Solution Brief

Mobile Operators
Open RAN Development

Cohere's Universal Spectrum Multiplier xApp Boosts 4G, 5G

Cohere's MU-MIMO enabling FDD and TDD Open RAN xApp runs on any RAN Intelligent Controller on Intel® architecture servers.

Wireless spectrum is the lifeblood of cellular voice and data services which means it's a valuable commodity for mobile network operators (MNOs) and enterprises implementing private 5G. Throughout the world, MNOs are paying billions of dollars for spectrum licenses offered by government telecommunications commissions and bureaus.

Table 1 shows the results of the last four 5G-related auctions by the U.S. Federal Communications Commission (FCC) that raised more than $90 billion.

But even with this infusion of spectrum, MNOs are realizing they need to manage this asset carefully because the demand for data is growing so quickly opening up the possibility of overwhelming the available spectrum. And because of the high cost of this spectrum MNOs need to maximize their ROI by ensuring the network has as much data running through it as possible.

AUCTION	FREQUENCY BANDS	DATE	AMOUNT RAISED
Auction 103	Millimeter wave (37, 39 and 47 GHz bands)	March 2020	$7.5 billion
Auction 105	Citizens Broadband Radio Service (CBRS) (3550-3650 MHz)	September 2020	$4.6 billion
Auction 107	C-band (3.7 GHz)	February 2021	$81 billion
Auction 110	C-band (3.45 GHz)	November 2021	$21.8 billion

Table 1. Recent US FCC 5G spectrum auctions.[1]

Demand for Data Services is Growing Rapidly

In 2022, demand for wireless bandwidth is forecast[2] to total 77 Exabytes per month, a 35 percent increase over the predicted 57 Exabytes of monthly wireless bandwidth consumed in 2021. At this rate of growth, the amount of available spectrum could be overwhelmed by data demand in the near future.

This leads to the potential for spectrum congestion that could require MNOs to reduce bandwidth for customers or initiate additional cell site construction activities to accommodate the traffic growth. Private 5G faces challenges due to the limited amount of shared spectrum allocated to it by national regulators.

To avoid or delay these conditions, MNOs and enterprises are now more closely managing their spectrum. One way to get more from their spectrum assets is to improve their spectrum efficiency, which is the measurement of the effectiveness of a given frequency in carrying packets. It is measured by throughput (in bits per second) divided by the channel bandwidth (as measured in hertz). By improving spectral efficiency, MNOs and enterprises can make better use of their spectrum resources which allows them to meet rising data demands cost-effectively.

Open RAN Sets Stage for Spectrum Efficiency

One development that is impacting the ability to improve spectral efficiency is the industry adoption of open radio access networks (Open RAN). Legacy RAN baseband units (BBU) are monolithic hardware appliances and are designed to make it difficult to insert third-party innovative technologies to manage spectrum. But Open RAN disaggregates the BBU software separating it into a distributed unit (DU) and a centralized unit (CU) and allowing each to be deployed on commercial-off-the-shelf (COTS) Intel® architecture servers. This disaggregation opens many innovations to RAN solutions including the use of the cloud and extensive remote orchestration and management capability.

The Open RAN architecture also includes deployment of a RAN intelligent controller (RIC) as a separate entity. As Open RANs grow there is an increased need for better management and orchestration. The RIC enables management and orchestration of Open RAN supporting applications that provide added functionality for the network.

The RIC is disaggregated into two separate parts based on the latency required by the network function. Non-real-time processing is required for service management and orchestration (SMO) functionality which are functions that operate with >1 second response. Applications that operate within the non-real-time RIC (Non RT-RIC) are called rApps.

Other network functions require faster response times (between 10 ms and 1 second) and are processed within the near real-time RIC (near-RT-RIC). Applications that work with the near real-time RIC are called xApps.

Intel® Network Builders ecosystem partner, Cohere Technologies, has demonstrated a proof of concept (POC) of its Universal Spectrum Multiplier xApp software running on a near-RT-RIC from VMware on Intel architecture servers. The POC demonstrates how Cohere's Open RAN xApp can improve network efficiency and boost the capacity of 5G networks where multiple subscribers are using the same site.

