WHITE PAPER

Get Ready for 5G. Deliver IP Differently.

Mobile connectivity is an increasingly integral part of daily lives. The first mobile generation, created to support on-the-go analog conversations, eventually became 2G—a major transformation in the mobile network industry that added data connectivity supported by digitization. Subsequent generations focused on improving internet connectivity capacity by offering more speed. IP has been a part of every generation since 2G and is exponentially more important as network operators contend with the new wave of impending applications and use cases enabled by 5G.

Legacy mobile networks are commonly based on an approach in which wireless interfaces are widely distributed for maximum geographic coverage. In contrast, the data and control elements like the Serving Gateway, Packet Data Network Gateway, Mobility Management Entity, and peering interconnections are typically centralized. These networks were built using a regional aggregation structure, which lent itself well to a network 'backhaul' architecture, with point-to-point traffic from cell sites to the mobile core supported by services like E-LINE on Layer 2 and VPWS on Layer 3.

An expansive application ecosystem was created around the mobile infrastructure, generating trillions of dollars of revenue for Mobile Network Operators (MNOs) and adjacent industries. Mobile services moved from being 'nice to have' to forming a vital part of the infrastructure in most societies—a network infrastructure that must support a high level of performance, resilience, and availability. Mobile network outages are simply unacceptable, and MNOs know it.

According to global market research firm Omdia, mobile Communications Service Providers (CSPs) are expected to expand capex spend to continue updating their infrastructure. Omdia predicts global mobile CSP CAPEX will grow from US$169B in 2021 to more than US$181B in 2026.

4G (LTE, LTE Advanced, and LTE-Advanced Pro) and 5G require increasing levels of IP connectivity to better support application demands related to capacity, performance, and availability.

For example, the LTE Coordinated Multipoint (CoMP) technique allows data to be transmitted to Users Equipment (UE) from multiple nearby base stations (eNodeBs) simultaneously, adding significant aggregate gains in uplink and downlink performance. CoMP uses the X2 protocol, over ideal or non-ideal backhaul, to synchronize the traffic between multiple neighboring eNodeBs. In a robust implementation, the neighboring eNodeBs can be in different sub-nets, requiring full IP connectivity to communicate efficiently.

As the initial 5G Non-Standalone (NSA) mode utilizes the existing 4G user and control plane in the Evolved Packet Core (EPC), full IP connectivity, supported by IP/MPLS requirements and Layer 3 VPNs, also applies. 5G NSA mode deployments use 5G New Radios (NRs) to enable MNOs to offer enhanced Mobile Broadband (eMBB) applications as well as Fixed Wireless Access (FWA).

But IP is not the only critical requirement for supporting the next generation of mobile networks. 10GbE, 25GbE and 100GbE connectivity with the cell site, time, and phase synchronization, and a rich feature set including Advanced OAM and Zero Touch Provisioning (ZTP) on the backhaul are fundamental to better support a wide variety of demanding applications and use cases.

Stepping up IP connectivity to support full 5G

5G Stand-Alone (SA) mode deployments first became available in 2021, which allowed MNOs to offer much more sophisticated use cases related to ultra-reliable Low-Latency Communication (urLLC), massive Machine-Type Communication (mMTC), as well as even higher performance related to eMBB services. These enhanced 5G services will unleash a new generation of innovative applications for the Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), gaming, and many others.

On full 5G implementations, there will be densification of wireless infrastructure to provide necessary geographic coverage using higher frequency bands, such as millimeter wave. This will result in more radio elements as part of an increasing number of disaggregated small cells with 3GPP F1 interface. With the sheer quantity of disaggregated small cells added to existing and new macro cell sites, there will be a massive increase in the amount of IP connectivity required to transport the F1 service flows from these disaggregated small cells to the CU (Centralized Unit) site. All of this infrastructure will have to intercommunicate in a fully connected manner, meaning far more IP endpoints to manage and operate.

The mobile infrastructure will be based on concepts such as Open Radio Access Network (O-RAN), Distributed RAN (D-RAN), Disaggregated RAN, and Centralized/Cloud RAN, which will be open, distributed, and highly virtualized. MNOs are breaking existing RAN vendor lock-in by opening and disaggregating radio and baseband units, as well as the fronthaul, midhaul, and backhaul transport networks that interconnect them. Network slicing will be essential to better allocate physical and virtual resources across both the wireless and wireline domains for a better overall experience for end-users—both humans and machines.

Network operators need a far more agile and dynamic IP network implementation to support full 5G in a simpler, cost-effective manner by delivering standards-based IP, albeit differently.

Legacy IP architecture will not deliver what is needed

Although IP is an essential part of every mobile network generation, operators cannot simply add more capacity and/or upgrade the existing IP infrastructure to better support 5G. Legacy IP implementations are designed to support static IP network connectivity while scaling capacity. They are hardware-centric, with all traffic-forwarding decisions happening at the infrastructure layer. A monolithic IP protocol stack, carrying too many obsolete or no-longer-relevant protocols, can significantly impact network efficiency. The lack of openness and programmability makes traffic engineering very complex, and service configuration operational tasks overly complicated, manually intensive, and needlessly time-consuming.

Looking into IP connectivity requirements for 5G deployments, it is easy to understand how legacy IP implementation will negatively impact MNO operation efficiency and service agility. Operational complexity, together with increasing power and space requirements, directly translates into increased OPEX. Additionally, legacy routers require bigger processing and storage capacity, affecting CAPEX. Increases in overall network complexity also affect the MNO time-to-market (TTM) and time-to-revenue (TTR) cycles.

Reimagine IP connectivity for 5G
Watch how

5G will require IP to be delivered differently

Evolving the existing IP infrastructure toward an automated, open, and lean model will enable MNOs to deploy and support the most complex 5G implementations, while keeping the network simpler, highly scalable, and more cost-efficient.

