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HEAVY READING

WHITE PAPER

Design for the Future: Telco Cloud Infrastructure

A Heavy Reading white paper produced for QCT

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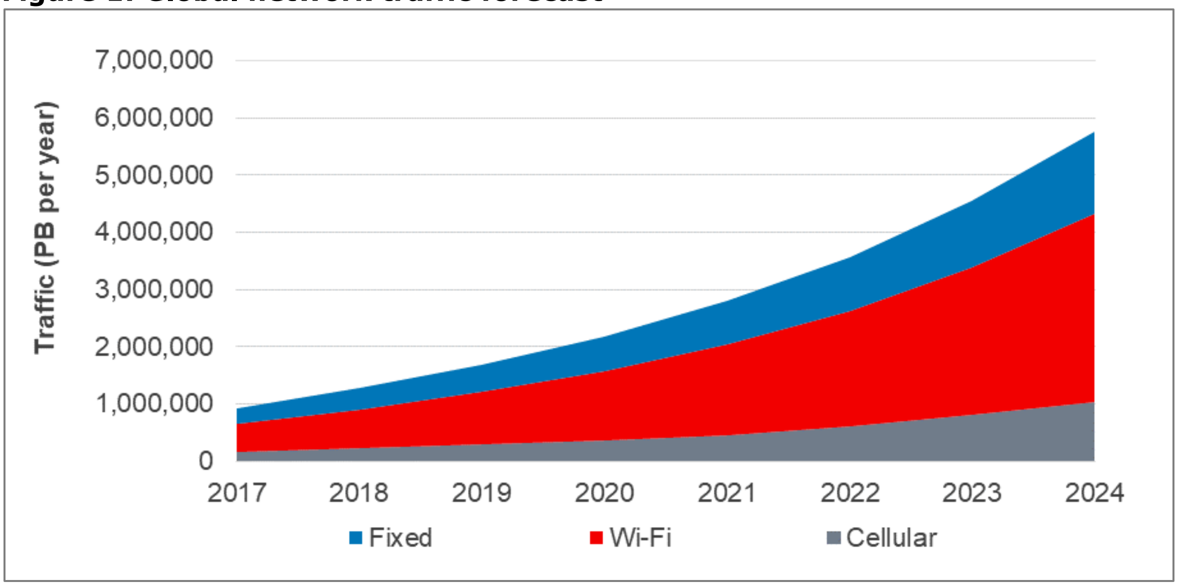
STRESS ON THE NETWORK

Carriers around the world know that their current method of designing and deploying mobile networks will not hold up to near-term demands, let alone future demands. Multiple waves of change are sweeping the network. The COVID-19 pandemic and the pressures that it has placed on the network illustrate that the world has moved beyond simply connecting people to one in which always-on access to digital services is seen as a basic need.

Consider the following network stressors:

- **Overall network traffic:** Omdia data shows network traffic continuing to double every three years (see **Figure 1**). Users are already generating more traffic from wireless devices than from wired devices. In terms of traffic, the vision of a wire-free world is becoming a reality.

