CASE STUDY

VCAC-A
Internet of Things
Intelligent Manufacturing

Driving Edge-Cloud Collaboration and Intelligent Transformation of the Manufacturing Industry by Strengthening Edge Computing Power

China Mobile IoT establishes the OneNET Edge Computing Platform and explores Intelligent Manufacturing with the Intel® Visual Cloud Accelerator Card

中国移动 China Mobile

"As an important part of China Mobile's 'Big Connectivity' strategy, China Mobile IoT is leveraging the advantages that network transformation brings to the edge to build the OneNET edge computing platform to provide technological support for the intelligent transformation of traditional industries. The MEC server with VCAC-A provides users with high computing power and efficient visual inference capabilities on the edge side. The machine vision based, industrial quality inspection solutions we have created based on the OneNET edge computing platform also support and assist the digital and intelligent transformation of manufacturing industries."

Yuan Liu
Deputy General Manager
and Senior Technical Director
Open Platform Department
China Mobile Internet of Things Co., Ltd.

The rapid development of communication and network technologies is injecting new impetus into the innovation and evolution of the Internet of Things. This creates more opportunities for the digitalization and intelligent transformation of traditional industries such as manufacturing. As an important carrier of China Mobile's IoT business and services, China Mobile Internet of Things Co., Ltd. (China Mobile IoT), guided by the company's "Big Connectivity" strategy, is integrating Edge Computing, Cloud Computing, Artificial Intelligence (AI), 5G and other cutting-edge technologies to build and improve the OneNET edge computing platform, accelerating intelligent innovation in manufacturing industries.

The main advantages of the OneNET edge computing platform are derived from its positioning as serving the "Edge". It provides users with a comprehensive IoT architecture in the form of "cloud-edge collaboration". To equip this platform with more efficient and flexible edge computing capabilities, China Mobile IoT, together with Intel, has introduced Mobile Edge Computing (MEC) servers with the Intel® Visual Cloud Accelerator Card – Analytics (VCAC-A). This enables both high computing power and strong deep learning inference capabilities for machine vision on the edge side.

Currently, solutions based on the OneNET edge computing platform have been successfully deployed in many industries including machinery manufacturing and textiles. As an example, its application to an automatic gas meter inspection management system has improved the accuracy and level of automation (LoA) of the inspection, saved labor costs and achieved greater productivity and efficiency, winning front-line users' recognition and acclaim.

Benefits of the China Mobile IoT solution:

- The OneNET edge computing platform enables data synchronization between the edge and the cloud and provides more data samples for offline big data analysis and AI training in the cloud. Meanwhile, the cloud can also transfer the upgraded AI models and algorithms down to the edge, ensuring that users continue to get more efficient and accurate inference capabilities;
- The efficient cloud-edge collaboration, visual processing and AI inference capabilities of the new solution help users improve LoA of gas meter inspection. The previous three data collectors' work can now be done by one, and a collector dedicated to collect devices' default information before their delivery is no longer needed, saving labor costs and reducing the total cost of ownership (TCO);
- With the accelerated computing performance by VCAC-A, the new solution enables efficient AI Inference like Optical Character Recognition (OCR) and dial reading when it is applied to gas meter inspection, with inspection accuracy of up to 99.5%[1]. This significantly reduces the missing of defective products while improving the efficiency of quality inspection.

Edge computing platform supporting cloud-edge collaboration

As an essential element or cornerstone of intelligent manufacturing, the development of information and network technology helps enterprises innovate their production line operations, production management and business decisions. For example, the development and integration of Internet of Things, cloud computing, AI and 5G technology help enterprises to enable more intelligent production line operations, more efficient production process and more informed business decisions.

The massive data and calculation processing required poses a challenge to the enterprises' IT workforce and their IT facilities' operation and maintenance. The traditional centralized cloud computing architectural model fails to meet the requirements for massive data processing that comes with the digital transformation of enterprises, while the current inadequate information base of traditional manufacturing enterprises also limits their ability to implement intelligent transformation.

To help address these challenges, China Mobile IoT is leveraging the benefits that network transformation brings to the edge to transfer some of the cloud capabilities down to the edge, creating and improving cloud-edge collaboration solutions with the OneNET edge computing platform as their core. The architecture of this platform is shown in Figure 1. The platform helps users obtain a series of complex capabilities such as AI model training, big data analysis and function compute in the cloud through service collaboration, intelligent collaboration and other methods, without DevOps on their own, and provides plentiful training analysis data samples for the cloud whilst significantly reducing the time for algorithm upgrades via data collaboration at the edge. It also takes advantage of data collection and equipment control capabilities as well as high computing power and inference capabilities deployed at the edge, to implement data aggregation, application execution, AI inference and security surveillance on production lines and equipment. This reduces the network pressure arising from data transmission and increases the agility and security of the system.

