Vehicle2X Communication

Abkürzungen

ETSI	European Telecommunications Standard Institute
ECDSA	Elliptic Curve Digital Signature Algorithm
IEEE	Institute of Electrical and Electronics Engineers
ITS	Intelligent Transport Systems
WAVE	Wireless Access in Vehicular Enviroments
CA	Co-operative Awareness
CAM	Co-operative Awareness Message (1Hz)
DENM	Decentralised Enviromental Notification Message (Event Triggered)
LCRW	Longitudinal Collision Risk Warning
ICRW	Intersection Collision Risk Warning
TIRI	Traffic Information and Recommend Itinerary (Reiseroute/-verlauf)
HMI	Human Machine Interface
CP	Content Provider
PKI	Public Key Infrastructure
CAN	Controller Area Network
DCF	Distributed Coordination Function
MANET	Mobile Ad-hoc NETwork (handheld devices)
WMN	Wireless Mesh Network (Freifunk)
WSN	Wireless Sensor Network
AODV	Ad-hoc On-Demand Distance Vector Routing
RREQ	Route Request
RREP	Route Reply
RERR	Route Error
DSR	Directed Source Routing
VANET	Vehicular ad hoc network
DSRC	Dedicated Short Range Communication
WAVE	Wireless Access in Vehiclular Enviroments
EDCA	Enhanced Distributed Channel Access
WSM	WAVE Short Message
CSMA	Carry Sense Multiple Access
STDMA	Self-organized Time Division Mutiple Access
TPC	Transmit Power Control
TRC	Transmit Rate Control
FHSS	Frequency Hopping Spread Spectrum
DCF	Distributed Coordination Function
DCC	Decentrialized Congestion Control
CIA	Confidentiality Integrity Authenticity
PI	Performance Indicator
GLOSA	Green light optimized Speed advisory

AEV	approaching emergency vehicle
V2V	Vehicle to vehicle Communication
V2I	Vehicle to Infrastructure Communication
RTS	Request to Send
CTS	Clear to Send
DCC	Decentralized Congestion Control

Applications

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Methodology Outline: Field Operation Tests

1. Test Campaigns (Scenario Creation <-> Scenario Validation)
2. Log Data (Text Execution <-> Test Validation)
3. Analysis Results (Technical/Non-Technical Analysis)

Co-operative Awareness
-> Longitudinal (Langzeit) Collision Risk Warning (LCRW)
-> Intersection Collision Risk Warning (ICRW)

Part 1 - Co-Operative Awareness

Inform drivers about upcoming road hazards with no immediate risk of collision
No need for accurate positioning
Initial list of Co-Operative Awareness applications

- Emergency vehicle approaching - CAM
- Slow vehicle indication - CAM
- Stationary vehicle (accident, breakdown) - DENM
- Emergency electronic brake light - DENM
- Wrong way driving - DENM
- Adverse weather conditions (visibility, stability) - DENM
- Hazardous conditions - DENM
- Traffic condition - DENM
- Signal violation - DENM
- Road work - DENM

Part 2 - Longitudinal Collision Risk Warning

- Warn drivers when risk of a longitudinal collision is detected
- Initial list of Part 2 applications
- Dangerous lane change – CAM (Forward Collision)
- Emergency electronic brake light – DENM (Forward Collision)
- Stationary vehicle (accident, breakdown) – DENM (Forward Collision)
- Road work – DENM (Forward Collision)
- wrong way driving – DENM (Frontal Collision)
- Slow vehicle overtaking warning – CAM (Frontal Collision)

- Collision Risk Warning from a Third Party – CAM & DENM (All)

Part 3 - Intersection Collision Risk Warning

Conditions for presenting the warning to driver

- High level of confidence in vehicles trajectories (target & subject),
- Vehicles are close enough (considering positions and speeds)

Initial list of Part 3 applications

- Stationary vehicle warning – DENM (Lateral collision)
- Signal violation warning – DENM (Lateral Collision)
- Collision risk warning from a third party – CAM & DENM (Lateral Collision)

