Case Study

Edge Computing
IoT
Intel® Optane™ SSD

Breaking the Bottleneck of Data Processing and Creating a More Agile and Intelligent Edge Computing Platform

With Intel® Optane™ solid state drives, China Mobile IoT improves the performance of its OneNET Intelligent Edge Suite (OES) and accelerates the adoption of the intelligent edge computing platform.

中国移动 China Mobile

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Introduction

The advent of commercial 5G has accelerated rapid development of the Internet of Things (IoT) technology and turned the "Internet of Everything" from vision to reality, making it a crucial driving force for digital and intelligent transformation in numerous industries. At the same time, enterprise users have higher requirements for the size, quality, speed, and availability in data transmission, which poses challenges to traditional cloud architecture. To cope with these, there is an urgent need for an innovative big data processing approach whose core is an edge computing model.

As a major carrier of IoT businesses and services at China Mobile, China Mobile Internet of Things Co. Ltd. (China Mobile IoT) provides innovative solutions to intelligent IoT for manufacturing, energy, power, and environmental protection by integrating advanced technologies such as 5G, edge computing, cloud computing, and artificial intelligence (AI), building OneNET Intelligent Edge Suite (OES) and introducing high-performance products like Intel® Optane™ solid state drives (SSDs) to enhance its ability in massive data processing.

Echoing 5G application trends, this case study explores the China Mobile IoT's OES, which is based on high-performance hardware products such as Intel Optane SSDs. It describes the features of OES such as the open architecture, low latency, and high security as well as the cloud-edge collaboration and how they help accelerate the innovation of edge computing infrastructures. It also shares the OES' usage in manufacturing and other scenarios, demonstrating the key role that Intel's innovative technologies and products play in the acceleration of commercial 5G applications as well as the commercial adoption of edge computing.

China Mobile IoT's OES Offers Numerous Benefits

By introducing high-performance storage products such as Intel Optane SSDs, China Mobile IoT's OES delivers low-latency, high-security data access, storage and processing. It can efficiently handle complex requirements in enterprise IoT scenarios with multiple clouds, heterogeneous structures and massive data, and offers numerous benefits:

Open architecture	OES is compatible with a variety of hardware and software platforms including Intel® architecture-based devices. It can be deployed easily on hardware devices from embedded devices to Mobile Edge Computing (MEC) nodes to data center servers, and support access to over 200 types of end devices and protocols, such as Open Platform Communications (OPC) and Modbus.
Intelligence at the edge	OES collects and analyzes the data, such as operating status and alarm information from IoT devices at the edge, enabling these devices to make independent decisions and respond quickly to various events without using cloud services.
Low latency and high security	With Intel® Optane™ SSDs featuring low latency and high throughput, OES can collect and analyze device data at high speed and provide service response much faster than in the cloud, meeting the needs of industries in real-time business, application intelligence, security, etc.
Cloud-Edge collaboration	By collaborating with OneNET cloud services, OES delivers unified "cloud-edge-end" control, enabling a large amount of IoT device data to be synchronized from the edge to the cloud, and the AI algorithm model trained in the cloud to be pushed to the edge for efficient inference.

Emergence of Edge Computing

The adoption of commercial 5G and IoT has driven an increasing number of traditional manufacturing enterprises to accelerate their digital transformation, as well as their movement towards intelligent production and management. For example, more intelligent quality tracing and integrated management of production, supply, sales, and finance are achieved through real-time sharing, calling, and analysis of image and video surveillance and production data from the factory floor and production lines. Traditional industrial parks, ports, and terminals are enabled to build a more responsive and cost-efficient anti-theft and fire prevention system for smarter and safer asset management with the help of edge computing. In this process, massive edge data from the frontlines of factory floors and industrial parks needs to be collected and analyzed in real time. This is highly latency-sensitive and poses severe challenges to the traditional centralized cloud service model. Driving businesses to the network edge and building an effective data processing mechanism is undoubtedly a highly effective response.

