Leveraging 5G Networks & EtherNet/IP: Unleashing the Power of TSN, Clustered Networks, and Deterministic Connectivity for Sensor-to-Cloud Architecture

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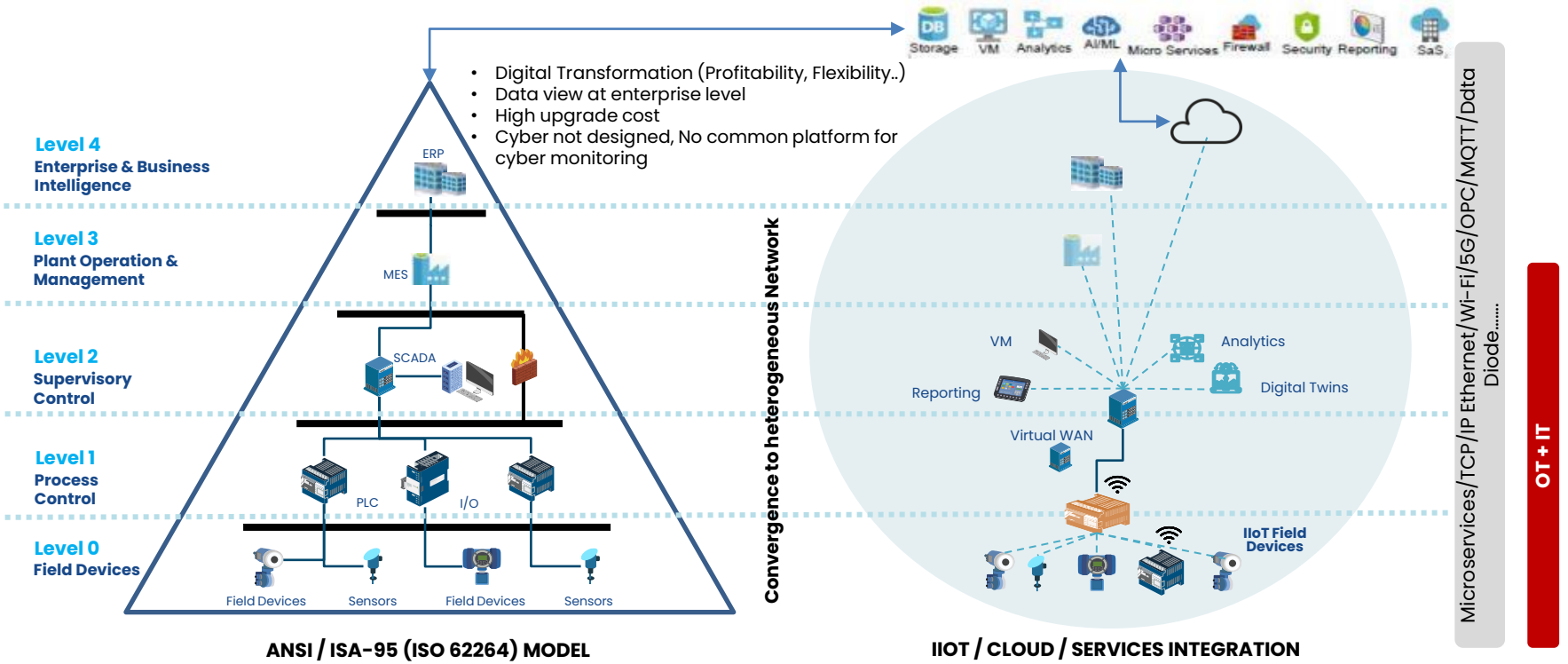
Outline

- **Smart Manufacturing & OT-IT Convergence**
- **5G in Smart Manufacturing**
- **5G & Relevance of ISA-95 Purdue Model**
- **Typical Network Architecture for EtherNet/IP + Private 5G**
- **Integrating EtherNet/IP with 5G**
    - OSI Layer Breakdown
    - Blended Architecture
- **MVP for 5G Testing**
- **Reference Design**
    - Hardware Architecture
    - Functional Architecture
- **EtherNet/IP with Private 5G – Use Cases & Applications**
- **Conclusion**

Smart Manufacturing & OT-IT Convergence



5G in Smart Manufacturing

The 5G specifications defined by 3GPP include the following elements that make it the next big thing for intelligent factories:

