

Technologies for Vehicle Safety Communications

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Vehicle Safety Communications Workshop
Hannover, May 31st 2005

Agenda

- Technological Drivers and Enablers
- Wireless Technology
- Applications with Heterogeneous Requirements
- Vehicle Ad-hoc Information Networks
- Car-to-Car Communication Simulation
- Car-to-Car Networking
- Security
- Prototyping Applications
- C2C as one building block for ITS and ADAS
- Summary

Technological Drivers and Enablers

Drivers

Hardware

- Semiconductors
- Consumer Devices
- Innovation Cycles

Services

- Short Life Cycles
- Multiple Providers

Software

- Development Cycles
- Maintenance

Process

- Towards interoperability
- 3rd party services
- 1st tier software



Storage

- Removable Media
- Harddisk
- Price
- Capacity

Wireless Communication

- GSM/GPRS, UMTS
- DAB / DVB
- **WLAN**
- Bluetooth

Hardware

- Power
- Integration

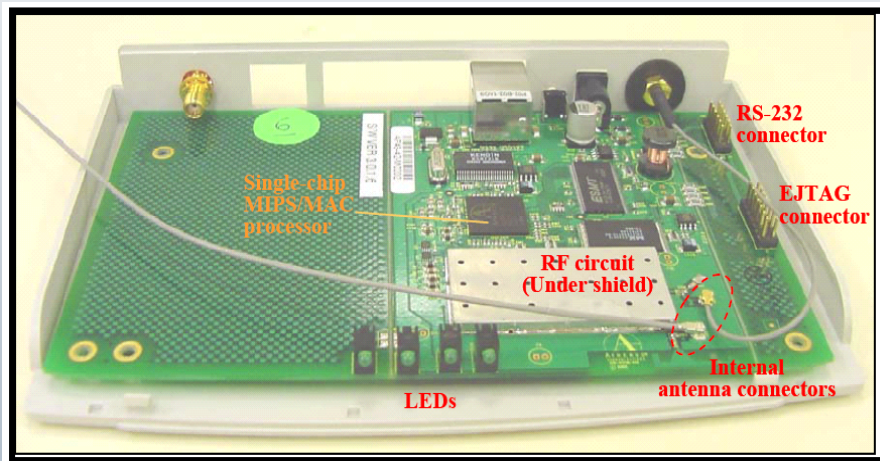
Platforms

- Open
- HW & SW
- Standardized Interfaces

Enablers

Wireless Technology: WLAN

- Different wireless technologies evaluated
- WAVE / 802.11p as basis
- Request for exclusive frequency band in Europe
- Vehicle antenna technology

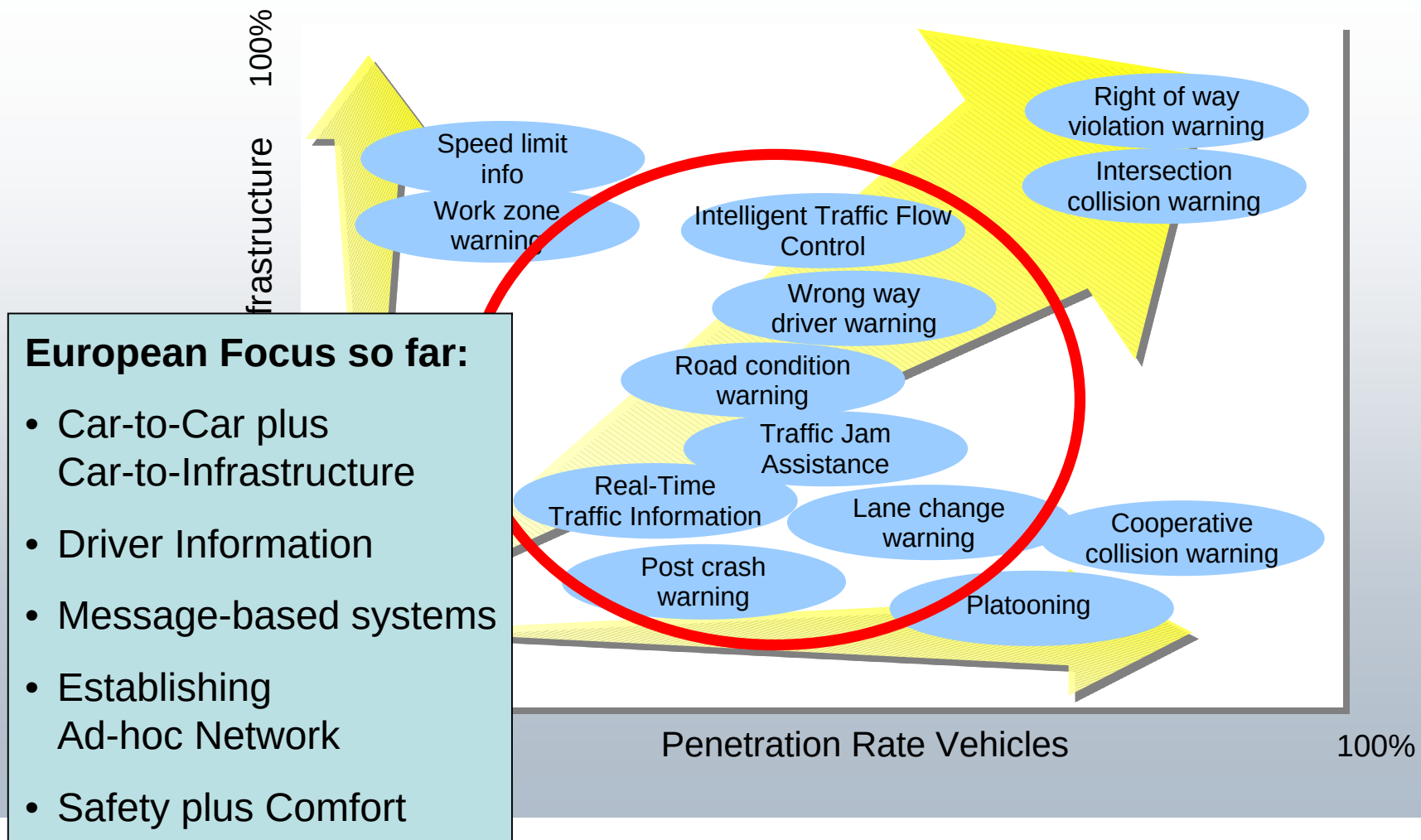


Denso WAVE Radio Modem



Antenna Integration

Safety Applications with Heterogeneous Requirements



Hazardous Scenarios (WILLWARN)

