

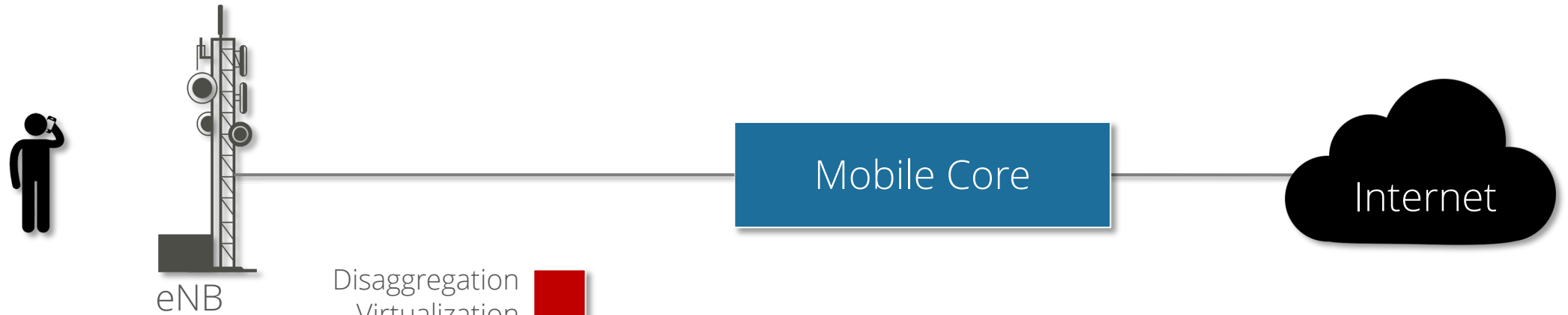


Deeply Programmable 5G Edge Cloud Fabric with P4

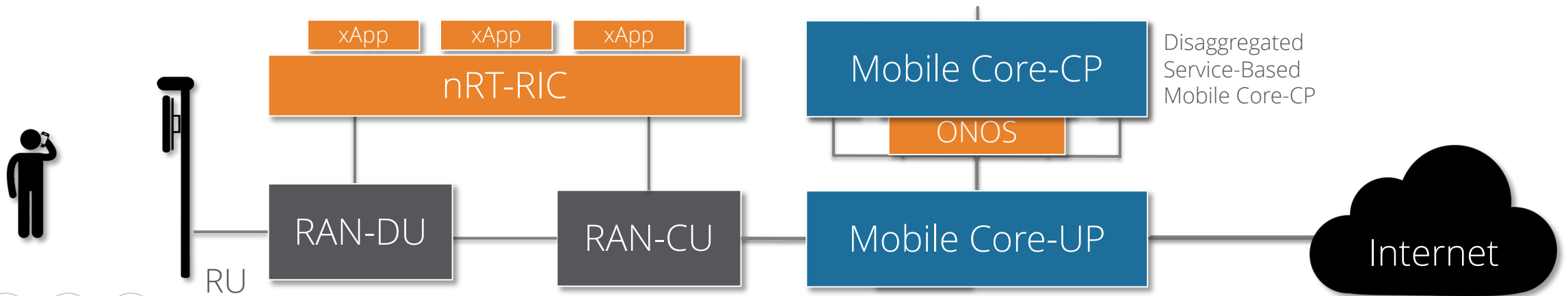
Oğuz Sunay
Carmelo Cascone

Open Networking Foundation

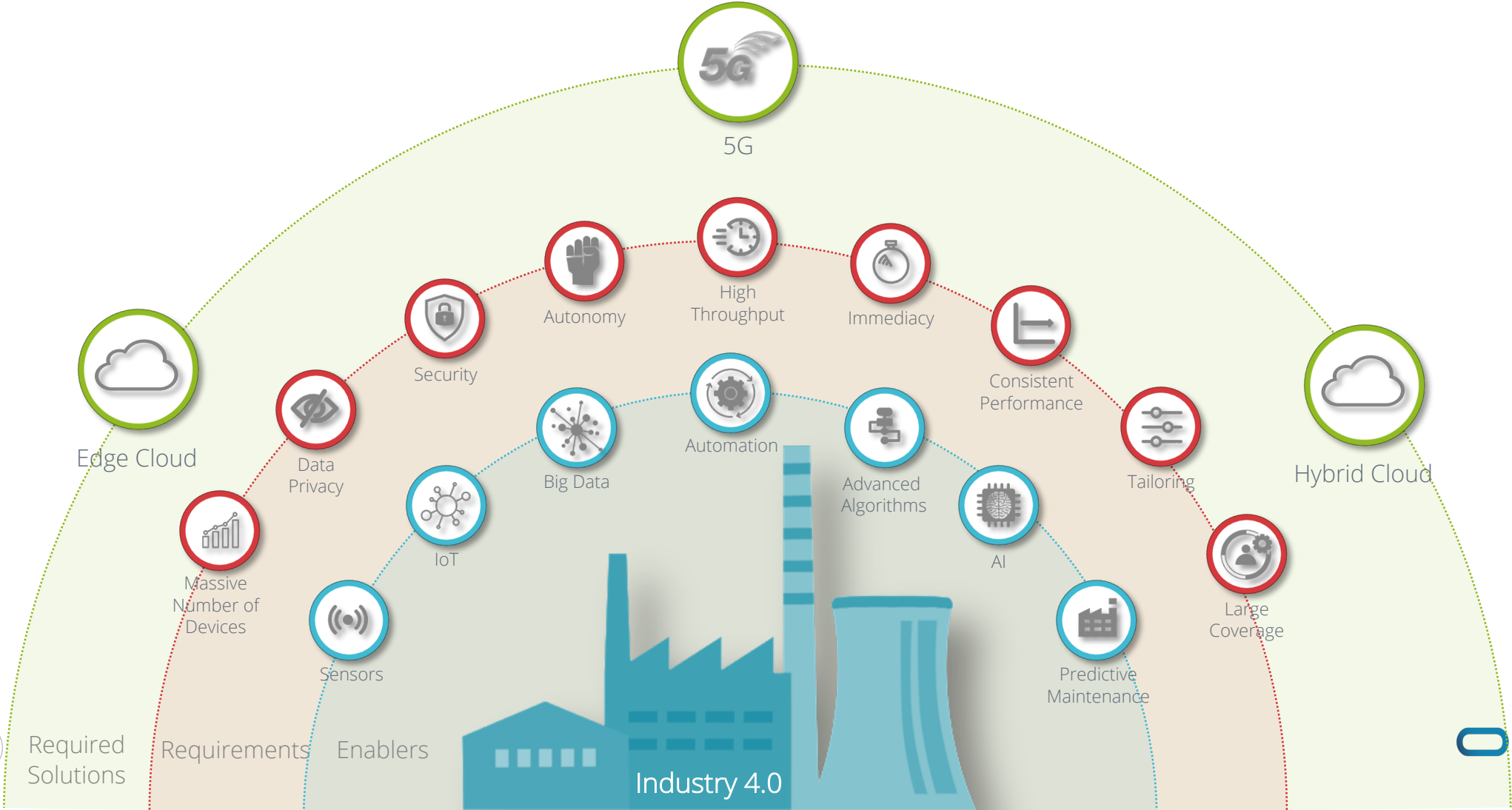
5G Mobile Connectivity



Disaggregation
Virtualization
SDN'ization



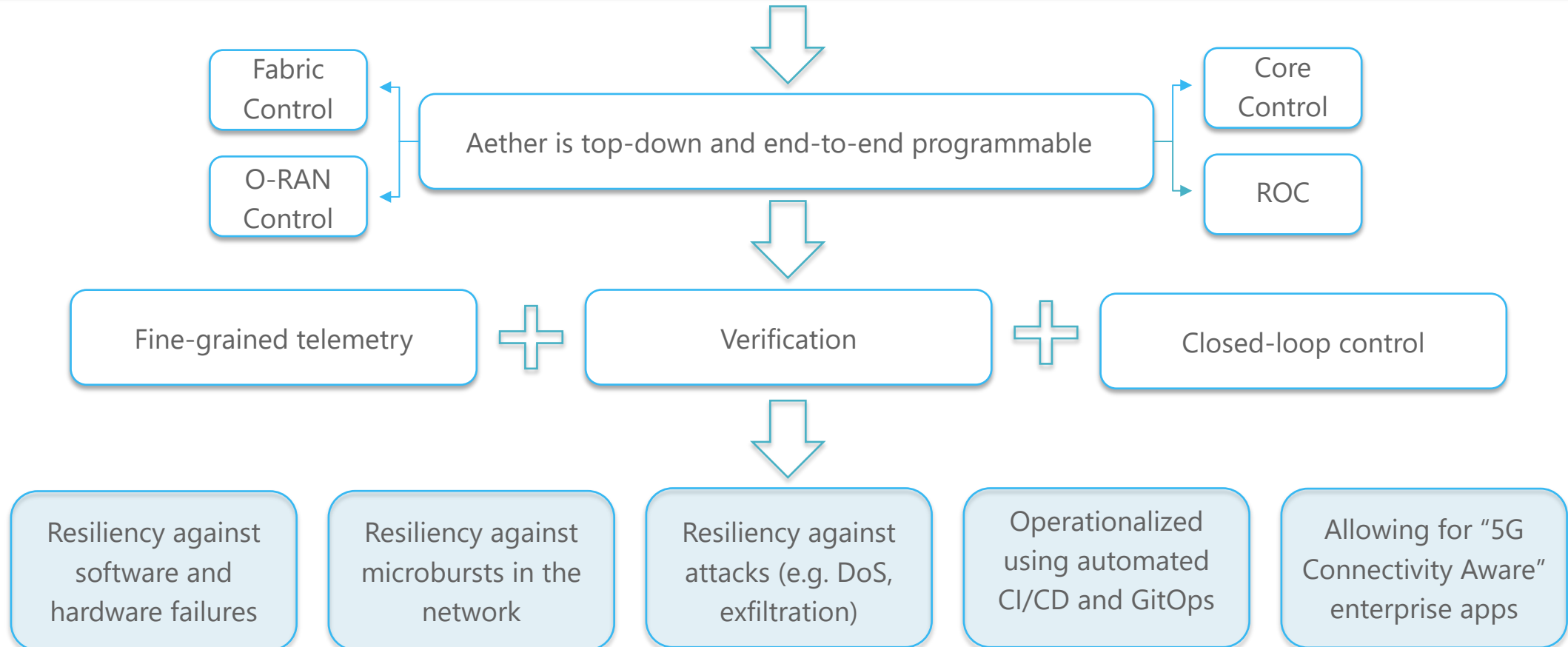