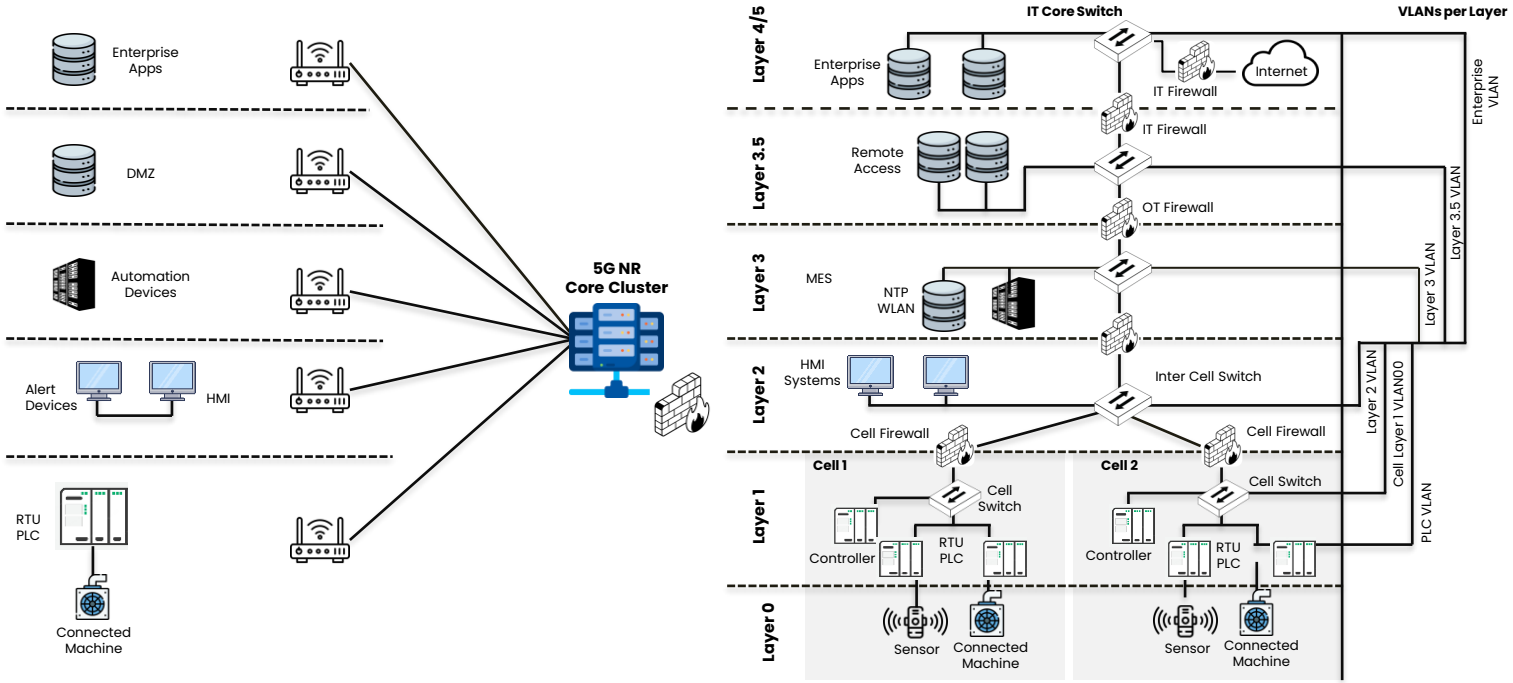
1. **QoS (Quality of Service)**: 3GPP has defined four parameters for 5G based on the types of traffic,
   - Periodic Deterministic Traffic: Stringent requirements are defined.
   - Aperiodic Deterministic Traffic: No pre-set sending time, but stringent requirements in terms of timeliness and availability are defined.
   - Non-Deterministic Traffic: Specifying lesser stringent requirements.
   - Mixed Traffic: Minimum stringent requirements.

2. **End-to-End Latency**: As less as 0.5 milli second that goes up to 500 milli seconds
3. **Data Rate**: Up to Gbits/second
4. **Communication Service Availability**: 99.9% to 99.999999%
5. **Seamless integration** with wired technologies on the same machines

