Smarter Infrastructure for a Smarter World

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The data networking infrastructure that connects our world must add intelligence to meet the needs of the Internet of Things, and semiconductor suppliers are developing innovative solutions to enable this intelligent networking infrastructure. These new solutions, based on the concepts of software defined networks (SDN) and network function virtualization (NFV), are revolutionizing how networks are built and what they can do.

Introduction

The Internet of Things will impact the design of not only physical devices and data centers but also the networks used to connect them. New concepts such as "cloud edge" are emerging to meet the requirements of processing data in a geographically distributed fashion. This data processing is often based on a virtualized processing model that provides much greater flexibility in the deployment and use of networking equipment.

Two important areas where this cloud edge model will be employed are in modern industrial facilities, such as factories, warehouses and distribution centers and along our roadways in support of intelligent transportation systems.

Secure networks managing the flow and processing of data in these environments will lead to greater efficiency, convenience and safety.

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What is the Internet of Things?

The Internet of Things (IoT) is regarded as the "next big thing" in technology. Over the last 45 years, the Internet and its uses have evolved significantly. When first conceived, the Internet was used for connecting research institutions together. It later became a foundation of business commerce and most recently has grown to support the information and communications needs of over two billion mobile devices and hundreds of millions of computers and home entertainment devices providing streaming music, video and social networking content among many other services. The "next big thing" is the connectivity for physical devices such as home appliances, office and factory equipment, and transportation systems. Such connectivity for physical devices promises great advancements in efficiency, convenience, and safety.

Some descriptions of the IoT over simplify it to a vast array of sensors sending information to big data applications running in large cloud data centers. Slightly less simplistic descriptions include actuators, so that the big data applications can implement a control loop. In these descriptions, the Internet does little more than provide connectivity between the sensors and actuators and the intelligence in the cloud. In reality, the IoT is built from a continuum of systems ranging from single function sensors and actuators, to multi-function embedded systems, to network infrastructure, to cloud data centers.

Further, there is a continuum of network infrastructure, with some networking equipment being more 'embedded' – hardware rooted, real-time, fixed function, while other systems are highly programmable, to the point where they can be considered part of the cloud themselves. Systems combining embedded and cloud characteristics are sometimes described as 'cloud edge'. This paper will examine the origins of the 'cloud edge', and then discuss two areas of Cloud Edge, which NXP expects will change the world as we know it.

The Edge of the Cloud

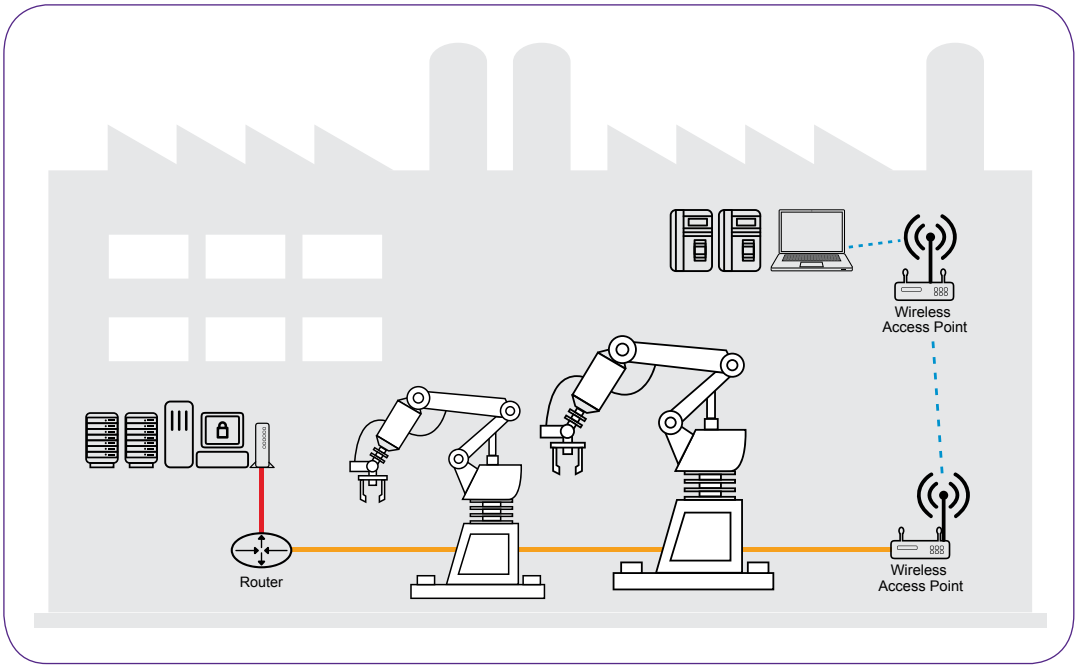
The Cloud is defined by its apparent lack of form or boundaries and lack of physical presence. Through the cloud, remotely located computing resources (processing and storage) are pooled and dynamically provided to users on demand. The cloud is implemented on hardware which is every bit as real as the hardware used in embedded systems, but the long term stability of commodity server architectures (x86 processor, DDR, HDD, and Ethernet NIC) incentivized developers to create hardware-abstracting middleware that allowed general purpose applications to run on any server. This virtualization middleware expanded in scope to allow multiple applications and even full operating systems plus applications called virtual machines (VMs) to share hardware. Decoupled from the physical resources, VMs could be migrated from one physical server to another and be scaled by 'cloning'.

