White paper
Cisco Public

The bridge to possible

Deploying the First 5G Network with Hybrid Cloud

Reflections and Lessons Learned

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Introduction

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Communication service providers (CSPs) are continually optimizing their network to achieve differentiation in the areas of cost, performance, time-to-market, and service offerings. One emerging optimization strategy is to partner with hyperscalers, with DISH Wireless pioneering this emerging phenomenon. This isn't surprising behavior for CSPs when viewed in the context of their rich history of activities with competitive operators to build and share 5G networks, roaming partnerships, alternate access vendor (AAV) agreements, and tower company leases. Indeed, the concept of a monolithic CSP that owns and operates the entirety of its infrastructure has been obsolete for many years.

CSPs have launched multi-access edge computing (MEC) solutions with hyperscalers. They're also moving some of their infrastructure workloads over to the cloud providers, thereby enabling hybrid and multi-cloud (i.e., a given telco will have relationships with multiple hyperscalers) architectures. With the right tools, CSPs can build a cloud-provider agnostic architecture that places their workloads across multiple cloud providers to achieve cost optimization, high scale and performance, resiliency, controlled latency, and data sovereignty requirements of customers and applications, while at the same time reducing the risk of vendor lock-in.

To understand why CSPs are partnering with hyperscalers, the top three reasons according to the Heavy Reading survey[1] are ease of deployment, accelerated service time-to-market, and enhanced cloud-based security. The ability to offer 5G services faster means more rapid time to revenue, and that's key for driving a return on their significant 5G investments.

Amazon Web Services (AWS), Microsoft Azure for Operators, Google Cloud Platform (GCP), and Oracle Connect Infrastructure (OCI) are among the providers that offer solutions dedicated to CSP infrastructure that can integrate directly into their 5G networks.

This partnership is mutually beneficial since CSPs have substantial assets, footprint, and telco domain expertise, while hyperscalers have developed mature cloud-scale platforms with global presence and connectivity. The result is that both parties leverage their respective strengths to offer value-added services to the enterprise, including private 5G, and bring the most innovative solutions to market in the most economical ways possible.

Some examples of U.S. mobile operator partnership include:

DISH Wireless

- Partnering with AWS
- Utilizing AWS as a platform to run the DISH 5G service infrastructure including some of the radio access network (RAN) components and 5G packet core
- First operator in the U.S. to leverage the public cloud to deploy and operationalize its network[2]

Verizon[3]

- Offering 5G network edge services with AWS
- Private mobile edge computing for enterprises with Microsoft Azure
- 5G edge with Google Distributed Cloud Edge (GDCE) to support real-time enterprise applications

AT&T

- Collaboration with AWS on cloud, security, and IoT[4]
- Azure for operators and solutions: operator 5G core, private 5G core, public MEC[5]
- Partnership with Google cloud to offer on-prem MEC and network edge capabilities targeting enterprise customers[6]

From a global perspective, the list continues to grow:

- Etisalat[7], Rogers[8], Telstra[9], SK Telecom[10], Telefonica[11], Telkomsel[12], and Vodafone[13] partnering with Microsoft Azure
- KDDI[14], SK Telecom[15], and Vodafone partnering with AWS
- BT[16], Telecom Italia[17], and Telefonica[18] partnering with Google cloud

Embarking on a telco cloud network transformation requires thoughtful consideration; getting it right will take time and effort from all stakeholders. First, telco workloads differ from enterprise applications due to regulatory, bandwidth, scale, and latency requirements. The learning curve of the telco-specific requirements for hyperscalers can be steep and it's important to get into the details up-front with a prospective partner. Performance and behavior characterization of telco workloads in hyperscaler infrastructure is crucial. Second, the cloud network architecture must provide the tools, visibility, and flexibility to support appropriate service level agreements (SLAs), as service providers require high availability, scalability, and security. Third, the CSP should be cognizant of the need to build a cloud-provider agnostic transport network to enable a hybrid-cloud/multi-cloud network architecture. The architecture should be capable of providing a unified routing domain to simplify routing across these clouds while hiding the complexity of managing different cloud provider networking solutions. Hence, it's essential to provide the operations team with a routing solution to which they're accustomed and familiar for their on-premises solution.