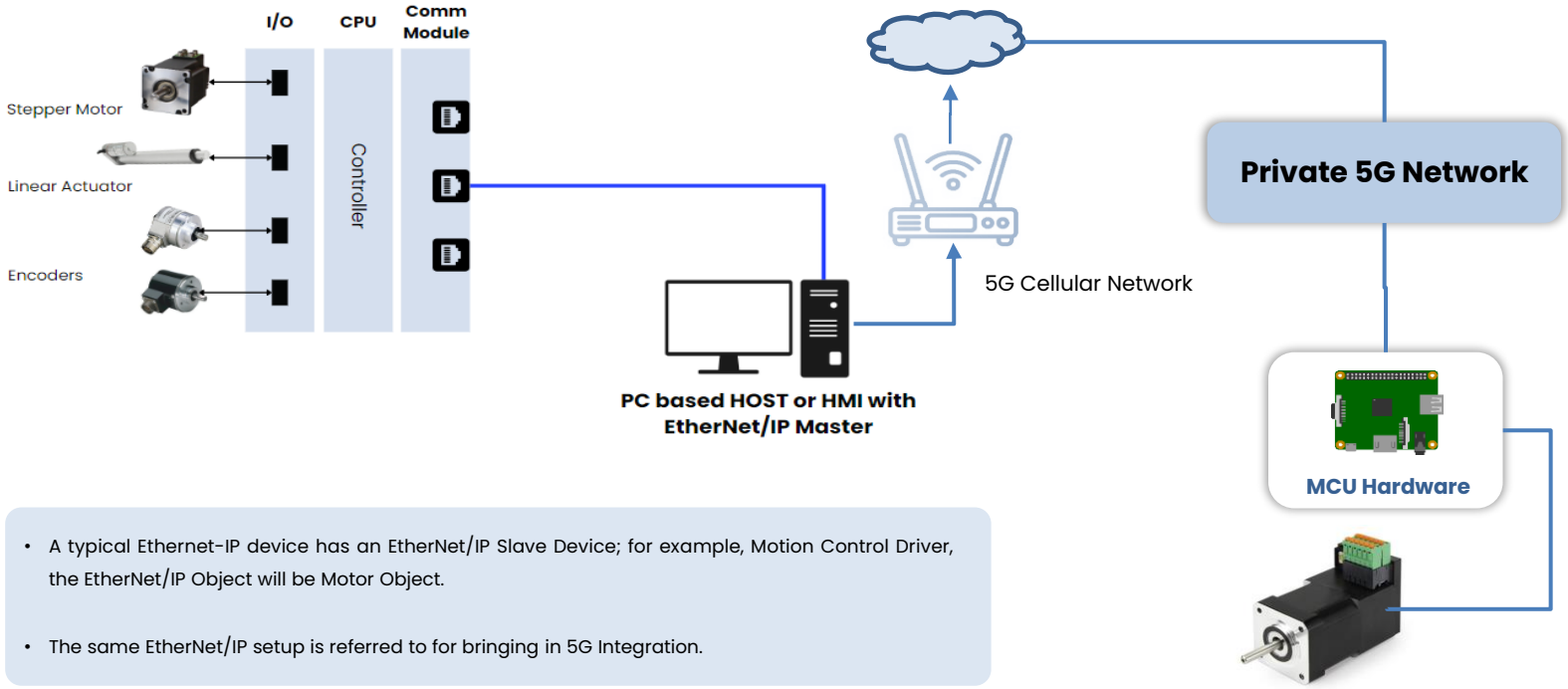
High-band or millimeter wave (mmWave) 5G

High speed but short range. High band 5G frequencies range from 24 GHz to 100 GHz, making it incredibly fast - enabling multi-gigabit per second speeds. But these high frequencies cause trouble going through buildings and walls, making it useful only for short distances.

