Vehicle to Network to Everything (V2N2X):
Architecture, Solution Blueprint, Use Case Implementation
Examples and Business Perspectives on V2N2X Deployments

5GAA online session, 18 June, 16:00 – 17:00 (CEST)
Structure

1. Opening remarks & introduction
2. V2N2X architecture
3. V2N2X Solution Blueprint and Use Case Implementation Examples
4. Business perspectives
5. Closing remarks
6. Q&A
Introduction

• 100s of Millions of connected vehicles are on the road today

• Too many car accidents around the world and resulting with injuries and casualties

• Focusing on the connectivity over the cellular networks

• Bring full complete solution, cover all aspects to create 'standard' document for deployment

• 5GAA terminology of C-V2X covers both network and the short range communication
Motivation

• Increase road users' situational awareness

• Will work wherever cellular coverage is available

• Can be deployed in vehicles that are already on the road

• The need to provide methods to implement and business model
V2N2X WI TR content

• Work Item Lead: General Motors – Yohay Buchbut
  • Co-Lead: China Mobile - Yinxiang Zheng

• E2E solution architecture
  • Lead: Deutsche Telekom - Johannes Springer;
  • Co-Leads: Ericsson - Tomas Nylander & Yunpeng Zang;

• Use Case Implementation Examples
  • Lead: Verizon – Shammi Amin, Jyoti Sharma;
  • Co-Lead: Vodafone - Tony Sammut

• Business perspectives
  • Lead: Monotch - Menno Malta;
  • Co-Lead: Monotch - Gary Lin
V2N2X White-Paper complemented by two Technical Reports

- For ecosystem stakeholders interested in using cellular networks for V2X services and applications:
  - Automotive OEMs (OEMs), Infrastructure Owners, and Operators (IOOs), Service Providers (SPs)

- To understand the V2N2X architecture, cross-stakeholder information sharing concept, and V2N2X technical details

- By existing use case implementation examples
  - Traffic event information sharing; Traffic signal information sharing and priority request, Emergency vehicle approaching, HD Map handling, Automated valet parking, Object detection and sharing, and Vulnerable road user protection.

Weblink to technical aspects
Weblink to business & deployment perspectives
V2N2X architecture

Tomas Nylander, Ericsson

Evolving steps in road traffic management

From an Analog to a Shared Digital Future

<table>
<thead>
<tr>
<th>1920s - 1990s</th>
<th>1990s - 2010s</th>
<th>2010s - Now</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure Builder</td>
<td>Infrastructure Operator and Maintainer</td>
<td>Infrastructure Service Provider</td>
<td>Infrastructure Service Manager</td>
</tr>
</tbody>
</table>

- **IOO Infrastructure**
- **Humans**
- **Devices**

**How to gain**
- Scale (systems/operation)
- E2E Consistency
- Rapid benefits
- Improvements in road safety and efficiency

**Maintaining**
- Local autonomy
- Trust in IOOs’ digital information

- Increased need to communicate with diverse digital devices (machines)
- New availability of digital information from diverse devices

**Major evolution steps in road traffic management (Source: FHWA, Dec. 2023)**

IOO: Infrastructure Owner and Operator (aka ‘road authority/road operator’)

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We define a deployable architecture and accompanying enterprise relationships... 

- Nationwide and cross-jurisdictional, cross-industry extensibility
  - Local, regional and state agencies
  - Vehicle OEMs
  - Communication service providers
  - Applications

- Includes structure for models of:
  - Governance
  - Initiation
  - Operations

...to address a broad range of mobility and use cases for systems management and to individual traveler.
Abstract view of an application-level reference architecture

Information sharing domain

- Service Provider and their connected clients
- IOO and their connected infrastructure
- Vehicle OEM and connected Vehicles
- Service Provider and their connected clients
- IOO and their connected infrastructure
- Vehicle OEM and connected Vehicles

Vehicle OEM and connected Vehicles
V2N2X applied architecture overview

**Eco system preparation:** Governance E.g. Framework for data sharing, data quality, privacy & security. Provide financial framework, Define eco-system Common Code of Conduct (CCoC), verify CCoC and partner engagement contract in place, oversee eco system operation and CCoC execution

**Service preparation:** Support functions, e.g. for service discovery, credential distribution and onboarding of actors, and prepare UC execution