5G will serve Industry 4.0 Transformation



Deeply Programmable 5G Edge Cloud Fabric with Aether

Aether

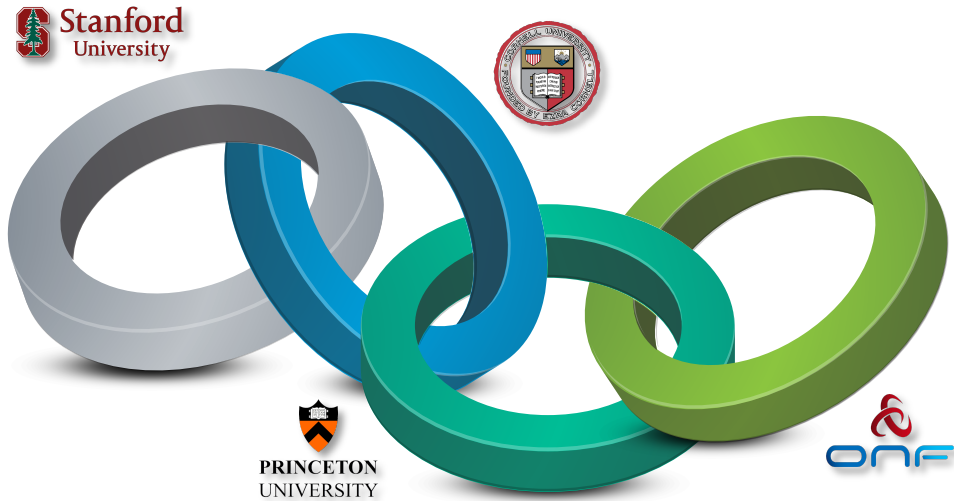
Aether is ONF's open-source 5G Connected Edge Cloud solution for enterprises that are transforming themselves towards Industry 4.0. It has been architected to be offered as a cloud managed service to the enterprises.



