The C-V2X Deployment Journey toward Next Generation Mobility

August 7
09:00 AM (PDT)
12:00 PM (EDT)
This webinar is the continuation of the 5GAA webinar series tailored for US Road Infrastructure Owner-Operators. The webinar will show

✓ that C-V2X deployment and end-to-end services are very real – and transformational

✓ on the ‘entrance ramp’ to C-V2X use of 5.9 GHz with the impeding FCC rulemaking

✓ the rich C-V2X technology ecosystem

✓ the ongoing C-V2X deployment activities

✓ end-to-end services to be delivered in the new future

Agenda

Introduction
Jim Misener, 5GAA Board Member/Qualcomm

Agencies Continue to Break CV Barriers!
Alan Clelland, Vice President, West at Applied Information

Neutral Host Digital Infrastructure For Intelligent Transportation
Youssef Abdelilah, Global Innovation – Office of CTO at American Tower

The role of MNOs in the Future of Transportation
Jyoti Sharma, Manager of Technology Strategy & Architecture at Verizon

Multi-Access Edge Computing (MEC) for C-V2X
Suman Sehra, Global Director at Intel and Ming Lei, Senior Platform Architect at Intel

Q&A
Moderated by Jim Misener, 5GAA Board Member/Qualcomm
Practical Information

• Attendees are by default on mute to avoid background noise

• The web-conference has two parts:
  – Speakers presentations (50 minutes)
  – Q&A session (40 minutes)

• We kindly ask you to submit your questions in a written form, using the question bar rather than raising your hand
Have a great web-conference!
Agencies Continue to Break CV Barriers!

Alan Clelland
Applied Information
Showcased Deployments using C-V2X technologies in Georgia:

- City of Marietta
  - 1\textsuperscript{st} city in the United States to deploy a city-wide C-V2X (C2N) cellular-based connected vehicle system
- City of Alpharetta
  - Mixture of intersections with DSRC and C-V2X Direct and Network
Applied Information C-V2X Intersection Deployment Approach

Field Monitoring Unit
Traffic Signal Controller
Dual Mode Radios
Easy-to-maintain Installation

Short Range Antennas
Network/GPS Antennas
Dual Mode Radios
Day 1 Applications provided Clear Benefits to the cities and their Residents/Road Users

• Emergency Response times decreased and lives saved
• Transit schedule adherence improved
• Cost savings in city operations
• Better monitoring of infrastructure equipment leading to higher availability
The Nimitz Corridor Project, Hawaii

- Joint project between Hawaii DOT and the University of Hawaii
- First deployment of dual mode/dual active equipment
  - Qualcomm C-V2X chip set used
- Assessment of technology and applications including:
  - Emergency Vehicle Preemption
  - Transit Signal Priority
  - Traffic Signal Efficiency Improvements
  - Red Light Violation Warning
  - Pedestrian in Crosswalk Warning
Dual Mode/Dual Active now in Operation!!

C-V2X Status
SPaT and MAP Tx
July 16, 2020
The Nimitz Corridor
... with Cities, too!

- City of Arlington, TX
  - City desire to continue initial investment in CV applications through C-V2X Direct and Network
  - Piggy-backs on existing fiber network
  - Emergency Vehicle Priority
    - 31 intersections
    - 10 vehicles
Conclusions Drawn/Results so far?

- C-V2X deployments continue and are gaining momentum when they:
  - Support Day 1 applications with clear benefits
  - Protect the agency’s investment through future-proofing
- Nimitz Corridor is the pre-cursor to the Hawaii DOT’s announced intention to equip all the islands
Thank you!

Alan Clelland
Applied Information Inc
aclelland@appinfoinc.com
Neutral Host Digital Infrastructure For Intelligent Transportation

Youssef Abdelilah

Office of the CTO
7th August 2020
American Tower Overview

AMT is a globally diversified provider of Mission-Critical Communications Real Estate

Comprehensive Portfolio

- U.S. (~41,000 towers)
- International (~138,500 towers)
- Indoor DAS (~1,800 global sites)
- Real Estate Connectivity Management
- Partnerships with leading global Mobile Network Operators

A Leading Independent Tower Provider and The Largest Neutral Host Infrastructure Provider in the U.S.
New Technology Transform New Digital Infrastructure

➢ Holistic and system level approach

➢ New paradigm to meet the new and fast changing emerging technologies

➢ ATC as a Neutral Host digital infrastructure provider can play a valuable role in intelligent transportation including C-V2X

➢ Private, local and federal collaboration and ecosystem

Leverage the right spectrum and the right technology solution for the right use case at much lower TCO
Neutral Host Smart Intersection for C-V2X