- Obstacle behind a curve



- Low friction on rural road



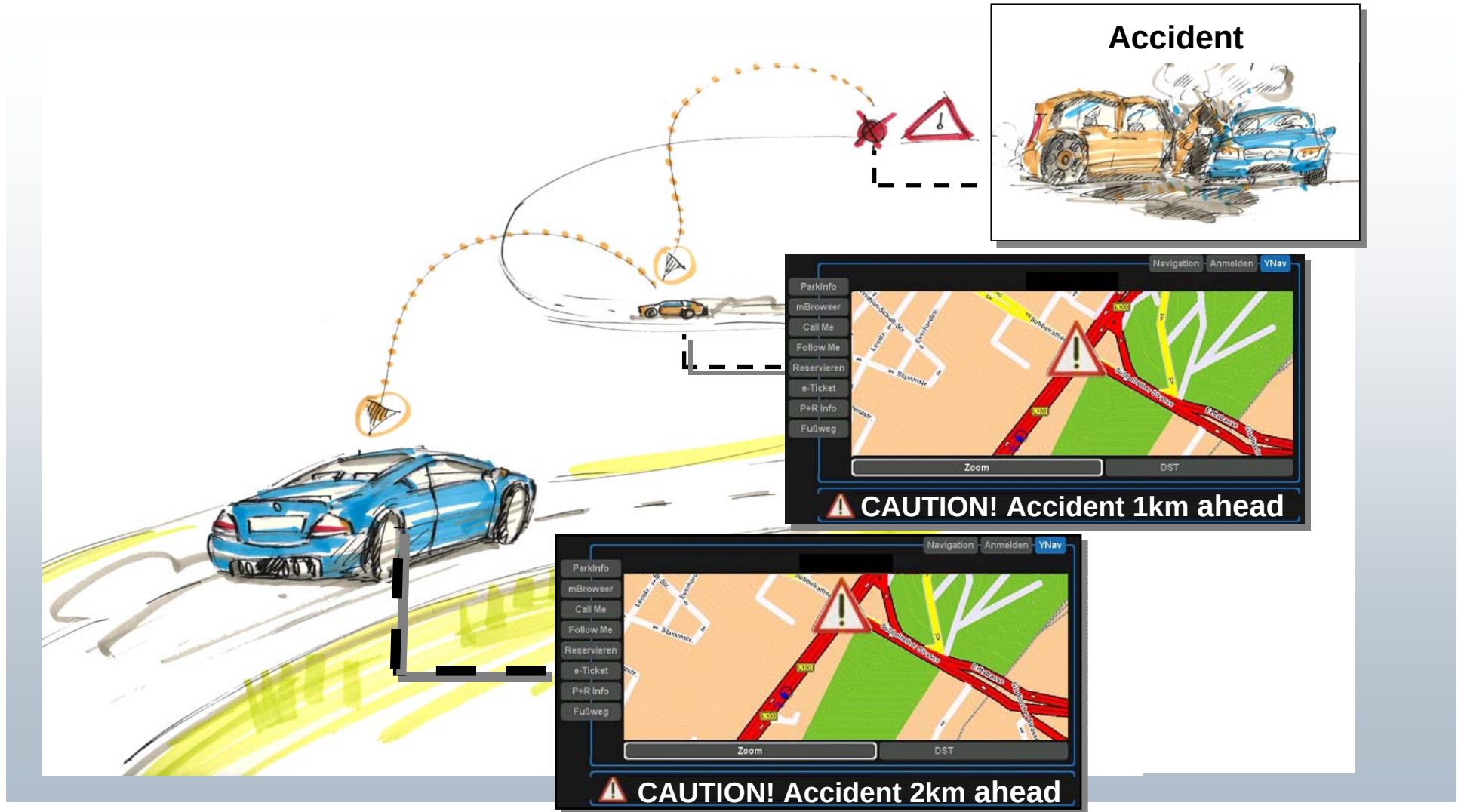
- Low visibility



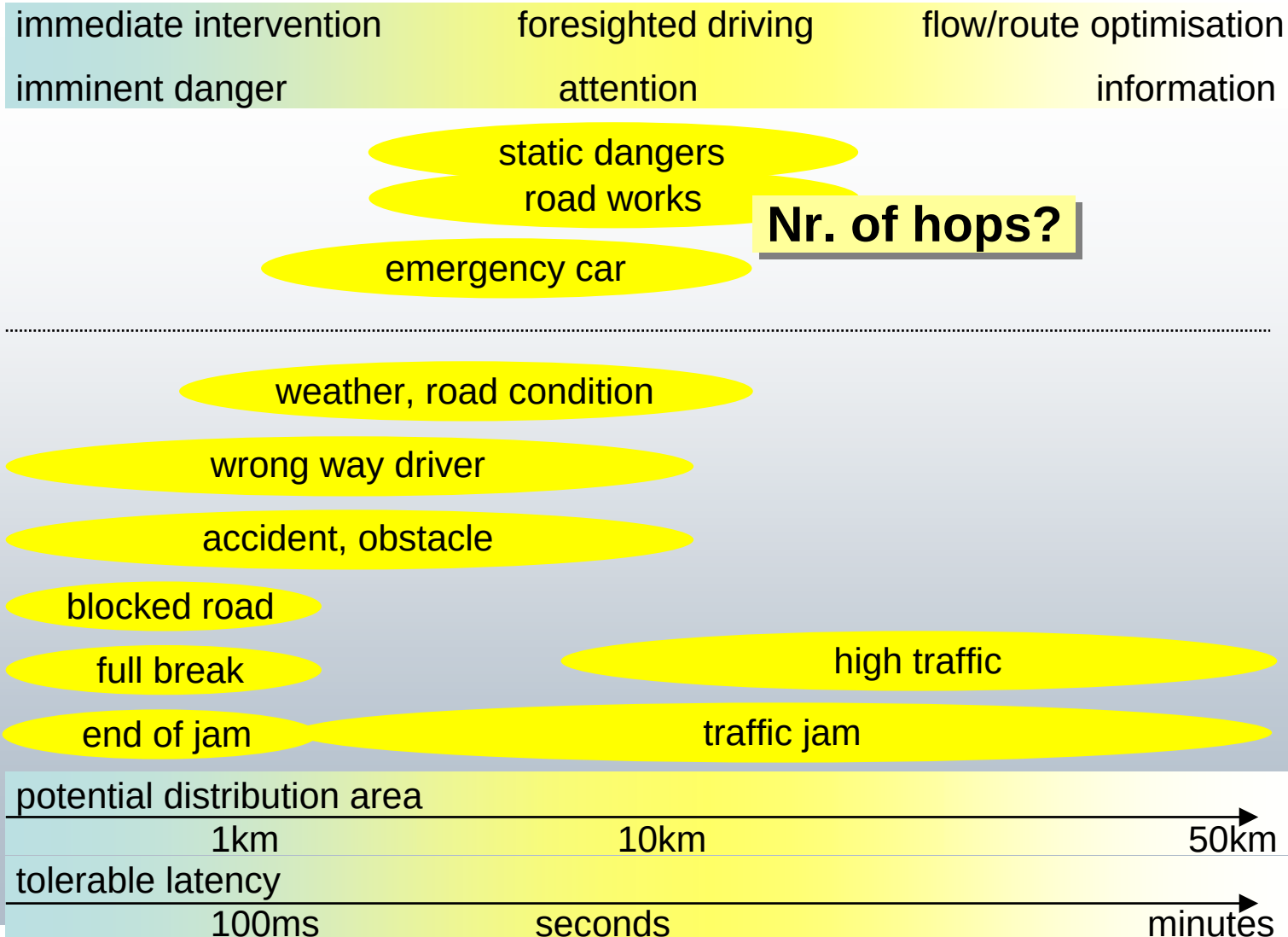
- Construction area



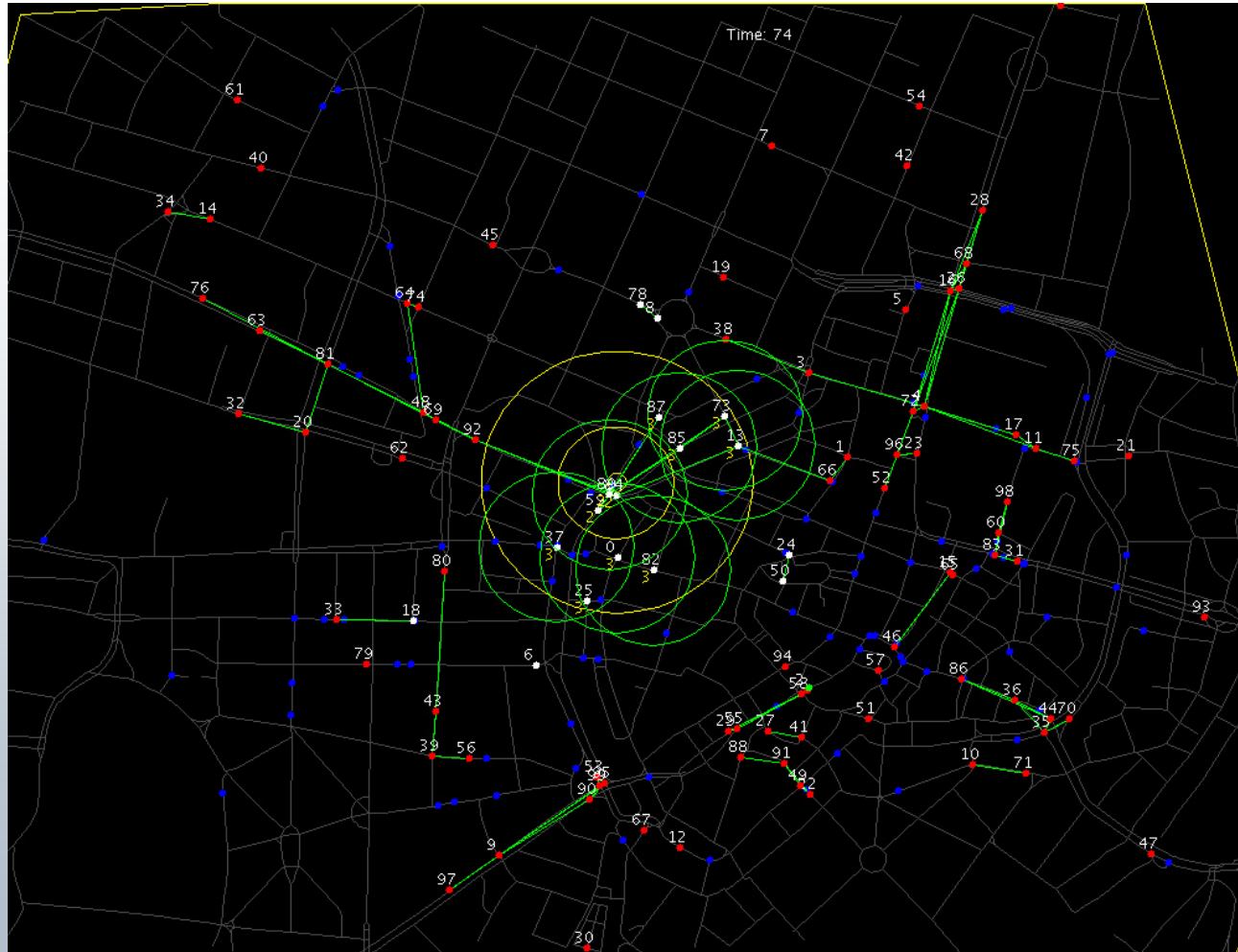
Driver Information Applications



Local Information



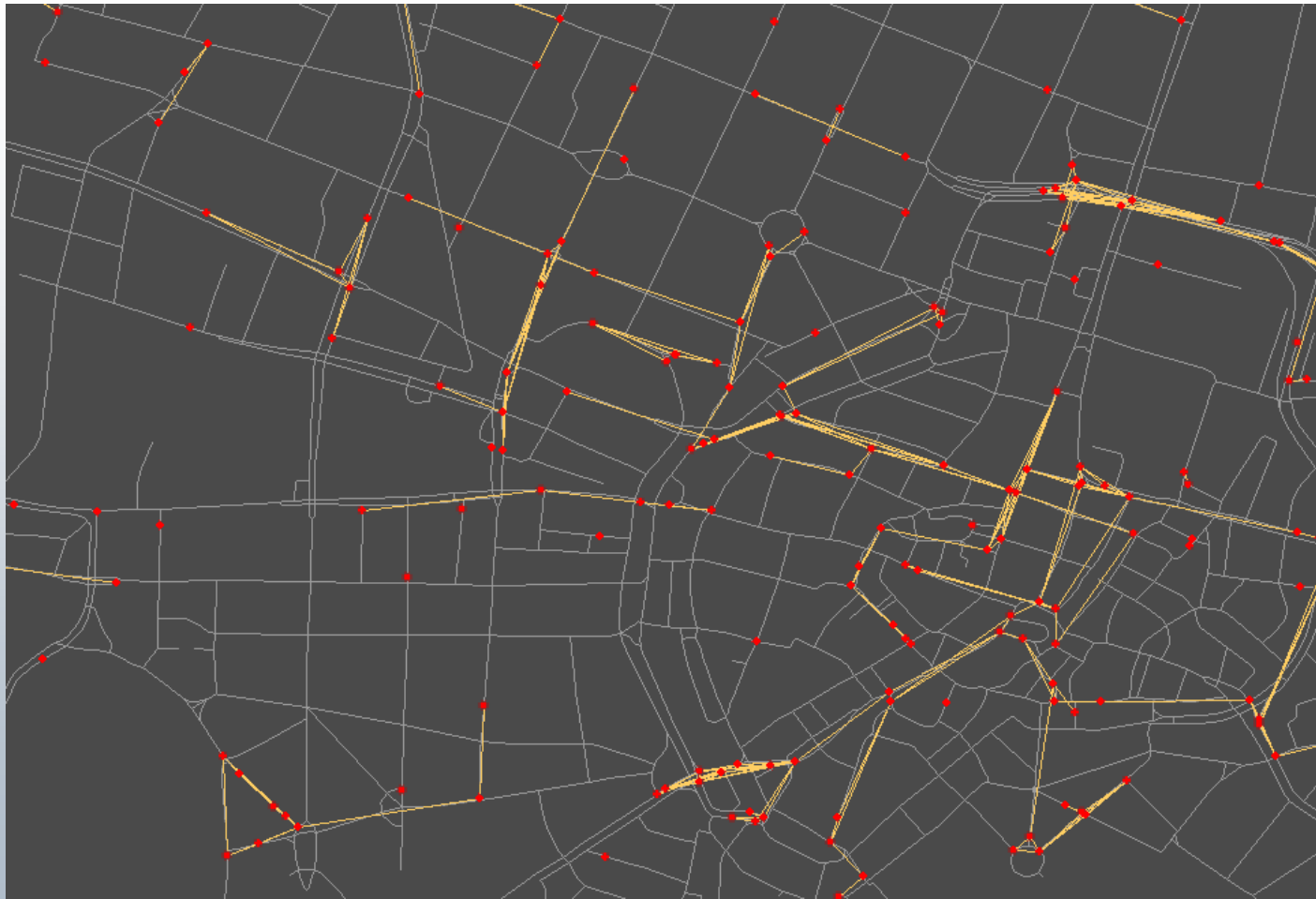
Building Ad-hoc Networks: Simulation



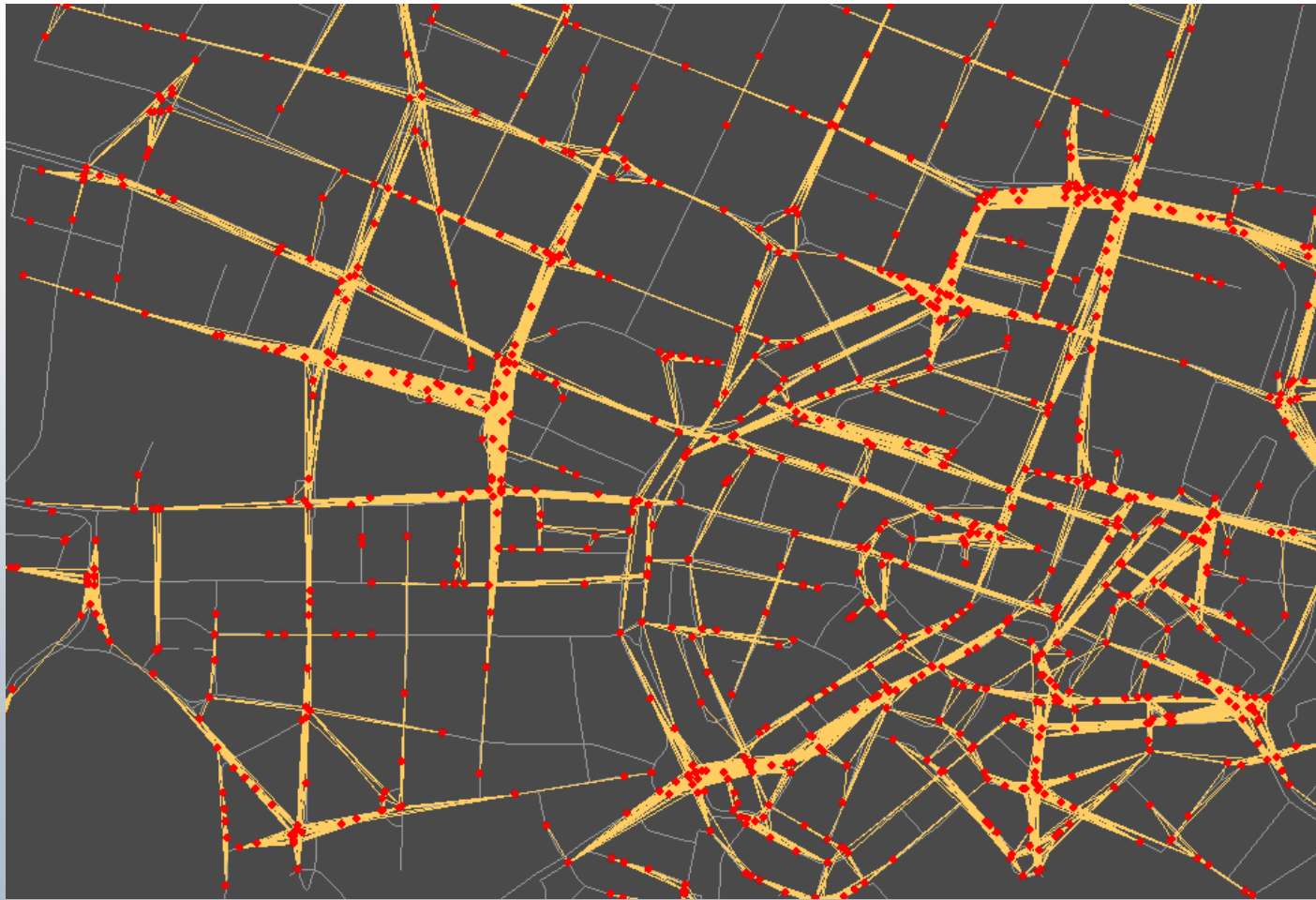