Operational complexity in IP network environments is a critical issue. To successfully support 5G deployments, MNOs will need to leverage real-time analytics-driven automation, simplify and optimize IP networks, and keep the network agile and cost-effective. Eliminating rigid, box-centric network designs and error-prone manual operational processes will allow MNOs to take advantage of network slicing techniques while adequately supporting different use cases.

An open and standards-based IP evolution allows MNOs to gradually and gracefully implement new IP capabilities while coexisting with current IP networks to maximize the use of network assets already in place. The evolution of IP networks must facilitate fast-paced innovation while eliminating proprietary protocols and vendor lock-in.

Monolithic software stacks incorporating obsolete and irrelevant legacy protocols add additional and unnecessary cost and complexity that keep MNOs from implementing a more efficient IP infrastructure for 5G networks. Functions like mobile packet core Serving Gateway (SGW) and Packet

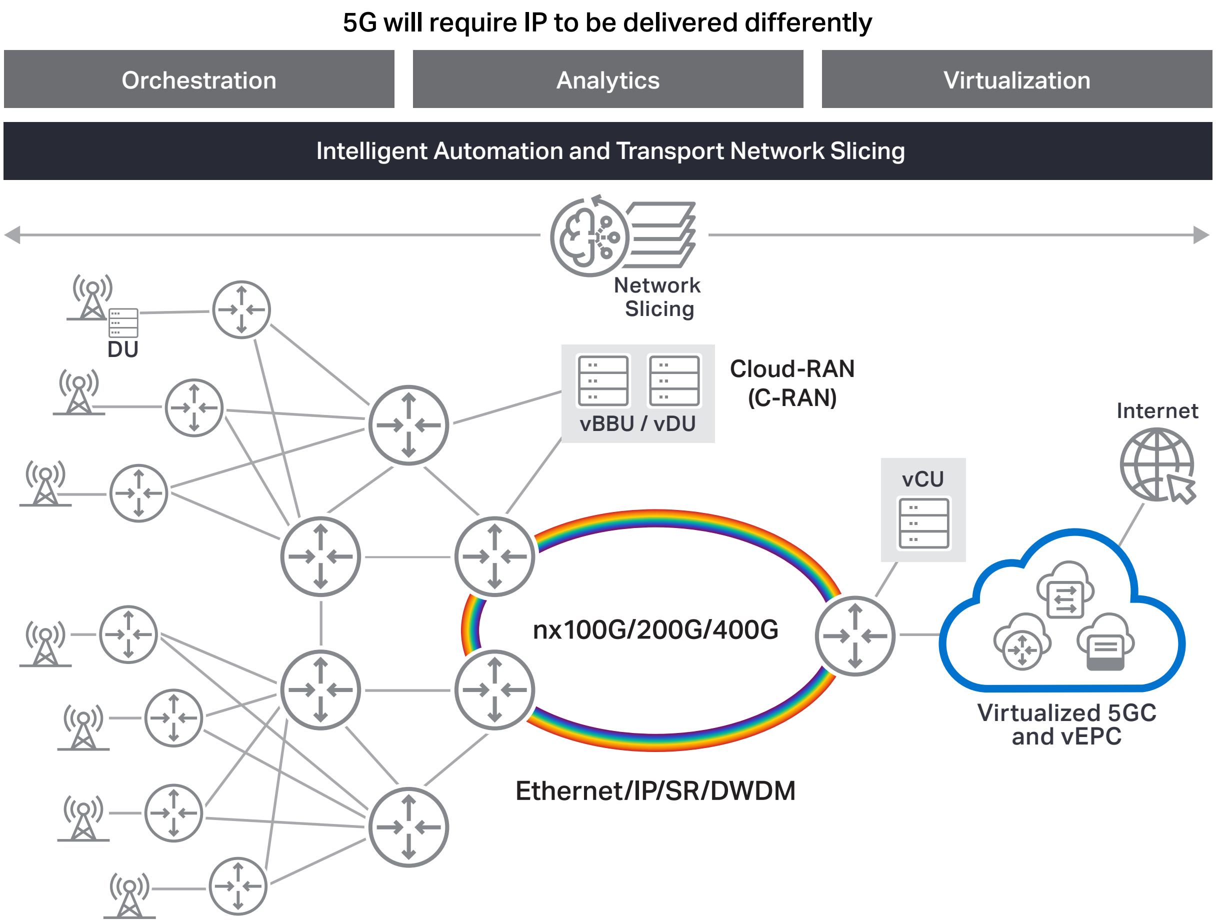

Figure 1. Full 5G implementation

Network Data Gateway (PGW) are embedded into legacy routers. In 5G architectures, these functions will be virtualized and distributed in data centers or Multi-access Edge Computing (MEC) infrastructures, meaning they will not be required in the router's IP stack. The next generation of IP software architectures will be microservices-based and containerized (optimized) to support specific use cases, such as 5G.

Adopting a robust, dynamic packet underlay like Segment Routing (SR), is an excellent example of how to build and manage an IP network at the scale required by 5G. SR is the evolution of MPLS in that it is more scalable, easier to operate, and can reduce the complexity of an IP/MPLS network when compared to one using LDP or RSVP-TE protocols. SR also supports the Ethernet Virtual Private Networks (EVPNs) at the service layer, providing full IP connectivity.

Intelligent network automation, assurance, and analysis tools powered by open protocols—such as 'good/generic' Remote Procedure Call (gRPC)-based streaming telemetry and NETCONF/YANG—enable policy-based closed-loop automation supporting even the most performance-intensive 5G use cases.

The success of any next-generation network implementation will depend on an extremely efficient IP network that is automated, open, and lean to deliver standards-based IP differently.

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