“Open Source 5G: Transforming Robotics and IOT for the Future”

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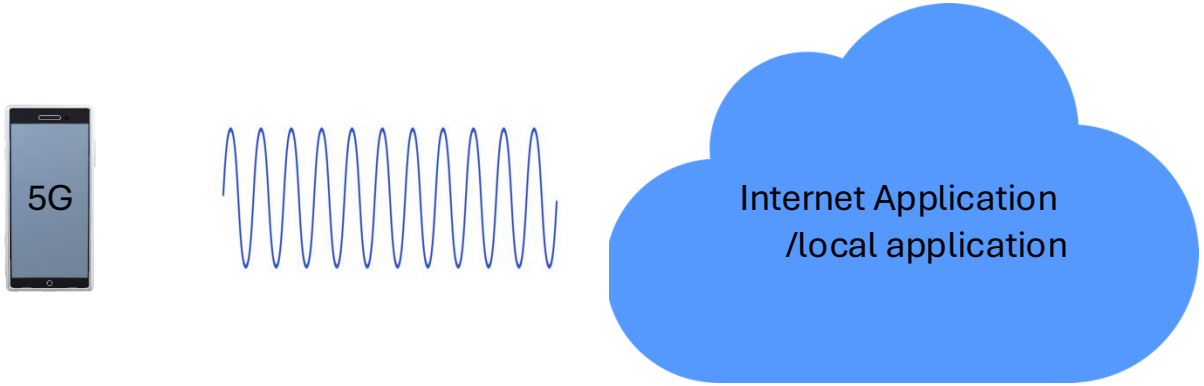
Agenda

- Overview of 5G
- Connecting dot with robotics
- 5G Broad use cases
- 5G Characteristics
- Overview of Open Source 5G (Aether)
- 5G Adoption Challenges
- 5G vs Wi-fi
- Q & A

What's 5G from User Perspective



Handset
- New Handset compatible with 5G
- Operator should support 5G

Speed
- Typical User Experienced Downlink Data Rate : 100 Mbps (targeted Peak Rate – 20Gbps)
- Typical User Experienced Uplink Data Rate : 50 Mbps (targeted Peak Rate – 10Gbps)
- User Plane latency: 1ms (varies depending on use case)
- Control Plane latency: 20 ms
- Large Connection Density
- Improved capacity, coverage, lower latency

Bands
- < 1GHz
- 3.5 to 6 GHz (Sub 6 GHz. 5G)
- 28 GHz mmWave (5G+)

Users
- 5G user can be any device having 5G modem. E.g. Dongles, sensors, Cars, Gadgets

5G Broad Usage

Enhanced Mobile Broadband (eMBB)

