

The Intel logo, consisting of the word "intel." in a lowercase, sans-serif font, is positioned in the top left corner of the slide. The background of the slide features a dark blue gradient with glowing blue lines and a detailed, glowing blue microchip in the center-right, which is the primary visual element.

intel.

TECH
tour.TW

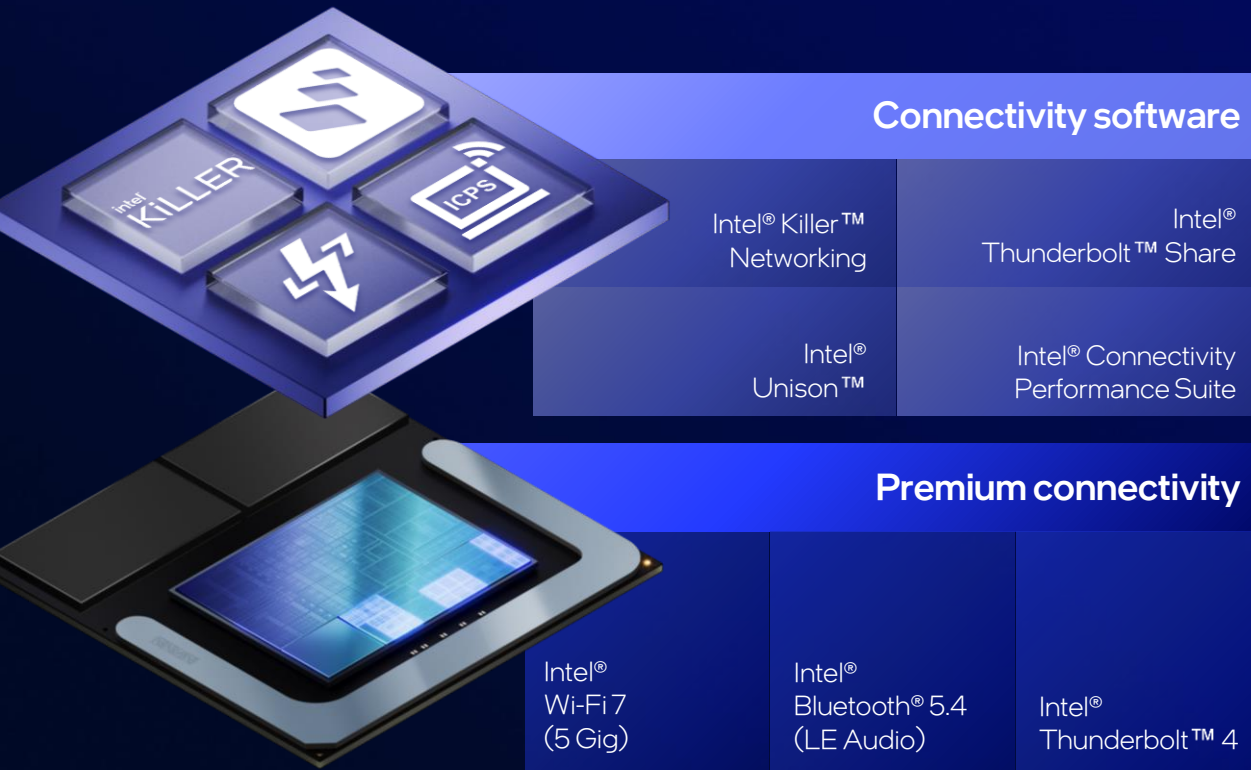
Intel Connectivity: Pioneering the Present, Creating the Future

Carlos Cordeiro

Intel Fellow & Wireless CTO, Client Computing Group

Lunar Lake Brings State of Art Connectivity

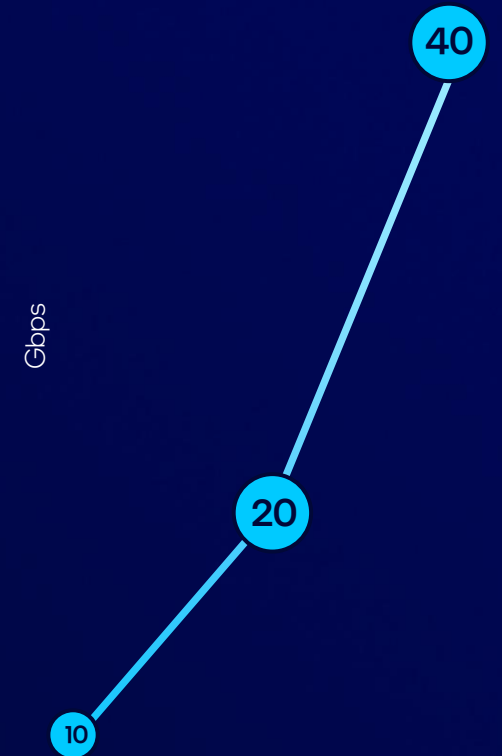
Driving revolution of PC connectivity



500x in 20 years



4x in 5 years

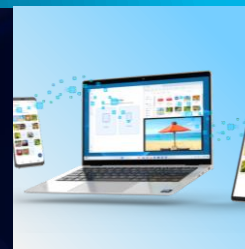


Connectivity Unlocks Great Lunar Lake Experiences

Through premium
connectivity and
innovative software



Experiences



Seamless
multi-device
control



Immersive
wireless PC
AR/VR



High-speed
wired
connectivity



Enhanced
wireless
collaboration



Connectivity software

Intel®
Unison™

Intel® Killer™
Networking

Intel®
Connectivity
Performance
Suite

Intel®
Thunderbolt™
Share

Premium connectivity

Intel®
Bluetooth® 5.4
(LE Audio)

Intel®
Wi-Fi 7
(5 Gig)

Intel®
Thunderbolt™ 4

AI PC and Connectivity: A Positive Feedback Loop

Enhancing AI PC experiences with performance, data/insights, and software optimization



3

Optimizations/remediations

Connectivity software enhancements

Intel® Killer™ Networking

Intel® Connectivity Performance Suite

3rd party IP "Powered by ICA" (AI Ops)

2

Data/analytics/insights

Client/network/peripheral information

Intel® Connectivity HW & SW

Intel® Connectivity Analytics - SDK/Program

1

High performance hardware

High-speed, low-latency, deterministic reliability

Intel® Wi-Fi 7 (5 Gig)

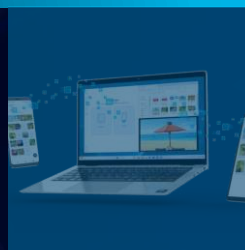
Intel® Thunderbolt™ 4

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connectivity and
innovative software



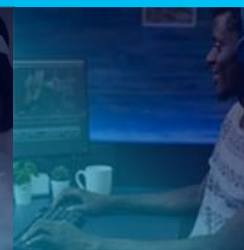
Experiences



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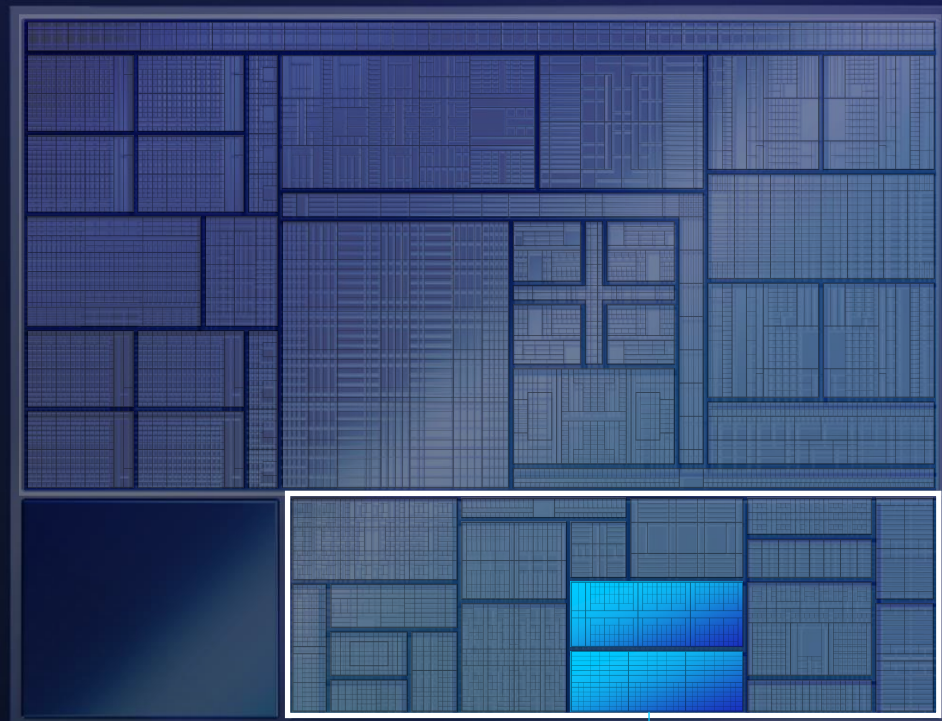
Intel®
Bluetooth® 5.4
(LE Audio)