Evaluation of Vehicle2X Applications

System requirements

Target relevance area (urban, inter-urban, rural)
Minimum system latency (ms, sec, minutes)
Communication delay tolerance (ms, sec, minutes, days)
Minimum required penetration rate (low, medium, high, full)
Localization precision (1m, 10m, 100m, 1000m)

Technical requirements

Required communication (V2V, V2I, 3G)
In-vehicle sensor access (e.g. ESP, turning or emergency light, brake, …)
Driver HMI warning (audio, visual)
Needs back-end support

Application	Group	Comm.	Sensor	System Lat.	Pen. Rate
Example	S/E/I	V2V/V2I/3D	Vel./Pos.	ms/s/m/h	high/low
GLOSA	E	V2I,3G	Vel,Pos, Dir	s	low

Application	Overall B.	Indivual B.	Bussiness V.	Tech. Feasibil.
GLOSA	3	5	low.-mittel	4

Technology Hurdles for Infotainment

User interface
- General interaction pattern
- Accessibility while driving at high velocities
- Configuration

In-car access
- CAN bus integration
- Head unit display integration
- Audio integration

Connectivity
- Sustained bitrate
- Coverage

Content provider access
- Independent content access
- Authentication, Authorization, Accounting (AAA)

Summary

Safety: V2V
Efficiency: V2X
Infotainment: 3G/LTE

1. Nenne zwei Anwendungsbereiche sowie jeweils zwei Anwendungen für Fahrzeug-zu-X-Kommunikation

1. Safety
   a. Appoaching emergency vehicle
   b. Slow vehicle warning
   c. Lane change assistance
   d. Motorcycle warning
   e. Road works warning
2. Efficiency
   a. Green Light optimal speed advisory (GLOSA)
   b. Intersection Managment
   c. In-vehicle signage
   d. Co-operative adaptive cruise control
3. Infotainment
   a. Media downloading
   b. Point of interest notification
   c. Electronic toll collect
   d. SOS service
   e. Stolen vehicle alert

2. Beschreibe den Unterschied zwischen individuellem und globalem Nutzen von Fahrzeug-zu-X-Anwendungen.

Individuelle Anwendung: Nur das einzelne Fahrzeug hat einen Nutzen von der Vehicle2X anwendung, andere verkehrsteilnehmer profitieren nicht davon.

Globale Anwendung: Alle verkehrsteilnehmer haben einen Nutzen durch die Anwendung der Vehicle2X Kommunikation, auch Teilnehmer ohne V2X fähiges Fahrzeug.

3. Nenne drei mögliche Kommunikationsarten der Fahrzeug-zu-X-Kommunikation.

1. Cellular (UMTS/LTE)
2. WLAN based vehicular ad hoc networks (ETSI ITS 5GA IEEE 1609 802.11p)
3. Satellite
4. MAN
5. Terrestial Broadcast

4. Entwickle einen Detektionsalgorithmus für die Stau-Ende-Erkennung. Welche Fahrzeugsensoren kommen zum Einsatz.

Ultraschallsensor: Erkennung des Stillstands des Vordermanns
Internetconnectivität: Online Information über Stau auf aktueller Straße -> GPS Information

Server-side

1. Collect position and speed from all vehicles
2. Calculate average speed per link (road segments)
3. Distribute link speeds DENM

Oder aufwändiger durch mehrmalige berechnung zu verschiedenen Zeitpunkten mit Datenbank

5. Nenne die Akteure bei Internet-basierten Anwendungen.

Auto -> Smartphone -> Mobile Operator ->Broker -> Internet -> Web Service Broker
Cosumer -> Connectivity -> Broker -> Content Provider

Routing

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Arten von Routing

- Position-
    - Geographic Unicast Routing (GUR)
    - Greedy Perimeter Stateless Routing (GPSR)

    - Greedy Perimeter Coordinator Routing (GPCR)
    - Connectivity-Aware Routing (CAR)
- Map-
    - Geographic Source Routing (GSR)
    - Spatially Aware Routing (SAR)
- Trajectory-based
    - Motion Vector Scheme (MoVe)
    - Geographical Opportunistic routing for Vehicular Network (GeOpps)