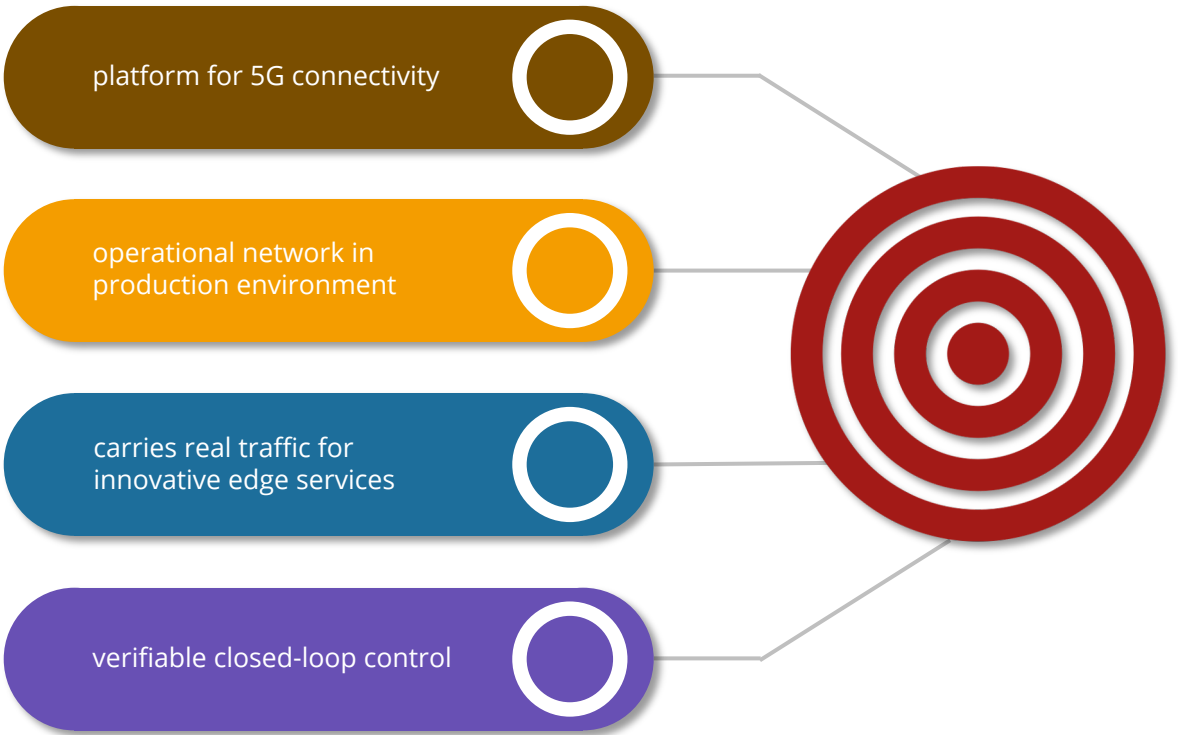
Introduction to the Pronto Project



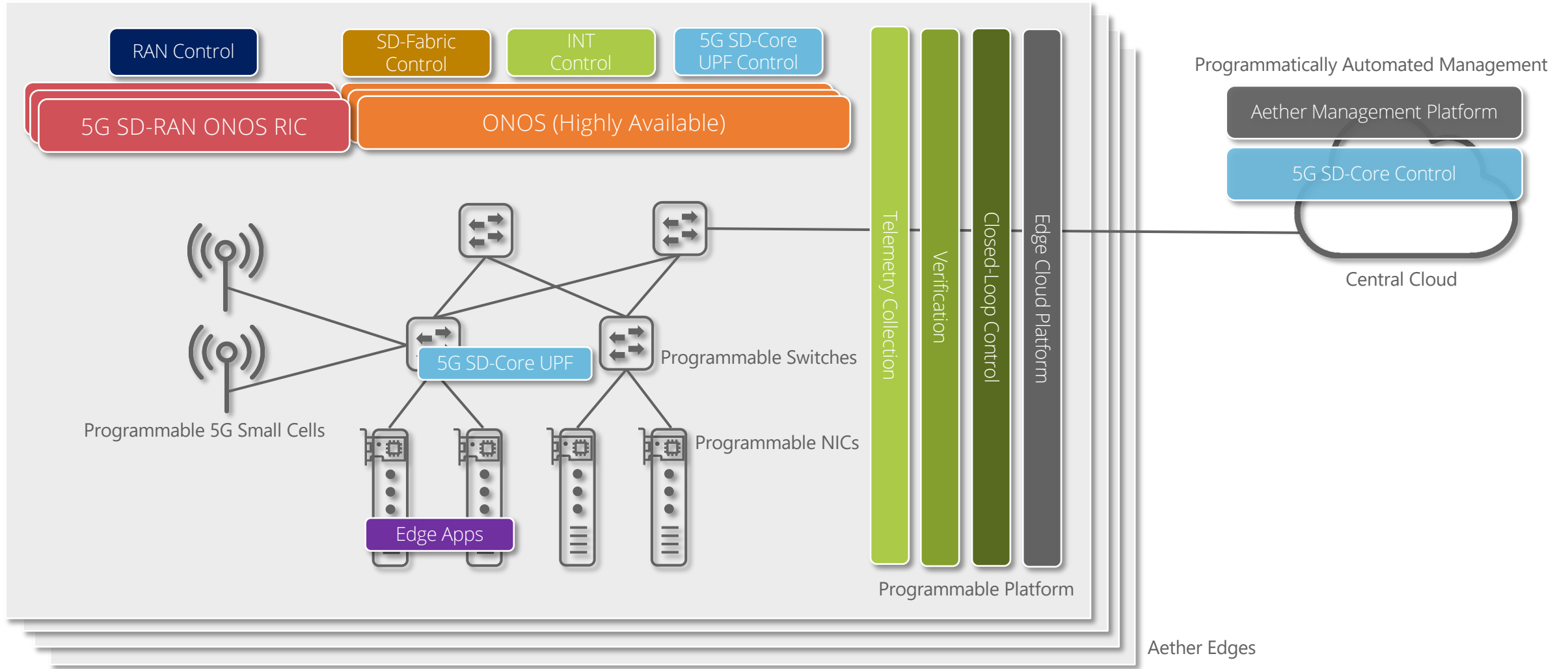
Integrated Platform: Operationalized, Software-Defined, Disaggregated, Verifiable 5G Networks Towards Pre-Productization