Intel®
Wi-Fi 7
(5 Gig)

Intel®
Thunderbolt™ 4

Lunar Lake

Do More with Thunderbolt™ 4

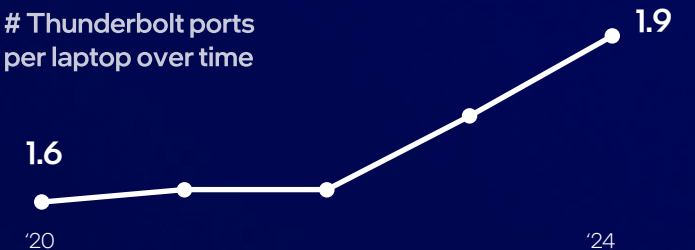


Platform
Controller Tile

Thunderbolt™ 4

Up to 3
Ports
Thunderbolt™ 4

Thunderbolt ports
per laptop over time



Up to 25%

Better read and
write speeds with
Thunderbolt™ 5
SSDs¹

Read

Write

4GB/s

3.2GB/s

2.9GB/s

2.5GB/s

TBT 5

TBT 3

TBT 5

TBT 3

Thunderbolt™
Share

for higher productivity with multi-PC connectivity

¹ Versus Thunderbolt™ 3. Based on estimated performance on Lunar Lake processors. See [Intel.com/PerformanceIndex](https://www.intel.com/PerformanceIndex) for details. Results may vary.



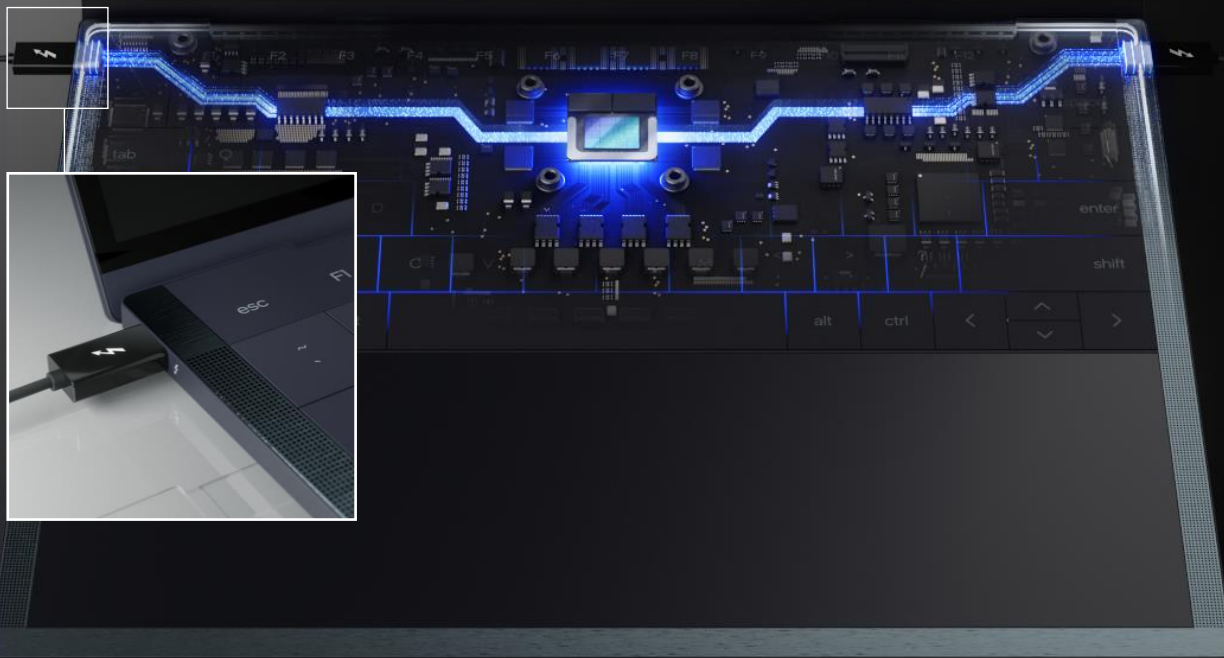
Driving Best In Class Thunderbolt™ Design

Unparalleled connectivity
for AI PC Era

AI PC → 2 Thunderbolt ports

3 video streams per Thunderbolt port

Look for Thunderbolt icon and
avoid mixing with USB-C





Thunderbolt™ Share

Get the most out of two PCs, and more from your Thunderbolt™ port



Fast multi-PC access for sharing screen/monitor at up to 60 fps, keyboard, mouse, and storage



Sync folders or drag-and-drop files between PCs with the speed of Thunderbolt™



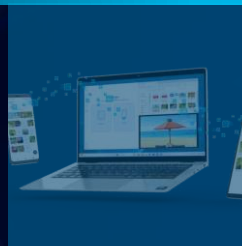
Quickly transfer from an old computer to a new one

Connectivity Unlocks Great Lunar Lake Experiences

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connectivity and
innovative software



Experiences



Seamless
multi-device
control



Immersive
wireless PC
AR/VR



High-speed
wired
connectivity



Enhanced
wireless
collaboration

Connectivity software



Intel®
Unison™



Intel® Killer™
Networking

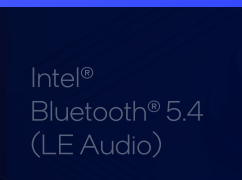


Intel®
Connectivity
Performance
Suite



Intel®
Thunderbolt™
Share

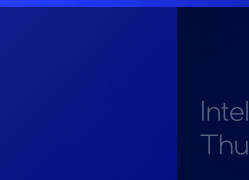
Premium connectivity



Intel®
Bluetooth® 5.4
(LE Audio)



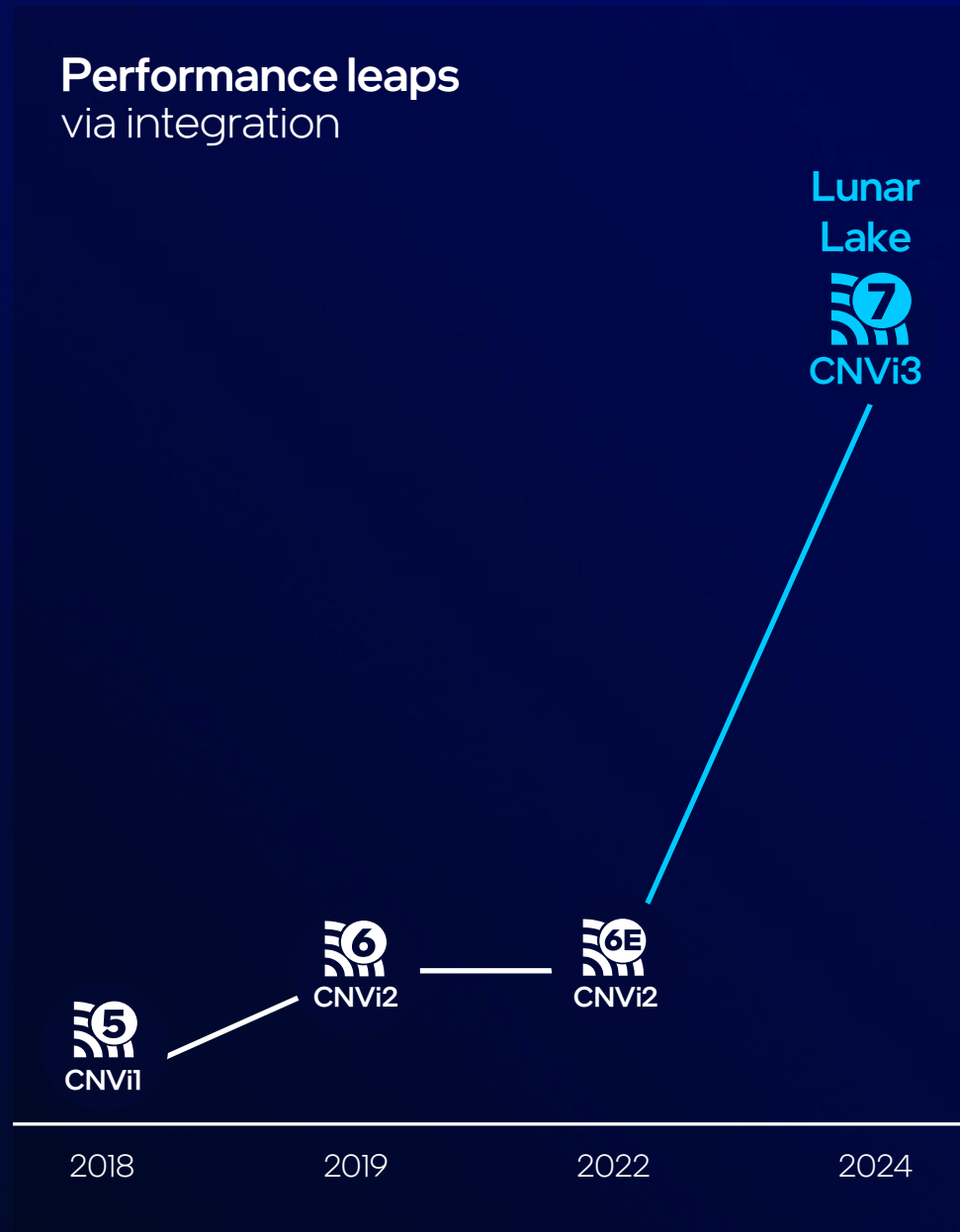
Intel®
Wi-Fi 7
(5 Gig)



