

Wi-Fi & Private 5G : Which to use where?

Introduction

The demand for new applications/use cases in enterprise and home networks has been steadily increasing, along with a drive towards lower deployment and maintenance costs. Some of the industry verticals spurring the new use cases are:

- Health care
- Manufacturing
- Data Centers
- Retail

The service requirements of these industry verticals vary widely with respect to coverage, data rates, latency, reliability, mobility and security. Use cases involving IoT devices impose power constraints too on the APs. With the opening up of the CBRS (3.5GHz) band in the US by the FCC for shared access, private cellular networks have emerged as a potential solution alongside Wi-Fi to cater to the new industry use cases.

The traditional boundaries that differentiated earlier generations of cellular and Wi-Fi technologies are blurring, with the advanced features introduced in Wi-Fi 6/6E/7 viz., better efficiency in wireless link utilization and 6 GHz operation. This white paper examines the capabilities of Private 5G and Wi-Fi 6/6E/7 in meeting the service requirements of each of the industry verticals. The choice of technology depends on the technical and commercial requirements of the specific use case in question.

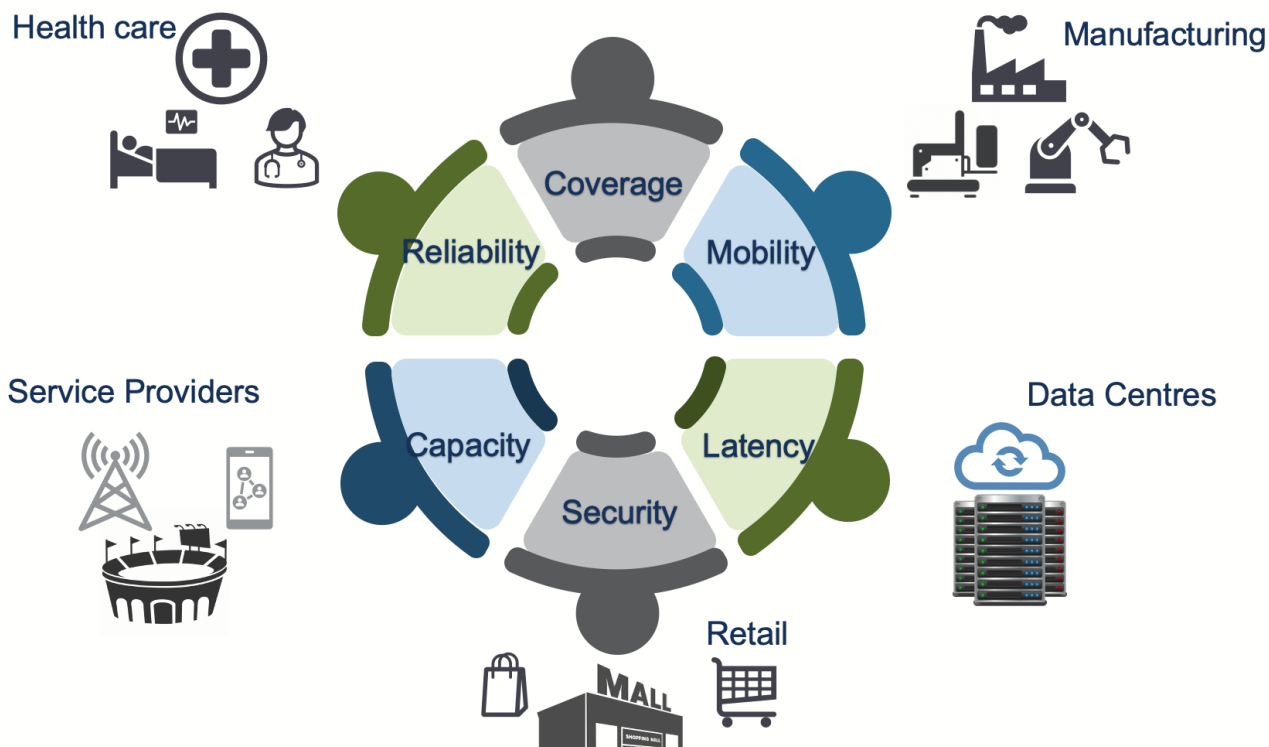


Figure 1: Industry verticals and service requirements for Private 5G & Wi-Fi 6/6E/7

