SD-Fabric Tutorial

Carmelo Cascone
Charles Chan

Cloud Software Development Engineers, Intel
SD-Fabric Project TST Members, ONF

github.com/opennetworkinglab/sdfabric-tutorial

# SD-Fabric: a Platform to Realize Your P4 Ideas

- Data center fabric entirely defined by software

  - Extend and modify to suit your needs

- Building blocks

  - Starter P4 program – with basic forwarding and advanced capabilities such as 5G UPF, INT, slicing, and more (if you need them)

  - Production-grade SDN control plane – with high-level APIs to build new control apps, while re-using built-in apps for common features

  - Integration with cloud-native and CI/CD tools – to make it easier to deploy and monitor the full stack in production

What is This Tutorial About?

- Learn about the architecture

- Deep-dive into existing features

  - Basic: L2/L3 forwarding

  - Advanced: P4-UPF, INT, slicing & QoS, …

- Hands-on exercises based on an emulated environment

Resources

- ## [SD-Fabric 1.1 release](#)

  - Apache 2.0 open-source license

- ## Learn more

  - [Website](#), [Whitepaper](#), [Techinar](#), [Wiki](#)

- ## Stay in touch

  - [Mailing list](#), [Slack](#) ([register](#))
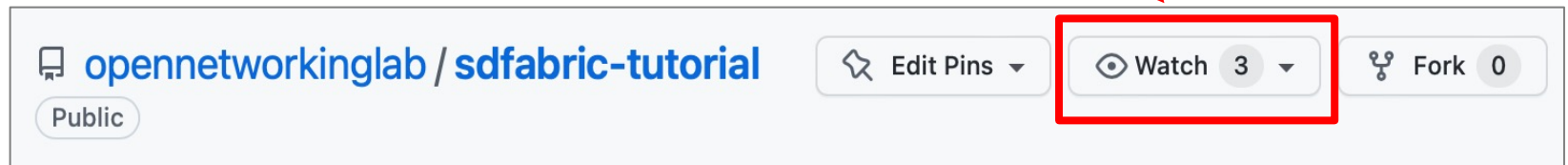

https://docs.sd-fabric.org
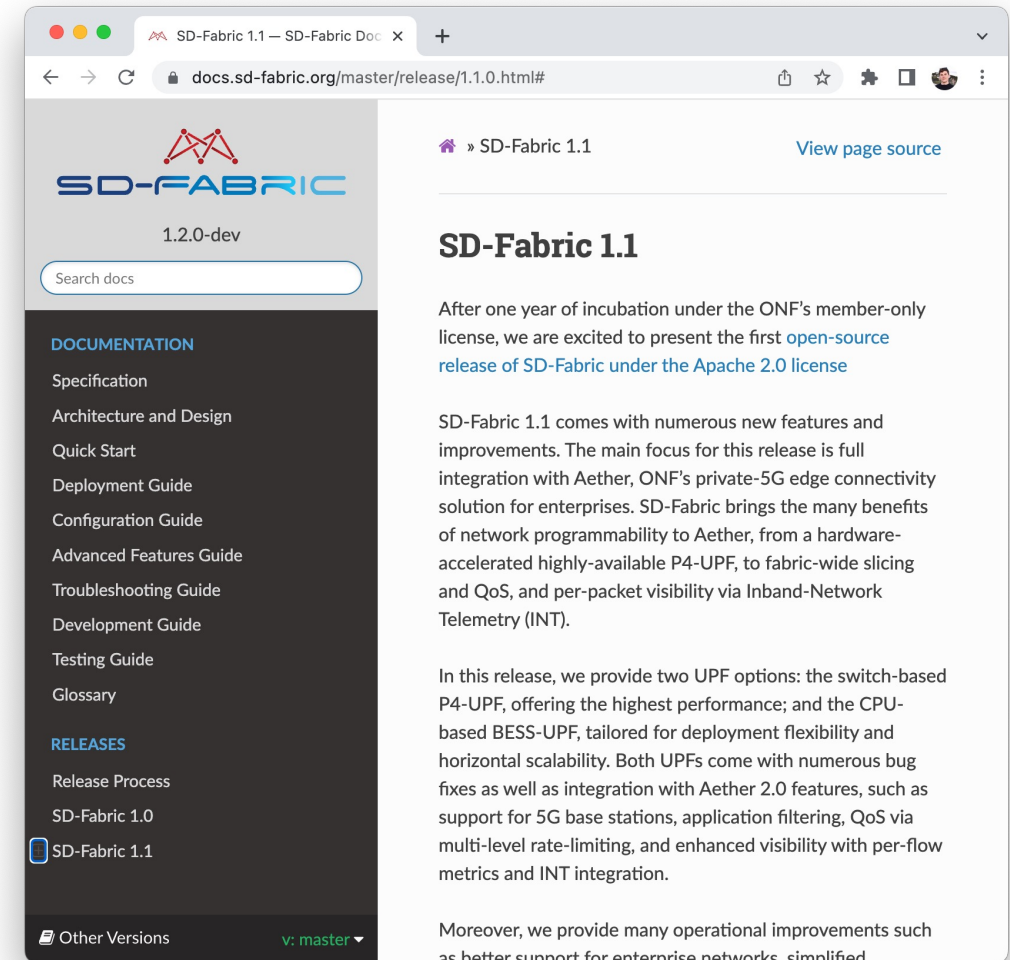
Today's Agenda

