

The Network as a Programmable Platform

Realizing Verifiable Closed-Loop Control in 5G Networks

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THIS TALK

Network as a Platform

- Where Software-Defined Networking (SDN) is taking us

What that means for networking in general

- And the cellular network in particular

An opportunity to get involved

- Aether: An Open 5G-Enabled Edge Cloud for Enterprises

SDN JOURNEY (SO FAR)



Compute mainframes



Network mainframes



Server running control plane



Whitebox switch

Closed & proprietary
Bloated & complex
Little incentive to improve

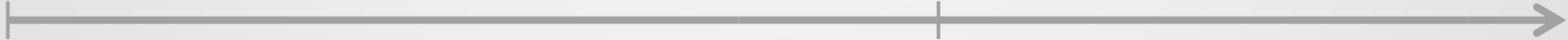
Hard to manage
Hard to secure
Hard to change

Merchant silicon
Open source
Cloud practices

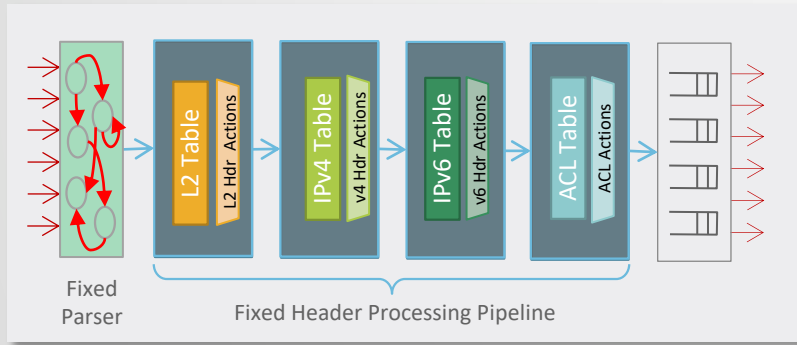
Easier to fix
Easier to innovate
Simpler to operate

2005

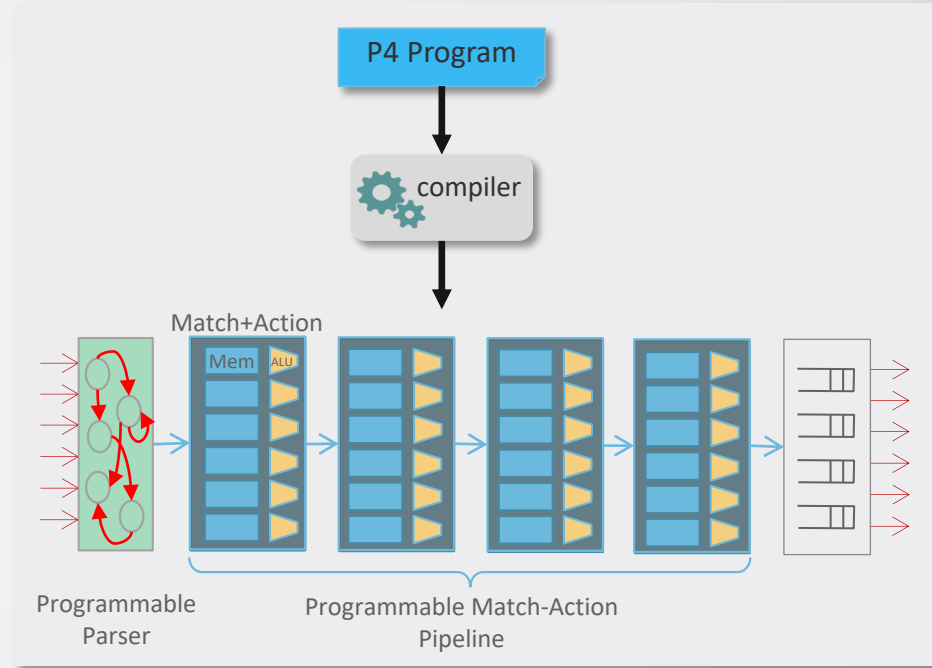
2020



SDN JOURNEY (IN PROGRESS)



