Universal Spectrum Multiplier (USM) on a Programmable Multi-G Network Built on the Intel FlexRAN Platform

- Art King, Director of Product Management and Marketing, Cohere Technologies
- Ranjit Cavatur, Sr. Director, Intel NEX SW
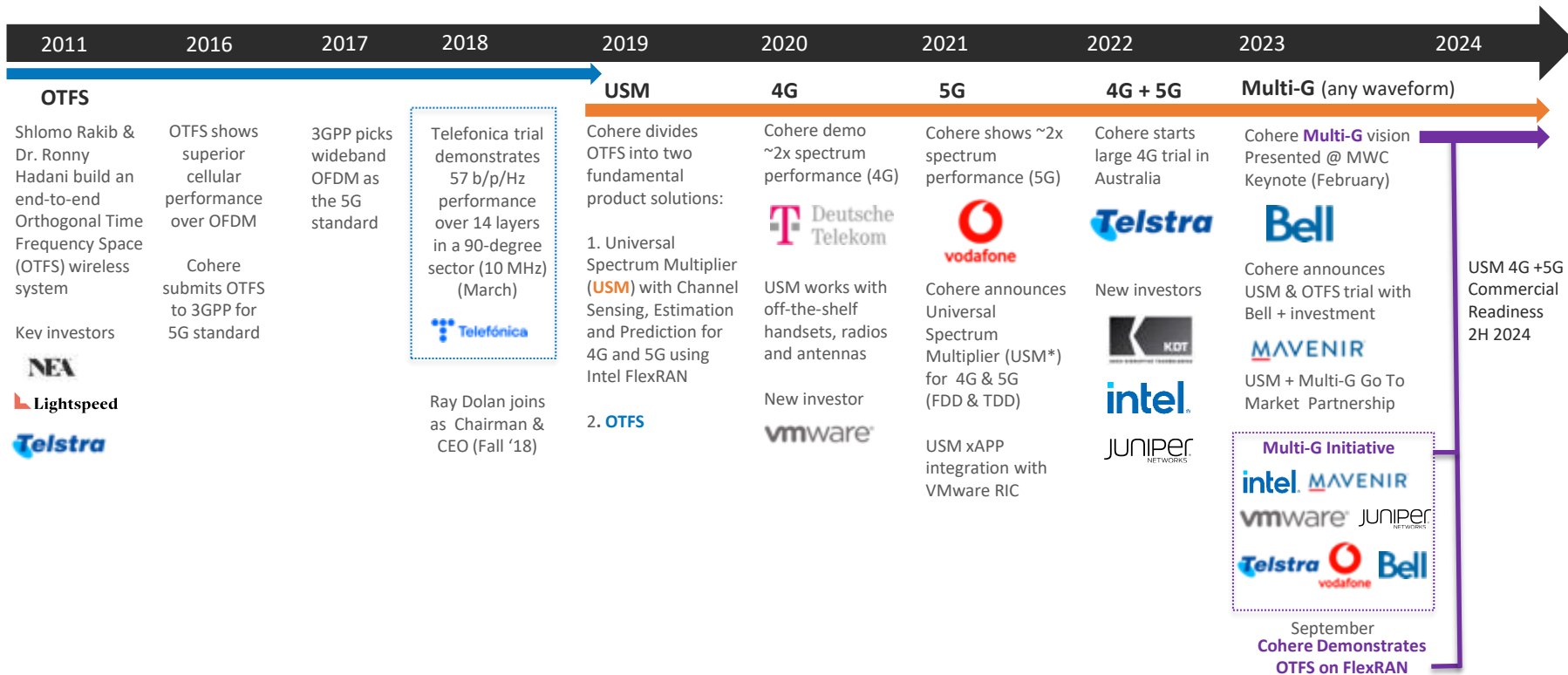
Multi-