To deal with the complexities of a hybrid-cloud/multi-cloud infrastructure deployment, Cisco built the Converged SDN Transport for 5G cloud-ready solution. A key component of the solution is the Cisco Cloud vRouter which enables end-to-end transport connectivity that effectively extends the premise-based telco transport network into the public cloud service provider, thereby bringing additional transport capabilities and technologies into the cloud. Coupling Cisco Cloud vRouter with Cisco's SDN-C control and assurance applications provides hybrid-cloud/multi-cloud transport with service assurance, network segmentation, and resiliency. We believe that CSPs adopting the Cisco 5G transport strategy will transform themselves into platforms for innovation. As the first in the industry, Cisco has delivered hybrid cloud transport for telco workloads (user plane forwarding and RAN centralized unit) hosted in AWS for the DISH Wireless network.

Reflections with DISH Wireless

To help better understand the process of adopting a cloud-first approach and evolving to a hybrid-cloud architecture, DISH Wireless reflects on their experiences over the past 18 months as they've implemented a truly unique transport overlay network with AWS as their underlay partner. The question-and-answer format to follow allows for exploration of DISH's guiding principles, innovative approach to networking, challenges encountered along the way, and thoughts about next steps in their collaboration with public cloud providers (PCPs) and software vendors/partners.

Q **What are the use cases driving the need for telco public cloud?**

A **DISH Wireless:**

- Specifically, for DISH Wireless as a greenfield operator entering a mature telecom market, the question wasn't so much "why public cloud"? It was more "why not public cloud"? Unlike legacy operators, DISH Wireless didn't have an existing footprint to worry about nor was it staffed to build a nationwide network in the aggressive timelines that were mandated by regulatory authorities such as the Federal Communications Commission (FCC). The specific use cases driving the decision by DISH Wireless to be the first operator in the US to build its network entirely in the public cloud include –
  - Leveraging the expertise of hyperscalers, developed over decades, to build and operate highly available state-of-the-art data centers at scale. This freed up DISH Wireless to concentrate on the job of building the first stand-alone 5G cloud-native network in the world without having to also worry about building, managing, and operating a nationwide footprint of data centers. Additionally, partnering with a public cloud provider also enabled DISH Wireless to leverage the PCP backbone transport network for nationwide connectivity and internet peering infrastructure for internet access that's required to support our services, eliminating the need to source, build, and operate our own transport backbone – as done by all the legacy operators.
  - The same logic extended to essential components required to run containerized workloads such as a stable, highly available Kubernetes (K8s) cluster. Early in the journey to run fully containerized, cloud-native network functions, DISH Wireless recognized the dependency on the container-as-a-service (CaaS) layer. Every hyperscaler has invested in providing fully managed K8s, and leveraging it made a lot of sense for DISH Wireless for the initial deployment and launch.
  - Finally, leveraging hyperscalers enabled DISH Wireless to easily move its workloads to the latest generation of hardware and services once they were made available. This is fundamentally different from the legacy model where investments in hardware/platforms have a life cycle of 7-10 years at minimum. DISH Wireless feels this is a huge competitive advantage and it offers a degree of agility in terms of taking advantage of new capabilities and offering new services that will be impossible to match in the legacy model.

The typical use case for leveraging CSPs is as a data-center-in-the-sky of some fashion, with the goal of avoiding the buildout of racks of servers in an on-premises data center. DISH Wireless has taken this a step further by first using the PCP CaaS infrastructure and extending their on-premises infrastructure and transport network into the cloud.

Once this is established, the service provider class features and network paradigms can be utilized by other DISH Wireless applications that are also running on the PCP's CaaS infrastructure. DISH Wireless has achieved an industry first by deploying in production a 5G packet core, O-RAN functions, and virtualized CSP-class routers in the hybrid cloud with SDN control.

Q What are some of the workload requirements and cloud challenges?

A DISH Wireless:

Telco workloads, particularly the user and control plane functions, are quite different from typical enterprise and IT applications that the public clouds were built to support. For example, telco workloads have strict requirements in terms of latency budgets, jitter, support for specific capabilities such as seamless failover to ensure service continuity, and regulatory requirements that are mandated by federal and/or state agencies. Examples of this divergence between requirements and capabilities include the lack of support for telco protocols such as SCTP, GRE, BGP, ANYCAST, etc. in the public cloud, multiple limits imposed on customers based on traffic flows, and virtual machine templates that aren't fully aligned with telco-specific requirements. Public cloud providers have never had to provide the level of visibility and control in their underlay network that telco requires. This includes support for quality of service (QoS) in PCP network underlay, which is not supported universally by the hyperscalers. DISH Wireless knew these would be challenges in any public cloud going in, but also understood that:

1. These challenges weren't hard blockers (i.e., DISH Wireless could operationalize the network in the public cloud and continue to drive the evolution of the public cloud platforms and services to overcome and eliminate these challenges).
2. DISH Wireless can drive the evolution of the public cloud and network functions in partnership with PCPs and independent software vendors (ISVs) to optimize performance and cost for its 5G network functions and continue to evaluate new and improved architectures incorporating the latest technologies and out-of-the-box thinking.
3. PCPs would be willing partners in this evolution because of their desire to enter the telco space to unlock new business/revenue streams.