Based on the OneNET edge computing platform with the above functions and focusing on the practical challenges and demands in the process of intelligent transformation of various industries, China Mobile IoT has proposed a series of industry solutions, including automatic inspection solutions for meters used by gas equipment manufacturers for the purpose of intelligent manufacturing.

New gas meter inspection solutions based on OneNET

Gas equipment manufacturers used to manually record readings of meters before delivery, count the number of distinct types of devices and test the accuracy of meters. This method inherently has the disadvantages of high meter reading error rate and low efficiency. Automated inspection solutions based on machine vision are an effective way to address this but, due to the substantial number of meter manufacturers as well as different models from any one manufacturer, there are many differences in data displays. Standard machine vision solutions find it a challenge to work with these diverse and differentiated situations. Every time a manufacturer adds a new product line or simply changes the design of dials, the standard visual algorithm needs to be re-developed, wasting time and resources while increasing costs.

The new cloud-edge collaboration solution based on the OneNET edge computing platform proposed by China Mobile IoT has brought a simplified solution to these issues. It leverages the powerful AI model training and big data analysis capabilities in the cloud to provide enterprises with real-time updating and optimization of their inspection models, reducing the cost and pressure on IT facilities' operations and maintenance. It can utilize the powerful edge computing capabilities to help enterprises efficiently and flexibly build new inspection solutions in their production lines based on machine vision and deep learning.

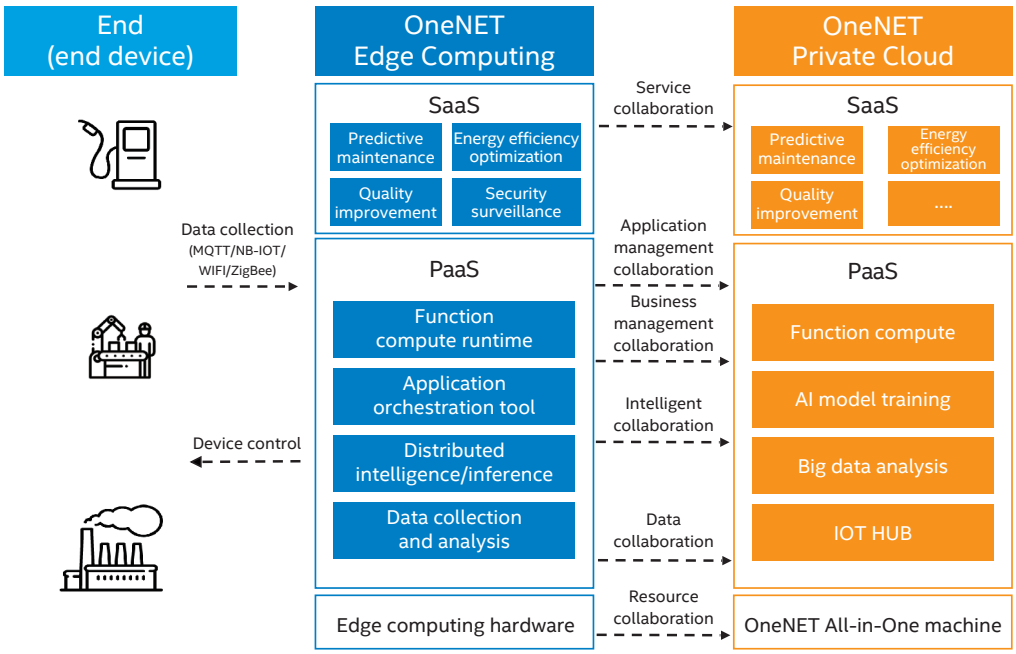

Figure 1. Overall architecture of the OneNET edge computing platform

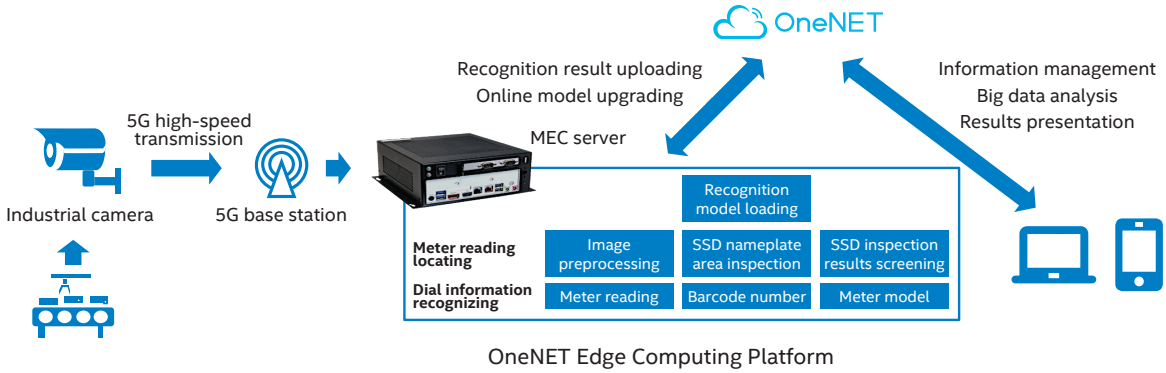

Figure 2. Gas meter inspection process based on the OneNET edge computing platform

