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Intel and VMware – Driving Application Transformation Together for 5G Networks

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Introduction

The 5th generation of wireless standards for cellular systems is 5G.

Although 4G provided applications with higher data transfer rates enabling more speed-intensive applications such as video and music streaming, 5G networks takes it to a whole new level. 5G technology is designed to provide higher data speeds, connect to more types of devices (from smart phones to sensors to robots), provide networking to more process-intensive, latency-sensitive workloads such as AR/VR, cloud gaming, autonomous car, eHealth.

5G networks are fundamentally designed differently than 4G networks. 5G networks are distributed, run on open RAN technology, support containerized applications on Kubernetes using internet-based protocols. In contrast, 4G networks can be centralized, running on conventional RAN, supporting VM/bare metal applications on cloud computing platforms like OpenStack using telco-specific protocols.

	4G	5G
Network	Centralized	Distributed
RAN	Conventional	Open RAN
Resources	VMs/Bare Metal	Containers
Protocols	Diameter/SIP/SCTP etc.	HTTP2, gRPC, JSON
Orchestration	OpenStack	Kubernetes
CNF Providers	Single Vendor	Multiple Vendors

With a distributed network with higher data speed and connecting more smart devices, 5G networks are enabling digitalization use cases in Industry 4.0, Smart Factory, Robotics, Intelligent Transportation Systems, Virtual/Augment Reality, Telemedicine/eHealth, etc.

In pursuit toward driving innovation in 5G applications and services, cloud service providers have turned to cloud native principles and Kubernetes in the development, deployment, lifecycle management of network functions to achieve velocity. Cloud native functions (CNFs) are commonly deployed alongside virtual network functions (VNFs) in 5G networks.

Not only is the lifecycle management of these microservices applications complex, these processing-intensive, workloads have high density connectivity requirements across the different networking types (LAN, LTE, 5G, WAN, etc.), strict latency requirements and variations of acceptable packet loss rates.

APPLICATION	EXPECTED LATENCY	ACCEPTABLE PACKET LOSS RATE
Industry 4.0/Factory Automation	0.5 – 5 ms	10^{-9}
Robotics	1 ms	User Defined
Intelligent Transportation Systems	100 ms	$10^{-5} – 10^{-3}$
Virtual/Augmented Reality	1-4 ms	10^{-4}
Telemedicine/eHealth	1-4 ms	10^{-4}

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Cloud-Native and Kubernetes

5G has designed in security controls to address many of the known threats facing telecom operators and provide preventive measures to limit the damaging impact. These controls include new mutual authentication capabilities, enhanced subscriber identity protection, and additional security mechanisms. However, with the adoption of cloud native technologies can introduce new potential new threats in the 5G applications for the telecom operators to manage. Cloud-Native Functions running in containers can make use of the *Kubernetes network policy*, which allows operators and developers to enforce network traffic using rules and secure access to their applications using Kubernetes constructs. In the Kubernetes networking framework, the container network interface provides pod security and network policy enforcement.

Faster network policy realizations

Antrea is a Kubernetes-native CNCF project that implements the Container Network Interface (CNI) and both native network policy and Kubernetes NetworkPolicy to provide network connectivity and security for pod workloads. Antrea supports standard Kubernetes NetworkPolicies to secure traffic between Pods. While developers can implement NetworkPolicies for their own clusters, Kubernetes itself does not have an ability to implement cluster-wide NetworkPolicies for the whole Kubernetes deployment. Antrea has developed a *Antrea-native policy CRD* (extension to Kubernetes) that gives the Kubernetes administrator more control to implement cluster-wide security policies, while co-existing and complementing the standard Kubernetes NetworkPolicies.

In addition to high density connectivity and latency-sensitivity, 5G applications have rigid security requirements and being able to establish new network connections will help deliver more seamless user experience, especially for VR/AR, cloud gaming, and connected car.

In a performance study, we have found that Antrea achieves 96% faster network policy realization, with three thousand pods consuming network resources than other leading CNIs. Network Policy realization is measured by convergence time, which is defined to be the time it takes for the cluster to support new network policies for the communications between a server/client pair.

Shorter convergence times are better. As figure 1 shows, increasing the number of network policies had little effect on the cluster using Antrea; convergence time from the baseline of 10 network policies was nearly the same as the convergence time with 4,000 network policies in place.

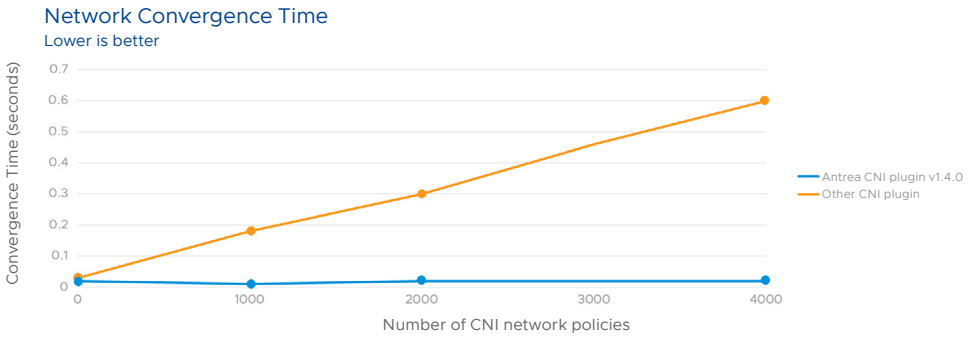

FIGURE 1: Convergence time, in seconds, for an increasing number of CNI network policies. The Antrea CNI plugin convergence times ranged from 0.017 to 0.025 seconds. Lower numbers are better. *Source: Principled Technologies.*

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WireGuard is a VPN protocol that utilizes cryptography that is rapidly gaining adoption because it is more secure, performant and easier to use than the previous IPsec protocol. Over a WireGuard VPN connection, the cluster using the Antrea CNI plugin achieved 9.80 Gbps throughput while the cluster using the other CNI plugin achieved only 2.16 Gbps—or 77.9 percent lower throughput than the Kubernetes cluster using the Antrea CNI plugin (see figure 2).

