aktiv

Adaptive and cooperative technologies
for intelligent traffic

Cooperative Cars - CoCar

Activating mobile traffic channels

Securing mobility - using cellular communication

Communication improves mobility: High-performance traffic management and dynamic route guidance already form an integral part of the transport system in modern society. They inform people of the traffic situation, reduce commuting times, enable flexibility in business and improve organization of commercial transport. Nonetheless, traffic systems are faced with enormous present and future challenges in order to provide people on the move with maximum safety, efficiency, and comfort.

These problems are specifically addressed by the research initiative Aktiv. Twenty-nine partners in three projects will develop applications in active safety, intelligent traffic management, and mobile traffic data communication technologies. In order to support and protect the driver in hazardous or critical situations, assistance systems such as active hazard braking and intersection assistance are being developed. They will precisely measure the vehicle environment and monitor driver alertness in order to react adaptively to each situation. By means of novel traffic management systems, the partners aim to network traffic users with traffic guidance systems, thus improving the performance of the roadway network.

The research initiative Aktiv comprises the following projects:

Traffic Management

- Network Optimizer
- Virtual Traffic Guidance System
- Cooperative Traffic Signal
- Adaptive Navigation
- Situation-Responsive Driving
- Information Platform
- Cooperation and Innovation Forums
- Assessment

Active Safety

- Active Hazard Braking
- Integrated Lateral Assistance
- Intersection Assistance
- Pedestrian and Cyclist safety
- Driver Awareness and Safety

Cooperative Cars

- Communication Protocols and Simulators
- Prototypes and Innovation Potential

CoCar Project partners

· Daimler AG
· Ericsson GmbH
· MAN Nutzfahrzeuge AG
· Vodafone Group R&D Germany
· Volkswagen AG

The future linkage of advanced driver assistance and traffic management systems will require a communication system providing efficient, timely exchange of traffic data with both local referencing and complete coverage. Cellular communication offers an attractive solution. The latest cellular communication generation provides high-performance channels suitable for traffic data transmission.

With data transmission rates of up to 14 Mbit per second and transmission latencies of less than one second, present cellular communication systems lend themselves to smooth communication between driver assistance and traffic management systems and thus offer an enormous potential for innovation. Future cellular communication systems will multiply this performance. The **Cooperative Cars (CoCar)** project, supported by the Federal Ministry for Research and Education, will test the suitability of UMTS technologies and their foreseeable extensions for direct, targeted transmission of traffic data arising both from stationary and vehicle-based sensors. By mid-2009, five partners from the telecommunications and automobile industry will identify which traffic management and driver assistance applications are suitable for use of this technology. In addition, the researchers will develop prototypes to test automotive communication using celluar communication systems.

14 Mbit

per second

transmission rate

Supported by

Federal Ministry
of Education
and Research

Traffic communication without borders

"If only I had known sooner...": a typical thought in critical traffic situations. Timely and precisely localized information comprises one of the most important functions of future driving safety and traffic management systems. For 14 characteristic traffic scenarios – involving local hazard warnings, traffic incident detection, advanced driver assistance, and traffic management – the research project CoCar will test the suitability of high-bandwidth, wireless cellular communication infrastructure for practical use in day-to-day traffic.

Local hazard warnings: Downstream vehicles will be able to warn following vehicles in case of emergency braking, jam formation, poor weather conditions, or accidents. The goal here is to test whether time-critical traffic data can be transmitted precisely to the target by cellular communications within milliseconds.

Traffic hindrances & bottlenecks: In order to advise vehicles on a freeway section of approaching ambulances, utility vehicles, moving road works, and the like, both a supervisory processing level and a means of transmitting local information are required. CoCar will analyze how this information can be effectively processed in cellular networks and traffic centers, in order to provide targeted information to electronic assistance devices in vehicles.

Ask the project manager: four questions to Dr. Guido Gehlen

Dr. Guido Gehlen is leading the CoCar project, supported by the Federal Ministry for Research and Education, within the Aktiv research initiative. Dr. Gehlen received his doctorate in electrical engineering and is working at Ericsson GmbH.

► ***Transmission of traffic and vehicle sensor data via cellular communication is a true innovation. What is the significance of a cellular communication based transmission system for the future European vehicle market?***

With over 220 million currently registered vehicles, we will reach an enormous pool of European users with access to a comprehensive cellular network. For this reason, CoCar is striving toward accelerated development of cellular communication technology for transmission of traffic information and testing of its performance attributes.

