CoCarX
Cooperative Cars eXtended

Cooperative Cars eXtended - CoCarX

Activating mobile traffic channels

Securing mobility - using cellular communication

"If only I had known sooner..." – a typical thought in critical traffic situations. Timely and precise information is an important aspect in future safety and traffic efficiency systems. The previous Cooperative Cars project (CoCar, 2006-2009) has clearly shown the large potential of cellular communication for such applications, focusing on cooperative systems.

In Cooperative Cars Extended (CoCarX, 2009-2011), the project partners now show how this approach can be brought closer to market introduction, how cellular-based solutions interact with other communication channels and how new technology developments can improve the solution even further.

Introducing the new cellular radio technology Long Term Evolution (LTE) is a game changer in many respects. For cooperative systems, it means that the typical car-to-car transmission delay improves even further to values clearly below 100 milliseconds. The increased system capacity of LTE leads to more vehicles that can be served. The ongoing rollout of LTE will soon, combined with the evolving High Speed Packet Access (HSPA) networks, lead to almost complete broadband coverage. And with its wide acceptance, LTE develops into the future radio standard, not only across Europe, but throughout the world.

The research in CoCarX also clearly shows that the cellular network can be combined with ad hoc based approaches such as 802.11p (pWLAN) into one heterogeneous communication system. This leverages the strengths of both systems and forms a combined, overall solution that is much more than just the sum of its parts. Standardized

CoCarX Project partners

- Bundesanstalt für Straßenwesen
- Ericsson
- Ford Forschungszentrum Aachen
- Vodafone D2
- Vodafone Group R&D

Cooperative Cars

- Technical feasibility confirmed using reference case Road Hazard Warning
- Car-to-car delay with HSPA below 500 ms
- Network capacity sufficient for market introduction
- Broadcast technology provides capacity for later stages
- Commercial feasibility of Road Hazard Warnings confirmed, break-even possible within three years

Cooperative Cars eXtended

- LTE further improves car-to-car communication delay times to below 100 ms
- Network capacity and broadband coverage further increased
- Heterogeneous communication system with pWLAN and LTE
- Multi-service capabilities and differentiated billing
- Enhanced data and service management

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message formats can seamlessly be used over both communication channels. This means that messages can be transmitted over the most appropriate channel or channels, depending on the nature of the message and the available communication means.

On the way towards commercial deployment, also the service and subscription management solution developed in CoCarX will play a vital role. Largely building on existing and widely deployed technology, it is possible to bring different services into the car over one radio connection. These services can be assigned different priorities during the transmission, e.g. to ensure that a video download doesn't slow down an important warning message. The different services can also separately be billed, with tailored tariffs matching the business model of the respective service. The standardized management and the economy of scale make it possible to cost-efficiently handle the large number of services and subscribers. As an additional benefit, relying on the standardized and proven solutions also enables cross-country operation and provides methods for lifecycle management. Common enablers, such as a Geo Messaging component, complete the picture. External services can be connected using a variety of methods, depending on the needs of the service. Such external connections are e.g. required to connect the data aggregation server also developed in the project or exchange data over a Mobility Data Marketplace.

We invite you to take a look at the details of the project results on the next pages, based on eight selected posters from the CoCarX final presentation.