~2x

The OTFS Innovator

cohere
technologies
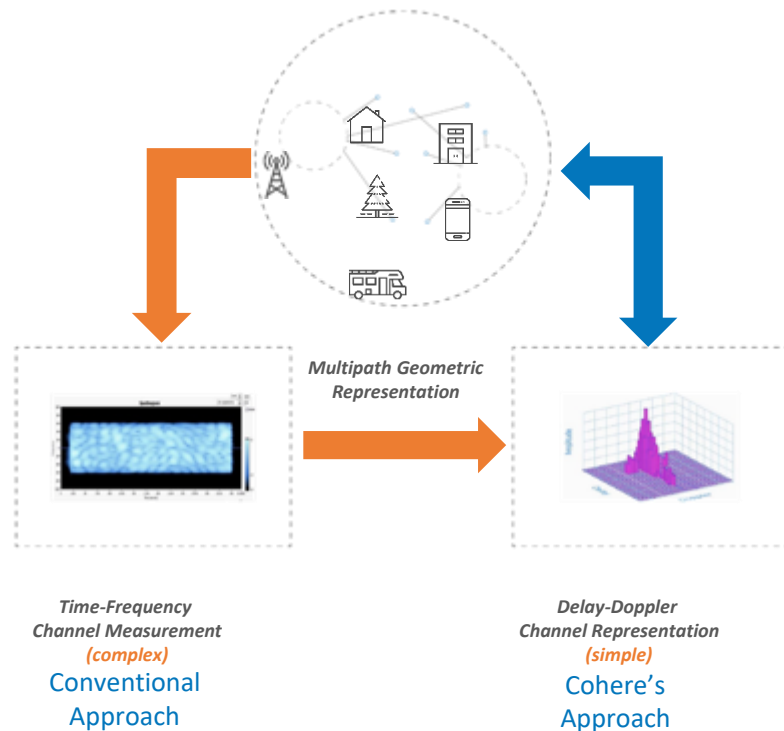
Multi-G

Programmable Layer 1 PHY & Intel FlexRAN

Cohere's Universal Spectrum Multiplier (USM) Software Dramatically Improves the Value of $1 Trillion Spectrum Assets Worldwide

Cohere's Journey

2011 | **2016** | **2017** | **2018** | **2019** | **2020** | **2021** | **2022** | **2023** | **2024**

OTFS ... **USM** ... **4G** ... **5G** ... **4G + 5G** ... **Multi-G** (any waveform)

2011 — OTFS

Shlomo Rakib & Dr. Ronny Hadani build an end-to-end Orthogonal Time Frequency Space (OTFS) wireless system

Key investors

NEA

Lightspeed

Telstra

2016

OTFS shows superior cellular performance over OFDM

Cohere submits OTFS to 3GPP for 5G standard

2017

3GPP picks wideband OFDM as the 5G standard

2018

Telefonica trial demonstrates 57 b/p/Hz performance over 14 layers in a 90-degree sector (10 MHz) (March)

Telefónica

Ray Dolan joins as Chairman & CEO (Fall '18)

2019 — USM

Cohere divides OTFS into two fundamental product solutions:

1. Universal Spectrum Multiplier (**USM**) with Channel Sensing, Estimation and Prediction for 4G and 5G using Intel FlexRAN

2. **OTFS**

2020 — 4G

Cohere demo ~2x spectrum performance (4G)

Deutsche Telekom

USM works with off-the-shelf handsets, radios and antennas

New investor

vmware

2021 — 5G

Cohere shows ~2x spectrum performance (5G)

vodafone

Cohere announces Universal Spectrum Multiplier (USM*) for 4G & 5G (FDD & TDD)

USM xAPP integration with VMware RIC

2022 — 4G + 5G

Cohere starts large 4G trial in Australia

Telstra

New investors

KDT

intel

JUNIPER NETWORKS

2023 — Multi-G (any waveform)

Cohere **Multi-G** vision Presented @ MWC Keynote (February)

Bell

Cohere announces USM & OTFS trial with Bell + investment

MAVENIR

USM + Multi-G Go To Market Partnership

Multi-G Initiative

intel MAVENIR

vmware JUNIPER NETWORKS

Telstra vodafone Bell

September
Cohere Demonstrates OTFS on FlexRAN

2024

USM 4G +5G Commercial Readiness 2H 2024

Cohere has 300+ Patents for OTFS + USM

Cohere's Channel Model Reveals the <u>Geometry</u> of the Environment in Software

