



Discover the Difference 5G Core Will Make this Decade

The industry is forecasting 5G network infrastructure revenue to reach US\$26 billion¹ in 2020, with the 5G Core (5GC) network alone fast becoming a US\$8.4 billion² industry by 2024.

Many vectors are driving this opportunity, including the combination of NFV adoption in the Wireless Core, 5GC infrastructure roll-out, IOT ramp, and demand for new services.

Intel optimizes mobile core workloads in virtualized and cloud environments, developing and exposing hardware technologies, and working with the industry to optimize software. Intel has invested in the ecosystem and partnered with CommSPs to bring

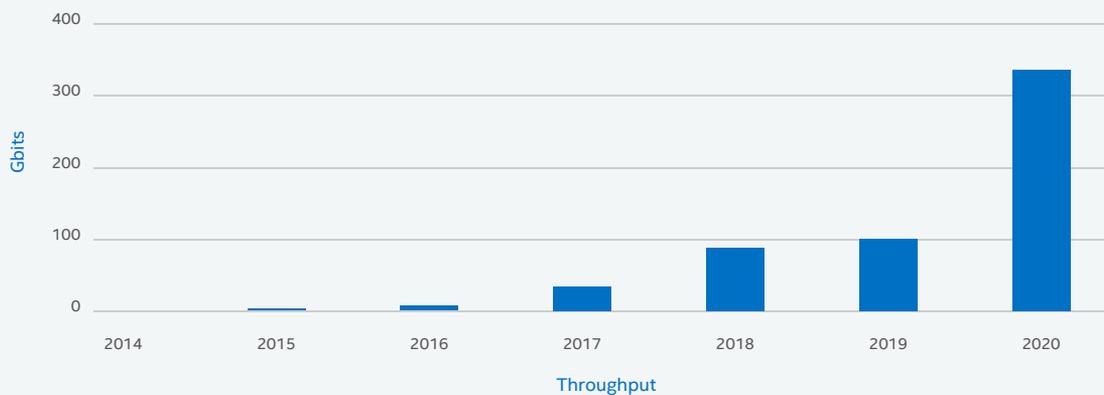
the benefits of efficiency, service agility, and scale of NFV and Cloud to the communications space. NFV will continue to grow and overtake traditional network sales in 2020, according to a recent Dell 'ORO'³ report. Through our transformative technologies and by delivering consistent generation on generation platform enhancements, Intel has become the go to silicon of choice for virtualized and cloud core network infrastructure solutions.

In 2019, we saw 5G Non-Standalone (5G NSA) Network rollout and now we are preparing for the first 5G-SA Core network upgrades. According to a recent IHS Markit Report⁴ 67% of respondents would deploy 5G Core by the end of 2021. In most cases, this means a roll-out of new

infrastructure providing increased capability and the much-needed capacity for the first wave of the 5G ramp.

In partnership with leading CommSPs around the world, Intel is consistently breaking new ground in delivering technological innovation and proving step function performance enhancements (Fig. 1) in a cloud native and containerized execution environment. Intel is leading this wave working with ecosystem partners like Affirmed (168G), Ericsson (193G) and Metaswitch (500G FWA) and demonstrating 240G 5G UPF eMBB.

eMBB User Plane Throughput per 1RU



This collaborative approach with the vendor market has led to the majority of Mobile Core deployments in 2019 being on Intel® architecture. Leading the 5G transition with key CommSPs, Intel demonstrates efficient and high-performance implementation of 5G capabilities. A good example of this is the collaborative work done with SKT on demonstrating the readiness of 5G platforms for Ultra Reliable Low Latency Communication services, and application detection and control.

The installation of new infrastructure is expensive and in the telecommunication market, the value of infrastructure must be leveraged as much as possible by maximizing the length of time before an upgrade is required. Therefore, upgrades conducted in 2020 will need to withstand the expected hike in magnitude and variety of network traffic through the first half of the decade.

For this reason, traffic density, or maximizing the traffic throughput capacity over the network, has never been more critical. In the second half of 2020, Intel and our partners will showcase a ground-breaking 1.3 Tbps 5G UPF throughput of eMBB live traffic. This massive traffic volume is achieved using sixteen Intel® Xeon® 6230Ns in a 4U configuration. The breakthrough performance



can be delivered with the Intel architecture based NFVi platforms either deployed in the Core network or distributed in an Edge location to meet requirements for 2020 and beyond. All on cost effective Intel® Xeon® Gold processors, with headroom to spare and the scalability to increase CPU core count/frequency and NIC throughput for even greater performance.

