

TCS Uses 5G RedCap in Industrial Meter Reading Solution

Consulting firm designs a 5G RedCap IoT network with deep learning models running on Intel® Core™ i9 processor-based servers and optimized with OpenVINO™ toolkit to process both image and sensor data



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The industrial metering market is rapidly evolving as organizations seek more efficient, data-driven methods to monitor environmental conditions and consumption of energy, water, and gas.

Meter reading has been reliant on manual inspection or basic automated meter reading (AMR) systems. But in many organizations, these systems are being replaced by IoT networks that are capable of real-time data collection, diagnostics, and remote management.

There are many wireless technologies put forth as solutions for IoT-based meter reading. These technologies need the right combination of data throughput, signal transmission range and power consumption, which impacts the life of sensor batteries. Network reliability and power efficiency are constant concerns, especially in remote or harsh industrial environments. Data security and lifecycle management, ranging from provisioning to operation to decommissioning, add further complexity.

This is where 5G RedCap (Reduced Capability) technology is emerging as a transformative enabler for next-generation industrial meter reading. Tata Consultancy Service (TCS), an Intel® Industry Solutions Builders Partner, put together an IoT demonstration system to show how a 5G RedCap network can facilitate use cases involving sensor data and image data.

Defining 5G RedCap

5G RedCap is a streamlined variant of 5G designed to bridge the gap between low-power IoT technologies and full-featured 5G connectivity. Introduced in the 3GPP Release 17 standard, 5G RedCap targets IoT applications that do not require the ultra-high speeds or massive throughput of enhanced mobile broadband (eMBB) but still need the reliability, low latency, and longevity of 5G infrastructure.

5G RedCap offers reduced cost, lower power consumption, and improved battery life for devices that support time-sensitive applications such as remote diagnostics, condition monitoring, and real-time metering, without the cost and power requirements of full 5G modules.

For industrial IoT (IIoT) environments, 5G RedCap offers a standardized cellular service that is energy-efficient, easy to deploy, and that provides infrastructure integration with private 5G networks. For use cases like industrial meter reading, 5G RedCap enables continuous, secure data transmission from thousands of devices while maintaining low operational costs and efficient energy usage.

How 5G RedCap is Used for Industrial Meter Reading

To show how 5G RedCap is used in an industrial IoT application, TCS worked with Intel to develop an IoT system that enables two use cases leveraging an end-to-end 5G RedCap network on Intel® platforms optimized with OpenVINO™ toolkit.

