5G vs. Wi-Fi 6: A False Dilemma

Abstract

Should we use 5G or Wi-Fi 6?
This well debated enterprise dilemma is false, as 5G CUPS provides the unifying architecture for 5G access and Wi-Fi 6.

Questions and Comments
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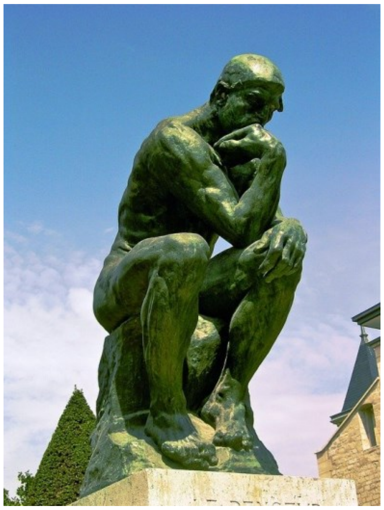
1 INTRODUCTION

A deep dilemma faces enterprises: What to choose for future wireless investments, 5G or Wi-Fi 6? To wait delays large potential benefits and there is no guarantee that a clear winner will emerge anytime soon. This paper addresses the dilemma by recommending a change of perspective. After reading this paper, you will be better prepared to select your best path forward.



The suggested perspective focuses on integration of 5G and Wi-Fi 6 wireless access technologies into a single, seamless system by using the enhanced versatility of the 5G control plane. Technology for such a system is fully standardized and can be purchased and deployed now, allowing you to broaden your vendor selection and optimize your wireless spending. Twenty years of competition between mobile and Wi-Fi may be finally coming to an end.

This paper is a call to action to:

- All decision-makers, who can resolve the apparent dilemma by integrating 5G access with Wi-Fi 6E using an integrated communications platform
- Focus on a fully standardized and ready to be operationalized architecture
- Allow enterprises to broaden their range of potential suppliers
- Help CSPs compete for greater enterprise share of wallet
- Enlarge the ecosystem to include enterprise solutions for Industry 4.0, smart agriculture, digital health, and smart cities

2 LESSONS FROM PAST EXPERIENCE

Analysts are still asking what went wrong. Why "Worldwide Interoperability for Microwave Access," or WiMAX (IEEE 802.16x) lost the marketplace to 3G?

WiMAX origins are in Ethernet LAN, while 3G grew out of traditional cellular technologies. Recent generations of mobile technologies have been standardized by 3GPP. On the other hand, both WiMAX and Wi-Fi originated from IEEE Ethernet standardization groups for Local Area Networks (LAN).

Table 1: Comparison LTE and WiMax[1]

Advantages	LTE	Mobile WiMAX
Time to market		✓
Stickiness of operators	✓	
Re use of existing infrastructure	✓	
Standardized technology		✓
Free from legacy burdens (Proprietary interfaces)		✓
Presence of interfaces in user devices		✓
Inherited mobility support	✓	
Speed		✓

Muhammad Khalil Shahid, Tang Shoulian and Ao Shan, 2008. Mobile Broadband: Comparison of Mobile WiMAX and Cellular 3G/3G+ Technologies. Information Technology Journal, 7: 570-579.

Both WiMAX and 3G promised new business models. WiMAX focused on the Wireless Local Loop (WLL) in competition with embedded DSL and cable modems. Unlike those embedded technologies, however, WiMAX was not designed to be managed using traditional telco approaches and didn't handle voice well at a time when voice still drove most revenues.

In contrast, 3G focused on adding faster mobile data to 2.5G voice, while locking-in customers with iPhone contracts. Data rates were lower for 3G than WiMAX, but 3G voice services were better from the start. And 3G avoided conflicts with existing telco services and associated capital investments that had not yet been depreciated.

By the time WiMAX figured out they needed to focus on mobility and improving voice services, it was too late. The rest is history.