As shown in Figure 2, in the new gas meter inspection solution based on the OneNET edge computing platform, high-definition industrial cameras installed on the gas meter production line perform real-time video capture of the products that are passing the production line and transmit this data at high speed through a high-bandwidth, low-latency 5G network to the OneNET edge computing platform on the edge side. After the MEC server deployed on the platform loads the preset recognition model, it takes two steps: locating the meter reading and recognizing the information on a dial.

Due to different models, orientations and intervals of the meters on the production lines and different angles of images the cameras capture from videos, the system needs to locate the meter areas first. In the new solution, a deep learning-based object detection algorithm is used to locate the meter reading area. To enhance its versatility and availability, the solution incorporates an SSD (Single Shot MultiBox Detector) 300 object detection model[2], which features inspection accuracy comparable to Faster R-CNN and enhanced inspection speed through accelerated computing performance by the new VCAC-A, meeting the demanding real-time inspection requirements of industrial production lines.

After locating the meter areas, the system utilizes different machine vision methods to automatically recognize three types of information, i.e., dial readings, the user's barcode and the meter model. For big differences in fonts and colors of dial readings, the solution applies a classification and recognition model based on deep learning. This model is more robust in terms of lighting and gradient, meaning that the quality of images taken from videos is not so critical and with shorter time for on-site fine debugging, the applicability of the solution improves. In the recognition of users' barcodes, the solution uses the edge response principle to implement barcode locating, meanwhile it corrects the barcode with the recognition module based on the strong gradient of the barcode in the x direction and then quickly decodes it.

Gas meter symbols are usually composed of letters, numbers and special symbols. To achieve rapid recognition and screening of the symbols, the solution utilizes a deep learning-based CRNN (Convolutional Recurrent Neural Network) model[3] to build an efficient OCR module. Compared with other deep learning models, the unique "convolutional layer - circulation layer - transcription layer" network architecture design of the CRNN model makes it better suited to text recognition.

After the information on a dial is recognized, the OneNET edge computing platform uploads the results to the OneNET cloud platform in real time. With its computing power and training and analysis capabilities in the cloud, it makes use of many data samples to further train and optimize the model. The updated model will be returned to the edge for online upgrading, so that the inspection efficiency and accuracy of the system are continuously improved through this cloud-edge collaboration and continuous iteration.

Intel VCAC-A providing acceleration of computing power

When creating intelligent solutions for various manufacturing production lines, China Mobile IoT is also seeking high-performance infrastructure for the OneNET edge computing platform so that the platform provides high computing power and efficient visual inference capabilities. In fact, the VCAC-A in the MEC server is right the key component that China Mobile IoT and Intel have jointly deployed on the platform for its visual inference capabilities.

It is a fact that much video decoding, scaling and analysis work needs to be performed in a machine vision based intelligent manufacturing solution. Traditionally, these tasks are performed by the processor. With the continuing improvement of video quality, especially the application of industrial cameras with higher than 1080p definition, the computing power required for the workloads increases many times over. If these tasks are executed by the processor, it will inevitably affect the overall performance of the system.

VCAC-A was first used in the MEC server of the OneNET edge computing platform under this background. Based on a single Intel® Core™ processor and 12 Movidius™ Myriad™ X vision processing units, it provides high-density video processing capabilities. When used with the dual-socket Intel® Xeon® Gold 6140 processor in the MEC server, it can support up to 24 channels of 1080p/30fps video decoding, scaling and analysis as well as other video processing needs in the solution. It also means that more processor resources are released, improving the overall efficiency of the system.

Another unique feature of VCAC-A is its excellent visual inference ability. As previously mentioned, intelligent manufacturing solutions based on deep learning are inseparable from a large amount of AI inference. The SSD300 model used in the gas meter inspection solution, for example, needs to prepare various sizes of "Default Boxes" in advance before the system quickly executes the "Single Shot" step in these boxes. The richer the default boxes, the higher the locating hit rate. In this solution, up to 8,732 default boxes need to be built, which is a huge challenge to the inference performance of the system.