As one of the leaders in the IoT industry, China Mobile IoT believes that an efficient edge computing platform can help users solve the following problems:

- **Alleviating the pressure on network bandwidth and data centers**
  In the IoT, only a small amount of data generated by devices is critical and most of the temporary data does not need to be stored for a long time. Edge computing can help users sort and filter data at the network edge, reducing the pressure on network bandwidth and data centers.
- **Enhancing the response capability of IoT services**
  The short-distance service model of edge computing can reduce problems like long latency, high jitter, and slow transmission caused by unstable links and routing, therefore ensuring low network latency and less jitter.
- **Improving 5G service capabilities**
  Edge computing is able to leverage its locality, short-distance, and low latency to help reform the 5G architecture, remove latency for data transmission, and enhance service response capabilities.
- **Improving data security**
  Edge computing provides the infrastructure for storing and using critical private data, ensuring the movement of private data is constrained within a firewall for higher security.

Building edge computing platforms, however, still faces technical difficulties and there remain several problems to be solved in the adoption of these applications, including:

- ? performance bottlenecks and real-time (low latency) requirements;
- ? accurate synchronization and interconnection of heterogeneous systems;
- ? complex deployment, operation, and maintenance, as well as high costs.

To help users quickly and efficiently create edge computing solutions suitable for industry applications, China Mobile IoT worked with Intel and other partners to launch the OES intelligent edge suite. This enables users to unleash data value more efficiently and accelerate their digital transformation.

Introduction of China Mobile IoT's OES

As an important part of China Mobile's "Big Connectivity" strategy, China Mobile IoT's OES provides users with multi-layered and differentiated edge computing solutions through "cloud-edge-end" collaboration as well as integrated software and hardware. As shown in Figure 1, OES is divided into several layers from bottom to top, e.g., edge devices, edge nodes, cloud management platforms, and industrial vertical applications.

