



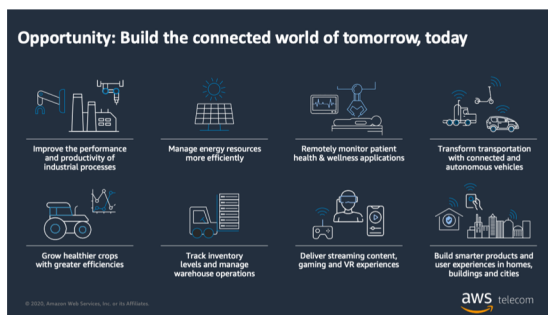
5G and Next G Innovation Opportunities and Challenges: Enabled by Disaggregation, SDN and Open Source

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5G Combined with IoT and edge cloud will have a transformative impact

Biggest Cloud Operators Pursuing 5G Powered Edge as Major Emerging Opportunity



The days of all cloud capabilities being centralized in data centers are beginning to disappear.

As 5G networks expand, operators are deploying Wavelength Zones so application traffic from 5G devices can take full advantage of the low latency and high bandwidth. And when fast connections to the cloud are pushed to the farthest edges of the network, great things can happen.

Werner Vogels, CTO, Amazon

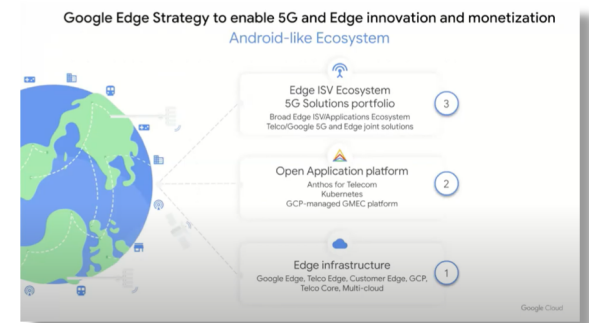


We are at peak centralization right now, as computing becomes embedded everywhere in our world, transforming how we interact with people, places, and things.

As physical and digital worlds converge, we will require more sovereignty and decentralized control. Cloud and Edge computing will evolve to meet all of these real-world needs.

Satya Nadella, CEO, Microsoft

Acquisitions
\$1.35B – Affirmed
\$270M - Metaswitch



With 5G, we see an opportunity to make the telecommunications network not just about latency and bandwidth, but as a platform to deliver applications.