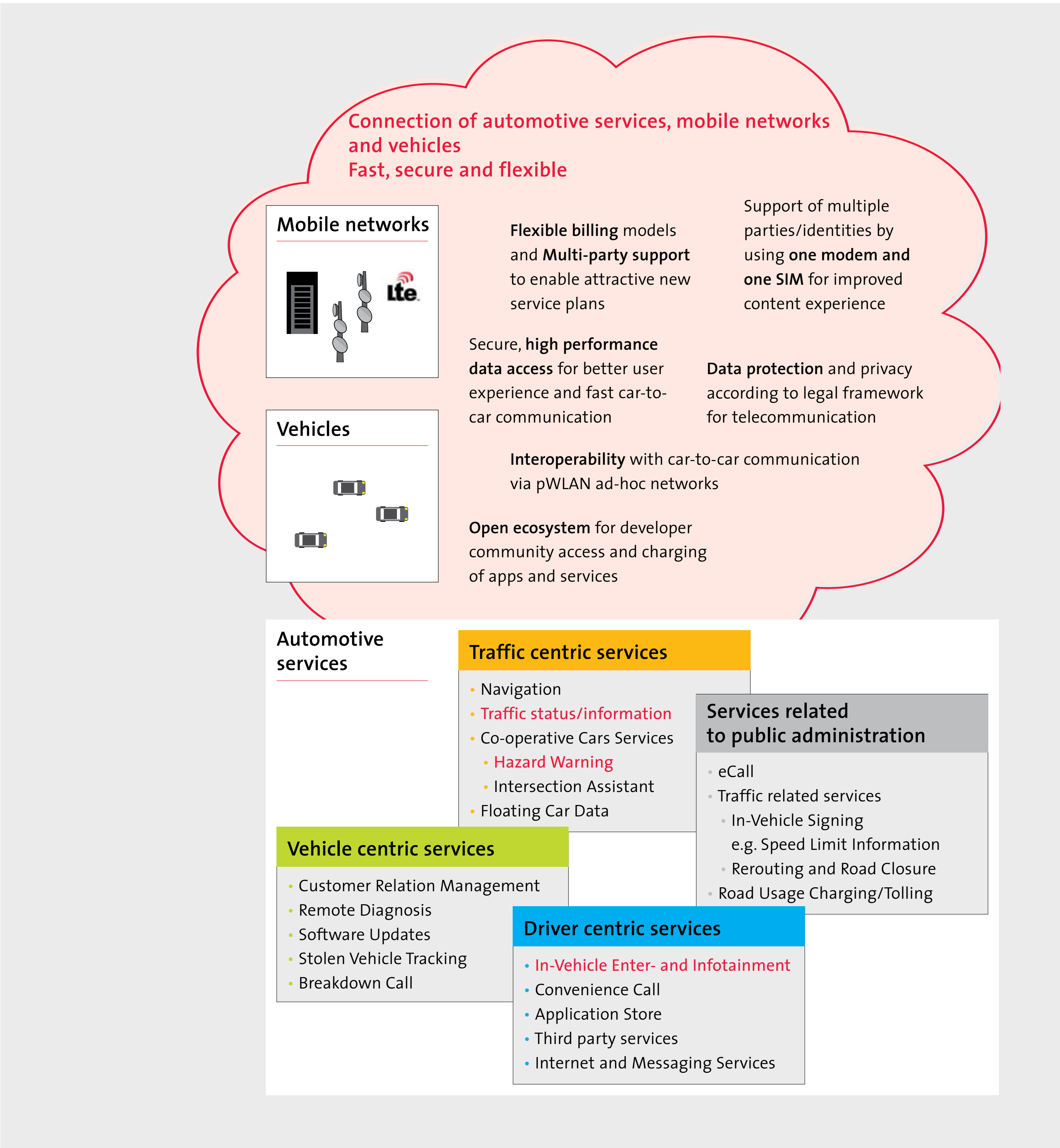
below

100ms

car-to-car delay

with LTE

CoCarX scope & requirements



Taking advantage of cellular mobile networks

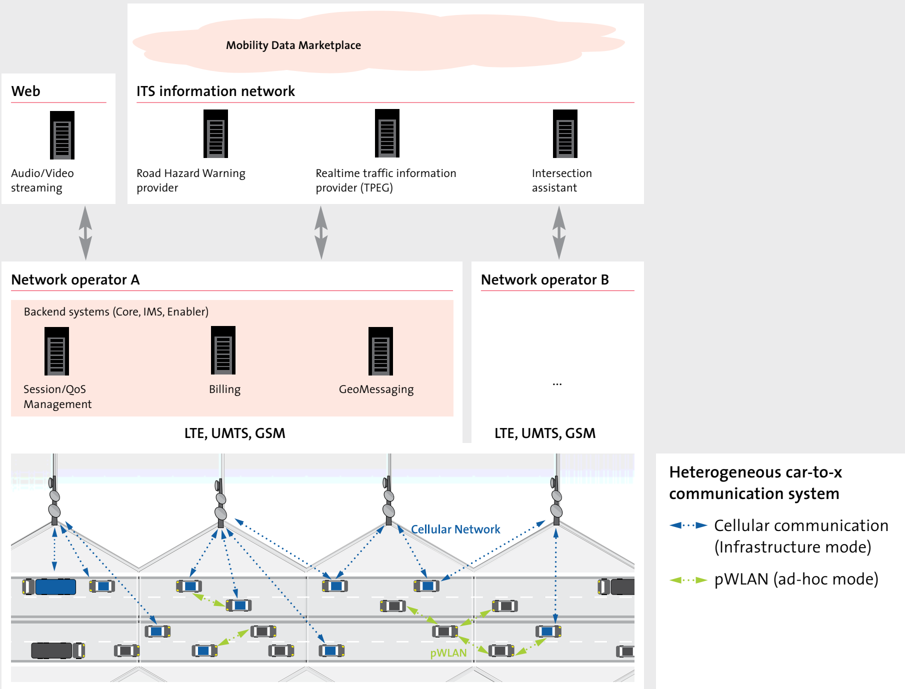
- **Cooperative systems can cost-efficiently be based on existing technologies and infrastructure**