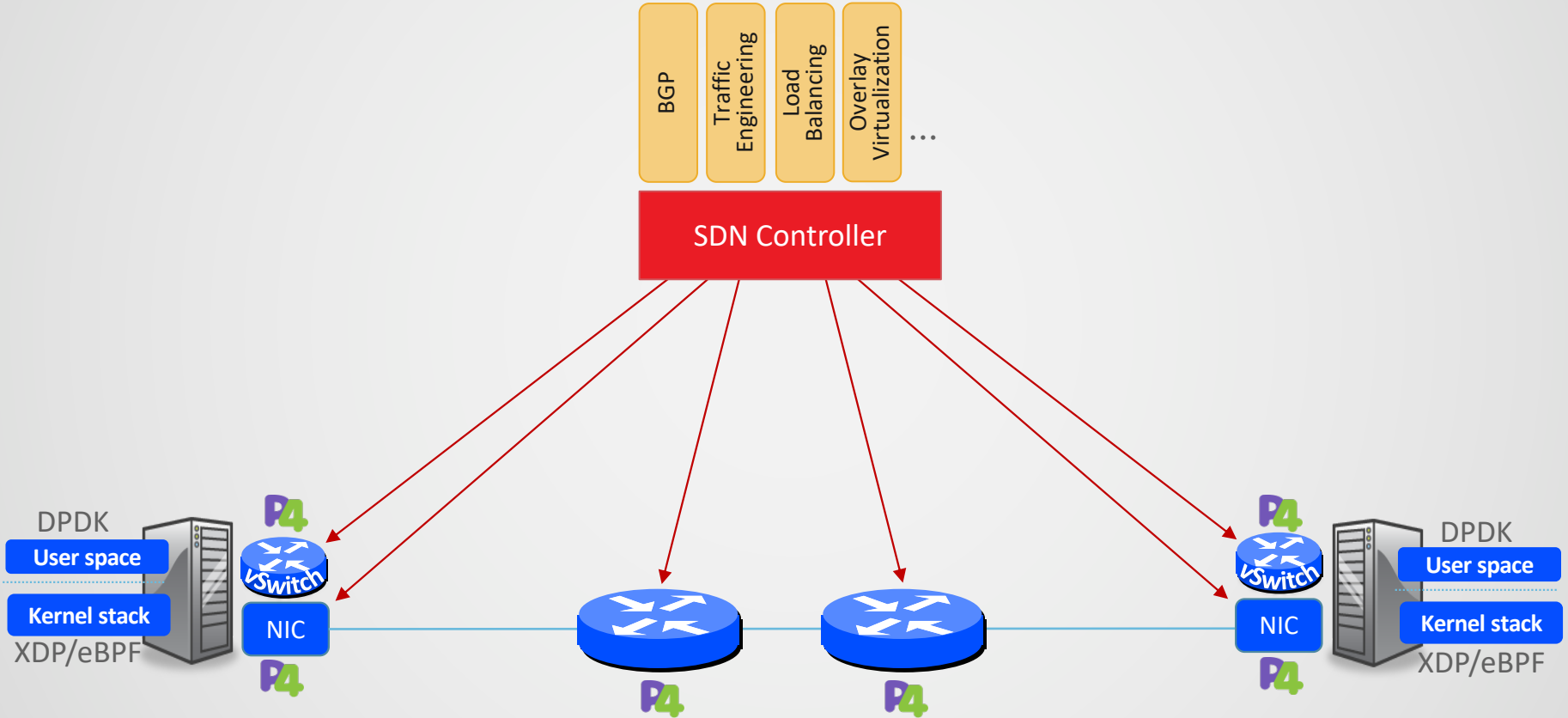
Fixed function switches and NICs



Programmable switches and smartNICs

What does this all mean for networks?