Complementary features

Parameter	Wi-Fi 6/6E/7	5G
Technical		
Coverage range	<50 m indoor, up to 300 m outdoor	100–300 m for small cells, up to tens of km for macro cells
Spectrum	2.4 GHz Unlicensed 5 GHz Unlicensed 6 GHz Unlicensed	Low-band (<1 GHz) Licensed Highband (~24–29 GHz) Licensed Mid-band (1–7 GHz) Unlicensed (CBRS)/Licensed
Deployment scenarios	Short range	Wide area, short range
	Indoor/outdoor	Indoor/outdoor
	Private, Public	Private, Public
Deployment type	Controlled, some managed	Controlled and managed

Competitive features

Parameter	Wi-Fi 6/6E/7		5G
Technical			
QoS	User Priority/WMM on air interface, Differentiated Service Code Point (DSCP) mapping on wired side. End-to-end QoS cannot be guaranteed.		QoS based traffic prioritization, Network slicing. Guaranteed end-to-end QoS
Latency	<10 ms (with multi-link aggregation in Wi-Fi 7) [1]		User plane latency: 4 ms for eMBB, 1 ms for URLLC Control plane latency: 20 ms (recommended 10 ms) [15]
Data rates		Wi-Fi 6/6E	Wi-Fi 7
	Peak data rate in 80 MHz	2.4 ¹ Gbps [13]	2.88 ² Gbps [14]
	1. 1024 QAM, 4 spatial streams 2. 4096 QAM, 4 spatial streams		Peak data rate in 80 MHz : 1.59 ³ Gbps [13] 3. 256 QAM, 4 spatial streams
Mobility	Nomadic, pedestrian, (handovers are controlled by clients)		Nomadic, pedestrian, vehicular, high-speed vehicular, (handovers are network driven)
Security	WPA3, OWE		(U)SIM based
Backward compatibility	Fully backward compatible		Legacy user devices are not always supported by the latest generation of networks.
Commercial			
Client ecosystem	Mature		Evolving
Enterprise Network deployment/management	Can be handled in-house due to availability of skilled personnel, doesn't require certified professionals		Needs to be managed by service provider/ managed services partner , to be deployed by certified professionals
Device/Network Identifiers	No cost involved		Identifiers to be purchased [12]
User device cost	Low		High
Spectrum cost	None (Unlicensed spectrum)		Cost involved in the case of Priority Access License (PAL) for CBRS band

Capex	Clients, APs, infrastructure	Radio: Wi-Fi 6/6E/7 APs Wi-Fi 6/6E/7 clients Network: Controllers, Switches, Cloud infra & Apps Cabling & Labor Moderate	Radio: P5G indoor radios P5G clients with SIM/eSIMs Network: eSIM management Switches Packet core Network Management System Cloud infra & Apps Cabling & Labor High
Opex	Maintenance	Maintenance & support Power Bandwidth Low	Maintenance & support Power Bandwidth EPC SAS High
Availability of skilled personnel for maintenance	In-house personnel critical for emergencies	High	Low (as per FCC, certified professionals required for registering devices)[3]
TCO	Capex+Opex	Medium	High (approx 33% higher, even after excluding eSIM, client costs) [2]

Use cases

Healthcare

Large healthcare establishments such as hospitals, diagnostic facilities, medical research centers, and homes for the elderly see an increasing need for reliable campus connectivity solutions. Service requirements in these establishments typically include live video feed for remote healthcare (consultation, monitoring) and assisted surgery, realtime commands to control medical devices for treatment (e.g., medication, surgery), remote monitoring of patients, connectivity for sensors, wearables and other medical devices.