- Part 1 – Introduction to SD-Fabric: motivation, architecture, use cases

- Part 2 – Basics & Configuration + hands-on lab

- Part 3 – P4 User Plane Function (UPF) + hands-on lab

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- Part 4 – In-band Network Telemetry (INT)

- Part 5 – Extending SD-Fabric

- Part 6 – Slicing & QoS

- Part 7 – Advanced Connectivity

- And more...

More sessions and labs on the way!
Make sure to watch the GitHub repo
github.com/opennetworkinglab/sdfabric-tutorial

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Public

Introduction to SD-Fabric

SD-Fabric Tutorial – Part 1

Era of the Multi-Cloud Connected Edge

IoT

Sensors

Surveillance

Multimedia

Employees

Visitors

Multi-Cloud Applications

IoT and 1000x Endpoints

5G Connected Devices

AI and ML

Telco Edge

Enterprise Edge

Hyperscaler Cloud
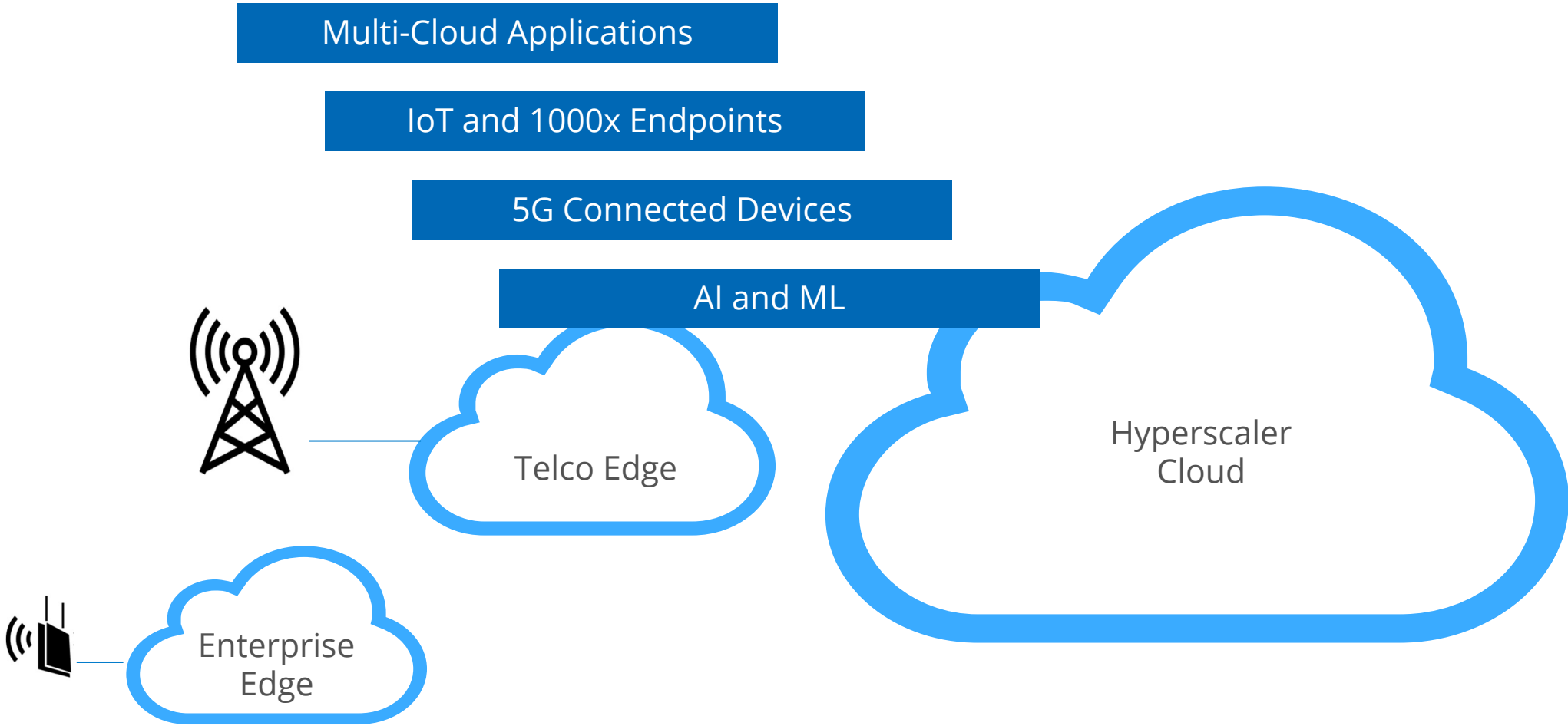
Needs of the New Datacenter (1/2)

