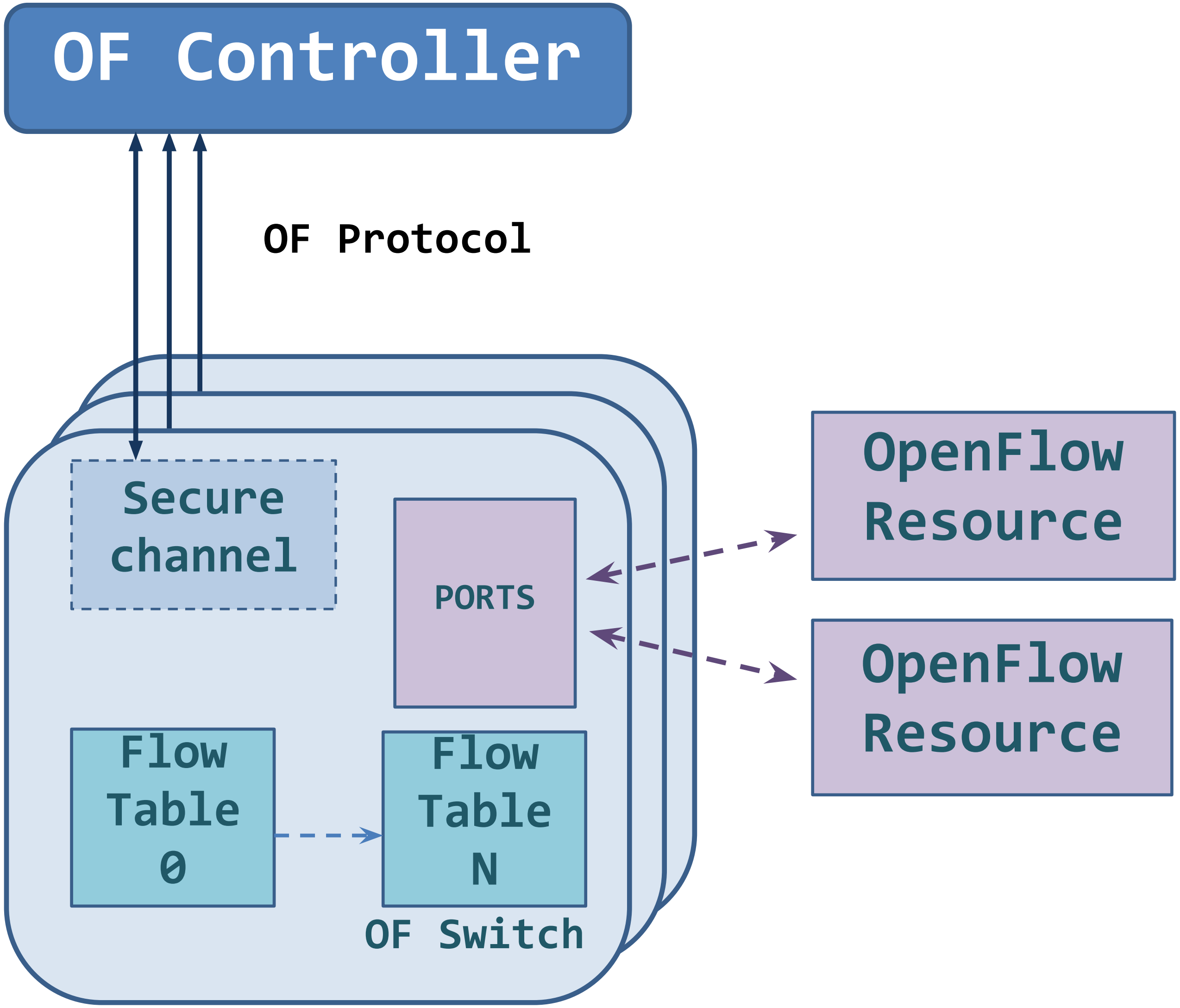
OpenFlow-enabled Device

OpenFlow-enabled Device

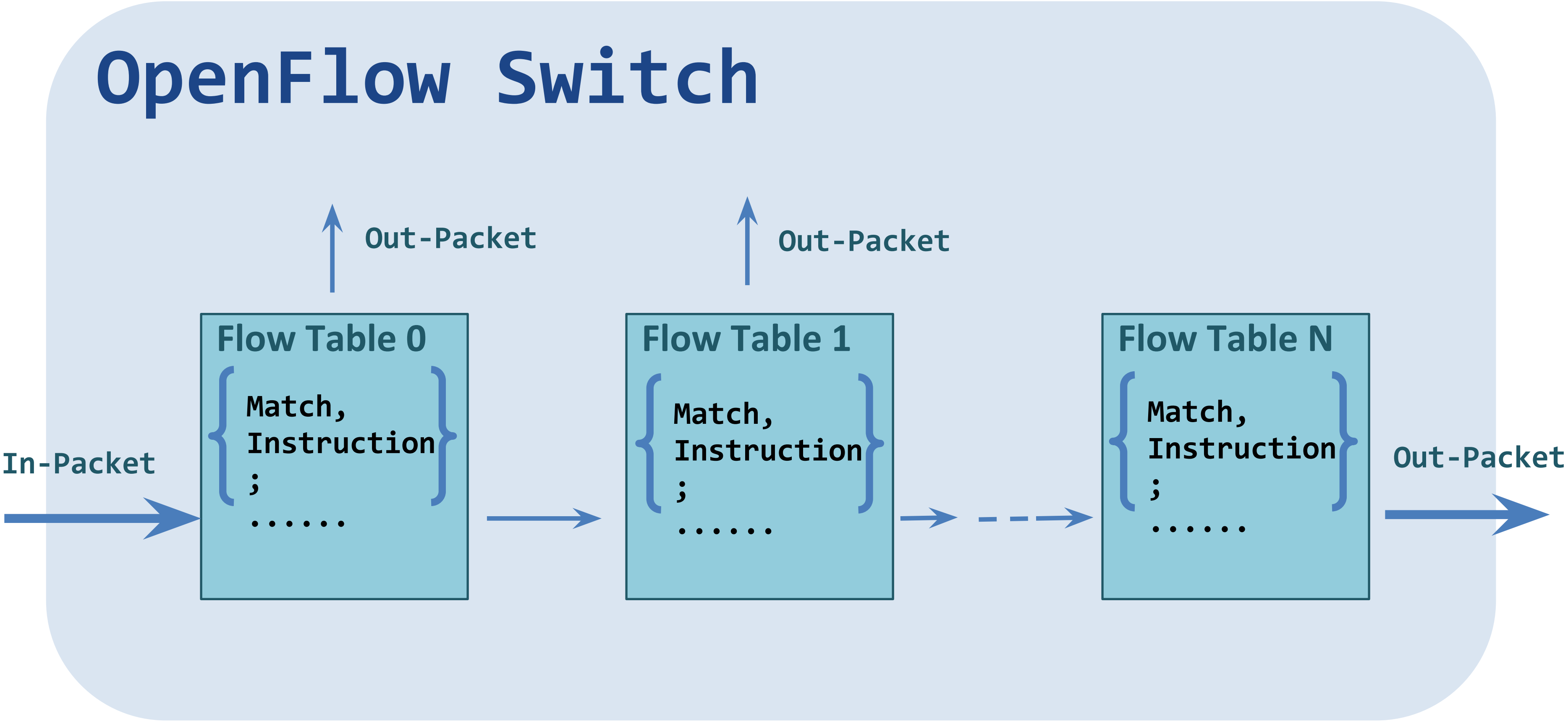
OpenFlow-enabled Device

OpenFlow is the first standard communications interface defined between the control and forwarding layers of an SDN architecture.