5G & Relevance of Purdue Model

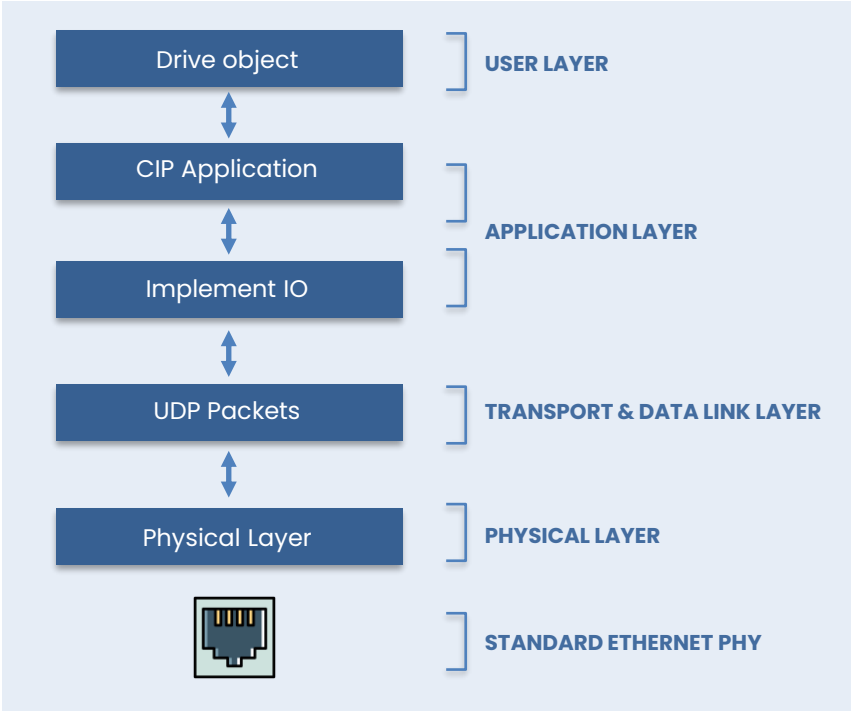


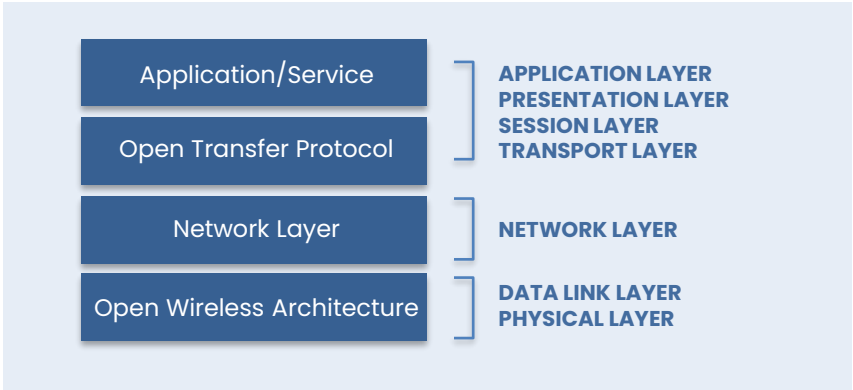
Typical Network Architecture for EtherNet/IP + Private 5G



- A typical Ethernet-IP device has an EtherNet/IP Slave Device; for example, Motion Control Driver, the EtherNet/IP Object will be Motor Object.
- The same EtherNet/IP setup is referred to for bringing in 5G Integration.