Multipath Geometric Representation

Time-Frequency
Channel Measurement
(complex)
Conventional
Approach

Delay-Doppler
Channel Representation
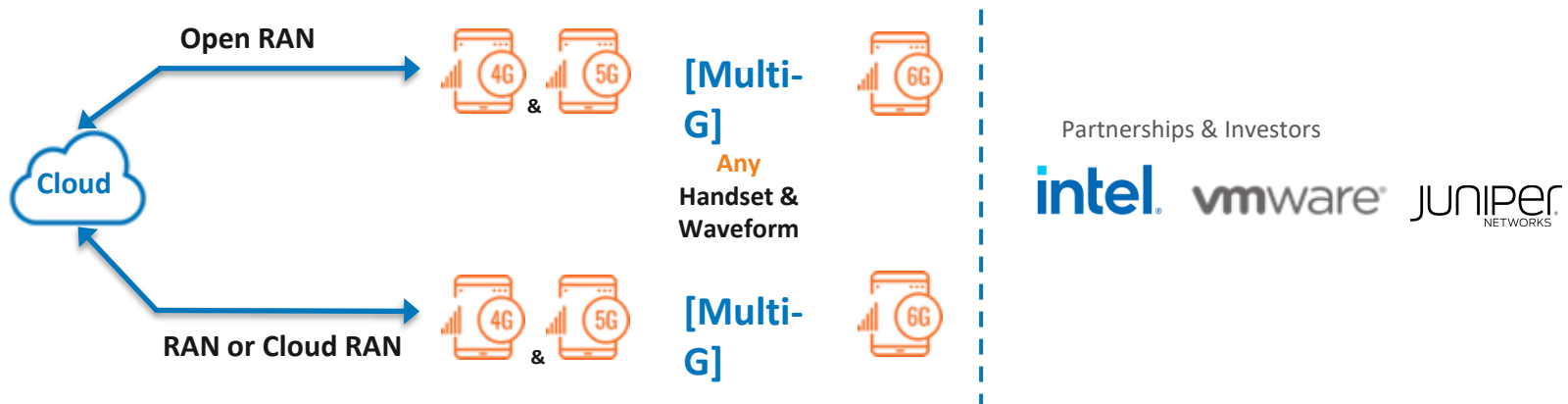(simple)
Cohere's
Approach

USM, built on FlexRAN, uses Fourier Transforms to translate Time/Frequency to Delay Doppler, which Dramatically Simplifies MU-MIMO for both FDD and TDD Spectrum

USM uses existing handsets, utilizing UL Reference Signals and DL CQI to Accurately Determine & Predict Channels Between Transmitters & Receivers, Resulting in Rank 2 (SU MIMO) and Rank 4 (MU MIMO)

◎ USM channel estimation reveals all dominant reflectors which resolves Mu-MIMO challenges

◎ Software enables fully isolated, multiple beams – without the need for explicit UE feedback

◎ By slowing down channel aging, the result is more <u>predictable</u> channels, improved spectrum reuse, performance and capacity

USM for Green or Brownfield Networks

Universal Spectrum Multiplier software can be integrated with the Base Station (CU/DU) or in the **Telco Cloud** as an xApp with the RAN Intelligent Controller (RIC)

Open RAN

Cloud

RAN or Cloud RAN

[Multi-G]
[Multi-G]

Any Handset & Waveform

4G & 5G   6G

Partnerships & Investors

intel   vmware   JUNIPER NETWORKS

Universal Spectrum Multiplier (USM) Software Creates a Platform to Host Any Waveform

Orthogonal Time Frequency Space (OTFS)

Universal Spectrum Multiplier

| OTFS | 4G OFDM | 5G OFDM | Multi-G |
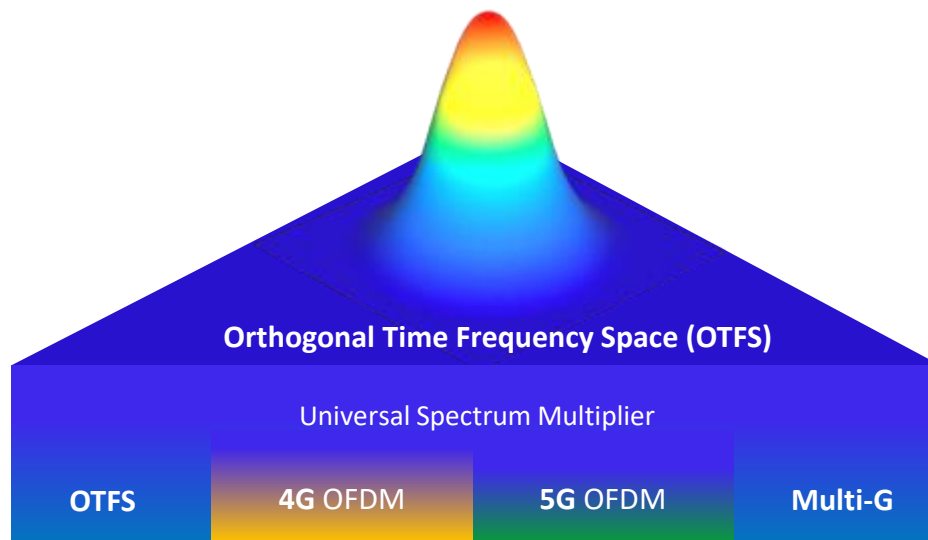
Multi-G Platform = Open RAN