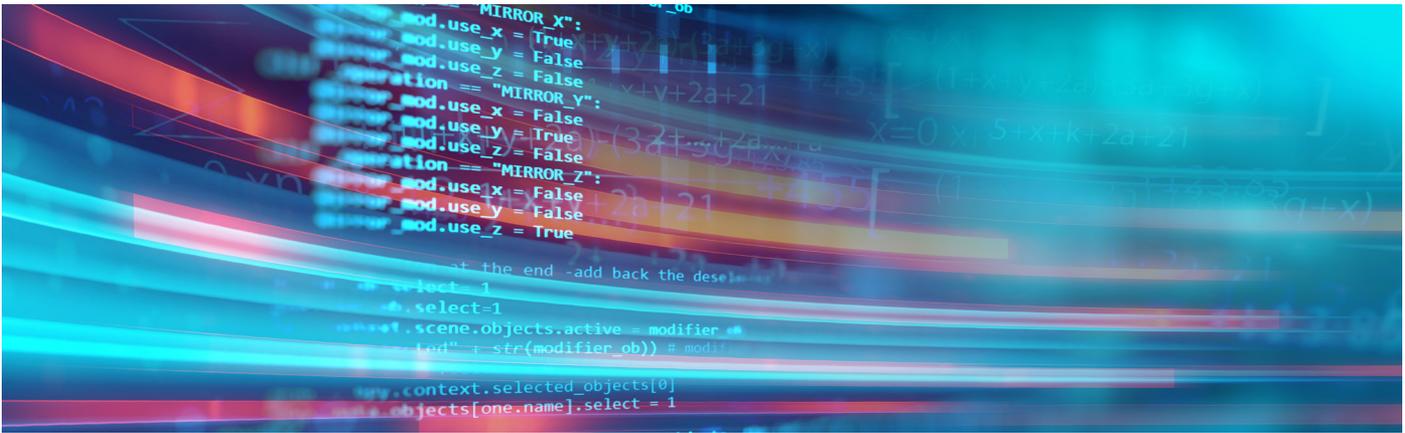
The live traffic demo will demonstrate a dense deployment of a standalone 5G UPF based on ASTRI's 5GC stack, optimized by Intel. This is deployed on two Supermicro BigTwin™ servers using 2nd Gen Intel® Xeon® Scalable processors (Cascade Lake) with Intel® Ethernet 800 Series 100GbE NICs. Each BigTwin server has 4 dual socket nodes, and each socket is paired with a 100G NIC. The system is container based

and orchestrated by Kubernetes. Telemetry is via Collectd into an influx database for demonstration of system-wide performance. This will show not only ground-breaking throughput, but deterministic end-to-end latency required to deliver advanced 5G services.

The latest 2nd Gen Intel Xeon Scalable processors are ideal for next generation virtualized and cloud workloads. Higher core counts, enhanced virtualization capabilities and increase memory bandwidth provide the resources to drive these improvements in performance for a wide range of telco workloads.

On the 800 series NICs, we will employ Intel® Dynamic Device Personalisation (DDP) to parse deeply into the packet and steer traffic based on data from inner header fields such as GTP TEID, source UE IP address, DSCP or UE flow, etc. This enables the NIC to distribute UEs in a very deterministic way into the appropriate core for PDU-Session processing without using the CPU for load distribution. The process, in turn, frees up valuable resources on the CPU and makes the entire system much more efficient and predictable with lower latency and jitter, even at high traffic and CPU loads.





We will use one Kubernetes master which deploys nodes on the Supermicro BigTwin servers. Here, we will run 16 UPFs in total and use Helm to scale the UPF number. Each node will run CPU-Manager for Kubernetes (CMK) for core isolation and pinning and PCI plugin containers for passing PF of NIC to UPF Pods. The Pods will then report back to the master the resources available for UPF Pods (Cores, NIC, Huge pages). We will also be using specific Intel developed plugins such as Multus for running high speed user plane interfaces.

Supermicro (Nasdaq: SMCI), a leading innovator in high-performance, high-efficiency server technology is a premier provider of advanced server Building Block Solutions® for Data Centre, Cloud

Computing, Enterprise IT, Hadoop/Big Data, HPC and Embedded Systems worldwide. Supermicro is committed to protecting the environment through its “We Keep IT Green®” initiative and provides customers with outstanding energy-efficiency.

For the demonstration of UPF, Supermicro supplies the BigTwin dense server platform (<https://www.supermicro.com/products/system/2u/2029/SYS-2029BT-HNR.cfm>).

The Hong Kong Applied Science and Technology Research Institute Company Limited (ASTRI) has been mobile core partner of Intel since 2016. ASTRI provides 5G SA core network technologies for technology transfer to the industry. Intel is licensed to conduct

developments upon ASTRI's 5G SA core network and to demonstrate the performance to the ecosystem using Intel optimisations for new CPUs, NIC and memory technologies. Besides UPF, ASTRI 5G SA Core Network offers a comprehensive set of standard compliant network functions, not limiting to AMF and SMF, with flexible deployment options such as cloud native, enterprise, and edge-based to support different 5G application scenarios.

To learn more about Intel's latest performance breakthroughs and why Intel is the architecture of choice for 5G developments, visit: <https://www.intel.com/content/www/us/en/wireless-network/5g-technology-overview.html>.



¹ “Mobile Core Network Five Year Forecast Report 2020–2014,” Dell ‘ORO Group Inc., January 2020.
² Alusha, Don, “5G Next-Generation Core and Service-Based Architecture,” ABI Research, 2019.
³ “Mobile Core Network Five Year Forecast Report 2020–2014,” Dell ‘ORO Group Inc., January 2020.
⁴ “2020: The Mobile Infrastructure Market is Poised for 3.5% Growth,” IHS Markit, Analyst Insight, January 9, 2020.

Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more complete information visit www.intel.com/benchmarks.

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