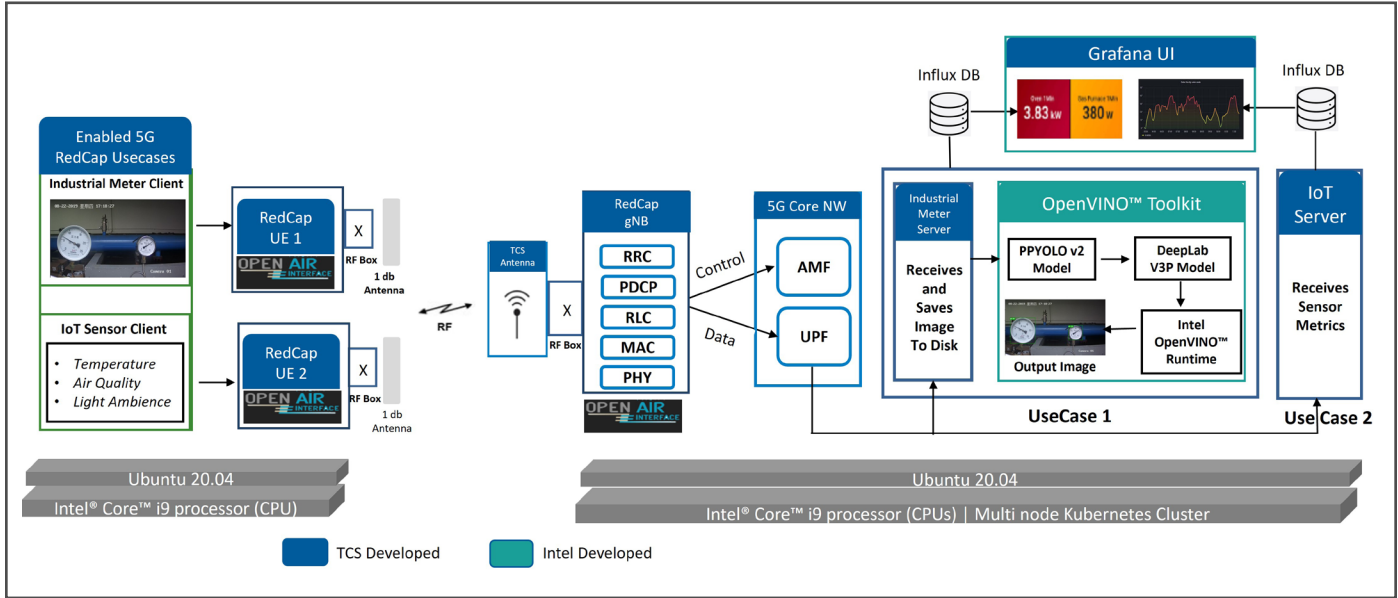


Figure 1. Two meter reading use cases that use TCS's 5G RedCap network. Image data is processed by deep learning models enhanced with OpenVINO™ toolkit for optimized inference.

The demonstration system (see Figure 1) showcases the full potential of 5G RedCap with high end processors from Intel for better utilization of network resources and capabilities and to address the requirements of power-centric applications which take intelligent decisions by deploying 5G RedCap technology and provide improved user experience with performance optimization.

Leveraging open-source Open Air Interface (OAI) 5G software, TCS developed cloud-native containerized next-generation radio access network (NGRAN) with virtualized 5G core and 5G user equipment with RedCap adaptation compliant to 3GPP Release 17. The RedCap gNB is connected to a 5G core network, which provides control plane and user plane functionality along with additional network services.

The 5G RedCap UE has reduced capabilities of 20 MHz bandwidth, using QPSK DL modulation order, PDCP and RLC sequence number size of 12 bits and reduced power consumption when compared to a standard 5G UE. A RedCap UE, with its reduced capabilities, acts like a low powered IoT device when combined with an IoT use case and sends the IoT data through the 5G network to the IoT server applications for processing.

The 5G RAN configuration of the demonstration setup includes the following:

- Band: n78 (license acquired), 3.3 GHz to 3.7 GHz (FR1)
- Mode: TDD
- Bandwidth: 20 MHz
- Modulation Scheme: QPSK

The above RAN stack is running on an Intel® Core™ i9 processor.

Figure 1 shows the end-to-end smart meter solution leveraging the TCS 5G RedCap solution with two RedCap UEs connected wirelessly.

The control plane data, sent by gNB, is processed by the access and mobility management function (AMF) of the 5G core network, which provides UE registration, authentication, connection management, and mobility across the network.

The data plane packets sent by the gNB are processed by the user plane function (UPF) of the 5G core network, which provides data plane services including routing and forwarding user data, managing quality of service (QoS), enforcing policies, gathering statistics, and serving as the anchor point for protocol data unit (PDU) sessions by interconnecting the UE to external data networks.

The smart meter solution (use case 1) involves an “industrial meter client” application running on the first RedCap UE device, which is an IoT device that captures the images of industrial meters in a factory environment at regular intervals.

The RedCap UE device transfers the captured images to the 5G network where the UPF of the 5G core network forwards it to the “industrial meter server” application. This application gives the images as input to the industrial meter reader application to detect the meters and calculate the readings from the images using deep learning models optimized with OpenVINO toolkit.

These values are further stored in the database and displayed on a Grafana UI where graphs are plotted for the readings and alerts are created based on threshold values.