Intel®
Thunderbolt™ 4

Platform Wireless Integration History

Scale and transition to Wi-Fi 7 with Lunar Lake, Intel's first platform with Wi-Fi 7 integration



9 Generations of platform integration, 3 generations of CNVi (Connectivity Integration)

Feature innovation

Wi-Fi proximity sensing

Bluetooth® over PCIe vs. USB

Bluetooth® performance/power

~55% reduced time to boot & from sleep¹

Low-power productivity and gaming

Cost/supply

Smaller footprint

Improved BOM

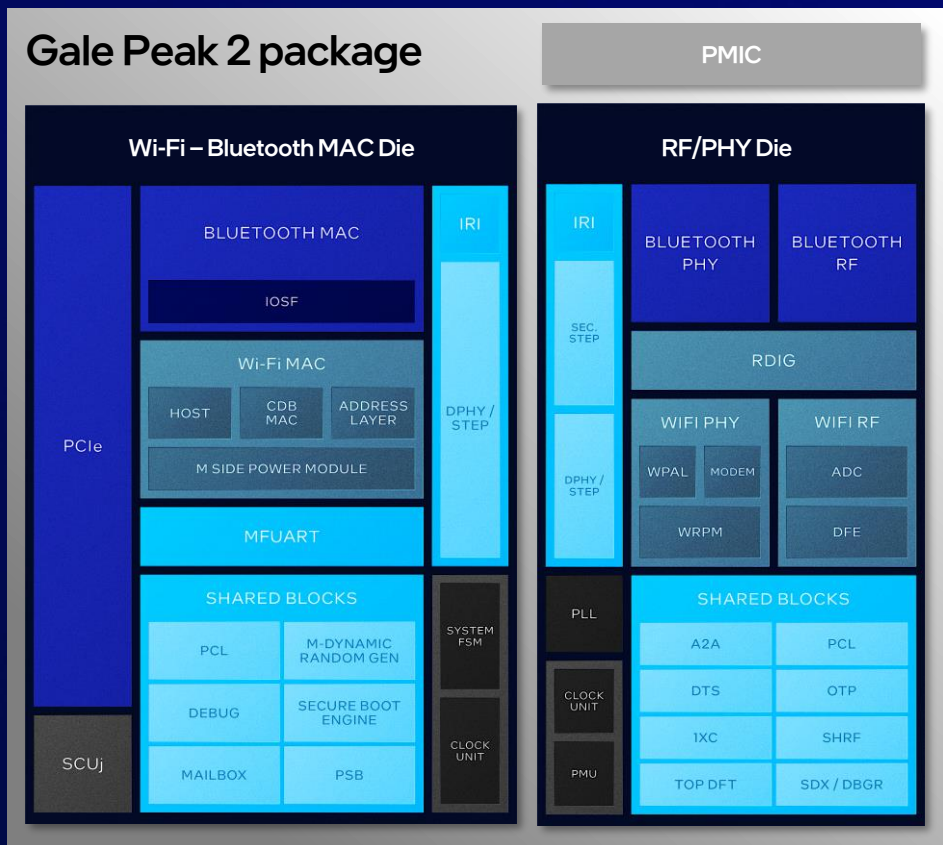
¹ See Intel.com/PerformanceIndex for details. Results may vary.

Wireless Implementation in Meteor Lake

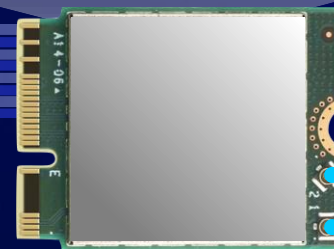
Discrete Gale Peak 2 module (Intel® Wi-Fi 7 BE200)



Meteor Lake

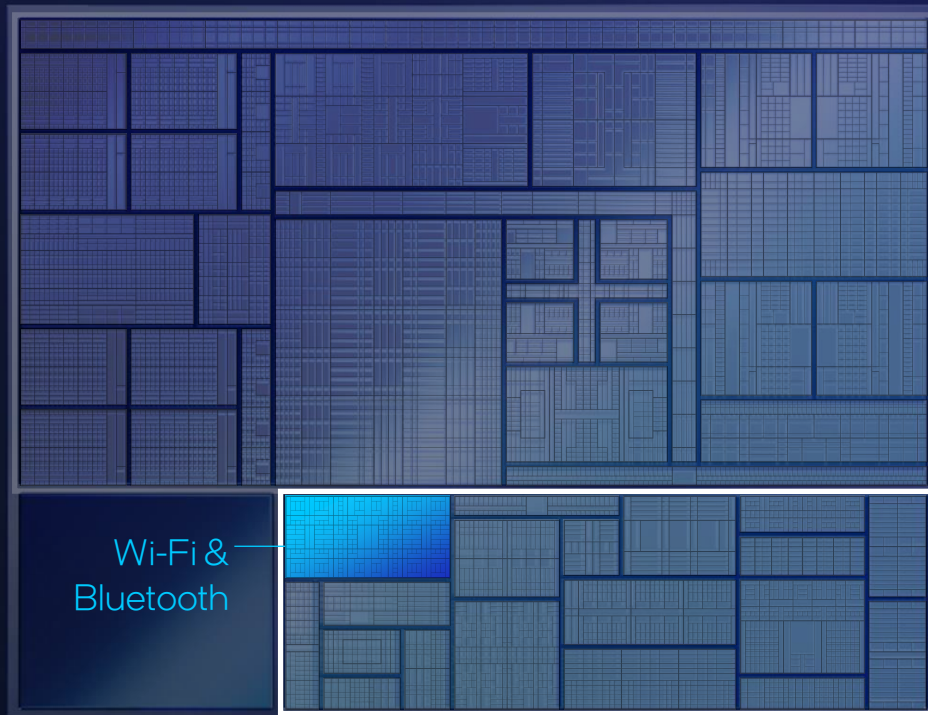


Intel® Wi-Fi 7 BE200



Lunar Lake

Intel's First Integrated Wi-Fi 7 & Bluetooth® 5.4



Platform Controller Tile

Integrated digital MAC

logic, and mem
on PCT

11 Gbps interface

between PCT
and CRF module

Scaling innovative features

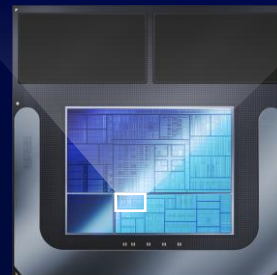
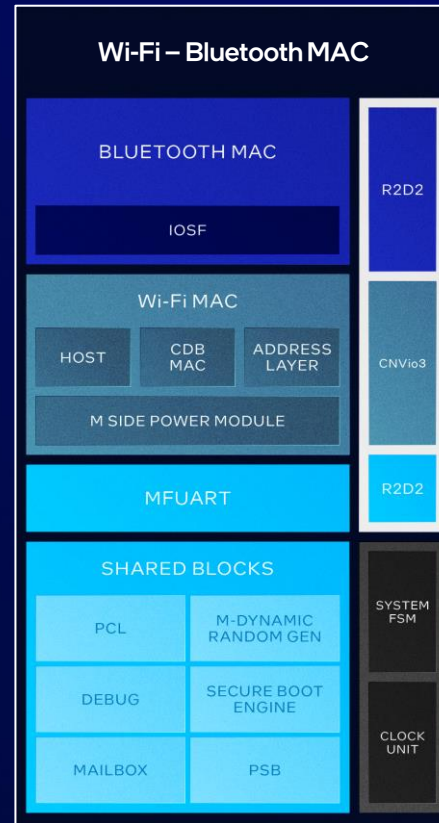
like Wi-Fi sensing: 10x growth
gen-over-gen