Business Case: Connectivity in large hospitals/health care institutions

Technical Requirements:

- Reliable voice and video calls for medical staff including coverage in enclosed spaces (labs, ICUs etc.)
- HD quality video for virtual consultations
- High capacity for large file transfers (MRI scans etc.)
- Low latency & high reliability for life-critical applications

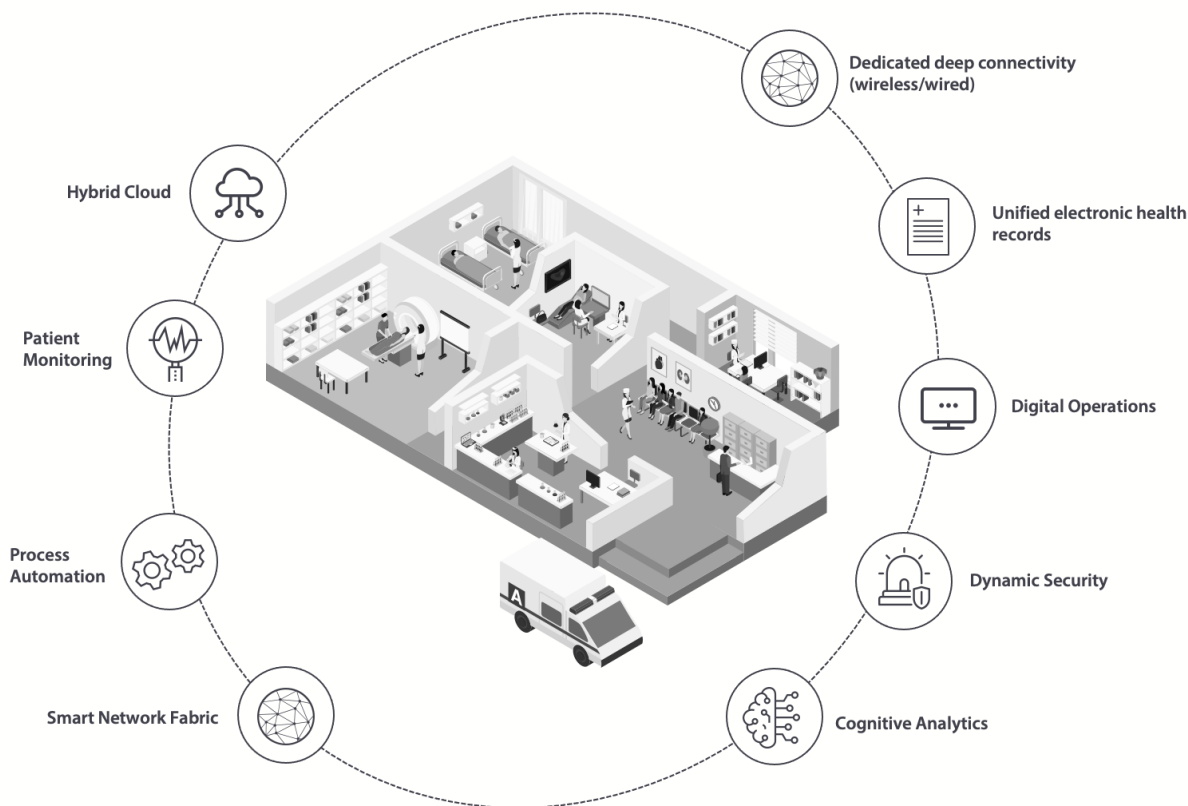


Figure 2: Technical requirements of a Healthcare establishment

Parameter	Use Case	Wi-Fi 6/6E/7	Private 5G
Technical			
Environment	Dense	Yes	Yes
Deployment Type	Amenity	Free, amenity	Free, subscription
Data rate	Application dependent requirement [Table]	Yes	Yes
Mobility	Nomadic , Pedestrian	Yes	Yes
Reliability	High	Yes	Yes
Latency	IP Packet delay for Voice < 50 ms [4]	Yes	Yes
	End-to-end packet delay (all apps) < 150 ms [3]	Yes	Yes
	Video frame delay < 5 s [4]	Yes	Yes
Power save mode	Support for IoMT	Yes (TWT)	Yes (CAT-M, NR-lite)
Security	Medium-High	Yes (WPA3-Enterprise, OWE)	Yes

Table 1: Application-wise data rate requirements

Application	Data rate [3]
480p video (640x480)	2.5 Mbps
720p video call (1280x720)	3 Mbps (each way)
1080p HD video (1920x1080)	8 Mbps
4k HD video	20-25 Mbps
Normal voice call	12 kbps
HD voice call	50 kbps