- **Traditionally standardised cellular mobile networks are already available and implemented**
  - GSM, UMTS, LTE
  - Adaptable core network architecture

- **Builds upon existing organisational infrastructure**
  - Network providers/operators
  - Operative business (billing, etc.)
  - Service platform

- **Cooperative systems' architectural requirements can easily be met**
  - Third party service provider (traffic information service)
  - Mobility Data Marketplace
  - Vehicle

- **Compliance with existing legal framework for telecommunication**
  (German Telecommunication Act [Telekommunikationsgesetz – TKG])
  - Priviliged data use for „value added services" in terms of data privacy possible (according to sec. 98 (1) TKG)
  - Precondition to use of service: User consent (e.g. electronically submitted, see sec. 94 TKG)
  - Presently foreseeable legal revision of sec. 98 TKG will in general not affect basic legal feasibility



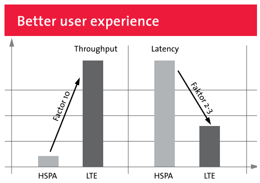
LTE - 4th generation mobile network

LTE key benefits

LTE as 4th generation mobile network technology provides a powerful basis for car-to-car and car-to-infrastructure communication.

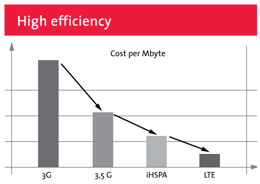
Better user experience

- High user data rates
- Low latency
- High throughput per cell
- Developed for „always on“ services



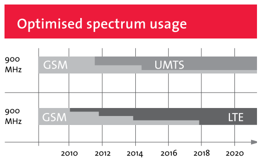
High efficiency

- Efficient network operation
- Strong IP-centricity
- Flat network architecture
- Low configuration effort



Optimised spectrum usage

- Suitable for current and future mobile spectrum
- Flexible channel bandwidth
- Suitable for paired and unpaired spectrum



Network coverage

Frequencies below 1 GHz provide ideal propagation properties for seamless mobile networks. New spectrum at 800 MHz and open GSM spectrum at 900 MHz on pan-European level.

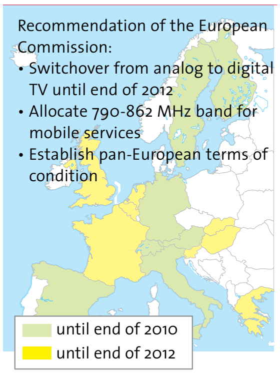
Current mobile broadband coverage

3G coverage, 2.1 GHz band

Future mobile broadband coverage

LTE coverage, 800 MHz band (digital dividend)

Situation in Europe



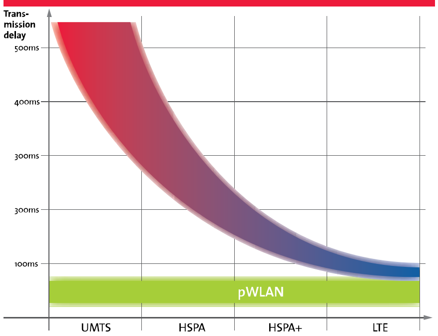
Digital switchover schedule of the European countries

UMTS/LTE transmission delay measurement results

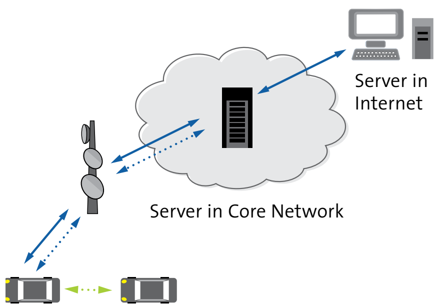
Transmission delay

Car-to-car transmission delay is the most important parameter for cooperative services

