WHITEPAPER

Connected Cars: On The Edge Of A Breakthrough

How the AECC's distributed edge architecture can drive revenue for MNOs

AECC
AUTOMOTIVE EDGE COMPUTING CONSORTIUM

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Executive Summary

Mobile networks will enable many of this decade's most promising technologies, and perhaps no other device holds as much potential as the connected vehicle. GSMA has forecast that the global connected car market will be worth $198 billion by 2025.[1] According to the analyst team at McKinsey, the average vehicle will generate an estimated $310 a year in connectivity revenue by the end of this decade[2] (annual smartphone revenue per user (ARPU) would have to grow at a compound annual growth rate (CAGR) of more than 10% to match that[3]).

As each vehicle on the road becomes part of at least one mobile network, the opportunity for operators is significant. So, too, is the cost of letting the connected car ecosystem evolve without coordinated cooperation from mobile network operators (MNOs). By 2025, at least 400 million passenger vehicles globally will have embedded connectivity, according to SBD Automotive's 2020 Connected Services Forecast.[4] A data deluge from connected cars is coming no matter what, and operators that get involved now will be ready to handle the data more economically and efficiently.

The AECC is a multi-industry collaboration formed to maximize the opportunities created by vehicular connectivity and automotive big data. Recognizing the connected car's reliance on cellular networks, leaders from the automotive industry are partnering with carriers, equipment vendors, software developers and cloud service providers.

Proactive mobile network operators are collaborating with the auto industry, which is increasingly focused on delivering services in addition to simply selling vehicles. Services such as dynamic HD maps and intelligent driving rely on the network's ability to instantaneously process localized data and transmit actionable insights. Mobile networks will need the computing resources to process the right data in the right place at the right time: a topology-aware distributed edge computing cloud architecture.

This white paper examines the opportunities for MNOs to become leaders in the emerging ecosystem of the automotive edge. To fully capitalize on this opportunity, mobile network operators need to work closely with a consortium of automotive, edge and cloud solution providers.

The AECC's Topology-aware Distributed Edge Computing Cloud Architecture

What is the AECC and how is its approach unique?

The AECC and its members are working to identify the connected vehicle requirements needed to design the next generation of networks that can think globally and act locally. As cars become increasingly autonomous, data will be processed by the vehicles, in the cloud and in between at strategically located edge compute locations that will capture data that does not need to be aggregated in the cloud.

Consider the numbers: with a billion cars already on the planet, each vehicle replacement represents a new connection. By 2025, 100% of all new vehicles, more than 100 million, will come to market connected, according to IHS, bringing new services and business models to bear. This next generation of connected cars will need to be equipped with fast internet access, artificial intelligence and access to big data analytics for high-definition map creation and distribution, as well as for services like intelligent driving and more. Within four years, hundreds of millions of vehicles will be sending a thousand times more data to the cloud than today's connected cars.