Visualization for

- Understanding
- Presenting
- Debugging

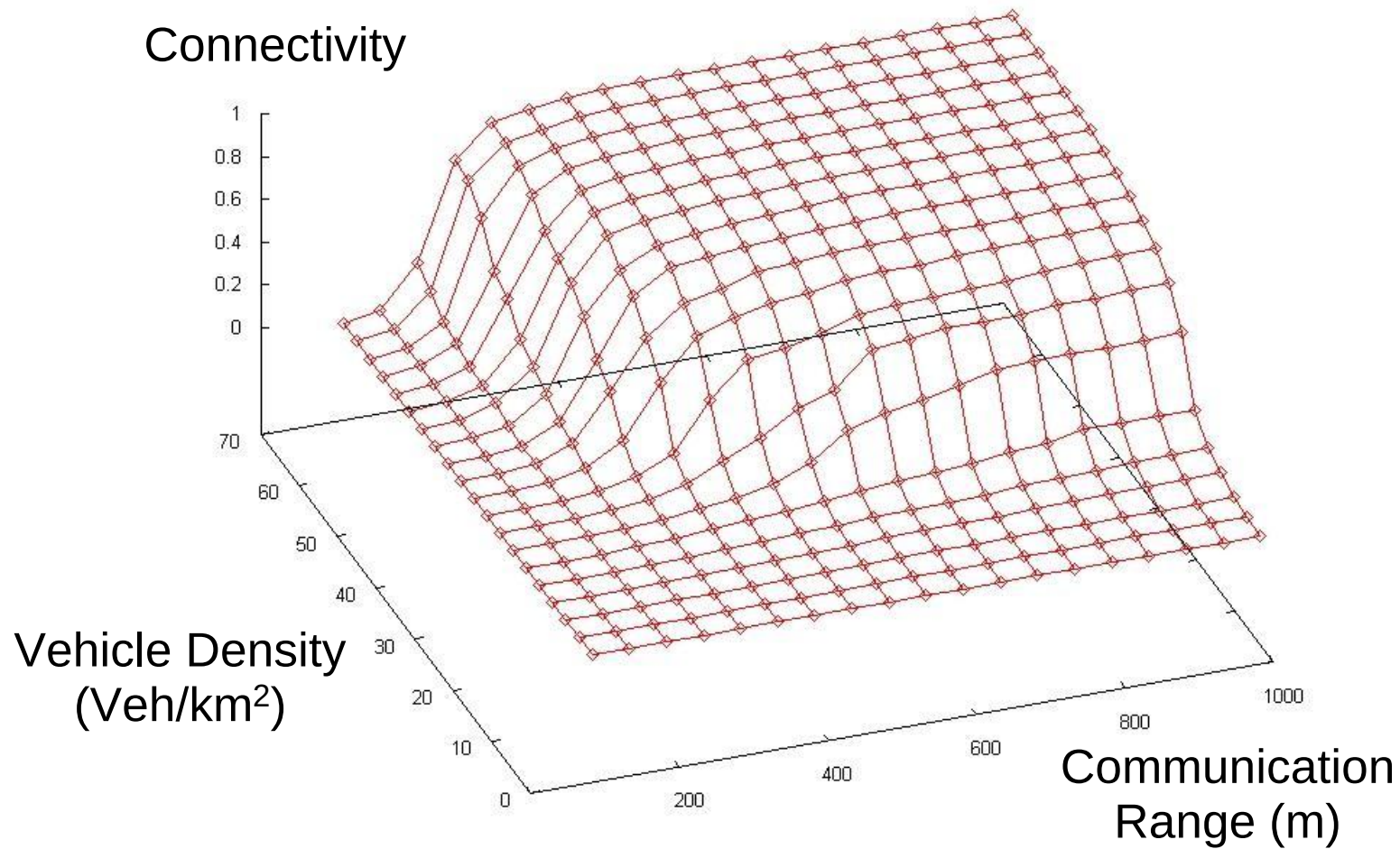
Building Ad-hoc Networks: Simulation



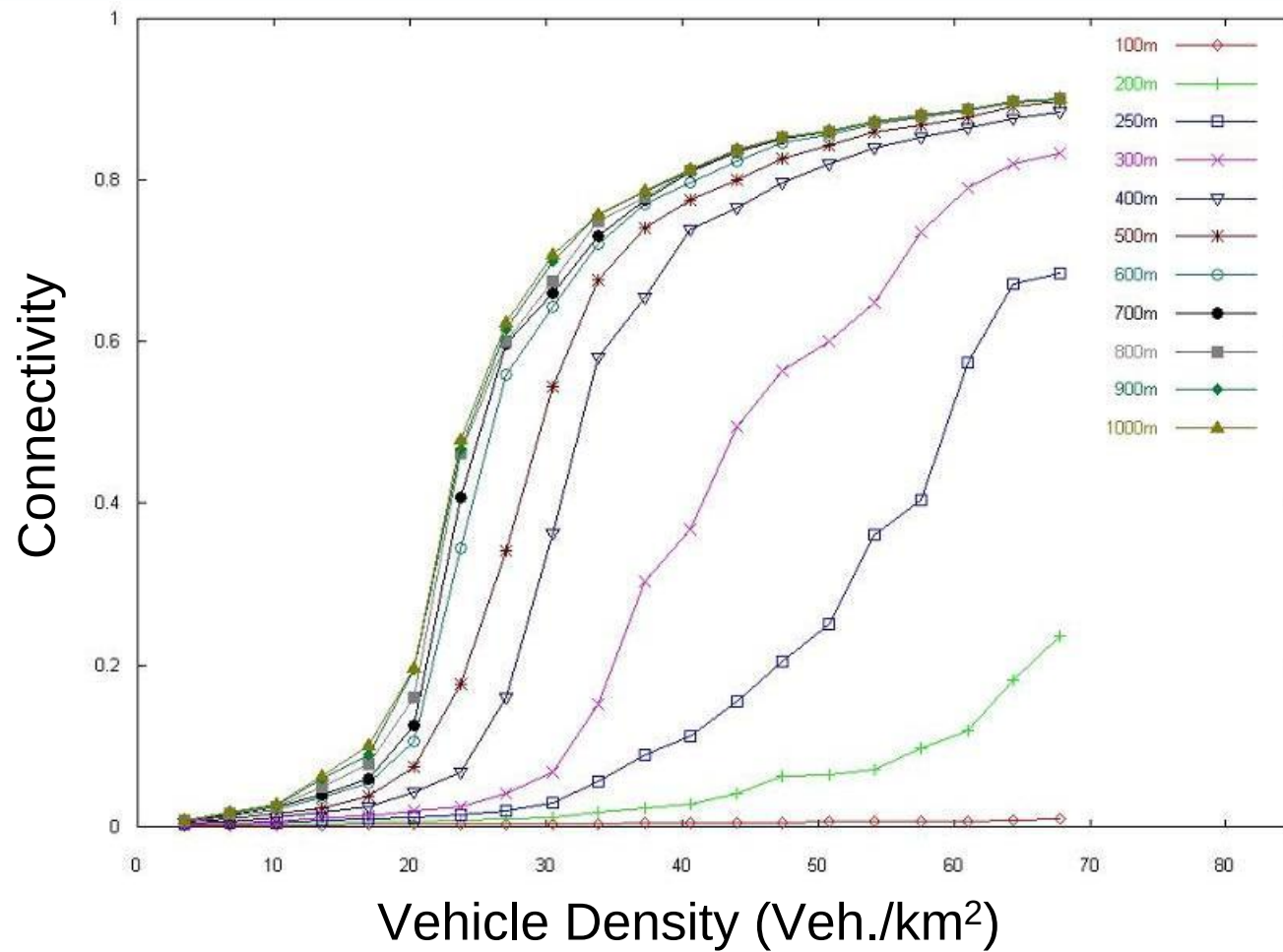
Building Ad-hoc Networks: Simulation



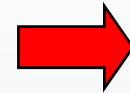
Simulation: Network Properties



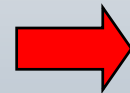
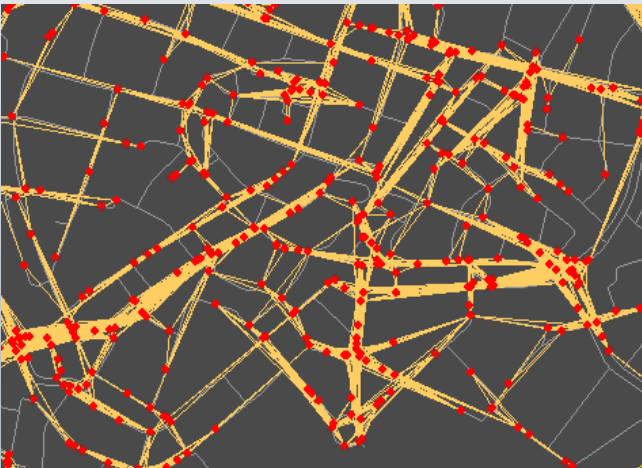
Simulation: Network Properties