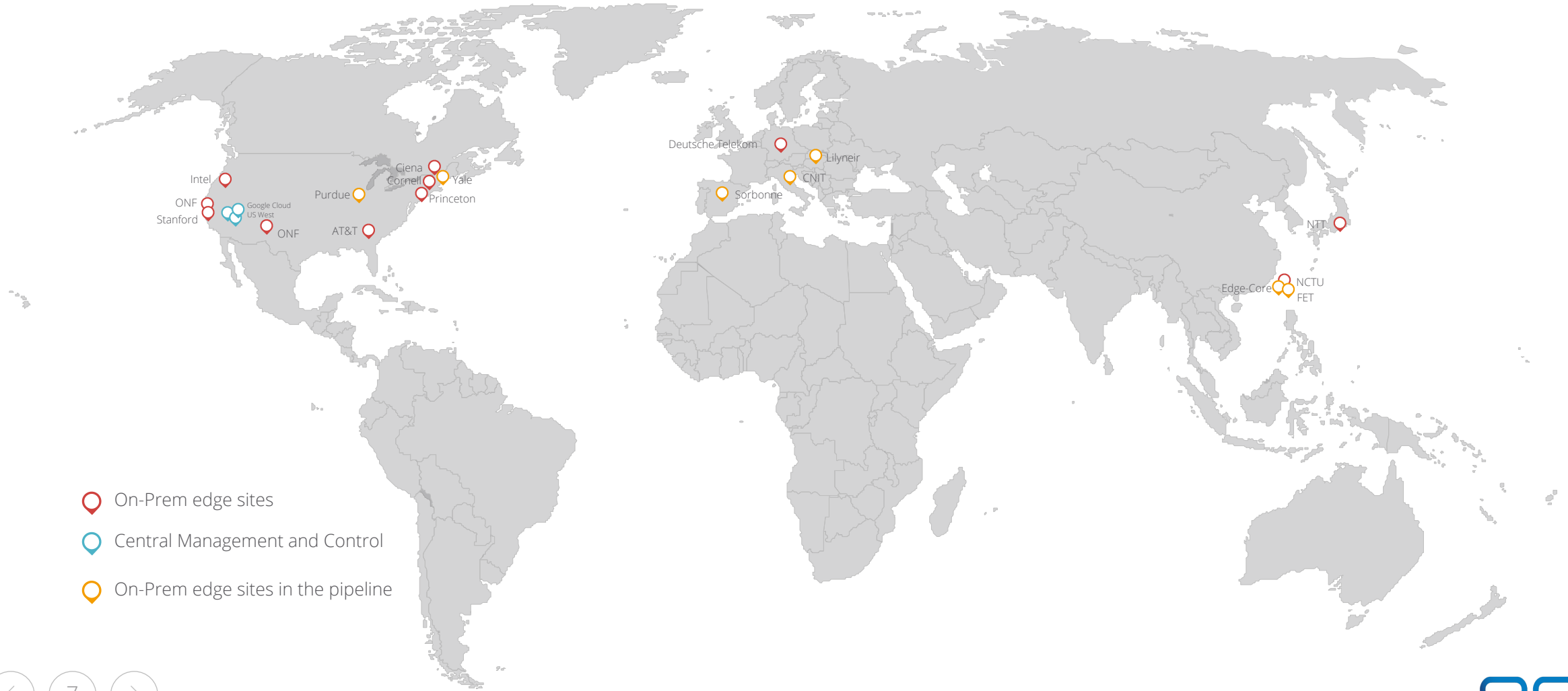
- Network Verifiability
- Verifiable Infrastructure
- Closed-Loop Control
- Software-Defined Edge Cloud Infrastructure
- Software-Defined Disaggregated RAN
- Software-Defined Disaggregated Core
- Edge Cloud Platform Operationalization Towards Pre-Production
- Edge Services



Deeply Programmable 5G Edge Cloud Fabric with Aether

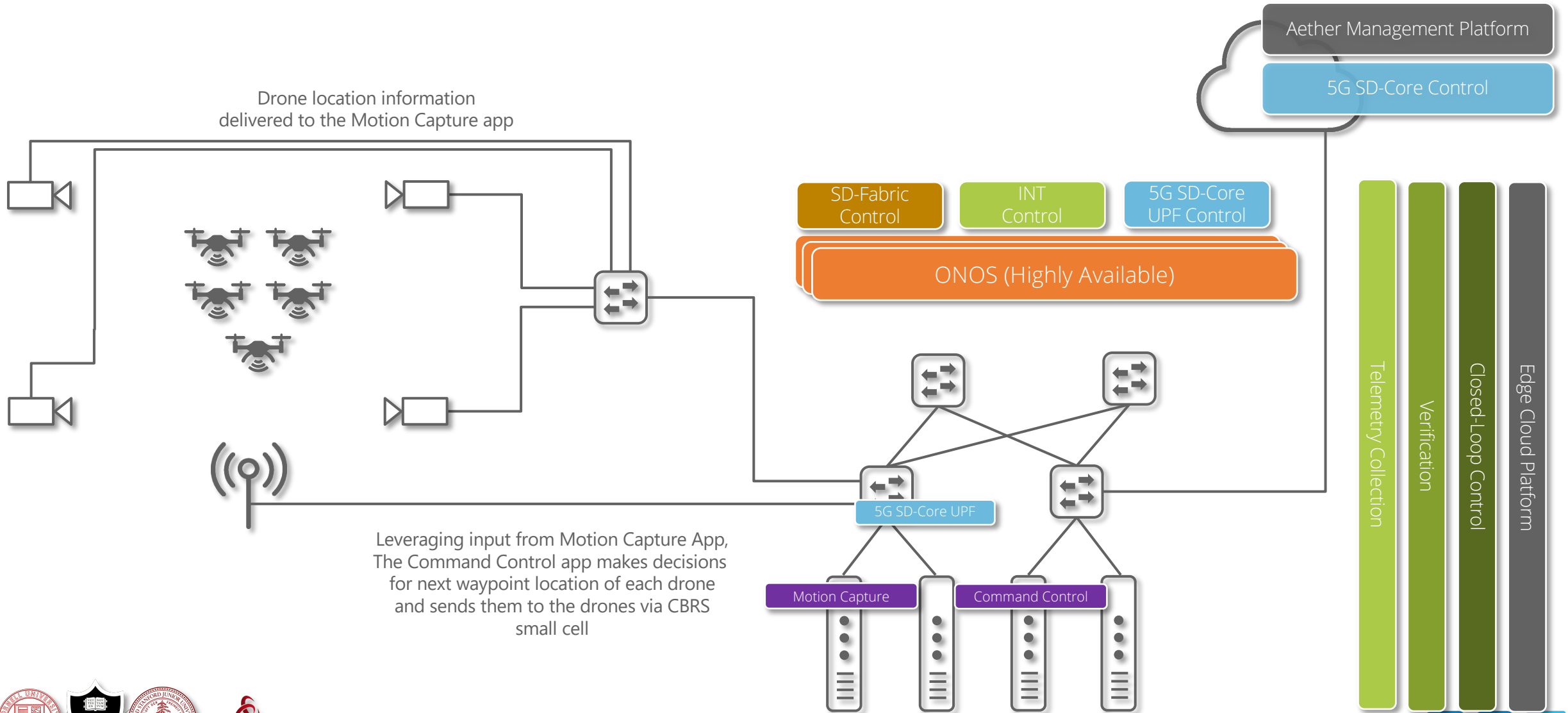


Operational Aether Pilot Network



- On-Prem edge sites
- Central Management and Control
- On-Prem edge sites in the pipeline