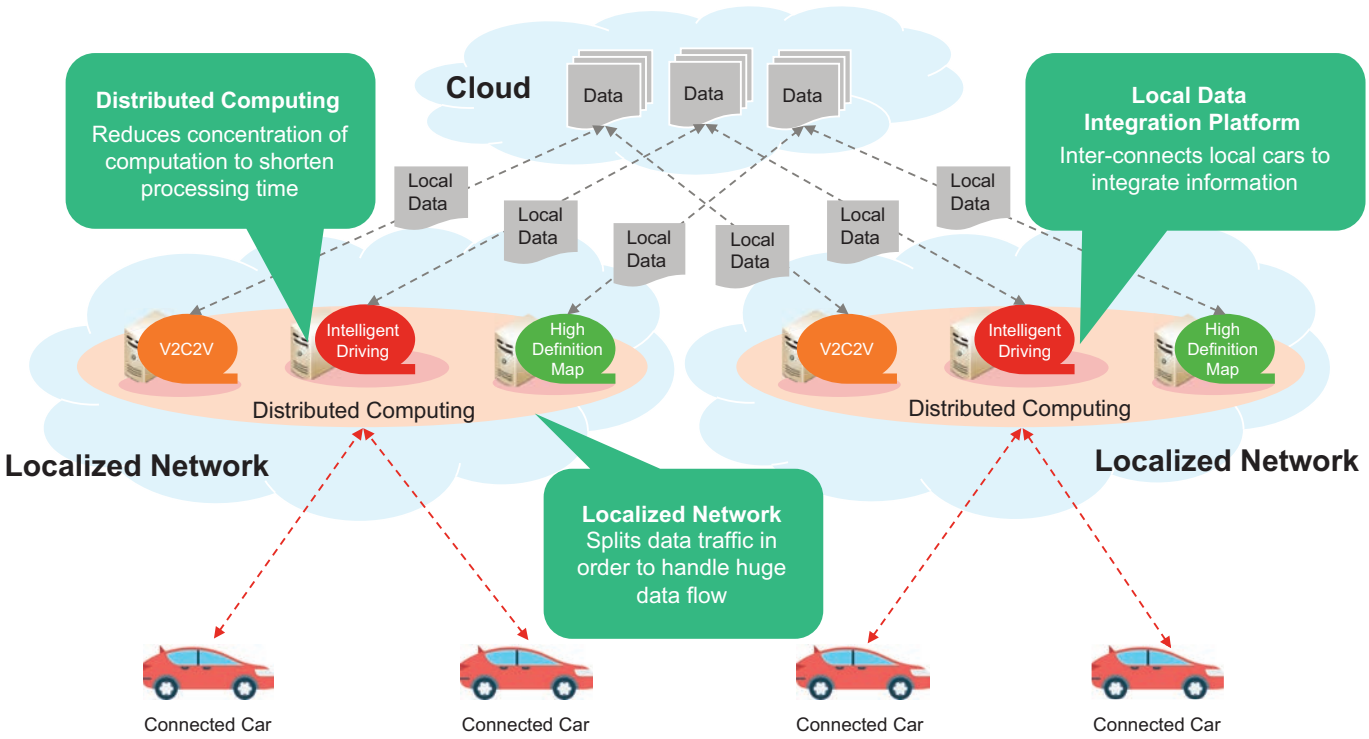
As the connected car market rapidly expands beyond luxury models and premium brands to high-volume, mid-market models, the industry will soon reach a tipping point. The volume of vehicle data generated will overwhelm existing cloud, computing and communications infrastructure resources.

Not all vehicular data needs to travel to the cloud. "Data has a nature of locality," explained Toyota's Ken-ichi Murata, Chair of the AECC, and Fellow and General Manager of Connected Cars at Toyota. "The vehicles in Texas do not need data from New York. … That's just a waste of network."

With the right infrastructure and protocols in place, connected cars will be able to interact with cellular networks rather than just using them to send massive amounts of data to the cloud. Navigation is a good example. Unlike today's navigation apps, which use relatively small amounts of cellular data, real-time high-definition maps will be in constant communication with the network, providing a service that will be highly valuable to drivers. Cars will be able to quickly alert drivers to dangerous traffic patterns or help them find parking in crowded areas.

A localized distributed edge computing cloud architecture speeds data processing by matching compute resources with the vehicles that need them. In the context of edge computing for automotive use, the "edge" means the hierarchically distributed non-central clouds where computation resources are deployed, and edge computing technology can be used to design a flexible topology-aware cloud infrastructure.

Distributed edge computing on localized networks



(Source: AECC)

This architecture creates an opportunity for mobile network operators to host edge servers running cloud-based applications. The cloud is dominated by a handful of hyperscalers, but at the edge, MNOs have more of a chance to participate, given their position as owners of the network access points. MNOs are already experimenting with this business model, according to the AECC's Proof of Concept Committee.

As mobile operators invest in edge-based servers meant to host cloud applications, the goal is typically to support mobile subscribers. But within a few short years, this infrastructure could support not just mobile but also mobility, the connected car ecosystem that auto executives call the mobility industry.