- High Throughput
- Low mobility
- E.g., streaming, AR/VR

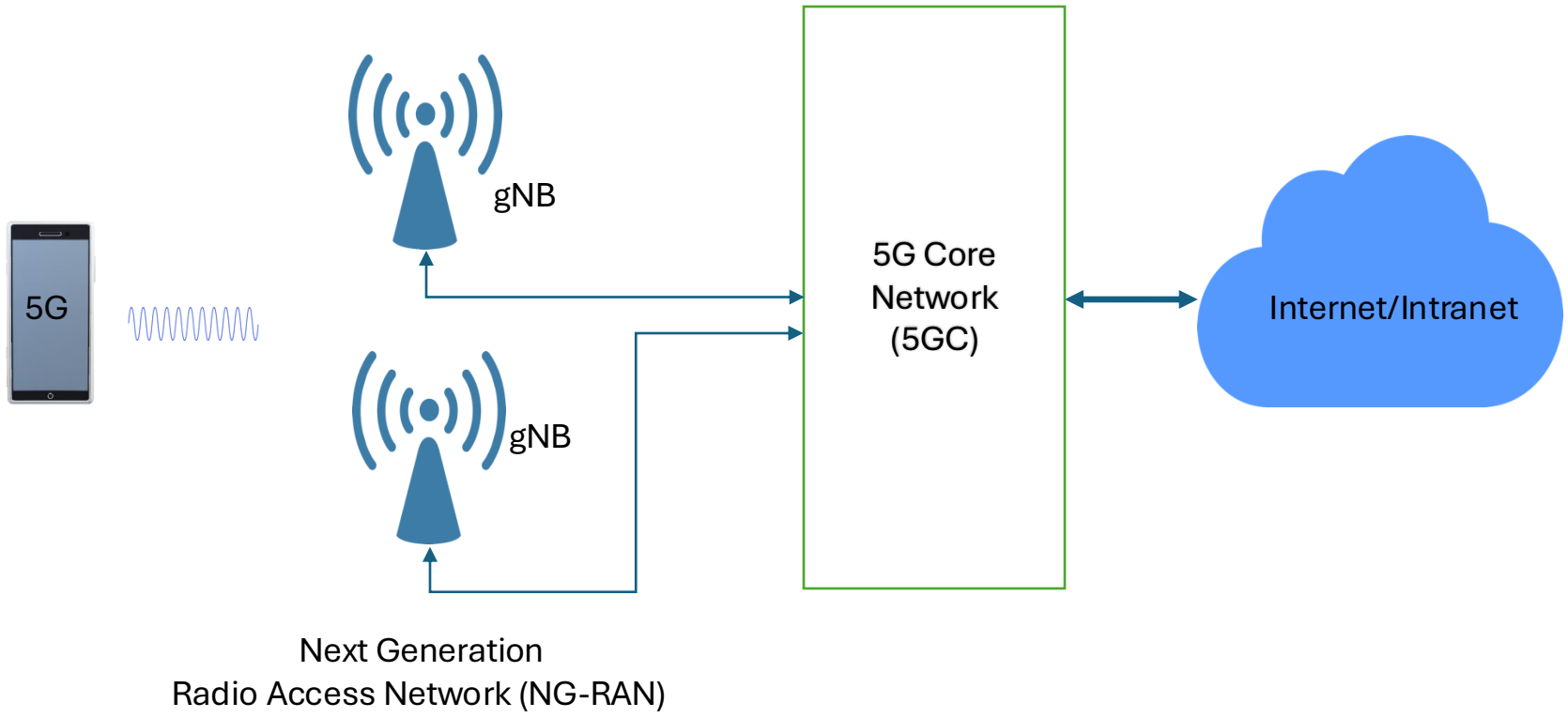
Massive Machine Type Communication (mMTC)

- Low Battery Life
- Extended Coverage
- Low Cost
- Large # of devices
- E.g., Mining/Industry Sensors, smart City

Ultra-Reliable and Low Latency Communication (URLLC)

- Extreme Reliability
- Low latency
- E.g., mission critical application, drones, connected cars