Figure 1: Global network traffic forecast



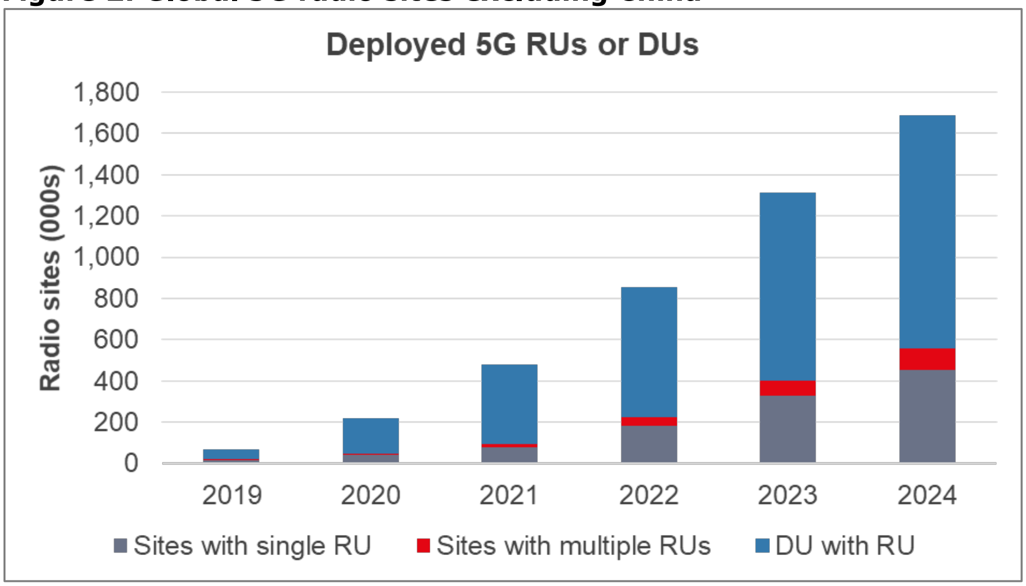
Sources: Omdia, Heavy Reading

- **Video traffic:** 80% of this traffic—both fixed and wireless—is video. Social video comprises the majority of traffic, followed by ad-based video on demand and then over-the-top subscription-based video.
- **5G rollouts:** 5G is rolling out faster than any previous mobile technology. Omdia forecasts show global 5G subscriptions will be 4x greater than 4G was at the five-year milestone.
- **Unlimited data plans:** With 5G, carrier ROI is further challenged as unlimited data plans become the norm due to both competition and the reduced cost (compared to 4G) of carrying data.
- **Internet of Things (IoT) penetration:** According to Omdia research, the number of IoT contracts awarded to carriers has grown from under 10 worldwide in 2009 to 1,168 as of 1Q20.

- **Connected cars:** The number of connected cars is growing worldwide, from 59 million in 2016 to 308 million in 2022.
- **Cell sites that must be managed:** The number of physical cell sites (i.e., not including multisectored antennas) will grow by an order of magnitude as a result of the rollout of 5G.
- **Not enough fiber:** 5G cell sites will drive significant transport and dark fiber requirements for xHaul.

Figure 2 shows the number of radio units and distributed sites globally, excluding China. China has been excluded because in-region service providers do not share transport infrastructure numbers. Additionally, informal estimates suggest China's numbers would more than double the market.

Figure 2: Global 5G radio sites excluding China



Source: Ovum (now Omdia)

THE CARRIER JOURNEY TO THE CLOUD

Carriers' capex spending on average ranges between 13% and 17% of revenue. With 5G investments coming fast on the heels of 4G rollouts, carriers are currently spending at the high end of that range. Omdia research shows that service providers have invested $3,132bn in mobile and fixed networks since 2010, an average of $313bn each year—about 17% of service providers' total revenue. Mega-scale cloud operators invest a fraction of this amount. Alphabet, Facebook, Microsoft, and Amazon collectively spent $264bn in capex between 2010 and 2019 and $373.6bn in R&D. Carrier spending assumes all of the costs that come with a highly distributed network and cloud providers reap all of the benefits of a highly centralized architecture. Nevertheless, carriers have spent the last 10 years trying to implement lessons learned from the cloud-scale providers while continuing to leverage their own dominance in customer touch and transport networks. This started a fail-fast (fast from a carrier perspective) cascade of proprietary, open, open source, and open API projects.

Software-defined networking: We hardly knew you

Carriers started with software-defined networking (SDN) and the separation of the control and data/user plane using the OpenFlow protocol. They quickly discarded the centralized control plane as not a viable solution for carrier-scale networks. However, the carriers kept the separation of control and data in a decentralized architecture. OpenFlow was discarded as an open source building block, but it is still used in what are essentially proprietary implementations.