Goal is to develop shared digital infrastructure to enable C-V2X adoption
Sensor Fusion for Smart Intersection

Single contact for easy operation, monitoring, and unified data analytics for multi-RAT technologies
ATC Paris2Connect Active Case Study
Vision of Smart City of the future - Attractive, Resilient, Low Carbon, Sustainable, People-Centered, Inclusive
Neutral Host for Accelerating CV2X Market Adoption

**Potential Funding**

- **Federal Support**
  - 2020 USDOT budget is $86.2B, $1B included for BUILD grants to support innovative projects to upgrade infrastructure
  - Local government and private sector may apply for grants
  - S 2302 (Senate) and H.R. 2 (House) call for $287B and $1.6T, respectively, for infrastructure improvements

- **State & Local Support**
  - Most state budgets have DOT funding
  - Cities discussed above have substantial funding available
  - Multi-city & regional partnerships to pool funding resources
  - Grants and assistance from USDOT

- **Private Sector**
  - Government interest in PPPs is on the rise, driven by COVID-19 success
  - Innovative contracting arrangements
  - Design-Build
  - Design-Build-Operate-Maintain
  - Design-Build-Finance-Operate

**Value Prop**

- Accelerate time to market & faster deployment
- Lower TCO with shared resources to optimize CAPEX and OPEX
- Future technology proofing
- A single contact to facilitate private/public collaborations & simplify ecosystem partnerships

**Business Model Example**

- Neutral Host
  - Passive Infrastructure
  - Active Infrastructure
- Infrastructure municipality landlord
- Value added services

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Source of data: Brownstein Hyatt Farber Schreck, K&L Gates, June 2020

Deploy shared digital infrastructure today's technologies and tomorrow's innovations to speed up the adoption of intelligent transportation including C-V2X, Autonomous Vehicle
A global leader in wireless infrastructure

For more information about American Tower, please visit www.americantower.com
The role of MNOs in the Future of Transportation

Jyoti Sharma
Technology Strategy
Verizon

August 7, 2020
Building blocks of 5G

All-band (low-band, mid-band and millimeter wave) spectrum

Fiber
- Significant fiber deployments in 60 major markets outside VZ ILEC footprint to drive densification.
- Multi-year project and Verizon has committed to invest $1.05 billion on new fiber-optic cable from Corning.

Ultra-dense small cell deployment

New Radio
- Advanced coding and modulation
- Massive multiple input, multiple output (MIMO)
- Beamforming
- Flexible spectrum use
- Flexible/full duplex

Software defined networking (SDN)/network function virtualization (NFV) + 5G next-generation core (NGC)
- Network evolution & slicing
- Service-based architecture
- Operational agility
- Universal adaptive core

Mobile Edge Computing (MEC)

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5G Ready – 5G First

First 5G network with first commercially available 5G-enabled smartphone

5G testing
11 markets
2017

- Chicago
- Minneapolis

35 cities launched as of February 2020

24 Stadiums 5G UWB enabled
**5G Currencies/Capabilities**

**Throughput**

- **10 Gb/s**

- AR/VR/4K immersive content streaming

**Latency**

- **5 ms**

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**Energy Efficiency**

- 10% of current energy consumption

- Intelligent Beam
- Forming/Steering
- Long Life, Low Maintenance Sensors

**Connected Devices**

- 1M / km²

<table>
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<tr>
<th>Connected Wearables</th>
<th>IoT Sensors</th>
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**Data Volume**

- 10 TB/s/km²

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<tr>
<th>Smart Stadiums</th>
<th>HD 3D Mapping</th>
<th>Intelligent Video &amp; localized AI/ML</th>
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**Mobility**

- **500 km/h**

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<th>In-vehicle connectivity</th>
<th>Drones &amp; AGVs/connected robots</th>
<th>IoT solutions via ThingSpace</th>
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**Reliability**

- **99.999%**

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<tr>
<th>Autonomous Vehicles</th>
<th>Secure Customer Driven Network</th>
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**Service Deployment**

- **90 mins**

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<th>Real-time face recognition/language translation</th>
<th>Unified comms &amp; security offerings</th>
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# 5G + MEC – Powering 4th Industrial Revolution

<table>
<thead>
<tr>
<th>Wireless site with MEC</th>
<th>Network slices</th>
<th>5G</th>
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<tbody>
<tr>
<td><strong>Edge Cloud Platform</strong></td>
<td>Ultra low latency</td>
<td></td>
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<tr>
<td><strong>Cloud Partner</strong></td>
<td>Massive Machine type</td>
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<tr>
<td><strong>verizon Network Cloud</strong></td>
<td>Extreme reliability</td>
<td></td>
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<td></td>
<td>Large bandwidth</td>
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- Public Cloud