Industrial control and automation

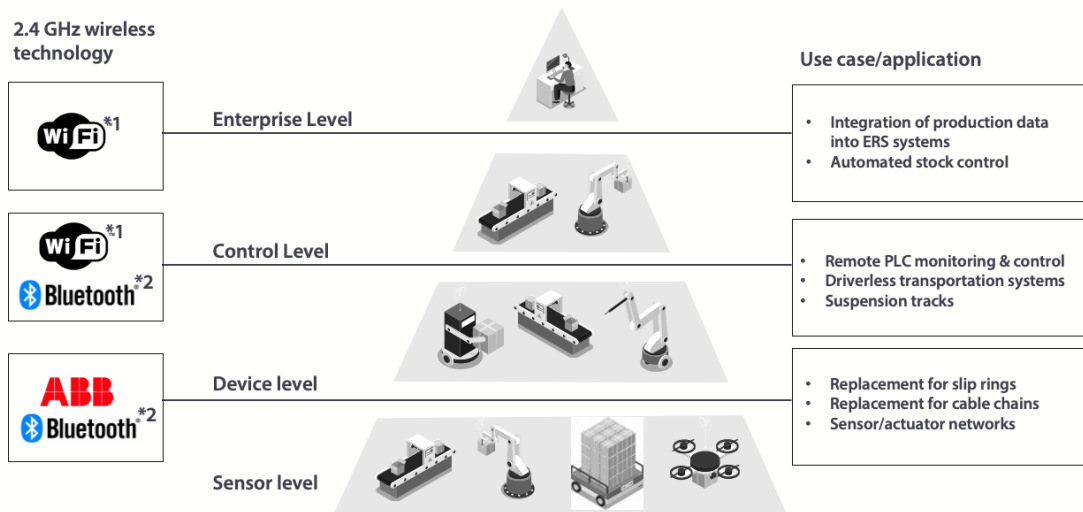
Industrial solutions typically have a lifetime in the range of several decades. Therefore, any underlying communication solution has to be available over at least 20 years. In this context, backward compatibility is of major importance.

Business Case: Automation of production line robots, asset tracking, worker safety monitoring, access control, remote diagnostics & predictive maintenance

Technical Requirements [7]:

• **Factory Automation**

Factory automation involves automating the discrete steps in manufacturing where products are assembled, tested and packed (automotives, semiconductors, consumer goods etc). Typically every single step is controlled by many sensors and actuators, all of which need to be controlled wirelessly. Requirements include in-time delivery of messages with high reliability, low latency, cyber security and functional safety.