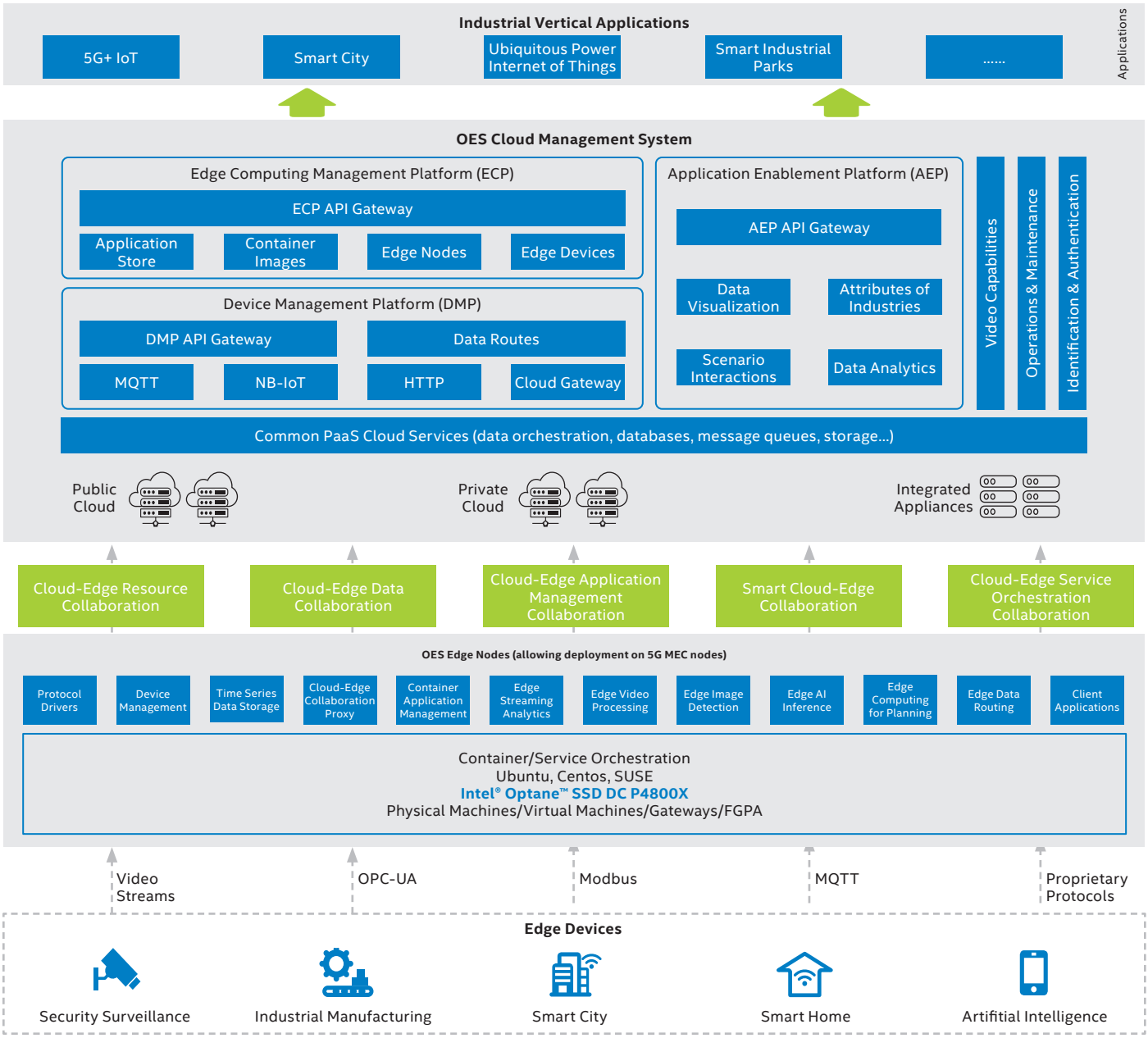

Figure 1. China Mobile IoT's OES architecture.

For edge devices, OES adopts a more open architecture which supports a variety of end devices and protocols, and can easily access general-purpose devices in application scenarios such as security surveillance, industrial manufacturing, and smart cities for effective data collection.

OES leverages a variety of hardware platforms, including 5G MEC devices, to provide strong support for edge nodes. This not only enables edge data to provide plentiful training analysis samples for the cloud through service collaboration, intelligent collaboration, and data collaboration, but also makes it possible to pull capabilities from the cloud, such as AI model training and big data analysis for the edge. With high-performance products like Intel Optane SSDs, edge nodes can implement data aggregation, application execution, AI inference, and security on production lines and devices in the IoT with its great data collection and device control capabilities. Deploying its powerful computing, it reduces the network pressure caused by data transmission and enhances the system's agility and security.

The cloud management platform provides high manage-ment capabilities for the system and excellent PaaS (Platform as a Service) capabilities for the upper-layer vertical applications. OES can effectively provide upper-layer applications with AI, big data, IoT device management, protocol adaptation of industrial end devices, video access, and massive time series data storage capabilities.

Relying on OES, massive data can be fed continuously into the edge nodes from bottom to top and processed in real time into more valuable information, providing data support for upper-layer vertical applications. As a result, data access and processing performance will also have a direct impact on the value of OES. To help users create greater value, China Mobile IoT, together with its partner Intel, enabled OES to have a data storage acceleration engine by introducing the Intel® Optane™ SSD DC P4800X.

Intel Optane SSDs Help OES Break Data Processing Bottlenecks

Edge computing application workloads, such as edge node resource management and data visualization, have high requirements for data processing capabilities like data throughput, response speed, and stability. For example, in a typical application scenario on intelligent analysis of device failures, the size of the devices' run-time data exceeds 20 GB per day and the response latency is required to be lower than 1 microsecond, while the devices need to maintain 24/7 operation for long periods of time. Therefore, the OES edge nodes place higher requirements on the design of storage systems, requiring that the throughput of small data blocks goes beyond a GB per second, storage latency falls in the range of 10-20 microseconds, and the endurance rating of storage which is PBW (Petabytes Written, the amount of data written for life) gets higher.