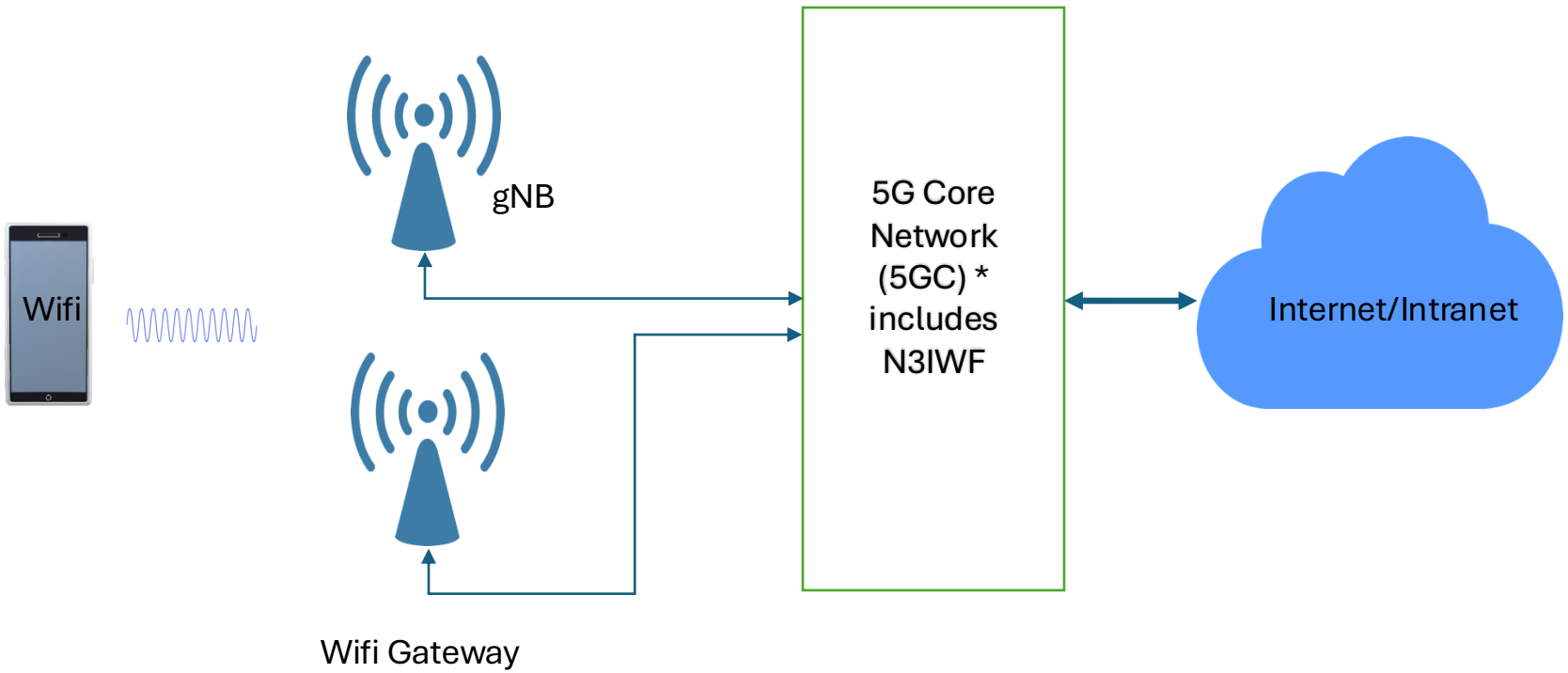
5G Network Subsystem



- Cellular network consists of two main subsystems: the *Radio Access Network (RAN)* and the *Mobile Core*
- The RAN manages the radio spectrum, making sure it is used efficiently and meets the quality-of-service requirements of every user
- All IP Network once packet received in RAN Network
- RAN, 5GC open source projects
- Private 5G un-Licensed spectrum available in many countries to run private network. In US – CBRS band

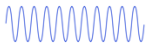
AETHER free5GC Open5GS open5Gcore OPEN AIR INTERFACE SRS RAN magma

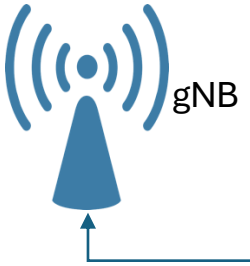
5G Network Subsystem + non3gpp Access

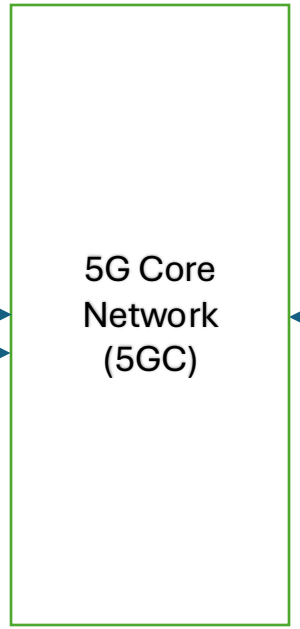


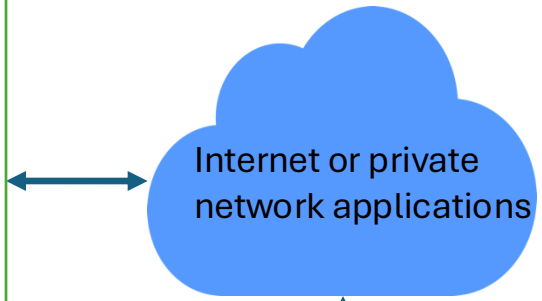
- Non-3GPP Interworking Function (N3IWF)
- Can connect Wi-fi Devices as well.
- Management of Private 5G + Ease of Wi-fi