Analyzing WiMAX we found three 'not to repeat' lessons that can be applied this time:

1. When choosing markets for new technologies, consider the legacy and adoption barriers
2. Plan new technology deployments with revenue retention in mind
3. Evolution is easier than revolution – rip and replace is hard to financially justify, although greenfield players may occasionally be able to leapfrog legacy competitors

Eighteen years later, 5G and Wi-Fi 6E target the enterprise and IoT. Let's apply the lessons learned to the new situation. 5G can unify LAN and WAN mobility using a single control plane. It supports digital transformation with network slicing (NS). It integrates edge cloud for real-time services such as new IoT and robotic applications. Enterprises can use the flexibility of the 5G control plane to operate a full range of communications technologies in a consistent way, including 4G, 5G, Wi-Fi 6E, legacy Wi-Fi and wired services, fiber and satellite communications. All these communication technologies can be used for IoT, robotics, manufacturing data, and to enable the more flexible application of AI.

[1] Mobile Broadband: Comparison of Mobile WiMAX and Cellular 3G/3G+ Technologies by Muhammad Khalil et al. Retrieved from https://scialert.net/fulltext/?doi=itj.2008.570.579

3 SOME KEY ASPECTS OF ENTERPRISE 5G

In this section, we are focusing on 5G services for enterprises and factories. As research shows, this is the fastest growing market for 5G services. To start, we discuss the novel 5G control plane and explore the NS mobile services inside the enterprise.

3.1 5G Control Plane

The main role of the control plane (CP) in 5G remains the same as the CP in previous 3GPP mobile standards: it configures user plane functions to route data traffic through the network. When compared with 4G EPC, the 5G CP is more appropriately viewed as a collection of distinct Network Functions (NFs). Interactions among these NFs allow 5G to deliver a Service-Based Architecture (SBA) easily optimized for consumers and enterprises.

Here is a rough outline of the evolution of the 5G CP:

- Decoupling of the control plane from the user plane, or CUPS (Control and User Plane Separation), was initially introduced in 3GPP R14.
- Similarly to 4G, the CP provides the forwarding path for information exchange in support of the service. A key difference is the SBA doesn't require specialized protocols between functional blocks, like the ones used in 4G. In 5G the only protocol for interaction between all control-plane entities is HTTP, which is a protocol widely used on the Internet and not telecom-specific.
- Signaling support. It establishes signaling to support the functions that establish and maintain the user plane. Signaling means the exchange of information to enable but not to provide end-to-end communication. One exception is when SMS messages are delivered to the UE using control messages.
- With 5G CP, the mobility management and session management are separated. As a result, non-3GPP access networks such as Wi-Fi can be integrated. The session management aspects are very accessed specific are specified initially for the Next Generation Radio Access Network Slicing

3.2 5G Network Slicing

Network Slicing is a type of systematic segmentation of network resources and network functions to allow them to be easily allocated to meet the needs of selected applications, services, and/or connections. Slices typically run in isolation from each other so they can each be configured for a specific business purpose.

The following are properties and examples of the use of NS in 5G:

- Contains dedicated or a combination of dedicated/shared resources
- Spans multiple parts of the network from UE/transport to the mobile core
- Can be configured across multiple service providers to enable new business models and granular Service Level Agreements (SLAs) that include specification of Application Flows, IP Packets that match a set of criteria, and Policies that describe rules and constraints on the forwarding of those Application Flows.
- 3GPP defines **four standard network slices** to be used for **global Interoperability** and efficient resource utilization

- Enhanced Mobile Broadband (eMBB),
- Ultra-reliable low-latency communication (URLLC),
- Massive IoT (MIoT), and
- Vehicle-to-everything (V2X)

- NS for the enterprise and manufacturing spaces. With 5G, an NS can be dedicated to an application; for example, Connected Cars (V2X) can be in a slice that has strict SLA requirements for jitter/delay/latency and dedicated bandwidth
- Open APIs. Each slice can allow an open Application Programming Interface (API) for a wide range of potential interactions with other functions and systems; for example, with third party Element Management Systems (EMS)
  - APIs can be used to provide control and management capabilities needed for a specific vertical application area; for example, to adapt the geographic spread of a slice or to control provisioning using various parameters related to the quality of experience, network conditions, bandwidth utilization, application performance, etc.

4 STRENGTHS OF 5G ACCESS

To better illustrate the strengths of 5G access, also known as 5G New Radio (5G NR), or 5G wireless link, we start by looking at the industry of the future. In Industry 4.0 computers, with minimum human supervision, make decisions and control all processes. Several critical elements must be in place to deliver real-time operations and processes, including new services introduced with 5G NR.