Traditional storage devices (HDDs or NAND SSDs) cannot meet the requirements of the demanding OES because of the drives' rpm and flash memory lifespan. For example, the speed of an HDD for a server is currently 15,000 rpm at most, and the maximum IOPS is often only several hundred rpms. For heavy workloads such as a write-intensive workloads, the flash memory-based NAND SSD often experiences longer latency response as well as jitter, and its working life depends on types of flash memory. Based on its new revolutionary storage architecture, the Intel Optane SSD DC P4800X is able to satisfy these requirements.

Featuring low latency, high endurance, high quality of service (QoS) and high throughput, Intel® Optane™ technology helps create solutions that can break data bottlenecks and increase processor usage. Intel Optane SSDs enable data centers and edge nodes to deploy larger and more cost-effective data sets, and Intel Optane SSDs enable data centers and edge nodes to deploy larger and more cost-effective data sets, and fully exerts its role in the OES real-world application. For example, the Intel Optane SSD DC P4800X has a 4K random read/write (IOPS) of up to 550K and storage of up to 1.5 TB per drive, which allows edge nodes to quickly collect data and hold however much is needed.[1]

A large traditional steel company hopes to empower their wireless on-premise devices with unified intelligent data access, analysis, management and application through the 5G network and the OES-based industrial IoT platform. The new platform needs to enable 100,000-level end device access and 10,000-level devices' concurrent operation, and support 10 TB wireless end device data analysis and processing per year. Consider monitoring harmful gases in the main gas pipeline network on multiple premises as an example. The platform will collect and monitor the data of harmful gases, such as nitric oxide in the working area in real time. Using massive sensors deployed in various pipeline networks and drains, it will then feed the data into the industrial IoT platform for steel mills. The system may have to handle millions of small files (less than 1KB) writing at high speed in an instant. Even with the flagship NAND SSDs with 200K-300K IOPS, users need at least 4-5 drives on the server to meet the demand. By using Intel Optane SSDs, only two drives are needed. Users can also reduce costs because of its write performance compared to NAND, and longer service life.

In summary, the Intel Optane SSD is the best choice for China Mobile IoT to help users build edge computing systems in the 5G era because it reduces network traffic with fast processing at the edge, can run AI models at the edge, meets the SLA for mission critical analyses, cost effectively writes critical data, and improves performance of edge compute.