What carriers kept

The idea that operational efficiencies and agility could be gained by the separation of the control and user planes. They also kept the overall concept of a move to software solutions.

Network functions virtualization: Much more work than we thought

When network functions virtualization (NFV) emerged as a network architecture in 2012, the hope was that it would enable carriers to move away from proprietary, appliance-based network solutions and toward software solutions running on commercial off-the-shelf (COTS) platforms. The aim was to lower costs, avoid vendor lock-in, improve network agility, and simplify the network. Some of these goals have been accomplished in some networks. However, the virtualization of the network has hit hurdles at each point in its evolution:

- **Scale out:** For virtual network functions (VNFs) that are highly distributed—residing at hundreds or thousands of points in the network—virtual solutions ran into problems early on with the performance of protocols such as OpenStack. These protocols were written for the data center, not for highly distributed and robust carrier networks. Virtual solutions also had issues with the integration and interoperability testing required if the network was supporting a heterogeneous set of software solutions. The same issues hold true for traffic traversing multiple different COTS devices, where sessions collect delay at each device, which can affect the user experience.
- **Scale up:** For VNFs handling high traffic volumes, carriers frequently had to revert to appliance-based versions of the solution to get the performance needed.
- **Interoperability:** While a multi-vendor environment was the goal, carriers were left with the choice of either standardizing on a reduced set of features from multiple vendors or becoming locked into a single vendor. Complexity was also multiplied with multiple software updates, particularly if multiple platforms were used.
- **Management:** There are multiple methods for managing a VNF, including, but not limited to, both VNF managers and VNF domain managers.
- **Service chaining:** Omdia research, surveys, and conversations with carriers underscore that this is where NFV implementations will encounter challenges, combining each of the previous hurdles into one complex scenario. Omdia carrier surveys reveal that virtual evolved packet core (vEPC) is the most widely deployed VNF in mobile networks because it is not part of a service chain. However, once carriers work to deploy service chains of firewalls, traffic management, Domain Name System (DNS), IP Multimedia Subsystem (IMS), and software-defined wide-area network (SD-WAN), all the problems with scaling up, scaling out, interoperability, and management become multiplied.

NFV has disappointed the carriers in terms of cost and complexity. They were looking for a simplified, agile architecture and what they brought on was an implementation challenge where both their overall opex and capex increased.

What carriers have kept

The move away from appliance-based solutions to virtualized software-based solutions. They also kept SD-WAN—which is the heir apparent to SDN and NFV.

What carriers are still looking for

Simplicity in the form of automation solutions that simplify the rollout, maintenance, and management of network applications. Network applications that work together.

Cloud-native: Now the goal – probably

Early in the implementation of VNFs, carriers realized that they were trading an appliance-based version of a product (e.g., a firewall) for a software-based version with the same features and functionality—and sometimes not even that. These VNFs were not written for the cloud and did not take advantage of the DevOps style of development. Cloud-native brings with it a move to containers, the implementation of Kubernetes to manage those containers, the ability to scale up and out quickly, and lower costs since the applications are realized in microservices. But it is still not clear to carriers if a move to cloud-native network functions (CNFs) will solve the challenges they have had with NFV and VNFs.

MPLS: The sunset has started

The time has come for the industry to evolve past Multiprotocol Label Switching (MPLS) and its derived models such as unified MPLS. While successful to date, MPLS techniques are characterized by a multiplicity of control planes which prove too complex as networks evolve.

Which company published these words in late 2019 in a public forum? Ericsson? Ciena? Amdocs? No—it was Cisco, the company that popularized MPLS, the now ubiquitous protocol, in the 1990s. If Cisco is throwing in the towel on MPLS as an evolutionary path, it is time to look elsewhere for tomorrow's solutions. Carriers value MPLS for its traffic management, scalability, bandwidth utilization, and performance and have been anxious about losing MPLS service revenue to SD-WAN services. However, they need to realize that the clock is ticking on the MPLS protocol.