- Ultra-Reliable Low Latency Communications (URLLC), allowing real-time control of multiple advanced services for factory automation, autonomous driving, the industrial internet and smart grid or robotics

  Enterprises Multi-Access Edge Computing (MEC) to support Industry 4.0 business models. The combination of 5G NR and MEC supports real-time artificial intelligence services such as Augmented Reality / Virtual Reality (AR/VR), predictive maintenance analytics, and digital twins simulation

- Massive Machine Type Communications, or MMTC allowing closed-loop real-time automation in manufacturing, chemical processes, healthcare to name a few

In addition to sharing similar functionality with Wi-Fi 6 and 6E (see Table 2), 5G NR access provides many unique capabilities for enterprises:

- Use of spectrum bands to match functionality, coverage, and latency requirements of applications (see Figure 1)
- Standards-based for integrated optimized latency for 5G access and MEC. Global standardization provided by 3GPP and ETSI
- Automate mitigation of interference at base stations
- Removing the technology separation between indoor and outdoor, and private and public 5G services

4.1 5G NR Spectrum Bands

5G access uses all existing spectrum bands. For 5G NR access, this includes the low bands (sub 1GHz), mid-bands (under 20 GHz), and newly assigned high bands or 'mm-waves' (24 GHz to 60 GHz). Besides, 5G access uses both licensed and unlicensed spectrum. This offers a large choice of connectivity within the enterprise space and interconnections with mobile public networks. For example, factory robots may use short-range, large capacity mm-waves, while the trucks may connect via mid-band 5G access.

4.2 URLLC and Enterprise Multi-Access Edge Computing (MEC)

Minimizing latency is the killer app in factory automation, as data must be collected and acted upon in milliseconds. Without the use of 5G NR and MEC, delays are caused by transmission to a cloud data center located hundreds or thousands of miles away, processing time in the cloud, and the return of an actionable instruction to the factory floor. For closed-loop automation, 5G NR URLLC delivers data with delays from wireless link handover on the order of ms

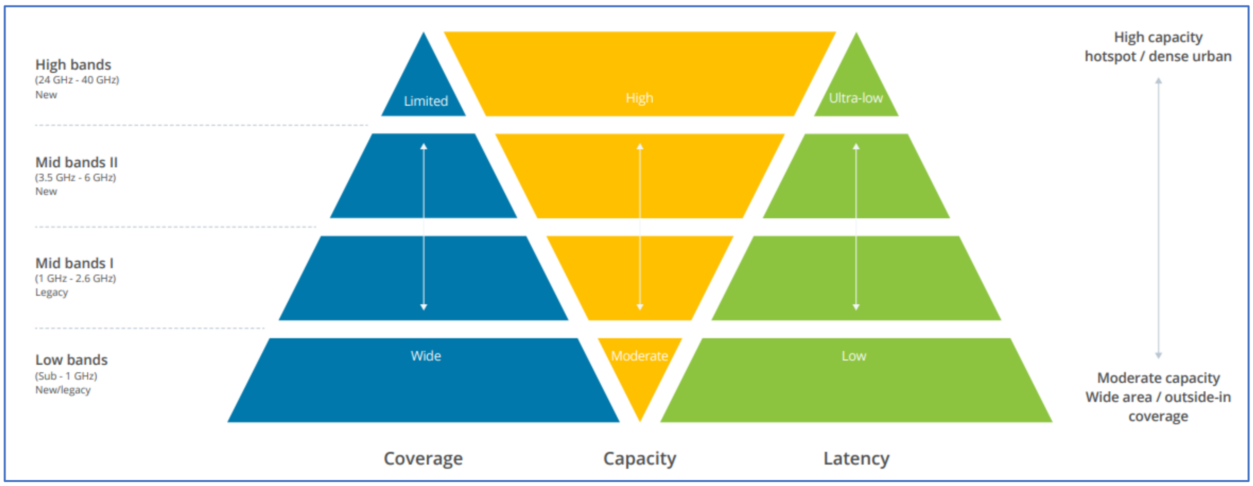


Figure 1: 5G Spectrum Analysis [2]

5G access services for enterprises can be delivered by either a public 5G service provider, such as AT&T, Verizon, or T-Mobile in the US, by the company's IT department, or by a private 5G network operator. In the latter case, the 5G network can be managed by the enterprise IT organization or by a 3rd party provider.