Aether at Stanford Flight Lab

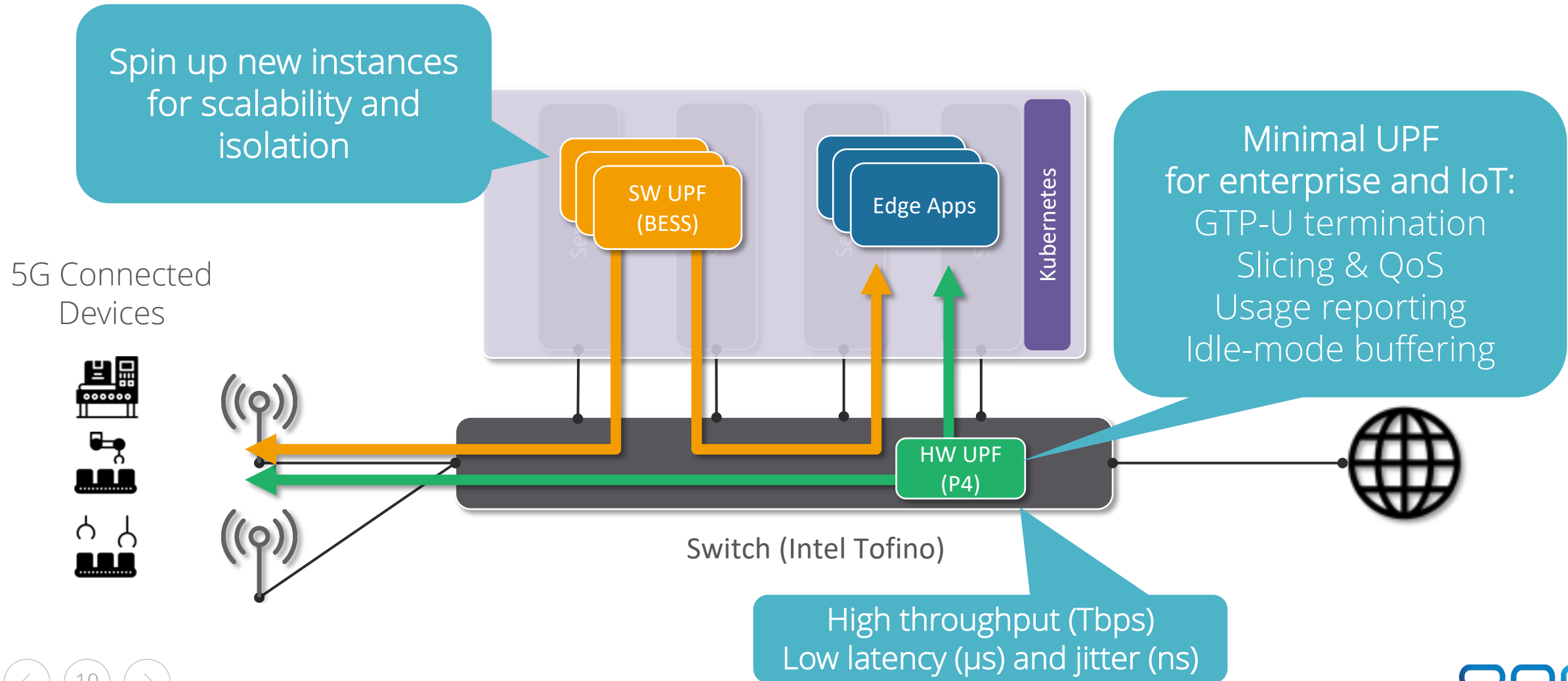


Takeaways

- With 5G, mobile networks are going through a transformation with disaggregation, cloudification and SDN.
- Unlike prior generations, 5G will serve a wide-variety of use cases, with vastly different connectivity requirements.
- Programmability will be essential.
- P4 will enable a programmable 5G edge cloud fabric.
 - 5G mobile core user plane can be realized using P4.
 - Next step will be bringing P4 to the RAN.
- This 5G fabric will enjoy all P4 has to offer:
 - High performance
 - Fine-grained telemetry with INT
 - Verification
 - Closed-Loop Control
- The programmable P4-based 5G fabric will empower
 - Operational visibility
 - Resiliency
 - Automation
 - Closed-Loop Control in multiple hierarchies:
 - Fabric control
 - 5G network control
 - End-to-end control including fabric, 5G network and edge application
- ONF's Aether, with the Pronto project, has developed and operationalized the programmable P4-based 5G fabric.
- Pronto partners continue to bring further programmability, verification and closed-loop control to the 5G fabric.