Amazon Web Services: How did you do that?

This journey to the cloud started with the webscale data centers. Amazon Web Services (AWS) was launched in 2006—three years before SDN and OpenFlow emerged on the market. The company pulled together open source software and SDN- and NFV-like strategies wrapped in proprietary technologies and shaped them into a high performance compute cloud. In 2019, AWS reported over $35bn in annual revenue.

When AWS was formed, Amazon was not concerned with how it could interoperate with other clouds—it did not have to be. Carrier networks, on the other hand, must consider interoperability as a founding principle. A call must be able to originate anywhere in the world and be terminated at any other connected endpoint.

Although carriers have learned much from the cloud providers of the world, the one lesson that they have not internalized is the primary reason for using proprietary elements. These elements should not be used just to add features, functionality, differentiation, and competitive advantage (though they should provide all of that). Rather, their key advantage should be to simplify and lower the cost of the network. As the next decade of network architectures and development approaches, "simplify" will be the guiding principle—whether through open source, COTS, proprietary systems, or a combination of all three.

THE PATH TO CLOUD-NATIVE

Carriers are seeing a cloud-native network as the goal, but they are not sure of the path that will provide the greatest ROI. Carriers such as India's Reliance Jio and Telefónica are innovating on a foundation of cloud-native development. However, Japan's Rakuten Mobile is out in front in the move to cloud-native with its fully virtualized, automated, and software-centric LTE network.

Rakuten Mobile—like pioneers in the NFV space such as AT&T and Telefónica—did much of the integration work itself. It has also done development work to fill some of the critical gaps in VNFs or tools needed in the management and orchestration (MANO) layer. While the network may seem to have appeared on the market overnight, 12 months of development (from the time the network was announced at MWC 2019) went into pulling it together. Full-scale commercial service on the network launched in April 2020 with about 4,000 sites, and Rakuten Mobile has since been continually expanding its base station buildout. One of the carrier's integration challenges was building a solution that could scale; it had to create a software platform that could orchestrate VNFs over a large number virtual machines.

Rakuten Mobile's radio access network (RAN) is completely virtualized, where each mobile site is only a remote radio head from different antenna vendors. All other components are implemented as virtualized functions running in different data centers and facilities in different locations (virtualized distributed and central units). The resulting solution can instantiate a cell site in under nine minutes after physical installation is complete.

Now Rakuten Mobile plans to take the same approach to 5G. According to the carrier, the level of virtualization it has achieved means its cost to deploy 5G is less than that for traditional telecom operators, with up to 40% reduction in capex and up to 30% reduction in opex. In a market such as Japan, this represents an opportunity because Rakuten Mobile is able to leverage its lower costs to offer aggressively priced service plans such as the Rakuten UN-LIMIT price plan launched in April. The plan offers unlimited data use within Rakuten network areas along with unlimited domestic calls at about half the price of competitors.

In-house software development capability is also critical to Rakuten Mobile's success. Much of the carrier's integration work has been focused on automation capabilities. To achieve the operational efficiencies the carrier is looking for, the majority of its sites must be able to operate in a zero-touch, lights-out environment. The carrier has employed a DevOps methodology for the current 4G network, as well as created software tools enabling developers to manage operational workflows, particularly for the fully containerized stack built by Rakuten Mobile. These tools are critical for site automation. An additional step toward full automation has been implemented by Rakuten Mobile with the carrier's innovative use of drones for site inspection post-deployment.

In addition to custom-built services from Nokia, Rakuten Mobile has worked with a carefully selected group of suppliers, including Altiostar, Cisco, Intel, Red Hat, OKI, Fujitsu, Ciena, Netcracker, Qualcomm, Mavenir, Quanta, Sercomm, Allot, InnoEye, and VIAVI. The carrier also participated in a round of investment in Altiostar, along with Qualcomm and Tech Mahindra.