(specifications are at 1ms). URLLC allows base stations or access points to cover 100% of the manufacturing area with a low latency wireless 'umbrella.'

To illustrate the URLLC's critical role in manufacturing, let's look at digital twins. A digital twin is a real-time representation of a product, a factory production line, or even an entire factory. Using 5G NR and edge computing, large amounts of IIoT data from

[2] Infopulse ebook, Intelligent Connectivity: 5G and Its Cross-industry Use Cases, 2020. Retrieved from https://go.infopulse.com/acton/media/27841/intelligent-connectivity-5g-use-cases

sensors and analytics can be used for predictive maintenance of plant machinery. When using AR/VR as part of the digital twin approach, operators can visualize key insights by combining physical and virtual environments.

4.3 5G NR Interference Management

5G NR is introducing new inter-cell interference coordination (ICIC) mechanisms. This is very useful in dense deployments of mm-Wave used in manufacturing, as well as in general deployments. In the uplink, ICIC of the 5G NR mitigates inter-cell interference, which can be especially severe for cell-edge users. In the downlink, coordinated small cell DTX controls interference and energy consumption to meet URLLC requirements. Massive MIMO antenna arrays can also be used effectively in mm-Wave bands in coordination with ICIC to further reduce interference. For the user equipment or UE, a wake-up signal has been added to 5G control and scheduling mechanisms to further reduce the probability of interference at UE levels, with the side benefit of saving UE power and increasing battery life.

4.4 Service Continuity (Indoor and Outdoor)

Currently, enterprise Wi-Fi wireless networks operate primarily indoors and do not provide seamless integration between indoor and outdoor services. 5G NR allows for a seamless transition between indoor access points and outdoor radio access networks, or RAN. Enterprises can extend their indoor mobile coverage to outdoor public networks for improved logistics, easier remote office communications, and seamless customer interactions.

There are three approaches to achieving this continuity of indoor and outdoor service. In the first case, a service provider, or Mobile Network Operator (MNO), can deliver both indoor and outdoor functionality. This is the simplest approach to achieving complete and seamless services for both indoor and outdoor mobile applications.

In a second approach, the enterprise provides the control and services for the indoor coverage and coordinates with the service provider for the outdoor service. In this case, the integration between the enterprise indoor 5G network and the outdoor service provider network will be achieved using technology interworking similar to that used between the service provider and a Mobile Virtual Network Operator (MVNO).

The third and final approach involves using neutral hosting for the 5G NR. Neutral hosts allow multiple operators to share the same infrastructure, so the enterprise can use outdoor neutral hosting to extend their 5G coverage while continuing to use their enterprise 5G control plane.

5 STRENGTHS OF Wi-Fi 6 and Wi-Fi 6E

Wi-Fi 6 addresses the shortcomings of earlier generations of Wi-Fi technologies like, number of concurrent attachments, performance at high-density locations, spectral usage efficiency, etc., all of which give Wi-Fi 6 better usability in the following aspects compared to its predecessors:

- Lower power consumption is driven by the use of Target Wait Time (TWT)
- Higher Wi-Fi speed, in some implementations, exceeds 10Gbps. Increased user capacity with reduced

- latency, support higher numbers of users and devices, with improved medium access control (MAC) signaling
- High performance levels in the densest environments
- Increased efficiency and lower latency with Orthogonal Frequency Division Multiple Access (OFDMA) uplink and downlink digital modulation

The introduction of two key technologies speeding up Wi-Fi 6 connections; Multi-User-Multiple Input Multiple Output (MU-MIMO) and OFDMA.

[3]Better interference management, which again significantly enhances Wi-Fi performance and scalability.