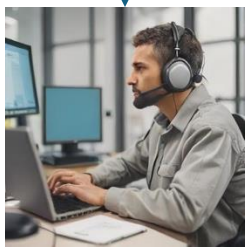
Robots using 5G Network











Next Generation
Radio Access Network (NG-RAN)

- Robot controlled by Operator
- Robot need connectivity to access applications, upload data to servers, etc.
- 5G gives - low latency, high bandwidth, massive scalability

5G Enhancing Real-Time Communication

- **Important factors**
  - **Low latency**
    - Critical for real time applications e.g. autonomous vehicles, robotic surgery
  - **High bandwidth**
    - Transmission of high amount of data quickly
    - Simultaneous video steaming or large amount of data from sensors
    - e.g multiple robots doing independent tasks
  - **Accurate positioning**
    - 5G helps in getting accurate position of the devices
  - **Collaborative operations**
    - Devices can talk to each other to do collaborative work

Enhancing Real-Time Communication Examples

- Examples in real-time robotics:
  - **Autonomous vehicles:** 5G enables self-driving cars to communicate with infrastructure, other vehicles, and pedestrians, ensuring safe and efficient operation.
  - **Teleoperated robots:** Low latency is essential for a responsive control experience, allowing the operator to feel like they are directly controlling the robot. High bandwidth is needed for transmitting high-quality video and sensor data.
  - **Industrial automation:** Low latency is crucial for precise control of robotic arms and other equipment, ensuring accurate and efficient manufacturing processes. High bandwidth is needed for data-intensive tasks like quality inspection and machine learning.

Enhancing Real-Time Communication Examples contd ...

- **Examples in real-time robotics:**
  - **Industrial robots:** 5G can improve the precision and efficiency of industrial robots by enabling real-time data exchange and control.
  - **Drone delivery:** 5G supports the reliable and efficient operation of drones for package delivery and other applications.
- **In summary**
  - low latency and high bandwidth are essential for real-time robotics, enabling timely data transmission, accurate control, and efficient operation.
  - 5G technology provides the necessary infrastructure for autonomous operation, precise control in robotic systems, enabling a wide range of applications across various industries.