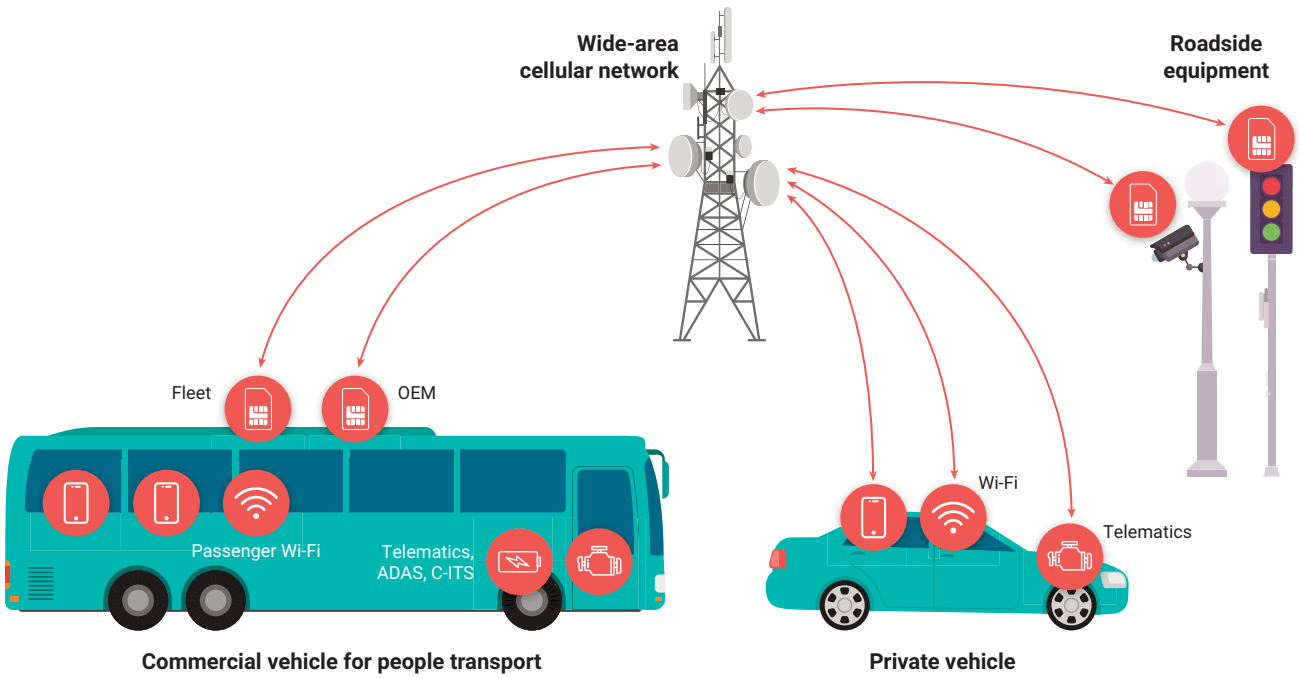
AECC Director Roger Berg, Vice President for R&D in North America at DENSO International America, sees smartphones already creating a need for a robust edge network. "If similar needs from the mobility industry can be met by a distributed computing network architecture set up for smartphone apps, then the MNO has another vertical from which to gather additional ARPU sources from the same network," Berg noted.

The Distributed Edge Ecosystem

These futuristic features will rely on the cooperation of many different ecosystem participants. Connected vehicles are supported not just by the automakers, but also by the thousands of companies that service cars and trucks, all of which can benefit from automotive big data. Makers of roadside infrastructure are also part of the mobility ecosystem, since street signs, billboards and stoplights can all potentially be connected to the internet.

Many different technology providers are investing human and financial capital to learn how to better serve the automotive industry. From the chips that connect devices and power servers to the data centers that process exabytes per day, IT hardware is integral to the connected car. In addition to mobile network operators, fiber providers, satellite operators and Wi-Fi equipment vendors are eyeing the connected car opportunity.