- USM performs Channel Sensing with massive efficiency
- USM is Predictive allowing scheduling from Cloud/data center
- USM is transparent to waveform – no changes to standards
- USM allows cellular networks to "host" entire industries

INDUSTRY LEADERS COLLABORATE ON NEW PROGRAMMABLE MULTI-GENERATIONAL FRAMEWORK THAT EXTENDS BEYOND 5G OPEN RAN

New and Open Software Interfaces Will Support Multiple Waveforms (4G, 5G, and Beyond)

With this new Multi-G framework, future Intel FlexRAN code releases will have the ability to support 4G and 5G and next-generation waveforms by enabling the disaggregation of important RAN intelligence and scheduling functions, making FlexRAN the first Multi-G Open RAN hosting platform for 4G, 5G, and beyond.

"This commitment from Intel, Juniper, Mavenir, and Cohere, with a software programmable L1 stack, is fully aligned with the vision of Open RAN and will bring us one step closer to the scale deployment of software defined RAN," said **Yago Tenorio, Vodafone fellow and director of network architecture, and chairman of the Telecom Infra Project (TIP).** *"This has huge potential for significant performance and capacity benefits for all existing cellular networks. We strongly endorse this initiative, and we look forward to seeing the critical interfaces published into the relevant O-RAN Alliance and TIP Working Groups."*

*"Cohere's Universal Spectrum Multiplier technology has the potential to unlock new architectural capabilities and opportunities for the RAN beyond today's architecture," said I*skra Nikolova, Network and Infrastructure Engineering Executive, Telstra*. "We're pleased to support this initiative and look forward to working with Cohere and the group to define the framework and accompanying critical interfaces."*

"A genuine Multi-G framework will enhance the benefits of Cohere's Universal Spectrum Multiplier, strengthen Open RAN vendor flexibility down to the silicon layer, and allow old and new waveforms to coexist— beyond 5G," said **Mark McDonald, Bell's Vice President, Wireless Access.** *"Bell looks forward to working with Cohere and partners later this year to further test this architecture."*
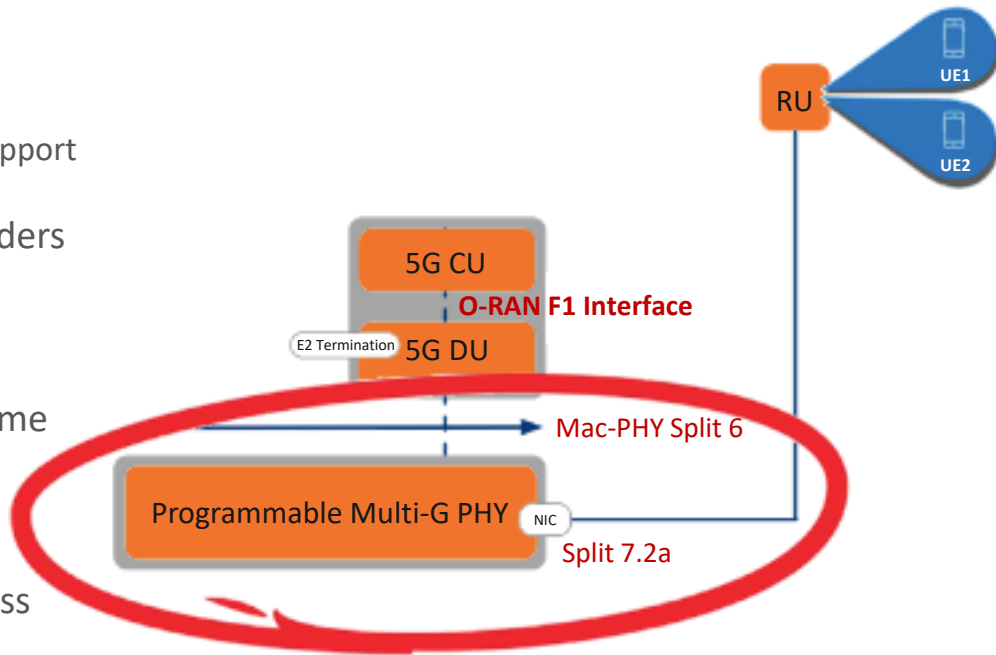
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Multi-G