- **Lines between servers and networks are blurring**

  - Rapidly increasing data demands

  - Programmable cluster of computing

- **Developer optimized**

  - Deeply Programmable via unified APIs

    - Distribute workloads on CPU, IPU or Switch

Needs of the New Datacenter (2/2)

- Needs to be **cloud managed**
  - Deployed and managed from the cloud
  - Easy to use gauges and dials for application visibility and control
- Need to consider traffic **end-to-end**
  - Include container network, software switch and IPUs
- Need to **orchestrate all these components**
  - Opportunity to build more resilient, secure and self-healing solutions

A Little Bit of History...

Evolution of ONF's open-source network fabric

- 2015 – Project Atrium
  - Demonstrate the feasibility of SDN and OpenFlow solutions by providing a complete software stack (app, controller, switch OS, SDK, ASIC...)
- 2016 – CORD network infrastructure
  - Focused on telco data center use cases
  - Introduced many new features
- 2017 – Trellis, Comcast collaboration started
  - Hardened platform, scaled up
- 2018 ~ 2019 – Field trial ~ Production deployment
  - Based on Broadcom OF-DPA switches
  - Start supporting programmable ASICs
    (Key design principle: keep controller app the same with Flow Objective API)
- 2020 ~ present – SD-Fabric
  - Integrate fully-programmable, fully-visible data plane
  - Aether as the driving use case (private-5G edge)

SD-Fabric Overview
Cloud-managed SDN Fabric as a Service
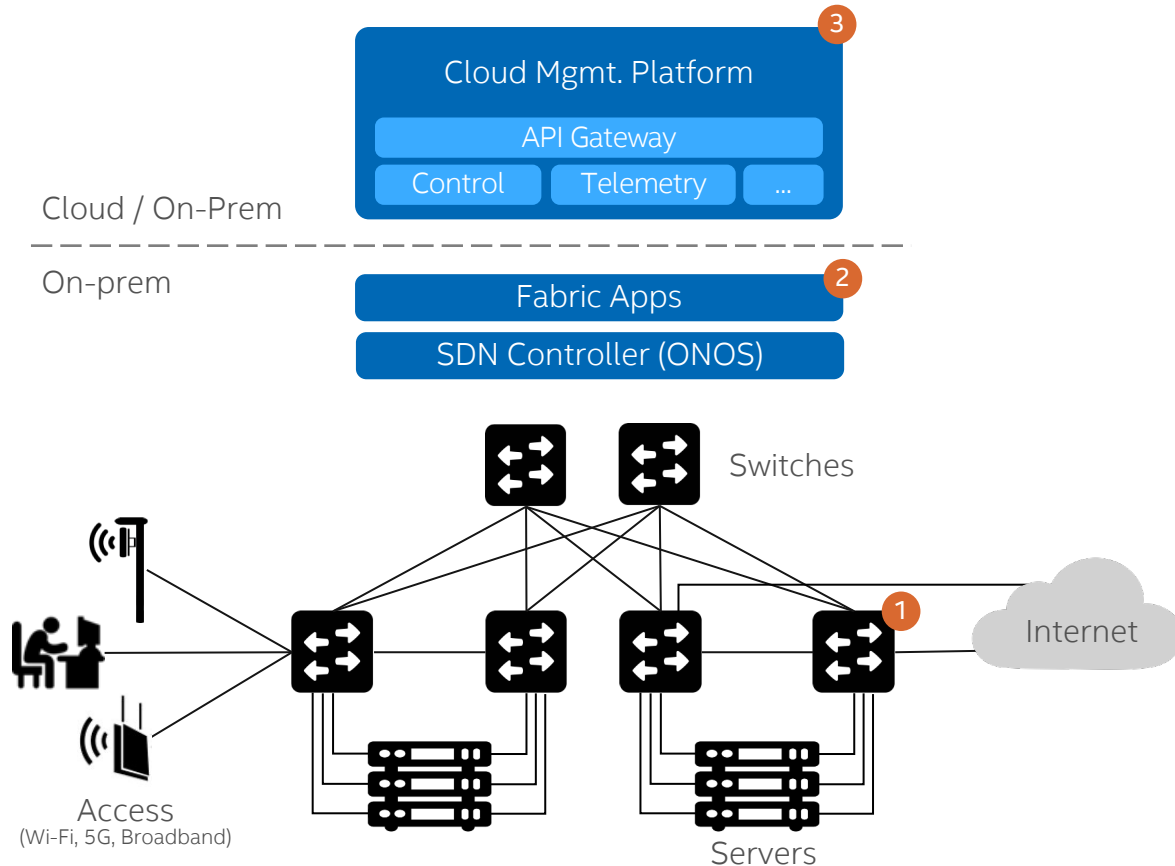
3 Cloud managed
- Automatic provisioning, lifecycle management and failure recovery for all servers and switches
- Manage multiple sites with state-of-the-art cloud-native CI/CD, monitoring, telemetry, logging and alert system