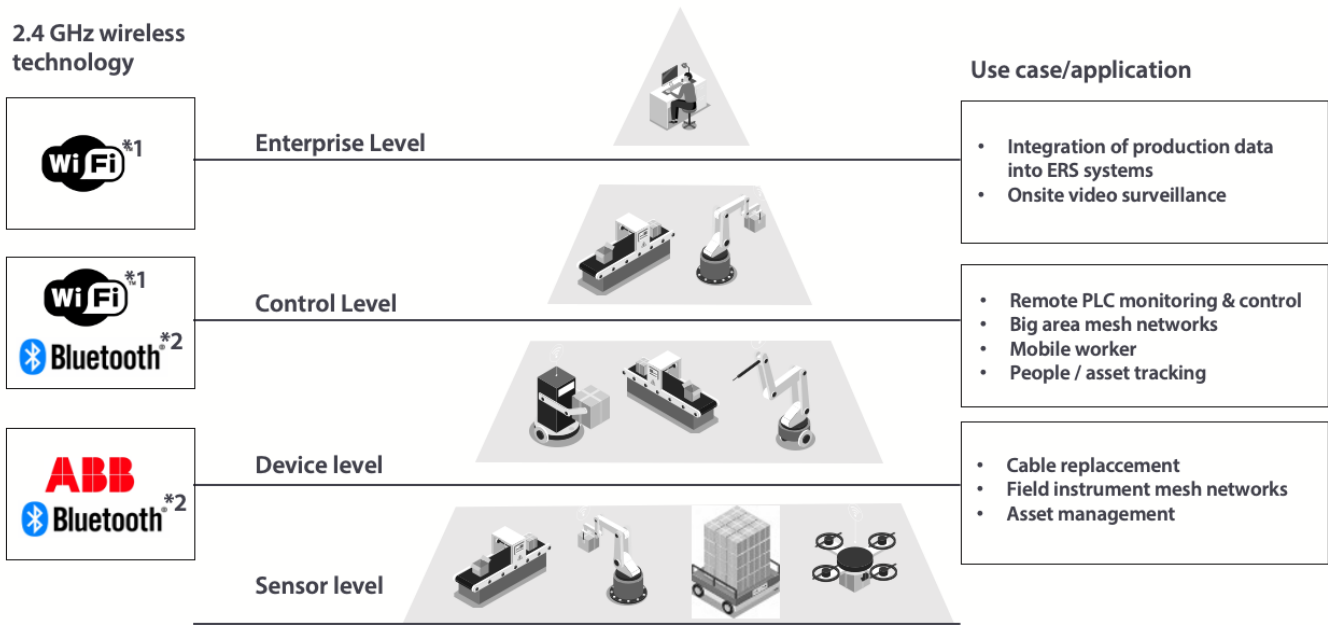


*1 industry specific derivatives of IEEE 802.11 (i.s.r) etc.
 *2 industrialized versions

Figure 3: Technical requirements of Factory Automation [8]

• **Process Automation**

The Process Industry deploys predominantly continuous production processes to produce or process large quantities or batches of a certain product (like fluids, chemical, or an “endless” product like e.g. wires, cables). Requirements include determinism, reliability, redundancy, cyber security, and functional safety. The sensor level connectivity needs a robust, long range, low power mesh network. The sensors are typically battery operated. Process automation needs low latencies in the range of 100 ms to a few seconds [7].



*1 industry specific derivatives of IEEE 802.11 (i.s.r) etc.

Figure 4: Technical requirements of process automation [8]

• **Audio-visual interaction**

Audio-visual interaction is characterized by a human being interacting with the environment or people, or controlling a device, and relying on audio-visual feedback. Requirements include reliable audio and video communication.

• **Remote Control**

Remote control is characterized by a device being operated remotely, either by a human or a computer.

• **Autonomous Guided Vehicles**

AGVs are mobile units for taking care of the supply of items and material on the shopfloor level, or intelligent forklifts, which may be flexibly used at different locations and possibly even facilitate a close human-machine collaboration.

Parameter	Use Case	Requirement	Wi-Fi 6/6E/7	Private 5G
Coverage area ¹	Factory automation - Motion Control	Medium ¹	Yes (with outdoor APs)	Yes
	Factory automation	Very High ¹	Yes (with outdoor APs)	Yes
	Process automation –Remote Control	High ¹	Yes (with outdoor APs)	Yes
	Process automation Monitoring	High ¹	Yes (with outdoor APs)	Yes
	Audio-visual interaction	High ¹	Yes	Yes
	Remote control	Very High ¹	Yes	Yes
	AGVs	Very High ¹	Yes	Yes
Latency	Factory automation - Motion Control	1 ms ²	Yes (Wi-Fi 7)	Yes (uRLLC)
	Factory automation	10 ms ²	Yes (Wi-Fi 6E)	Yes (uRLLC)
	Process automation –Remote Control	50 ms ²	Yes	Yes
	Process automation Monitoring	50 ms ²	Yes	Yes
	Audio-visual interaction	10 ms ²	Yes (Wi-Fi 6E)	Yes
	Remote control	5 ms ²	Yes (Wi-Fi 6E)	Yes
	AGVs	50 ms ² [16]	Yes (Wi-Fi 6)	Yes
Availability	Factory automation - Motion Control	Very High ⁴	Yes	Yes
	Factory automation	High ⁴	Yes	Yes
	Process automation –Remote Control	Very High ⁴	Yes	Yes
	Process automation Monitoring	High ⁴	Yes	Yes
	Audio-visual interaction	High ⁴	Yes	Yes
	Remote control	Very High ⁴	Yes	Yes
	AGVs	Very High ⁴	Yes	Yes