Aether's UPF: Hybrid Software/Hardware Architecture

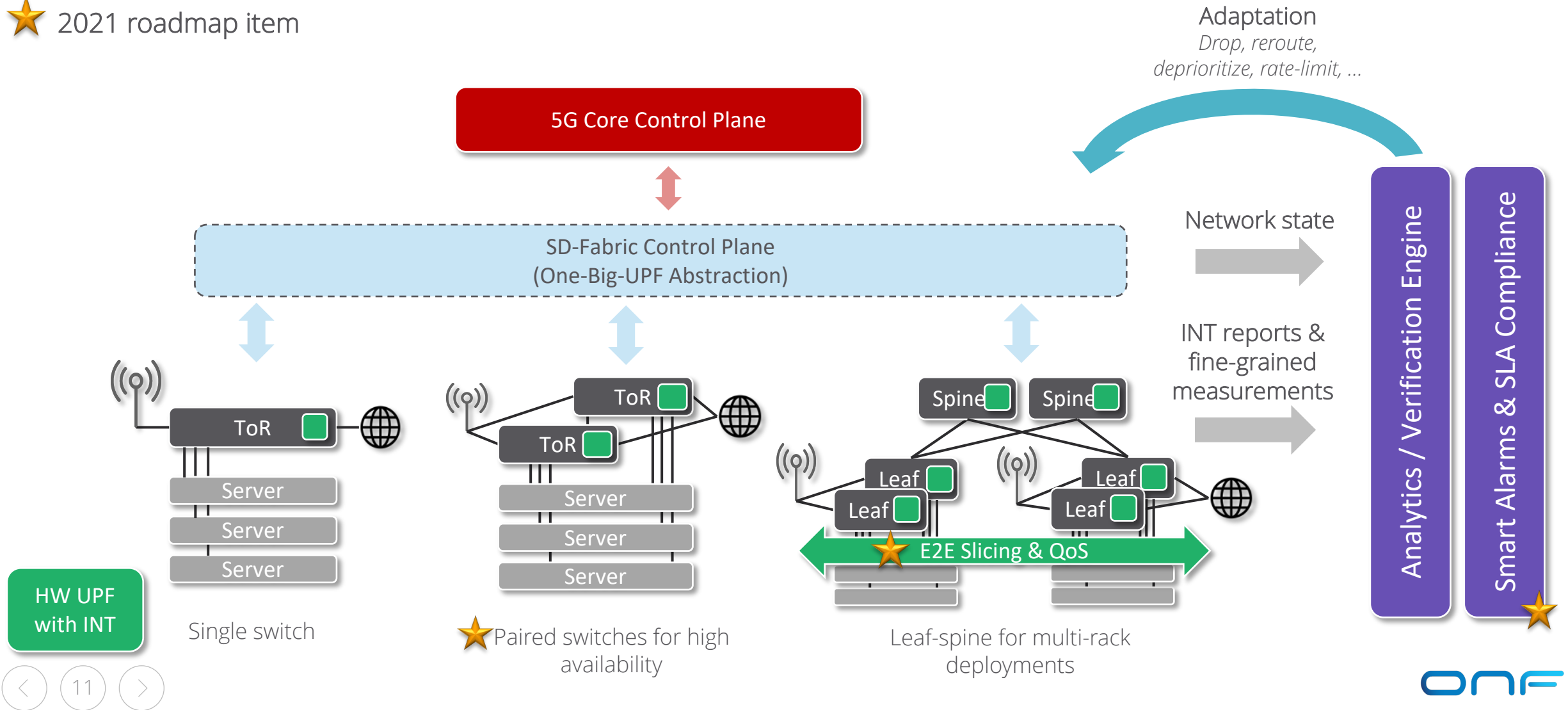
Maximize Scalability and Performance



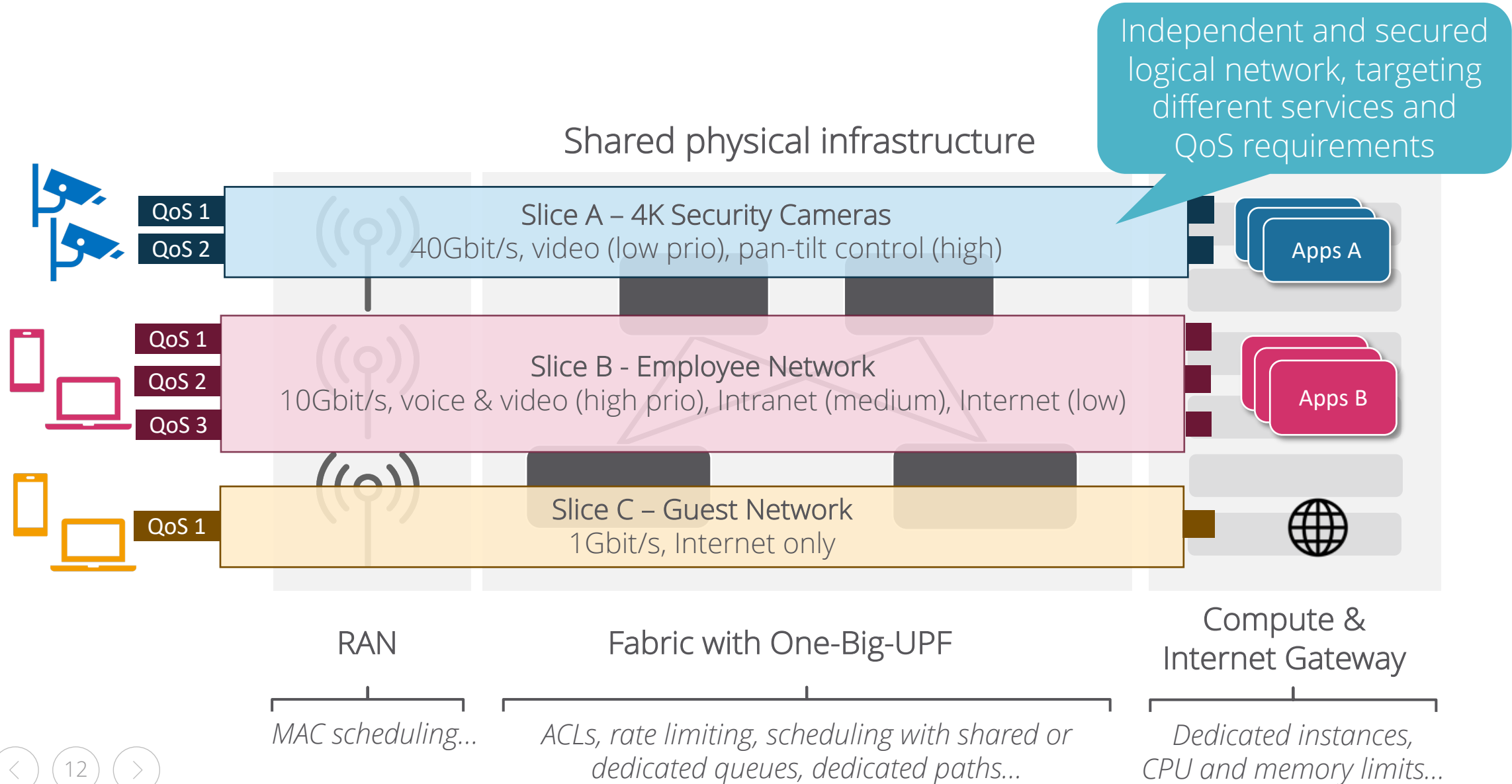
One-Big-UPF as a SD-Fabric Service

Already in production, with deep visibility, and closed loop control

★ 2021 roadmap item



An Important 5G Requirement: E2E Slicing & QoS