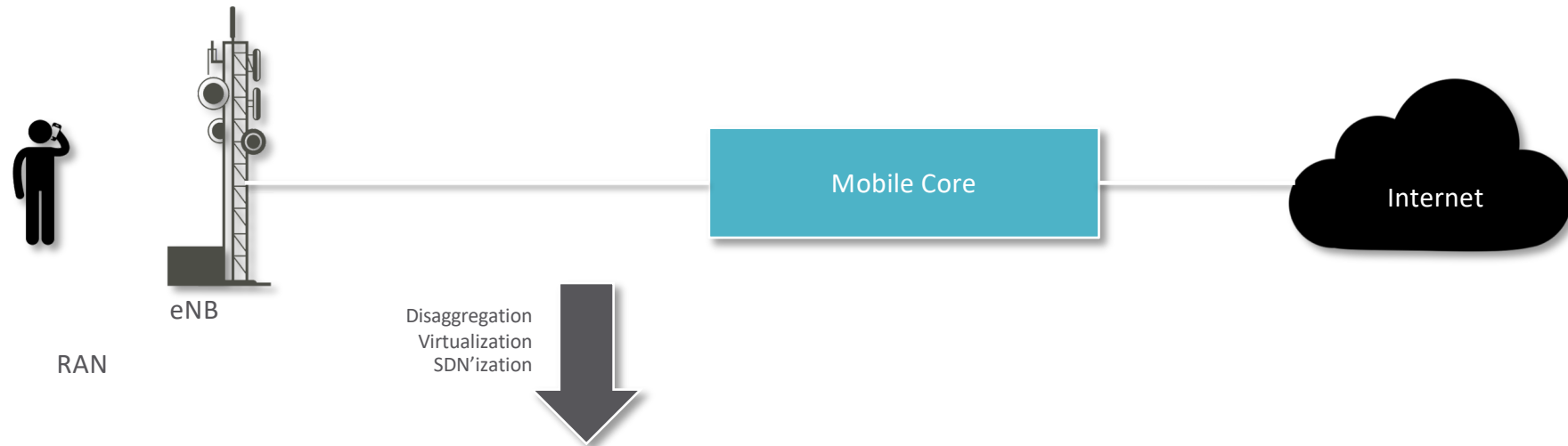
Thomas Kurian, CEO, Google Cloud

Researchers have a big opportunity to shape this transformation

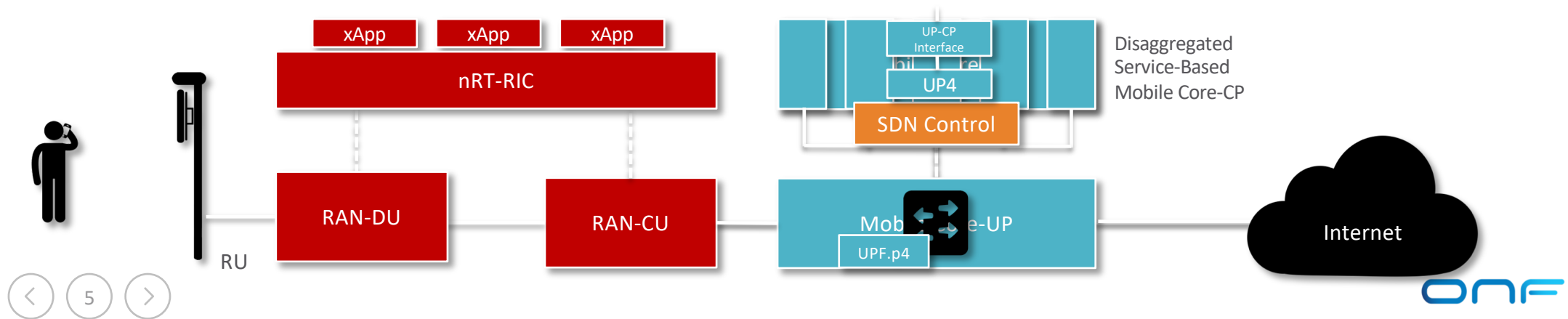
Enabled by Disaggregation, SDN and Open Source

Mobile Network Evolution to 5G to Next G

In part enabled by O-RAN



Disaggregation
Virtualization
SDN'ization

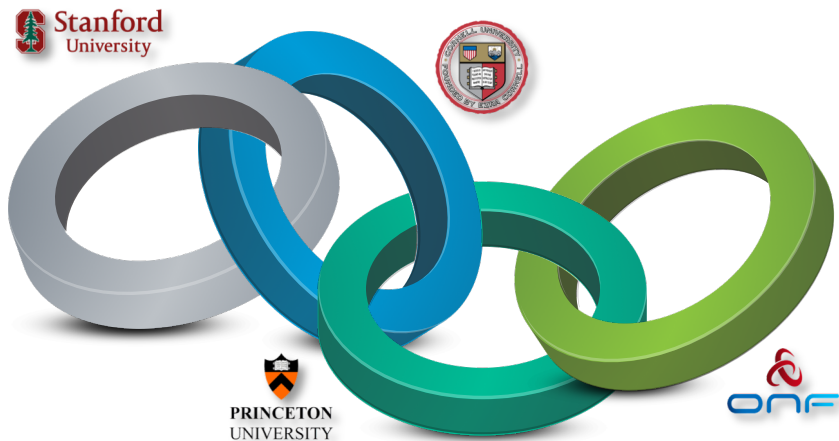


Multiple open source platforms are emerging for
the research community to use and build on

Pronto Project: Example 5G Platform with Open Source & Disaggregation



\$30M DARPA Grant to Realize an Integrated Platform for 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

platform for 5G connectivity

operational network in production environment

carries real traffic for innovative edge services

verifiable closed-loop control



Aether (Pronto's 4G/5G Connected Edge Cloud Infrastructure) has been operational



A rack of 2x2 SDN fabric, CPU (and GPU) servers at each edge location forming the edge cloud



Small cells providing 4G/5G capacity and coverage serving real-life traffic for Internet access and edge applications



Drones, IoT devices and mobile phones as end-user devices



Aether Pilot Network Deployments



Aether (or any such infrastructure) as a Resource to Researchers

- Aether is software-defined and deeply programmable: top to bottom and end-to-end
 - Any part of the network can be modified
- Aether is standards compliant (3GPP and O-RAN)
 - Bring off-the-shelf devices and you can expect them to work with Aether
 - Higher probability of impact with real networks
- Aether is production ready
 - Not a research prototype: Aether has scale, performance, HA, operational tooling
 - A researcher can test her work in a close-to-real-life setting
 - Higher probability of impact with real networks

