WHITEPAPER

Connecting to Opportunity: AECC shows PoCs for next-gen vehicles

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Executive Summary

"The car is rapidly becoming a platform where electronics and connectivity are essential. We see a 40-fold increase in connectivity consumption in these next-gen vehicle platforms. And that will further expand with autonomous vehicles in the future." Rasesh Patel, Chief Product and Platform Officer, AT&T Business[1]

"The average driver would just be blown away if they knew how much cooler their applications could get if the application developer had access to some of the information the vehicle produces." Nick Lefler, Worldwide Business Lead, Automotive Industry Products, AWS [2]

Mobile networks will be the data highways for connected vehicles, and as cars become increasingly advanced, these networks will be as essential as physical highways. For mobile operators, automotive data will make the connected car one of the biggest opportunities since the smartphone.

"We see the vehicle as a sensor … sensing everything and using that data for producing new assets. That's where we see the big value," said Christer Boberg, Director, Ericsson Group Strategy.

Drivers also see value in connected vehicle services. PwC's Digital Auto Report 2021 found more than two thirds of survey respondents willing to pay for connected vehicle services, with European consumers expressing the strongest interest. Sixty-nine percent of those surveyed in Europe said they would pay for a full set of connected vehicle services, and the average price they were prepared to pay was $180 per year.[3]

Accessing a single network will not enable next-generation connected cars to offer consistent services for their drivers or to move data efficiently. Like smartphones, vehicles will need to roam automatically and share data via multiple networks in order to reach their potential in a world where connectivity is ubiquitous and infrastructure is noticed only when it fails to perform.

The standard consumer model of roaming is not well suited for connected cars, which need to work across multiple networks with the same behaviour and fast seamless handovers between networks. A new paradigm has been developed by the Automotive Edge Computing Consortium (AECC).

The AECC is an association of cross-industry, global leaders working to explore the significant data and communications needs involved in instrumenting billions of vehicles worldwide. Automobile original equipment manufacturers (OEMs), mobile network operators (MNOs), and infrastructure providers are working together to develop a reference architecture to support the processing of vehicular data in multiple cloud environments. Elements of this architecture have been demonstrated through proofs of concept (PoCs) involving MNOs and automotive manufacturers.

This paper will summarise the AECC's most recent proofs of concept, as well as the importance of cooperation and data sharing for MNOs as they capitalise on the connected vehicle opportunity.

1 AT&T Investor Day March 11, 2022 | 2 Get In: The Connected Vehicle Podcast January 2. 2022 | 3 PwC Digital Auto Report 2021

Enabling Distributed Edges

Edge computing is foundational for context-aware automobiles because data cannot make a round trip to the cloud in time to support real-time decision making in a dynamic environment.

Furthermore, connected vehicle applications need to operate in multiple edge-cloud environments. Different public clouds will be available in different places, and not all clouds are created equal.

"Certain clouds may be more suited for certain things," explained Said Tabet, Chief Architect for Intelligent Connected Vehicles at Dell Technologies, a contributing member of AECC. "One may be good for training the artificial intelligence/machine learning algorithms and others may be more suited for gathering the data."

The AECC distributed edge PoC, anchored by Oracle Japan, verified interoperability with multiple clouds: Oracle, AWS, Microsoft Azure, Google Cloud Platform, and Wasabi. The use case tested was high-definition mapping (HD mapping), which consolidates static and dynamic information such as vehicle position in relation to other vehicles, pedestrians, and obstacles.

The PoC addressed accessibility by creating a distributed edge testbed simulation to serve one million connected vehicles. It addressed performance and scalability by validating AECC's concept on managing HD mapping data in a hierarchical manner.

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Said Tabet, Chief Architect for Intelligent Connected Vehicles at Dell Technologies

Results confirmed dynamic event management and the ability to optimise driving routes with an average processing time of less than 200 milliseconds. Summary indexes used a subquery engine, considering the minimum and maximum values of each column per data block and performing filtering and subtotal operations on data from senders. The subquery component produced a 10x reduction in query latency.