Once virtualization technology was broadly used, hardware evolved to better meet the needs of virtual machines. Virtual MACs, NICs and hardware accelerators were added to support Ethernet connectivity to VMs. PCI Express also added IO Virtualization technology, and new classes of data center equipment such as server load balancers/application delivery controllers (ADCs) were introduced to steer the appropriate network traffic to the physical hardware that a targeted VM resided on at a specific moment in time. Servers, storage arrays, virtualization-aware switches, and ADCs collectively allowed cloud data centers to reach hyperscale.

Soon virtualization proponents turned their eyes toward the routers, switches and ADCs. Were these specialized networking boxes really necessary or could these networking functions also be implemented as virtual machines running on the same commodity hardware as the applications themselves? The concepts of Software Defined Networking (SDN) and Network Function Virtualization (NFV) began as proofs of concept that networking functions like switching, routing, and firewalling could also be performed on commodity server hardware.

IoT Gateways

Whether running networking-ish functions on networking boxes with more flexible provisioning constitutes cloud edge is debatable. Running data analysis applications and 'publish and subscribe' database services on networking boxes certainly qualifies as cloud edge computing, and such data analysis functionality is found in the relatively new class of product called the Industrial IoT (IIoT) gateway. Similar to existing industrial gateways, IIoT gateways are differentiated from home and enterprise gateways by supporting a wider range of interfaces (Ethernet, CAN, serial, ZigBee®) and industrial network protocols such as Modbus TCP/IP, and Profinet in order to forward traffic between a range of IoT sensors and actuators and a central control system.



IIoT gateways built with NXP QorIQ processors and enabled by standards-based orchestration software support the on-boarding of distributed analysis and control applications, allowing the IIoT gateway to understand the data. As a logical aggregation point of sensor data, IIoT gateways will summarize the uninteresting data, forward the outliers, and perform locally appropriate control operations with higher reliability and lower latency than is possible when the control loop reaches all the way into the cloud. The IIoT gateway also ensures that only authorized traffic may pass the gateway and only authorized data analysis or other applications are allowed to run on the processing resources resident on the gateway.

Leveraging a virtualized processing platform for gateway-based analytics work provides greater platform flexibility in meeting diverse and changing industrial cloud edge computing challenges.

