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Intel and JHCTECH Jointly Create ETC Solutions Based on Intel® Architecture

JHCTECH

Business Contacts

Jiagang Cheng
Director of Products, JHCTECH
chengjiagang@jhctech.com.cn

Ming Lei
Senior Platform Architect, Intel
ming.lei@intel.com

Ronghua Jiang
Business Development Manager, Intel
ronnie.jiang@intel.com

Overview

The continuous development of the global economy and urbanization has driven the rapid growth of the traffic flow, which puts huge pressure on the existing transportation infrastructure. It has become an important task for the transportation authorities in major countries around the world to promote the construction of the Intelligent Transportation System (ITS) through the digitalization and intelligentization of the transportation infrastructure. In September 2019, the Chinese government issued the Outline for Building China's Strength in Transportation, which proposes to continue promoting the development of a modern comprehensive transportation system and to make China one of the world's leading countries in transportation by 2035.

The Electronic Toll Collection (ETC) system, as an important part of the intelligent highway, is playing an important role not only in the toll collection for the roads, bridges and parking lots, but also in improving the traffic efficiency and mining the value of the traffic data.

Intel and the partners including the Shenzhen JHC Technology Development Co., Ltd.* (hereinafter referred to as JHCTECH) have launched the products and solutions for the ETC systems, which can collect, process and analyze the traffic data including the ETC data at the roadside edge and in the cloud, help users accelerate the deployment of the ETC systems, and lay the solid foundation for the ITS.

Background: Rapid Development of China's ETC System

The ETC system can automatically detect and identify vehicles, so that the toll transactions can be completed without stopping the vehicles. This allows vehicles to quickly pass through the toll stations, alleviates their bottleneck effect of delaying the traffic, and improves the overall traffic efficiency. In addition to the toll collection for the roads, bridges and parking lots, ETC systems based on the vehicle identification and financial payment capabilities, as well as the gantry systems and networks, also play an important role in areas such as the traffic control, flow investigation, path labeling, congestion charges and management, and traffic law enforcement.

Therefore, the construction and promotion of ETC has become an important part of building a modern comprehensive transportation system that is safe, convenient, efficient and green. In May 2019, the Ministry of Transport (MoT) of China issued the Notice on Vigorously Promoting the Development and Application of ETC on Expressways, calling for the active promotion of the installation and use of ETC to create conditions for the elimination of the traditional physical toll stations at the provincial borders of expressways. According to the plan, by the end of 2019, more than 80% vehicles in all provincial administration regions in China will be installed with ETC, more than 90% vehicles driving on expressways will use ETC, and fast toll collection without stopping the vehicles will be basically realized[1].

Among them, the elimination of province-border physical toll stations on expressways is of epoch-making significance, completely changing the way of expressway organization and operation, from the independent province-level operation to the national network operation, helping accelerate the informatization, intelligentization and high-quality development of expressways, while improving the travel experience of drivers and passengers, promoting the efficient development of logistics industry, and making an important contribution to the economic development.

Unlike the traditional Manual Toll Collection (MTC), ETC uses the Dedicated Short Range Communications (DSRC) technology for the information exchange between the Road Side Unit (RSU) and the On-Board Unit (OBU) to complete the vehicle identification, send relevant information to the backend servers through the network, and perform settlement processing based on the bank account information bound to the vehicle to achieve the automatic non-cash payments.