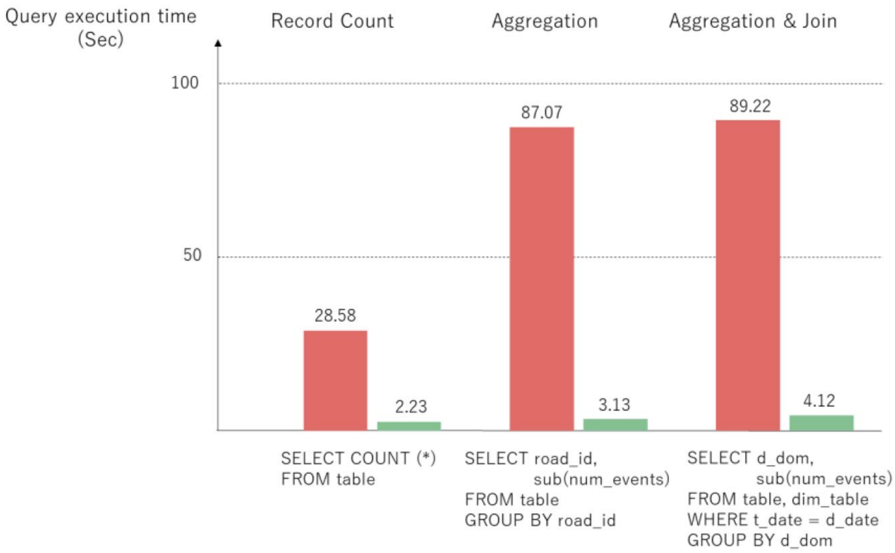
Roger Berg, VP for R&D in North America at DENSO International America, and AECC Communications Vice Chair, said this 10x reduction in latency is a result that should attract attention from automotive service providers as well as MNOs. Performance with a single replica set of 2-5 servers syncing the data provided roughly 100,000 transactions per second for update requests with sub-millisecond response time for single records and 2-3 milliseconds

"The AECC architecture will support multiple use cases for connected vehicle services."

Roger Berg, Vice President North America Research and Development, DENSO

"We invite MNOs for collaboration on PoCs."

Christer Boberg, Director, Ericsson Group Strategy



Source: AECC

for multiple records when queried by a specifying area. With additional replica sets, results scaled in a linear fashion.

Berg predicted this capability could support a myriad of connected car use cases. Examples include intelligent driving support by sensors and LIDAR, and advanced ride-sharing applications that communicate directly with cars.

The study also simulated the AECC's concept of data offloading at distributed edge computing locations, as well as edge server selection, which ensures that processing occurs at the server where the data resides.
Data preprocessing at the edge, combined with the subquery component, produced a dramatic reduction in query execution time.

The next phase of this PoC will examine the addition of other related data sources, such as smartphones, tablets and wearables. The AECC invites the collaboration of member companies and other interested stakeholders.

"We invite MNOs to work with us to demonstrate the values of AECC," said Ericsson's Boberg, an AECC Board Member.

Efficient Data Transfer

Not all data generated by connected vehicles is mission critical. For example, data about the status of vehicular components helps automakers push maintenance reminders to car owners, but should not supersede information about real-time driving conditions. And vehicles will collect some information about the environment which will be of less value, and which needs to be eliminated/down-prioritised to conserve bandwidth for critical data.

AECC developed PoCs with two MNOs, Vodafone and KDDI, in conjunction with other AECC members, to demonstrate efficient data transfer.

Vodafone/Ericsson/Toyota PoC

In this PoC, gateways were used to connect to edge cloud instances where filtering, cleaning, and selection of data was performed. Only the relevant data was forwarded to the central cloud instance, to achieve optimal processing at the right place.