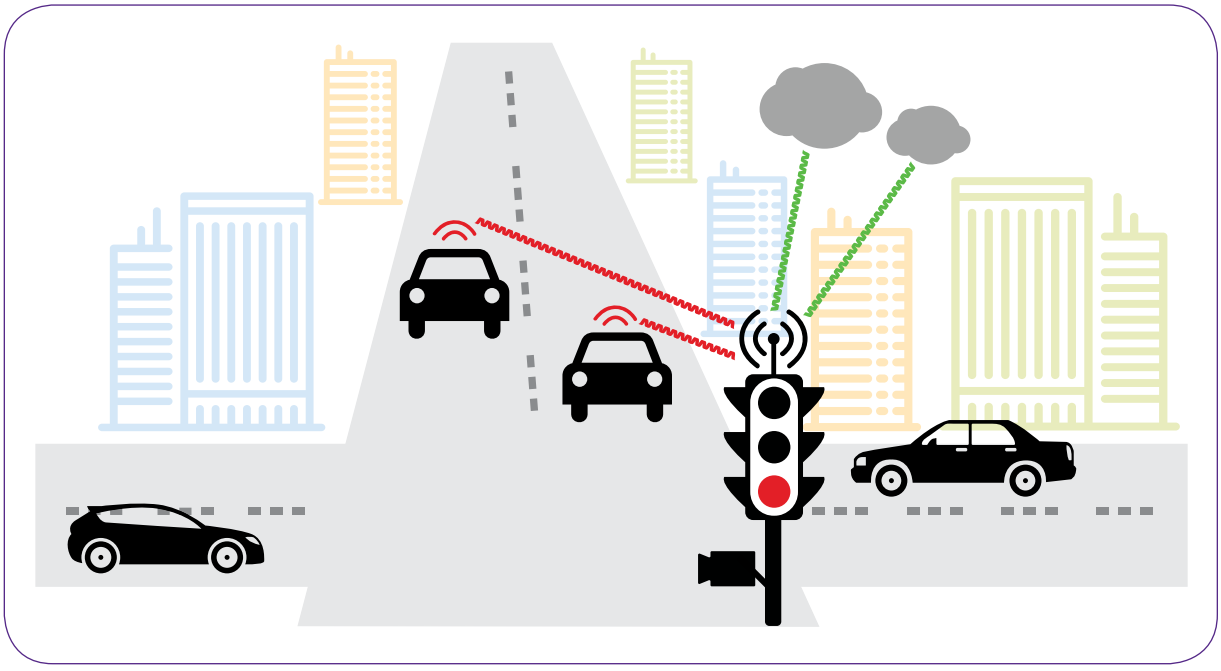
Intelligent Transportation Systems

The marriage of sensing, analysis, control, and communications in cloud edge becomes particularly evident in intelligent transportation systems (ITS). While the looming revolution in connected and automated vehicles (CAVs) captures the headlines, developments in roadside infrastructure will be equally stunning. Roadside Unit (RSU) sensors will mimic those found in the automated vehicles themselves; including vision, radar, and V2X wireless communications. The RSU's will be responsible for a fixed geographic area, such as a busy intersection. RSUs will provide automated cars situational awareness beyond the car's own sensor range, warning of hazards, and analyzing traffic flow to adjust signal timing to smooth traffic, amongst other things.

When interacting with CAVs, an RSU at an intersection could tell the approaching CAV to ignore a red light, as the RSU has determined no other vehicles or pedestrians are present. One could even imagine a future in which traffic lights and stop signs will only apply to 'legacy' human-driven vehicles; the RSU could transmit velocity adjustments to autonomous vehicles to allow traffic in all directions to transit an intersection at full speed. This 'green driving' would eliminate the city driving fuel efficiency gap, and generate environmental and roadway efficiency benefits on top of the safety benefits derived from more conservative visions for V2X communications.

RSUs are most needed where vehicle traffic is highest. Not surprisingly, the ideal sites for RSUs are also the ideal sites for broadband service delivery. 5G small cells hosting virtualized media servers and web caches will be in high demand as drivers become passengers. Liberated of paying attention to the road, the humans travelling the roadway will want to utilize travel time catching up on news and working in their truly mobile office.

As the market leader in automotive sensors, V2X communications modules, processors for driver assist systems, and processors for communications equipment, NXP is uniquely positioned to deliver solutions for RSUs and other intelligent transportation systems equipment. As the example of CAVs transiting an intersection at full speed indicates, the vehicles and RSUs must have high levels of functional safety (resistance to random faults) and cyber security (resistance to directed attack). These are areas in which NXP also excels, with automotive components up to ASIL D safety levels, and Common Criteria EAL6+ certified security solutions.



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Conclusion

With the merger of Freescale Semiconductor, NXP becomes a semiconductor technology powerhouse with business lines leading their respective markets in automotive sensors and processors, RF, security and authentication, and networking. These products and technologies converge in the cloud edge, where sensors, wireless, and wireline communications provide the data used by flexibly provisioned applications running on high-performance virtualized processors to provide real time control and coordination, enabling industry, infrastructure, and cities to become safer, more convenient and more efficient.

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