Network Properties: Sparse & Dense Nets

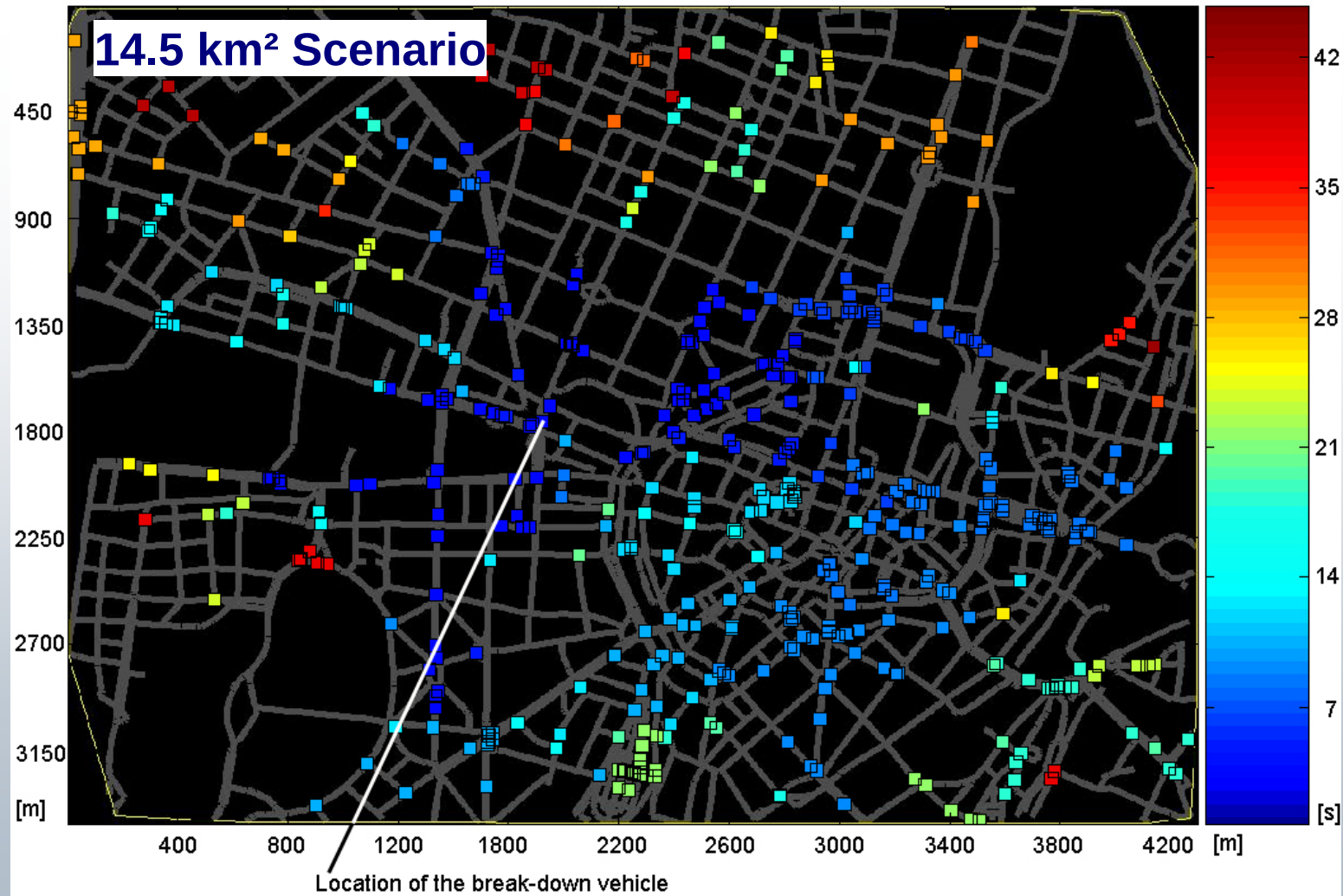


Sparse Network



Dense Network

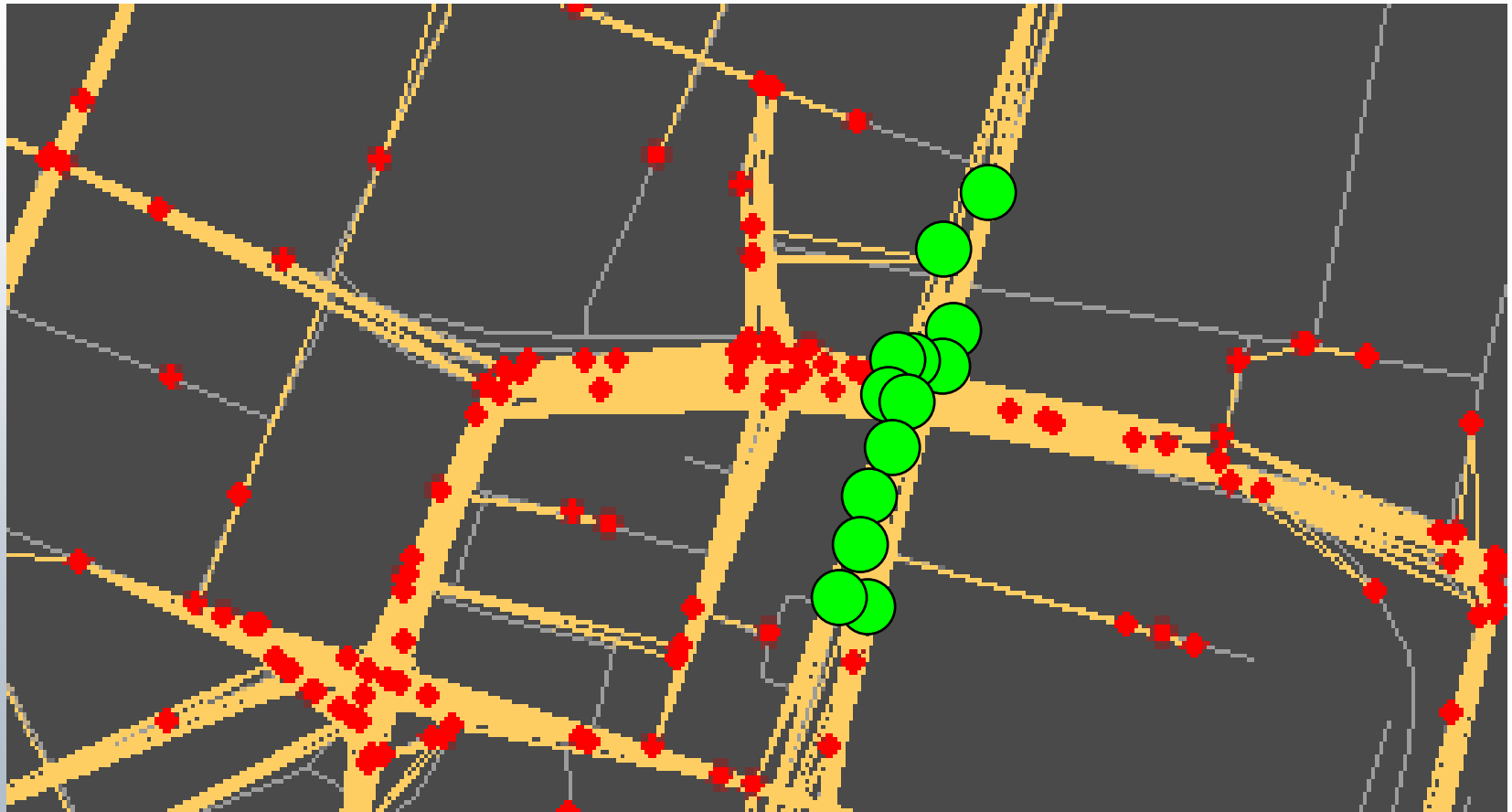
Sparse Nets: Store & Forward



Dense Nets: Efficient Geocasting



Dense Nets: Efficient Geocasting



Dense Nets: Efficient Geocasting



Dense Nets: Efficient Geocasting