Edge servers are key for local execution of mobility services to reduce traffic flow between vehicle systems in the cloud, and for pre-5G separation of traffic and mobility using evolved packet core control and user plane separation (CUPS). A key function of this PoC was the use of CUPS to implement the distributed user plane for two edge servers while also having one central server and a centralised control plane. The edge or central server selection was managed using different access point names (APNs), both of which connected the car to the network. One APN was configured to offload to the edge servers and the other was configured to offload data at the central gateway to the central server.

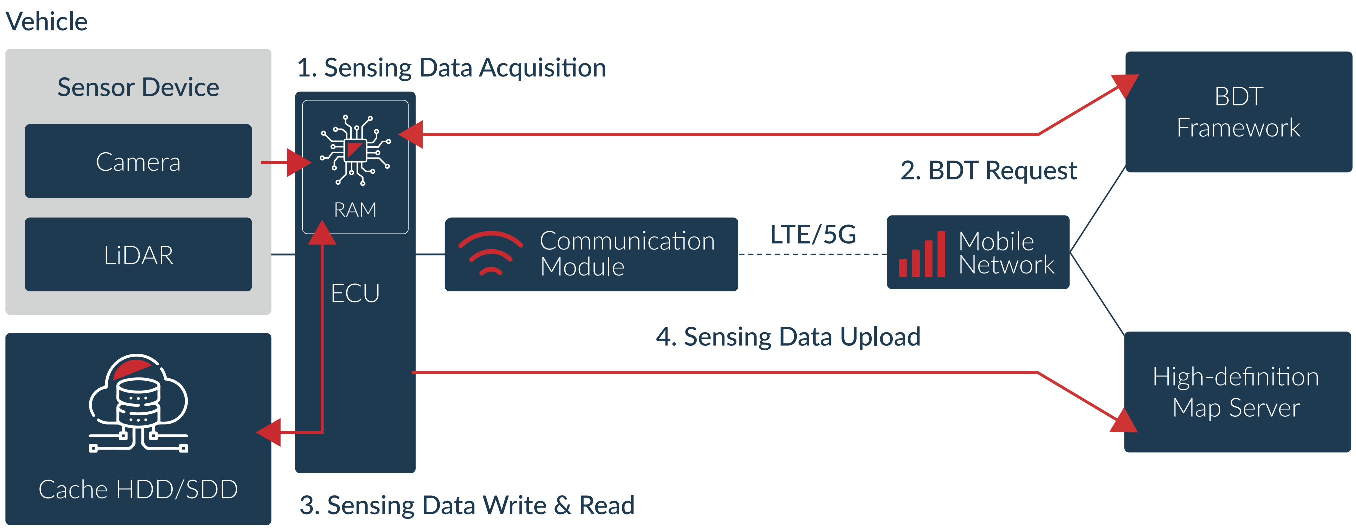
This PoC also demonstrated AECC's 'make or break' protocol. As a car travels, it establishes a session with a new gateway before releasing the old session, guaranteeing consistent connectivity.