Table 2: Wi-Fi 6 vs. 5G Comparison [3]

Comparison Item		Wi-Fi 6	5G
Technology	Modulation technology	1024QAM	256QAM
	MIMO	8T8R/12T12R-8 streams	Outdoor: 64T64R-16 streams Indoor: 4T4R-4 streams
	Frequency	Free of charge, no limitation	Limited, controlled by carriers
	Typical frequency bandwidth	Household: 160 MHz Campus: 80 MHz	100 MHz (in total)
	Scheduling mode	Similar to centralized scheduling	Centralized scheduling
User experience	Per-user rate	100 Mbit/s	100 Mbit/s
	Latency	Average: 20 ms Priority scheduling algorithm: 10 ms	eMBB: 4 ms uRLLC: 0.5 ms
	Mobility	50 ms * Terminals initiate roaming. Key services require device-pipe synergy.	10 ms
	Interference	Unlicensed, interference may occur	Licensed, no interference
Terminal ecosystem		Various enterprise terminals (PCs, projectors, monitoring devices, AGVs, and VR helmets)	Personal mobile terminals prioritized, few enterprise devices embedded with SIM cards
Per-bit cost		Low (enterprise LAN coverage, about 1/30 5G)	High (enterprise LAN coverage) Low (WAN coverage)
Deployment period		Small- and medium-sized enterprises (days to 1 month) Large-sized enterprises (2 to 3 months)	Long (WAN: 1.2 to 1.5 years; LAN: 4 to 5 months)
Security		Guaranteed security using latest protocols, traffic not forwarded out of enterprise networks	High air interface security, traffic forwarded through carriers' networks
Management requirement		Enterprise management personnel, smooth transition	New field, controlled by carriers

When compared with cellular technologies, Wi-Fi has always had limitations in network scalability, and Wi-Fi's use of only unlicensed spectrum makes it prone to spectral interference, which makes Wi-Fi performance even more challenging.

The introduction of Wi-Fi 6 addresses the first two limitations. Improvements in high spatial efficiency protocols, MU-MIMO, OFDMA, and beamforming techniques are shared with 4G and 5G cellular networks. Hence removing barriers for large scale Wi-Fi 6 deployments in industrial settings.

5.1 Key Wi-Fi 6 Features

5.1.1 MU-MIMO Use in Wi-Fi 6

MU-MIMO (Multi-User Multiple In-Multiple Out) was introduced in Wi-Fi 5 but with limited capacity and only 4 streams per download data stream. MU-MIMO is greatly enhanced in Wi-Fi 6 in terms of capacity & operations.

Generally speaking (especially before Wi-Fi 6), Wi-Fi performance declines as the number of users increases. This is due to the

[3] Huawei Technologies. (2020). What Is 802.11ax (Wi-Fi 6). Retrieved from https://support.huawei.com/enterprise/en/doc/EDOC1100102755

round-robin algorithm used to allocate the spatial space among users. Therefore at concentrated high density areas like sports events, malls, etc., Wi-Fi performance declines rapidly. In Wi-Fi 6, MU-MIMO capabilities increased from 4DNx1UP in Wi-Fi 5.0 to 8DNx8UP.Wi-Fi uses multiple independent data streams on the same frequency channel.

Because of more efficient spatial use of spectrum, per-user performance is largely sustained as more users join the Wi-Fi 6 network. This makes Wi-Fi 6 suitable for applications requiring large numbers of devices to be connected in small areas, such as IoT deployments on factory floors, and high density areas, like malls and stadiums.

5.1.2 Beamforming Integration with MU-MIMO

Introduced in Wi-Fi 4 with very limited vendor support. With Wi-Fi 5, beamforming was widely implemented but wasn't yet combined with MU-MIMO. The ability to focus the signal in the client's direction increases the signal power to the client, hence can reach longer distance, better signal stability, and reach a higher speed.

5.1.3 Adaptive Transmit Power

The Access Point has the ability to instruct the client to adjust its transmit power, avoid interference while maintaining the same data rate.

5.1.4 OFDMA

OFDMA is a high efficiency spectral protocol shared by cellular networks.

Before Wi-Fi 6, a round-robin period is allocated for each user in the network, users will have to leverage this time to send as much data as possible, if more data is required, they would have to wait for the next turn to use the allotted time. No other user can use the same channel during that time.

With OFDMA in Wi-Fi 6, multiple users can transmit at the same allotted time frame by breaking the frequency channel into multiple sub-channels, hence performance is substantially enhanced and latency is leveled

5.1.5 BSS Coloring

Before Wi-Fi 6, when the wireless access point (AP) detects another AP signal, it doesn't transmit on that particular channel till it finds a clear channel.

