NILE UNIVERSITY

SCHOOL OF ENGINEERING AND APPLIED SCIENCES

Report On

Mobile Robots Communication

Robots and Vision

(OPT 242)

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1. Introduction

Wireless communication involves transferring information from your controller to a robot without them being physically connected to the controller. Wireless communication range can be as short as few centimeters to as long as millions of kilometers depending on the technology used. Most wireless communication uses radio waves for communication.

Types of wireless Communication:

1. **Infrared (IR)**
   This is the first wireless control technique available for a beginner. Since the wavelength of IR light is longer than that of visible light, it is invisible to the human eye. A transmitter in your controller transmits IR light (or pulses) and an IR receiver on your robot receives the signal, which is decoded with the help of a microcontroller. IR requires line-of-sight control and is best suited for applications that require a shorter control range.

2. **Radio Frequency modules (RF communication)**
   Similar to Infrared communication, RF communication consists of a transmitter and a receiver module. A transmitter creates electromagnetic waves in a particular frequency and a receiver captures this signal. A microcontroller can decode this signal and use it to control other peripherals.

3. **Wi-Fi (802.11 networks)**
   Using Wi-Fi, we can control your robot through the internet. In this type of communication, a wireless network adapter in a computer converts digital data into radio signals and the Wi-Fi unit on the robot (another network adapter) converts these signals into digital data. The Institute of Electrical and Electronics Engineers (IEEE) has come up with a set of standards for these wireless networks with the title "IEEE 802.11".

4. **Bluetooth**
   Bluetooth is an open wireless technology that can be used to transfer data over short distances, typically 8-10 meters. One of the advantage of Bluetooth modules is that it does not require a line of sight to communicate which makes it a good choice for your mobile robots.

5. **Satellite communication (GPS controlled)**

   GPS or Global Positioning System is a satellite navigation system that provides location coordinates of objects on earth which has a GPS receiver. A GPS receiver on a robot precisely calculates its position based on signals sent by satellites orbiting the earth. GPS devices are also capable of providing information on the speed and direction of your robot.

2. Robot: MiR1350

MiR1350 is the latest AMR (Autonomous Mobile Robot) model from manufacturer MiR to date. These Robots are used for the transportation of pallets and heavy goods by navigating smoothly and efficiently in dynamic logistic environments.

MiR1350 safely maneuvers around all kinds of obstacles and should a person walk directly out in front of it, it will stop. With advanced technology and sophisticated software, the robot can navigate autonomously and choose the most efficient route to its destination. When encountering obstacles, the robot automatically redirects and can reroute to prevent stopping or delaying the delivery of materials.

The Robot is operated by the intuitive MiR Robot Interface via smartphone or computer and can be programmed based on previous experiences. It can also be integrated into the MiR Fleet alongside the rest of MiR’s robots to interact with each other.

The robot is powered by a lithium battery that can be charged with a MiR cable charger or a MiR Charge 48V charging station.

2.1 Key Specifications:

Communication:

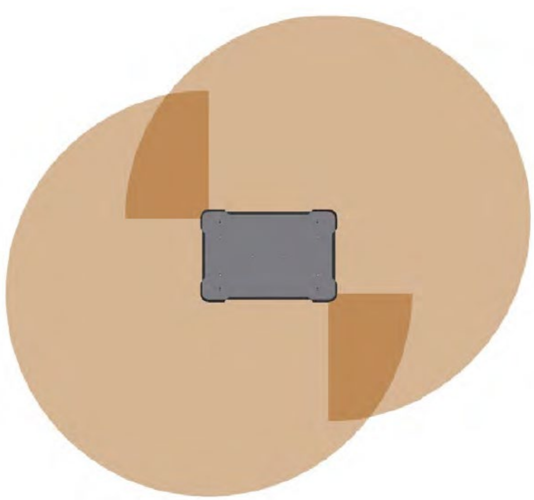
- WiFi (internal PC) - Router - 2.4 GHz and 5 GHz.
- Internal computer: Wi-Fi adapter: 2.4 GHz and 5 GHz, 2 internal antennas
- Ethernet: M12 plug, 4p. 10/100 Mbit Ethernet with Modbus protocol, adapter for external antenna.
- Safety I/Os – 6 digital inputs, 6 digital outputs

Sensors:

- SICK safety laser scanners 2 pcs: microScan3 (diagonally placed at the front and rear corner) FOV 270deg.); Provides 360° visual protection.