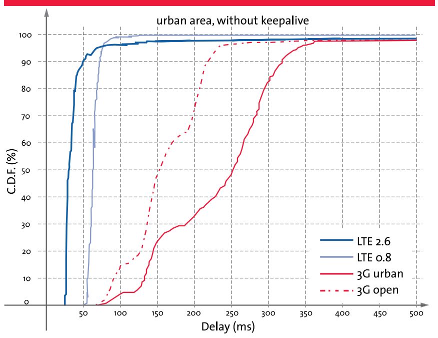
Technology evolution



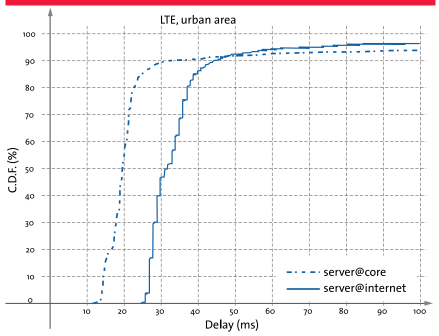
Measurement Setup



UMTS versus LTE delay



Over the air vs. End-to-End delay



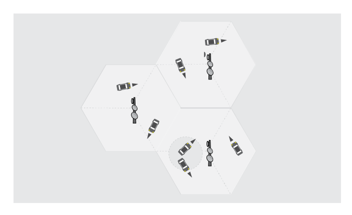
Key results

- LTE shows significantly improved network delay compared to UMTS
- Good results even under network load
- Network topology can be optimised for delay-critical services (e.g. placement of application server in core network)

LTE Capacity Evaluation

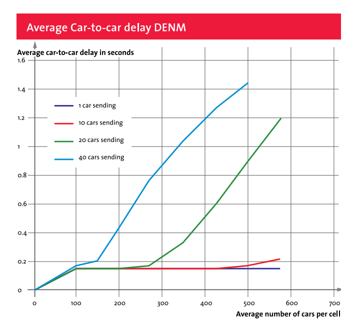
Approach

- LTE radio network simulations
- Full protocol stack and mobility simulated
- 9 cells, 3 sites, 5 MHz LTE carriers
- Over 5000 cars simulated
- Message sizes based on ETSI DENM/CAM



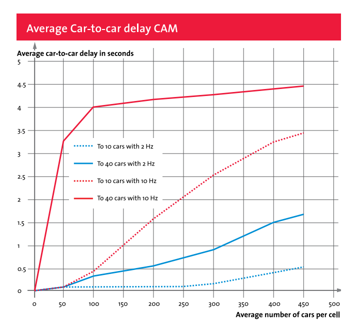
Event Notification Messages

- Limiting: Downlink data channel capacity
- 1 Hz average message rate per sender
- Distribution of messages to cars in same cell
- Comparison of average of 1, 10, 20, 40 cars per cell with hazard to report
- Stable results for 10 senders per cell
- Car-to-car delay < 200 ms even under load
- Linear scaling for other parameter sets



Cooperative Awareness Messages

- Limiting: Downlink signaling channel capacity
- Distribution of messages to 10 or 40 cars in vicinity
- Message rate 2 Hz and 10 Hz compared
- Substantial system data and signaling load generated
- Lowering message rate and good downlink filtering required to manage load