It's in the interest of the CSP, PCP, and software vendors to work together towards a shared vision of how a CSP-class network can be realized with a hybrid/multi-cloud architecture. Through innovative design and features, the CSP and software vendors can provide a very solid set of network services. To truly innovate and differentiate, however, the PCP should be enlisted as a willing and collaborative partner to expose capabilities such as enhanced visibility and deterministic behaviors of their underlay network.

Q

What architectures are needed for hybrid and multi-cloud to fulfill those requirements?

A

DISH Wireless:

DISH Wireless believes that not only will the use of public cloud for telco become mainstream – a shift that's already clearly visible – but the next evolution in this journey will be large-scale adoption of hybrid and multi-cloud designs. It's inevitable as telcos expand into providing private networks integrated with public macro 5G/6G cell sites and services move closer to the edge to support use cases that require ultra-low latency and the ability to host workloads near customers. Operators must be able to deploy their workloads and integrate them seamlessly across a multitude of target environments – public clouds, operator edge, and enterprise private cloud – to support these requirements. DISH Wireless feels that the following are essential to successfully evolve to a hybrid/multi-cloud architecture:

1. A unified routing domain, using industry standard routing technologies to enable connectivity that's agnostic to where the workload is located, on-premises or any PCP over any platform - be it physical, virtualized, or containerized. This will accelerate adoption, remove any cloud-specific dependencies and/or obstacles while simplifying engineering and operations as the entire network has the same look and feel. In the DISH Wireless deployment, segment routing-multiprotocol label switching (SR-MPLS) has been deployed for on-premises and PCPs with multiprotocol-border gateway protocol (MP-BGP) running end-to-end. We pride ourselves on being the first to ever run SR-MPLS in the cloud supporting our production environment.

2. Centralized intelligent network controller that provides the ability to orchestrate, automate, and provide service enablement from a single pane of glass in a hybrid-cloud/multi-cloud environment providing end-to-end network visibility

3. A cohesive, transparent, and high-performance transport fabric that enables workloads to seamlessly communicate within the tight tolerances and latency budgets required by telco workloads. This is even more critical as various use cases such as ultra-reliable low latency communications (URLLC) become part of the services provided by operators.

4. The adoption of DevOps for telco workloads to enable features to be developed and rolled out with the same agility that's commonplace in other software and technology domains. DISH Wireless firmly believes that the legacy cycle of 12-18 months for the introduction of features and platforms in telco networks is diametrically opposed to the use cases that are envisioned for the next generation of networks (5G and beyond). Operators will need to be able to develop, test, and rollout features in days to realize the potential of the next generation networks that are currently being built.

5. Automation and portability of the stack through independent continuous integration/continuous delivery (CI/CD) mechanisms to allow operators to deploy network functions and services into any target environment that their customers require, whether in the public or private cloud, in centralized locations or at the edge.

Key capabilities of an on-premises service provider transport network include granular service separation, advanced packet queuing capabilities, deterministic routing of data flows, rapid failure detection and failover in the transport network, ability to create and measure meaningful SLAs, network-based security, and tight controls over IP routing decisions. All of this must be delivered with high performance and scale. This is accomplished on-premises with highly scalable service provider-class routers. It turns out that the advanced features such as segment routing, BGP VPN, packet classification and queuing, streaming telemetry, BFD, BGP peering, etc. can be delivered by a cloud-native implementation of the familiar service provider-class network operating system (NOS) of the routers.

The general-purpose compute that comprises the PCP's platform is not optimized for the large-scale forwarding of IP datagrams that CSPs require, but this can be mitigated by implementing containerized routers in a scalable architecture. To achieve the scale that's typically implemented in high-performance ASIC-based routers, a "horizontal scaling" architecture can be used in combination with a feature/performance roadmap that's negotiated with the PCP.

SDN control is another key component of the architecture that enables the automation of the overlay transport network to implement modifications and closed-loop optimizations. The SDN controller also becomes an execution element that interfaces to northbound back-office systems that manage business-critical functions such as service definitions and order entry.

Q What were some operational challenges?