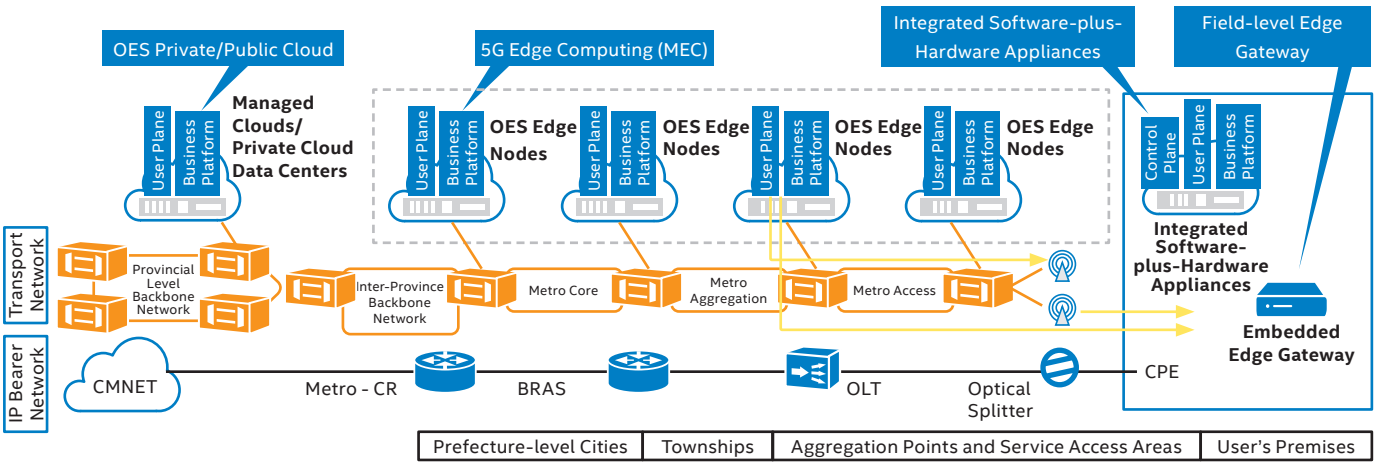

Figure 2. OES networking in 5G scenarios.

China Mobile IoT's OES Application Scenarios

5G+ Edge Computing

The three typical application scenarios of 5G—enhanced mobile broadband (eMBB), ultra-high reliability and ultra-low latency communication (uRLLC), and the big-connectivity Internet of Things (mMTC)—are all closely related to edge computing, and are inseparable from efficient support of the edge computing platform. As shown in Figure 2, OES can effectively integrate with multi-layer 5G network nodes and enables smart real-time analysis of business data at the network edge through deployment in the central offices (COs) in the prefecture-level cities and with UPE/BRAS-UP being used for data distribution. OES, coupled with PaaS capabilities such as wireless network information services, location services, and QoS services encapsulated, can be widely deployed in industrial Internet, smart transportation, live video, and other application scenarios.

In these typical 5G application scenarios, the collection and transmission of massive data put the system's data storage and processing under great pressure. Taking the 5G-based automatic energy control system of the large traditional steel company mentioned above as an example, it needs to collect energy data from thousands of sensors through Programmable Logic Controller (PLC)-based substations. Data is then transferred to the OES cloud with the wireless transmission module integrated with the 5G network and finally is fed into the dynamic energy management system to implement optimal resource allocation. The particularity of energy control means that the OES edge computing nodes require both higher data bandwidth and lower latency for data processing. By introducing Intel Optane SSD DC P4800X, the system effectively improves the data storage and processing performance of the edge nodes and ensures a better user experience with 10 µs read/write latency and 550K IOPS.[2]

Smart Industrial Manufacturing

China Mobile IoT actively explores the adoption of edge computing in scenarios such as factories' intelligent upgrades and connected production lines. The large traditional steel company mentioned above deploys the OES-based intelligent operation and maintenance system for special rolling mills. On one hand, it improves surveillance over the production processes by collecting real-time parameters and monitoring production equipment and material consumption. On the other hand, it also enables intelligent equipment diagnosis and maintenance as well as feeds decision-making on spare parts through on-line and off-line precision diagnosis of data, improving production optimization.

As shown in Figure 3, the company uses a variety of sensors and communication networks to monitor the width, thickness, and temperature of processed products in real time during production. To meet vibration sensors' demanding requirements for high system performance when implementing massive data collection and real-time analysis, the OES edge nodes are also deployed in servers with Intel Optane SSD DC P4800X drives. Massive data from frequently used devices, such as vibration sensors, are collected into the OES edge nodes. Then it goes through high-speed storage and