Wireless Integration Lunar Lake

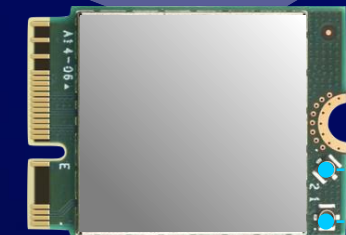
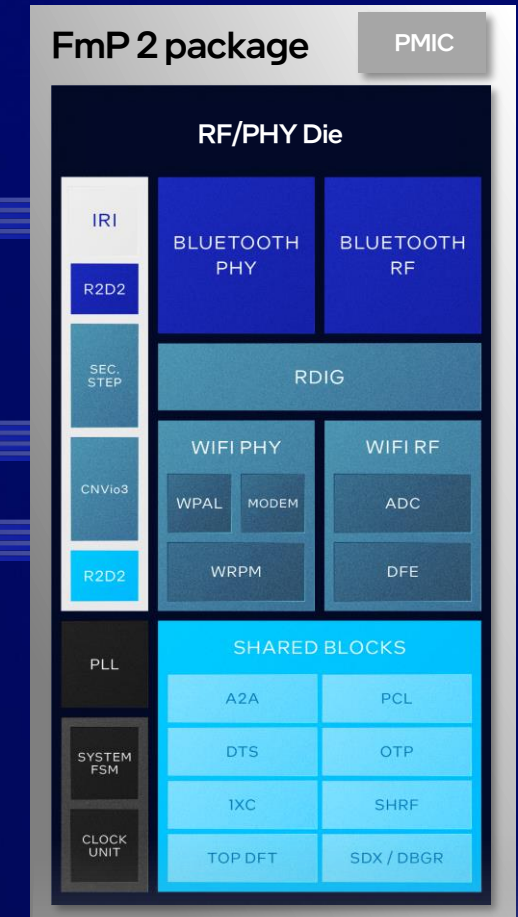
Integrated Wi-Fi and Bluetooth® for superior efficiency, latency and bandwidth

Analog PHY and RF on Companion module
28% smaller Si size (vs BE 200)

CNVio 3 interface connects CRF to SOC
at 11 Gbps (vs. 5 Gbps for CNVio 2)



Lunar Lake



Intel® Wi-Fi 7
BE201 CRF
module



RF Interference Mitigation Technology

dynamically adjusts the DDR clock frequency, mitigating impact on Wi-Fi

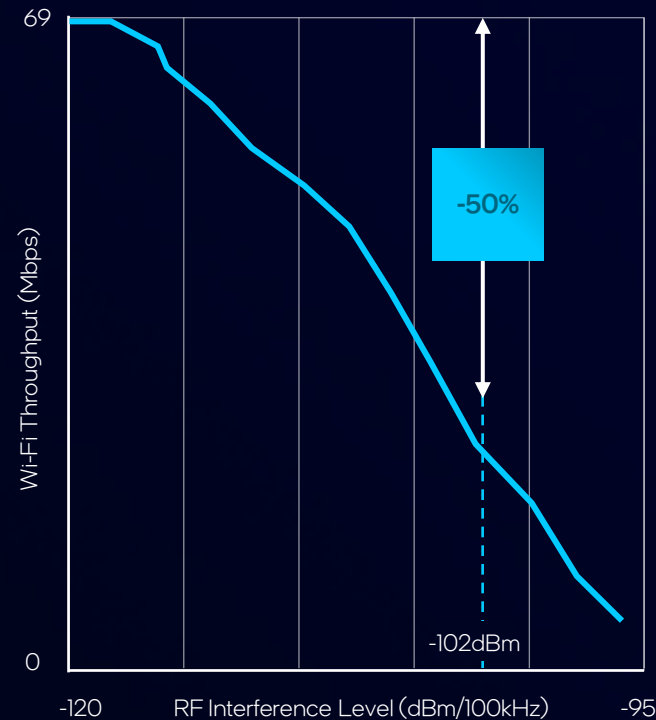
DDR Memory clock frequency has a major impact on Wi-Fi performance

Up to ~50% throughput degradation caused by memory noise in channels used by Wi-Fi¹

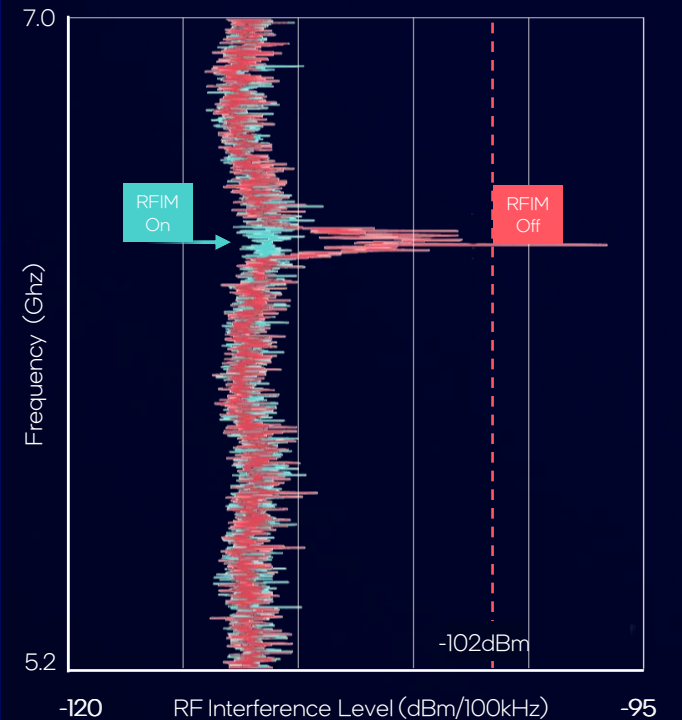
RFIM technology avoids degradation by dynamically adjusting the DDR clock frequency based on the Wi-Fi channel in use

¹ See Intel.com/PerformanceIndex for details. Results may vary.

Wi-Fi Throughput Degradation from DDR clock noise



RFIM Noise Mitigation through frequency adjustment



Wi-Fi 7

Multi Link Operation

Increased reliability

duplicating packets across links

Throughput boost

Aggregating multiple links

Latency improvement

Load balancing across links

Traffic separation/differentiation

Separating traffic across links



Wi-Fi 7

Multi Link Operation

Increased reliability

duplicating packets across links

Throughput boost

Aggregating multiple links

Latency improvement

Load balancing across links

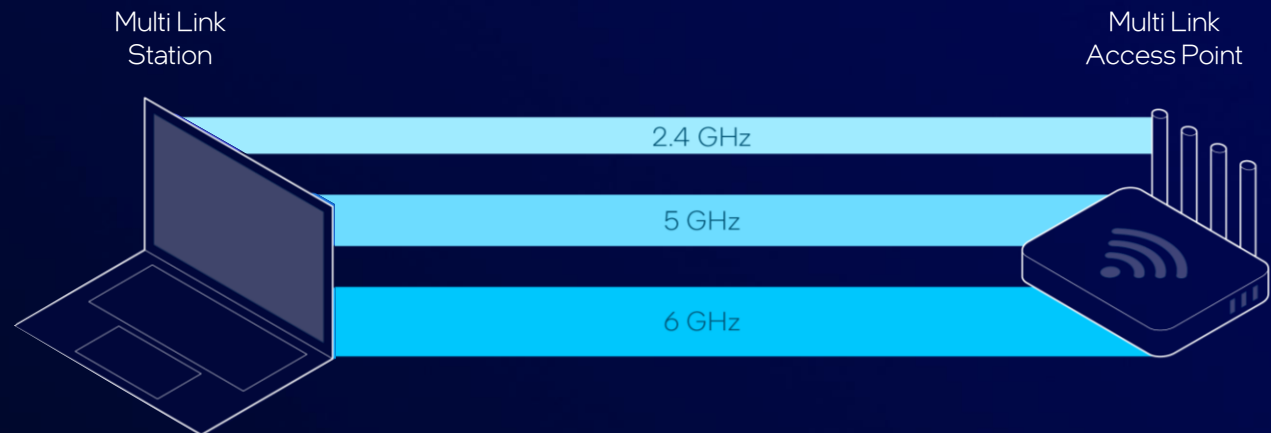
Traffic separation/differentiation

Separating traffic across links

Increased reliability



Throughput boost



Wi-Fi 7

Multi Link Operation

Increased reliability
duplicating packets across links

Throughput boost
Aggregating multiple links

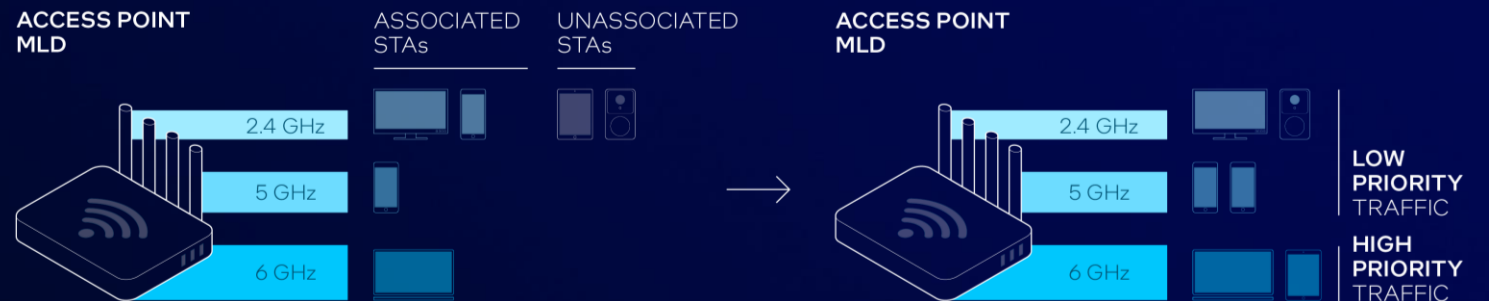
Latency improvement
Load balancing across links