- 3D cameras: 2 pcs 3D camera Intel RealSense™ D435 for navigation.
  Vertically up to 1800 mm at a distance of 1200 mm in front of the robot.
  Horizontally in an angle of 114° and 250 mm to the first view of ground.

- Proximity sensors 8 pcs : pointing downwards to detect low objects around the corners outside the FOV of safety scannners and 3D cameras.



2.2 System Overview:

The purpose of the navigation and guidance system is to guide the robot from one position on a map to another position. The user provides the map and chooses the goal position the robot must move to.

The main processes involved in the navigation system are:

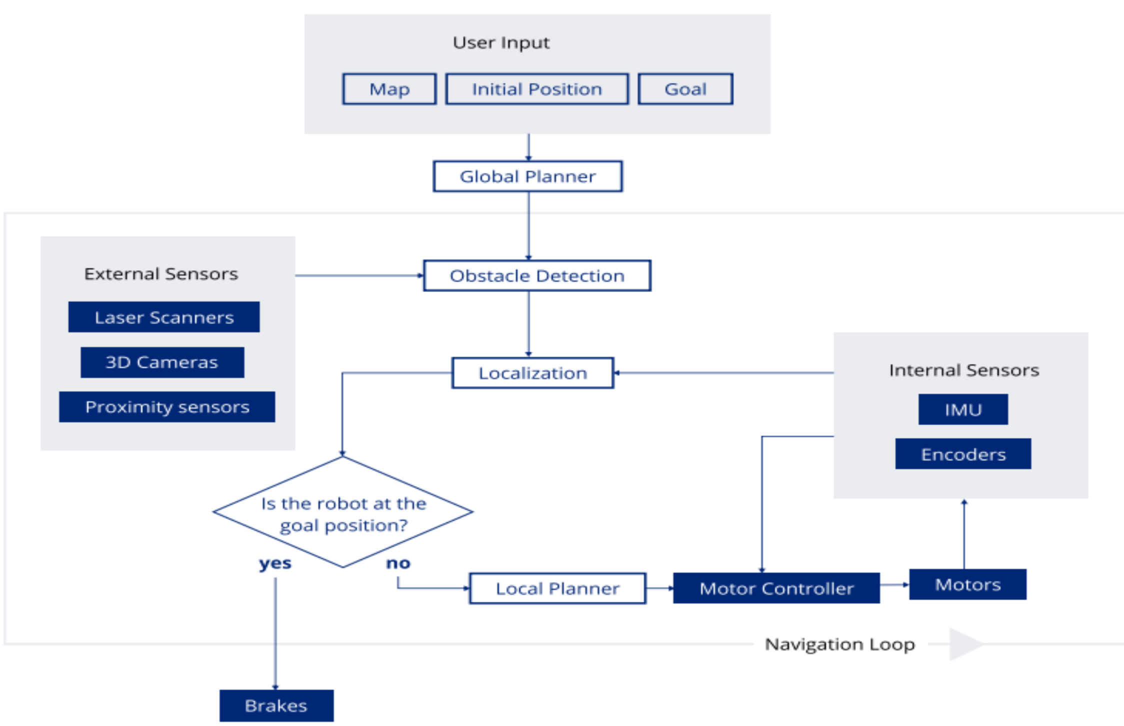
• **Global planner**: The navigation process starts with the global planner determining the best path for the robot to get from its current position to the goal position. It plans the route to avoid walls and structures on the map.

• **Local planner**: While the robot is following the path made by the global planner, the local planner continuously guides the robot around detected obstacles that are not included on the map.

• **Obstacle detection:** Safety laser scanners, 3D cameras, and proximity sensors are used to detect obstacles in the work environment. These are used to prevent the robot from colliding with obstacles.

• **Localization**: This process determines the robot's current position on the map based on input from the motor encoders, inertial measurement unit (IMU), and safety laser scanners.

• **Motor controller and motors:** The motor controller determines how much power each motor must receive to drive the robot along the intended path safely. Once the robot reaches the goal position, the brakes are engaged to stop the robot. Each part of the process is described in greater detail in the following sections.