Hardware in a software world

Rakuten Mobile uses specific configurations for its servers that are sourced from Quanta Computing Technology (QCT) in Taiwan. QCT is a company known for suppling server solutions to cloud operators such as Facebook, and it is now taking its lessons learned to the carrier environment.

Rakuten Mobile and QCT worked together to design bespoke platforms that utilize the 2nd Generation Intel technologies for higher agility, flexibility, and scalability. The data centers at the heart of Rakuten Mobile's fully virtualized network are equipped with QCT's servers that use Intel Xeon Scalable processors and are supported by Intel field-programmable gate arrays (FPGAs) to achieve accelerated radio performance. For this collaboration, QCT provided a portfolio of acceleration technology that Rakuten Mobile can pick and choose from, including Intel Streaming SIMD Extensions (SSE) and Intel FPGAs and graphics processing units (GPUs). Utilizing Intel Xeon Scalable processors and Intel FPGAs for acceleration, this underlying foundation built a platform that not only scales, but also enables continued innovation to create services on an agile Rakuten Mobile network.

QCT worked closely with Cisco to integrate the platform with Cisco's Virtualized Infrastructure Manager (cVIM). The company also worked closely with virtual RAN (vRAN) supplier Altiostar to integrate both software and hardware elements into the platform. This solution is Network Equipment Building System (NEBS) compliant, and the multiple form factors are hardened and power optimized for upcoming 5G deployments. Perhaps most notably, QCT delivered the completed platform to Rakuten Mobile in three months.

By standardizing on a single, custom-built, hardware platform, Rakuten Mobile reduced the complexity of its network, simplified the VNF integration process, and improved its ability to automate, manage, and troubleshoot the environment. Telco operators normally maintain infrastructure with hundreds of different configurations. Rakuten Mobile uses less than 10 configurations in total and only 4 configurations for network edge sites.

The cloud-native endgame for this carrier journey

Carriers started down the path toward software-defined, virtualized, and ultimately, cloud-native networks more than 10 years ago. Rakuten Mobile is a new, greenfield network, without the installed base of multiple previous generations of network technologies and infrastructure. It is still early days to predict whether the Rakuten Mobile network design template will be a model for 5G networks that follow. However, many of its architectural choices have a certain ring of inevitability, particularly when viewed in the light of cloud provider successes and the struggles that carriers have had on the road to virtualization and cloud-native.

Is the industry likely to see a mixture of both open source and bespoke solutions making up the carrier networks of the future? Interoperability is a key intent behind open source. Open interoperability is indispensable for service-level agreements (SLAs), installing and managing networks, quality assurance, and serviceability. Rakuten Mobile and all its supplier partners contribute to the open source and standards community—including, in most cases, the O-RAN Alliance and Telecom Infra Project (TIP)—initially in the RAN space and more recently in groups addressing the 5G core network. Open source has become a way to identify and develop the ecosystem in which a carrier wants to participate.

Today, the network is a basic need. And the number of stresses on the network are only accelerating. As carriers look to their 5G rollouts, they are focusing on strategies to meet future demand while removing cost and complexity. The Rakuten Mobile network was built with these goals in mind. Telco operators today are examining that strategy and evaluating whether a similar path is the direction they can, and should, take with their own evolution to 5G and cloud-native.

ABOUT QCT

This section provided by QCT.

Quanta Cloud Technology (QCT) is a global datacenter solution provider. We combine the efficiency of hyperscale hardware with infrastructure software from a diversity of industry leaders to solve next-generation datacenter design and operation challenges. QCT serves cloud service providers, telecoms and enterprises running public, hybrid and private clouds.

Product lines include hyper-converged and software-defined datacenter solutions as well as servers, storage, switches, integrated racks with a diverse ecosystem of hardware component and software partners. QCT designs, manufactures, integrates and services cutting edge offerings via its own global network. The parent of QCT is Quanta Computer, Inc., a Fortune Global 500 corporation.

For more information on QCT 5G solutions, visit: https://go.qct.io/telco/.