OSI Layer Breakdown – Integrating EtherNet/IP with 5G





Blended Architecture – Integrating EtherNet/IP with 5G

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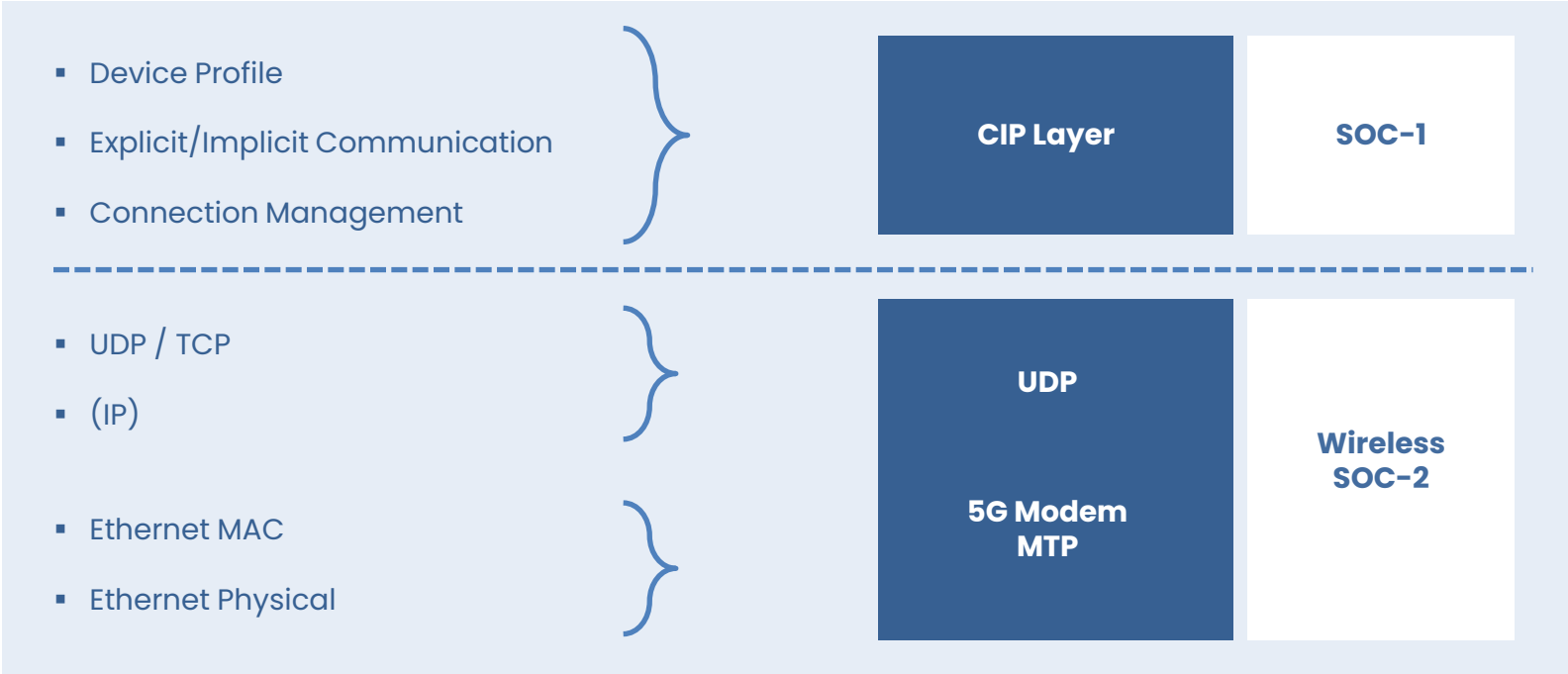
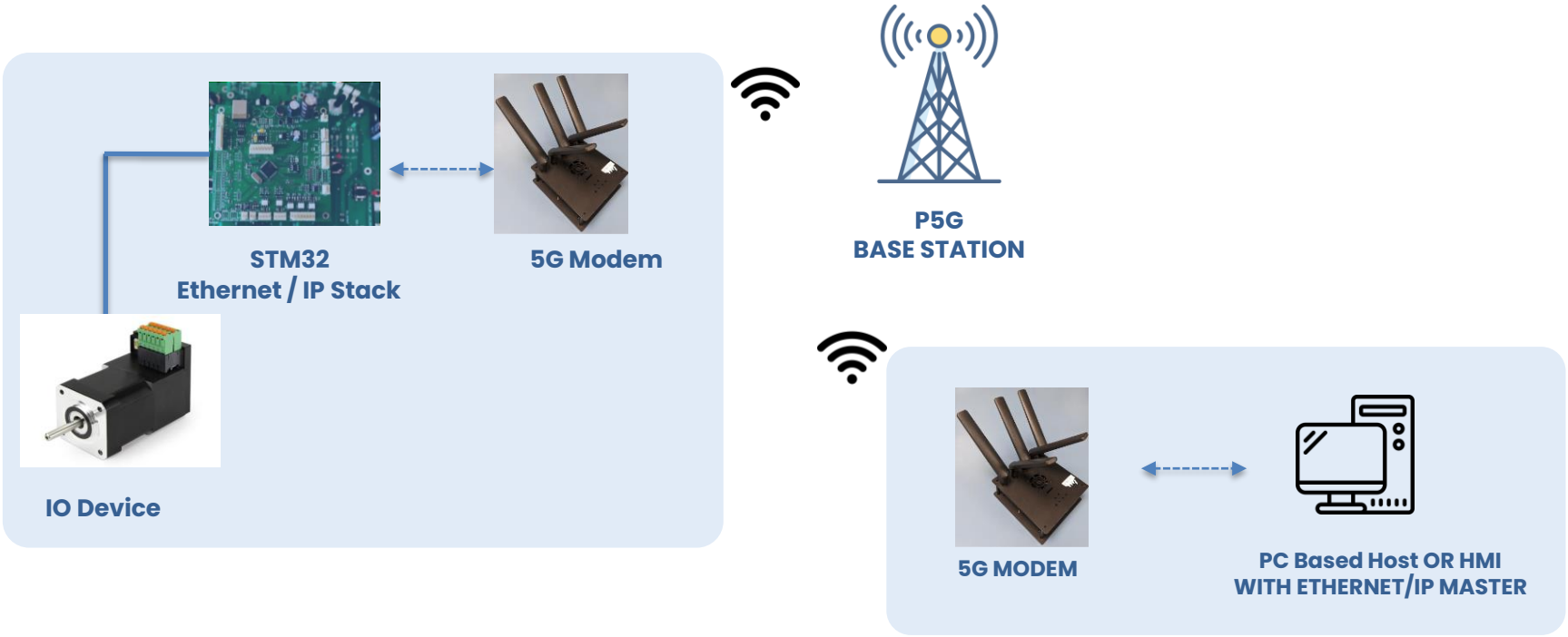
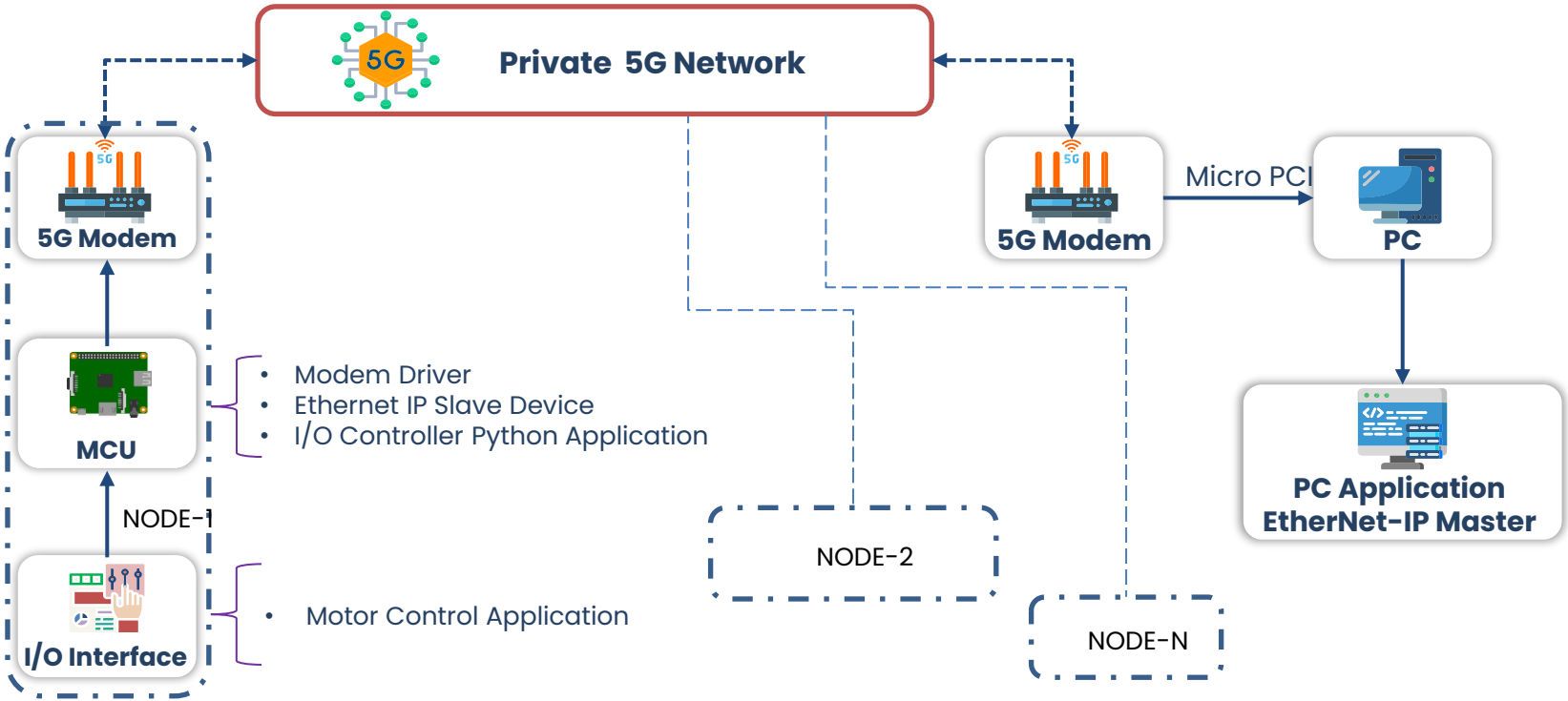