Data rate	Factory automation - Motion Control	10 Mbps	Yes	Yes
	Factory automation	10 Mbps	Yes	Yes
	Process automation –Remote Control	100 Mbps	Yes	Yes
	Process automation Monitoring	1 Mbps	Yes	Yes
	Audio-visual interaction	250 Mbps	Yes	Yes
	Remote control	1-10 Mbps	Yes	Yes
	AGVs	1 Mbps	Yes	Yes
Connection density	Factory automation - Motion Control	100 000/km ²	No	Yes (mMTC)
	Factory automation	100 000/km ²	No	Yes (mMTC)
	Process automation –Remote Control	1 000/km ²	Yes	Yes
	Process automation Monitoring	10 000/km ²	No	Yes
	Audio-visual interaction	Low	Yes	Yes
	Remote control	Low	Yes	Yes
	AGVs	100/km ²	Yes	Yes

1: The coverage requirement applies to the service area, e.g., inside a factory (LxWxH) [7].

Very High - 1000x1000x30 m

High - 300x300x50 m

Medium - 100x100x30 m

2: Traffic prioritization and hosting services close to the end-user may be helpful in reaching the lowest latency values.[7]

3: Audio-visual interaction requires very low-delay audio and video coding, and high video frame rates (e.g., 120 fps).[7]

4. Very high - 99.9999% [7]

High - 99.9%-99.9999%[7]

Data Centers

Wireless solutions within a data center premises are required to deliver high capacity, reliability and security. Data centers and edge computing facilities need both indoor and outdoor connectivity owing to the large campuses over which they are located. Inside the Data Center server rooms, the radio environment is very challenging due to the massive number of servers, switches and storage devices mounted on rows of racks. The data center environment is characterized by a very high noise floor, spanning a wide range of frequencies. Typical noise floor is above -70dBm in the Wi-Fi bands, with a much higher noise floor in the lower end of the spectrum.

Business Case: Communication services in Data Center facilities

Technical Requirement:

- Reliable voice and video calls, uninterrupted coverage with seamless mobility within the Data Center
- Video surveillance for security
- Automation will introduce new types of clients like AGVs, robots etc.