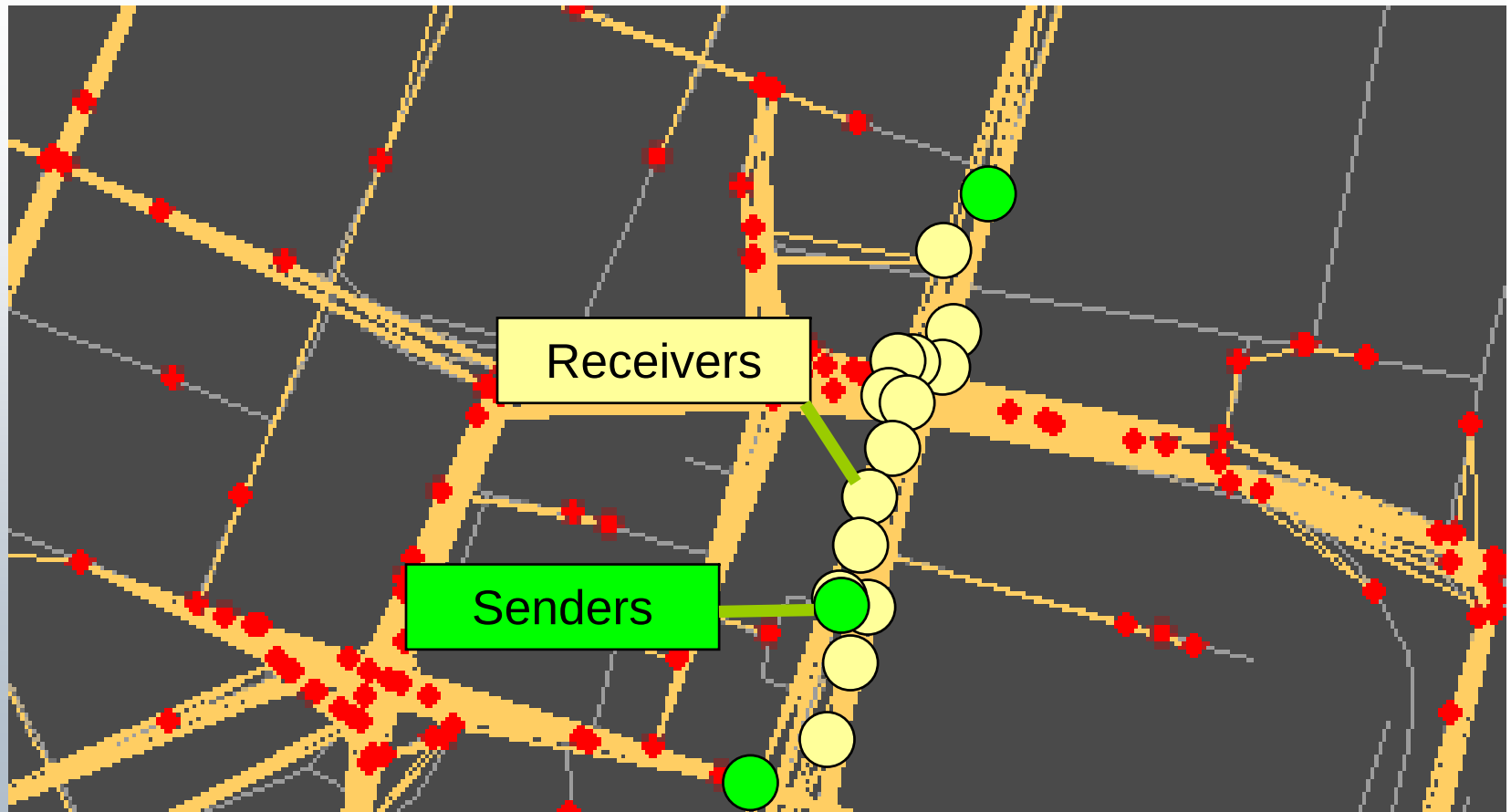
Dense Nets: Efficient Geocasting



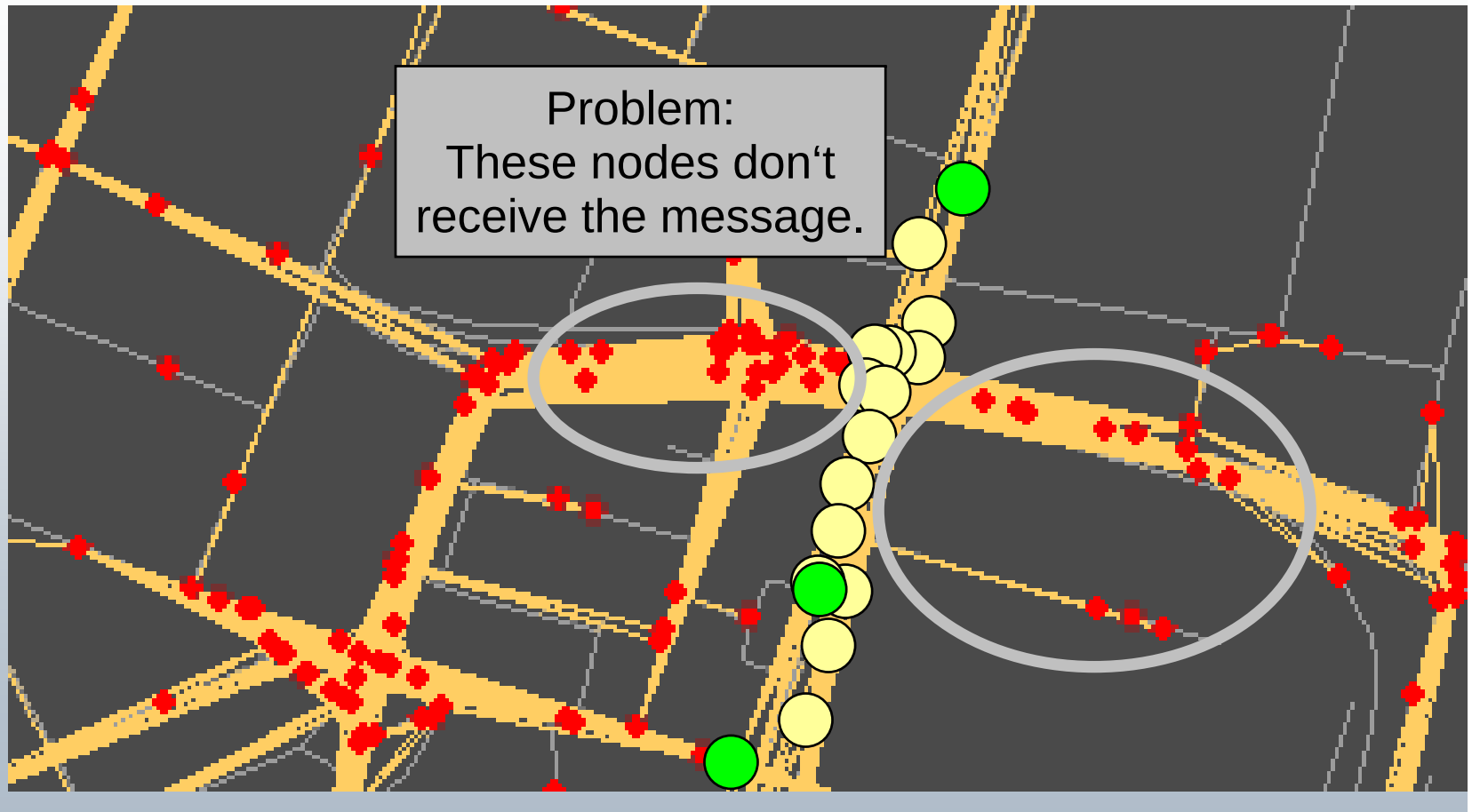
Dense Nets: Efficient Geocasting



Dense Nets: Efficient Geocasting



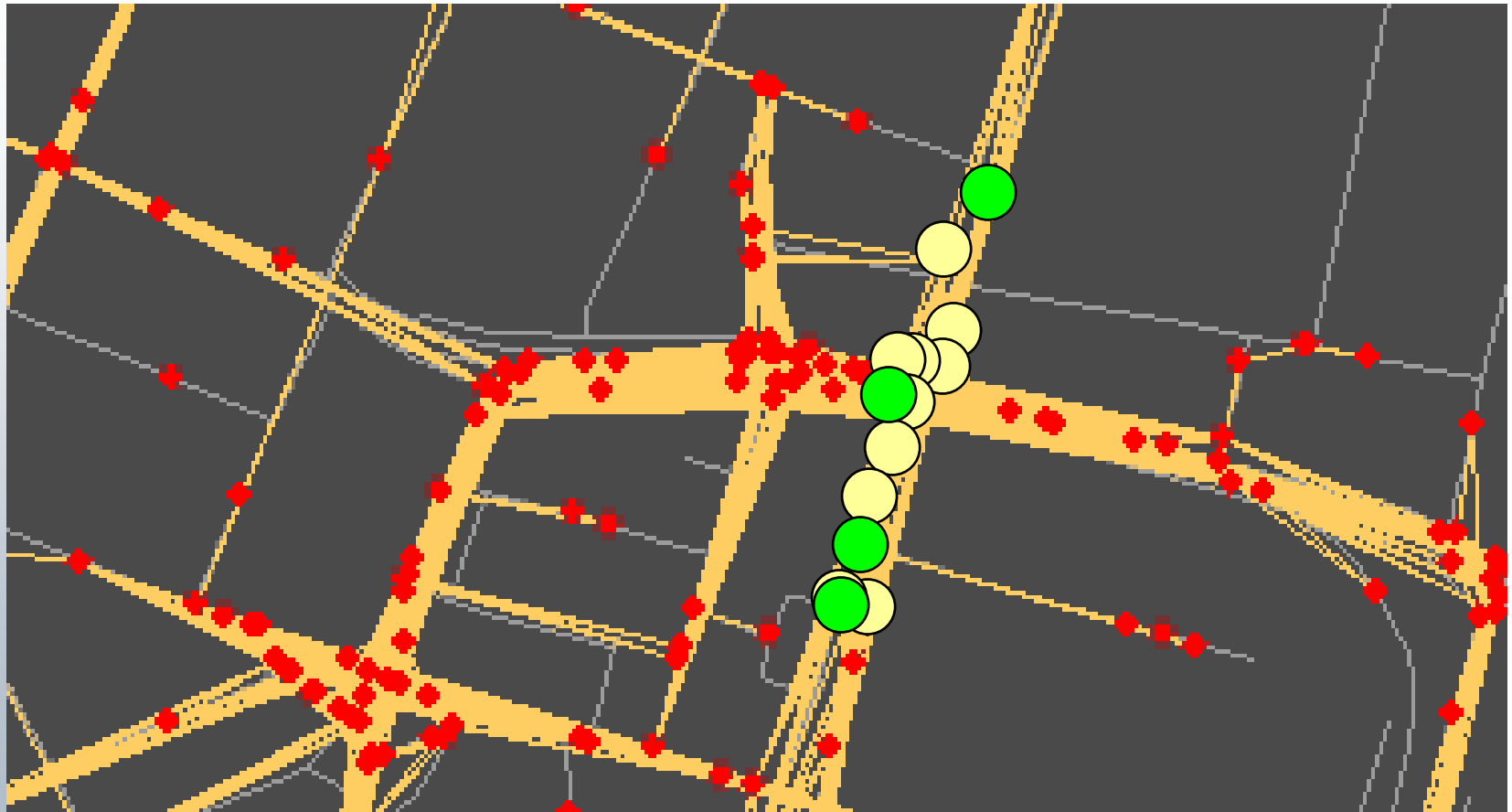
Dense Nets: Efficient Geocasting



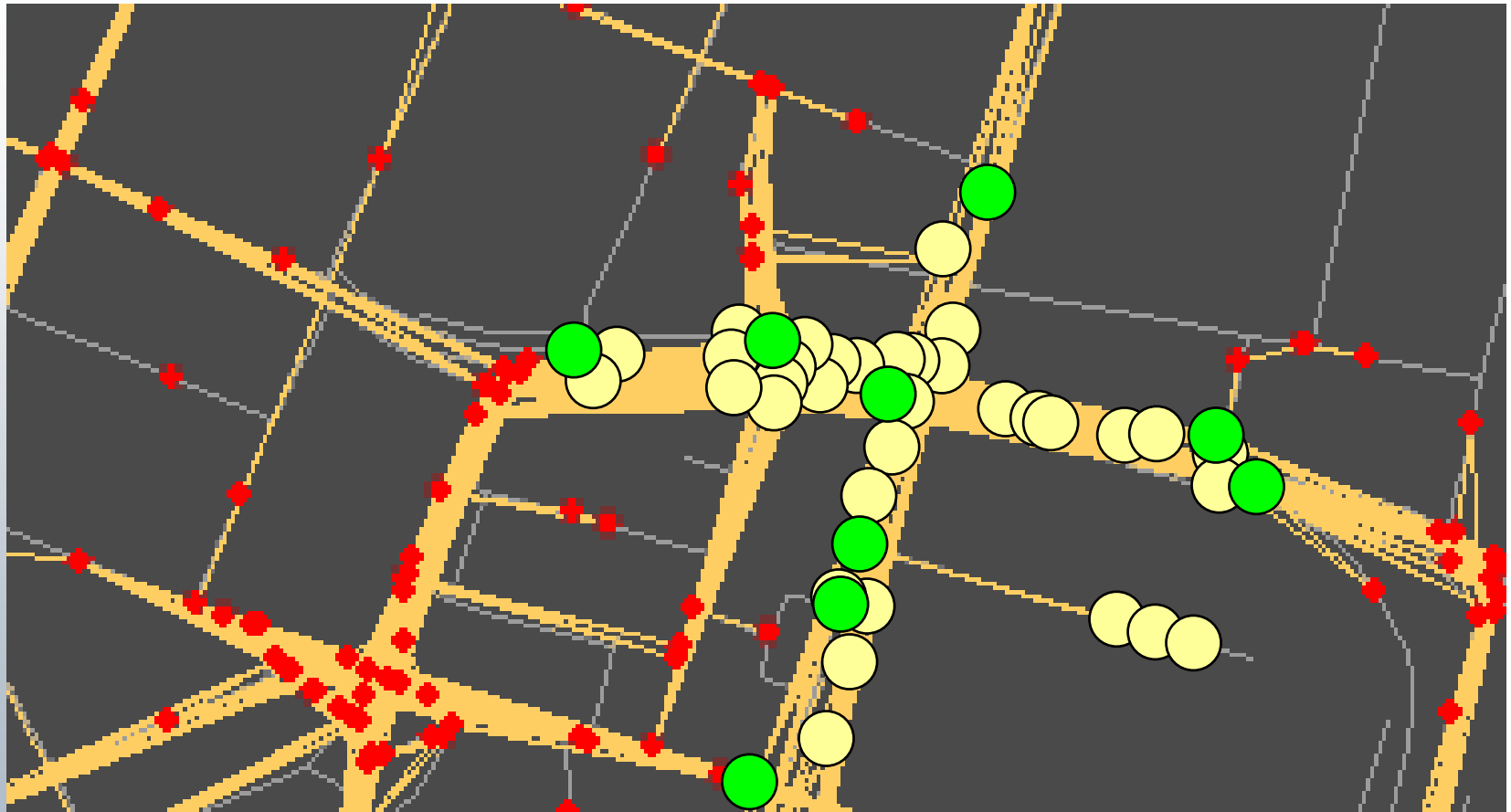
Dense Nets: Efficient Geocasting