A lot of similarity to 1980s when the research community shaped the Internet

1980s and Internet

- 1983: ARPANET adopted TCP/IP
- 1980s: DARPA funded UC Berkeley (CSRG) to develop open source BSD Unix including TCP/IP stack
- 1986: NSFNET went online
- 1980-90s NSF funded many infrastructure grants to allow CS/EE departments & campus IT to
 - Acquire Ethernet, VAX, and a set of workstations running BSD UNIX with TCP/IP stack
 - Connect this campus network to NSFNet
- 1985-1993: number of Internet connected computers grew from 2000 to 2M+

Research community shaped the Internet in 1980s with key visionary investments by DARPA and NSF

2020s and 5G/Next G with Edge Cloud

- 5G and O-RAN architecture and spec are mature
- DARPA has been taking the lead in funding disaggregated software defined open source 5G
- NSF has been funding shared facility (PAWR) for research on 5G and next G
- It is time for funding agencies (NSF?) to allow many CS/EE departments and campus IT to acquire
 - Open source private 5G with connected edge cloud
 - Connect these campus 5G connected edges to national infrastructure

And enable the community to innovate and shape 5G/Next G and Edge Cloud transformation

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 - Connect this campus network to the Internet
- 1985-1993: number of computers connected to the Internet grew rapidly

Research community shaped the Internet in 1980s with key vision and funding by DARPA and NSF

2020s and 5G/Next G and Edge Cloud

- 5G and O-RAN are maturing
 - DARPA is funding open source 5G research and development facility (PAWR) for Next G
 - Request for funding agencies (NSF?) to allow many CS/EE departments and campus IT to acquire
 - Open source private 5G with connected edge cloud
 - Connect these campus 5G connected edges to national infrastructure
- And enable the community to innovate and shape 5G/Next G and Edge Cloud transformation

Are you ready to ask your funding agencies to get your own open source private 5G with connected edge cloud so you can shape this transformation?

THANK YOU!

Challenge:

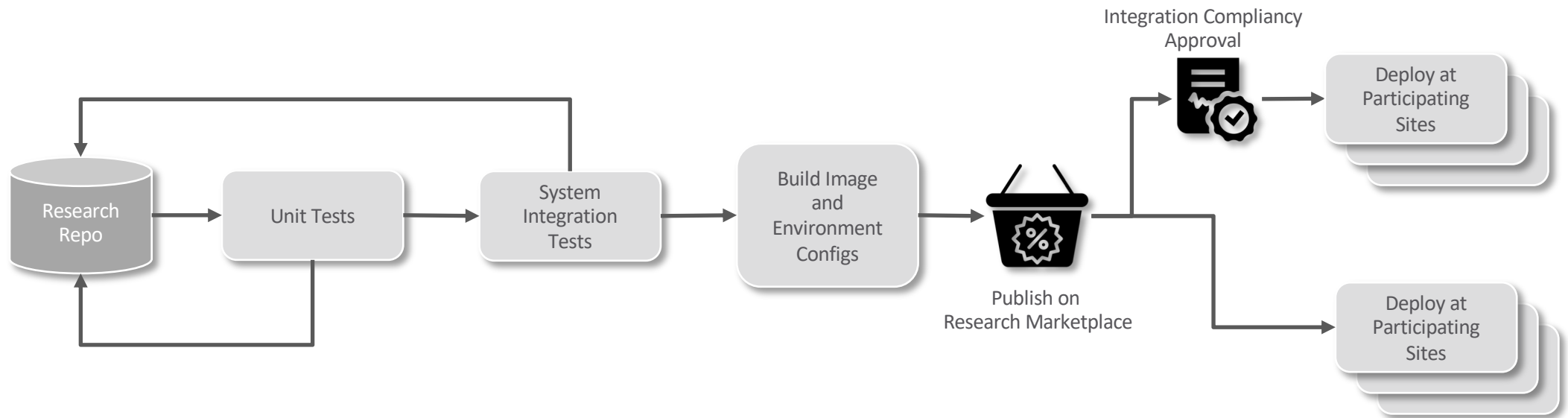
There is a learning curve: complex software systems with state-of-the-art CI/CD tools and processes

Return on Investment (ROI) is very high

You can shape the future of 5G/Next G and Edge Cloud
Software and CI/CD expertise will make graduate students hot in the job market

ONF is trying to make it easier for researchers to contribute

(Learning from various App Store models)



Aether (or any such infrastructure) as a Resource to Researchers

- Aether has a state-of-the-art CI/CD toolchain
 - Automated toolchain for software development, testing, integration and deployment
 - Automated toolchain for incremental software upgrades in an operational network
 - Highly instrumented to allow monitoring, debugging
 - If a researcher invests the time to learn the toolchain, then software development, testing and deployment becomes easy
- Aether is easy to deploy
 - A university can deploy Aether Connected Edge (ACE) – costs only \$30K – and become part of a larger network
 - ONF makes it easy to deploy and operate ACE