Traffic separation/differentiation
Separating traffic across links

Latency improvement



Traffic separation & differentiation

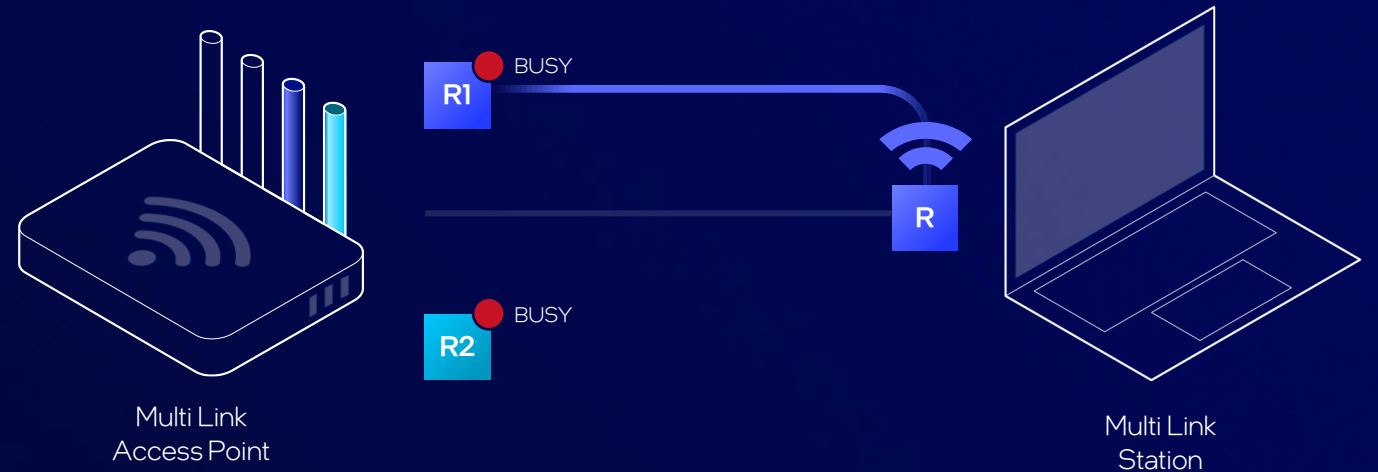


Wi-Fi 7 - MLO

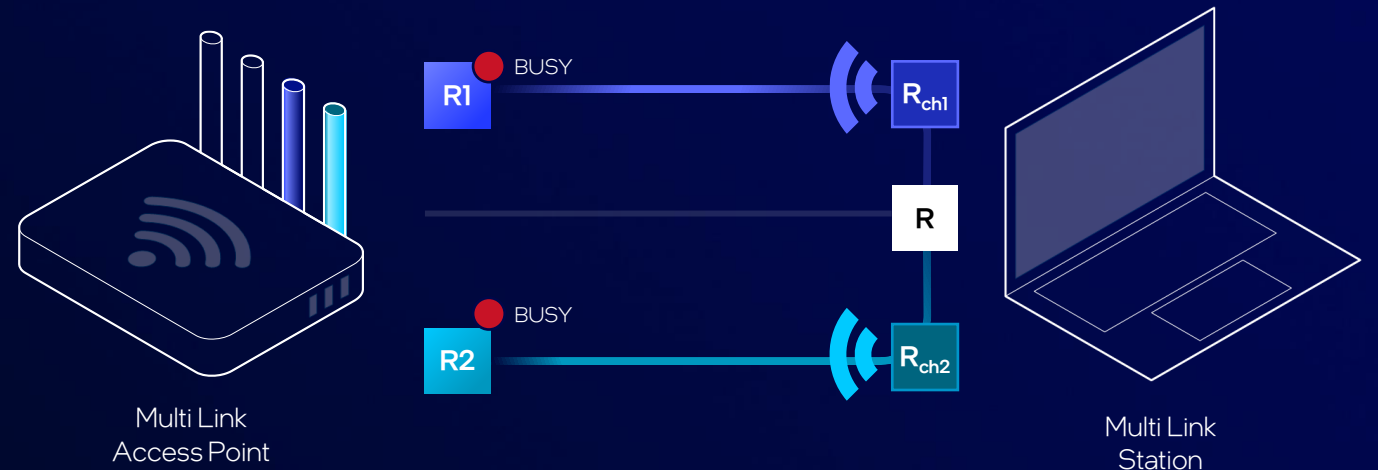
Enhanced Multi-Link Single-Radio (eMLSR)

Superior performance to other
single-radio solutions¹

Multi-Link Single-Radio (MLSR) Operation



Enhanced Multi-Link Single-Radio (EMLSR) Operation



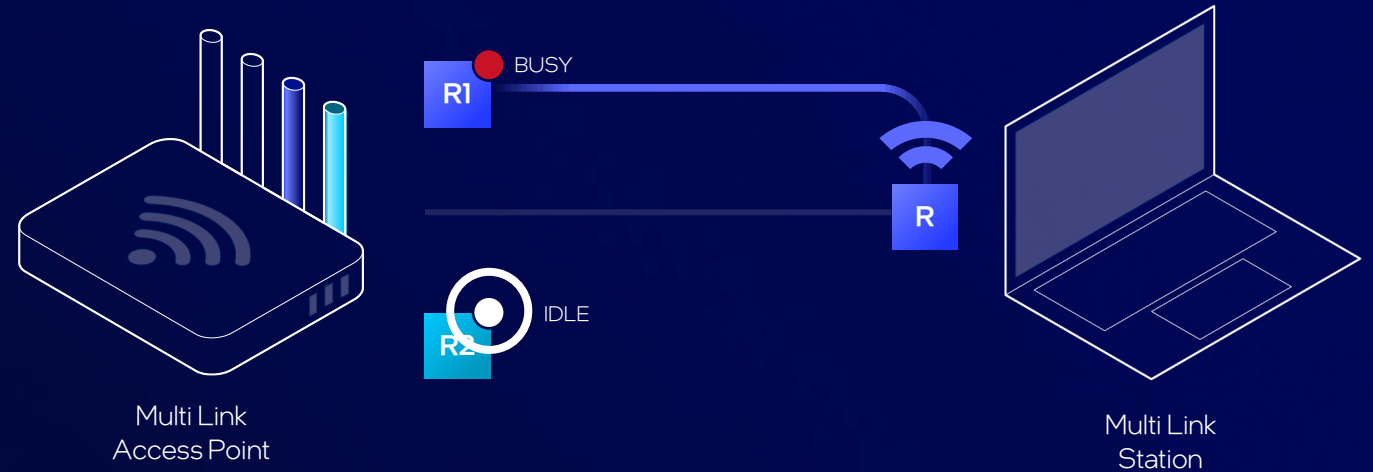
¹ See Intel.com/PerformanceIndex for details. Results may vary.