ETC has been widely used in the toll collection for the roads, bridges and parking lots, of which expressway toll collection is the main application scenario. At present, China's ETC system architecture for expressway toll collection is as shown in Figure 1.
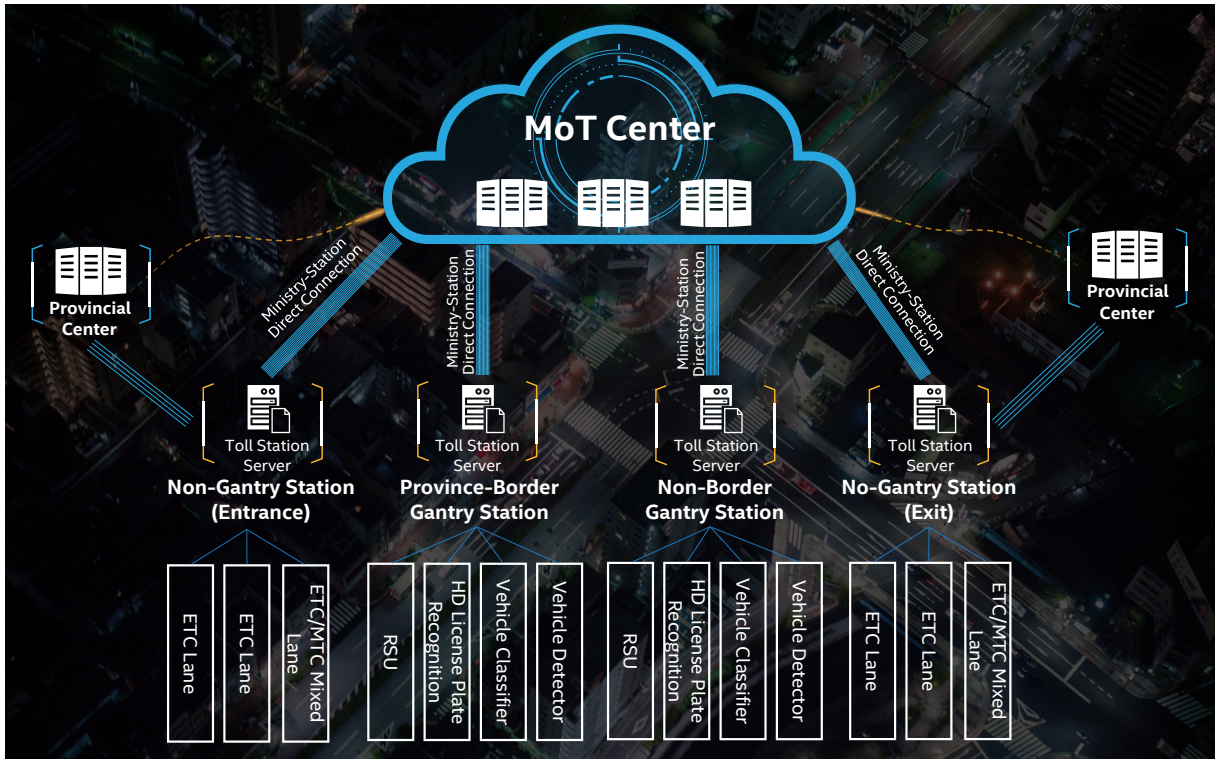
Content

Figure 1: China's expressway ETC system architecture

It can be seen from Figure 1 that the current China's expressway ETC system includes the Non-Gantry Stations (including ETC Lanes and ETC/MTC Mixed Lanes) at the entrance and exit of the expressway, as well as the Province-Border Gantry Stations and Non-Border Gantry Stations located on the expressway, which can meet the automatic or manual toll collection requirements of passing vehicles (OBU vehicles and CPC vehicles). Among them, the Province-Border Gantry Station is a system erected above the expressway with functions such as charging and path labeling. It is equipped with RSUs that can communicate with the OBUs in the vehicles, as well as the high-definition license plate recognition (LPR) systems, vehicle classifiers, and vehicle detectors and other equipment. It can perform vehicle identification and charging under normal high-speed driving conditions, replacing the traditional province-border physical toll station that requires vehicles to slow down, therefore significantly improving the traffic efficiency.

Challenge: Industrial PC Design for ETC System

In the ETC system, the industrial PC (IPC for short, or Box PC) plays a vital role. It is connected not only to the RSU, high-definition LPR system and other lane equipment, but also to the Toll Station Server to complete the calculation, storage and forwarding of ETC data, and control of various lane equipment. The functions of the ETC IPC are different according to the specific type of ETC toll station and lane where it is located:

- **Province-Border Gantry Station:** The IPC calculates, stores and forwards the data such as the vehicle's charging amount and its driving path to meet the requirements of the applications such as the toll settlement among provinces;

- **Non-Border Gantry Station:** The IPC is mainly used to label the driving path of the vehicles (both OBU and CPC vehicles) passing through the gantry, and undertakes the functions of calculating, storing and forwarding the relevant data;

- **ETC Lane of Non-Gantry Station:** In addition to the calculation, storage and forwarding of billing amounts and other data, the IPC also needs to control various lane equipment (including the RSU, IP camera, toll info display, traffic lights, fog lights, sound and light alarm, barrier gate and roadblock, etc.), to achieve the automatic operation of the ETC Lane;

- **ETC/MTC Mixed Lane of Non-Gantry Station:** In addition to the above-mentioned IPC functions for the ETC Lane, the IPC for the ETC/MTC Mixed Lane needs to be connected to the keyboard, mouse, monitor, printer and other equipment to establish the human-machine interaction (HMI), and supports the manual control of the lane when necessary.

