MAVEN
(Managing Automated Vehicles Enhances Network)

V2X communications for infrastructure-assisted automated driving

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General Information

- **Duration**
  - 36 months (Sept ’16 – Aug ‘19)

- **Funding**
  - ~3M€ under EC H2020 programme

- **Partners:**
  - From five countries: DE, NL, CZ, BE, UK

- **Website**
  - [www.maven-its.eu](http://www.maven-its.eu)
Project summary

Assumption

- Road infrastructure applications will still play a key role in future cooperative automated driving era

Main objective

- Increasing traffic efficiency and safety in urban areas by exploiting automated driving

Approach

- V2X-assisted traffic management solutions for cooperative automated vehicles (CAVs) at signalized intersections (traffic lights) and intersection corridors
- V2X-based automated driving extensions for perception and planning
- Use of simulation verification as well as real-road experiments with CAV and infra prototypes (ETSI ITS G5-based)
Use cases overview

- **I2V interactions**
  - V2I “explicit” probing + I2V speed/lane advisory + V2I feedbacks on compliance to advisories

- **Traffic light controllers optimization**
  - Signal optimization, priority management, queue estimation, green wave

- **Platoon management**
  - Forming, joining, travelling in, leaving, breaking a platoon

- **Inclusion of conventional traffic and VRUs**
  - Detection/reaction in presence of non-coop cars & VRUs

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MAVEN I2V interactions

- **V2I explicit traffic probing (1)**
  - CAVs and/or platoons transmit planned route, desired speed, platoon size, etc.

- **Traffic light controller signal timing re-optimization and I2V advisories (2)**
  - Based on rx info/calculations, infra transmits new speed/lane change advisories

- **V2I feedbacks on compliance to advisories (3)**
  - CAVs and/or platoons communicate if suggestion can be executed
  - If yes, traffic light controller “freezes” signal timing optimization

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### V2X for I2V interactions (1)

<table>
<thead>
<tr>
<th>Ext CAM on SCH0</th>
<th>CoopAwareness CAMParameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>ItsPduHeader (as in [ETSI EN 302 637-2])</td>
<td>GenerationDeltaTime (as in [ETSI EN 302 637-2])</td>
</tr>
<tr>
<td>BasicContainer (as in [ETSI EN 302 637-2], includes car position)</td>
<td></td>
</tr>
<tr>
<td>HighFrequency Container = BasicVehicleContainerHighFrequency (as in [ETSI EN 302 637-2], includes dynamic info)</td>
<td></td>
</tr>
<tr>
<td>LowFrequencyContainer = BasicVehicleContainerLowFrequency (as in [ETSI EN 302 637-2])</td>
<td></td>
</tr>
<tr>
<td>SpecialVehicleContainer = MavenAutomatedVehicleContainer</td>
<td></td>
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</tbody>
</table>

#### Message for V2I traffic probing

- Backward-compatible extension of CAM (on Day1 SCH0)
- MavenAutomatedVehicleContainer includes info needed by TLC
  - CAV route at intersection (e.g. Ingress/egress lane)
  - Distance to preceding/following vehicle
  - Platoon id (tx by platoon leader if platoon is present)
  - Platoon participants (tx by platoon leader if platoon is present)
  - Desired platoon speed (tx by platoon leader if platoon is present)
  - ...

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Messages for I2V advisories

- Lane-specific GLOSA
  - Suggests speed to be adopted on a given lane, calculated based on queue estimation
  - Use current standard SPATEM/MAPEM
  - SPATEM/MAPEM profiled to allocate lane-specific signal groups when needed (even if 2 or more lanes are logically associated to the same signal group)

- Lane advice message
  - Suggests the lane a CAV or platoon should change to at an intersection
  - Indicates target lane, distance to stop line, and time for starting the maneuver
  - Uses a newly defined Lane Advisory Message (LAM) including individual advices

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V2X for I2V interactions (3)

- **Message for V2I feedbacks on compliance to advisories (3)**
  - Backward compatible extension of CAM message (on Day1 SCH0)
  - MavenAutomatedVehicleContainer includes feedback needed by TLC
    - Real-time Acknowledgment on whether the GLOSA is being applied by the CAV
    - Real-time Acknowledgment on whether the lane change is being executed by the CAV

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MAVEN platooning

- **Mix between distributed and centralized approach**
  - Based on common distributed algorithm and V2V exchanged info, individual vehicles form platoons and manage their operation (joining, leaving, etc.) (1)
  - Yet, platoon leader has the central role of communicating platoon features to the infra for explicit traffic probing (2)

- **Use of 2 parallel ITS G5 channels**
  - One for advertising vehicle and/or platoon characteristics to other vehicles or infra
  - The other, to convey more frequent platoon control and management info

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V2X for MAVEN platooning

- **Message for platooning initialization**
  - Backward compatible extension of CAM message (on Day1 SCH0)
  - MavenAutomatedVehicleContainer carries info for CAVs to detect opportunities for building/joining a platoon (e.g. Based on same expected route, desired speed, etc)

- **Message for platooning management and control**
  - Shorter CAM tx on a parallel SCH with higher frequency [10-30Hz]
  - Carries limited set of info
    - for platoon control (e.g. Planned path, position, speed, acceleration, heading)
    - for platoon management: joining, brake-up, termination (e.g. flags representing the vehicle status in the platoon and used by the platoon logic)

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Inclusion of conventional traffic and VRUs

- **Use of collective perception for improved detection and reaction**
  - Both CAVs and infra can detect and share info about non-cooperative road users
  - Improved awareness used to adapt CAV maneuver/path planning for increased safety
  - Isolated CAVs or CAVs in platoon keep monitoring the environment and control the system all the time to possibly undertake emergency (automated) reactions

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V2X for inclusion of conventional traffic & VRUs

- Message for collective perception
  - Adoption of Collective Perception Message (CPM) in pre-standardization at ETSI ITS (TR 103 562 and TS 103 324) and consideration at the C2C-CC
  - Active contribution to ETSI CPM standardization to accommodate MAVEN requirements
    - General restructuring of CPM to accommodate detections from RSUs
    - Definitions based on RSU-specific reference system in all containers
    - Possibility to match detected objects to topological information transmitted in MAP messages

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Functional verification

Initial verification on test bench
- Verification of ASN1 co/decoding and tx/rx on specified ITS G5 channels

Integration with automated driving framework
- Verification of generation and reception of data at dedicated AD SW modules via specified UDP socket interfaces

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ANS.1 definitions for all presented messages and V2X solutions details soon available at:

www.maven-its.eu

Do not hesitate to contact us!

Thank you!

Questions?