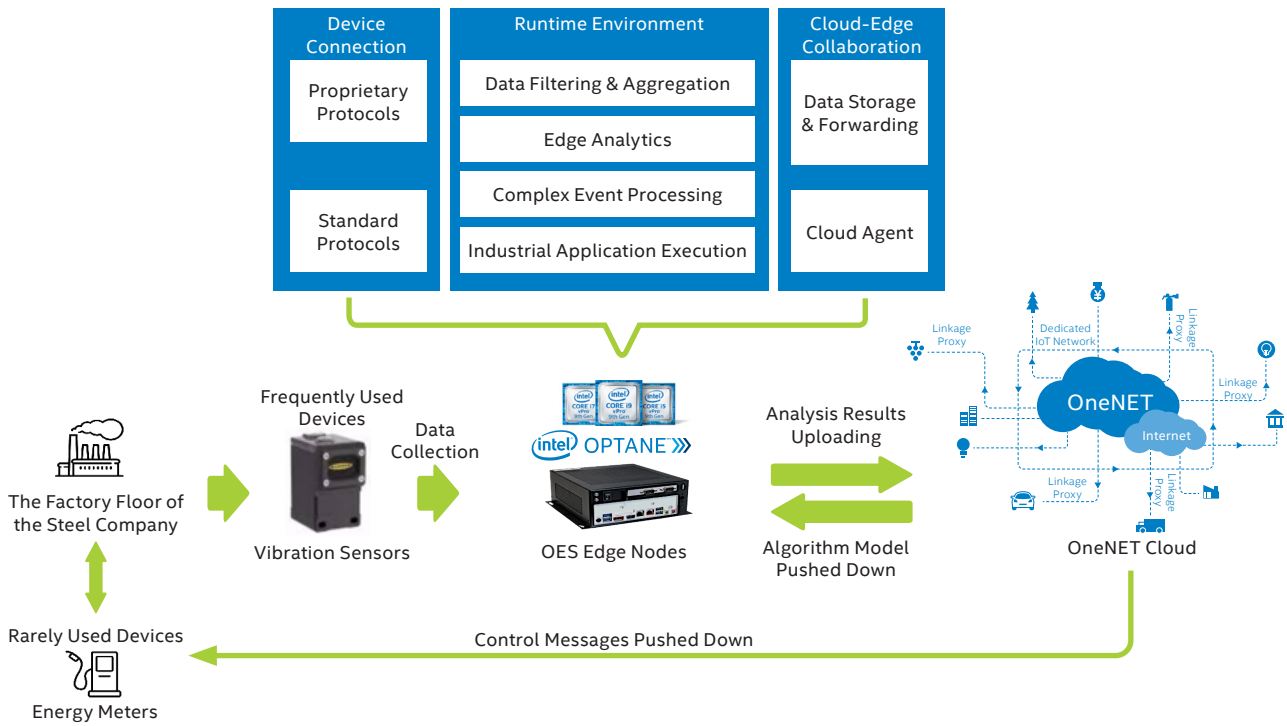

Figure 3: OES system deployed in a large steel company.

real-time analysis at nodes using the algorithm model from the cloud. After that, the analysis results are uploaded to OneNET for the algorithm model training and optimization. At the same time, the OES control nodes also control the rarely used devices such as energy meters based on the analysis results.

At present, the system at the user's premise has access to more than 3000 multi-type end devices, enabling the simultaneous reporting of data from more than 20 vibration sensors. With the high-performance Intel Optane SSD DC P4800X, the system achieves up to 50,000 writes per second per device and the average daily storage data exceeds 160 GB.[2] Through the application of OES, the environmental awareness has been greatly improved on the company's production lines, its manufacturing efficiency enhanced, the overall cost of resource energy consumption reduced and its core competitiveness increased.

Outlook

The China Mobile IoT's OES solution plays an increasingly important role in China Mobile's 5G edge computing placement. Besides, it is widely and successfully used in industries including steel, textile, machinery manufacturing, logistics, industrial parks, ports and terminals, security, and industrial automatic control. For example, in an application for the textile industry, OES has been able to implement efficient real-time detection of textile defects; in an automatic detection management system for gas meters, it has helped to greatly improve detection accuracy by introducing Intel® VCAC-A to create a machine vision based industrial quality inspection solution. These practices, in turn, contribute to the continuous optimization of the OES platform and Intel Optane technology, enabling China Mobile to maintain its leading position in the development of 5G edge computing and IoT technologies. Featuring high response, high stability, and low latency, Intel Optane SSD DC P4800X, as one of Intel's advanced storage technologies, has become a key driver in satisfying users in the 5G era and helping OES to win market share.