**Information Sharing Domain (for scalability)**

Key functions: E.g. Data exchange, repositories, governance enforcement, data quality assurance, system monitoring and alerts

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**Run-time operation**

**Governance**

**Eco-system initialization**
Some key concepts for information sharing using backend communication (Details in whitepaper and report)

- Standard IT security on application layer (E.g. TLS, X509 certificates)
- Privacy based on user consent, ensured by backend systems
- Application level interoperability
- Message Queuing Protocol (AMQP) with Publish/subscribe methods
- Meta data to enhance information and to allow filtering
- Geocasting/geo-referencing (e.g. ‘Quadtree’)
- Federated information assisted by a HTTP REST based protocol
- Discovery functions
V2N2X Solution Blueprint, and Use Case Implementation Examples

Presenter: Yunpeng Zang (Ericsson)
V2N2X Application Layer Reference Architecture

Information Sharing Domain (for scalability)

Information Sharing Entities

- Information Sharing Instance

Information Sharing Entities

- Regional actor, e.g., Road Authority, Road Operator, City, parking provider
- 3Pty Service provider, e.g., VRU protection, map provider, traffic info provider; fleet operator
- End user device, e.g. OEM-supported in-vehicle app, in-vehicle after market device, smartphone.

Component in Functional view
- APP: Application
- AS: Application Server
- IOO: Infrastructure Owner and Operator
- OEM: Original Equipment Manufacturer
- SP: Service Provider

Component in Deployment view
- Stakeholder Domain
- Logical Interface

Legend

Service Provider Domain
- SP AS
  - 3Pty Service provider, e.g., VRU protection, map provider, traffic info provider; fleet operator
- SP App
  - End user device, e.g. OEM-supported in-vehicle app, in-vehicle after market device, smartphone.

Operator Domain
- IOO AS
  - Regional actor, e.g., Road Authority, Road Operator, City, parking provider

Vehicle (OEM Controlled parts)
- OEM AS
  - OEM Backend
- OEM App

Vehicle OEM Domain
- Vehicle (OEM Controlled parts)
Hight level sequence diagram of V2X services

Step 1: Ecosystem Stakeholder Preparation

Step 2: Service Preparation

Step 3: Service Execution

Step 4: Service Termination
In-Vehicle Deployment Options

Option I: OEM App (Automotive OEM-controlled)

Option II: SP App (Automotive OEM-supported)

Option III: SP App (Automotive OEM-independent)
Cellular network features and deployment options

**Quality of Service (QoS) & Network Slicing**
Application level QoS, V2X network slice

**Multi-access Edge Computing (MEC)**
Federated multi-MNO MEC

**Network Exposure & APIs**
3GPP network exposure and CAMARA APIs

**4G/5G Connectivity**
Existing high penetration in vehicles
Constantly improving cellular performance & coverage

**Local Breakout (LBO)**
Regional breakout & Possible deployment with MEC
Use Case Implementation Examples

- Traffic Signal Priority Request
- Traffic Event Information Sharing
- Vulnerable Road User protection – VRU Collision Risk Prediction and Alert
- Traffic Signal Information Sharing
- Emergency Vehicle Approaching
- HD MAP Handling
- Automated Valet Parking/Automated Vehicle Marshalling
- Object Detection and Sharing
Traffic Signal Priority Request

Information Sharing Domain

Information Sharing Entities

Information Sharing Instance

1. Regional actor: E.g. Road Authority, Road Operator
   - OEM Controlled parts
   - OEM Backend
   - OEM App

2. 3Pty Service provider: E.g. Fleet operator
   - SP AS
   - IOO AS
   - P1
   - P2

3. Local Actor Domain
   - SP App
   - In-vehicle after market device, OEM supported SP App.

4. Service Provider Domain
   - SP AS
   - IOO AS
   - OEM AS
   - Component in Functional view
   - Component in Deployment view
   - Stakeholder Domain
   - Logical Interface

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Traffic Event Information Sharing

Information Sharing Domain

Information Sharing Entities

Information Sharing Instance

Local Actor Domain

Service Provider Domain

Vehicle OEM Domain

Legend

Component in Functional view

Component in Deployment view

Stakeholder Domain

Logical Interface

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Summary of V2N2X Architecture and Deployment Solutions