Wi-Fi 7 - MLO

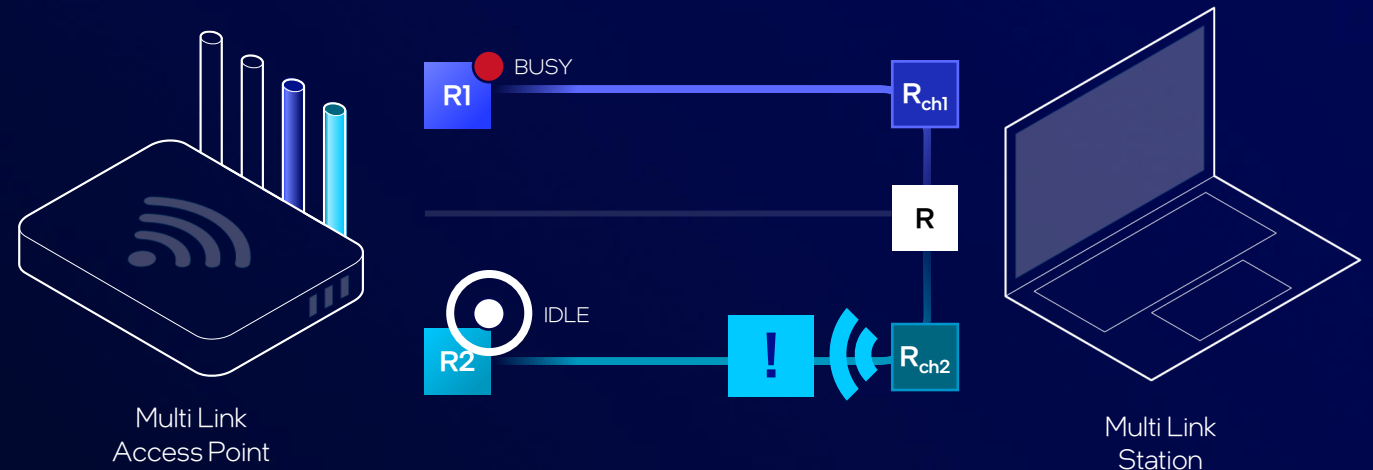
Enhanced Multi-Link Single-Radio (eMLSR)

Superior performance to other **single-radio solutions**¹

Multi-Link Single-Radio (MLSR) Operation



Enhanced Multi-Link Single-Radio (EMLSR) Operation



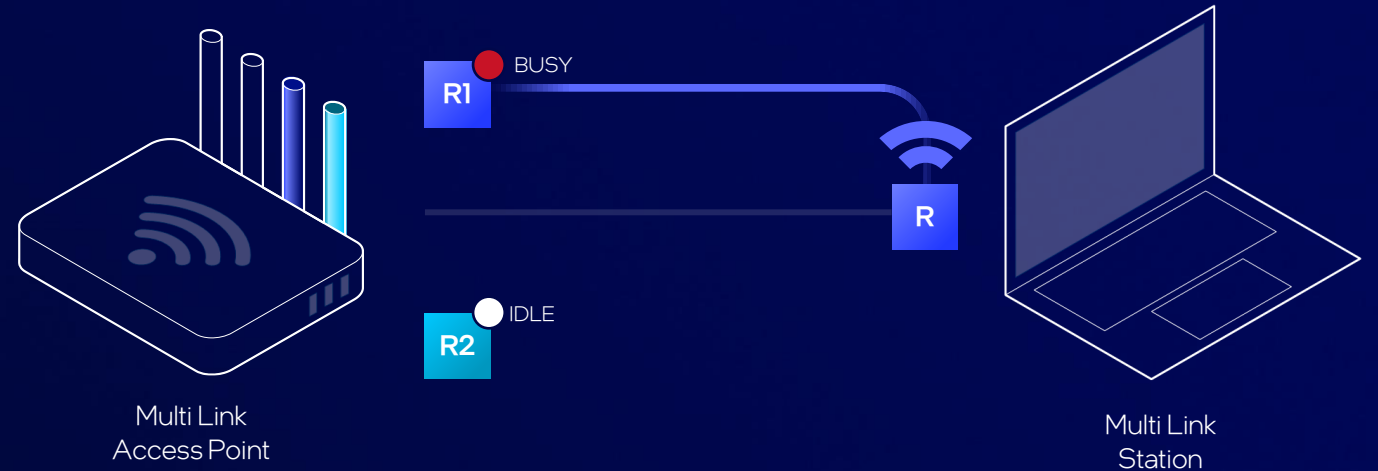
¹ See Intel.com/PerformanceIndex for details. Results may vary.

Wi-Fi 7 - MLO

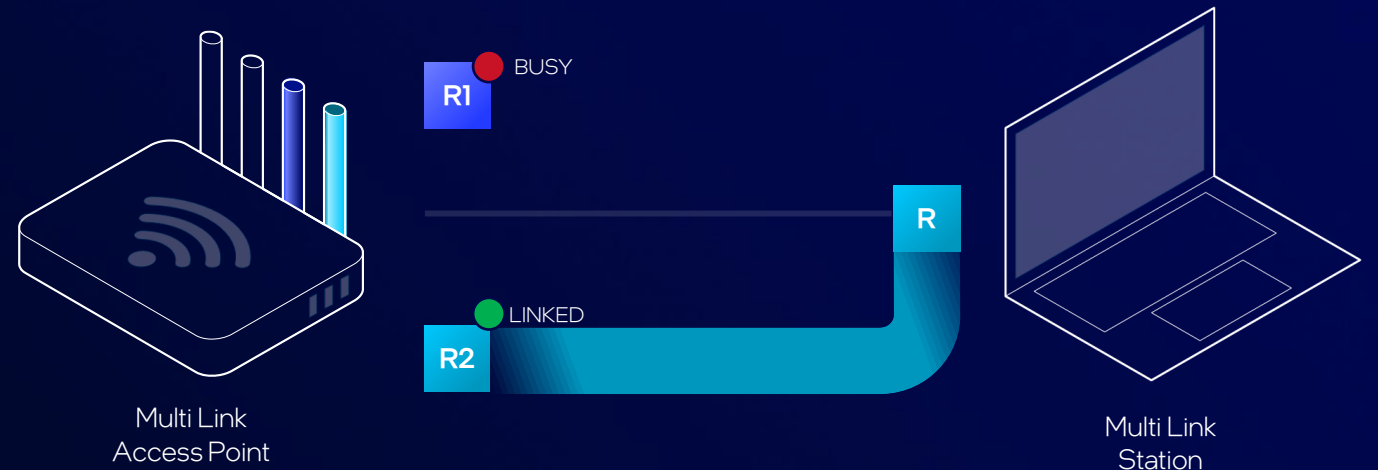
Enhanced Multi-Link Single-Radio (eMLSR)

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Multi-Link Single-Radio (MLSR) Operation



Enhanced Multi-Link Single-Radio (EMLSR) Operation



¹ See Intel.com/PerformanceIndex for details. Results may vary.

Wi-Fi 7 - MLO

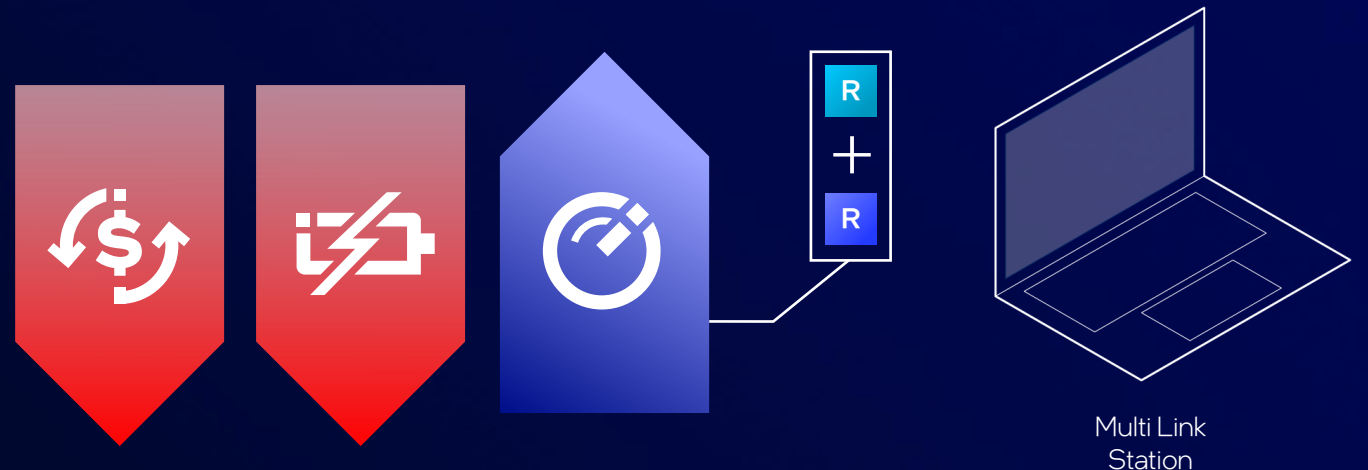
Enhanced Multi-Link Single-Radio (eMLSR)