In addition to supporting the above various functions, the ETC IPC also faces many challenges and needs to have the following capabilities.

- **Ruggedness to overcome harsh environmental impacts:** Most ETC IPCs are deployed beside the roads with variable environment. It is common to see the large fluctuation of temperature and humidity, exposure to the sun and rain, and impact of foreign objects and so on, which requires the IPC to have strong adaptability to the environment (including the changes in temperature and humidity), water-proof, dust-proof, corrosion-resistant, shock-proof and other capabilities, while also having the excellent electromagnetic compatibility (EMC) and anti-interference capabilities to ensure the uninterrupted provision of stable and reliable services throughout the product life cycle.

- **Supporting many different types of I/O interfaces:** As mentioned above, ETC IPCs need to connect to a variety of different lane devices. Therefore, IPCs need to be configured with different types of I/O interfaces that connect with these devices to meet the functional requirements such as the ETC data calculation, storage and forwarding, control of lane equipment, and scalability.

Solution: ETC IPC Solution based on Intel® Architecture

JHCTECH has developed the ETC IPC series based on Intel® Architecture, including the following Intel® chips and technologies: Intel® Core™ Processor Family, Intel® vPro™, Intel® H110 & Q170 Chipsets, Intel® I219-LM & I211-AT Ethernet Controllers. They have the advantages of strong processing power, low power consumption, scalable performance, ultra high security and reliability, remote management and so on.

Intel® Core™ Processor Family

This series of industry-leading processors supports different operating systems (OS) and a wide range of workload requirements, providing ETC users a wide range of performance options. Intel® Core™ Processor Family not only has powerful computing capability, but also has characteristics of low power consumption, high performance cost ratio, ultra high security and reliability. Based on this family of processors, JHCTECH® IPCs are fully capable of calculating, storing, and forwarding ETC related data, as well as controlling various lane equipment and other functions, and can support the reliable and stable operation of ETC system, therefore they have been highly commended by the ETC users.

Intel® vPro™ Technology and JHCTECH® Remote Management View Software

Intel® vPro™ technology is a comprehensive platform technology designed to reduce IT maintenance cost, improve security and save energy consumption. At this platform, Intel® Active Management Technology (AMT) is a hardware-based remote management technology that enables system administrators to remotely manage, repair, and protect various types of networked computer devices, including ETC IPCs, through the network. Based on Intel® vPro™ technology which includes Intel® AMT, JHCTECH has successfully developed the Remote Management View software. This tool can be easily integrated into the existing ETC network, allowing system administrators to remotely service the ETC IPC at any time, even when the OS of the ETC IPC is not started. Therefore, there is no need for management personnel to go to the site, which greatly reduces the response time and significantly lowers the operation and maintenance cost.

Intel® H110 & Q170 Chipsets

These two types of chipsets are integrated on the motherboards of JHCTECH® ETC IPCs. The H110 chipset has excellent performance cost ratio, while the Q170 supports Intel® vPro™ technology based remote management functionalities (see above) and the Redundant Array of Independent Disks (RAID) technologies that enhance the data security and memory read/write performance. Both chipsets provide rich PCIe interfaces and expandability, thus supporting the connection and integration of ETC IPC with a variety of different peripherals.

Intel® I219-LM & I211-AT Ethernet Controllers

Both chips are characterized by the high data rate, low power consumption and low cost, support for the accurate time synchronization protocol (IEEE 1588) and wide-temperature operation. Among them, the Intel® I219-LM Ethernet Controller supports Intel® vPro™ technology and can be used as the management network interface for ETC system administrators to use JHCTECH® Remote Management View software to perform the remote maintenance on ETC IPCs; while the Intel® I211-AT Ethernet Controller is used as the data network interface to support the ETC-related data communication between the ETC IPCs and the back-end equipment.

Intel has been working closely with partners including JHCTECH to achieve the tight integration of software and hardware, and the rapid deployment of ETC IPC products. These products can be widely used in different scenarios such as the Province-Border Gantry Stations, Non-Border Gantry Stations, and Non-Gantry Stations (including ETC Lanes and ETC/MTC Mixed Lanes) at the entrance and exit of expressways. These ETC IPC products comply with the strict Chinese and overseas industrial standards and specifications. They all use the reinforced fan-free design, can work in a wide temperature range from -35°C to +70°C, and have the extreme reliability of dust-proof, corrosion-resistant, anti-shock and anti-electromagnetic-interference, and can operate stably under the harsh environmental conditions.