In Wi-Fi 6, each channel is assigned a unique color (3-bit value) to the Physical Layer Frame (PHY) to identify its transmission, and accordingly, the AP would ignore any transmission on the same channel with a different color value, which leads to an increased density of access points and ability maintain performance as user Wi-Fi attachments increase.

5.1.6 Target Wait Time (TWT)

In TWT, the AP and devices negotiate specific times to transmit and receive data, and only devices that are communicating with the APs stay awake during the transmission while other devices stay in sleep mode, which reduces power consumption markedly.

Low power consumption and prolonged battery life are highly valuable for IoT devices and deployments.

5.1.7 Passpoint or Hotspot 2.0

To be able to integrate 5G with Wi-Fi, you need clean and seamless handoff between both networks.

Hotspot 2.0 has been available for years, however, with HotSpot Release-3 that came out in 2019, the interaction between the Wi-Fi network and the carrier is highly improved through the exchange of certain metadata and information about the Wi-Fi network's performance like, possible charges, Wi-Fi current performance, capacity, load, quality of experience, etc., and accordingly make the decision on whether to switch the handset to the Wi-Fi network or not.

Hotspot 2.0 makes authentication automatic, eliminating the need to manually login to every Wi-Fi network available, which helps to make the handoff seamless. Hotspot 2.0 also automatically encrypts traffic from the client to the AP using WPA2 or WPA3.

5.1.8 Other Wi-Fi 6 Enhancements

There are other enhancements beyond the scope of this whitepaper that include 1024 Modulation, Channel Bonding, Large Symbol (high indoors efficiency and “persistent?” outdoor users)

5.2 Wi-Fi Network Slicing

Compared with 5G network slicing, Wi-Fi 6E network slicing requirements can be realized using different techniques.

- In **controller-based deployments**, VLANs can be dynamically allocated by the network to packet flows associated with different groups of users, dynamic VLAN assignment enables the slice selection to be based on the network policy.
- In **Wi-Fi networks**, this slice selection assistance functionality can be realized using multiple Basic Service Set Identifier (BSSID) functionalities. With such a configuration, a Wi-Fi device will use its selected SSID to “indicate slice selection assistance information” to the Wi-Fi network, other options will be AAA based on Slice/VLAN allocation.
    - IEEE 802.11e follows traditional Quality of Service (QoS) implementation. QoS on wireless LANs provides prioritization of traffic from the access point over the WLAN based on traffic classification. QoS on the wireless LAN focuses on downstream prioritization from the access point, Wi-Fi 6E slice prioritization implementation is vendor-specific this feature requires a solution that is vendor-agnostic ability to define prioritization between the slice.

6 THE (FALSE) DILEMMA

As 5G NR delivers large capacity and performance improvements when compared to 4G, many enterprises consider using 5G access either as a substitute or complement to Wi-Fi 6.

Owing to previous competition between IEEE and 3GPP architectures, the rivalry between 5G and Wi-Fi 6 is gathering momentum. This white paper demonstrates that we can have the best of the two technologies work together to deliver quality user experience, factory automation, and multiple services.

6.1 Recommendations for Unified Network Slicing

Waiting for additional standardization. At present, end-to-end network 5G slicing will be created by a dedicated 5G Network Slice Orchestrator and Software Define Network (SDN) controllers for the transport network based on ETSI reference architecture.

Wi-Fi 6E has its Orchestrator and controller. Life Cycle Orchestration (LSO) of Wi-Fi 6E and 5G slicing is an important next step to enable vendor-agnostic, API based solutions. Service providers, 3GPP and IEEE/Wireless Alliance should significantly enhance the capabilities of the resulting APIs needed for such orchestration.

The requirement is to integrate Wi-Fi 6E and 5G Orchestration and Life Cycle Management for the hybrid scenario. The evolution of 5G and Wi-Fi 6E should include a unified Orchestrator and Controller for the ability to interconnect with each other and to rapidly onboard new service offerings.

6.2 Combining 5G and Wi-Fi 6

Through many of the above-mentioned features, Wi-Fi provides scalable and robust wireless connectivity that is comparable to cellular network wireless access. As higher frequency bands are awarded for 5G NR, public antenna signal penetration to indoor environments will become challenging, and leveraging existing Wi-Fi 6 infrastructure to integrate with 5G networks will become the practical route for connectivity.