Connected vehicles are supported by a heterogeneous ecosystem



(Source: AECC and AECC member Ericsson, 2021)

The AECC has assembled a partnership that connects industries and brings together the connected vehicle ecosystem. AECC members include automotive technology heavyweights DENSO and Toyota, along with information and communications technology (ICT) leaders AT&T, Dell EMC, Cisco, Ericsson, Intel, KDDI, NTT and Samsung. Data center leader Equinix is also a member, as is Google. The consortium also includes software giants Oracle and Microsoft, which has recently made two significant acquisitions of companies that develop mobile network technology.

Exploring the Market Opportunity

Some companies will participate in the market solely by selling products or services, while others will want to monetize the data generated by connected cars. Ownership of that data is a complex issue, especially since drivers may naturally assume that some of the data their cars generate belongs to them. But most of that data will be analyzed and repurposed, and it will generate significant value for a number of industries.

"I expect multiple sources of data … will be used to build a multi-use case, multi-sector analytics platform for mobility data collected through vehicles and related transportation infrastructure," said AECC Director Roger Berg of DENSO.

Network operators may have a role to play in monetizing automotive data, especially if they host edge cloud servers to help process this data. But for operators, hosting applications at the network edge is likely to be a more immediate opportunity. The AECC has identified five primary use cases that will be enabled by a topology-aware distributed edge computing cloud architecture.

Use Cases

HD Mapping

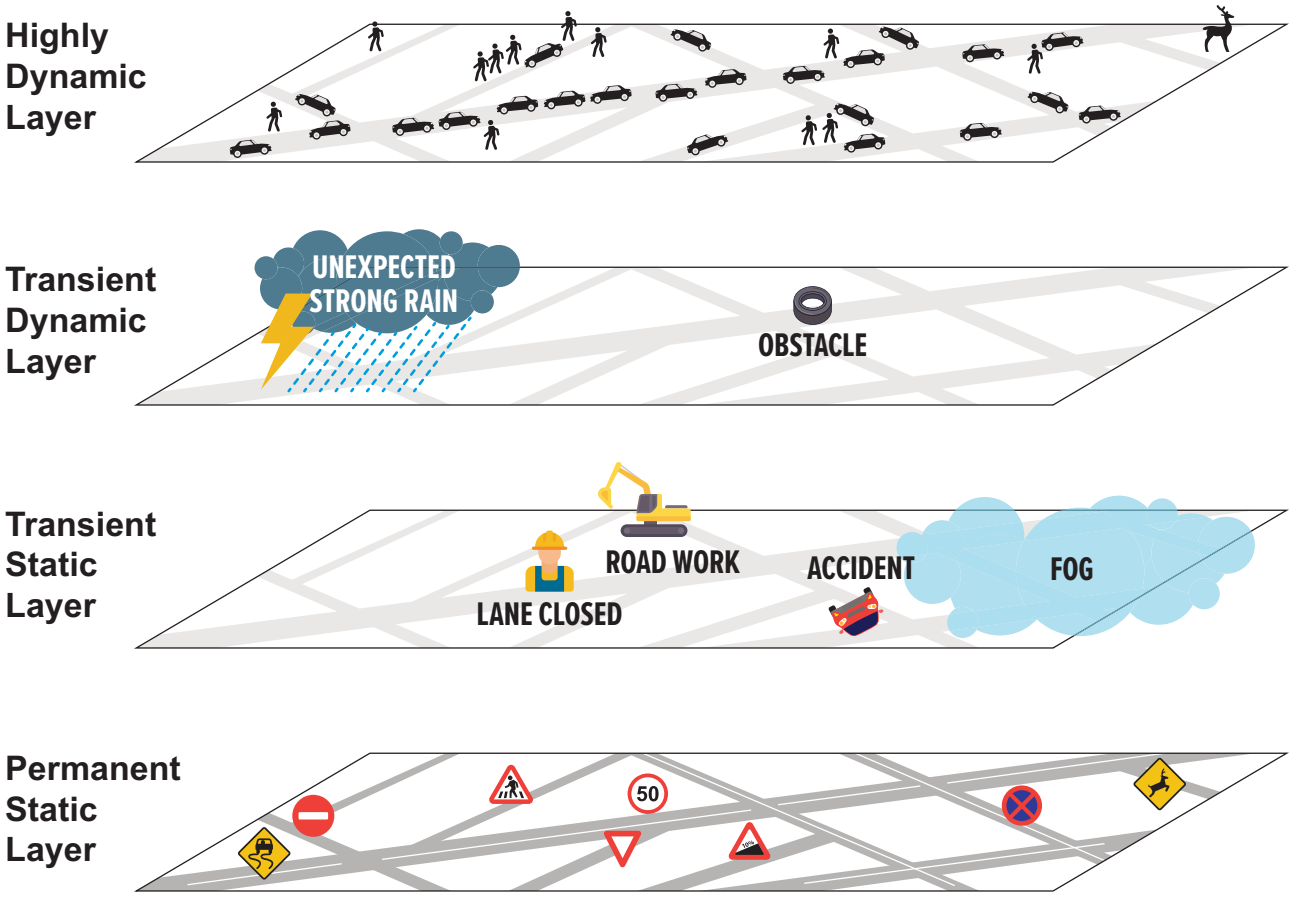
An HD map is a frequently updated map overlaid with various information such as traffic situations, access ways and road obstructions, with high precision at the centimeter level. In the AECC model, dynamic information is classified into four layers according to the time intervals at which dynamic information changes.