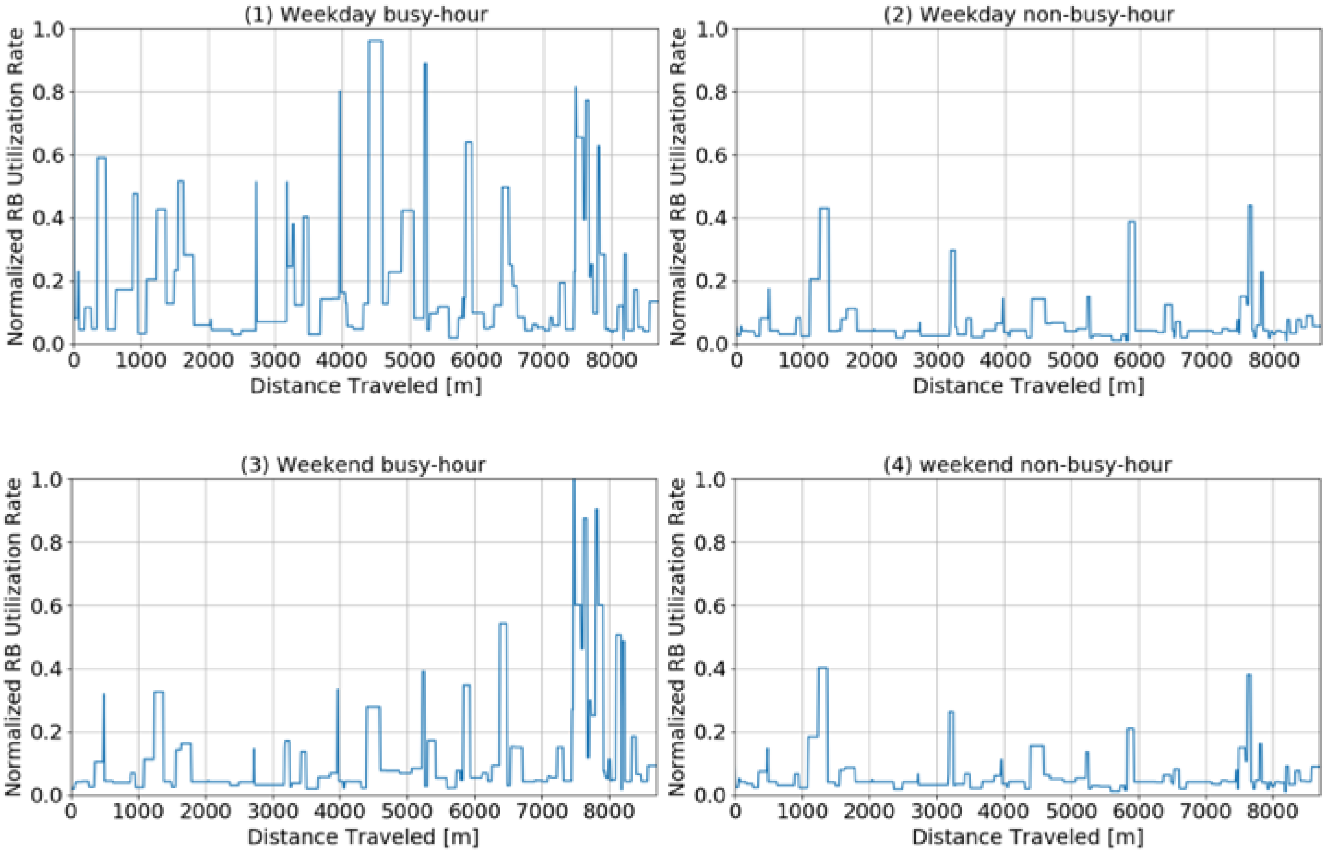
KDDI/DENSO/Toyota PoC

In this PoC, AECC demonstrated Opportunistic Data Transfer (ODT), shifting transmission of lower-priority data to non-busy hours, which enables the mobile network to support connected vehicles deployed at scale with existing network resources. ODT is based on Background Data Transfer (BDT), a 3GPP standard which enables non-time-critical traffic to transmit during times when the network is not congested. BDT was designed for downstream traffic such as software updates, but can also be used for the upstream data generated by automobiles.

ODT uses an on-vehicle cache, the size of which will depend on various factors such as location, data, and applications. In this PoC, the size of the cache was roughly 62MB. Assumptions for this number included four cameras per vehicle, each taking a 2MB image every 10 seconds, with upstream bandwidth of 10Mbps.

An API standardised by 3GPP was used for BDT. It was modified to include parameters crucial for connected vehicle applications such as username and IP address. The API can be exposed by a mobile operator to third party applications, such as HD mapping, the application used for this PoC.





Use of available spectrum, or resource blocks, was successfully managed by ODT. The resource block utilisation rates shown above indicate the percentage of allocated time-frequency radio resources for mobile users served in the LTE base station.