The various models, application scenarios and technical parameters of the above ETC IPC products are shown in Table 1.

Model	KMDA-3610	KMDA-3601	KMDA-3920	KMDA-3920/ETC	KMDA-3921	KMDA-3821
Type of ETC Station/Lane	Gantry Station		ETC Lane (Non-Gantry Station)		ETC/MTC Mixed Lane (Non-Gantry Station)	
CPU	Intel® Core™ i3/i5/i7 CPU (Standard Edition)					Intel® Core™ i3/i5/i7 CPU (Low Power Edition)
Chipset	Intel® H110/Q170		Intel® Q170	Intel® H110/Q170		SoC
Memory	2*DDR4-2400MHZ Maximum 32 GB					1*DDR4-2133MHZ Maximum 16 GB
Extension Slots	Mini-PCIe	2*Mini-PCIe, 1*M.2	1*PCIex16, 1*PCIex4, Mini-PCIe	1*PCIex16, Mini-PCIe	1*PCIex16, 1*PCIex1, 2*PCI, Mini-PCIe	1*PCIex4, 1*PCIex1, 1*Mini-PCIe
Ethernet Controller	1*I211-AT, 1*I219-LM, 2*RJ45	6*I211-AT, 1*I219-LM, 7*RJ45	1*I211-AT, 1*I219-LM, 2*RJ45			2*I211-AT, 1*I219-LM, 3*RJ45
vPro™	JHCTECH® Remote Management View Software based on Intel® vPro™ Technology					
RAID	Support					
SATA	2*SATA3.0, 1*M.2, 1*mSATA					1*SATA3.0, 1*mSATA
Display	1*HDMI, 1*VGA, 1*DP					
COM	2*RS232, 2*RS485			8*RS232, 2*RS485	2*RS232, 2*RS485	
Audio	Line out, Microphone					
DIO	8- or 16-bit	16-bit, isolated	8- or 16-bit	16- or 32-bit	8- or 16-bit	8-bit
Operating Temperature	-35~70°C					

Table 1: Models, application scenarios and technical parameters of ETC IPC products

Effect: Significantly Improved Traffic Efficiency of Expressways

With the promotion of the "eliminating the province-border physical toll station" project and the continuous system upgrading, the requirements of China's expressway ETC system for IPCs continue to increase. At present, the ETC IPC solution jointly created by Intel and JHCTECH has been successfully applied in different provincial administration regions, which has successfully satisfied the requirements of different types of ETC toll stations and lanes.

According to the statistics from the MoT of China, after eliminating the province-border physical toll stations and using the Province-Border Gantry Stations with ETC IPCs, the average time for passenger vehicles to pass the provincial border is reduced from 15 to 2 seconds, and the time

of cargo vehicles to pass the provincial border was reduced from 29 to 3 seconds. The traffic efficiency of expressways is significantly improved.

In the transformation and upgrading of China's ETC system, JHCTECH® ETC IPCs based on Intel® Architecture have played a very important role. Here are just two examples:

- **National Expressway G65 (Baomao Expressway):** This expressway crosses the mountainous areas in Hunan Province, with frequent climate change, large elevation rise and fall, and harsh environment. Various models of JHCTECH® ETC IPCs, which are based on Intel® Architecture, have been widely deployed in the Province-Border Gantry Stations, Non-Border Gantry Stations and Non-Gantry Stations at various entrances and exits (Figure 2), fully satisfying the requirements of ETC users.
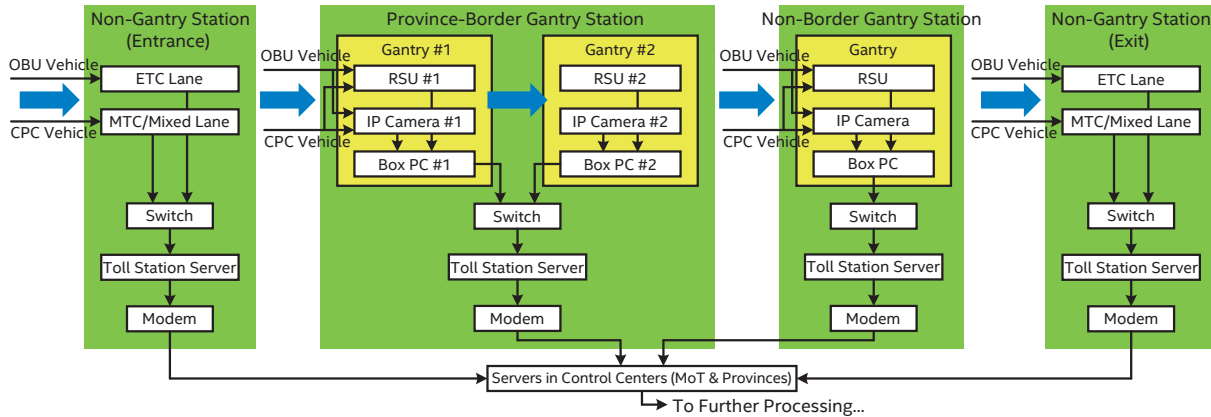
Figure 2: ETC system (including Gantry Stations, Non-Gantry Stations & Lanes) and vehicles