HD maps are dynamic because they are constantly updated with information collected by the vehicles. This data can be analyzed by the vehicles or by an edge server, but the maps should be updated by the servers because they rely on information from multiple vehicles. To reliably send and receive HD map data in transit, vehicles need to be able to start a data session in the vicinity of one edge server and continue it in another.

This data session portability is a cornerstone of several connected vehicle use cases, and it relies on the readiness of mobile network operators to use uniform and transparent protocols.

Vodafone, Ericsson and Toyota are testing a proof of concept of 5G core session and service continuity, also called "make-before-break." The team found no loss of connectivity with 5G core make-

Layers of an HD map



(Source: AECC)

before-break gateway switching in its published results and takeaways from joint trials at the Aldenhoven Testing Center.[5]

Technically, session continuity is likely to be achievable, but operationally it will rely on carrier cooperation, like many other standard network features. "That's a big discussion with our MNO friends," said AECC Director Christer Boberg, director of IoT and Cloud Technology Strategies at Ericsson. "How do we build this network of edges to cater to consistent behavior on a global scale? Maybe not the same provider or supplier, but it should have the same methods." Boberg said that if operators are willing to work together, their cooperation can jump-start the connected car market by giving automakers confidence in the networks.

"If there are differences in networks, how can I build one car at production time and deliver it to any of these countries, any of these operators?" Boberg said. "I think that is the main thing that makes it easy … to produce a car, knowing the technology I have incorporated into the car can be used in any operator network I connect to."

Intelligent Driving

A second key use case enabled by a distributed edge is intelligent driving, which relies on sensor data generated by both the vehicle and the driver (biometric data). One goal is to give drivers a complete and dynamic picture of their driving profiles so that exhausted drivers in unsafe cars get off the road. Edge servers can instruct the vehicle on what data to send to the cloud and help to pre-process the data before it is sent. The driver sees near real-time performance metrics.

A driver monitoring his or her performance/alertness on a road trip is likely to move from one edge server's region to the next during the journey. The ability to transfer a data session from one edge server to another again becomes critical.

Insurance

The same data that drivers use to monitor their own performance can be used over time by insurance companies to reward good drivers with better rates. Data from connected cars is highly valuable to insurers, and the most valuable data can be collected at the scene of an accident. This information can be analyzed in the cloud, but if pre-processing occurs at the edge, cars may be able to make prescriptive suggestions to drivers while they are still at the scene. For example, drivers can be prompted to photograph skid marks on the road or to document aspects of a collision before the cars are moved.