optimized cost, power, and
performance vs. **dual-radio solutions**

Enhanced Multi-Link Single-Radio (EMLSR) Operation



Dual Radio Operation

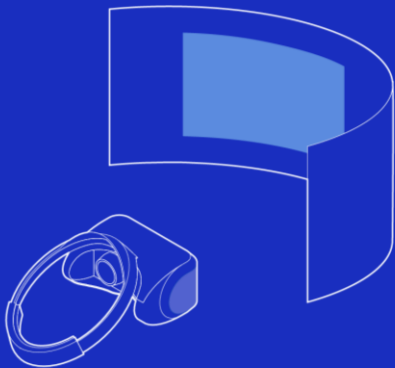


intel + ∞ Meta

Improving VR Experiences with Wi-Fi 7



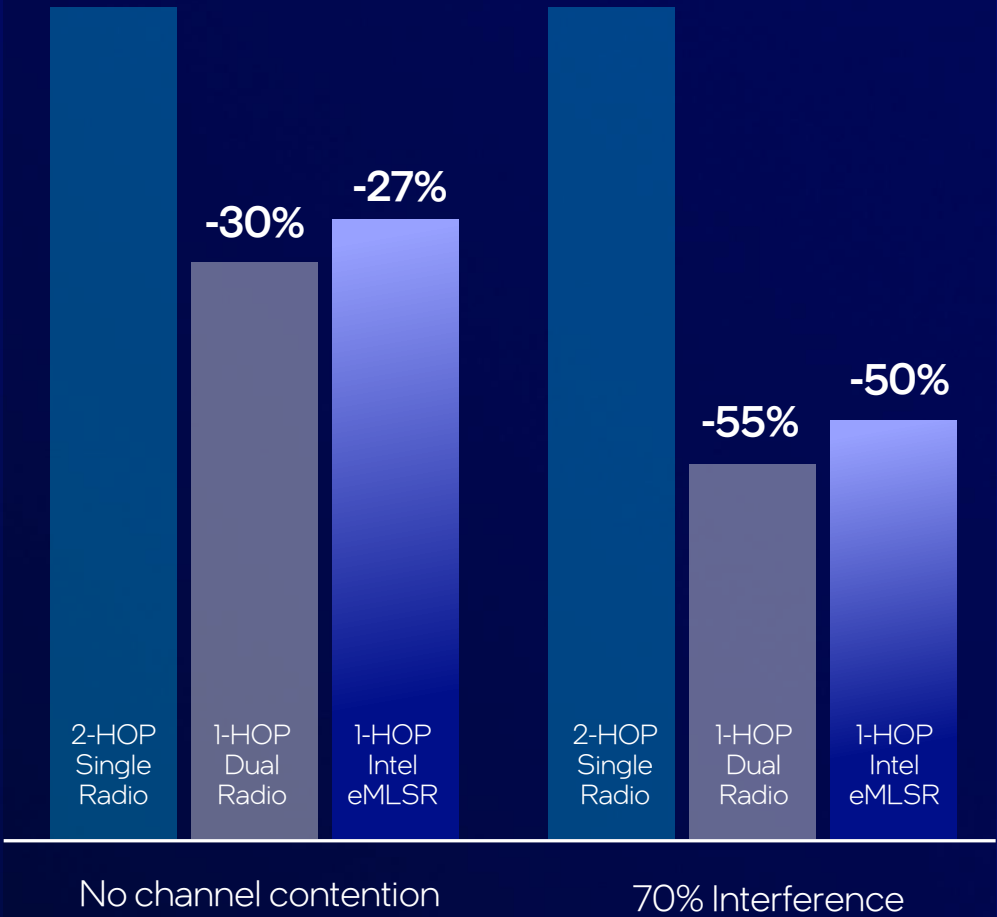
Remote PC VR desktop



HMD-PC onboarding



P95 video latency performance vs. single-radio and dual radio



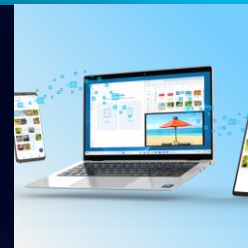
See Intel.com/PerformanceIndex for details. Results may vary.

Connectivity Unlocks Great Lunar Lake Experiences

Through premium
connectivity and
innovative software



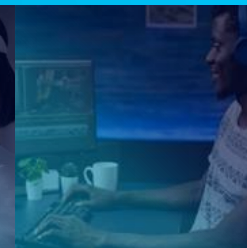
Experiences



Seamless
multi-device
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Immersive
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High-speed
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Enhanced
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Bluetooth® 5.4
(LE Audio)

Intel®
Wi-Fi 7
(5 Gig)

Intel®
Thunderbolt™ 4



Intel Unison

Multi-device
experiences
with Lunar Lake

NEW



Tablet control
w/PC mouse and KB

NEW



Swift connect
for file sharing w/ non unison

NEW



Universal hotspot*
Phone-PC



**Phone texts /
extended screen**



File sharing



Phone calls

*Available post Lunar Lake launch.

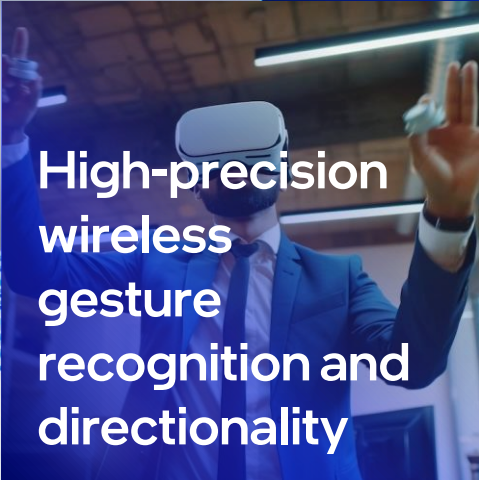
The future of Connectivity-Powered AI experiences

A woman is shown from the chest up, looking slightly to her right. A translucent digital face overlay is visible on her face, with glowing blue lines and points, suggesting facial recognition or secure authentication technology.

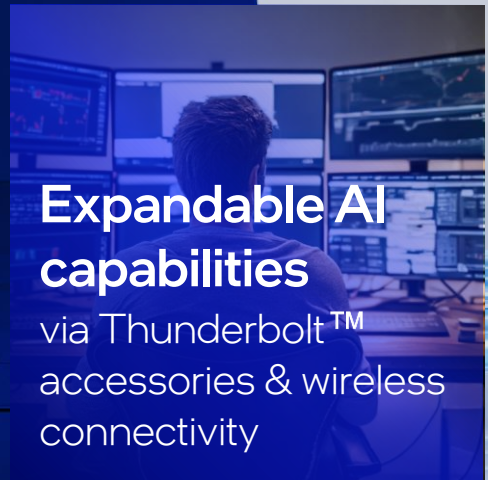
**Wireless
human
presence
detection**
and secure
authentication

A laptop screen displays a complex dashboard with various charts, graphs, and a human silhouette, representing health monitoring data. The interface is dark-themed with blue and green highlights.

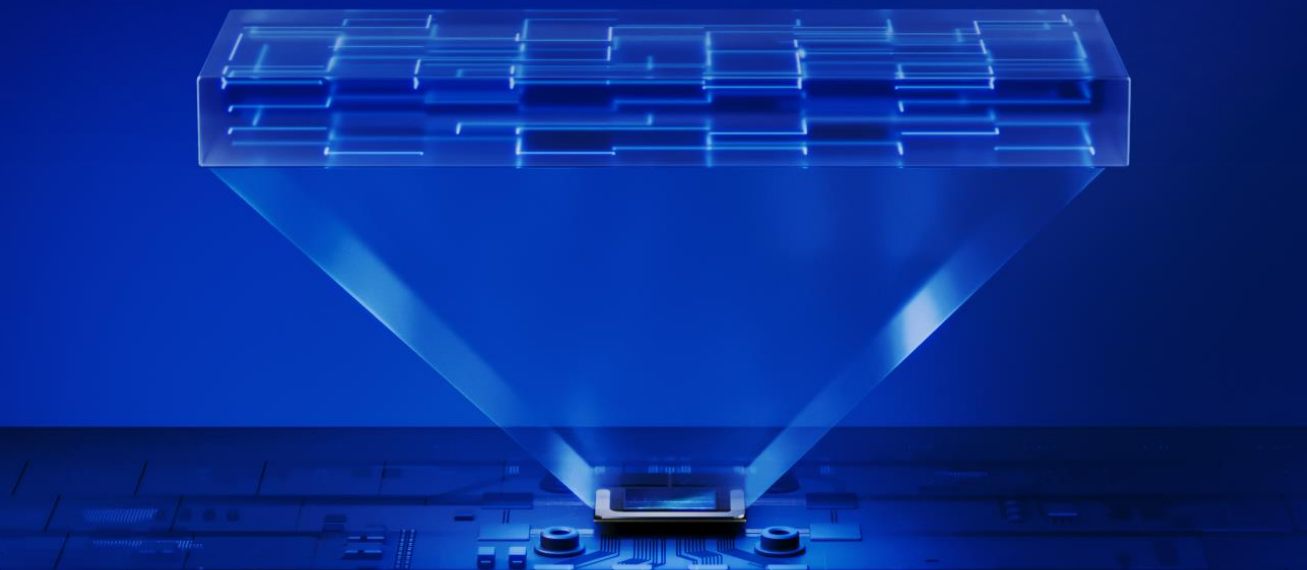
**Wireless health
monitoring**
with real-time
telemedicine

A man in a suit is wearing a VR headset and has his hands raised in a gesture, demonstrating high-precision wireless gesture recognition and directionality.

**High-precision
wireless
gesture
recognition and
directionality**

A person is seen from behind, sitting at a desk with multiple computer monitors displaying various data and charts, illustrating expandable AI capabilities.