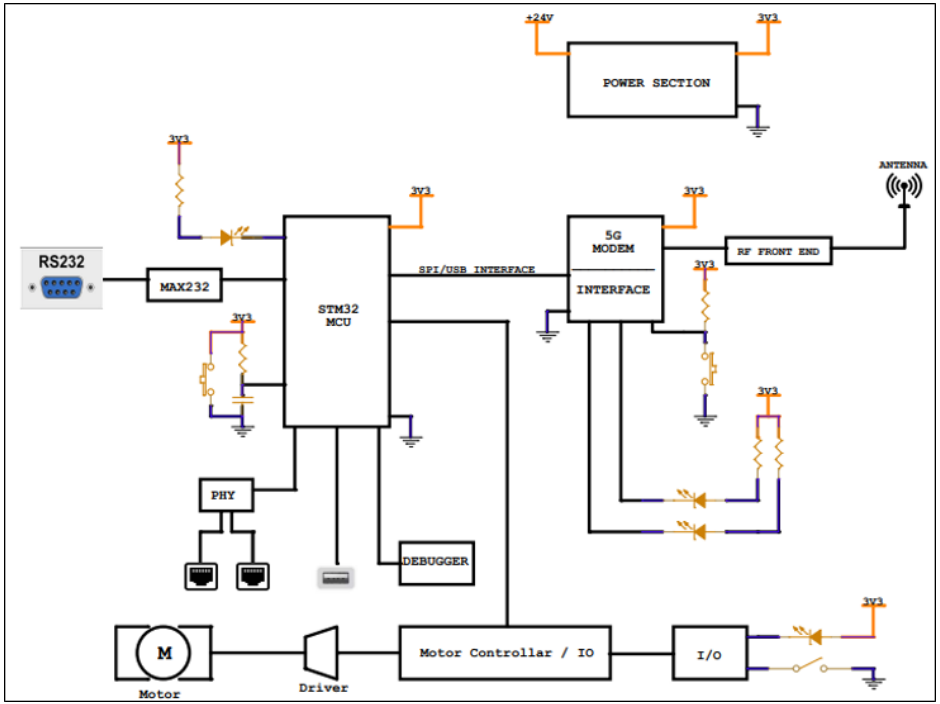
Blended Architecture – Integrating EtherNet/IP with 5G