In the future, China Mobile IoT will work closely with Intel to introduce more advanced products and technologies to drive the evolution of the OES-based edge computing solutions. The application of the Intel Optane SSD DC P4800X to China Mobile IoT's solutions mentioned above proves to be a great example of efficient processing massive data in the process where both parties work together to drive edge computing solutions. Going forward, China Mobile IoT will continue to work with Intel to explore the optimization and innovation of various data processing and storage systems.

Intel® Optane™ Technology Brief

With a unique combination of Intel® Optane™ media and advanced software and hardware, Intel® Optane™ technology helps users in various industries to greatly improve their system performance with low latency, high service quality, high endurance, and high throughput. It provides a variety of form factors for customers to choose. Here are five reasons to choose Intel Optane technology.

intel OPTANE™

Access data faster for greater insights	Intel Optane technology provides great data access for use cases where the average response time is not desirable and faster access is needed. It improves response and performance for applications such as intelligence, automated detection, monitoring, and management in the production processes.
Boost the bottom line	Compared with alternative solutions, Intel® Optane™ SSDs can do more work with the same number of servers, helping users reduce costs or use the resources saved to expand functions and services.
Innovate with a flexible architecture	Intel Optane SSDs combine low latency, high endurance and consistent response speed, making them an ideal choice for fast caching or fast storage applications. The high performance and endurance also optimize, store and accelerate complex and large data sets. Even in a dynamic environment, they can easily cope with the challenges of demanding memory and storage workloads.
Handle the breadth of storage workloads	Intel Optane SSDs are ideal for working data and realtime data stored in large volumes; highly random storage bound applications; and random workloads at low queue depths, which is where the majority of activity occurs in real-world scenarios, enabling each server to do more, across applications.
Fully connected platform	Intel's end-to-end integrated architecture optimizes the Intel® Xeon® Scalable processor, Intel Optane technology and Intel® 3D NAND technology to create an efficient data center that can move data faster, store more of it, and process everything from cloud to the edge. Platform-connected capabilities link the compute and storage pools to efficiently manage storage at scale, accelerate applications, and simplify systems.

Overview of the Intel® Optane™ SSD DC P4800X

The Intel® Optane™ SSD DC P4800X is the first product to combine the attributes of memory and storage. With an industry-leading combination of high throughput, low latency, high QoS, and high endurance, this innovative solution is optimized to break through data access bottlenecks by providing a new data storage tier. The Intel Optane SSD DC P4800X accelerates applications with fast caching and fast storage to increase scale per server and reduce transaction costs for latency sensitive workloads. In addition, the Intel Optane SSD DC P4800X enables data centers to deploy bigger and more affordable datasets to gain new insights from large memory pools, bringing many new features and significant advantages:

High throughput (fast data transmission)	The read/write speed is faster without compromising performance under pressure.
High QoS (fast execution in mixed workload benchmark tests)	In an environment of fast growing data and ever demanding needs, data centers can deploy solutions that enable predictably fast service.
Low latency and fast response	With NAND-based SSDs, random write operations can add significant delay to the read operations. No matter how the write throughput changes, Intel Optane technology maintains consistent read response times. Even under the low queue depth where most applications generate storage workloads, it still delivers fast service in any workload.
High endurance	The Intel Optane SSD DC P4800X is designed for high write environments, and can withstand intense write traffic that is typically demanded of memory. With its extremely high endurance, the life of the Intel Optane SSD DC P4800X is extended, making it suitable for write-intensive applications such as online transaction processing, high performance computing, write caching, boot, and logging.

For more information, please see:

Intel® Optane™ Technology: Memory or Storage? Both.
Top 10 Reasons to Deploy Intel® Optane™ Technology in the Data Center

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1. The data is cited from the relevant introduction on Intel's official website:
https://www.intel.com/content/www/us/en/products/docs/memory-storage/optane-technology/what-is-optane-technology-brief.html
2. Based on internal testing completed by China Mobile.

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