Advanced Computer Networks

Control and Data plane

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ACN: Network virtualization
Distributed control plane

http://aryaka.com/
Centralized control plane

http://aryaka.com/
SDN is better

- Fast reaction time (Efficiency)
- Quick behaviour updates (Scale)
- Flexible flow management (Innovation)
SDN vs Virtual Networks

Network Virtualization (NV)
- Self-Service Portal
- Firewall
- Load Balancer
- Packet Broker

Virtual Services
- Virtual Network
- Virtual Topology

Physical Infrastructure
- Physical Topology

Software Defined Networking (SDN)
- NorthBound API
- Network Control System
- SouthBound API
- Abstraction of Control Plane from Networking Devices

Source: VMWare
SDN layer cake

Control applications

Controller

Infrastructure
SDN layer cake

- SDN Controller
- Open Flow protocol
- Local CPU/NPU
- Switching fabric

Control applications

Controller

Infrastructure
Control plane: Management functionality that provides instructions on how traffic should be handled.
Data plane:
Forwarding functionality that moves traffic and forms a topology.
SDN: Control plane

It needs as input ...

It provides as output ...

Source: bavaria.travel.com
SDN: Control plane

- It needs as input
  - Discovery messages
  - Topology changes
  - Flow stats

- It provides as output
  - Flow handling instructions
SDN: Control plane

- aka Network Operating System (NOS)

- Implements control functionality
  - Topology discovery & abstraction
  - Rule conflict avoidance

- Communicates with the data plane
  - Open Flow protocol
  - P4
  - Platform-specific protocols

Diagram:
- SDN Controller
- Open Flow protocol
- Local CPU/NPU
- Switching fabric
SDN: Control plane

- Implementation: Single- vs multi-threaded

- Deployment
  - Centralized
  - Physically distributed [KoT10, ToA10]
  - Logically distributed [ShR10]
  - Hierarchical controllers [YaS12]

- Flow management mode
  - Proactive mode [ReJ10]
  - Reactive mode [CaM07]
**SDN: Control channel**

- Implements the OpenFlow protocol [OF14]
  - Messages, incl. flow rules and corresponding actions
  - Switch & controller behaviour

![Diagram of SDN control channel](image)
P4: Programming Protocol-independent Packet Processors

- Parser: header state machine
- Control program: table graph
- Actions
P4: Programming Protocol-independent Packet Processors

- Protocol independent
- Target independent
- Reconfigurable
SDN: Data plane

- Streaming algorithms on packets
  - Matching on some headers (40 fields)
  - Perform some actions

- Wide range of functionality
  - Mapping header fields
  - Buffering and marking
  - Forwarding
  - Traffic monitoring
  - Access control
  - …

OF rules = (match, action)

match

Local CPU/NPU

Switching fabric

action
SDN: Data plane

- Packet handling
  - Based on (match, action) pairs
  - Multi-stage matching tables

- Installed flow

  OF rule = \((\text{match XYZ, fwd})\)

  \[\text{action} = \text{fwd}\]
SDN: Data plane

- New flow

![Diagram showing SDN data plane](image-url)
**SDN: Data plane**

- **ASIC**
  - fast packet processing
  - slow & expensive updates

- **FPGA and NPU**
  - fast, reconfigurable
  - hard to program

- **CPU**
  - slow packet processing
  - easy to program

Source: Altera
SDN: Control plane

References for the interested

- [ReJ10] Rexford, M.J. Freedman, and J. Wang. Scalable flow-based networking with DIFANE. In SIGCOMM 2010
SDN: Data plane

- References for the interested
  - M. Kuzniar, P. Peresini and D. Kostic. What You Need to Know About SDN Flow Tables. In PAM. 2015
SDN in practice
Software Defined Networking: Challenges

- **Scalability**
  - Decision elements responsible for many routers

- **Response time**
  - Delays between decision elements and routers

- **Reliability**
  - Surviving failures of decision elements and routers
Software Defined Networking: Challenges

- **Consistency**
  - Ensuring multiple decision elements behave consistently

- **Security**
  - Network vulnerable to attacks on decision elements

- **Interoperability**
  - Legacy routers and neighboring domains
Above the control plane
Software Defined Networking: Control applications

- Implement diverse control functionality
  - Routing
  - Bandwidth provisioning
  - Load balancing
  - Packet inspection
  - Monitoring
  - ....

Control applications
SDN Controller
Open Flow protocol
Local CPU/NPU
Switching fabric