Vehicle2X Nework Implications

- Large Network Size
- High, Non-random mobility
- Very low energy limitations, large local resources
- High location dependency

Advanced Addressing: Globally vs Locally Unique

Globally unique adresses

Require either rigid scheme or central address assignment
Targets can be immediately identified by sender
Good for throughput, bad for privacy
No lookups necessary

Locally unique addresses

Identify only neighboring nodes uniquely
Good for privacy
Can be initialized locally, can take more time due to race conditions
No k-hop routing (k > 1) without additional topology and naming scheme

Communication Regimes

- Bi-directional Communication
    - adressing specific vehicles
    - Low latency, short range
    - specifc vehicles
    - Discovery/Establish/Unicast
    - Safety Applications
- Location-based Communication
    - adressing via locations
    - medium latency, low-medium range
    - optain releveant location/optain source location/boardcast/receiver filter non relevant messages
- Multi-Hop Location-based Communication
    - adressing via locations
    - large latency, large range
    - same as above but with message forwarding

Ad-hoc Mutli-hop Routing Algorithms

Constraints

- only local addresses
- destination identified by location coordinates
- moving nodes
- only semi-static node topology

The Obvious Suspects

- ❖ Flooding
- ❖ Ad-hoc On-Demand Distance Vector Routing (AODV)
- ❖ Geographic Unicast Routing

Ad-hoc On-Demand Distance Vector Routing

- ❖ Reative protocol with routing tables
- ❖ Target identified by location
- ❖ intermediate nodes only require local addresses
- ❖ Route request (RREQ) per flooding
- ❖ New route on RREQ forwarding
- ❖ Target acknowledges with route reply (RREP)

Pro:

- Can utilize semic-static topologies, e.g. highways
- Only local addressing necessary
- Routes discovery on-demand
- Routes allow for increased bitrates

Contra:

- Slow start
- Fails considerably in fast changing topologies

Geographic Unicast Routing

General Idea:

location-based addressing
No routing tables
On the fly forwarding with greedy cost function minimizing location distance
Neighbor discovery through beaconing

Move

1. Nenne vier Unterschiede zwischen Fahrzeug-Netzwerken (V2X) und anderen mobilen Ad-hoc Netzwerken (MANET).

V2X/MANET

- Network size (Large/Medium)
- Mobility (High, non-random/Random)
- Energy limitations (Very low/High)
- Computing Power (High/Low)

- Memory Capacity (High/Low)
- Location dependency (Very High/Low)

2. Nenne jeweils zwei Vor- und Nachteile beim Einsatz von Flooding in Fahrzeug-Netzwerken.

Pro:

- No setup costs
- Always shortest path to all receivers
- Well suited for mobility
- No global addresses

Contra:

- Maximum network traffic
- High probability of collisions
- No limitations according to e.g. location
- Broadcast storm problem

3. Beschreibe den Algorithmus von Ad Hoc On-Demand Distance Vector Routing.

- Route request (RREQ) per flooding
- New route on RREQ forwarding
- Target acknowledges with route reply (RREP)

4. Welche Vorteile bieten geo-basierte Adressierungsverfahren in Fahrzeug-Netzen?

Pro:

- Simple
- Faster start than AODV
- Anonym

Contra:

- Greedy routing may lead to looping messages or may fail altogehter
- may fail

5. Nenne drei Adressierungsverfahren, die beim Routing in Fahrzeug-Netzen zum Einsatz kommen können.

1. Location Based
2. Geobasiert
3. Unique Identifier (MAC)
4. locally globally (IP)
5. (no addressing -> nearest neighbor)?