VMware Provides RIC

The VMware RIC is the software subsystem that the Cohere Universal Spectrum Multiplier xApp plugs into.

The VMware RIC abstracts the underlying RAN infrastructure and provides developer APIs for xApps and rApps to program the RAN. VMware has engineered its RIC to seamlessly integrate with both traditional RAN equipment and Open vRAN network functions.

The VMware RIC platform includes two controllers:

- **VMware Centralized RIC:** an implementation of the non-real-time RIC (non-RT RIC) that manages and hosts rApps.
- **VMware Distributed RIC:** an implementation of the near-real-time RIC (near-RT RIC) that manages and hosts xApps.

These controllers can run separately or together. Cohere is part of the VMware RAN application developer program and has integrated its Universal Spectrum Multiplier xApp into the distributed application environment.

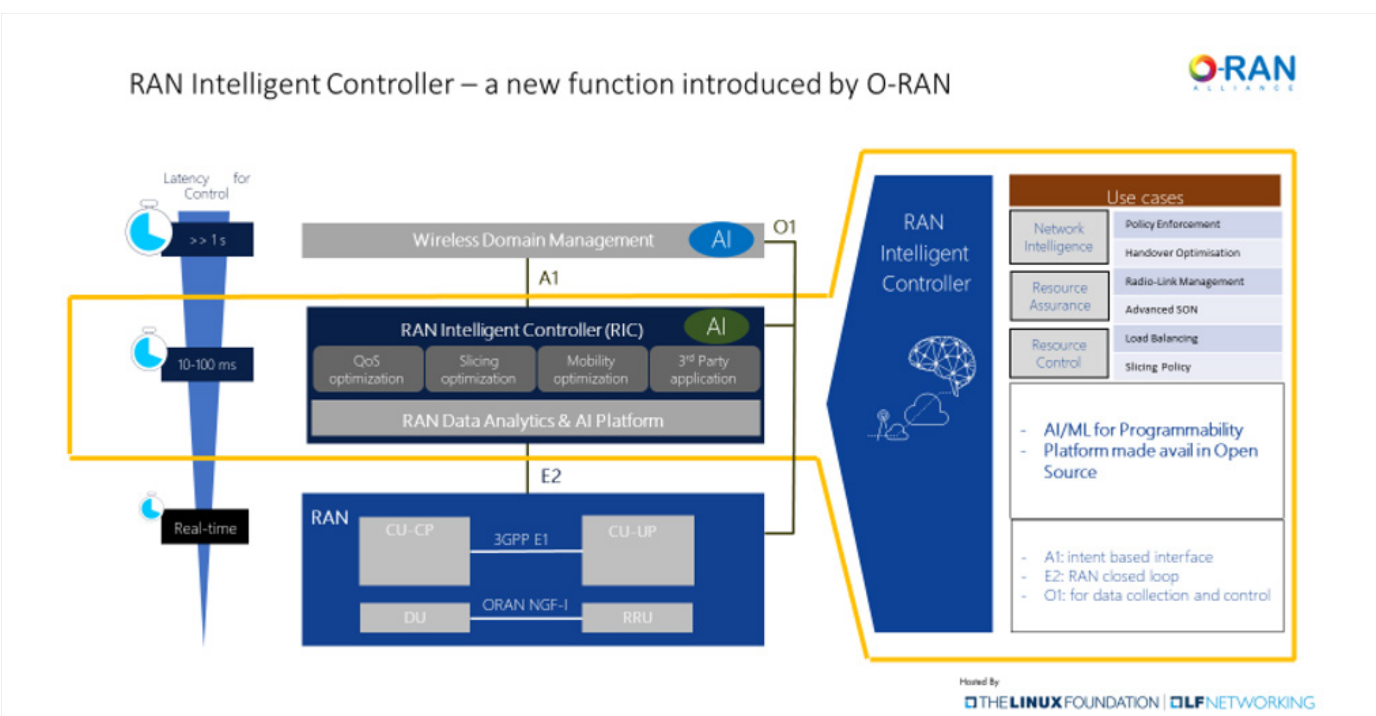

Figure 1. RIC block diagram.