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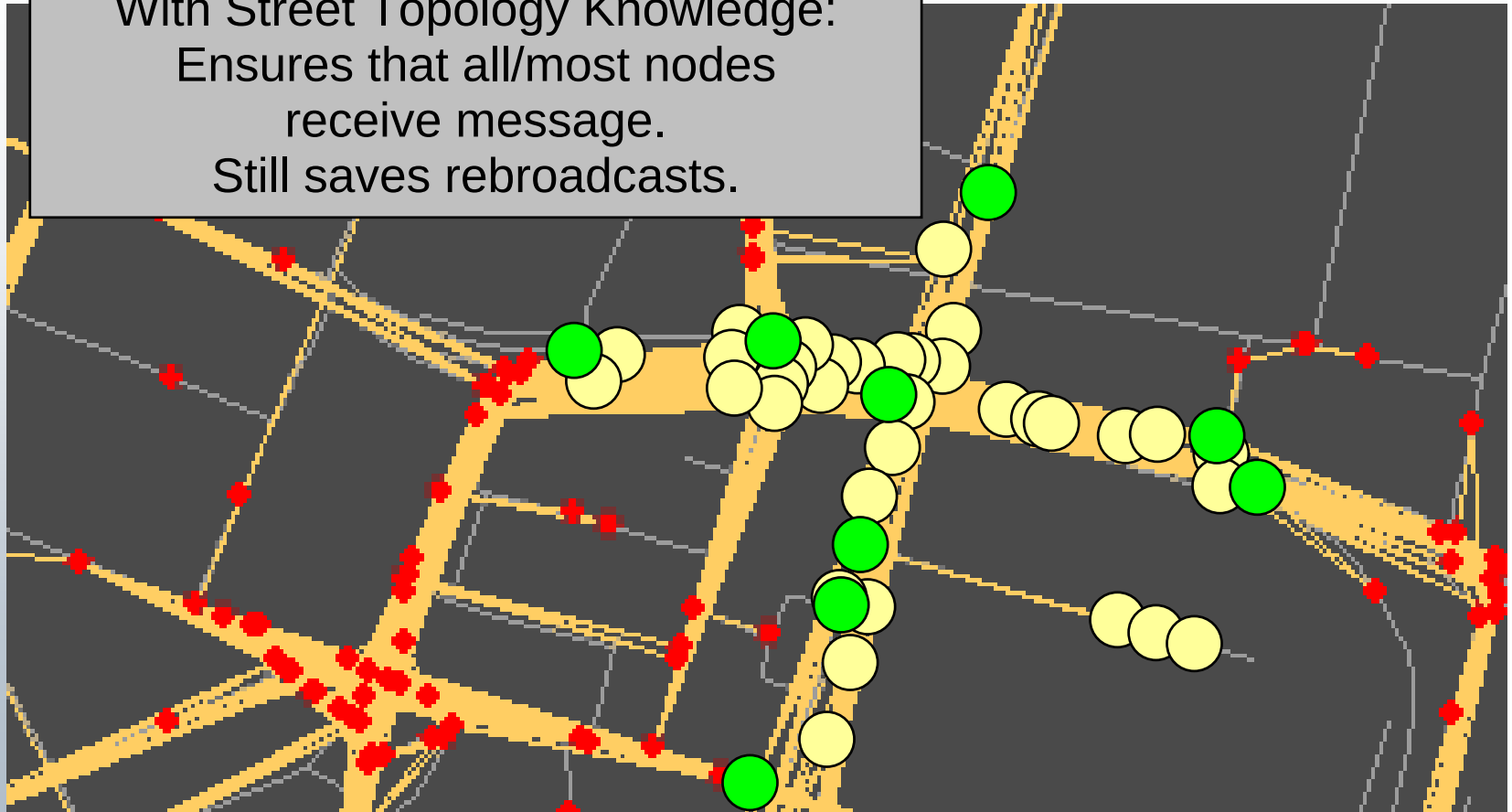


Dense Nets: Efficient Geocasting

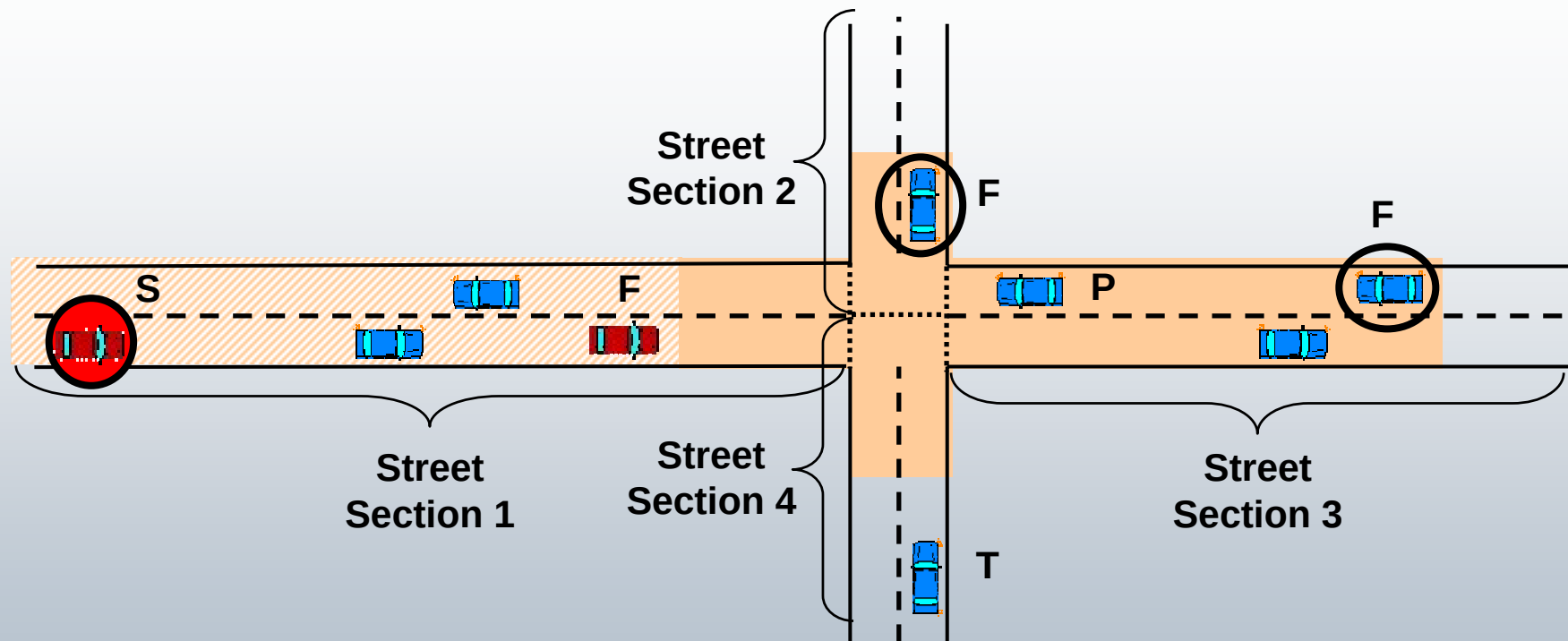


Dense Nets: Efficient Geocasting

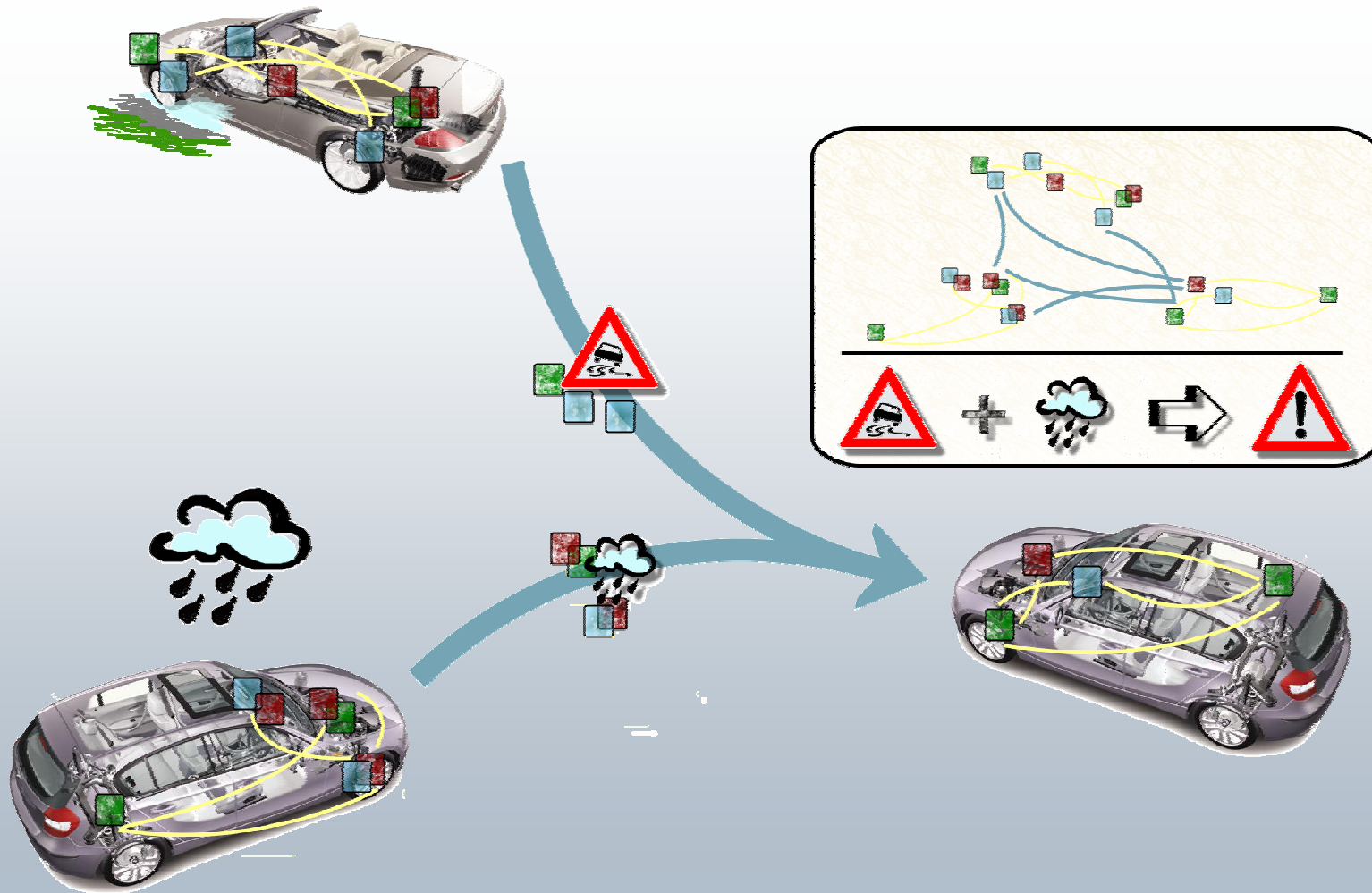
With Street Topology Knowledge:
Ensures that all/most nodes
receive message.
Still saves rebroadcasts.