Introduces a Programmable Layer 1 PHY

- ◉ Built on Intel FlexRAN platform
  - • Intel's deep developer and vRAN/O-RAN support
  - • Strong low - and mid-band capabilities
- ◉ Multi-G will enable other O-RAN stack builders

Multi-G realizes high performance spectrum multiplication and waveform co-existence in same spectrum

FlexRAN opens unprecedented innovation access

RU

UE1

UE2

5G CU

O-RAN F1 Interface

E2 Termination 5G DU

Mac-PHY Split 6

Programmable Multi-G PHY

NIC

Split 7.2a

Validated

Field-tested, pre-integrated software and hardware stack

Optimized

Dev Ops cloud native SW development delivering continuous SW releases improving capacity, wireless performance and energy efficiency

Scalable

5G/4G vRAN capacity adjusts to support single cell, D-RAN, C-RAN, LTE, 5GNR, narrow band and massive mimo all from the same SW Base

Portable

Applications run on public or private cloud or at the edge: DRAN, CRAN, enterprise, CSPs

FlexRAN™ Reference Software

Proven 4G and 5G baseband PHY reference design for DU virtualization using Intel® Xeon® Scalable processors

intel.

Intel FlexRAN™ Reference Software

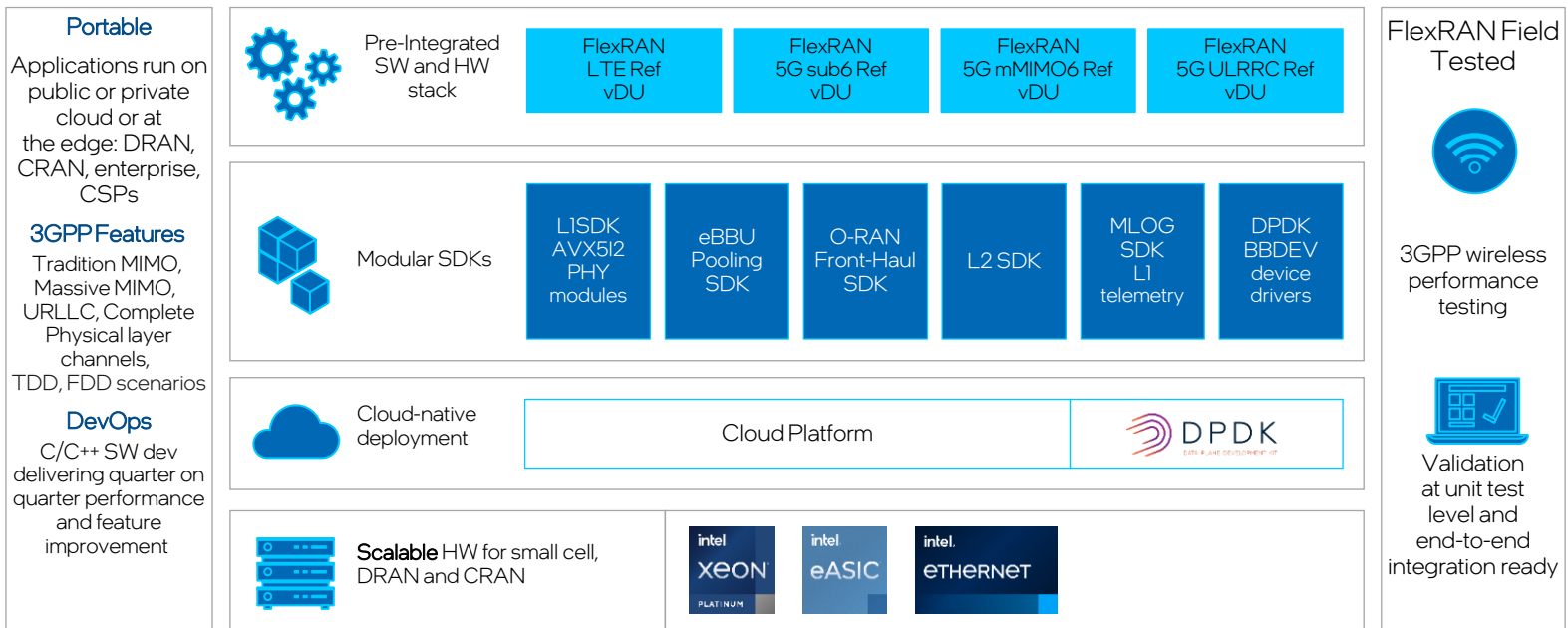|	
WHAT IS FLEXRAN?	▪ Software reference implementation of base-band unit (BBU)/distributed unit (DU) vRAN stack
FLEXRAN OBJECTIVE	▪ Help ecosystem bring vRAN solutions to market quickly
ENGAGEMENT MODEL	▪ vDU vendor uses FlexRAN software as reference ▪ Ecosystem uses FlexRAN software to validate compatibility and performance of their solutions
FLEXRAN SEGMENTS	▪ All RAN Segments (4G, 5G, Macro, Small Cells, mmWave and other segments)