Cohere's Universal Spectrum Multiplier

Cohere's Universal Spectrum Multiplier xApp improves spectral efficiency for CSPs by as much as two times by enabling mobile networks to communicate with multiple users simultaneously using the same time and frequency resources.

The xApp is designed to overcome several challenges, including reference signal contamination (intercell interference); channel state information aging; stability under mobility and other channel dynamics; higher number of layers per antenna configuration; computational complexity; and the requirement for explicit device feedback.

This is achieved by using dynamic and smart pairing as well as precoding techniques. Specifically, the Universal Spectrum Multiplier has harnessed Delay Doppler channel representation, which enables highly accurate predictions of signal-to-noise ratio (SNR) and user pairing. This channel representation reduces computation complexity and can be used for predicting the future given that its geometric nature is slow changing.

The left side of Figure 2 shows the block diagram of the RIC and the Universal Spectrum Multiplier xApp, with the exploded view in the middle of the figure. The software runs in the service and management orchestration (SMO) stack with a pre-coding function attached to the RAN distributed unit (DU). On the right hand side of the image is the benefit: multiple users sharing the spectrum. The result is improved spectral efficiency and network latency that helps MNOs deliver a better user experience and ease capacity bottlenecks when demand is high.

Capgemini provided its ViNGC 5G core software for the PoC. ViNGC is an optimized virtualized core network for 5G standalone deployments. The software follows a service based architecture (SBA) and supports complete 5G core functionality and delivers high levels of orchestration and automation for operational efficiency.

The Universal Spectrum Multiplier xApp works in the network and requires no changes to handsets. The software offers significant MU-MIMO benefits, and can work with existing base stations. Moreover, it allows simultaneous 4G and 5G co-existence without the performance issues of DSS via a vendor neutral approach to dynamic spectrum reuse.

Cohere's Universal Spectrum Multiplier software works in all networks thanks to the underlying Delay Doppler algorithms that work for waveforms in any spectrum as well as operating in either Frequency Division Duplexing (FDD) or Time Division Duplexing (TDD) networks. This enables them to improve the strength and efficiency of any generation ("any G") mobile network.

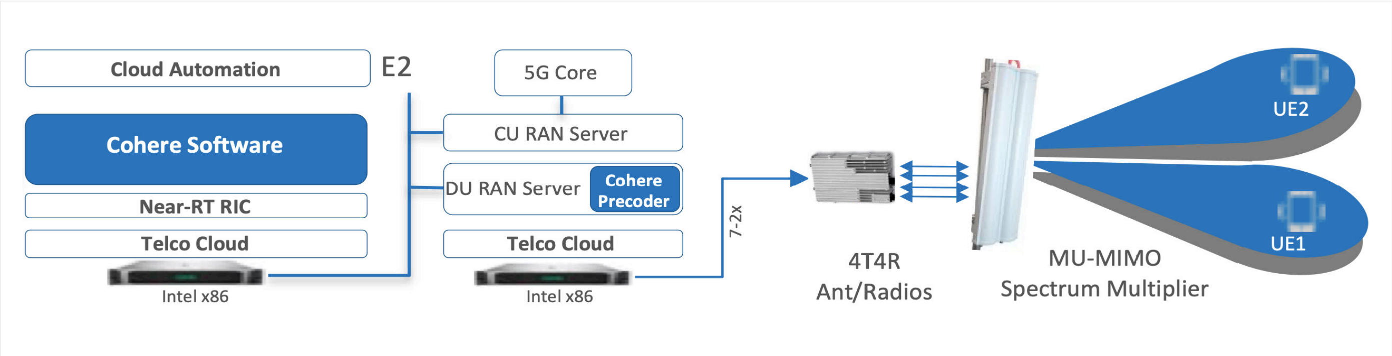

Figure 2. Cohere Universal Spectrum Multiplier xApp block diagram.