**Expandable AI
capabilities**
via Thunderbolt™
accessories & wireless
connectivity

A blue-tinted image of a Wi-Fi router with a beam of light projecting from it, symbolizing connectivity. The router is a sleek, modern design with multiple antennas.

Wi-Fi sensing and multi-PC sharing
are the beginning of an inflection point in
connectivity capabilities beyond communications

The Intel logo, consisting of the word "intel." in white lowercase letters on a blue square background.

intel.

The Tech tour.TW logo, featuring the word "TECH" in bold white uppercase letters, a small blue pixelated square, and "tour.TW" in white lowercase letters on a blue square background.

TECH
tour.TW

The words "Thank You" in a large, white, sans-serif font, centered on a dark blue rectangular background.

Thank
You

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Performance hybrid architecture combines two core microarchitectures, Performance-cores (P-cores) and Efficient-cores (E-cores), on a single processor die first introduced on 12th Gen Intel® Core™ processors. Select 12th Gen and newer Intel® Core™ processors do not have performance hybrid architecture, only P-cores or E-cores, and may have the same cache size. See ark.intel.com for SKU details, including cache size and core frequency.

Built-in Intel® Arc™ GPU only available on select Intel® Core™ Ultra processor-powered systems; OEM enablement required.

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While Wi-Fi 7 is backward compatible with previous generations, new Wi-Fi 7 features require PCs configured with Intel Wi-Fi 7 solutions, PC OEM enabling, operating system support, and use with appropriate Wi-Fi 7 routers/APs/gateways. 6 GHz Wi-Fi 7 may not be available in all regions. Performance varies by use, configuration, and other factors. For details on performance claims, learn more at www.Intel.com/performance-wireless.

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APPENDIX

Claim # & Statement	Slide # & Title/Details
	SLIDE 6: Do More with Thunderbolt™ 4
Up to 25% better read and write speeds with Thunderbolt™ 5	Versus Thunderbolt™ 3. Based on estimated performance on Lunar Lake processors. Results may vary. Tested on Intel Reference Validation Platform (RVP) with Lunar Lake Ultra 5 processor running Windows 11 Enterprise (version 10.0.26100 Build 26100) with 16 GB RAM. Tested with Gen 4 NVMe 1 TB SSD used behind a Thunderbolt™ 3 dock (with Titan Ridge) and Thunderbolt™ 5 dock (with Barlow Ridge hub) connected to the Lunar Lake RVP. Storage Read and Write speeds were measured with CrystalDiskMark tool with settings of 5 test count and 32 GiB test size.
	SLIDE 11: Platform Wireless Integration History
Lunar Lake’s integrated Bluetooth® new capability to use a PCIe interface enables up to ~55% reduced time to boot & from sleep compared to legacy USB implementations	Results as of May 2024. Lunar Lake is the first Intel platform to integrate Wi-Fi 7 technology and enable use of PCIe vs. USB interface for integrated Bluetooth® technology routing. The use of PCIe frees up additional USB lanes for use by PC OEMs and enables improved Bluetooth® initialization and wake times. Intel engineering measurements using a LNL reference validation platform with PCIe-based Bluetooth® showed an average boot time of 0.648 seconds which was approximately 55% lower than the 1.439 seconds required for USB-based Bluetooth® designs. Similar levels of improvement were measured when comparing PCIe vs. USB Bluetooth® interface wake from sleep times for connected peripherals (Human Interface Devices) in both Classic Bluetooth ~55% (34.355 vs. 75.933 ms) and Bluetooth Low Energy ~56% (32.189 vs. 74.098 ms) modes.

APPENDIX

Claim # & Statement	Slide # & Title/Details
	SLIDE 15: RF Interference Mitigation Technology
Up to ~50% throughput degradation caused by memory noise in channels used by Wi-Fi	Results as of May 2024. PC platform DDR memory can operate at many of the same frequencies as the 5 GHz and 6 GHz channels used by Wi-Fi technologies. When DDR frequencies interfere with Wi-Fi on these channels, the throughput degradation can be as high as 8 dB or about 50% lower, based on measurements by Intel platform engineering teams. Lunar Lake platform Wi-Fi integration enables Radio Frequency Interference Mitigation (RFIM), which coordinates simultaneous platform memory and Wi-Fi operation. DDR RFIM dynamically moves memory speed to clear the connected Wi-Fi channel from memory narrowband noise and helps avoid the potential Wi-Fi performance impact from DDR memory operating on the same frequencies.

APPENDIX

Claim # & Statement	Slide # & Title/Details
	SLIDES 19-21: Enhanced Multi-Link Single-Radio (eMLSR)
eMLSR has superior performance to other single-radio solutions	Results as of May 2023. Intel Wireless Engineering teams conducted network performance simulation analysis comparing congestion scenarios with multiple clients in both consumer and corporate scenarios to evaluate the latency advantages enabled by Wi-Fi 7 Multi-Link Operation vs. Wi-Fi 6/6E on 2-stream laptop PC video streaming. The Consumer scenario assumed a typical home environment where the (1) Device Under Test (DUT) operation was challenged by (2) concurrent Wi-Fi 6 and 6E laptops operating in 160 MHz channels on both the 5 and 6 GHz band while generating 50 Mbps of traffic. With MLO (or Enhanced Multi-Link Single Radio = EMLSR) the Wi-Fi 7 DUT was able to rapidly switch between 320 MHz channels on 6 GHz and 160 MHz channels on 5 GHz to avoid interference from other devices. The baseline average latency for Wi-Fi 6/6E devices in this scenario was 0.90 ms. The average latency for the Wi-Fi 7 DUT was 0.39 ms (-57%). The 99th percentile of all the measured latencies for the Wi-Fi 6/6E device was 2.50 ms compared to 0.95 ms (-62%) for the Wi-Fi 7 DUT. The Enterprise scenario assumed a typical corporate environment where the (1) DUT operation was challenged by (15) concurrent Wi-Fi 6 laptops operating in 80 MHz channels in the 5 GHz band while generating 50 Mbps of traffic. 80 MHz instead of 160 MHz channels were used due to the inability for corporate networks to deploy numerous APs in a building at 160 MHz channels. With MLO (EMLSR) the Wi-Fi 7 DUT was able to rapidly switch between 320 MHz channels on 6 GHz and 80 MHz channels on 5 GHz to avoid interference from other devices. The baseline average latency of Wi-Fi 6 devices in this scenario was 5.85 ms. The average latency for the Wi-Fi 7 DUT was 1.80 ms (-69%). The 99th percentile of all the measured latencies for the Wi-Fi 6 device was 28.25 ms compared to 10.00 ms (-65%) for the Wi-Fi 7 DUT.

APPENDIX

Claim # & Statement	Slide # & Title/Details
	SLIDE 23: Improving VR Experiences with Wi-Fi 7
Up to 50% lower latency vs. typical single-radio solutions	Results as of February 2024. A typical Wi-Fi VR setup to a PC with a standard single-radio Wi-Fi card requires the HMD to make 2-hops and go through the router to access the PC, which adds latency to the user VR experience. High-end gaming PCs with premium dual-radio Intel® Killer™ Wi-Fi 6E AX1690 cards are able to dramatically reduce latency for wireless VR gaming using Intel® Double Connect Technology. This solution uses one Wi-Fi radio for the PC-HMD VR connection and a second Wi-Fi radio for the PC-router connection, allowing the Meta Quest headset to bypass the router for direct wireless access to PC games, resources, and Intel® Killer™ Networking software. To deliver the high-quality Wi-Fi connectivity that the Meta Quest HMDs need, working closely with Meta, Intel has enabled laptops configured with its connectivity software and Intel® Wi-Fi 7 (5 Gig) cards to deliver 1-hop single radio Wi-Fi PC VR performance that was similar to the high-end gaming PCs with its dual-radio Killer solution. Intel-Meta VR tested these three Wi-Fi PC VR configurations using 80 MHz channels in the 5 GHz band. In clean environments without channel contention and in a challenging environment with 70% channel contention, the 1-hop <u>dual-radio</u> solution enabled a -30% / -55% reduction in latency, and the new 1-hop <u>single-radio</u> solution enabled a similar -27% / -50% reduction compared to the standard 2-hop configuration. Test Platform: Dell Alienware x15 R2, Processor: 12th Gen Intel® Core™ i7, OS: Windows 11 (26052.1), Wi-Fi Cards: Intel® Wi-Fi 7 BE200, Intel® Killer™ Wi-Fi 6E AX1690, Wi-Fi Driver: 23.30.0.6; Wi-Fi Router: Netgear Nighthawk RAXE500; HMD: Meta Quest 3 (OS v57 496821007900511).

The Intel logo is centered on a dark blue background. It features the word "intel" in a white, lowercase, sans-serif font. A small, solid blue square is positioned above the letter "i". To the right of the word "intel" is a registered trademark symbol (®).

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