- Cost
- Energy
- Reliability
- Security

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MEC: 5G currencies enable new use cases

**General Purpose**
- App development and testing
- SaaS (CRM, ERP, Vertical)
- Generic web hosting
- Big data analytics
- Data storage
- Cloud enablement of apps

**Metro**
- Real-time supply chain
- Augmented reality in stores
- Shelf inventory
- Volumetric rendering

**Far Edge**
- Remote patient monitoring
- Cloud gaming
- Autonomous vehicles

**On-site**
- Predictive maintenance
- QA automation
- Industrial/robotic control
- Thin client
- Private/secure network

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**5G Currencies**
- Peak Data Rate
- Service Deployment
- Energy Consumption
- Connected Devices
- Reliability
- Mobility
- Energy Use
- Performance

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**Latency**
- **Cloud**: Latency >80 ms
- **Service Access Point**: 80-20 ms
- **Centralized Radio Access Network**: 20-7 ms
- **Enterprise**: <7 ms

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## Six ways MEC delivers value

<table>
<thead>
<tr>
<th>Better performance</th>
<th>Faster data access</th>
<th>Greater efficiency</th>
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<tbody>
<tr>
<td>Speed is the requirement and promise of transformation projects, and Verizon 5G Edge reduces application response times and performance latency. Edge computing reduces the latency that comes with compute and storage residing at faraway data centers.</td>
<td>Data is the new differentiator; the faster and better you are able to harness, process, analyze and use data, the clearer the advantage. Data can be acted on near where it’s created, which can result in greater performance, contextually aware applications and improved security.</td>
<td>The Verizon 5G Edge platform with AWS preintegrates networking and compute services, which enables developers to easily configure and optimize their application through end-to-end services. It provides highly reliable compute and network services.</td>
</tr>
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<tr>
<th>Alignment of cloud and mobile</th>
<th>IoT expansion</th>
<th>Accelerating transformation</th>
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<tr>
<td>Verizon 5G Edge offers connectivity and device management solutions that enable enterprises to plan their mobile and cloud strategies together.</td>
<td>The right edge approach is critical to meeting the rapid expansion of IoT, which is where Verizon 5G Edge comes in. It can even address IoT challenges such as energy use and battery life.</td>
<td>Verizon 5G Edge can enable new applications across many industries—improving customer experiences, creating new efficiencies, etc. It might also help realize myriad AI applications.</td>
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## C-V2X Use Cases transform the CAV experience

<table>
<thead>
<tr>
<th>Infotainment</th>
<th>Safety</th>
<th>General</th>
<th>Smart City</th>
<th>Fleet*</th>
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<tbody>
<tr>
<td>• Content Delivery and Updates</td>
<td>• Collision Avoidance</td>
<td>• Over the Air (OTA) Vehicle Systems Updates</td>
<td>• Smart Parking</td>
<td>• Real Time Situational Awareness</td>
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<tr>
<td>• 3D and HD Mapping</td>
<td>• Traffic Signal Detection</td>
<td>• Compute Offload</td>
<td>• Emergency Vehicle Priority</td>
<td>• Teleoperations</td>
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<tr>
<td>• Heads up Display AR</td>
<td>• See-Through</td>
<td>• Remote Vehicle Health Monitoring</td>
<td>• Green Light Optimization</td>
<td>• Truck Platooning</td>
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<tr>
<td>• Video Sharing between Vehicles</td>
<td>• Vulnerable Road User</td>
<td>• V2X Security</td>
<td>• Visual Monitoring of Intersections</td>
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<tr>
<td></td>
<td>• Left Turn Assist</td>
<td></td>
<td>• Curbside Management</td>
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Public Private Partnership

- **Cellular Vehicle to Everything (C-V2X) Solution** - supports broadcast messages to vehicles, pedestrians, and bicycles utilizing sophisticated computer vision on smart cameras and signal phase data from traffic cabinet.

- **4G/5G Communications Infrastructure** - 4G/5G radios, wireless network, Multi-Access Edge Compute (MEC) infrastructure and fiber backhaul used as foundational network supporting C-V2X communications in real time.

- **Connect** - cloud based fleet management solution. Devices installed on board vehicles to track location, speed, diagnostics, and driver safety metrics. Compliments data from connected and autonomous (CAV) vehicles and C-V2X to offer additional safety insights.

- **City Data Insights** - Cloud based central data repository provided as a managed service, which will serve as the data management platform for the program. Data to be collected from CAVs, C-V2X, Connect, and other sensor data made available by CCTA and municipalities.