2 SDN Control Plane + Fabric Apps
- No distributed protocol overhead
- Global optimization
- Control and data plane redundancy
- One big router abstraction
- Bridging, ECMP routing, ACL, LLDP, DHCP...

1 Fully programmable & visible data plane
- Powered by Intel® Tofino™ Intelligent Fabric Processors (and potentially IPU later)
- Network function offloading (SASE, tunnel termination, FWaaS, 5G UPF...)
- In-band network telemetry & closed loop control
- Resource optimization per use case

Fully-Programmable and Visible Data Plane

Cloud / On-Prem

On-prem

Cloud Mgmt. Platform
- API Gateway
- Control
- Telemetry
- ...

Fabric Apps

SDN Controller (ONOS)

Switches

Access
(Wi-Fi, 5G, Broadband)

Servers

Internet

- Two options to program/configure devices
  - ONL + Stratum (via P4RT/gNMI)
    - Fully customizable P4 pipeline
    - Config, managed and monitored by SD-Fabric cloud management platform (more in the next few pages)
  - Roadmap: SONiC + PINS (via P4RT/gNMI)
    - Require custom P4 table support to unleash the full potential of programmable data plane

SDN Control Plane & Fabric Apps

Cloud / On-Prem

On-prem

Cloud Mgmt. Platform
- API Gateway
- Control | Telemetry | ...

Fabric Apps

SDN Controller (ONOS)