PROGRAMMABLE END-TO-END & TOP-TO-BOTTOM



PROGRAMMABLE END-TO-END & TOP-TO-BOTTOM

Specified Behavior

Compile

SDN Controller

Partition

Compile

Compile

Compile

DPDK

User space

Kernel stack

XDP/eBPF



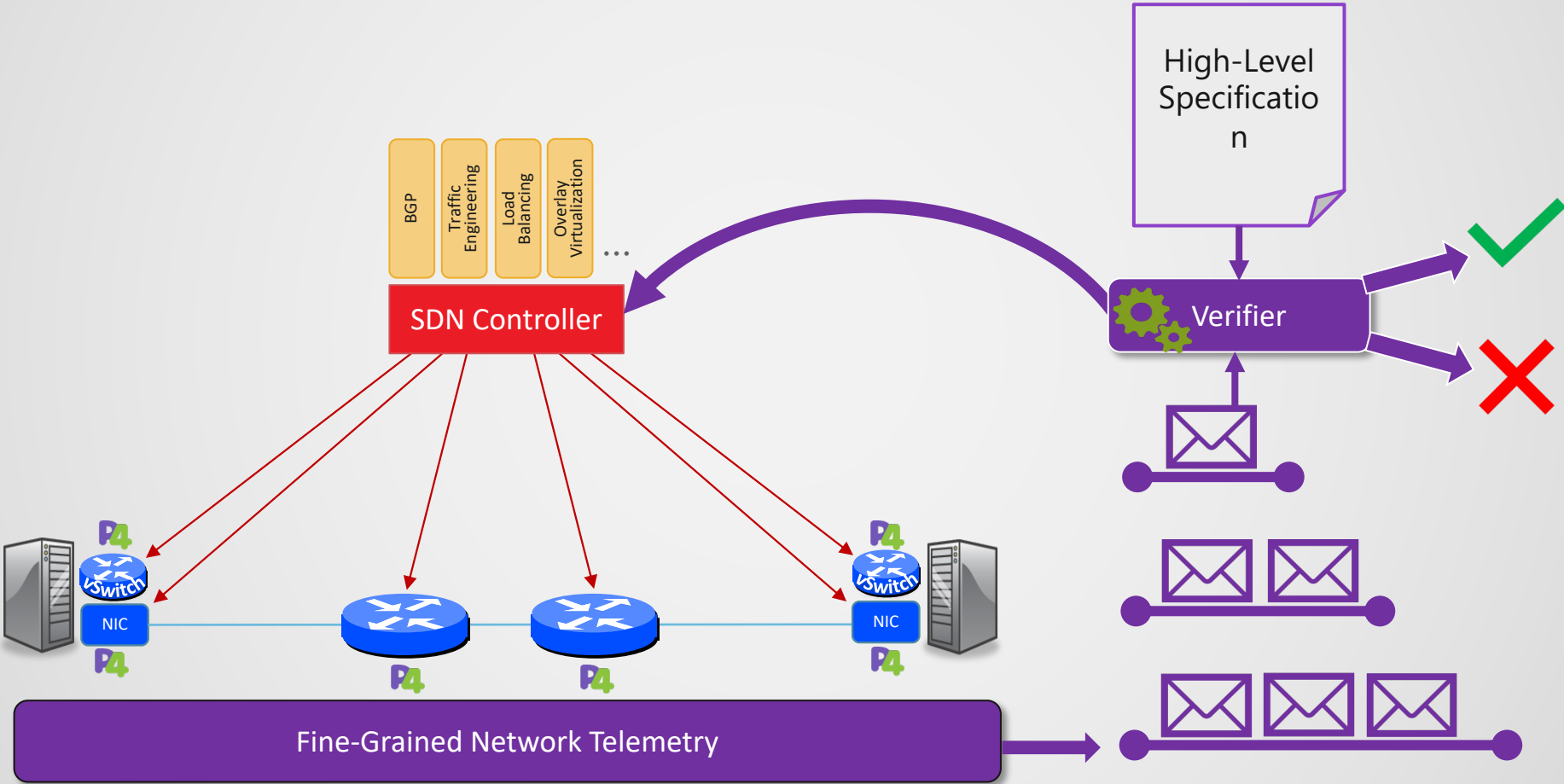
DPDK

User space

Kernel stack

XDP/eBPF

VERIFIABLE CLOSED-LOOP CONTROL



PROGRAMMABLE END-TO-END & TOP-TO-BOTTOM

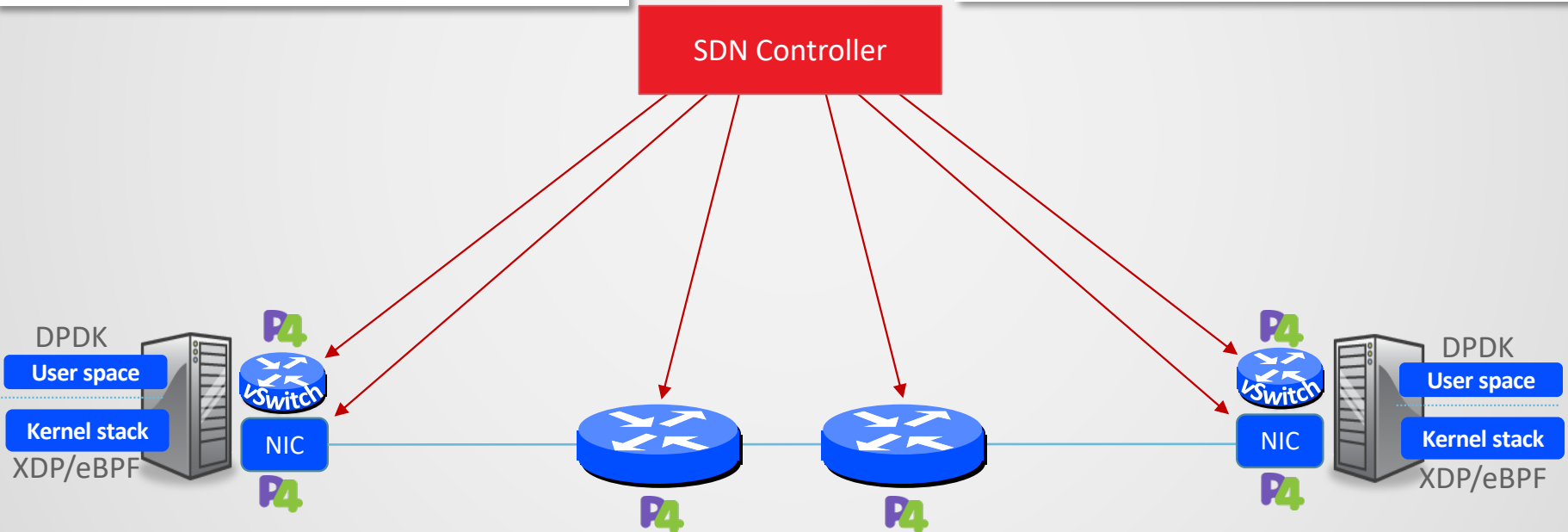
Networks, for the first time, will be:

- Programmable end-to-end
- Specified top-to-bottom
- Defined entirely by software