OpenFlow switch and Controller



Packet forwarding inside OpenFlow switch



- Packet may transferred to other table
- Packet header may be modified
- Packet may be forwarded to given port or just dropped
- Packet may be applied to given QoS

OpenFlow Switch: key elements

OpenFlow tables

Pipeline

Ports

OpenFlow Channel

Flow table entry: key elements

Match Fields	Priority	Counters	Timeout	Cookies	Instruction set

Match criteria:

Ingress-port

Ethernet MAC

ARP

IPv4 and IPv6

TCP ports

VLAN, MPLS etc.

Instruction:

Go-To Table

Modify Metadata

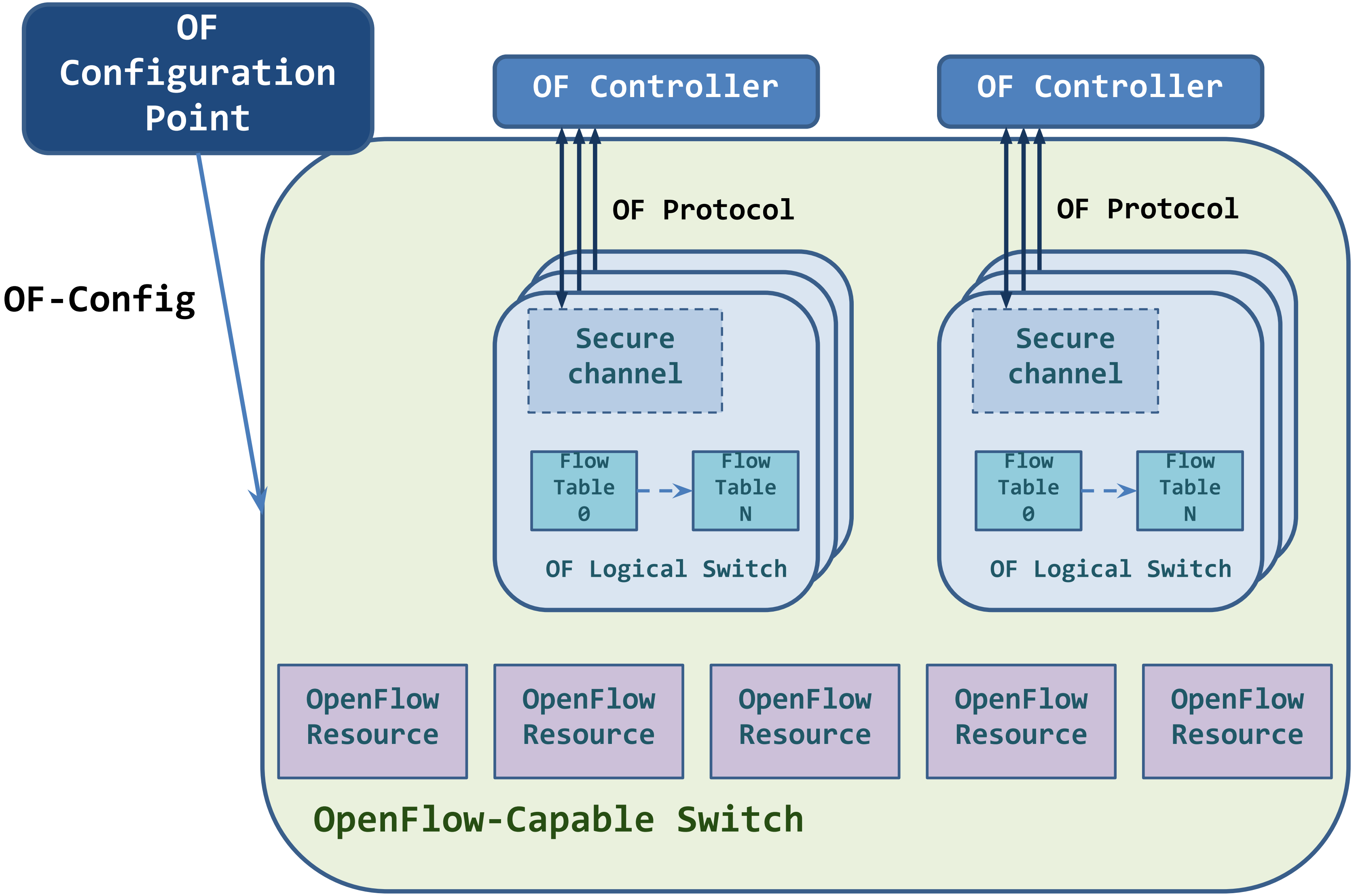
Action Set {forward, apply QoS, drop}

OpenFlow examples

	Switch port	MAC src	MAC dst	Eth type	VLAN ID	IP Src	IP Prot	TCP sport	TCP dport	Action
Switching	*	*	00:1f:..	*	*	*	*	*	*	Port6
Flow switching	Port3	00:20..	00:1f..	0800	Vlan1	1.2.3.4	5.6.7.8	4	17264	Port6
Firewall	*	*	*	*	*	*	*	*	22	Drop
Routing	*	*	*	*	*	*	5.6.7.8	*	*	Port6
VLAN switching	*	*	00:1f..	*	Vlan1	*	*	*	*	Port6, port7, port8

OpenFlow can be compared to the instruction set of a CPU. It specifies basic primitives that can be used by an external software application to program the forwarding plane of network devices, just like the instruction set of a CPU would program a computer system.

OF Config


OF Configuration Point
OF-Config
OF Controller
OF Controller
OF Protocol
OF Protocol
Secure channel
Flow Table 0
Flow Table N
OF Logical Switch
Secure channel
Flow Table 0
Flow Table N
OF Logical Switch
OpenFlow Resource
OpenFlow Resource
OpenFlow Resource
OpenFlow Resource
OpenFlow Resource
OpenFlow-Capable Switch

OpenFlow Protocol: key messages

- Handshake
- Configuration
- Modify
- Statistics
- Error

- Asynchronous messages: Packet-In

- Symmetric messages

OF Controller – Switch: Feedback

- Packet-In – Packet-Out: Controller learns Switch based on information about incoming packets sent by Switch

- Error messages: Switch sends to controller messages about malformed or inappropriate packets.

OpenFlow is evolving fast

- Active and professional community
- Support of academic people and majors (IBM, HP, Huawei etc...)
- Close communication between attendees: mailing lists, JIRA, face-to-face events (interop plugfest)

As a result - moving from 1.0 to 1.3.1!