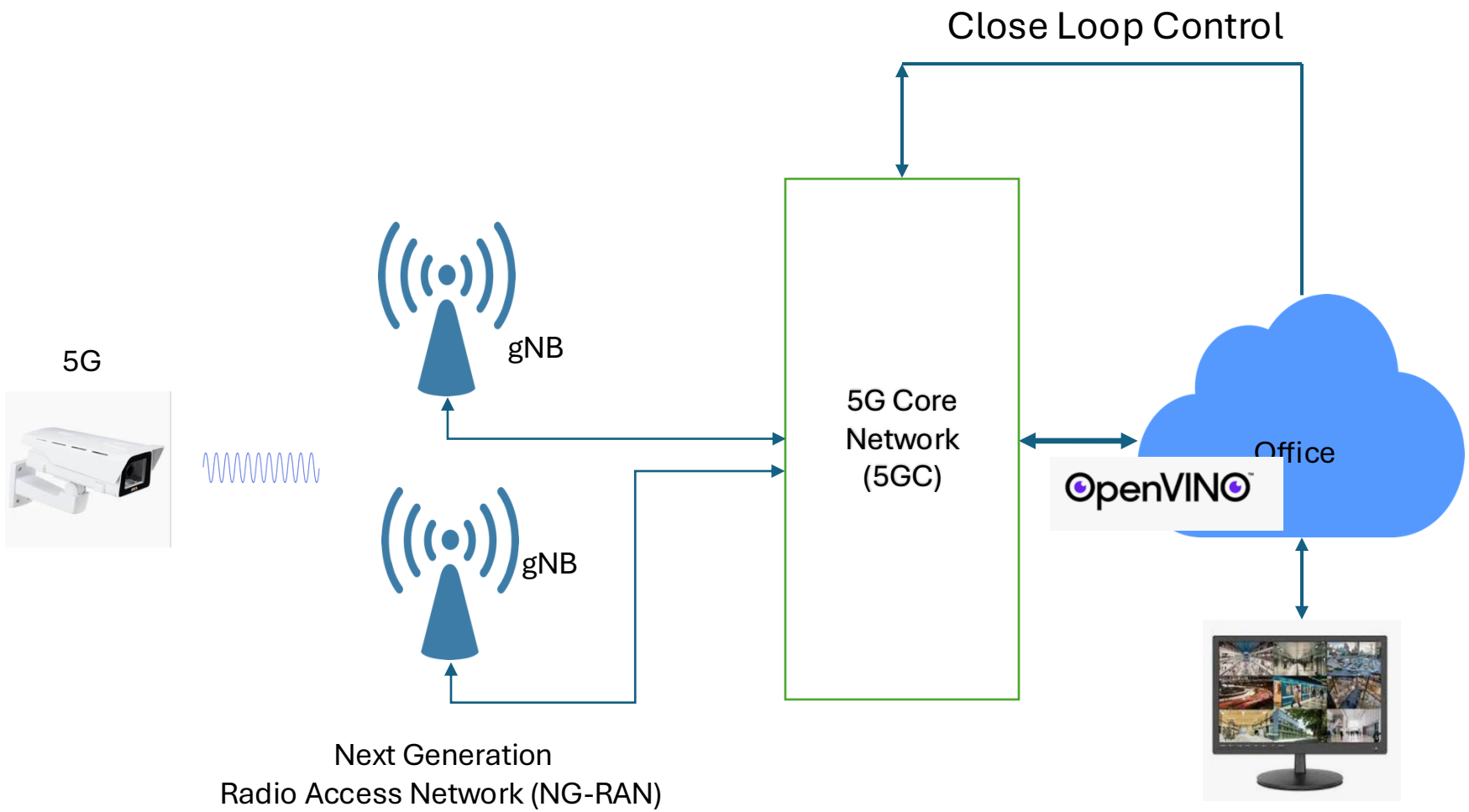
5G in IoT: Massive Device Connectivity

- **Massive device connectivity**
- **Examples of 5G-enabled IoT applications:**
  - Smart cities
  - Industrial IoT
  - Connected agriculture
  - Autonomous vehicles

Overview of Open-Source 5G

- You can operate you own network on unlicensed band (CBRS band in USA)
- Many open-source options available – RAN, Mobile CORE, SIM card writer
- **Aether** Private 5G solution started by Open Networking Foundation (now part of Linux Foundation)
- Started as 3 year $30 million project funded by DARPA and now actively maintained by community
  - Primary partners in the project – Stanford, Princeton, Cornell University
  - Later many universities joined the project as contributor & project user e.g. Purdue Univesity
  - Other research Organizations using Aether for their research e.g. IOS-MCN, CPQD
  - Canonical (Ubuntu publisher) has made Aether available through charm-sd-core.
- Open-source benefits: flexibility, cost-effectiveness, and opportunity for innovation
- Sample Applications
  - Person detection Application
  - Rouge user removal