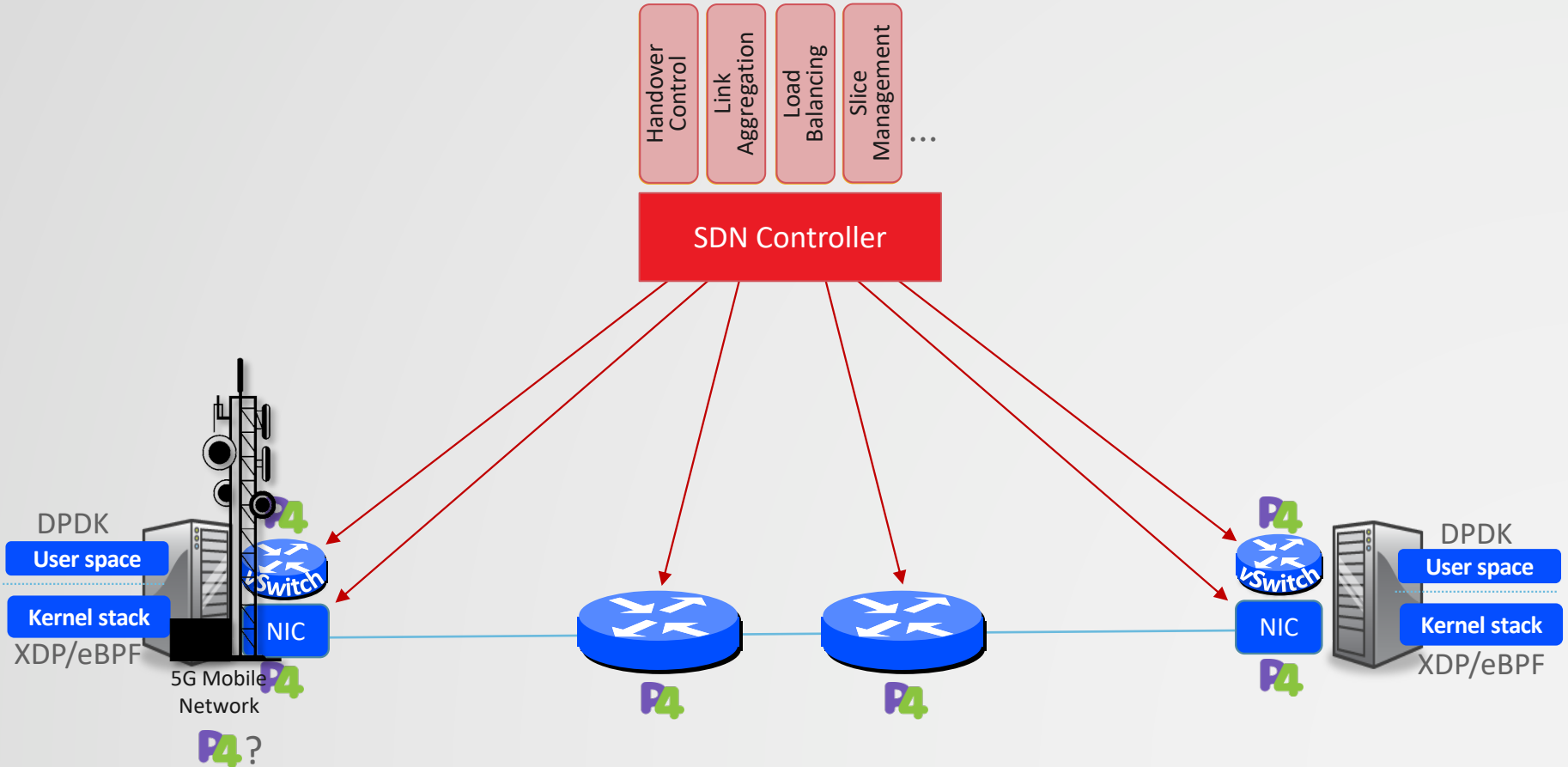


This creates new possibilities:

- Network is correct-by-construction
- Verify against network specification
- Correct through closed-loop control