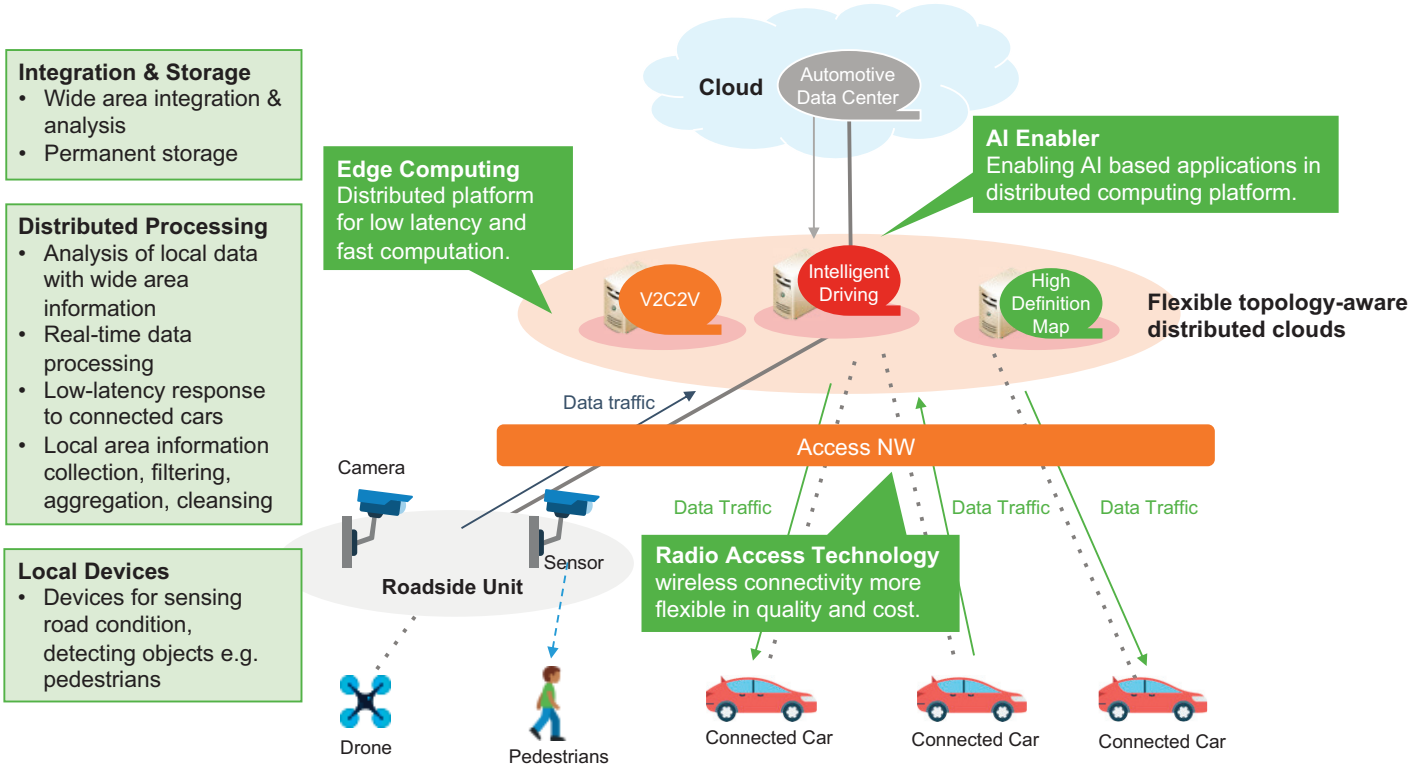
V2Cloud Cruise Assist

V2Cloud Cruise Assist is an evolution of intelligent driving into a more flexible service model. Here the network mediates vehicle-to-vehicle communications by integrating information obtained from neighboring cars. This mechanism is called the vehicle-to-cloud-to-vehicle service or simply V2C2V. This service scenario is especially effective when used to broadcast information to vehicles that need the same information, by utilizing the combination of neighboring vehicles, roadside units and others.