MAC / PHY

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Dedicated Short Range Communication (DSRC)

- dedicated to single hop communication
- based on IEEE 802.11**a**

- now IEEE 802.11**p** (WAVE)

Wireless Access in Vehiclular Enviroments - IEEE 802.11p

6+1 Channel at 5.9GHZ, 10MHz wide, 3-27 Mbps

- 1 Control channel (178)
- 6 Service Channels
  - 2 channels (172,184) dedicated for safety

1. Nenne drei Unterschiede zwischen Consumer WLAN und IEEE 802.11p WAVE.

1. 79 channels instead of 7
2. at 2.4 GHz instead of 5.9GHz
3. verschiedene arten von Kanälen

2. Welche Aufgaben haben Service- und Kontrollkanäle bei IEEE 802.11p?

Kontrolkanäle:

- Hält das ganze am laufen
-

Service Channel:

- 2 Service Channels just Safety
- road sefety applications
- road traffic efficiency applications

3. Wie erfolgt die Selektion des richtigen Servicekanals?

Advertisement on the controle channel (include appropirate service channel transmission power, data rate)
No Feedback
Manche Channels Vorgegeben - Safety Effenciency

enventuell FHSS angucken

4. Nenne zwei Unterschiede zwischen dem ETSI Basic Profile und Extended Profile.

1. Unterstützt IPv6
2. Kann auch andere Protokolle wie TCP oder UDP
3. Verbindung mit ITS-G5B und UMTS

Security

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Security: „Informationssicherheit“
Safety: „Funktionssicherheit“
Protection: „Datensicherheit“

CIA

Confidentiality

unauthorized Information **retrieval**

Integrity

unauthorized Information **manipulation**

Authenticity

Ensure originality

ITS Requirements: Low Latency, Limited Resources, Privacy Protection

Protect + Detect + React = Secure and Trustworhty System

Security Aspects of ITS

- Personal-Security
- Vehicle Security
- Communication Security
- Car2X Security

1. Nenne drei Aspekte, die mittels der Sicherheitsarchitektur geschützt werden.

1. Confidentiality
2. Integrity
3. Authenticity

1. Personal-Security
2. Vehicle Security
3. Communication Security
4. Car2X Security

2. Nenne drei mögliche Angriffe auf Fahrzeug-Netzwerke.

- Flooding (DDOS)
- ID diebstahl
- packet manipulation
- Sybil Attack
- Resource and Network Jamming
- Modification of ITS System Enviroment
- Extraction/Modification of secret material
- fake messages

3. Beschreibe die Sicherheitsarchitektur für Fahrzeug-Netzwerke.

1. Protect
2. Detect
3. React

4. Nenne zwei Unterschiede von X509.v3 und IEEE 802.11p Zertifikaten.

- X eher generell
- X sind größer
- Algorithmus ist variable bei X und bei Wave ECDSA algorithmus

5. Wie kann die Nicht-Verfolgbarkeit von Fahrzeugen sichergestellt werden?

- Häufige adresswechsel
- Geoadressierung
- Privacy Trade off (wichtige sachen weniger privacy unötige mehr privacy)
- Authorisation Tickets

6. Welche Aufgaben hat die Validation Authority Component?

Überorüft das Certificate gegenspieler von Signing Authority Component

Simulation - Validation

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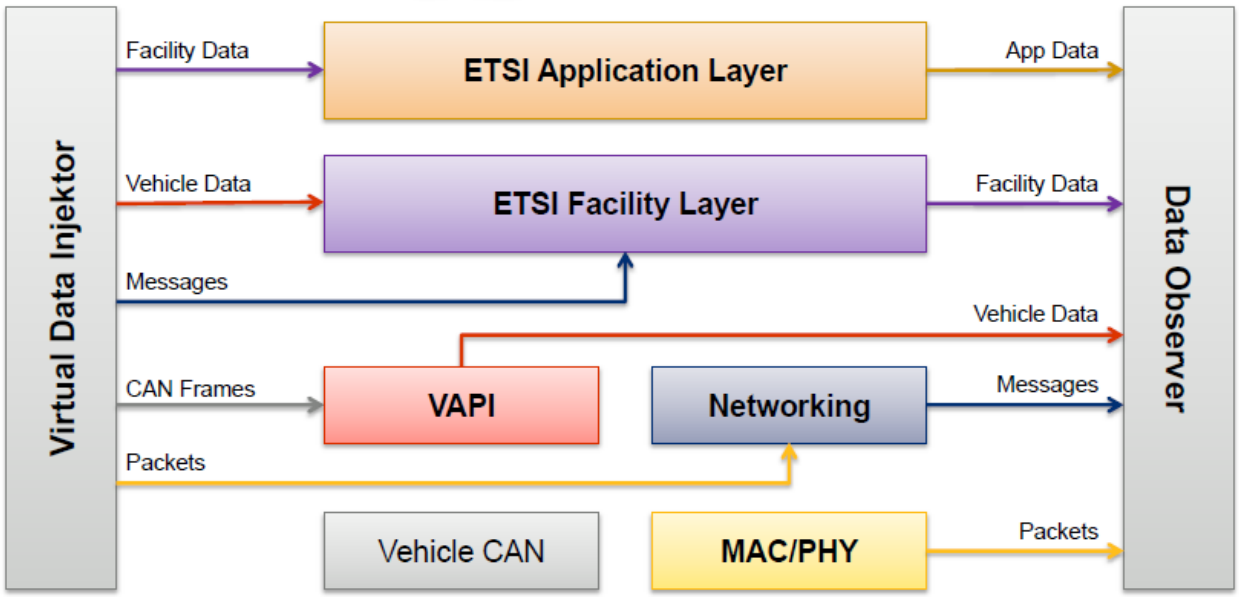