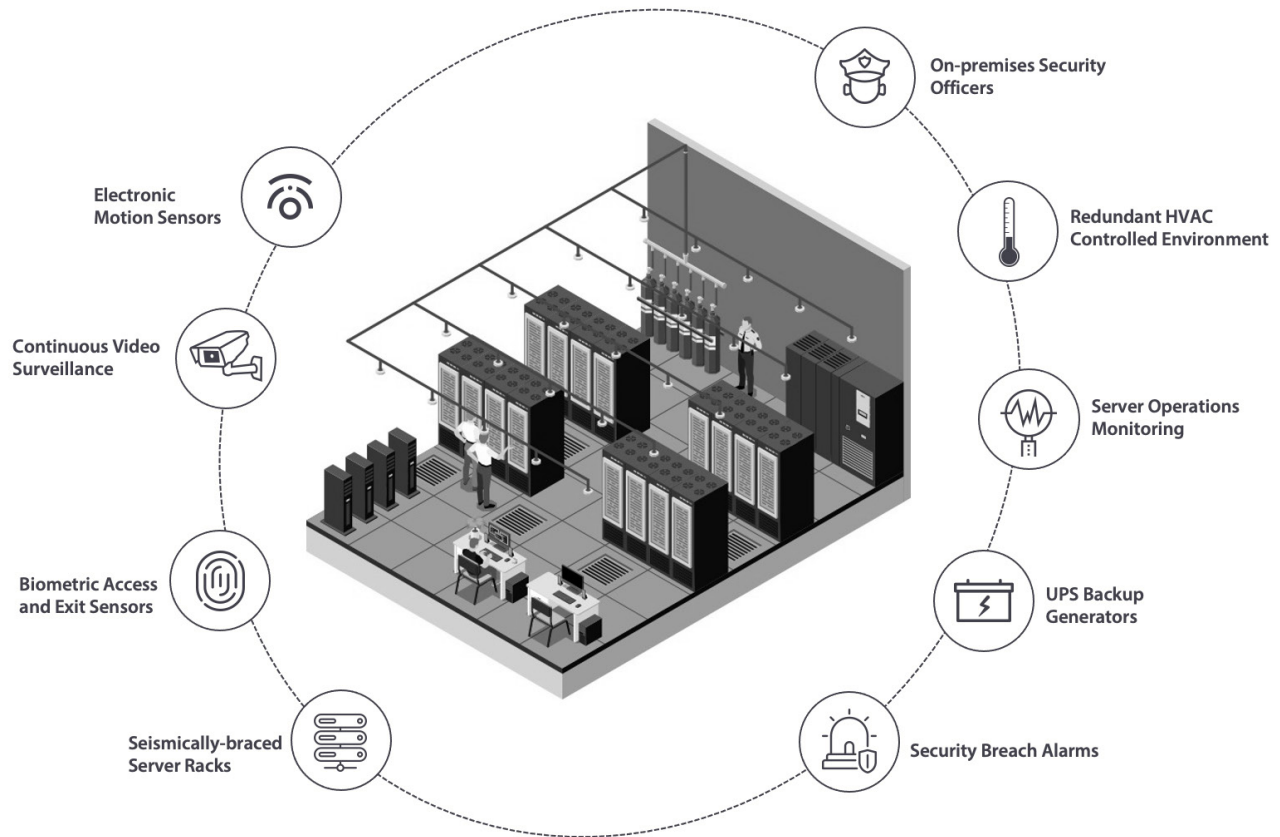


Figure 5: Technical requirements of a Data Center

Parameter	Use Case Requirement	Wi-Fi 6/6E/7	5G
Technical			
Environment	Moderately dense	Yes	Yes
Deployment type	Amenity for employees	Free, amenity	Free, subscription
Data rate	Application dependent requirement [Table]	Yes	Yes
Mobility	Nomadic , Pedestrian, Vehicular (for AGVs/ robots)	Yes	Yes
Reliability	High	Yes	Yes
Latency	IP Packet delay for Voice < 50 ms [4]	Yes [5]	Yes
	End-to-end packet delay (all apps) < 150 ms [3]	Yes	Yes
	Video frame delay < 5 s [4]	Yes [6]	Yes

Retail

Retail and entertainment venues are densely populated environments requiring support for high traffic from promotional audio-visual content, targeted advertising, high quality voice and video calls, and point-of-sale systems with secure connectivity. Retail venues also need accurate location tracking applications for asset tracking within stores and around the mall area.

Business Case: Coverage and capacity within large retail spaces with shopping and entertainment facilities

Technical Requirements:

- Reliable voice and video calls
- Push notifications with HD audio-visual marketing content
- Location tracking services
- Secure connectivity for Point-of-sale systems
- Video surveillance