Tier 1 MNOs Report Performance Gains

The capabilities of Cohere's Universal Spectrum Multiplier have been demonstrated and verified via numerous licensed spectrum network tests and scalability simulations with leading mobile network operators. Cohere first showcased its software in Feb. 2020 at Deutsche Telekom's Headquarters in Germany, as part of a public O-RAN showcase. Cohere showed a two-times spectrum and capacity multiplier effect for mobile devices connected to the commercial spectrum, with no changes to the devices, radios or antennas. In June 2021, Cohere announced the results of a 5G Open RAN lab trial with Vodafone that leverages Cohere 's software solution in partnership with Intel, VMware and CapGemini Engineering. Collectively, the technology partners demonstrated an end to end, multi-vendor, open platform and achieved two times the spectral efficiency using Cohere's Universal Spectrum Multiplier capability.

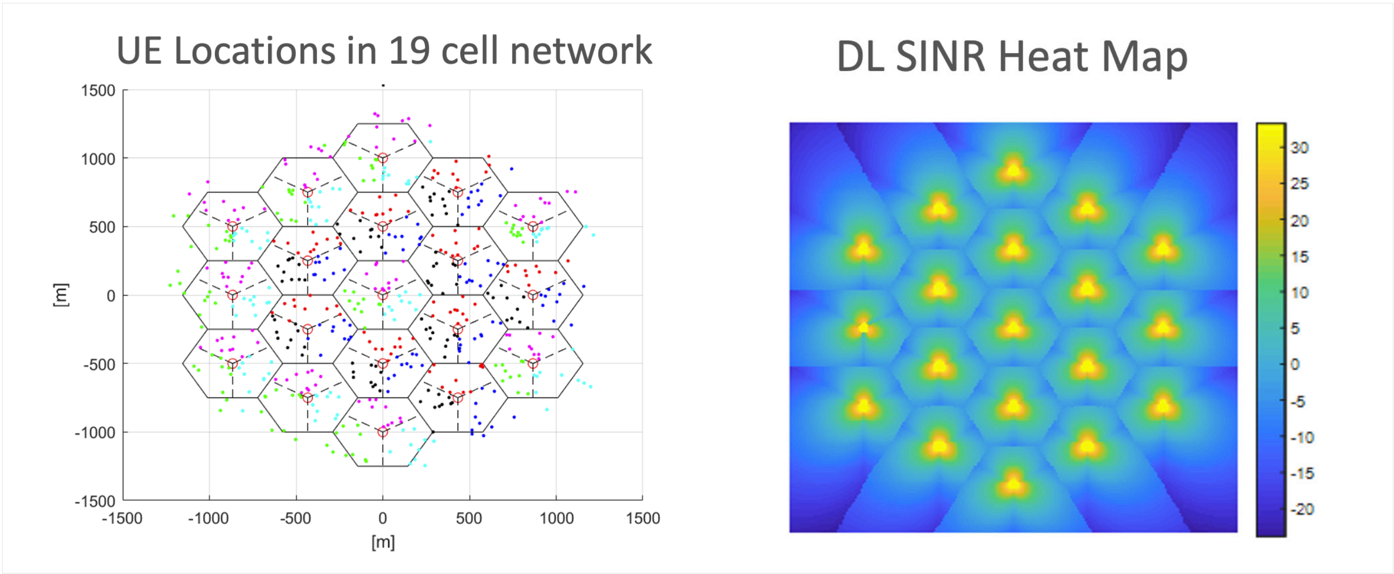

Figure 3. The left image shows the 3GPP TR 36.814 physical layout for a 19-cell test network. The right-hand image shows the radio signal strength "heat map." In the demonstration, the signal strength was varied by a channel emulator.