- **National Expressway G93 (Chengdu-Chongqing Ring Expressway):** The traffic flow of some sections of this expressway reaches about 30,000 vehicles per day[2] during holidays, which poses a great challenge to the ETC system. After using JHCTECH® ETC IPCs based on Intel® Architecture, the traffic management authorities can process the ETC billing data at very high speed, and meet the requirements of both stability and reliability, relieve the bottleneck effect caused by the MTC or province-border physical toll stations, and further improve the traffic efficiency of the expressway.

Prospects: ETC Will Facilitate Vehicle-Infrastructure Integration in Future ITS

The existing ETC systems, in addition to the toll collection for the roads, bridges and parking lots and path labeling, can also be easily upgraded for the traffic control, flow survey, congestion charging and management, and traffic law enforcement (for example, detecting overspeed vehicles and automatically generating tickets).

In the future ITS, the ETC system can be used as the infrastructure to support the Vehicle-Infrastructure Integration (VII), as Figure 3 shows. On the ETC gantry, in addition to the RSU and LPR equipment,

the cameras, radars and other sensing devices that monitor the road and traffic conditions can be deployed. When these sensing devices detect any abnormal conditions or temporary events, such as the road obstacles, traffic accidents, road construction, etc., they can use the Artificial Intelligence (AI) based Computer Vision and other technologies to analyze the types of emergencies, and generate safety messages to inform nearby vehicles or pedestrians through the RSU's V2X communications link in time to avoid accidents. The meteorological sensors can also be deployed on the ETC gantry to detect and analyze the abnormal meteorological conditions (such as the heavy fog, mass fog, cross wind or hailing, etc.) to generate emergency message and send it to the vehicles via RSU to ensure the safety of driving.

Many scenarios of VII require the Computer Vision based on AI for analysis and processing, which will have a high demand for the computing capabilities at the edge of the network. The Mobile Edge Computing (MEC) equipment can be deployed on the ETC gantries to provide these capabilities. Intel, with deep technology accumulation in the fields of AI and edge computing, can provide a rich and diverse product portfolio.
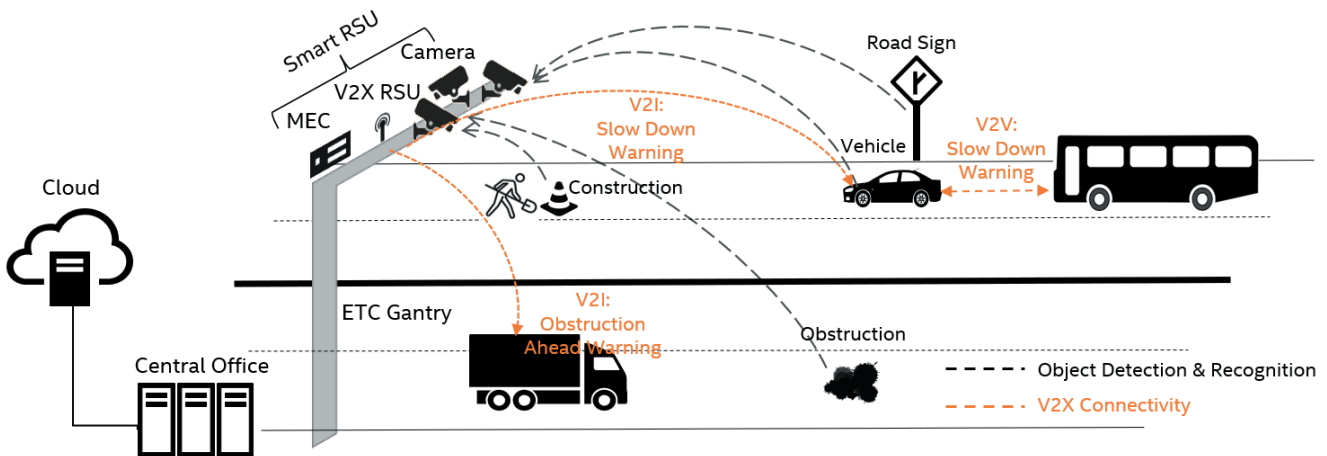