Vehicle groups are highly dynamic, with individual vehicles moving seamlessly from one group to another. Group sizes are also expected to be fungible, as the set of vehicles that needs a given piece of information will vary with the nature of the information.

AECC Director Said Tabet, Chief Architect for Intelligent Connected Vehicles at Dell Technologies, said that edge computing will be essential to managing and processing this data in a timely manner. He said that even hyperscale cloud providers will probably end up directing safety-related vehicular data to the edge.

Connected vehicle services enabled by a distributed, coordinated edge cloud



(Source: AECC)

Another aspect of V2Cloud Cruise Assist is simply expediting the process of moving information from the vehicle to the cloud. According to Tabet, test fleets of autonomous vehicles are generating more data than today's network architectures can handle – they download it and ship cartridges by FedEx to cloud providers. This is not a sustainable model; network architectures need to evolve.

Mobility-as-a-Service

Ridesharing is just one aspect of mobility-as-a-service. Automakers are starting to see cars as generators of ongoing service revenue, and in some cases the car itself becomes the service. "Within one day you will see a vehicle being used as a mobile library or a mobile store or a clinic," said Tabet. "Mobility as a service is about integrating into the environment."

Now Is the Time To Join the AECC

Wireless carriers created a multibillion-dollar smartphone industry by standardizing network protocols, and supporting the next wave of innovation will require even greater levels of cooperation. Connected vehicles will need to move seamlessly from one carrier's edge servers to the next, without service interruption or loss of data.

"It doesn't work for automakers and their service providers if different networks have different capabilities in Dallas than they do in San Antonio," said AECC Director Roger Berg of DENSO, adding that mobile service providers who ignore the reasons to work together run a significant risk.

"In the age of eSIM, a mobile user equipment provider and applications aggregator can virtually instantaneously change MNO/MSP network services in a mobile environment," Berg said. "So for a given application with certain key performance requirements from the network, the mobile equipment *could* choose the network with the necessary capabilities and roam to that network even if the incumbent MNO/MSP has a network overlay. … MNOs need to assess the value of the capital expenditure necessary to invest in multi-access edge computing, and stay competitive in markets where more than one MNO provides service."

Investments in edge computing resources should be made with as much information as possible about how those resources will be used. The Automotive Edge Computing Consortium will define requirements and develop use cases for emerging mobile devices, with a particular focus on the automotive industry, bringing these requirements and use cases into standards bodies, industry consortia and solution providers. The consortium will also encourage the development of best practices for the distributed and layered computing approach. Mobile network operators have an immediate opportunity to be part of this process, instead of waiting until the distributed edge architecture has developed and trying to adapt at a later time.

Connected vehicles are about more than new revenue models for automakers and service providers. Vehicle emissions are one of the biggest contributors to climate change, and traffic accidents claim a life every 25 seconds. These problems can be mitigated when vehicles have a shared perception of their environment. The applications that will enable this are predicated on wireless network interoperability and performance.

The wireless industry's history has repeatedly demonstrated the power of collaborative standard-setting and technology testing. This will prove true once again as mobile network operators approach what is likely to be the biggest opportunity since the smartphone.

AECC
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About the AECC: The Automotive Edge Computing Consortium (AECC) is an association of cross-industry, global leaders working to explore the rapidly evolving and important data and communications needs involved in instrumenting billions of vehicles worldwide. The AECC's goal is to find more efficient ways to support the high-volume data and intelligent services needed for distributed computing and network architecture and infrastructure. The AECC's members are key players in the automotive, high-speed mobile network, edge computing, wireless technology, distributed computing, and artificial intelligence markets.

For more information about the AECC and its membership benefits, please visit aecc.org.

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