The backward compatibility with Wi-Fi decouples infrastructure and end-point upgrades and investments, which makes Wi-Fi adoption higher, much easier, and much more cost-effective. Endpoints can maintain connectivity and operations with new Wi-Fi 6.0 infrastructure upgrades. In the case of 5G however, both infrastructure and end-points are tightly coupled together, and therefore a forklift upgrade is necessary for the technology adoption.

Combining the best of the two worlds between both 5G and Wi-Fi makes the best sense. 5G for macro-level coverage, while Wi-Fi 6 on micro-level indoor coverage. Deployments would then form silos of Wi-Fi 6 connected by 5G and backhauled to the carrier's 5G control, management, and data center forming a converged management and control infrastructure for both 5G & Wi-Fi 6.0 (could be three times better battery life). Wi-Fi to offload 5G in poor coverage areas

Deploying 5G indoors would also require some cost associated with the device cost itself due to the cost of the 5G radio chipset compared to the Wi-Fi chipset that the device needs to have. Also, end-points, sensors, devices, subscriptions, and possible metered data usage, something that enterprises won't have to worry about in the case of Wi-Fi 6.

7 DILEMMA NO MORE

5G standardized control (CUPS) with slicing, open architecture and multiple radio technologies, the use of a large number of spectrum bands meets all services demands

But the jury is still out on:

- Pricing of each solution
- Availability of devices taking advantage of either, or both, solutions
- Deployment of 5G NR by mobile operators, and enterprises
- Cloud Edge ecosystem

7.1 How the Benefits of Wi-Fi 6 and 5G can be Complementary

But, of course, there are benefits of 5G technology compared with Wi-Fi 6 as well. 5G will be a revolutionary technology for enterprise IT in areas where Wi-Fi is not ideal. Again, the mantra for network architects is this: Use Wi-Fi when you can, and 5G when you must.

One example of this principle is an IoT sensor deployment with hundreds or thousands of IoT devices that need wireless connectivity. Within corporate-owned buildings, Wi-Fi 6 will be the go-to wireless technology to connect IoT devices. When IoT moves outside the walls of a corporate building, a sensor can still connect with ample speed and reliability by exploiting 5G as the wireless mode of transport another example is to use 5G to achieve mobile broadband Internet connectivity for a temporary or mobile location – then have others use Wi-Fi to connect other wireless users. This can be accomplished with 5G-capable routers or firewalls combined with built-in or external wireless access points to allow others to access the Internet through a single 5G broadband connection.

Lastly, 5G is likely to be used in situations where Wi-Fi struggles to operate efficiently, or simply lacks coverage. Remember that for Wi-Fi 2.4 and 5GHz spectrum is an unlicensed spectrum. This means that individual users or entities don't own the wireless spectrum Wi-Fi operates on, as is the case with a licensed 5G spectrum. This can create a situation where wireless spectrum interference occurs in locations such as multi-occupancy buildings. In scenarios like these, 5G that operates over carrier-licensed spectrum will likely perform far better than Wi-Fi in low latency and high-density IIoT deployments.

Wi-Fi 6 still operates on the Wi-Fi usual two frequency bands, 2.4GHz, and 5GHz. The FCC just recently opened the 6GHz frequency band for unlicensed Wi-Fi 6E access, which makes a 1,200 MHz of spectrum available for unlicensed use. Vendors are currently adding support for this band as the new "Wi-Fi 6E", which will bring even better performance in the future.

7.2 A Tale of Two Technologies

IT pros are right to turn to 5G as the next massive revolution in enterprise wireless connectivity. The technology is a tremendous improvement over 3G and4G and LTE iterations. But, as noted, the benefits of Wi-Fi 6E shouldn't be downplayed either. It has plenty of features–and the ability to connect Wi-Fi users far more efficiently and reliably than previously. In tandem–and when deployed in the proper situations– the combination will allow businesses to be flexible when connecting users and devices both inside and outside the corporate LAN.

7.3 Wi-Fi 6 and 5G

First of all, let's be clear: Wi-Fi 6E is not 5G. Although Wi-Fi 6 supports some similar features as 5G like improvements in network speed, capacity and latency, Wi-Fi 6 is not an alternative to 5G but a compliment. Wi-Fi 6 and 5G are different technologies built for very different use cases. 5G is designed for wide area networking whereas Wi-Fi 6 offers high speed, low-latency connectivity for local area networks.