Intel 5G Technologies Power Virtualized RAN Software
Cohere's software needs a high-performance hardware platform for running virtualized and containerized RAN applications with great performance. Some of the key 5G technologies that Intel provides for these applications include:

3rd generation Intel® Xeon® Scalable processors: These processors are a next-generation platform for cloud-optimized, 5G-ready networks, and next-generation virtual networks. With up to 36 cores, these CPUs offer higher base frequency for greater throughput for virtualized network functions and lower power for dense or constrained physical deployments.

Intel FlexRAN™: The virtualized L1 function in the DU server is enabled by Intel FlexRAN™ reference architecture, which is a flexible and programmable platform for software-defined RANs. The software enables MNOs to use the open RAN ecosystem to build and deploy optimized 4G and 5G scalable cloud-native RAN solutions on Intel architecture processors.

Intel® vRAN Dedicated Accelerator ACC100: This acceleration card accelerates Layer 1 FEC algorithms, making more processing power available for increased channel capacity on edge-based services and applications. The accelerator is a dedicated device that works with Intel® Xeon® Scalable processors and Intel® Xeon® D processors in power-efficient 4G and 5G vRAN networks.

Spectrum Multiplication in Action

The ability to double cellular bandwidth was demonstrated in the June 2021 trial at Vodafone's test lab. The companies set up a wireless network demonstration that was compliant with the 3GPP TR 36.814 specifications for a 19-cell network with three sector channels per cell (see Figure 3). The left image shows how in each cell, the antennas are aimed in three directions of the hexagons. The image on the right of the figure is a heat map that shows the signal strength of each radio. For the demonstration, the network emulator signal strength was changed to demonstrate how the xApp worked under different network conditions.

The basestation under test utilized virtualized RAN software in an Open RAN compliant network and were configured with the Cohere xApp running on the VMware near-RT RIC. The mobile devices (user equipment / UE) were positioned by the emulator in each sector and the resulting signal-to-noise ratio (SINR) was computed by determining the intended received signal from the nearest antenna and then the sum of the unwanted signals from all other UEs in the other sectors.

Figure 4 shows the results of the trial. The blue dots represent downlink network performance with Cohere xApp turned on, while the red dots show performance with Cohere turned off. The Y axis is the throughput as measured in megabits per second and the X axis depicts network conditions from very high SINR resulting in poor signal strength to very high signal strength. The blue dots show double the bandwidth at almost all points of the test.