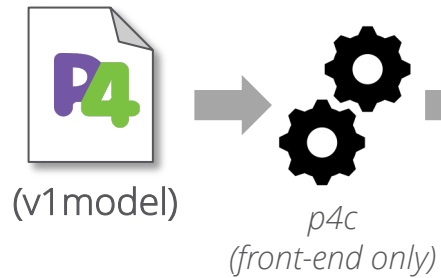


Leveraging P4 in the Control Plane

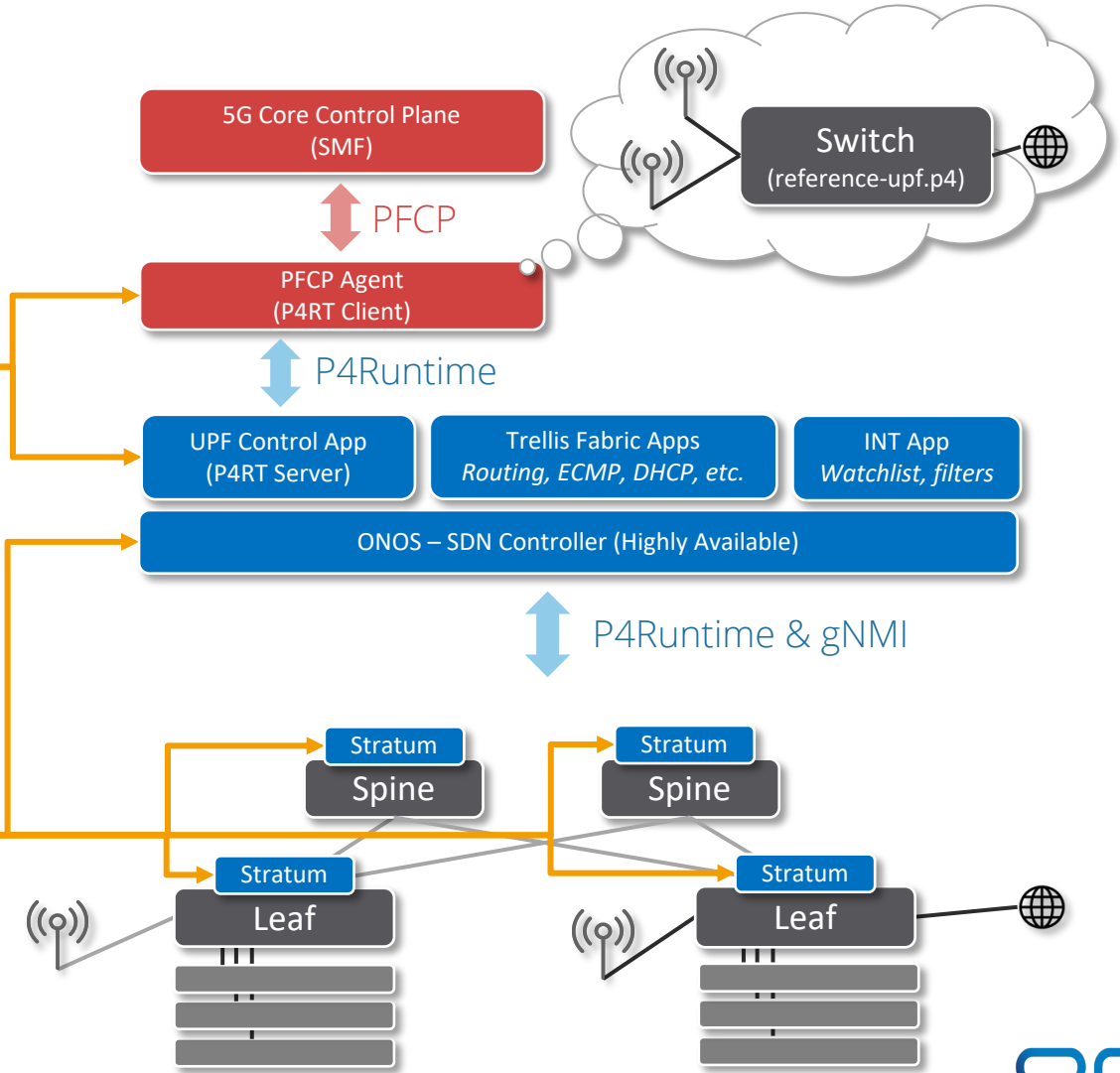
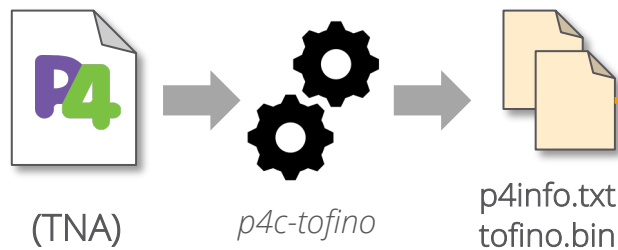
With a Virtual P4-defined Reference UPF

Two P4 programs:

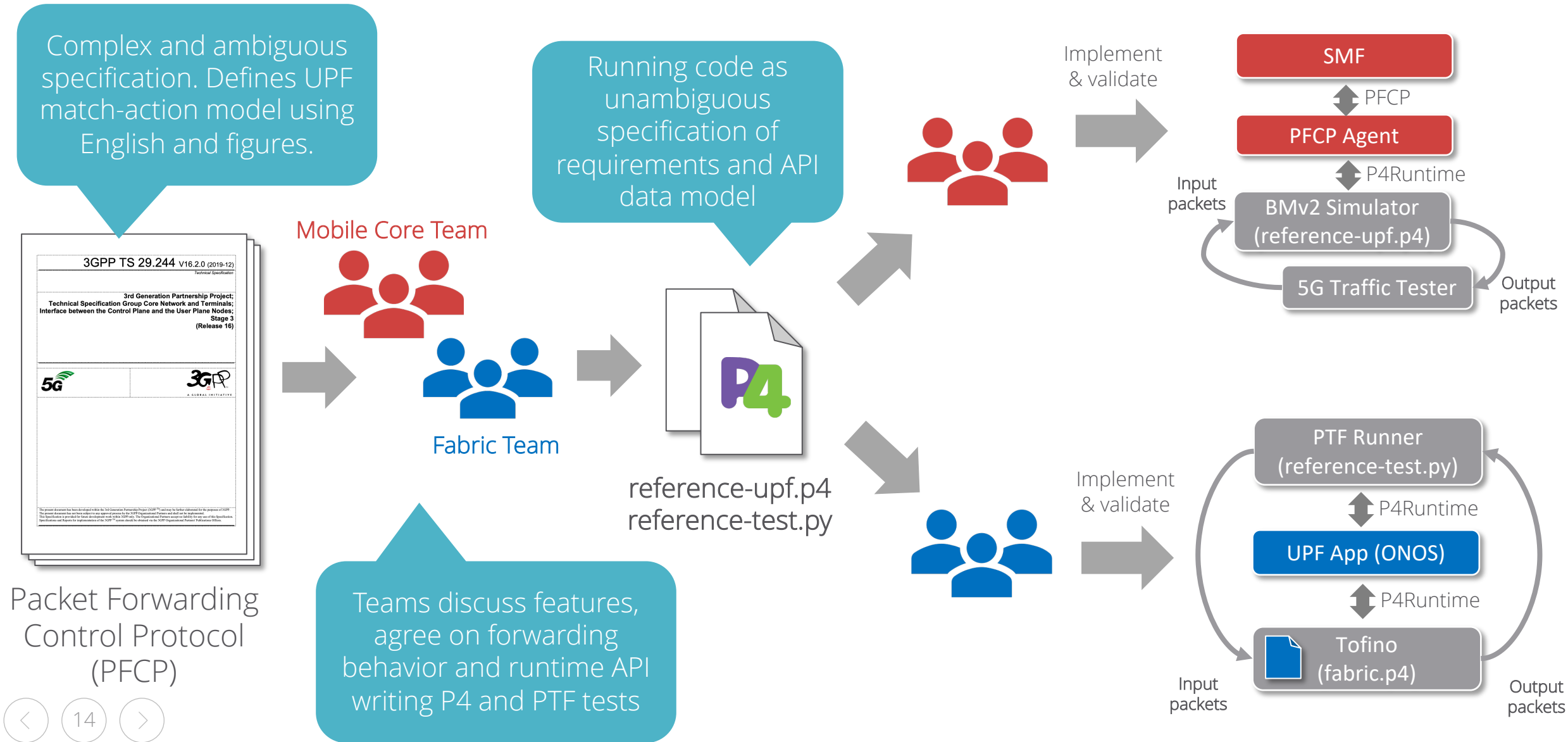
reference-upf.p4
Database-like UPF tables, not optimized for any HW target