1. Nenne vier Arten von Protokolltests.

- Conformence Test
- Interoperability Test
- Perfomace Test
- Robustness Test

2. Beschreibe den Unterschied zwischen Konformitäts- und Interoperabilitätstests.

Implementierung muss korrekte Schnittstelle zum Test System haben. Dazu muss es die Spezifikationen erfüllen.

3. Beschreibe die Aufgaben von Upper und Lower Tester.

Upper Tester: Overservation data
Lower Tester: Virtual Test Data

4. Beschreibe den generellen Ablauf der Fahrzeug-zu-X Simulation. Welche Arten von Simulatoren kommen zum Einsatz?

Network Simulator

Simulates communication network
Mostly multi-hop routing, but can include lower level aspect through e.g. ray tracing

Traffic Simulator
Simulates vehicle motion including accelerating, braking, lane changing
But rarely traffic accidents, due to internal "perfect" driver
Mostly used for road network analysis or traffic data "gap filling"

Application Simulator
Represents high level V2X communication application
Either implemented specifically for simulation environment or "software-in-theloop"

5. Nenne drei Möglichkeiten der Synchronisation von Simulatoren zur Laufzeit.

1. Discrete Event based
2. Sequential
   - not parallel
3. Conservative Synchronization
   - each simulator indicates lookahead (L)
4. Optimistic Approach
   - rollback

6. Nenne drei Probleme bei der dynamischen Koppelung von Simulatoren zur Laufzeit.

1. Problem 1: Data Exchange
2. Problem 2: Simulators have their own local time
3. Problem 3: Simulators do not have standard interfaces

Field Operational Tests

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FESTA handbook provides scientific methodology on FOT's

1. Nenne und beschreibe die Stufen der FESTA FOT Chain.

- V-Modell
  - Specification
    - Function Identification and Description
    - Uses Cases
    - Research Questions and Hypotheses
  - Operationalization
    - Performance Indicators/Study Design
  - Implementation
    - Mesasures and Sensors
    - Data Acquisition

2. Beschreibe den Unterschied zwischen Research Questions und Hyptheses.

Frage und Behauptung

3. Nenne vier Areas of Impact von Research Questions.

direct on driver

- less travel time
- more safety

Direct effects on the user driving
indirect effect on the user driving
indirect effects on non user
Modifying acciedent consequences
Effects of combination with other systems

Impacts can be short-term long -term and intended and unintended

4. Nenne vier Measures aus dem FESTA Handbuch.

- Direct measures
- Derived measures
- Events
- Self-reported measures
- situation variables

5. Welche ethischen Probleme können bei der Durchführung von Feldtests auftreten?

- System Safety
- Approval for on-road use
- Insurance
- Risk Assessment
- Ethical approval

6. Beschreibe den generellen Datenfluss von den Fahrzeugen bis zur Versuchsauswertung.

Vehicle to ITS central station (USB Terminal)
ITS Roadside to ITS Central Station (USB Terminal)
from ITS central station into Database
form Database to evaluation Partner