Leveraging 5G Infrastructure Deployment

**4G/5G unified connectivity**

Intelligently connecting the car to cloud and surroundings

Deployment Scope:

- **GoMentum** - proving grounds for testing solution before deployment to other locations
- **Rossmoor** - providing shared AVs to serve elderly community
- **County Hospital/Martinez** - autonomous shuttles to serve the disabled
- **Personal Mobility on I-680** - test the impact of CAV/C-V2X on personal mobility
Multi-Access Edge Computing (MEC) for C-V2X

Ming Lei (ming.lei@intel.com)
Senior Platform Architect

Suman Sehra (suman.a.sehra@intel.com)
Global Director of Smart Cities & Transportation

Intel Corporation

5GAA Webinar on "The C-V2X Deployment Journey toward Next Generation Mobility"
August 7, 2020
Outline

• Overview of Scenarios & Use Cases
• Smart Intersections Enabled by MEC and C-V2X
• Safety Service Enabled by MEC and C-V2X
• System Architecture
• From Concept to Proof
Overview of Scenarios & Use Cases

4 scenarios including 11 use cases can be defined by the interaction among the 3 entities:

**Multi-access Edge Computing (MEC), Vehicles and Roadside Equipment**

**Scenario A**: Interaction among MEC, roadside equipment and multiple vehicles
- A1: Smart intersections
- A2: Traffic merging assistance at the ramp junctions
- A3: Large-scale collaborative path planning & navigation

**Scenario B**: Interaction among MEC, roadside equipment and single vehicle
- B1: Warning of reckless or fatigue driving
- B2: Warning of violating traffic regulations

**Scenario C**: Interaction between MEC and multiple vehicles
- C1: V2V message forwarding
- C2: Vehicle sensing info sharing

**Scenario D**: Interaction between MEC and single vehicle
- D1: Local info dissemination
- D2: Dynamic high-precision map
- D3: Driving assistance enhancement
- D4: On-line vehicle diagnosis

Source: Illustrations adapted from the material from C-V2X WG of IMT-2020 PG, March 2020
Smart Intersections Enabled by MEC and C-V2X

**TODAY**

Legacy Architectures inhibit Improvements that are necessary for improving Traffic Management and Safety

- Limited Compute, Use Case Specific Solutions
- Discreet Edge Nodes/Boxes With Unique HW
- High TCO
- Discreet Solutions with Unique HW/Sensors
- Induction Loop Traffic Sensors
- Data Centric Solutions

**FUTURE**

- Real Time Video Analytics
- Latency, Bandwidth, Security, Connectivity
- Artificial Intelligence and Optimization
- Increased Revenue
- Improve TCO
- Future Proof Infrastructure
- Workload convergence enables better TCO, system management
- Modularity allows device heterogeneity and future proofs infrastructure
- RSU Sensor Modality for complete scene intelligence
- Cost efficiency and improved processes reduce TCO
- RSE - IoT and N/W WLC with high compute
- Vehicle Detection ALPR
- Pedestrian Detection
- V2X
Safety Service Enabled by MEC and C-V2X

- **C-V2X** is a **connectivity technology** and can be complemented by **sensing capabilities** deployed at the roadside.
- **Computer Vision** can be used for the **detection & classification** of the road users, incidents & situations.
- **Safety Messages** based on the **Computer Vision Analytics** are:
  - Directly disseminated from RSUs to connected vehicles and other road participants (e.g. pedestrians).
  - Relayed from the source RSU to neighboring ones and transmitted to connected road participants, for a large scale of information dissemination.

**Smart RSU**: Convergence of
- Computer Vision
- Wireless Communications
- Edge Computing
System Architecture

Edge Applications
- Information & Service
- Traffic Efficiency
- Traffic Safety
- Other Edge Apps

MEC Platform (Cloud Edge)

Access Network, Roadside & Terminals
- Access Network
- MEC Platform (Roadside Edge)
- Intelligent Traffic Management System (Traffic Signals, Digital Signs, ...)
- Roadside Sensing Equipment (Cameras, Radars, Sensors, ...)
- Vehicle / Pedestrian
- RSU

Cloud

Other MEC Platforms

MEC supports C-V2X services over both 5.9GHz PC5 and Uu links
A PoC system to demonstrate MEC supporting C-V2X services

Diagram source: Soo Jin Tan & Andrew Khor, Intel
Thank you!

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Senior Platform Architect

Suman Sehra (suman.a.sehra@intel.com)
Global Director of Smart Cities & Transportation

Intel Corporation
Questions?
Thank you for joining!

For more information please contact:

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