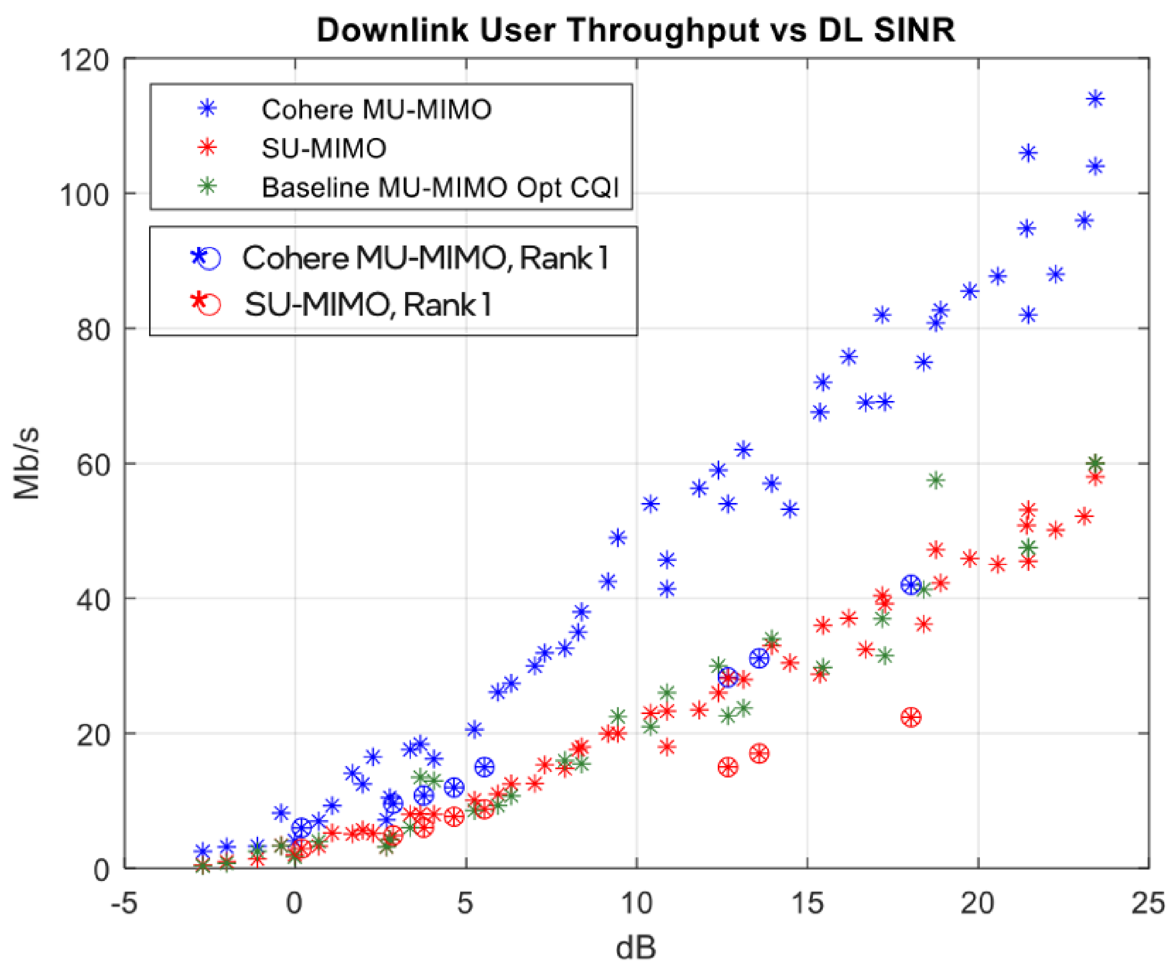

Figure 4. Network throughput in Mbps with Cohere turned on (blue dots); red dots show performance without Cohere turned off across a range of signal strengths.

The mean of the data plotted in Figure 4 is shown in the table below:

	SPECTRUM MULTIPLIER DISABLED	SPECTRUM MULTIPLIER ENABLED	GAIN (%)
Mean User (Mbps)	22.2	44.2	99.1
Mean Cell (Mbps)	44.5	88.4	98.7

Conclusion

Spectrum is very important to MNOs and it's costing them tens of billions of dollars to license, but the new spectrum may not be enough given the dramatically increasing demand for wireless services. Enterprise private 5G infrastructure may be limited in the availability of spectrum that could result in congestion and performance problems. The Universal Spectrum Multiplier software enables significant capacity improvements to both public mobile networks and private 5G via adding the xApp to an Open vRAN basestation.

Cohere is a leader in spectrum efficiency technologies that can double the effective spectrum for "all G" networks including 5G. The company's Universal Spectrum Multiplier software is an xApp running in VMware's RIC platform on Intel architecture hardware. The solution provides CSPs with a powerful option that introduces spectral efficiency into the network to allow MNOs to get the most from their spectrum investments.

Learn More

Cohere Technologies

VMware RIC

3rd generation Intel® Xeon® Scalable processors

Intel® FPGA PAC N3000

FlexRAN™ software

Intel® Network Builders

Notices & Disclaimers

[1] Auction 103: https://www.fcc.gov/document/fcc-concludes-largest-ever-spectrum-auction
Auction 105: https://www.fcc.gov/document/fcc-announces-winning-bidders-35-ghz-band-auction
Auction 107: https://www.fcc.gov/document/fcc-announces-winning-bidders-c-band-auction
https://www.fcc.gov/document/fcc-mid-band-spectrum-auction-successfully-concludes-clock-phase

[2] https://www.statista.com/statistics/271405/global-mobile-data-traffic-forecast/

0222/TM/H09/PDF ♻ Please Recycle 350027-001US