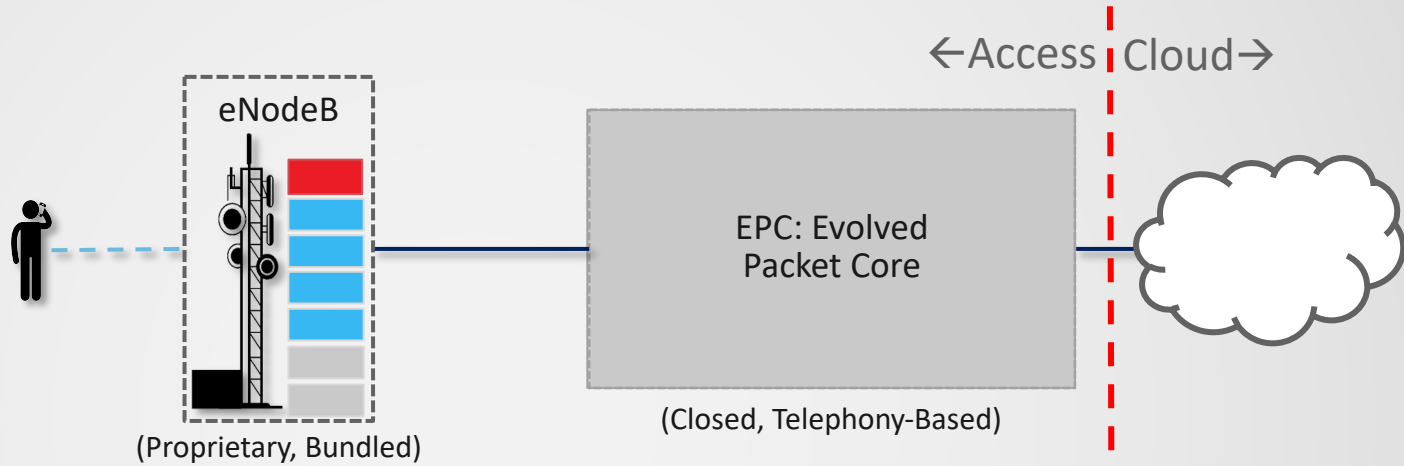


PROGRAMMABLE END-TO-END & TOP-TO-BOTTOM

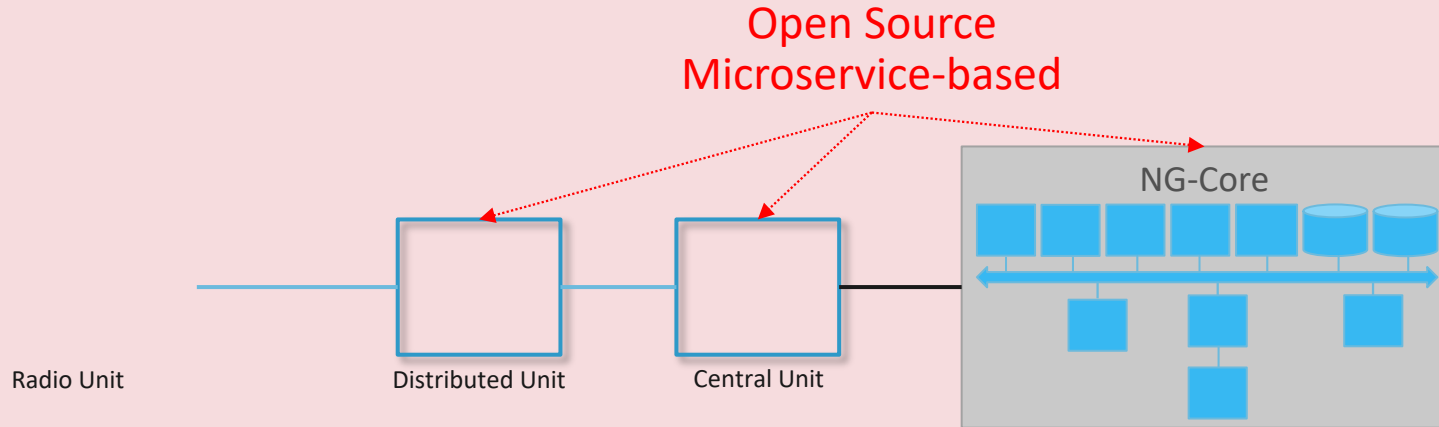


5G TRANSFORMATION

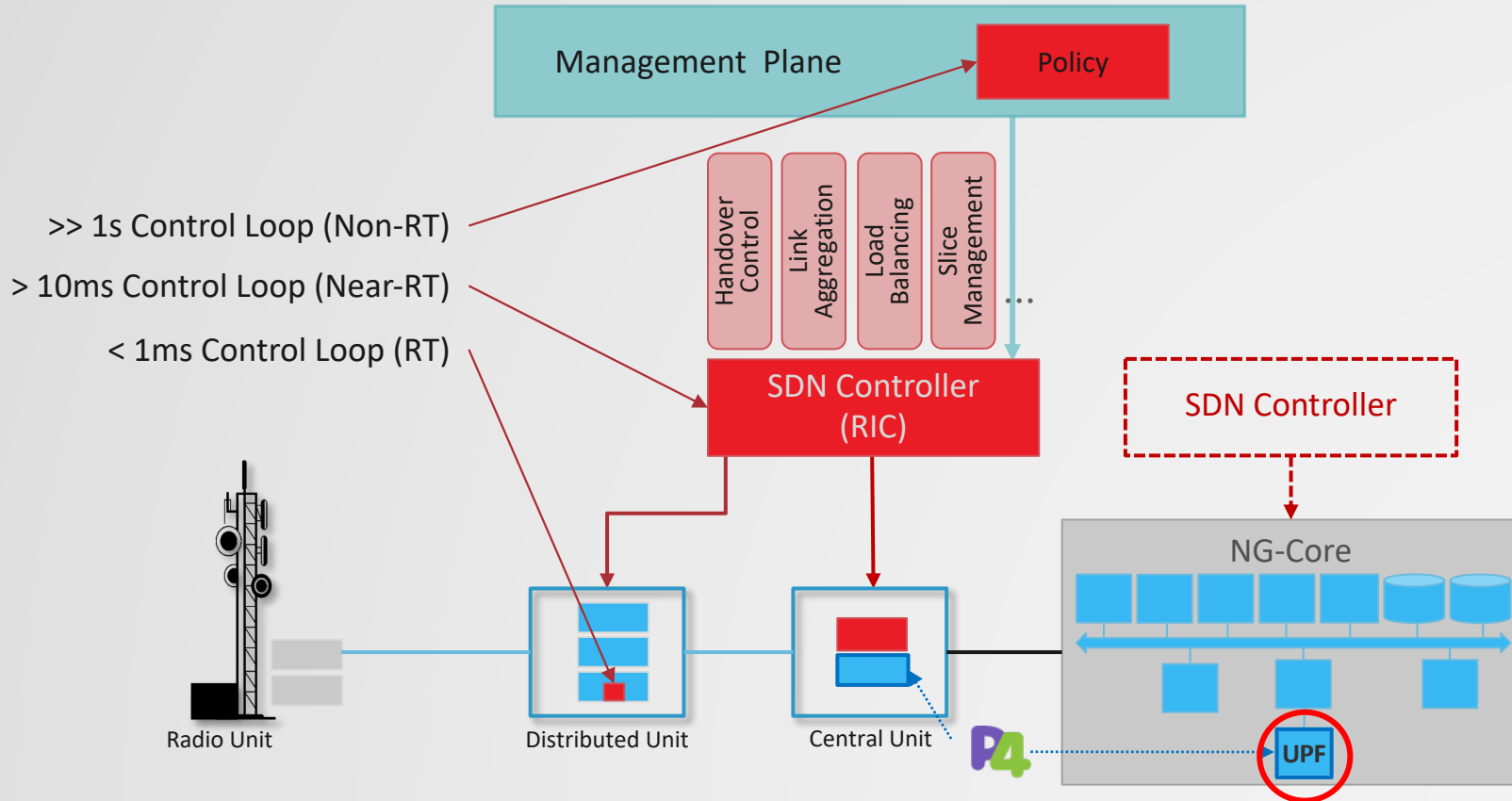
4G



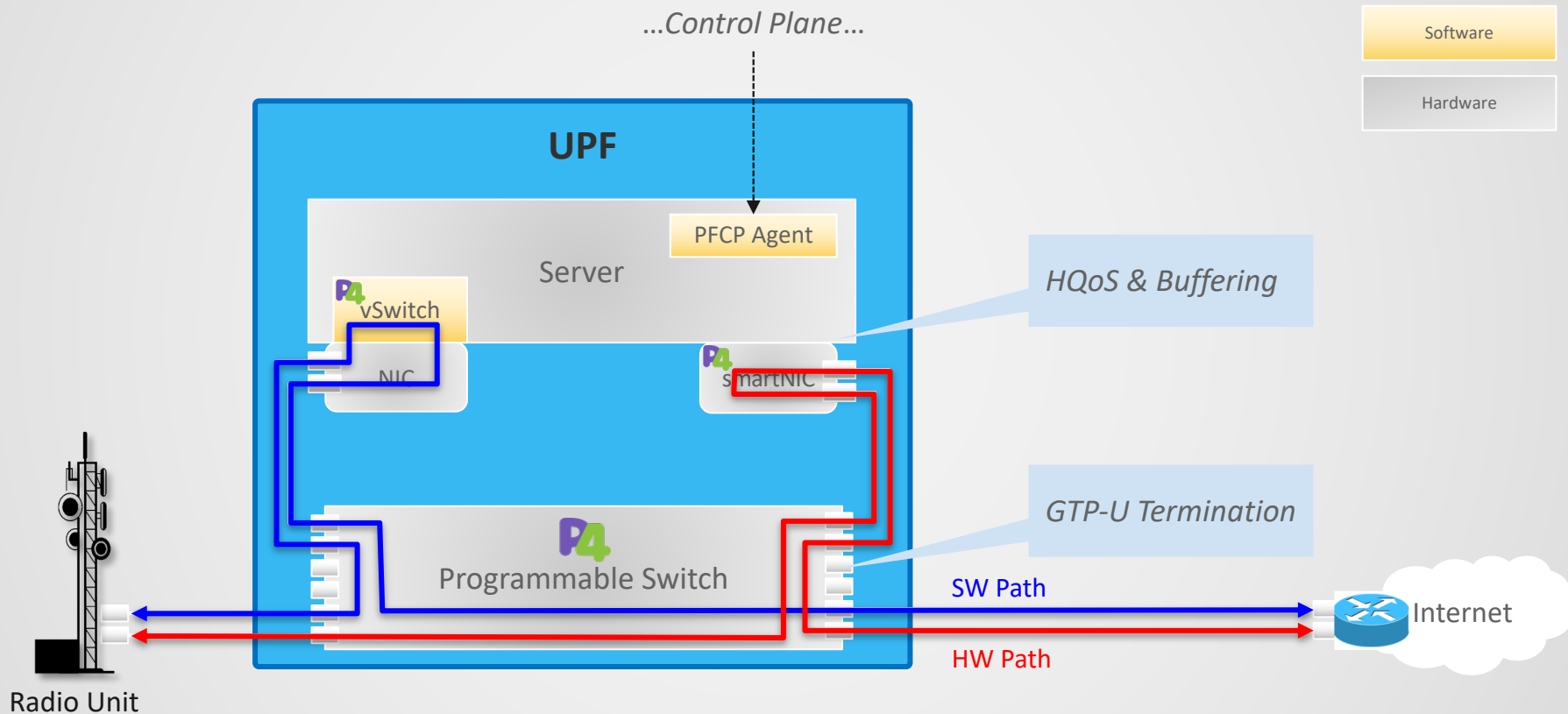
5G



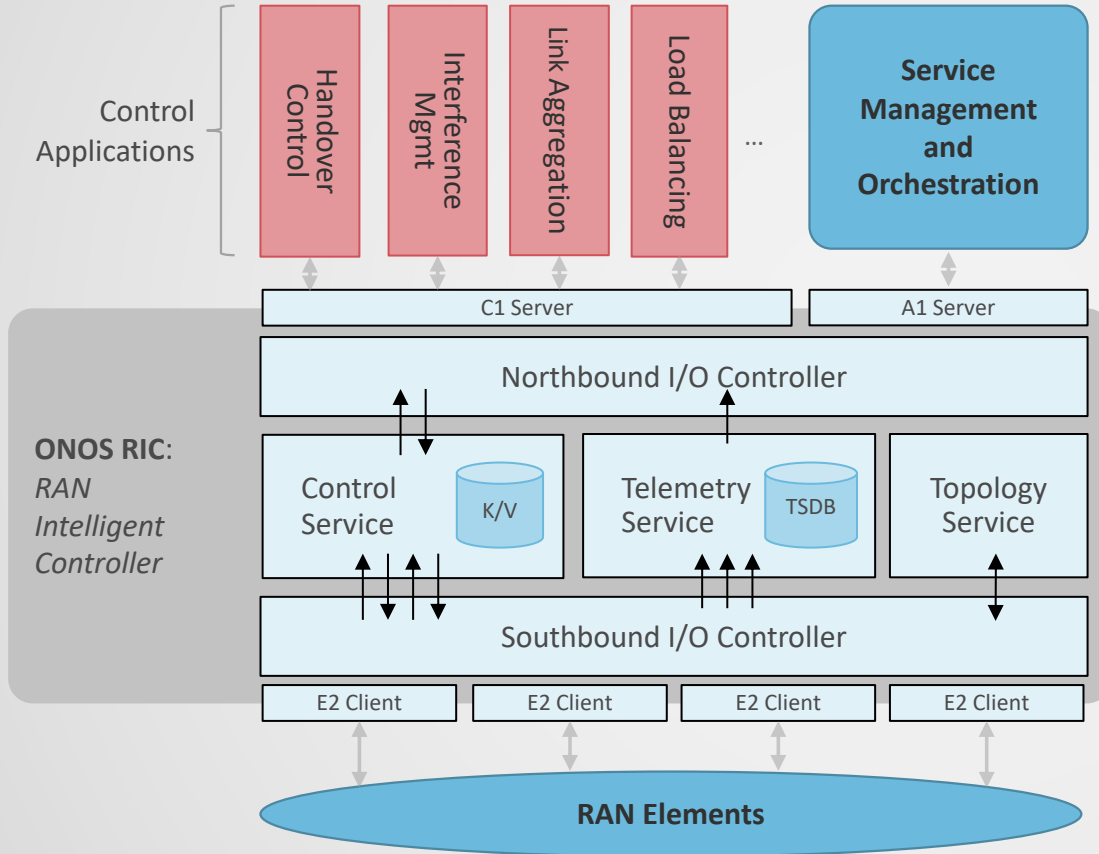
PROGRAMMABLE END-TO-END & TOP-TO-BOTTOM



DEEP PROGRAMMABILITY



ONOS-BASED RIC



Handover Performance
(200-300 per-second)

Latency	Number of UEs		
	10,000	25,000	100,000
Average	0.8 ms	1.3 ms	1.5 ms
90%	1.3 ms	1.5 ms	1.5 ms
95%	1.9 ms	2.5 ms	1.9 ms
99%	4.6 ms	8.3 ms	4.4 ms