A DISH Wireless:

We realized that implementing the world's first 5G network in the public cloud wouldn't be without its set of challenges, but we didn't feel these would be insurmountable. The challenges faced during the initial build phase were predominantly related to the fact that the public clouds weren't built with telco in mind. We were the first to build a 5G network in the cloud; therefore, you would expect that what we were asking of the PCPs was being asked for the first time. The limitations and restrictions imposed in the cloud must be understood in greater detail to architect and design around them. Some of these limitations were well known, some were documented, and others were discovered by the PCP during the implementation phase where we had to re-think how we overcome these challenges.

In some cases, the operational challenges required the hyperscaler to develop new capabilities and features, while in other scenarios the right approach was to make design choices, such as the use of an overlay routing fabric to overcome the immediate challenge and ensure that we retained the level of flexibility required to extend to a multi-cloud posture without the need for ground-up redesigns. At DISH Wireless, we have higher expectations. We demand excellence and expediency from our partners. Our vRouter selection process didn't come overnight nor was it done in a vacuum. There were a few features specific to our deployment that we asked Cisco to develop for us and perform feature level/platform/performance testing in the cloud prior to accepting this network function as an approved solution. This was a joint effort between DISH, Cisco, and AWS over multiple iterations. This was one of the first network functions in our network, and now we've established a baseline and performance result based on its placement in the respective data centers.

During the deployment, we encountered challenges (e.g., bandwidth limits imposed per flow, underlay visibility, lack of high availability features, etc.) It required architectural changes and thorough testing to overcome those limitations. DISH Wireless was deeply engaged in the process, providing valuable feedback that significantly helped to accelerate solution delivery.

Q What are some lessons learned through the deployment journey?

A DISH Wireless:

Telco cloud adoption is a journey, not a sprint, so there's a long way to go before cloud providers can claim they support 5G workloads with no caveats. We think we've got a good understanding of what it takes to build a 5G network but operationalizing it and accelerating the cloud adoption is something that we continue to refine within DISH Wireless and with our partners.

A few of the key lessons learned in our journey are 1) optimizing the stack footprint is secondary to other objectives such as operationalization and automation, 2) time-to-market can be accelerated by using native tooling provided by the hyperscalers but this risks lock-in, which is an important consideration for operators, 3) having a clear plan and strategy for evolving the CaaS and PaaS is just as critical as the evolution of the telco stack, 4) leveraging open-source platforms and tools is essential for multi/hybrid cloud.

On the Cisco side we learned -

- Close collaboration between the CSP, PCP, and application vendors is critical
- Testing of the vRouter, on-premises infrastructure and applications, and cloud-based applications must be done in advance of deployment to characterize performance, scale, and feature interworking
- Stakeholders must be open to navigating through design challenges to make the solution work
- PCP networks need to evolve to simplify telco workload hosting in a hybrid-cloud architecture

Q What's the future of this evolution?

A DISH Wireless:

As mentioned above, we're at the beginning of our journey. DISH Wireless has a lot of ideas on how to disrupt the industry from a network, virtualization, and workload perspective. Just like we defined the path to 5G cloud adoption for the industry, we believe what comes next will follow suit.

Cisco will continue to be the trusted advisor of DISH Wireless in this exciting and innovative journey. The possibilities are endless as DISH Wireless launches new 5G services.

Performance, scalability, visibility, and network features are all areas of interest for future development and collaboration.

The bridge to possible

Learn more

Get more information on Cisco's Converged SDN Transport solution and learn how to transform network economics in your favor.

Conclusion

Public cloud providers are a resource that CSPs can use to achieve their business objectives, including faster time-to-market, reduced initial capital outlay, access to enterprise customers, and greater flexibility in deploying the network functions upon which they create their services.

Looking at the resources that the PCPs bring to the table, we see the following:

- The powerful compute resources of the PCP can run the business-critical workloads such as 5G packet core, IMS core, and virtualized IP transport routers.
- PCPs also have networking services and infrastructure that can serve as an effective underlay network upon which the CSP can build an overlay transport network complete with advanced service provider networking.
- Using the Cloud vRouter, unique characteristics inherent in PCP networks and service offerings can be abstracted, enabling the CSP overlay transport network to span multiple PCPs.
- The overlay network(s) can be seamlessly linked with the CSP's on-premise network, creating a hybrid-cloud/multi-cloud network that operates as a single cohesive transport network upon which the CSP can build mobility services, voice services, VPN services, network slicing, and much more.

As the CSP develops cloud strategy and architecture, there's work to be done to baseline critical success factors including performance, reliability, scale, visibility, automation capabilities, and SLAs. By methodically working through the necessary testing and integration, the CSP can achieve a service delivery platform that can be rapidly expanded to meet the ever-increasing demand for communication services.

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Endnotes

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