► ***In the future, traffic data will be transmitted within the blink of an eye; however high transmission rates are not the only characteristic of cellular communication. What are the advantages of this technology for implementation in traffic?***

Clearly, rapid transmission is a basic requirement for many safety-critical vehicle driving applications: Early warnings extend virtually the driver's visual horizon and thus are a key element in accident prevention. From the point of view of the CoCar partners, the cellular communication system offers the decisive advantage of access to an infrastructure with an established and secure economic operational basis.

► ***The performance of 2.5G, 3G, 3G+, LTE – cellular communication systems has been steadily improving. What makes the current generation so***

Driving Assistants: A high concentration of sending and receiving vehicles within a small area will be a common occurrence in traffic, for example, if several vehicles equipped with intersection assistance and speed control systems enter an intersection, or if numerous passengers in different vehicles use multi-media services. The capacity of the cellular communication system will be investigated for such situations to ensure that targeted data transmission and exchange of significant traffic information function – even in the presence of high data channel demand.

Traffic management: Modern traffic management systems can only act efficiently if the data of all component systems – ranging from assistance functions to traffic guidance infrastructure – are systematically processed and fused. The CoCar partners are developing strategies for automatically measuring, processing, and distributing enormous quantities of data on a large scale and in real time. Centralized data transmission will supply the data to traffic service providers, while decentralized distribution will make the data available to devices such as intelligent traffic signals.

Whether traffic management or hazard warnings are involved, an important requirement for success is a viable operating scheme connecting different devices and entities: e.g., on-board vehicle computers, cellular networks, and supercomputers in traffic information centers. Solutions are being developed in CoCar to provide smooth data transmission between different vehicle and communication generations as well as different service providers.

attractive for active safety and traffic management applications?

For the first time, the current generation of cellular communication devices and infrastructure enable rapid transmission with high data rates. They also provide a basis for broadcast technologies, which can be used to create attractive channels for efficient transmission of regionally specific traffic data to all affected vehicles.

► ***Basic research for practical use – what applications are currently envisioned by the CoCar partners?***

One future goal is to use cellular networks to warn the driver of traffic hazards such as black ice, accidents, or moving road works directly and with minimal latency. Another aim is to provide navigation systems with information about the road and traffic state in order to achieve convenient, economic, and environmentally friendly mobility.

Dr. Guido Gehlen

Virtual preview

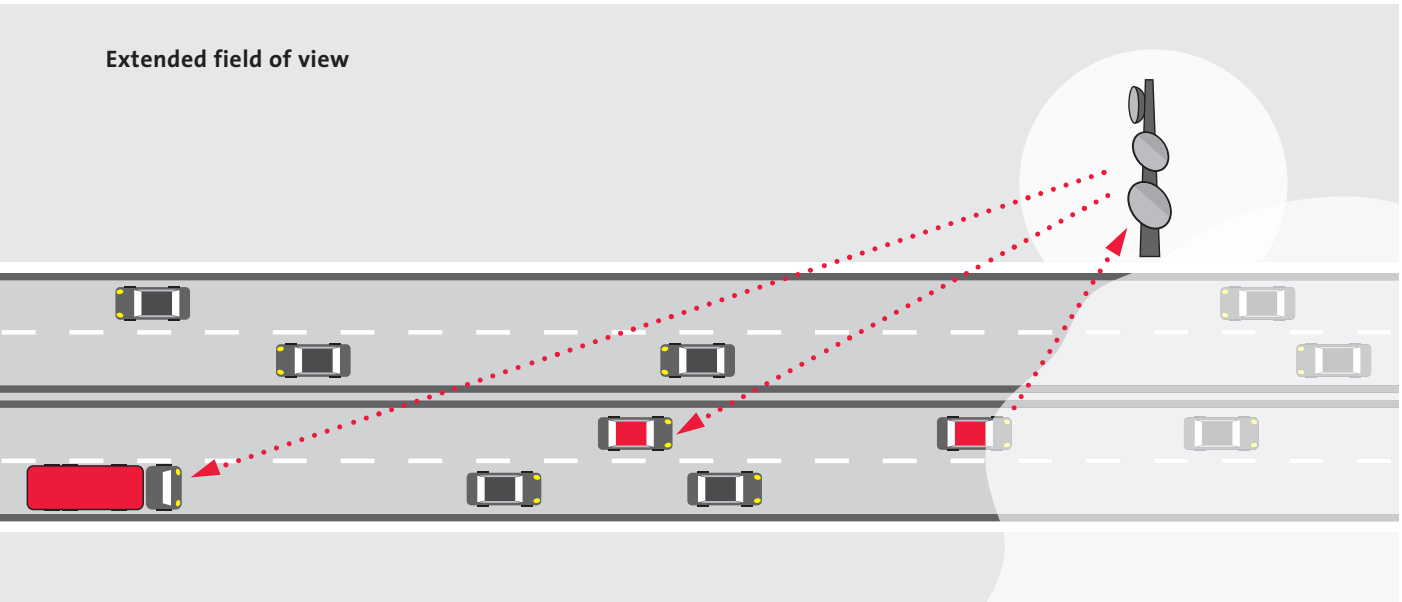
Thick fog ahead, visibility less than 50 meters. This information is available to the on-board computer long before the driver perceives it or the vehicle sensors can detect it – the vehicle is about to penetrate a fog bank within the next few kilometers.

