## c@mmsignia



#### Information exchange aspects of autonomous driving

### Safety on the road



Source: WHO: Global status report on road safety 2013



## Safety on the road

#### WHO: Decade of Action road safety program



Source: WHO: Global status report on road safety 2013

### commsignia Safer roads, mobility, vehicles? How?



#### Minimize the human-factor!

#### Autonomous driving!

### **Autonomous driving?**



## **Autonomous driving? How?**



#### Autonomous driving? How? Vehicle-to-vehicle communication



### Introduction of V2X

- Vehicle-to-vehicle (V2V) communication
- Vehicle-to-infrastructure (V2I) communication

 Continuous information exchange, including all vehicle-related information and details of relevant events

### **Local Dynamic Map**



### **Local Dynamic Map**

# Collect Store Aggregate Filter Manage (e.g. expiration)

### **ETSI CAM, IEEE BSM**

LO	CAL	STATIONS	DENM	INTERSECT.	LIVE MAP	STATS	PROFILING	FAILURES		
L	SF	Station ID	Locati	on	Туре	e Dist	tance P	riority	EU/US	i
		9008	52.514	1307, 13.396 <sup>-</sup>	758 Bus	356	.95 m		0	<b>F</b>
		9012	52.514	173, 13.395	367 Bus	446	.74 m			<b>F</b>
		9002	52.509	9710, 13.394	260 Car	841	.82 m		0	
		9010	52.514	1254, 13.396	121 Car	397	.31 m		0	
		9004	52.513	3350, 13.398 <sup>-</sup>	740 Car	337	'.30 m		0	
¢		2	52.515	5960, 13.401:	280 Spe	c. 0.00	) m		0	

StationObject{basicInfo=StationBasicInfo{ stationType=SPECIAL\_VEHICLES, referencePos=ReferencePos{ latitude=525159600, longitude=134012800, headingConfidence=127, heading=3600, semiMinorConfidence=4095, semiMajorConfidence=4095, altitude=3500, altitude=3500, altitudeConfidence=UNAVAILABLE}, positionInfo=StationPositionInfo{ headingValue=900,

## commsignia

### **ETSI CAM, IEEE BSM**

Position (latitude, longitude, lane number, etc.) Movement (speed, heading, acceleration, etc.) Control (throttle, brake, etc.) Miscellaneous (e.g. exterior lights) Light bar and siren in use **Priority request** Special information (e.g. closed lanes)

### **ETSI DENM**

	LOCAL	STATIONS	DENM	INTERSECT.	LIVE MAP	STATS	PROFILING	FAILURE	ES	i	
SF	ID	Location	Cau	se			Su	b Cause	Terminatio	on Validity d	
	1.3	52.515280, 13.3	397150 RES	SCUE_AND_R	ECOVERY_W	ORK_IN_PRO	GRESS 1			80 s	
	1.0	52.514107, 13.3	893679 TRA	FFIC_CONDI	TION		6			80 s	
	1.2	52.513096, 13.4	104240 ROA	ADWORKS			5			80 s	
DENI det ref isN isC eve lati lon hea sei	Alactic ection erence legatic ancell entPos tude= gitude adingC ading= miMine	DIDEDENMActionID Time=Thu Jan 01 01 Time=Thu Jan 01 01 Din=false, ation=false, ition=ReferencePos 525130960, e=134042400, Confidence=127, 3600, DirConfidence=4095,	{stationID=1, se :10:54 CET 200 1:10:54 CET 200	equenceNumber= )4, )4,	LOCAL	STATIONS DENM	INTERSECT. Re 2.2 n	IVE MAP ST/	ATISTICS PROFILIN	ery in prog	
alti alti relo val tra sta	tude= tudeC evance evance idityDu nsmis tionTy	Si Confidence=4095, 800001, onfidence=UNAVAIL eDistance=LESS_THA TrafficDirection=ALI uration=80, sionInterval=1000, pe=null, onOuality=0	ABLE}, AN_1000M, ∟_TRAFFIC_DIR	ECTIONS,	20 29 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 2	Francósische Straße	Reger 2007	Whenderscher Markt	17.4 m <sup>-</sup>	Statts as solution Statts as solution of Manag and Tech B Spenness C Ope	BND Cebaude bol ement hology wernerspece wernerspece wernerspece se wernerspece man track

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### **ETSI DENM**

### Event position Timing (detection, validity) Event type Linked events Recommended itinerary

### **Other facilities**

#### **MAP and SPAT**

	LOCAL	STATION	s	DENM	INTERSECT.	LIVE MAP	STATS	PROFILI	NG FAI	LURES	i
L	SF		ID		Locatio	n		М		S	i
			500	3	52.5135	530, 13.404	4857			8	
			500	1	52.5149	978, 13.393	3063			8	
			LN	Lane attribute	es		Node count	Connected Lar	nes Speed L	imit	
			1	BIDIRECTION	IAL, VEHICLE, mo	otor	10	3(1)	N/A		
			2	BIDIRECTION	IAL, VEHICLE, mo	otor	10	4(2)	N/A		
			3	BIDIRECTION	IAL, VEHICLE, mo	otor	10	1(1)	N/A		
			4	BIDIRECTION	IAL, VEHICLE, mo	otor,pedestriar	า 10	2(2)	N/A		
		SG	State			Start time	Min end time	Max end time	Likely time	Next time	
		1	STOP	_AND_REMAIN		N/A	6957	N/A	N/A	N/A	
		2	PERM	ISSIVE_MOVE	MENT_ALLOWED	D N/A	6957	N/A	N/A	N/A	
			500	0	52.5143	345, 13.396	6955			8	
			500	2	52.5123	328, 13.399	9367		nm		gnia

### **Other facilities**

- SRM/SSM: Signal Request/Status Message
- IVI: In-vehicle Information
- PVD: Probe-vehicle Data
- Road Tolling Messages
- Service Advertisement

# GeoNetworking

- ETSI V2X network protocol
- Geo-dissemination
- Common protocol types:
  - Single-hop broadcast
  - Topologically-scoped broadcast (a.k.a. N-hop broadcast)
- GeoBroadcast!
- Transport protocol: BTP



### GeoBroadcast





- Simple network & transport protocol
- Minimal header frame
- Widely applied in the US

### commsignia IEEE 802.11p (WAVE) = ETSI G5 = ISO CALM M5

#### 5840-5910 MHz

### Different channels for different applications Control channel 5,9 GHz Ad-hoc

#### Same MAC and LLC format as common IEEE802.11x





### Sign - verify Elliptic-curve cryptography Validity restrictions (time, region, application)

Key exchange Encrypted messages

### **Summary of V2X**

Shortest possible packet size Fastest possible message dissemination Priority for safety communication Real-time information exchange

## Source of data? Simple case-study

- My vehicle breaks-down
- Disseminate DENM: Stationary Vehicle Warning
  - Position: 🗸
  - Vehicle identification:  $\checkmark$
  - Time: 🗸
  - Cause and estimated end of event:
  - Lane-level information: X

### commsignia Source of data? Simple case-study

### V2X communication needs complex sensors, which are able to feed the communication unit!

## **Google Car (again)**



## Why V2X instead of and sensors?

Cooperation is a must for autonomus driving! Driving is a multiplayer game played in real-time!

> Less processing load Quicker processing Cooperation Message exchange (e.g. notifications)

Fully (cooperative) autonomus driving won't exist without V2X communication

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### **Q&A time**