intel. 11

FlexRAN Reference Software

Portable

Applications run on public or private cloud or at the edge: DRAN, CRAN, enterprise, CSPs

3GPP Features

Tradition MIMO, Massive MIMO, URLLC, Complete Physical layer channels, TDD, FDD scenarios

DevOps

C/C++ SW dev delivering quarter on quarter performance and feature improvement

Pre-Integrated SW and HW stack

FlexRAN LTE Ref vDU	FlexRAN 5G sub6 Ref vDU	FlexRAN 5G mMIMO6 Ref vDU	FlexRAN 5G ULRRC Ref vDU

Modular SDKs

L1SDK AVX512 PHY modules	eBBU Pooling SDK	O-RAN Front-Haul SDK	L2 SDK	MLOG SDK L1 telemetry	DPDK BBDEV device drivers

Cloud-native deployment

Cloud Platform	DPDK

Scalable HW for small cell, DRAN and CRAN

intel XEON PLATINUM intel eASIC intel. ETHERNET

FlexRAN Field Tested

3GPP wireless performance testing

Validation at unit test level and end-to-end integration ready

FlexRAN is a SW and HW **reference architecture** to enable the vRAN/O-RAN ecosystem to build and deploy **highly optimized, feature rich,** 4G/5G **scalable cloud-native** RAN solutions on Intel® architecture

4th Gen Intel® Xeon® Scalable Processors
with Intel® vRAN Boost

Up to
2x
capacity gain[1]

Additional
~20%
power savings[1]
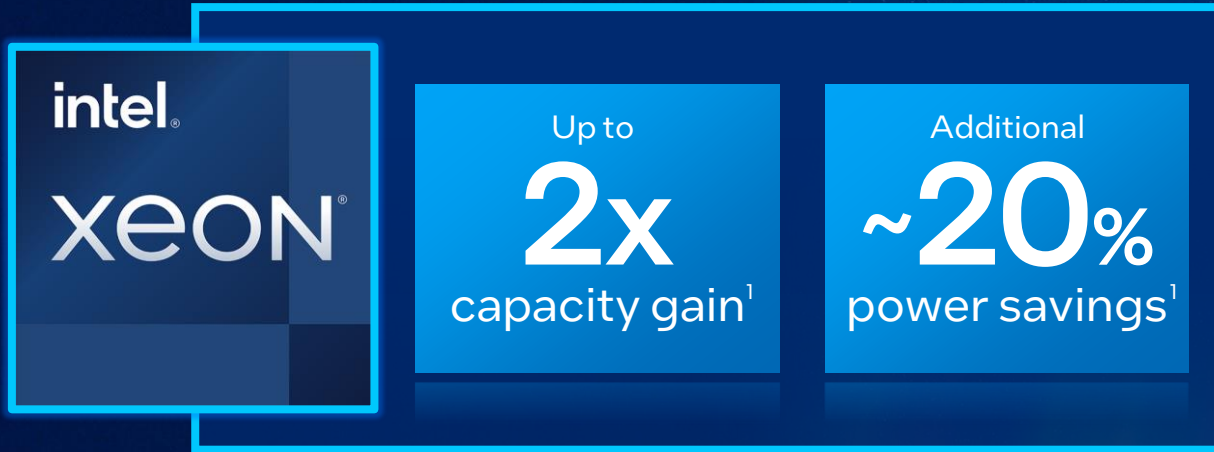
Delivering **ease** and **compatibility** for **today**, **scalability** and **flexibility** for **tomorrow**

Thank You