openflow.h

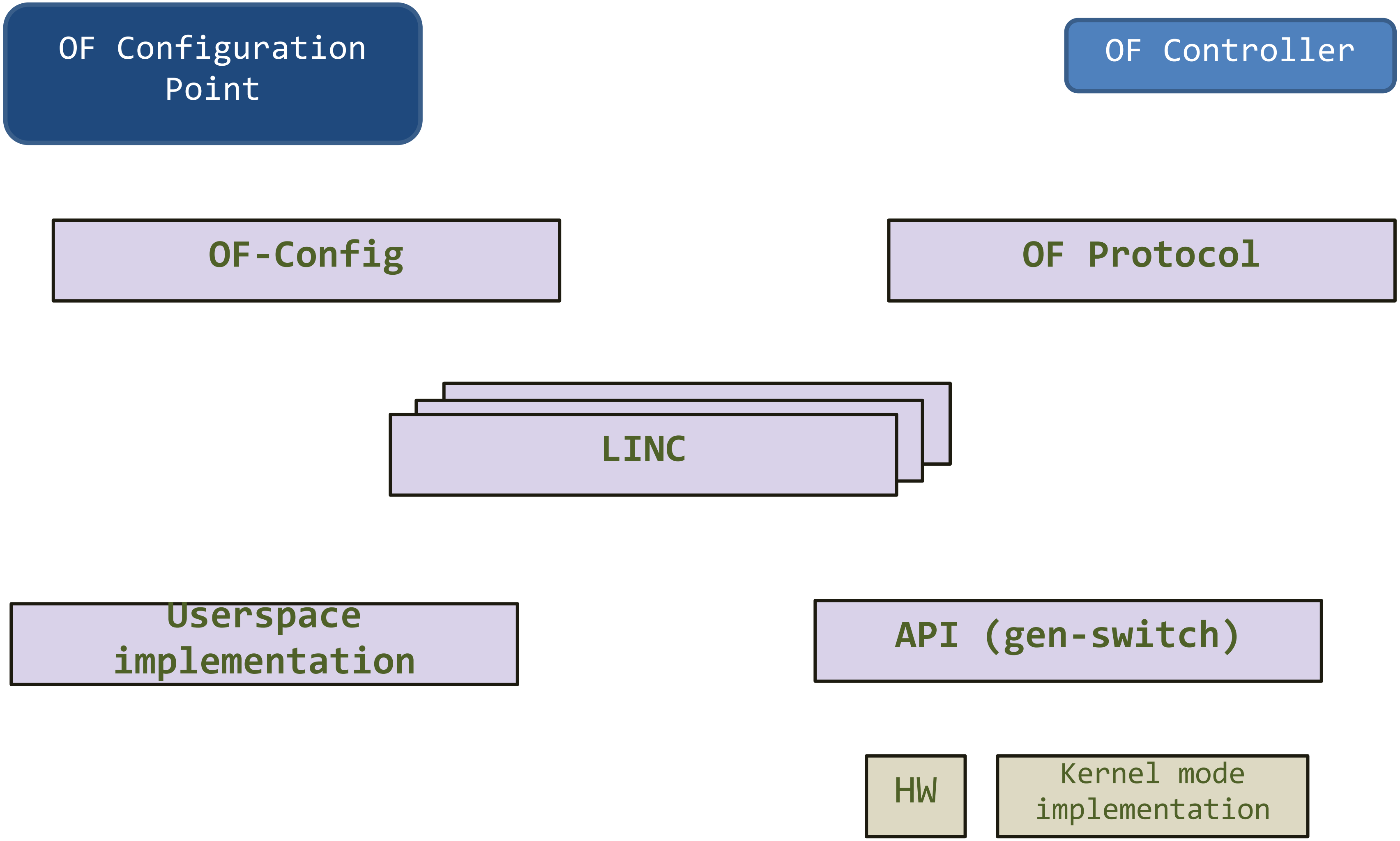
All necessary information is stored in openflow.h

```
/* Header on all OpenFlow packets. */
struct ofp_header {
  uint8_t version;   /* OFP_VERSION. */
  uint8_t type;      /* One of the OFPT_ constants. */
  uint16_t length;   /* Length including this ofp_header. */
  uint32_t xid;      /* Transaction id
};
OFP_ASSERT(sizeof(struct ofp_header) == 8);
```

Open Source implementations

- CPqD (http://www.cpqd.com.br/) + Ericsson Research: **NOX** Controller (C), **POX** Controller (Python). OpenFlow library for switch (C, python) OpenFlow 1.2, 1.3
- Open vSwitch (http://openvswitch.org/)
  Used as a switch in Xen, VirtualBox. OpenFlow 1.0
- FloodLight controller (http://floodlight.openflowhub.org/). OpenFlow 1.0, LOXI announced.

LINC switch


OF Configuration Point
OF Controller
OF-Config
OF Protocol
LINC
Userspace implementation
API (gen-switch)
HW
Kernel mode implementation

Apache Avro

- Serialization library like Protobuf or Thrift

Schema written on JSON-based specification
Also you can use IDL

- Schema may be parsed in runtime.

Resulting Java-objects contains all information about data.
No metainformation put into a wire.
Dynamic parsing.

But encoding still exists. Also, some lack in Avro schema specification

Reference

- OpenNetworking Foundation (OpenFlow documents)

  https://www.opennetworking.org/about/onf-documents
- FlowForwarding (LINC Switch)

  http://www.flowforwarding.org/
- Floodlight OpenFlow controller

  http://floodlight.openflowhub.org/
- Apache Avro

  http://avro.apache.org
- And me, Dmitry Orekhov (Dmitry_Orekhov@epam.com)

Thank you!