Although the processor could be used to complete inference operations, this will affect the overall performance of the system;

alternatively, data could be sent back to the cloud through the network for processing, but this will consume valuable network bandwidth, potentially affecting real-time performance and security. The nimbler solution is to implement efficient inference operations by on-premises deployment of VCAC-A. The built-in SHAVE 128-bit VLIW floating-point vector processor in VCAC-A can provide high-speed, low-power AI inference capabilities. This shortens the inference process and allows the system to complete the inspection tasks at the edge, enabling one-stop processing of the original lengthy work chain on the MEC server.

This new solution has been successfully deployed in a gas meter automatic inspection management system. Feedback from the production line shows that the adoption of the new solution has driven the transformation of production and inspection processes towards automation and informationization and that employee productivity has been significantly improved. Especially in the meter accuracy test session, three data collectors have been reduced to one and a collector dedicated to collect devices' default information before their delivery is no longer needed, thus saving labor costs and reducing the total cost of ownership (TCO); moreover, the machine vision algorithm based on deep learning is not limited by the design of dials and can be applied to test the operation of different models of meters with over 99.5% of online recognition accuracy[4]. This achieves the goal of having one set of equipment for all the production lines, bringing efficiency and benefits to front-line manufacturing enterprises.

Conclusion

With the maturity of the China Mobile IoT's OneNET edge computing platform solution, more opportunities have been recognized for its use in steel, textile, machinery and other manufacturing industries.

For example, in a textile production line, this solution can perform real-time detection of textile defects. Flaws such as incorrect stitching and holes that are difficult to detect with the naked eye when the textile machinery is running at high speed can be detected. Operations including automatic start and stop of the production line and fabric quality calibration can be enabled with the integration of the cloud-edge collaboration architecture into the textile production management system. Equally, its deployment for a large servo press manufacturer helps the enterprise successfully implement intelligent analysis of motor vibration in equipment and predictive maintenance on the edge side, reducing unplanned downtime of the enterprise by 15% every year.[5]

China Mobile IoT plans to cooperate more closely with Intel in the future to apply more cutting-edge technological advancements in network and information to the construction of IoT and intelligent manufacturing solutions, as well as take practical action to drive digital and intelligent transformation of manufacturing industries.

Celestica VCAC-A accelerator card

Celestica VCAC-A (Visual Cloud Accelerator Card for Analytics) is a visual cloud accelerator card for media analysis with standard PCI-E interfaces. It integrates a low-power Intel® Core™ i3 processor (integrated Intel® HD Graphics 620) and 12 Movidius™ Myriad™ X vision processing units (VPUs) and has two small outline dual in-line memory modules (SODIMMs) that support up to 8GB of DDR4 memory. This accelerator card can provide more efficient and economical visual cloud solutions for edge applications such as artificial intelligence inference, media creation and analysis that are developing at high speed.

Technical specifications
1 x Intel® Core™ i3 processor • Dual core • 2.40 GHz (clock speed) • 3MB cache • 15 W TDP • Intel® HD Graphics 620
2 x 4GB DDR4 SODIMM memory, total 8 GB
12 x Intel® Movidius ™ Myriad ™ X MA2485 vision processing unit (VPU) • 700 MHz operating frequency • 16 x SHAVE 128-bit VLIW floating-point vector processor • 2 x LEON4 32-bit RISC processors • 4 Gbit LP DDR4 package memory
PCIe Gen 3 x 4 host interface
Power consumption & cooling
75 watts (maximum power)
Passive cooling

Physical dimensions
Height: 126 mm overall height
Width: 254 mm at ¾ length
Single slot width
Operating environment
Operating temperature: 0 °C to 55 °C @ 15CFM
Non-operating temperature: -20 °C to 70 °C
Humidity: Relative humidity 8% to 85%
Operating altitude: 3,050 m
Accreditation
Electromagnetic compatibility: Class A, CISPR 22, FCC, CE
Safety: CB Scheme, UL, cUL, CE

Note: All information and data provided in this article are subject to change at any time without notice

[1, 4] Test results are based on an MEC server with the following configurations: Intel® Wolf Pass R2208WFTZS server; processor: 2-socket Intel® Xeon® Gold 6140 processor; memory: 12 × 16 GB; storage: 2 × 800 GB SDD, 1 × Celestica VCAC-A accelerator card. For more details, please contact China Mobile Internet of Things Co., Ltd.
[2] For details of the SSD object detection model framework, see Liu W, Anguelov D, Erhan D, et al. SSD: Single Shot MultiBox Detector [J]. 2016.
[3] For details of CRNN model framework, see Shi B, Bai X, Yao C. An End-to-End Trainable Neural Network for Image-based Sequence Recognition and Its Application to Scene Text Recognition[J]. IEEE Transactions on Pattern Analysis & Machine Intelligence, 2015, 39(11):2298-2304.
[5] The test results are cited from the internal tests of China Mobile Internet of Things Co., Ltd. For more details, please contact China Mobile IoT Co., Ltd.