Figure 3: Vehicle-Infrastructure Integration (VII) based on ETC infrastructure

Intel and JHCTECH Jointly Create ETC Solutions Based on Intel® Architecture

As shown in Figure 4, to support the Computer Vision capabilities in the future VII systems based on ETC, Intel provides a variety of general-purpose processors with different processing power (including Intel® Atom™, Core™ and Xeon® CPU families), Intel® Movidius® Myriad X™ Vision Processing Unit (VPU), and Intel® hardware acceleration solutions based on VPU or FPGA. To support the product development across different Intel® hardware platforms, Intel provides the OpenVINO™ software toolkit. Based on its abundant resource of software tools, the

OpenVINO™ toolkit can significantly improve the productivity of the developers and reduce the R&D time for the products. With its rich high-performance hardware and software platforms, Intel has laid the solid foundation for the future development and evolution of ETC systems.

As a data-centric company, Intel has the world's leading end-to-end technology, strong processing power and rich portfolio of products. Intel will work with the industry partners to facilitate the innovation of the global ITS industry.
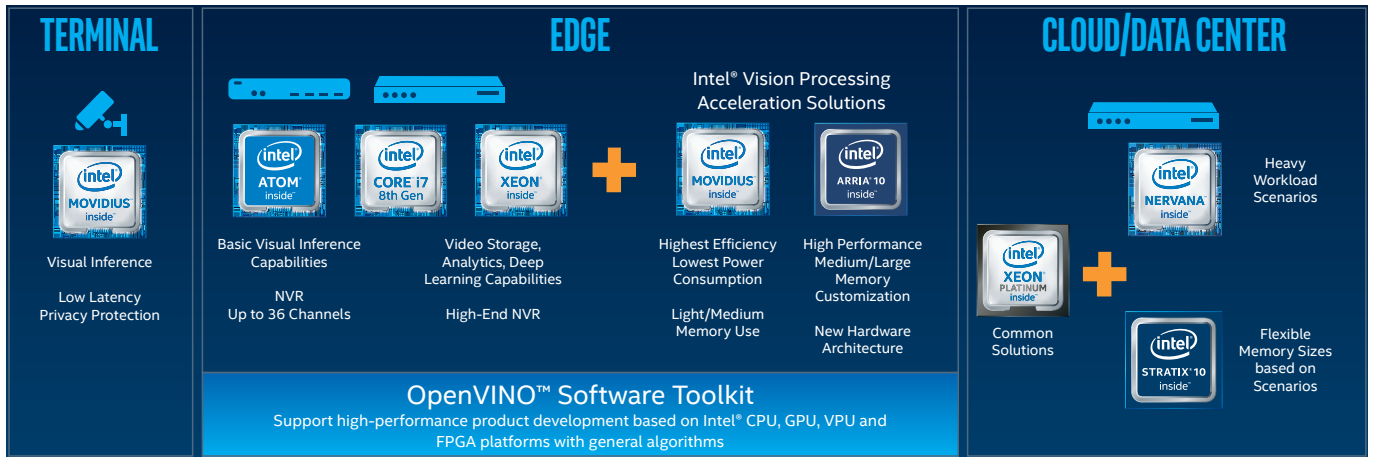
Figure 4: Intel's computer vision technology supports AI at terminals, edges and clouds

ETC system is playing an important role in the ITS industry, while the ever-increasing scenarios and requirements bring new challenges to the subsystems such as IPCs, toll station servers, and control center servers. We will work with JHCTECH and other partners to provide solutions for the terminal, edge, and cloud through Intel's rich portfolio of products. These solutions will meet the needs of various workloads such as the data processing, lane equipment control, system analysis, and computer vision processing. Intel will actively empower the innovation of ITS.

Dr. Wei Chen
General Manager of Intel IoT Business Group China
VP of Intel Corporation