Key technical parameters are the traffic data trans mission latency and the data rate of the cellular network

Preceding vehicles have reported the fog bank to the on-board computer by cellular communication– data have been transmitted within a fraction of a second. The elapsed time statistics are evaluated and displayed by the simulation computer. Currently the vehicles, the poor-visibility report, as well as the data transmission processes exist only virtually in computer simulation in CoCar.

The simulations are designed to compute the technical performance that will be required from cellular nets in order to transmit timely, localized, and comprehensive road and traffic information. The results of this work package led by Ericsson GmbH will form the backbone for developing a communication system for transmitting traffic data. It will establish appropriate data formats and communication protocols, test the value of cellular communications in typical use cases and traffic situations, and minimize the need for construction of expensive system components.

The key technical parameters for the engineer are the latency of traffic data transmission – duration from creation of a connection to data acquisition at the destination – and the capacity of the cellular network: How many vehicles can communicate simultaneously within a small area? Which information is required to warn all approaching vehicles? What transmission speed is required to inform following vehicles on time? What filters are necessary to minimize the quantity of information required?



18,109

injury accidents in the year 2006 due to slippery roads or poor visibility in Germany!

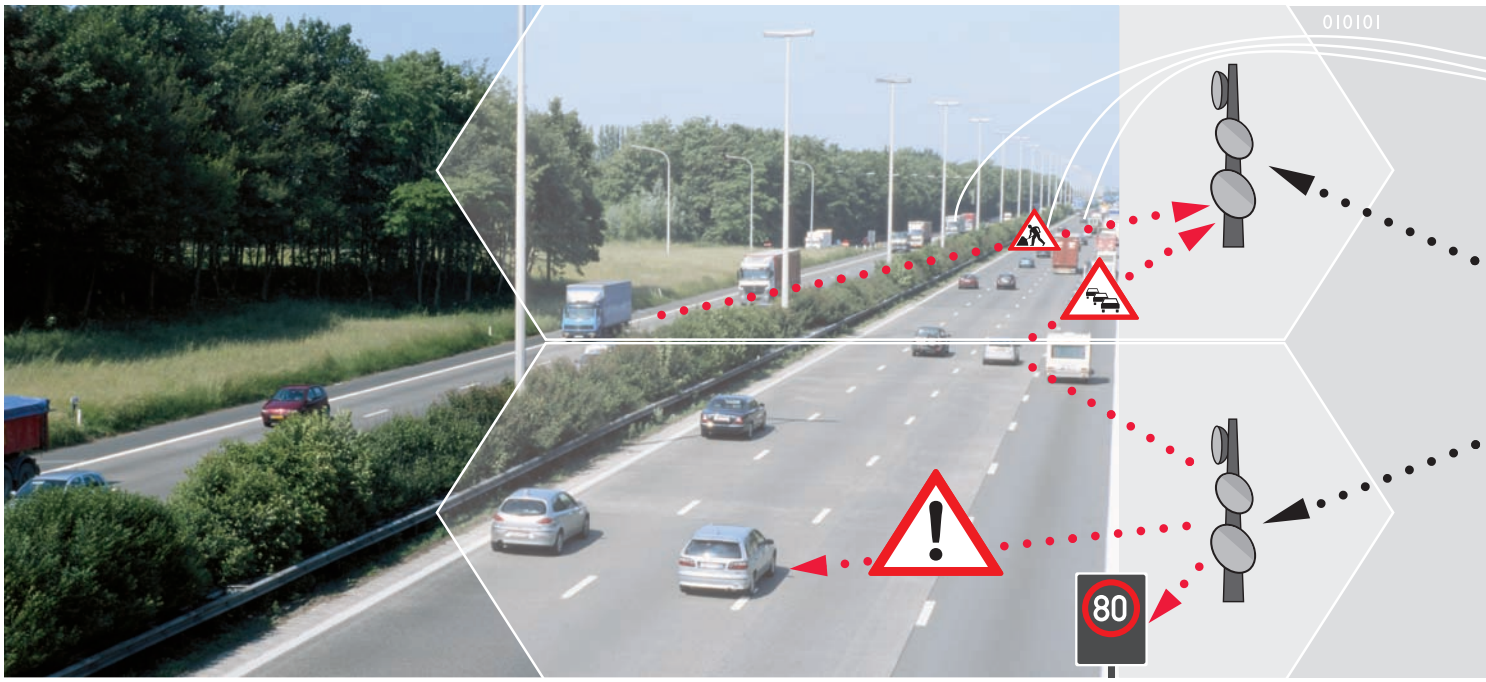