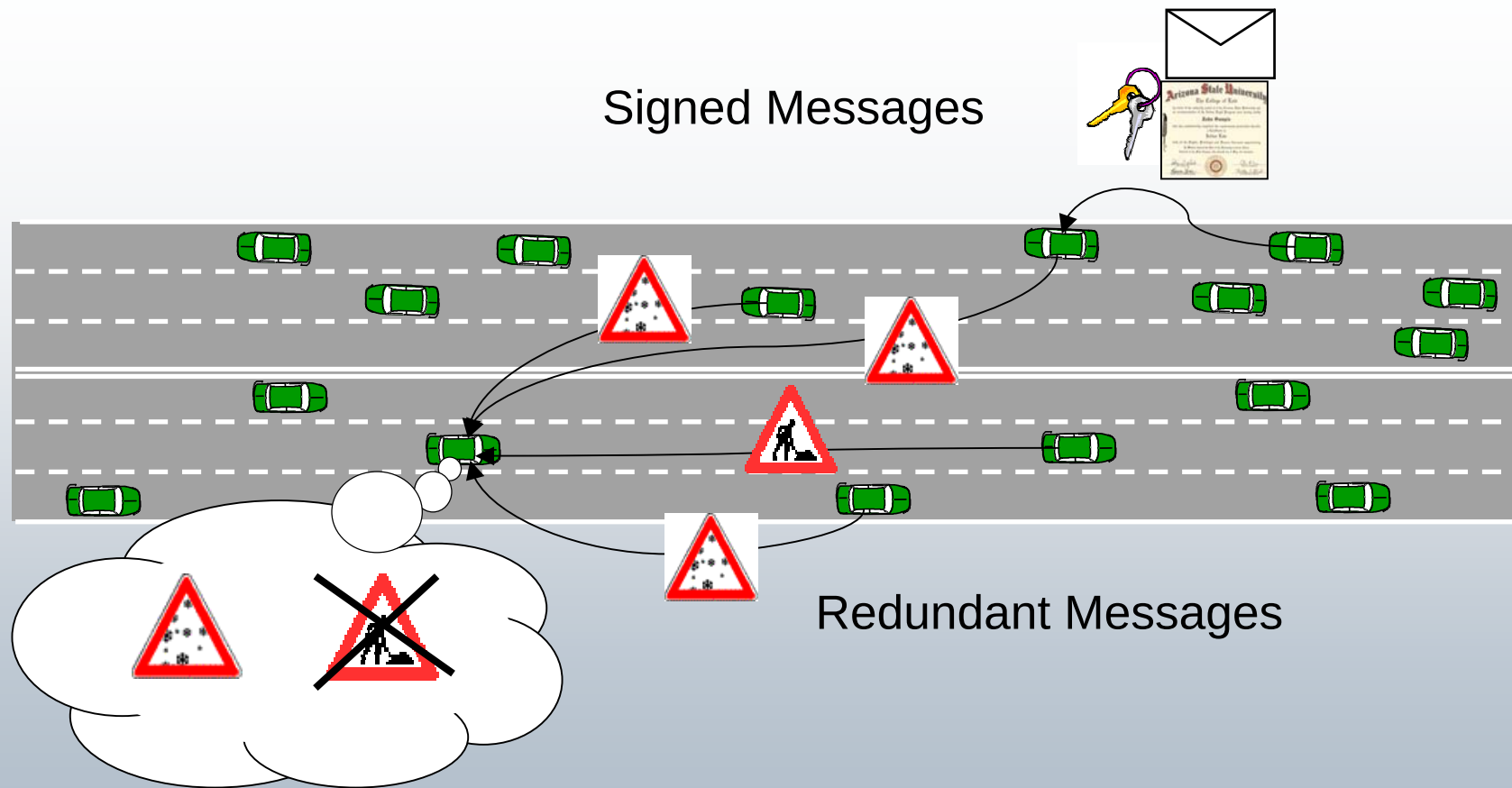
Dense Nets: Efficient Geocasting



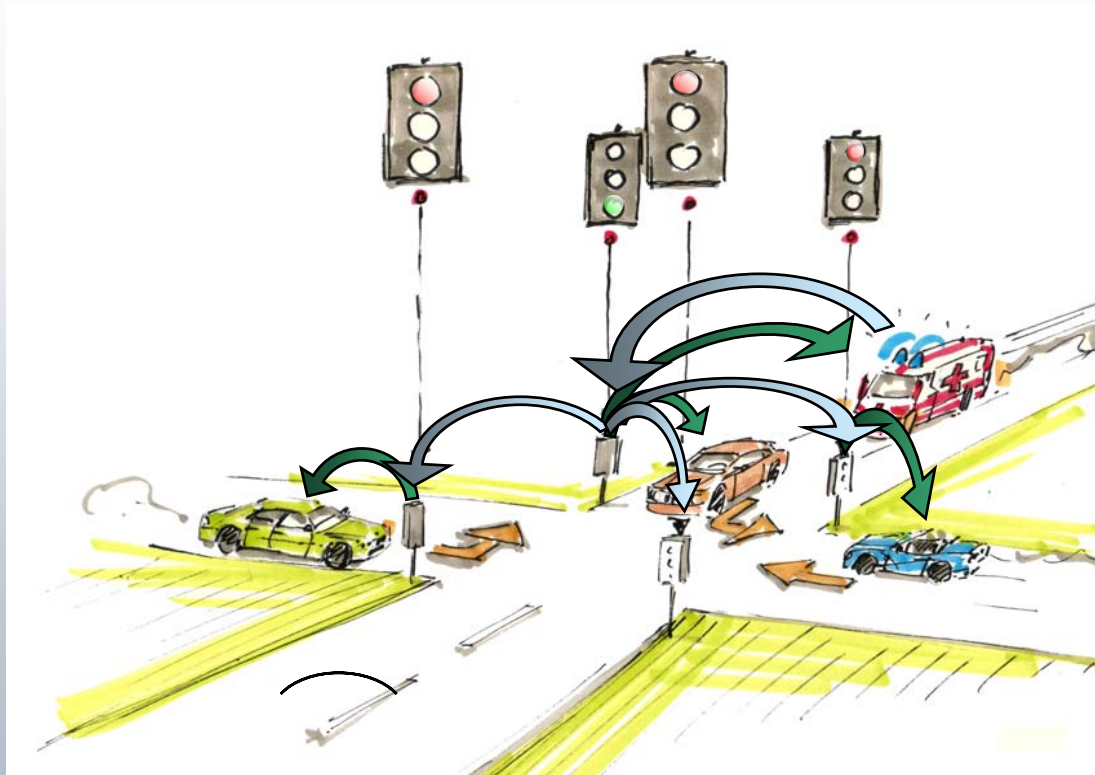
Sensor Network: Content-based Messaging



Data Integrity, Security & Privacy



Data Integrity, Security & Privacy



**Traffic
Lights**

**Emergency
Vehicle**

$M_S, \text{Sig}_{\text{Lights}}\{M_S\}, \text{Cred}_{\text{Lights}}$

p, g und X ($X = g^x \bmod p$)

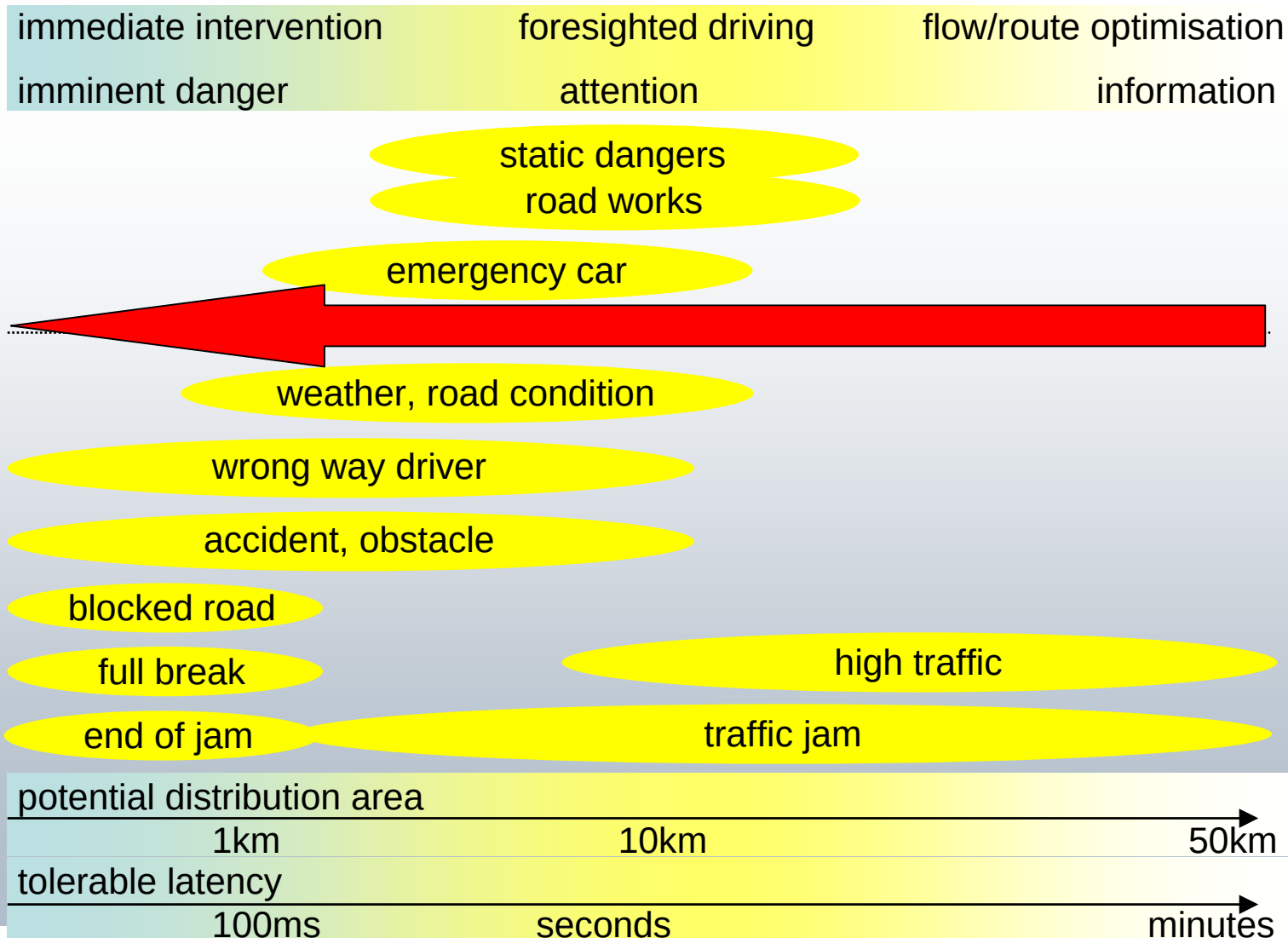
Y ($Y = g^y \bmod p$), $\text{Crypt}_K\{\text{Sig}_{\text{Lights}}\{Y, X, p, g, M_S\}, M_S\}$

$\text{Crypt}_K\{\text{Sig}_{\text{Car}}\{Y, X, p, g, M_C\}, \text{Cred}_{\text{Car}}, M_C\}$

$\text{Crypt}_K\{M_C\text{-ACK}\}$

M_S :	periodic status message
$\text{Sig}_{\text{Car}}\{x\}$:	signature of "x" created by "Car"
$\text{Cred}_{\text{Lights}}$:	credential of "Lights"
X, Y, p, g :	public Diffie-Hellman key parameters
x, y :	secret Diffie-Hellman key parameters
$\text{Crypt}_K\{x\}$:	encryption of "x" using Key "K"
M_C :	control message
$M_C\text{-ACK}$:	Acknowledgement for control message M_C

Immediate Information



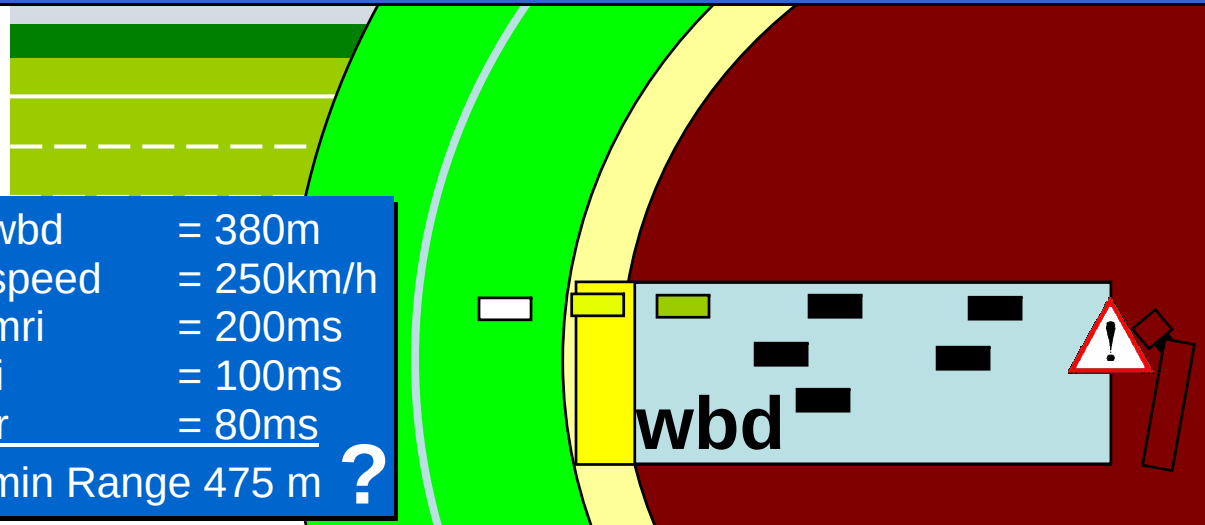
Immediate Information

Minimum radio range:

- Dependent on worst case max. braking distance (wbd)
- Dependant on overall latency (l_i / l_r)
- Dependent on message resend intervall (mri)

$$\begin{aligned} \text{min radio range} = & \text{wbd[m]} + l_i[\text{s}] * \text{speed[m/s]} \\ & + (\text{mri[s]} + l_r[\text{s}]) * \text{speed[m/s]} \end{aligned}$$

wbd = 380m
speed = 250km/h
mri = 200ms
 l_i = 100ms
 l_r = 80ms
min Range 475 m ?



Immediate Information

Overall latency: Process chain

- **Sensor activation**
- **Hazard/Danger Interpretation**
- **Message Creation**
- **Medium Acces**

- **Message Transmission**
- **Integrity check**
- **Reputation check?**
- **Relevance check**
- **Driver Information**
- **Driver Response**

Necessity for signing every message with a valid certificate?