MVP for 5G Testing



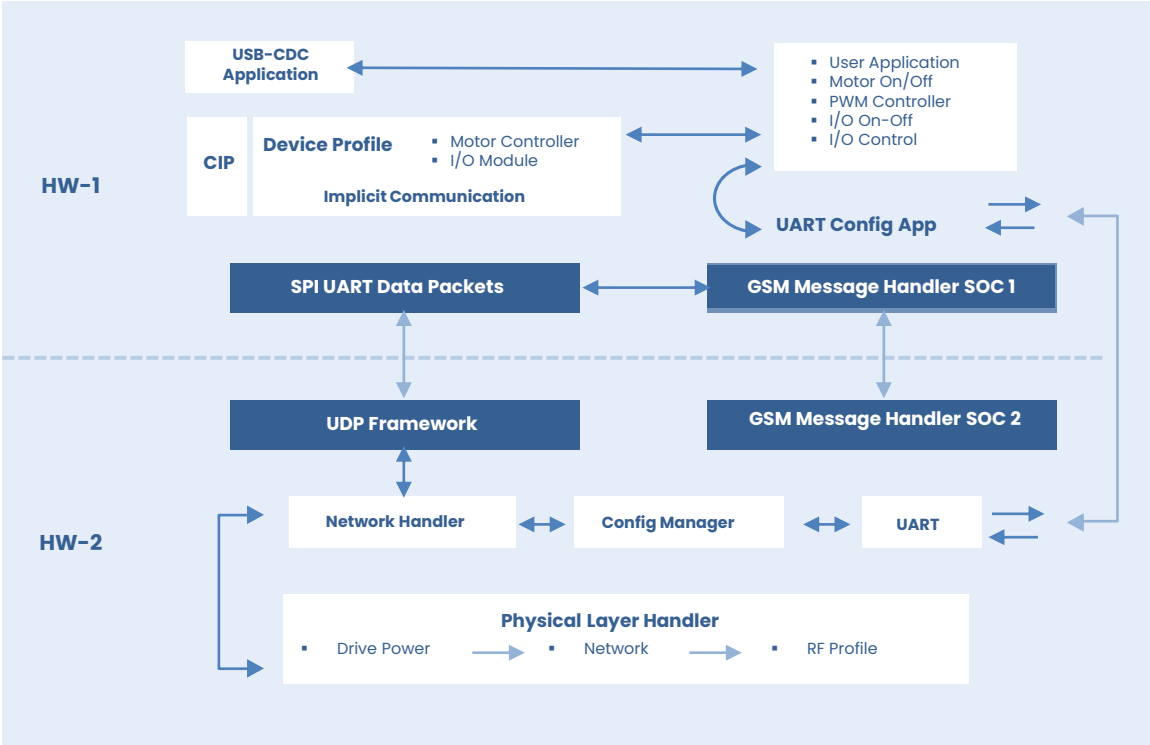
Reference Design – Hardware Architecture