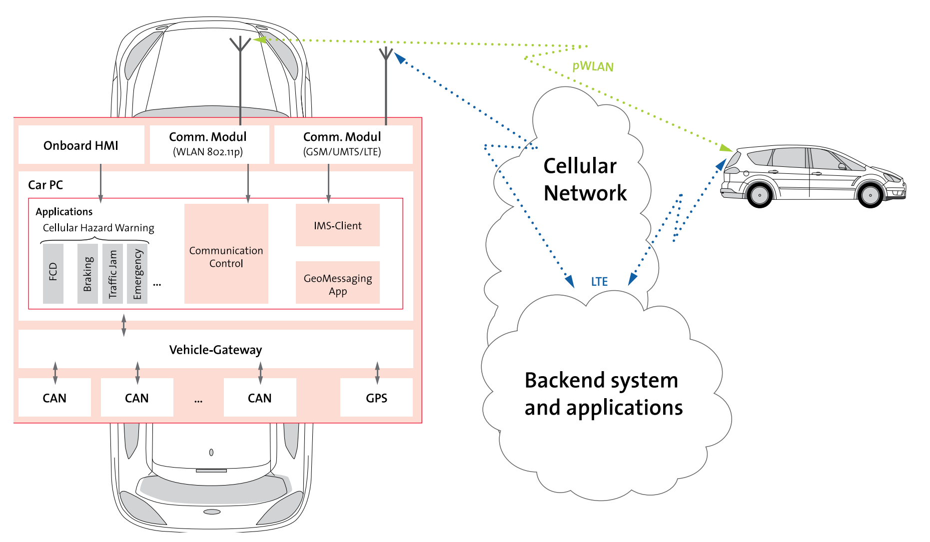
Key Results

- Event notification messages handled well for typical scenarios
- Cooperative awareness messages possible, but require significant adaptations
- System capacity improvements compared to UMTS confirmed

Heterogeneous communication

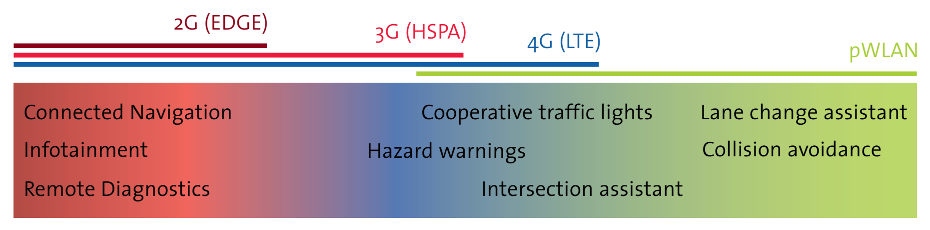
CoCarX vehicle communication platform

- Platform combines pWLAN (IEEE 802.11p) and LTE (Mobile network)
- Compatible to simTD and ETSI standards related to pWLAN
- Additional components to support the CoCarX Architecture:
  - IMS Client for link and session management
  - GeoMessaging Application
  - IP-based CAM and DENM transport over mobile network, compatible to simTD



Heterogenous platform with both communication technologies

- Supports widest range of in-vehicle features/services
- Increases communication reliability, because of alternative link
- Demonstrates similar latencies (less than 100ms)



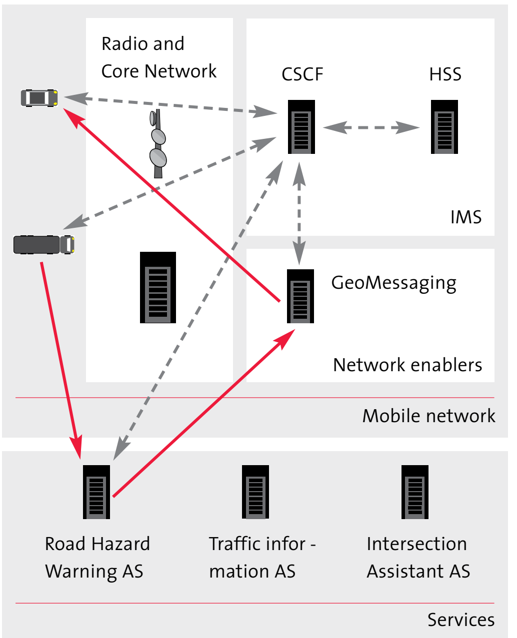
Session handling

IMS-based session management

Session handling via IMS
- Establish connection
- Handle quality of service
- Establish connection to application servers
- Collect billing information

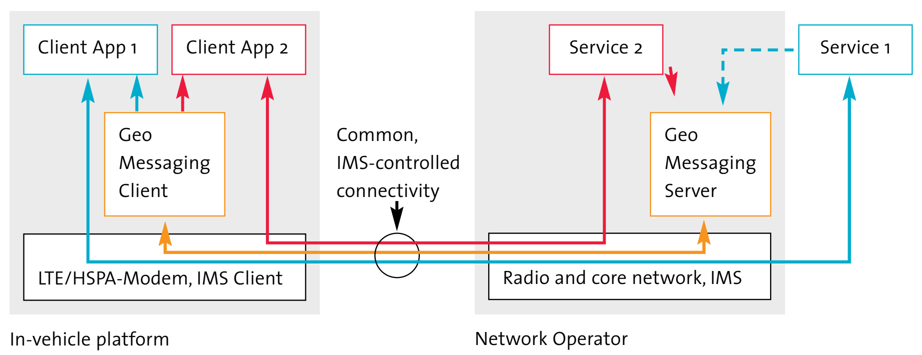
Application data directly between client and server
- Efficient handling of time-critical messages