Message size?

Necessity for evaluation of certificate!

Prototyping: Local Danger Information



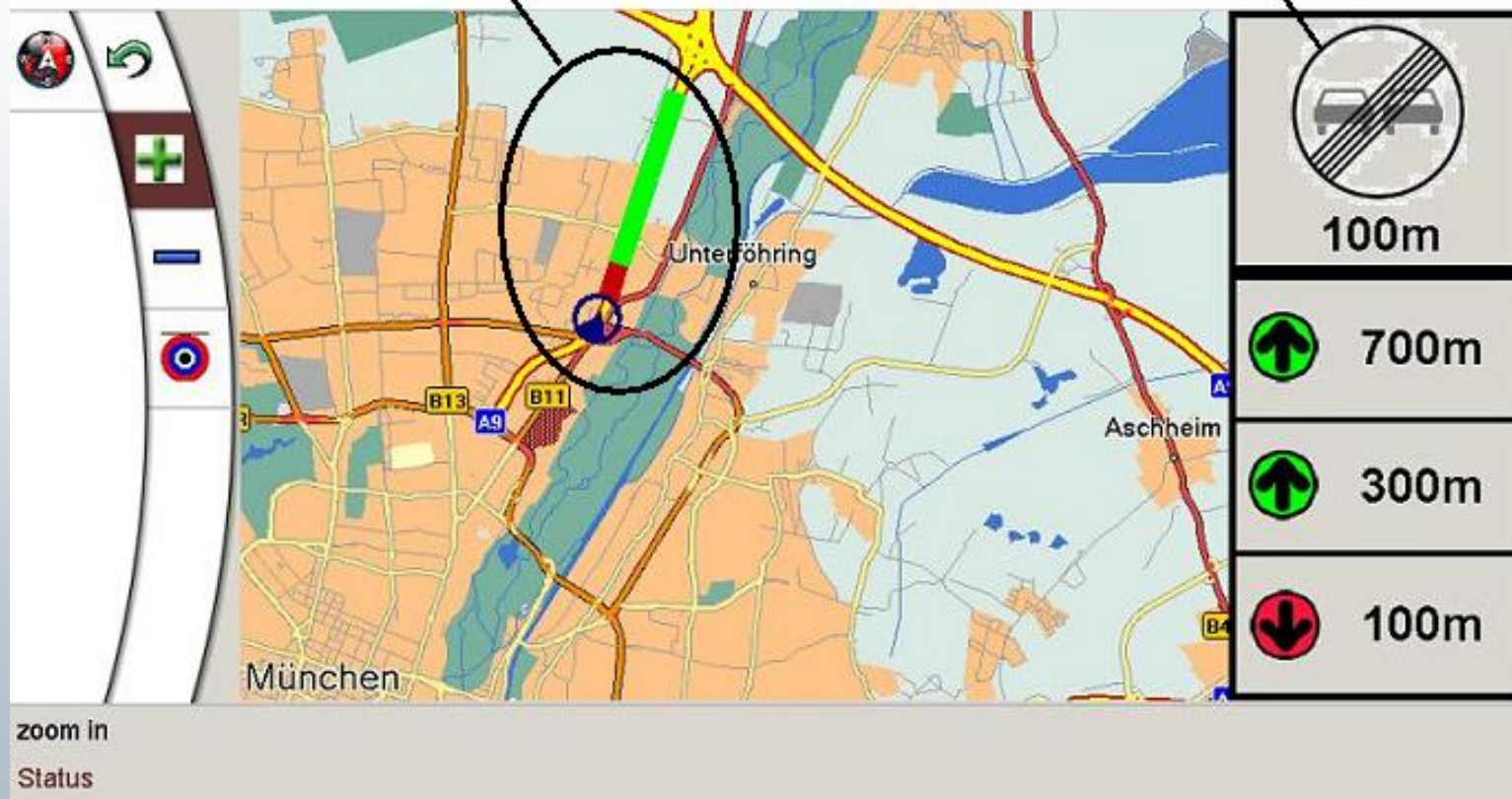
Prototyping: Local Danger Information



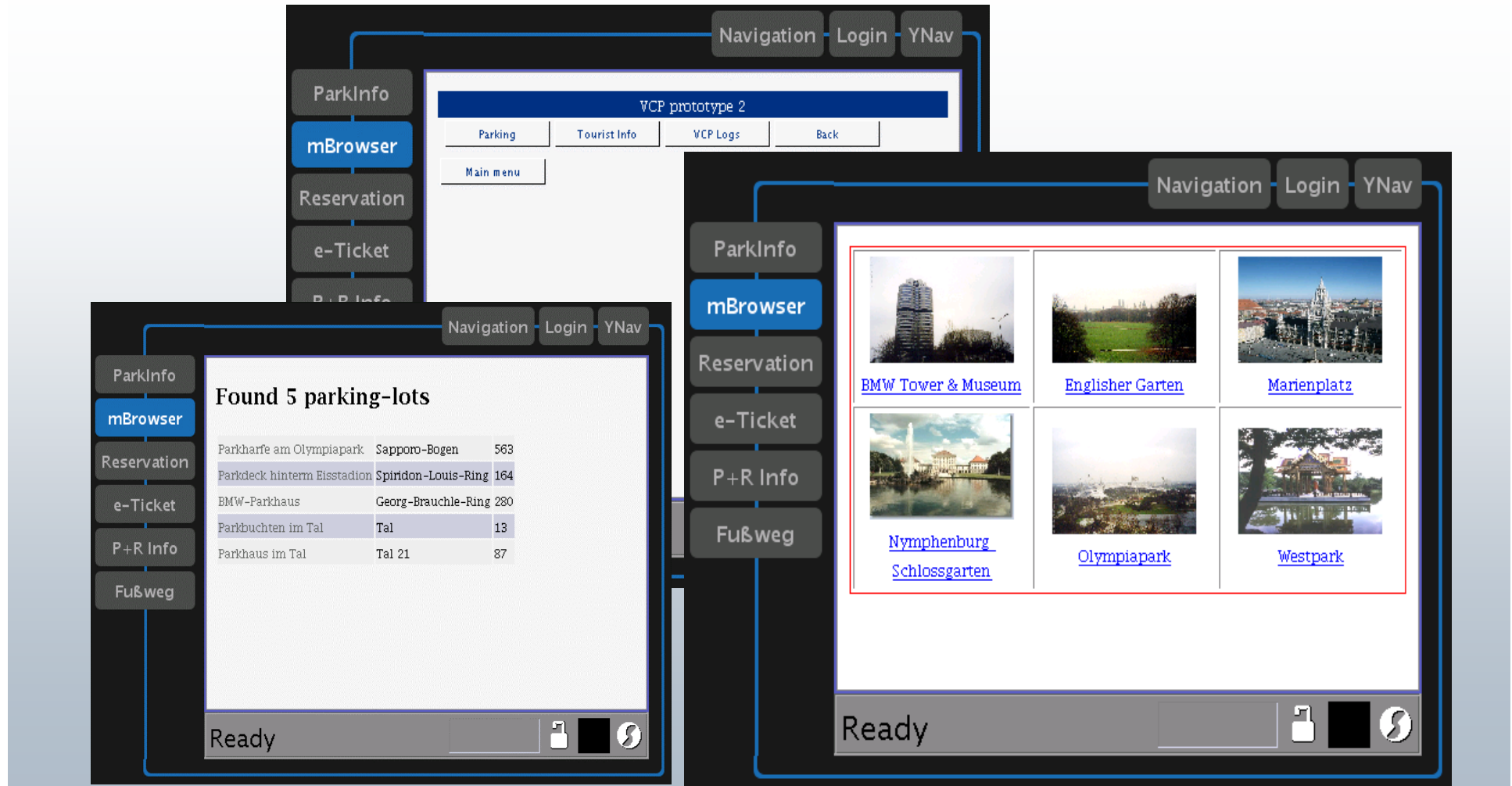
Prototyping: Immediate Traffic Information

Einfärbung der vorausliegenden Straßenabschnitte
gemäß aktueller Verkehrslage aus VLA Fzg.-Fzg.-Kommunikation

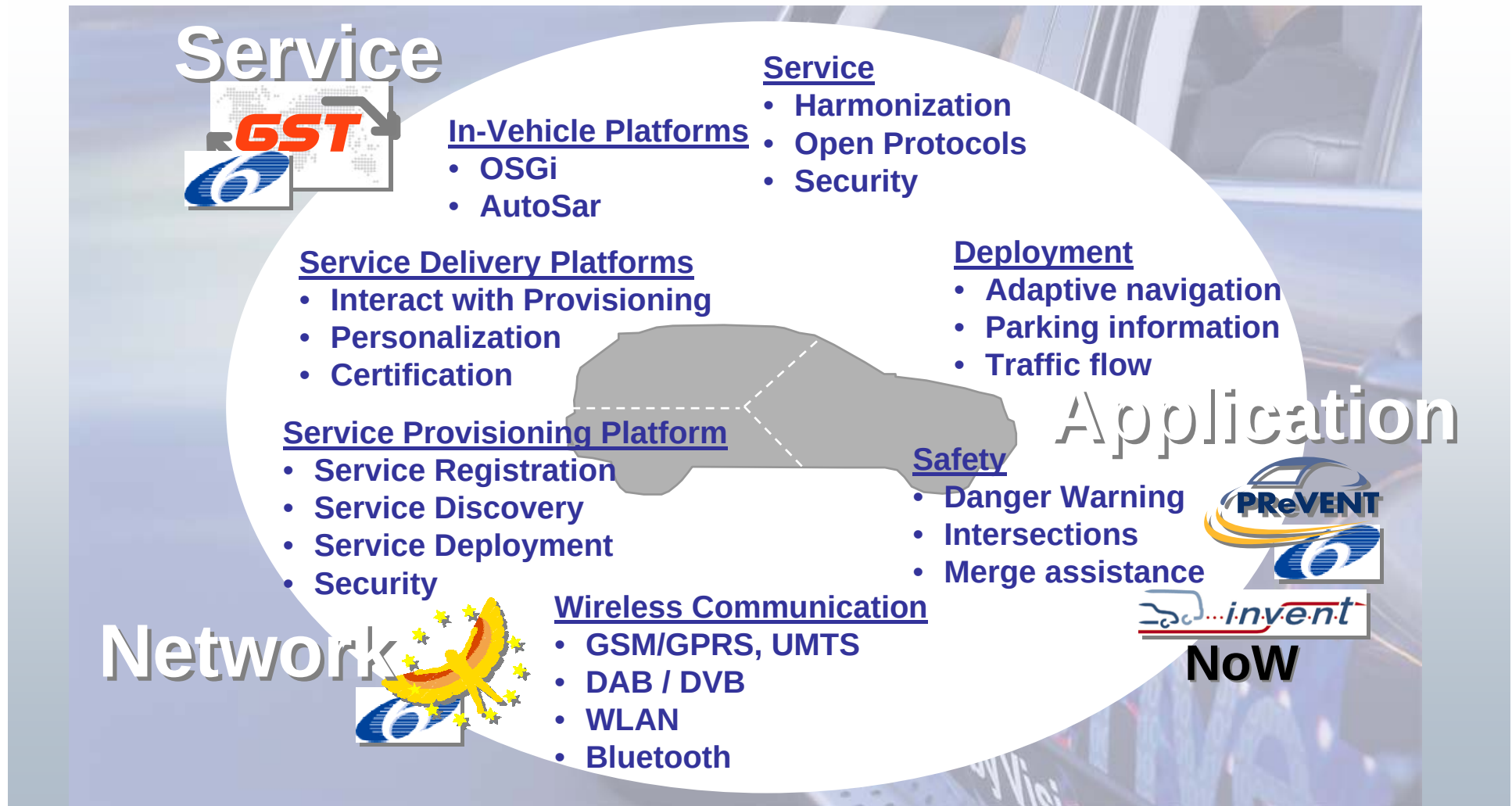
Freie Fahrt in 100m



Hot Spot Access: Virtual City Portal



The Technical Environment



Thank You.