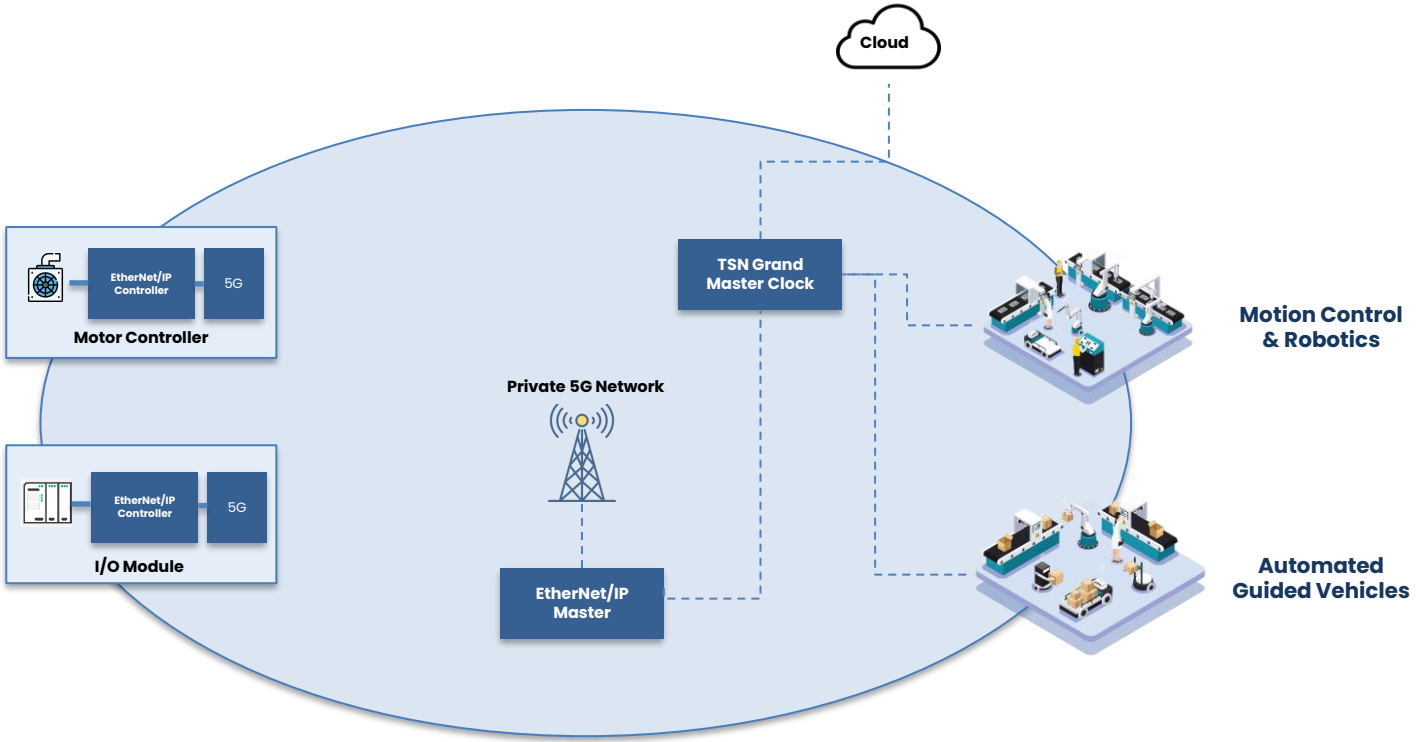
Reference Design – Functional Architecture

The above architecture describes the high-level software/firmware architecture of a 5G-based Ethernet/IP Device, which can control a DC motor's speed and handle some of the I/O functions.

- Encapsulation for EtherNet/IP to work with 5G.
- This architecture describes the message handling between the two SoCs.
- The two SoC hardware are interconnected over an SPI bus to have a maximum 10mbps connection.
- Inter-chip connection over serial (UART) interface with a USB-CDC connection device class was used to configure the SoCs.



EtherNet/IP with Private 5G – Use Cases & Applications



Conclusion

- The amalgamation of 5G networks with EtherNet/IP represents a pivotal advancement in industrial automation, further bolstered by the potential of Time-Sensitive Networking (TSN).
- This synergy promises ultra-responsive, deterministic, and broad bandwidth communication platforms uniquely suited to the multifaceted requirements of modern industrial ecosystems.
- Drawing upon collaborative insights from leaders like Rockwell Automation, Ericsson, Qualcomm, and Verizon, this integration crafts a foundational pathway for organizations aiming to exploit the full spectrum of real-time data communication.
- The outlined hardware and software architectures not only facilitate streamlined MVP developments but also position industries at the vanguard of a burgeoning digital evolution.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