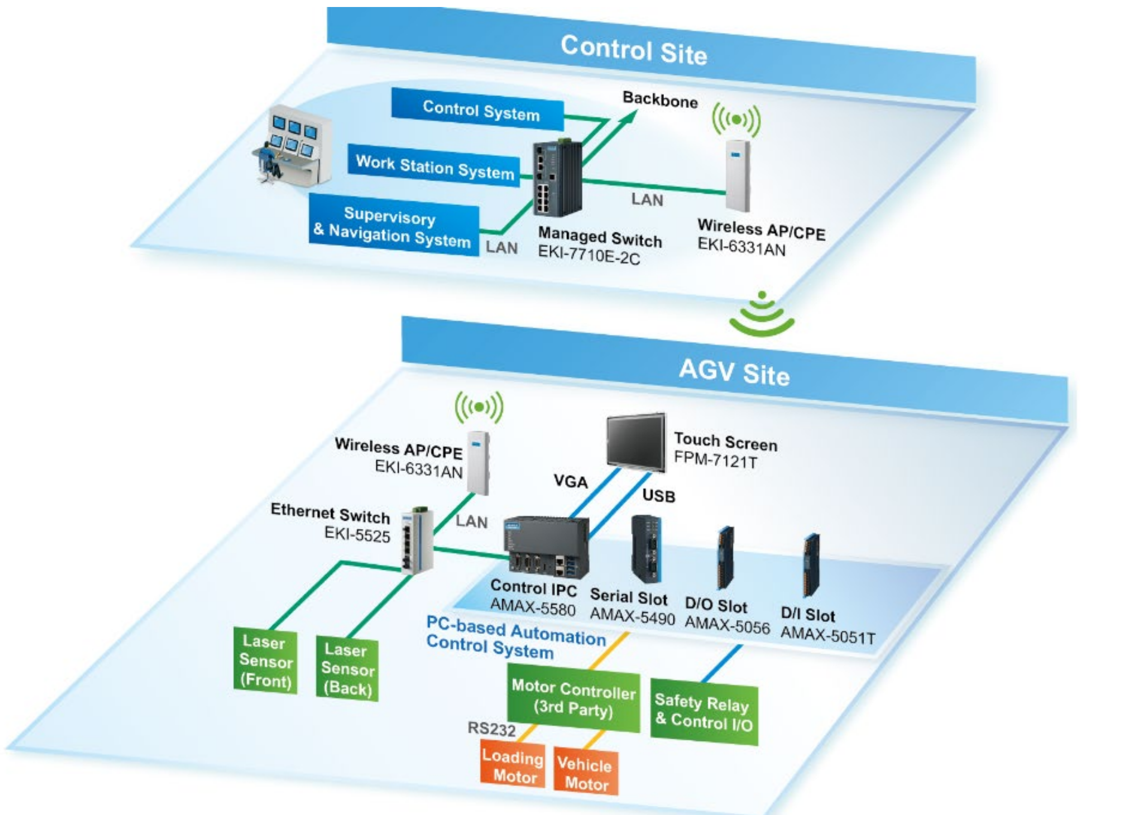
2.3 Communication architecture

A communication architecture for a warehouse mobile robot typically involves several layers of communication between the robot, other robots in the warehouse, and a central control system.
Here is an example of a communication architecture for a warehouse mobile robot:

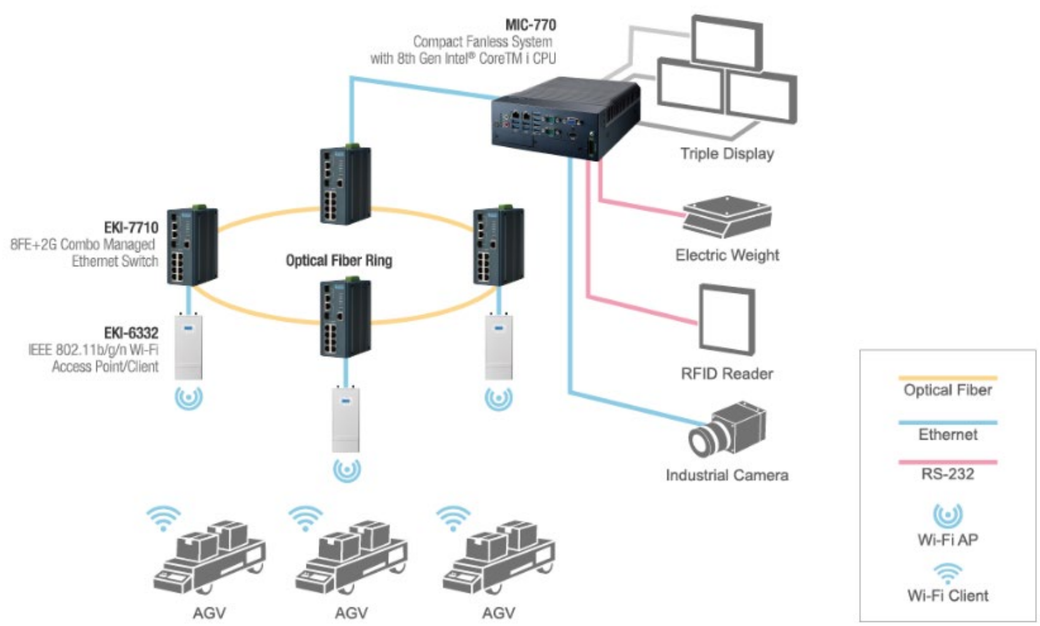
1. **Physical layer:** This layer involves the physical communication hardware that is used to transmit data between the robot and other devices in the warehouse, such as Wi-Fi or Bluetooth transceivers.
2. **Data link layer:** This layer involves the protocols and procedures used to transmit data between the robot and other devices in the warehouse. Examples of data link layer protocols include the IEEE 802.11 Wi-Fi protocol and the Bluetooth protocol.
3. **Network layer:** This layer involves the protocols and procedures used to route data between the robot and other devices in the warehouse. Examples of network layer protocols include the Internet Protocol (IP) and the Transmission Control Protocol (TCP).
4. **Application layer:** This layer involves the software applications that are used to control and monitor the robot, as well as exchange data with other devices in the warehouse. Along with communication architecture, they also provide algorithms and drivers to solve specific problems concerning robotic applications. Examples of application layer protocols include the Robot Operating System (ROS), Simple Object Access Protocol (SOAP), YARP (Yet Another Robot Platform).

Overall, the communication architecture for a warehouse mobile robot should be designed to enable efficient and reliable communication between the robot and other devices in the warehouse, while also ensuring the security and integrity of the data being transmitted.

The figure below shows the basic Communication architecture for AGV/AMRs. The AGV transmits and receives data from the centralized control system through Wireless Access points.



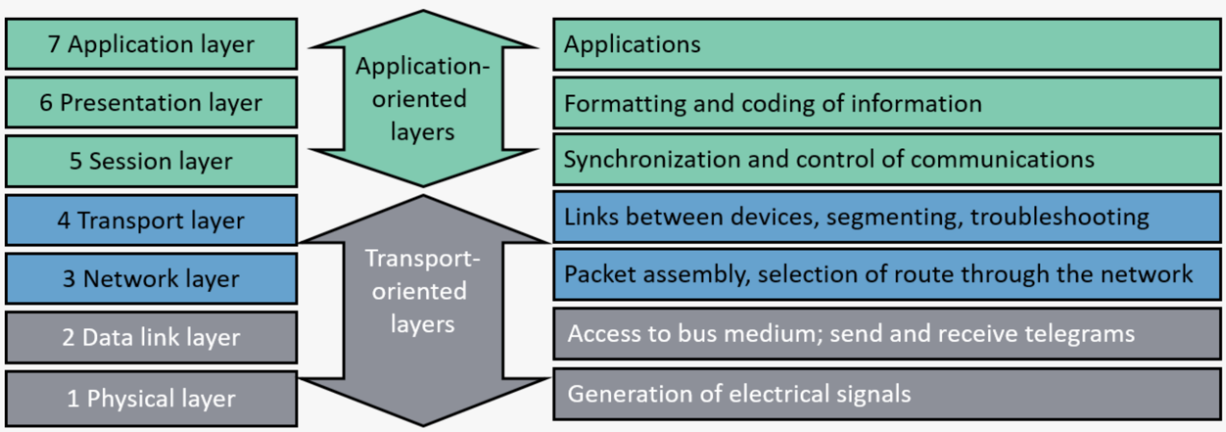
Here, the figure depicted below shows how the different access points are connected to the central CPU through switches arranged in a ring topology.