• V2X Use Cases (UCs) supported by existing cellular networks combined with cross-stakeholder information sharing.
• Especially for I2V/V2I UCs requiring long communication distance but less stringent latency.
• V2N2X solutions have been proven by various deployments.
• More demanding V2X UCs can be addressed by cellular communications in the future, thanks to improving network coverage, radio capacity and features.
Business Perspectives

Presenter: Menno Malta (Monotch)

Link to the technical report
Large scale V2N2X deployment examples

Examples

• The Netherlands (Talking Traffic, Safety Priority Services)
• Flanders, Belgium (Mobilidata)
• The US (Cloud Safety Alert Service)
• China (Wuxi)

Selection criteria

• Use the cellular network to exchange data with road users
• Cover a significant geographical area
• Serve, or expect to serve within the next 12 months, at minimum 100,000 unique road users
• Focus on deployment
• Broad range of public-private actors from multiple sectors

• In The Netherlands 2.5 million passenger cars (out of 8.6m) are consuming and sharing real-time data through aftermarket solutions.

• In Belgium the road authority is deploying 29 use cases.

• More than 1.8 million vehicles in the United States and Canada receive alerts of a safety hazard (emergency vehicles, road works).

• Wuxi (China) pilot site Intelligent Connected Vehicles has reached about 700km, including the deployment of over 400 pieces of intelligent roadside equipment (TLC’s, sensors etc.).
Analyzed example deployments

✓ Deployment summary description

✓ Use-cases

✓ Connections

✓ Actors, roles and revenue flow
V2N2X Business perspective

• V2N2X is a subset of $20\text{ Bn market (2030)*}$
• Indirect communication via the cellular network (e.g., V2N2X, I2N2V) constitute the most significant yet untapped V2X channel*

• Key Factors driving market growth:
  • Growing societal challenges (addressed globally by public policies)
  • Digitalization / Tech capabilities / Network coverage & capabilities
  • Legislation (specifically the EU)
  • EURO NCAP Vision 2030

*Sources in Technical report
Profiles Direct V2N2X Stakeholders

**Infrastructure Operators and Owners**

**Gains**
- influence behaviour of road users
- reduce investments in field equipment
- get (near real time) insights on the behaviour of road users
- getting information about road conditions
- innovative image
- deploying dynamic traffic management policies

**Jobs to be done**

**Pains**
- investing in technology that does not result in instant impact
- replacing/supplementing fuel tax

**Vehicle OEMs**

**Gains**
- offer enhanced services based on data that is only available through the cellular network
- innovative corporate image
- gather additional insights into customer behaviour
- the opportunity to experiment with a ‘service menu’

**Jobs to be done**

**Pains**
- Lack of scalable solutions
- Access to Infrastructure data
  - reduce the need for investments in technology without short / medium term results
  - reduce future physical ‘legacy’ in-car equipment

**Vehicle OEMs**

**Gains**
- Meeting legislation
- Improving the delivery of safety-relevant applications
- improvement of customer comfort
- the generation of additional service revenue

**Jobs to be done**

**Pains**
- investing in technology that does not result in instant impact
- replacing/supplementing fuel tax
Business models in example deployments*

- **IOOs** are digitalizing operations, investing in, and sharing an increasing amount of data.
- **Service/App Providers** have business models around Consumer subscriptions & monetization of road user data.
- **Tech providers** have business models around supporting development, deployment and connectivity.

*Talking Traffic (The Netherlands) / Safety Priority Services (The Netherlands) / Mobilidata (Flanders, Belgium) / Cloud safety alert service (US) / ICV Zones (China)
Conclusions

• V2N2X Deployments are growing in data, use-cases and connections

• Example deployments and market factors show a way forward:
  • IOOs have access to early, yet significant, benefits
  • Vehicle OEMs expected to become more active in the V2N2X eco-system in the future
  • V2N2X eco-system offers excellent capabilities to standardize and harmonize data and manage privacy and security

• Some technical concerns: data quality, security, privacy

• Need for continuous education of the eco-system on existing large-scale showcases and cellular coverage
Closing remarks
Closing remarks

• TR covers all relevant areas in high detail >> plug and play 😊

• V2N2X and short-range communication can and will co-exist

• The two techs will be used as one in complementary mode

• V2N2X can work immediately and effectively (as we just heard from various deployments)

• Start with V2N2X kickstarts overall V2X deployment
Thank all for tuning in!
Q&A

If you have any further questions, please contact the 5GAA marketing and communications team: marcom@5gaa.org