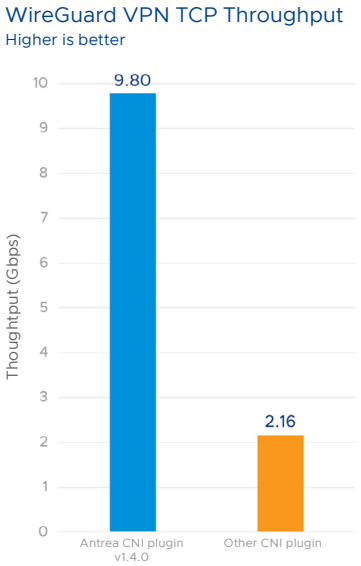


FIGURE 2: Throughput, in GPS, that the Kubernetes clusters achieved with a WireGuard VPN connection. Higher numbers are better. *Source: Principled Technologies.*

Intel Technologies power 5G value chain

Intel technologies are embedded throughout the 5G value chain, supporting latency-sensitive workloads for core, RAN, cloud, edge networks.

Intel® 3rd Gen Xeon® Scalable Processors family has enabled technologies designed to improve container networking workload performance. Compared to the last generation processor family, the *Intel® 3rd Gen Xeon® Scalable Processor* provides up to 1.62x average performance improvement across network and communication workload, 1.58x higher performance on cloud-based microservices, and 1.72x higher virtualization performance.

Intel® QuickAssist Technology (Intel® QAT) provides hardware acceleration to assist with the performance demands of workloads such as 5G UPF, IPsec, or TLS networking while reserving processor cycles for application and control processing.

Intel® QAT accelerates and compresses cryptographic workloads by offloading the data to hardware capable of optimizing those functions. This makes it easier for developers to integrate built-in cryptographic accelerators into network and security applications.

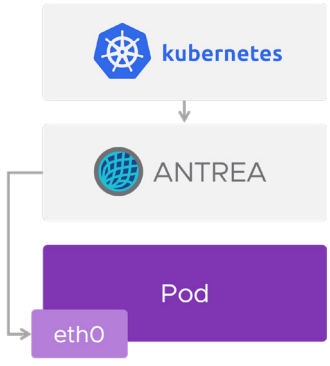
Intel Ethernet 800 series adapters offer port data rates from 10 Gbps to 100 Gbps, supporting both PCIe Gen 3 and Gen 4 across a variety of port counts to address every workload:

- Intel's Application Device Queues (ADQ) feature prioritizes application traffic to help deliver the performance required for high-priority, network-intensive workloads
- Enhanced Dynamic Device Personalization (DDP) uses the fully programmable pipeline to enable frame classification for advanced and proprietary protocols on the adapter—to increase throughput, lower latency, and reduce host CPU overhead

With the latest member to the adapter family, the Intel Ethernet Network Adapter E810-2CQDA2 can increase network data throughput up to 200 Gbps per adapter for high-performance *vRAN*, NFV forwarding plane, storage, HPC, cloud, and CDN. Intel has created a joint solution with VMware, *Intel Select Solutions for vRAN for VMware Telco Cloud.*

Intel and Antrea – better together

By default, a pod in Kubernetes only exposes one interface (loopback) as assigned by pod networking.



Antrea CNI (default).

FIGURE 3.

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While this is a simple and powerful approach, telecom operators make use of multiple interfaces for use cases such as separation of control and data plane traffic, especially for VNF/CNF applications, support for load balancers for telco protocols, and multitenant networks.

Working with Antrea, Intel has enabled multiple interfaces for a single Kubernetes pod allowing the pods to add a secondary interface and address ranges such as macvlan or ipvlan or SR-IOV devices for hardware or accelerated interface.

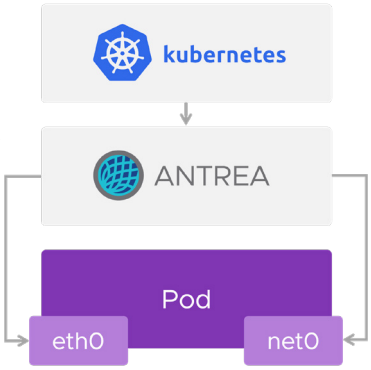

FIGURE 4. Intel enabling multiple interfaces to the pod with Antrea contribution.

Intel will continue to contribute into the Antrea. Intel plans to add Intel NIC-specific feature for flow classification and Dynamic Device Personalization (DDP) to support telecom workloads. Classifying the flows helps to reduce processing time and DDP improves throughput performance by programming advanced and telco-specific protocols on the adapter at run time.

Additionally, Intel plans to contribute the service functional chaining feature into Antrea, providing agility and scale while reducing cost for telecom workloads.

These technical advancements from Intel will help facilitate the adoption of NFV & 5G use cases in container environments.

Application Modernization paves the road to 5G

5G can deliver higher data rates, more network capacity and lower latency for a more immediate response and more seamless user experience supporting Industry 4.0/Smart Factory, Connected Car/Autonomous Driving, Virtual/Augment Reality, Robotics, Telemedicine/eHealth, you name it, changing the way we live, work and play.

Modern applications based on Kubernetes are being will accelerate 5G adoption providing high density connectivity, low latency and security needs for global telecom operators.

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