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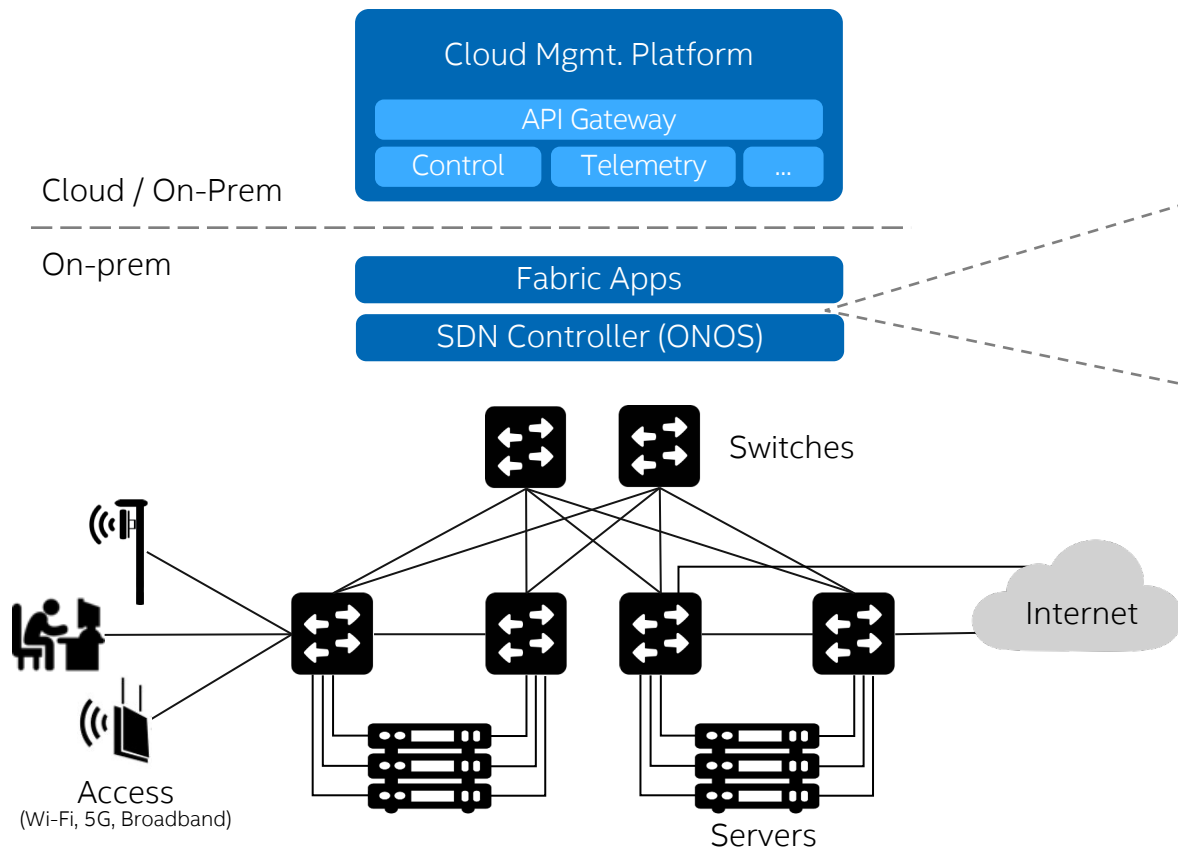
- **Production grade, open source SDN control plane**
  - Scalable & redundant
  - Support various southbound protocols (e.g. P4RT and gNMI)

- **Example Fabric Apps**
  - **Forwarding**
    - L2 Bridging, L3 ECMP routing, ACL
    - IPv4/IPv6 multicast
    - DHCP relay, dual-homing
  - **4G/5G User Plane**
    - GTP-U tunnel termination
    - QoS
  - **INT Watchlist**

- **Roadmap: hybrid SDN**
  - Some features controlled by switch-local control plane (e.g., SONiC)
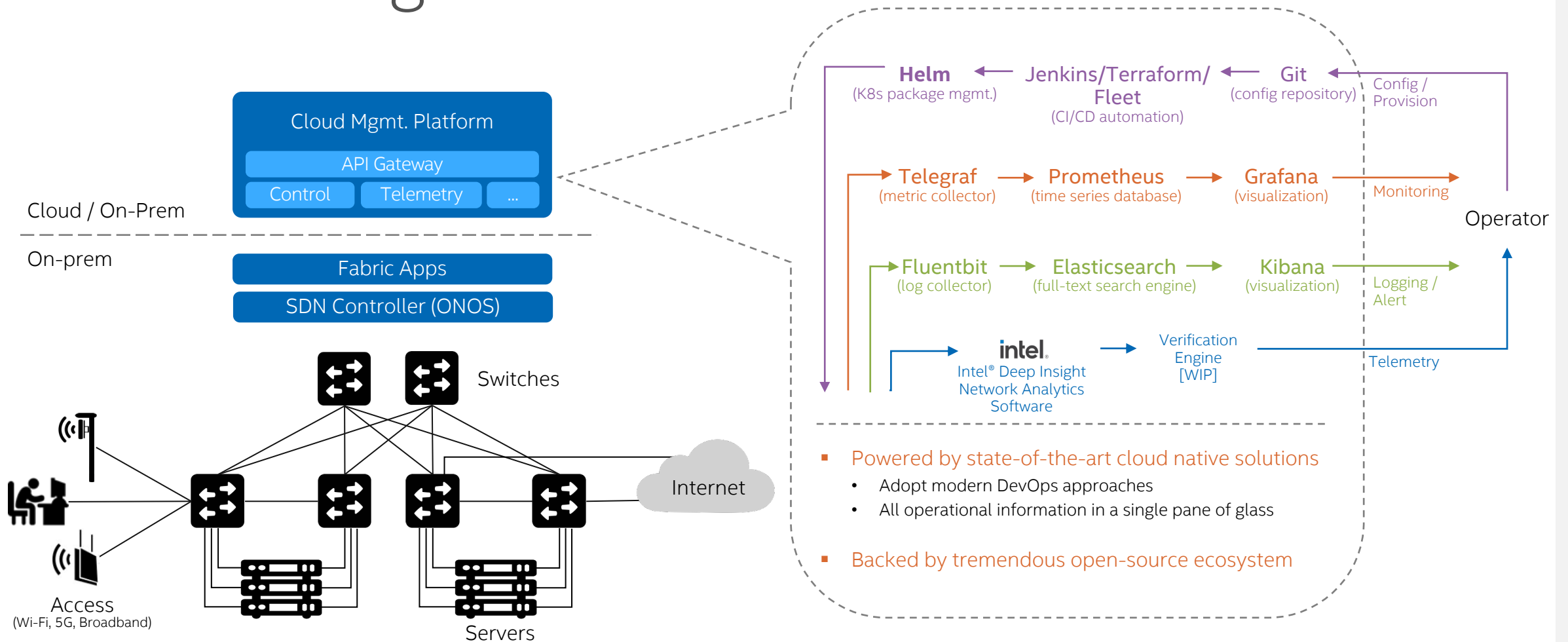 - Some features controlled by remote SDN controller (ONOS)