8 CONCLUSIONS

Applying the three lessons learned.

1. When choosing markets for new technologies, consider the legacy and adoption barriers

   Adoption barriers for 5G and Wi-Fi 6E: both require the rollout of new access points and control capabilities. The cost and complexity of the new rollout can be reduced by

   - deploying a universal control plane – this is 5G CUPS
   - using slicing to align all access technologies around the new control plane
2. Plan new technology deployments with revenue conservation in mind

   - 5G CUPS a universal control plane allows total flexibility in the selection of access technologies suitable for use cases as they arise
   - all enterprise communications can be managed with the unified control
   - enterprise IT workforce and skillsets are used to deploy and manage 5G CUPS
3. Revolution vs. evolution – rip and replace is very hard to justify financially, although completely greenfield player may be able to leapfrog legacy competitors

   - New technology can be introduced gradually, as required by technology replacement cycles and capacity growth
   - Requires a plan for migrating legacy technologies to the newly unified control plane
     - Avoid vendor lock-in by using standardized 5G control and slicing architectures

Figure 2: Dilemma no more[4]

[4] RCR Wireless News. Retrieved from **https://bit.ly/3crwi41**

9 ACRONYMS

Acronym	Meaning
2.5G	Mobile Wireless Technology between 2G and 3G
3G	Third Generation
3G+	Third Generation Plus
3GPP	3G Partnership Project
4G	Fourth Generation
5G	Fifth Generation
AAA	Authentication, Authorization, and Accounting
AI	Artificial Intelligence
AP	Access Point
API	Application Programming Interface
AR	Artificial Reality
BSS	Business Support Systems
BSSID	Basic Service Set Identifier
CP	Control Plane
CSP	Communication Service Provider
CUPS	Control Plane User Plane Separation
DN	Downstream
DSL	Digital Subscriber Line

Acronym	Meaning
DTX	Direct Transmission
eMBB	Enhanced Mobile Broadband
EMS	Element Management System
EPC	Enhanced Packet Core
ETSI	European Telecommunications Standards Institute
FCC	Federal Communication Commission
Gbps	Gigabits per second
GHz	Gigahertz
HTTP	hypertext transfer protocol
ICIC	inter-cell interference coordination
IEEE	Institute of Electrical and Electronics Engineers
IIoT	Industrial Internet of Things
IoT	Internet of Things
IP	Internet Protocol
LAN	Local Area Network
LSO	Lifecycle Service Orchestration
LTE	Long Term Evolution
MAC	Media Access Control

Acronym	Meaning
MEC	Multi-Access Edge Computing
MHz	Megahertz
MIMO	Multiple Input Multiple Output
MIoT	Massive IoT
MMTC	Massive Machine Type Communications
mm-Wave	millimeter wave
MNO	Mobile Network Operator
ms	millisecond
MU-MIMO	Multi-User-Multiple Input Multiple Output
MVNO	Mobile Virtual Network Operator
OFDMA	Orthogonal Frequency Division Multiple Access
PHY	Physical Layer
QoS	Quality of Service
R14	3GPP Release 14
RAN	Radio Access Network
SBA	Service Based Architecture
SDN	Software Defined Network
SLA	Service Level Agreement
SMS	Short Messaging Service

Acronym	Meaning
SSID	Service Set Identifier (802.11b)
TWT	Target Wait Time
UE	User Endpoint
UP	Upstream
URLLC	Ultra-reliable low-latency communication
V2X	Vehicle-to-everything
VLAN	Virtual LAN
VR	Virtual Reality
WAN	Wide Area Networking
Wi-Fi	Wireless Fidelity IEEE 802.11
Wi-Fi 4	Fourth Generation Wi-Fi
Wi-Fi 5	Fifth Generation Wi-Fi
Wi-Fi 6	Sixth Generation Wi-Fi
Wi-Fi 6E	Wi-Fi 6 Enhanced
WiMAX	Worldwide Interoperability for Microwave Access
WLAN	Wireless LAN
WLL	Wireless Local Loop
WPA2	Wi-Fi Protected Access version 2 (802.11)
WPA3	Wi-Fi Protected Access version 3 (802.11)

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