AECC noted real-world traffic conditions will result in multiple vehicles uploading similar videos or images, creating redundant data. ODT will help prevent this data from straining network resources or pre-empting critical driver data. And as connected vehicles scale, ODT will be necessary for sustainable management of the data generated.

“We haven't deployed hundreds of millions yet, but it's going to happen,” said Dell’s Tabet. “As we go full scale, sustainability is going to be another issue.”

Laying the groundwork for commercial deployments

AECC is working to create a foundation for commercialisation of connected vehicles, but technical proofs of concept are just one element. Standardisation and cooperation between MNOs is another condition automakers are likely to require before making significant investments in applications that require real-time distributed edge computing.

"There's still some reticence, if you will, on deploying the system without knowing that their users have a consistent experience with some of those services," said DENSO's Berg.

Just as Europeans rely on their smartphones to connect to operator networks outside their home countries, drivers will count on cars to provide similar services in different geographies. Even within one country, motorists will need to transition seamlessly when they leave their carrier's coverage area, or connect to a different cloud provider's edge data center.

"I need to have the same services in New York that I do in Miami that I do in Dallas that I do in Spokane," summarised Berg, adding automakers are not yet convinced this will be the case.

Tim Hatt, Head of Research and Consulting at GSMA, argued the time is right for MNOs to support automakers with cross-border roaming. He sees the trends of a recovery in roaming and electrification of vehicles converging around connected cars.

"Just as roaming was one of the areas in the telecoms business hit hardest by the pandemic, its recovery is starting to feed through as international travel and cross-border commerce recovers – as we noted in our Radar series," said Hatt. "This dovetails with the parallel rise in connected cars, something that will accelerate organically and as EVs take a larger share of new car sales. The revenue upside for operators, however, depends in part on having roaming compatibility in place for commercial logistics and passenger vehicles to support edge processing for HD mapping and other features that require low latencies in real time."

Ericsson's Boberg said network operators cannot simply translate their smartphone roaming models to the automotive arena. "The current roaming model with home routing of traffic where you route back to your home network is not suitable for large data transfer type of use cases where edge compute is needed," he explained. "You rather need to do a swap to the local network that you are visiting to meet behaviour and performance needs."

Embedded SIM (eSIM) technology will help cars move from one network to another. The automotive industry supports the GSMA Embedded SIM specification, which replaces operator SIM cards with

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Tim Hatt, Head of Research and Consulting at GSMA Intelligence

chips that can be remotely provisioned to a network. This speeds up auto manufacturing by eliminating the need to build different cars with various connectivity modules for each market. Instead, an automaker can use the same module in all vehicles, and provision them to a given operator's network via a remote software update that can occur late in the production process. In theory, remote provisioning can also be used to move cars from one mobile network to another in transit.

"We need operators to support it on a broad scale," said Boberg. "It's not enough if we have a few since automotive is a global industry."

Collaboration unlocks opportunity

Data will be the engine driving profits for both traditional and non-traditional automotive market participants. “Everything relates to owning and managing the data and creating value based on the collected data,” said Boberg. MNOs need to cooperate so that all can benefit from the new revenue connected cars will generate.

In order to capitalise on vehicular data, MNOs need to enable interoperable distributed edge architectures.

Failure to collaborate will lead to siloed solutions and will fragment the market for next-generation automotive services. Since most automakers are not limited by geography, they may choose to bypass MNOs for some data capture, if the distributed edge technology automakers want to use is not widely available. For example, most of the information needed for predictive maintenance and insurance rate calculation could be uploaded to automotive service providers at night over a driver’s home internet connection if the car connects to Wi-Fi. On the road, cellular has a clear advantage over Wi-Fi, and MNOs need to utilise this advantage in order to make their networks the preferred path for all automotive data.

For MNOs, this is the time to collaborate with one another and with automotive companies, software developers, and infrastructure providers. AECC invites collaboration between AECC member companies and other stakeholders who are interested in developing efficient data transmission for connected vehicles and associated applications and service.

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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