In order to obtain a thorough understanding of cellular network performance, information transmission, and driver behavior, the engineers are simulating a wide range of typical traffic situations. They focus on scenarios in which advanced driver assistance and traffic management systems support the driver. These include for example poor road conditions such as hydroplaning or poor visibility. The extensive simulation of traffic scenarios required here poses challenges even to specialists. Transmission of data between traffic management and driver assistance systems by cellular communication is being emulated for the first time in CoCar. In a nutshell, the challenge is to simulate a very large and spatially varying number of rapidly moving components: vehicles and traffic infrastructure components, which flexibly exchange data, as well as the dynamics and interactions of evolving traffic situations that continually generate new information. These reports must either be continuously transmitted, such as reports on moving road works, or triggered, such as tail-back or fog warnings.

One can imagine a typical scene unfolding on the A8 Autobahn in Bavaria, on a stretch from the Irschenberg hills down to lake Chiemsee: Heavy traffic is rolling down from Irschenberg at 100 km/h. Five kilometers ahead, the first vehicles enter a thick fog and brake abruptly. Future vehicle sensors detect the fog, and the on-board systems report sharp braking from 100 down to 60 km/h. Now the task is to establish a connection to the cellular communication system within milliseconds, to send the information, and to warn the following vehicles. In the simulation, only a fraction of the vehicles are assumed to be equipped with a cellular communication unit capable of sending or receiving a report. Subsequently the report is also received by vehicles located kilometers behind the first vehicle entering the fog bank.

Future vehicle sensors detect fog, and at the same time the on-board system reports strong braking

Supported in key traffic szenarios

Technological jumps create new opportunities for innovation. Recent progress in cellular communications technologies will now enable novel, high-performance channels for traffic data transmission.