Cloud Managed

Cloud / On-Prem

Cloud Mgmt. Platform
- API Gateway
- Control | Telemetry | ...

On-prem

Fabric Apps

SDN Controller (ONOS)

Switches

Access
(Wi-Fi, 5G, Broadband)

Servers

Internet

Helm
(K8s package mgmt.)
← **Jenkins/Terraform/ Fleet**
(CI/CD automation)
← **Git**
(config repository)

Config / Provision

Telegraf
(metric collector)
→ **Prometheus**
(time series database)
→ **Grafana**
(visualization)

Monitoring

Operator

Fluentbit
(log collector)
→ **Elasticsearch**
(full-text search engine)
→ **Kibana**
(visualization)

Logging / Alert

intel
Intel® Deep Insight Network Analytics Software
→ **Verification Engine [WIP]**

Telemetry

- Powered by state-of-the-art cloud native solutions
  - Adopt modern DevOps approaches
  - All operational information in a single pane of glass

- Backed by tremendous open-source ecosystem

Scalability and Redundancy

Single Switch
Minimal setup

Scale

Single Leaf Pair
Minimal HA setup

Scale

Scale

Leaf-Spine Fabric
With ECMP and N-way redundancy

ECMP Groups

Spine 1

Spine 2

Leaf 1

Leaf 2

Leaf 3

Leaf 4

Paired Leaves (Dual-ToRs)