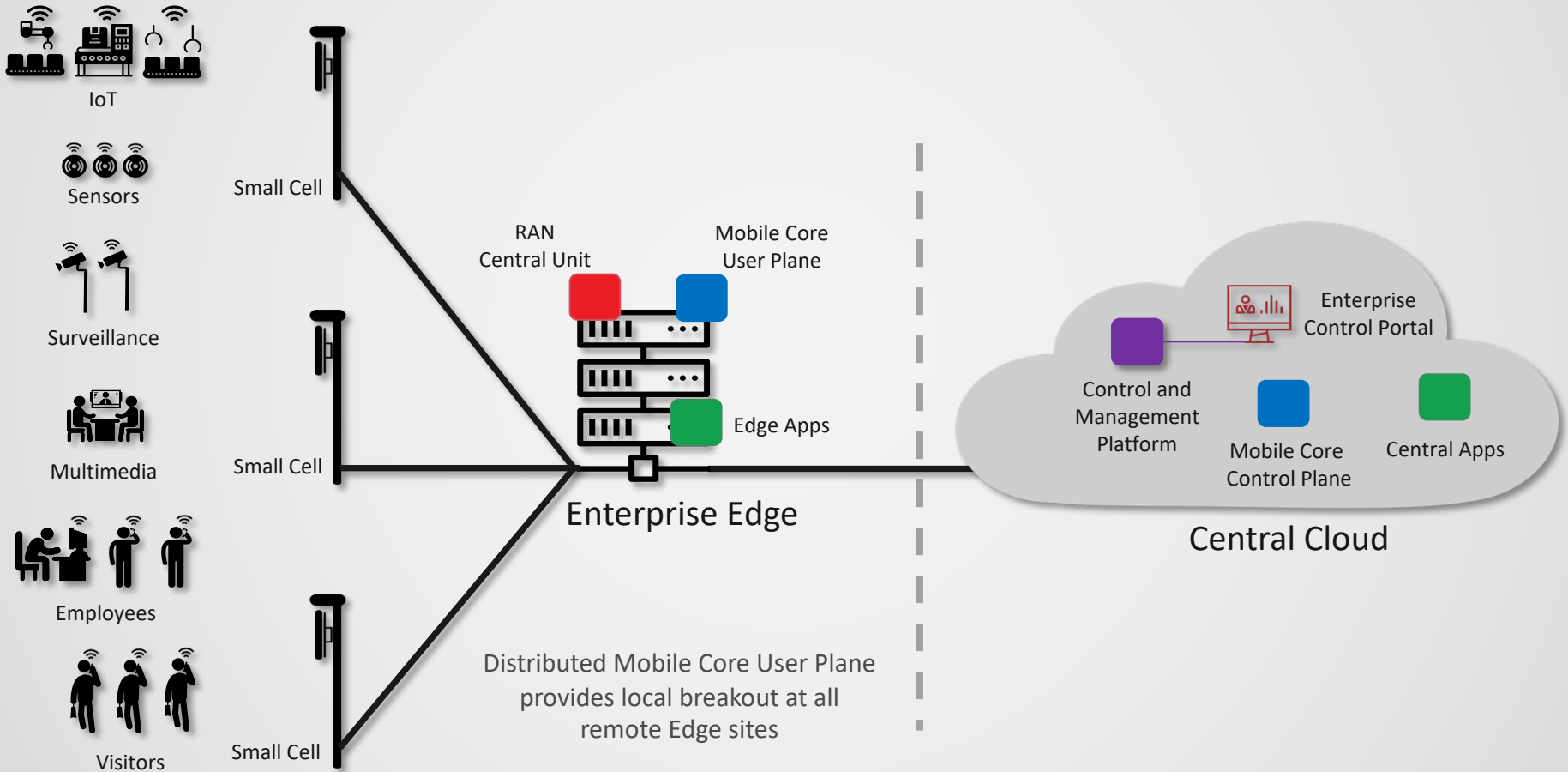
Compute Resources: 1x

3x

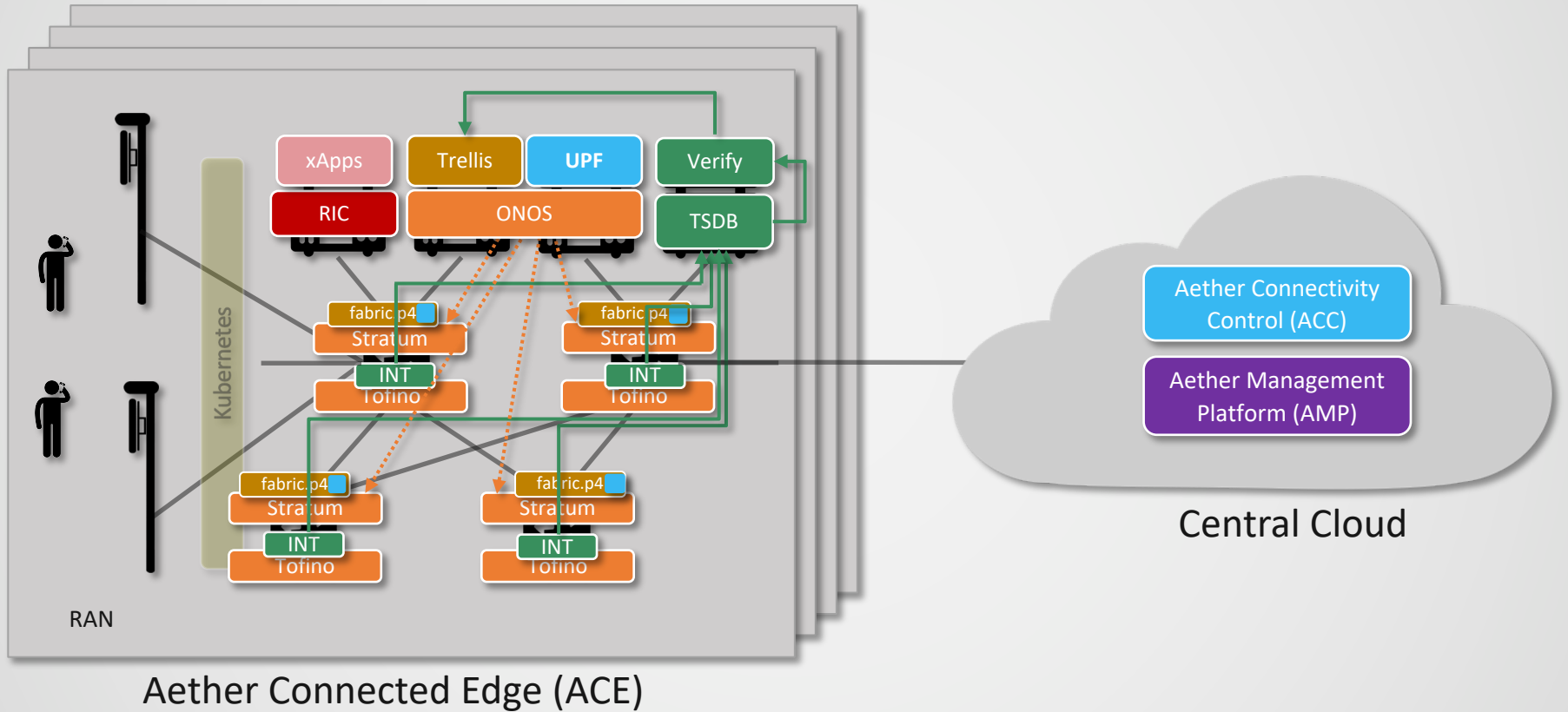


Managed 4G/5G Edge Cloud for Enterprises
(an ONF Project)

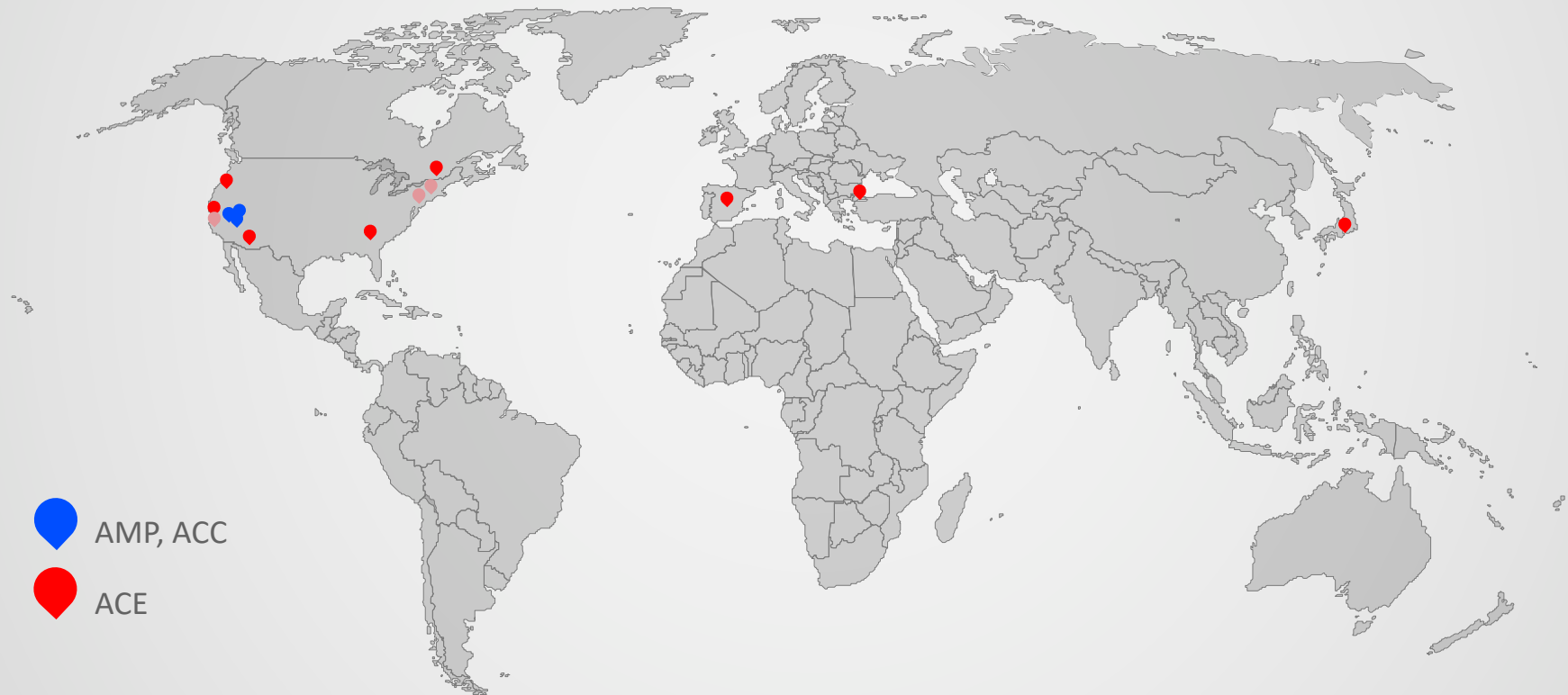
AETHER OVERVIEW



AETHER COMPONENTS



AETHER HAS BEEN OPERATIONAL SINCE DECEMBER '19



MORE INFORMATION

Deep Programmability

- *ACM SIGCOMM Computer Communication Review*, Oct 2020 (to appear)

Aether

- <https://www.opennetworking.org/aether/>

SD-RAN

- <https://www.opennetworking.org/sd-ran/>

Background Tutorials

- <https://5G.systemsapproach.org>
- <https://SDN.systemsapproach.org>