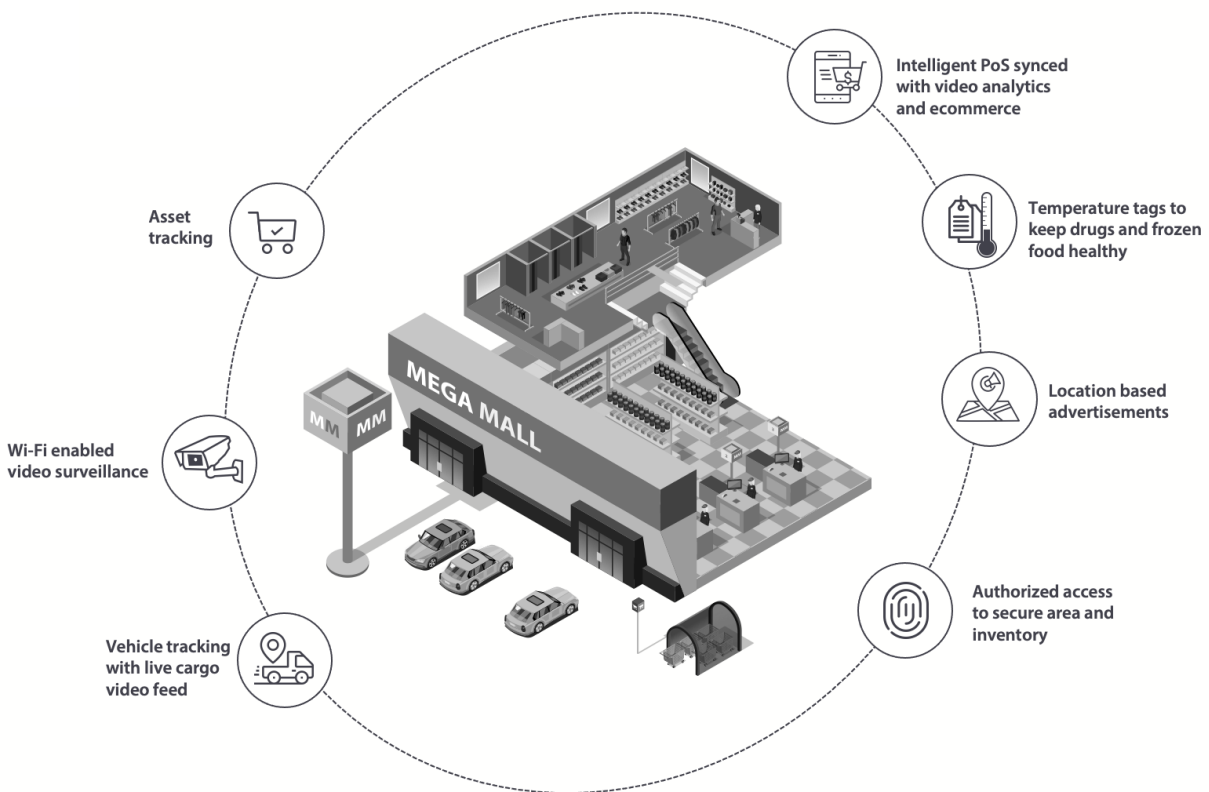


Figure 6: Communication requirements in large retail spaces

Parameter	Use Case Requirement	Wi-Fi 6/6E/7	5G
Technical			
Environment	Dense	Yes	Yes
Deployment type	Amenity	Free, amenity	Free, subscription
Data rate	Application dependent requirement [Table]	Yes	Yes
Mobility	Nomadic , Pedestrian	Yes	Yes
Reliability	Medium	Yes	Yes
Latency	IP Packet delay for Voice < 50 ms [4]	Yes [5]	Yes
	End-to-end packet delay (all apps) < 150 ms [3]	Yes	Yes
	Video frame delay < 5 s [4]	Yes [6]	Yes
Security	Medium-high	Yes (WPA3-Enterprise, OWE)	Yes
Location tracking	Accurate location tracking to track in-store and outdoor assets	Yes	Yes
Support for IoT	IoT systems for asset monitoring & management, environment sensors	Yes	Yes

Conclusion

Communication needs across industry verticals are getting more diverse and need careful requirements analysis before zeroing in on any technology solution. The latest enterprise wireless technologies - Private 5G and Wi-Fi 6/6E/7 offer best in the industry capabilities, with specific advantages weighing in favor of each of them. The advantages Private 5G offers are ultra low latency, wider outdoor coverage and vehicular mobility whereas Wi-Fi 6/6E/7 offers ubiquity, ease of deployment & management with a much lower TCO. The higher capex/opex investments in Private 5G networks are justified only when the applications and environment in question impose stringent latency and mobility demands. The two technologies have the potential to deliver better value by complementing each other, rather than individually.

Use case	Services	Wi-Fi 6/6E/7	Private 5G
Healthcare	Voice & video calls	✓	✓
	HD video for virtual consultations	✓	✓
	Transfer of large scan images from medical devices	✓	✓
	Robotic surgeries	Latency constraints	✓
Industrial Control & Automation	Factory automation - Motion control	Connection density constraints	✓
	Factory automation	Connection density constraints	✓
	Process automation - Remote control	✓	✓
	Process automation - Monitoring	Connection density constraints	✓
	Audio-visual interaction	✓	✓
	Remote control	✓	✓
	Autonomous Guided Vehicles	✓	✓
Data Centers	Voice & Video calls	✓	✓
	Video surveillance	✓	✓
	High data rate applications	✓	✓
Retail	Voice and video calls	✓	✓
	Push notifications with HD audio-visual marketing content	✓	✓
	Location tracking services	✓	✓
	Secure connectivity for Point-of-sale systems	✓	✓
	Video surveillance	✓	✓

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