Figure 1 also shows a second use case running with the end-to-end 5G RedCap Solution. Use case 2 involves an “IoT sensor client” application running on the second RedCap UE device that is considered an IoT sensor device that collects the temperature, air quality and light ambience of a room.

Both use case 1 and use case 2 used separate RedCap 5G devices for test design purposes, but in a real-world application, they could both be implemented on the same RedCap UE device.

The RedCap UE device transfers the IoT sensor data to the 5G network where the 5G core UPF forwards the data to the IoT server application which stores the data in database and forwards it to the Grafana UI where the IoT stats are displayed in graphs for monitoring and alerts creation.

Extracting Images With Deep Learning Models

The use case 1 image data must be further processed to extract the meter information from the image. The received packets are transferred to an open source industrial meter reader application that TCS has integrated into this solution. This application is optimized with the OpenVINO toolkit, which streamlines the deep learning inference that takes place in this phase of the process.

This application uses a multi-step process to accurately identify the meter reading values. The Notebook application in the OpenVINO toolkit downloads and loads the two-deep learning models - PP-YOLOv2 and DeepLabV3P.

The process starts with a PP-YOLOv2 (PaddlePaddle You Only Look Once) model, a deep learning model that is used for meter detection from the image. It is used to find analog meters in the image. To detect the meters, the model prepares the input tensor (resized image + any model specific preprocessing), executes synchronous inference, and decodes the detector's outputs (boxes, scores, classes). The Notebook then filters detections (e.g., by confidence), and for each detected meter crops the region of interest (ROI) from the original image.

The ROI's information is then passed along to the DeepLabV3P, a deep neural network (DNN) architecture that segments the sensor information into a pointer mask and a scale mask which are post-processed to estimate the pointer angle/position relative to the scale which is a 3D-to-2D conversion process of the reading scale to plot the values accurately.

The result is that the sensor data is extracted from the image and is displayed on the Grafana UI giving the technician monitoring the data a comprehensive picture of legacy and IoT-enabled meters.

TCS set up a test version of this network with both the 5G RedCap network and the OpenVINO toolkit accelerated inference for data processing running on Intel Core i9 processor-based servers. The tests confirmed the functionality and integration of the solution and use case 1 demonstrated a throughput of one image per second².

Intel® Core™ i9 Processors

TCS developed the 5G RAN and core system with 5G RedCap capability on servers using the Intel Core i9 processor family which is the highest performance device in the Intel® Core™ processor product family. Intel Core processors power AI and compute-intensive use cases at the edge – with tailored performance, high-performing graphics capabilities, flexible LGA designs, and long-life availability and support.

The devices feature up to 16 Efficiency cores (E-core) and eight Performance cores (P-core) with a clock speed up to 5.6 GHz. The device family is engineered with cache sizes up to 36MB making it ideal for servers that need to support multiple high-demand applications simultaneously without slowdowns.

Intel Core i9 processors provide the computational power and advanced instruction sets needed to run deep learning models like PP YOLOv2 for object detection and DeepLabV3 for semantic segmentation efficiently. With high core count, advanced threading capabilities, and support for Intel® technologies like Advanced Vector Extensions 512 (AVX-512), Intel Core i9 processors enable efficient execution of TCS' end-to-end 5G solution as well as running OpenVINO deep learning models efficiently.

²Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.



Conclusion

5G RedCap offers unique capabilities for IoT use cases like industrial metering applications. It combines low power consumption, wide data transmission rate range and flexibility along with the reliability and standardization benefits of being a part of the 5G standards body.

Recognizing these benefits, TCS engineered an IoT system that collects both sensor data and image data – showing the adjustable throughput of a 5G RedCap network with low latency. This network transports the data to an OpenVINO toolkit optimized meter reading application that uses deep learning to extract meter readings from images of the sensor face. The entire application runs on Intel Core i9 processor-based servers for optimal output. The solution demonstrates how the emerging 5G RedCap solution is used to support an IoT network with multiple use cases.

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