2.4 PROFINET Communication Protocol

PROFINET is an open Industrial Ethernet solution based on international standards. It is a communication protocol designed to exchange data between controllers and devices in an automation setting. PROFINET defines cyclic and acyclic communication between components, including diagnostics, functional safety, alarms, and additional information.

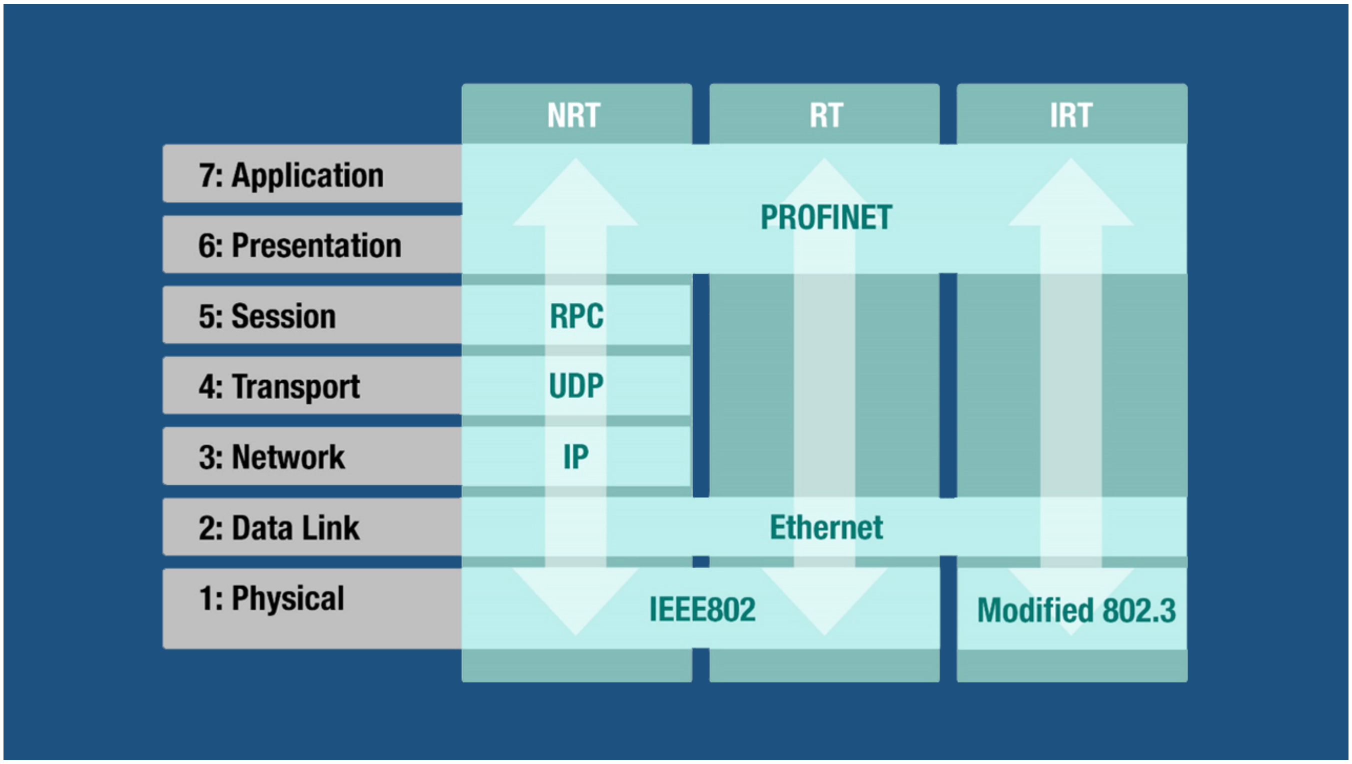
To link all of those components, PROFINET employs standard Ethernet for its communication medium. Ethernet cables connect PROFINET components within a network, allowing other Ethernet protocols to coexist within the same infrastructure.