AS - Application server
CSCF - Call Session Control Function
HSS - Home Subscriber Server
IMS - IP Multimedia Subsystem



Multi-Service Capability

- IMS manages connectivity, QoS and billing
- Separate data streams through one common connection
- GeoMessaging as a common service
- Various integration options for applications
  - Standard SIP user agent
  - Protocol translation, e.g. to HTTP REST
  - Simplified communication through gateway

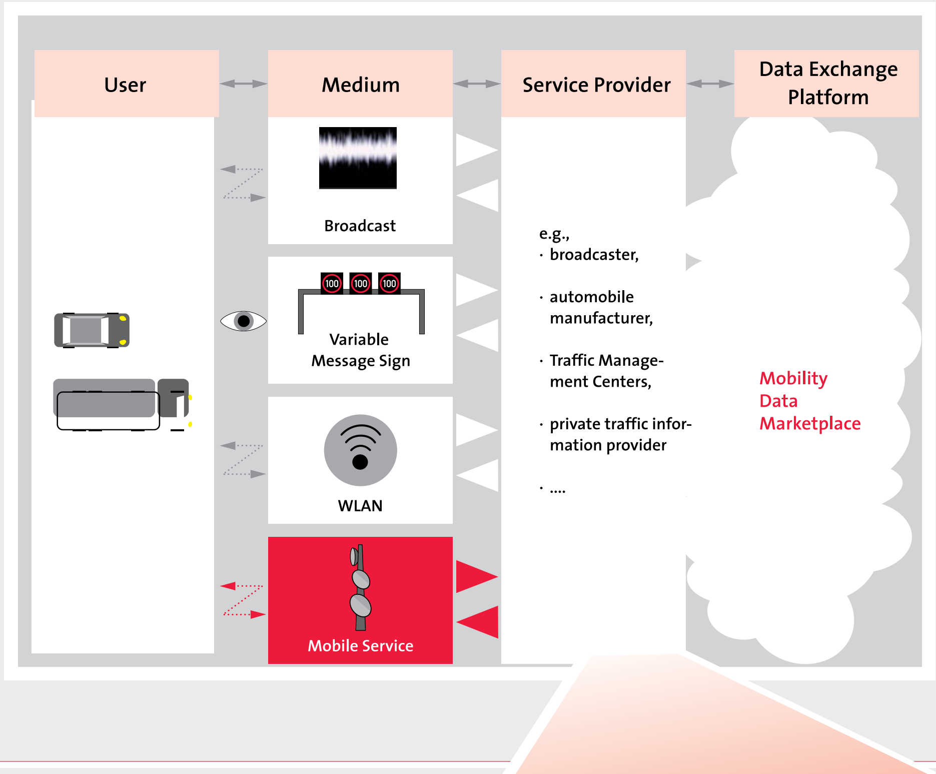


Information Management

Traffic Information

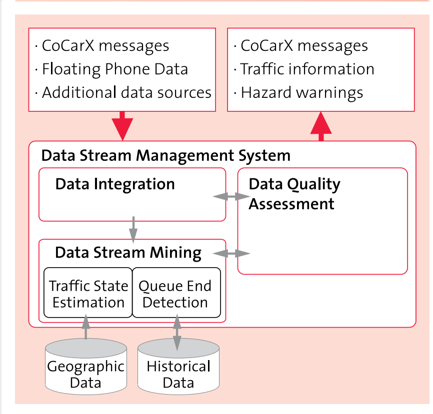
Services of Mobile Network Operators in the Field of Traffic information

- Simple provision and acquisition of traffic data
- Optimisation of business processes
- Standardised interfaces and communication methods for data exchange



Traffic Data Management

- Data Streams: flow of data, processed in real-time
- Utilization of mobile data sources
- Data fusion in Data Stream Management System
- Continuous data quality assessment
- Determination of traffic state and hazards using data stream mining techniques



As at may 2011

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