Pair-link

Dual-homed Servers

Server

Server

External Routers

Linux Bonding Active-active
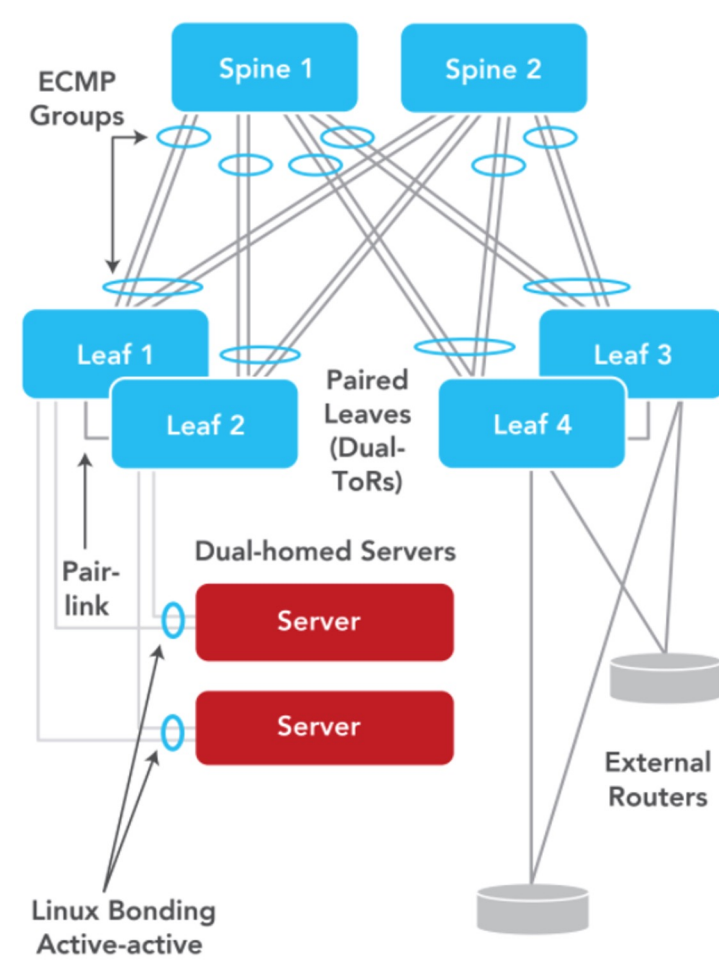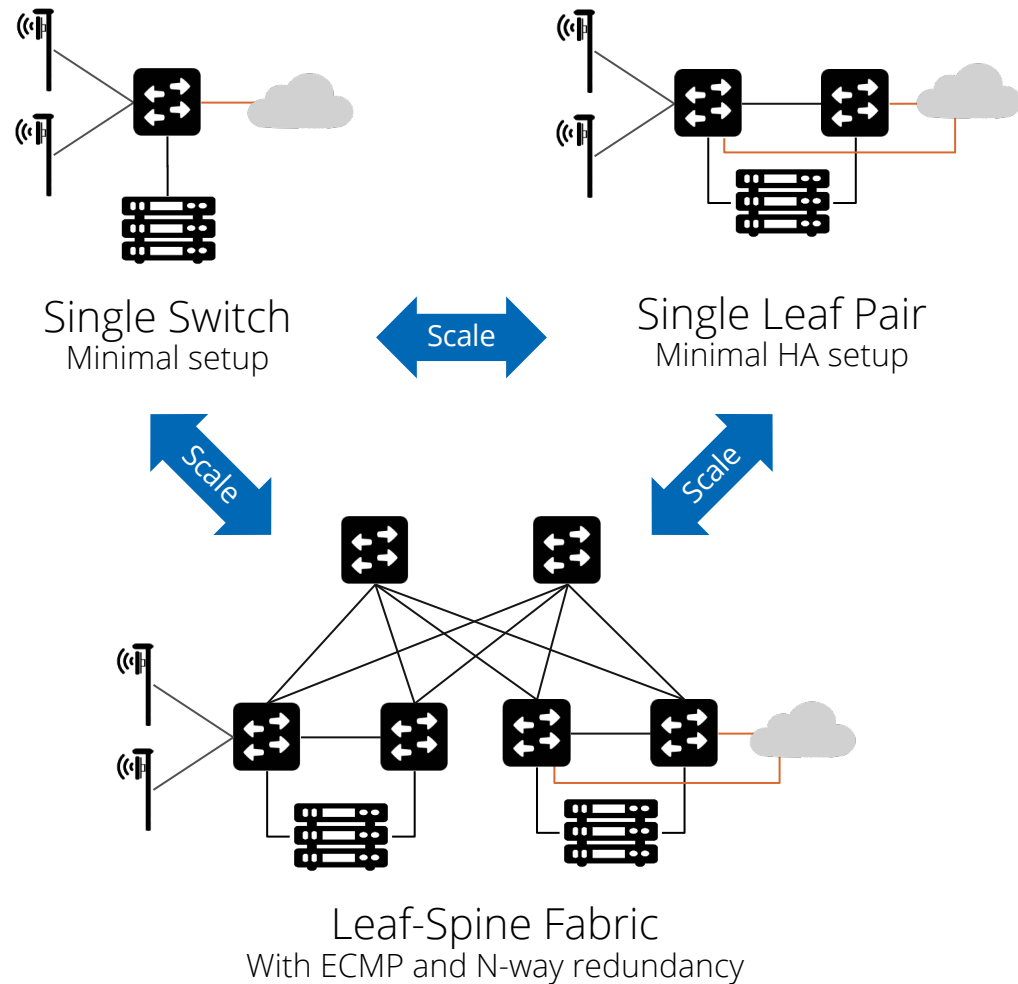
SD-Fabric provides a solid foundation for developers to take advantage of programmable data planes to deliver innovative features