fabric.p4
Optimized for Tofino. Defines tables for UPF, routing, ECMP, MPLS, INT, etc.



P4 as the Lingua Franca Between Development Teams

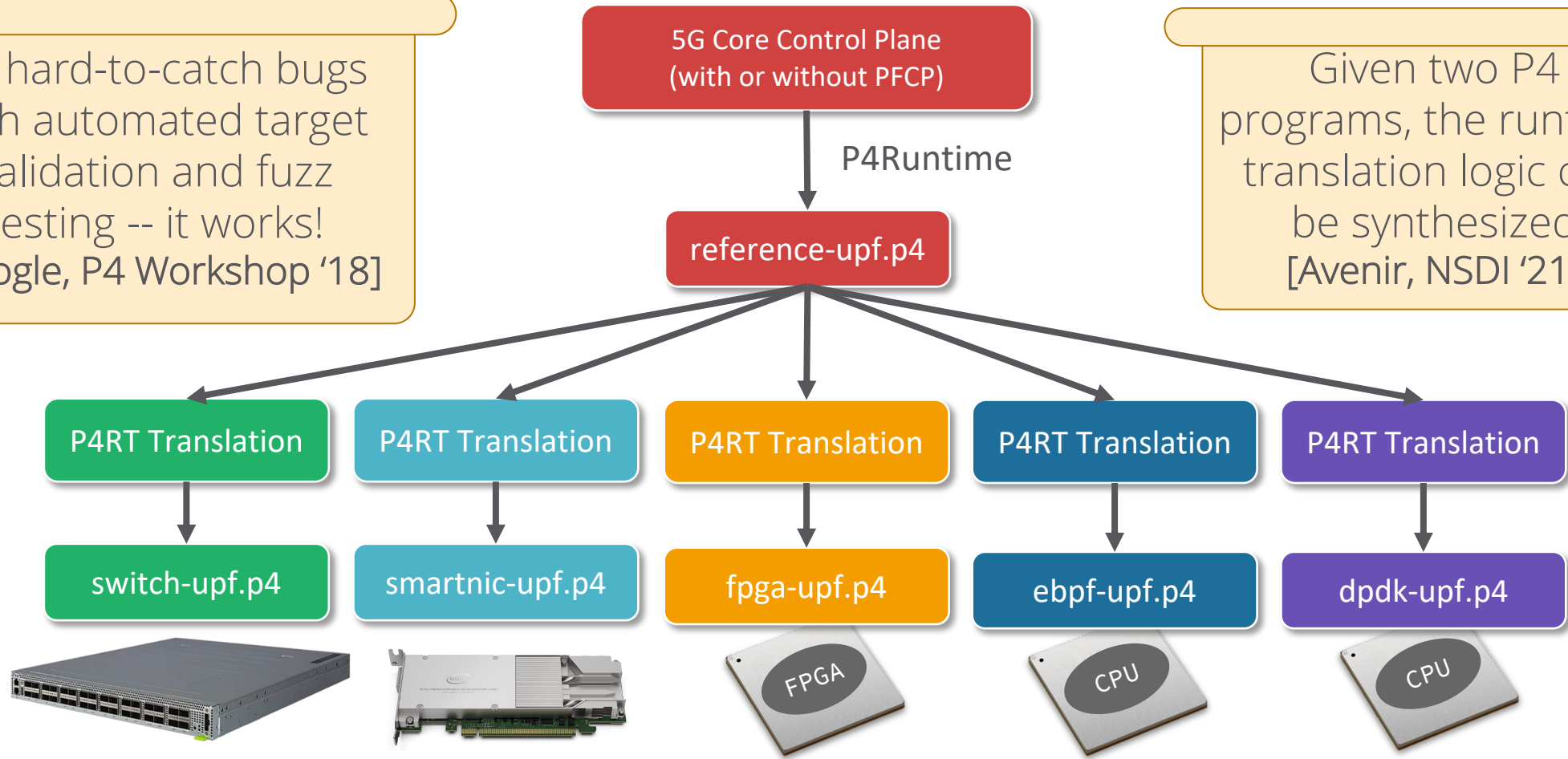


Opportunity: Unlock True Control Plane Portability

Not just for UPF, but other telco appliances: RAN, BNG, OLT, etc.

Fix hard-to-catch bugs with automated target validation and fuzz testing -- it works!
[Google, P4 Workshop '18]

Given two P4 programs, the runtime translation logic can be synthesized
[Avenir, NSDI '21]



Many data plane targets

Equivalent forwarding behavior, but different architectures and pipelines

Closing Remarks

- **Benefits of P4**

- HW UPF allows to free up CPU resources while offering low latency/jitter and high throughput
- Improve control plane development processes and interoperability (reference-upf.p4)

- **Challenges → Research opportunities → Talk to us 😊**

- UPF slicing with shared HW resources: security, isolation, QoS
- Dynamic allocation of sessions to HW or SW UPF
- Automated validation of new HW/SW targets using reference-upf.p4

- **Looking forward**

- Heterogenous HW UPF strategy with SmartNICs and FPGAs for deployments without ToR
- Extend P4 programmability into the RAN for E2E visibility and closed loop control

Thank You