PROFINET is a communication protocol that lives at layer seven of the ISO/OSI model, the seven-layer model that generically describes the abstraction layers of a communication system.

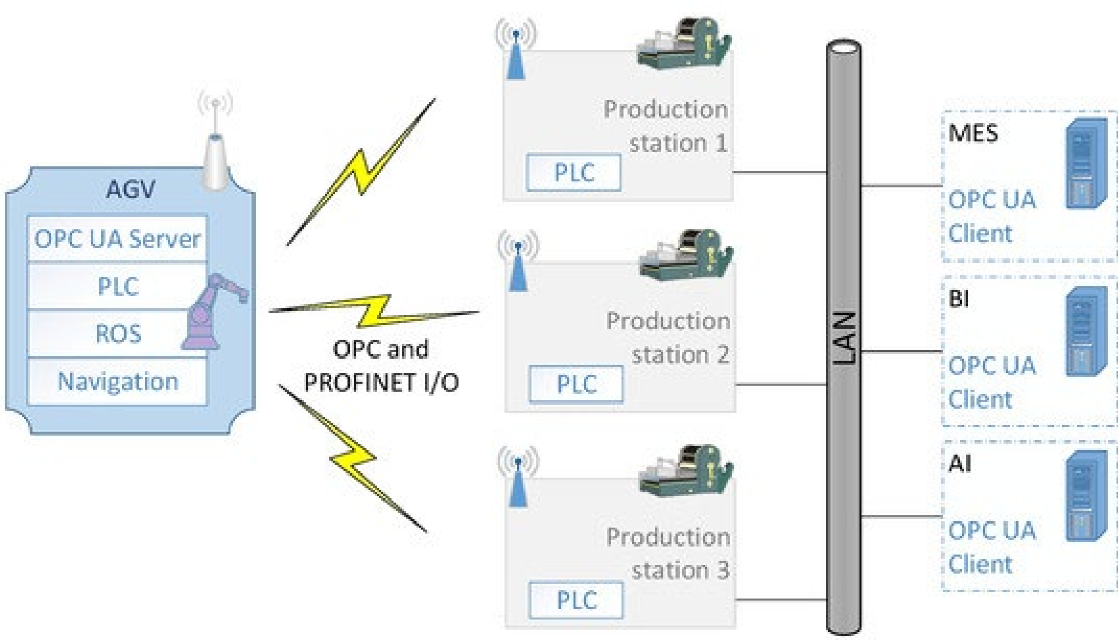
The PROFINET protocol supports three communication classes.

- Non-real time (NRT): sometimes referred to as TCP/IP communication, is acyclic traffic such as sensory, diagnostic, or maintenance data transferred at best-effort speed.
- Real-time (RT): cyclic traffic consisting of high-performance process data transmitted over standard networking infrastructure.
- Isochronous Real-time (IRT): highest performing type of deterministic traffic within the PROFINET standard.



The PROFINET RT and IRT communication classes involve a cyclic data exchange over standard Ethernet and take place directly on Layer 2 without any TCP/IP overhead to minimize latency. This means that in an RT/IRT PROFINET environment, data frames are forwarded based on the devices' MAC address.

The figure below shows how AGVs are connected to the station PLCs and the station PLCs are connected to different clients.