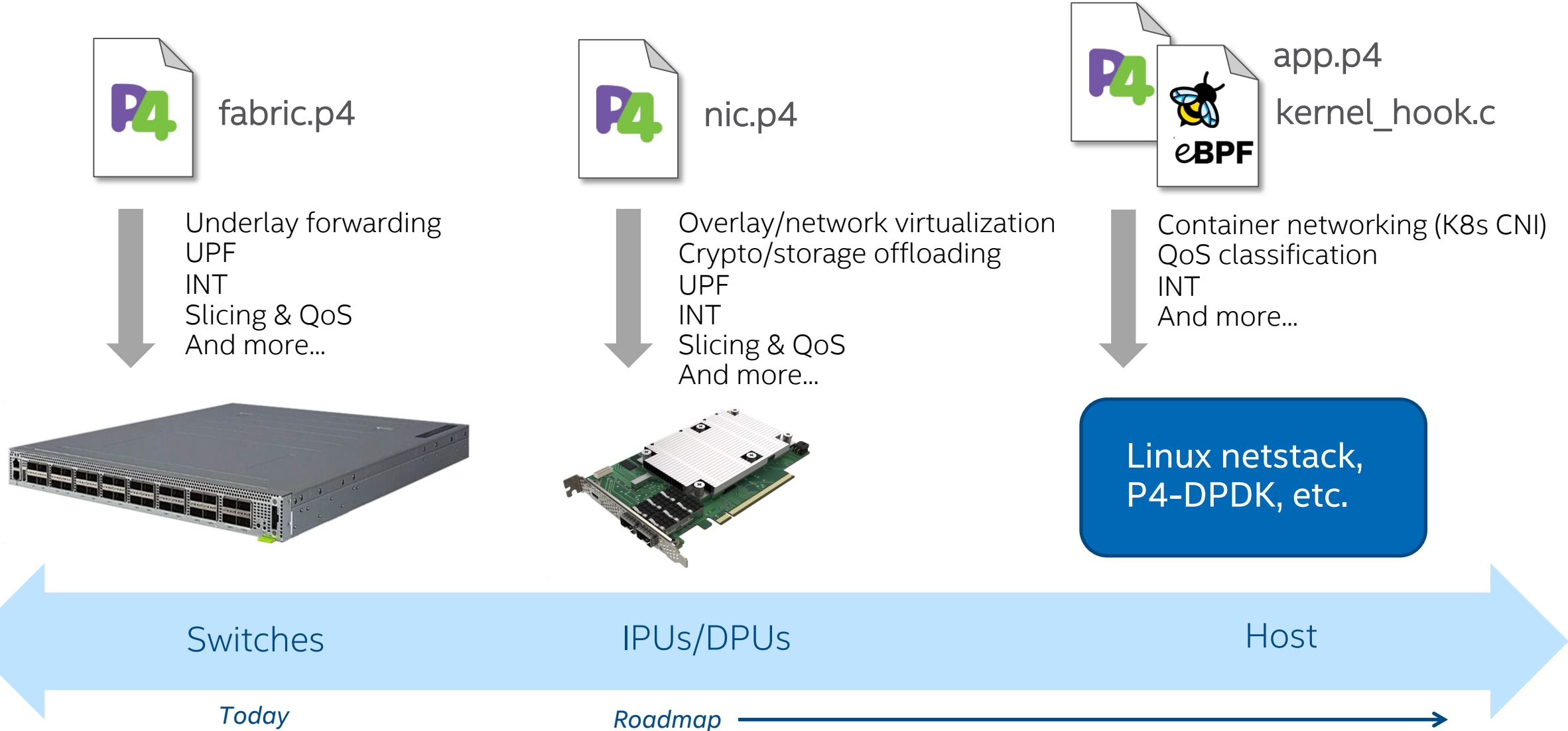github.com/opennetworkinglab/sdfabric-tutorial

intel.

Vision: End-to-End Programmable Data Plane

fabric.p4

Underlay forwarding
UPF
INT
Slicing & QoS
And more...

nic.p4

Overlay/network virtualization
Crypto/storage offloading
UPF
INT
Slicing & QoS
And more...

app.p4

kernel_hook.c

Container networking (K8s CNI)
QoS classification
INT
And more...

Linux netstack,
P4-DPDK, etc.

Switches	IPUs/DPUs	Host

Today

Roadmap

Current Use Case: Private-5G Connected Edge

Self-adaptation and healing

Smart alarms

5G Core

Operation & Control
Site, subscribers, and apps configuration

Configuration state

Verification Engine
(roadmap item)

Cloud / On-Prem

On-Prem

End-to-end INT visibility for tracking path, drops, latency, and congestion (prototype eBPF impl. for host, NIC in roadmap)

UPF App
One-Big-UPF API (PFCP)

Slicing App
Classification and QoS API

INT App
Anomaly thresholds and watchlist API

ONOS

Network state

Anomalies and per-flow stats

Distributed UPF data path fully offloaded to Tofino: GTP-U tunnel termination, app filtering, and more.

DPDK-based UPF for horizontal scalability

small cells

Edge Apps

Edge Apps

HW-enforced isolation and QoS (NIC & host in roadmap)

Data plane telemetry (INT)

Intel® Deep Insight Network Analytics Software

SD-Fabric Tutorial

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Next

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