5G Network Subsystem – Network Exposure Function

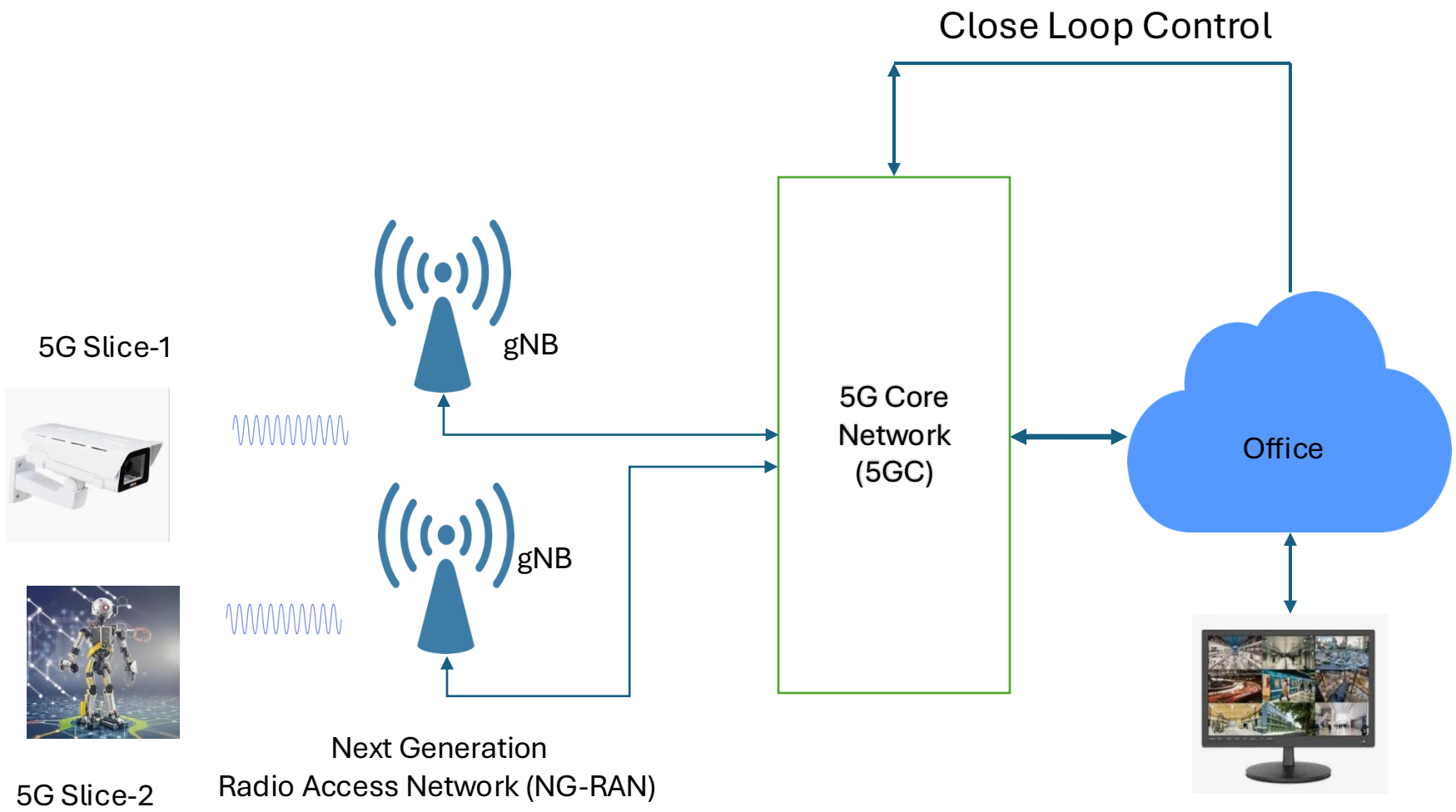


- Person detection Application
- Computer vision solved using Intel OpenVINO

- Rouge User Removal
- Security algorithm to detect bad subscriber

- **Opportunity to Innovate**

5G Network Subsystem – Network Slice



- Different Network for each slice
- APIs to create Slice
- Different Bandwidth assignment per slice
- **Application Isolation** - Security measure per Slice
- Devices can talk to each other
- Example - smart factories where robots and IoT devices work in tandem

Open-Source 5G Platforms: Aether

- Join hands if you are
  - Interested in learning 5G
  - Motivated to contribute to Open Source 5G Core
  - Motivated to carry out research on 5G network
  - Motivated to learn Cloud Native System Designs
- Web - https://aetherproject.org
- Github - https://github.com/omec-project

5G Adoption – Challenges & Consideration

- **Cost:** The deployment of 5G infrastructure can be expensive
- **Interoperability:** Ensuring compatibility between different 5G devices and networks is important for the widespread adoption of IoT applications.
- **5G Network Operation** needs specialized skills
- Despite these challenges, 5G is poised to transform the IoT landscape by **enabling new and innovative applications** that were previously impractical or impossible.

Is Wi-fi Still Used in Robotics and IoT?

- **Factors to consider**
  - Speed
  - Range
  - Use cases
  - Dual Connection
  - Quality of Service
  - Deployment Scale
- **Note - Users can select Wi-fi or 5G/6G depending on their use case.**

Wrap-Up

- Sweet spot
  - Industry automation + 5G + IoT + Robotics + AI/ML
  - Open Source + Private 5G
- There are opportunities for innovation
  - New applications can be written per use case

Thank you !
Any Questions?