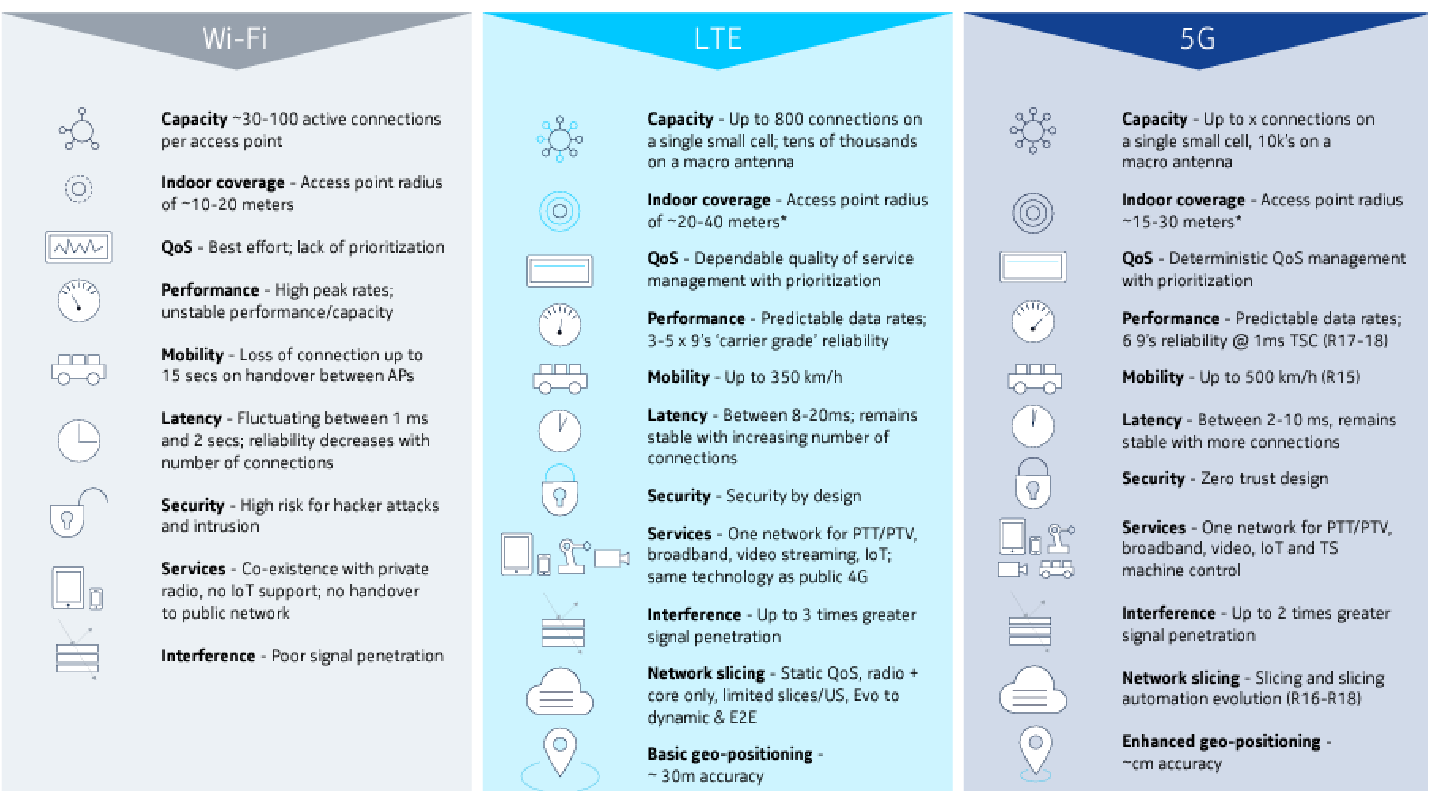
2.5 Further Developments

For higher bandwidth data applications, the principal wireless technology has been Wi-Fi, which virtually all warehouses use today for wireless scanners. Recently standardized Wi-Fi 6 provides an incremental performance improvement over Wi-Fi 5 and supports a growing range of devices with its proponents touting it as the connectivity solution for the warehouse.

Wi-Fi, for instance, only supports walking speed mobility and, so, does a poor job of supporting next-gen AGVs and mobile robots, which will often lose connectivity when moving between Wi-Fi.

In terms of latency, for instance, Wi-Fi can deliver <10 ms latencies, but we may also get 10–50 ms delays or even hundreds of milliseconds when the access point is congested, and this isn't predictable. This is because Wi-Fi is a "best-effort" protocol. So, It is hard to design warehouses and logistics operations around a communication technology that is unpredictable.

Over the last decade, industries have used LTE cellular as a more robust, single alternative to all these diverse wireless technologies. It supports all the communications needs outlined above, and it is more secure and provides more reliable coverage and greater scalability (or density per sqm). The latest version is 4.9G/LTE and the next generation, which is 5G is being finalized and can easily be added to existing networks.



*dependent on frequency selected, max output power authorized, type of radio solution used and total spectrum bandwidth

Latency is often the bigger issue with remote control. For instance, excessive latency for remote-controlled processes increases cycle times slowing down operations compared to direct manual control. 4.9G/LTE can deliver latencies of <10 ms, whereas 5G is expected to be able to achieve <1 ms.