cellular communication operator

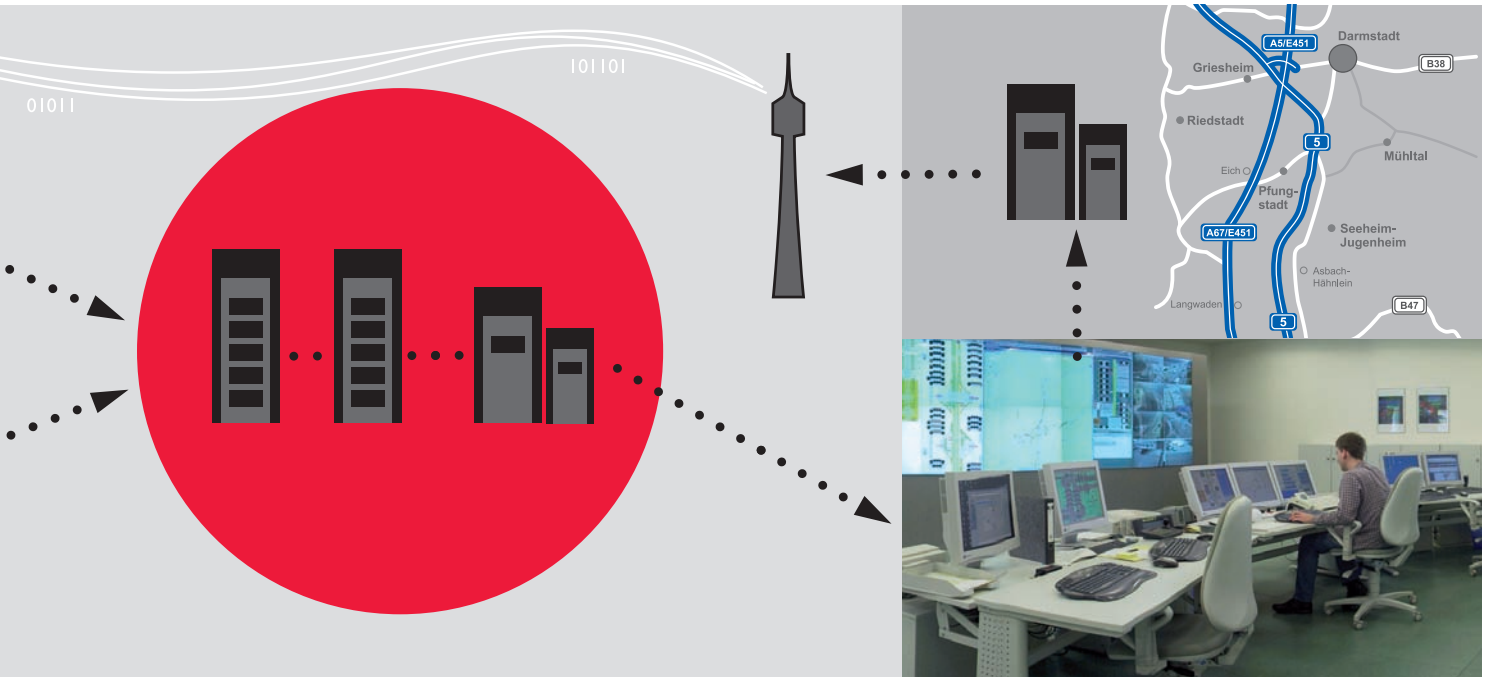
The potential of cellular communications for traffic management and vehicle driver assistance will be analyzed and tested using prototypes in the project CoCar. To this end, typical traffic situations known as “scenarios” will be simulated as a basis for analyzing the value of cellular communication for inter-vehicle traffic data transmission and for data exchange between vehicles and traffic guidance systems, using cellular infrastructure.

Using these scenarios, the researchers will analyze applications in traffic and in vehicles as well as the resulting technical challenges for cellular communication: requirements for smooth information exchange between the vehicle computer, traffic infrastructure, and traffic centers; business models; and vehicle implementation.

Risk of congestion on a freeway

In addition to other scenarios, the researchers have selected a classical situation occurring frequently on freeways, which requires simulation of many important processes and functions: Risk of congestion at the beginning of road works on a multilane freeway.

traffic management center



CoCar information service

external traffic service provider

Attractive Information channels

"Beginning road works with stop-and-go traffic, coordinates 47°49'47.21" North, 11°54'44.82" East". The traffic state is detected by vehicles entering the road works which generate short reports and transmit them by cellular communication. The cellular network receives numerous such asynchronous reports.

There, the data undergo several stages of processing: In a first step, the raw data are forwarded to all vehicles in the surrounding area and interpreted in the vehicles by intelligent assistance systems. In a second step, the cellular communication provider processes traffic reports within the network and transmits them for example only to those vehicles heading toward the road works. Third, probe data streams are transmitted to a traffic information service provider, where they are collected, fused, and analyzed. From here, they can be sent either to classical traffic guidance systems – e.g., variable message/speed signs – or to public traffic management centers. Via broadcast channels such as RDS-TMC, DAB or DVB, all vehicles can be informed – even those not equipped with the latest cellular communication units.

radio station (RDS-TMC, DAB, DVB)

base transceiver station

road works message

hazard warning

traffic jam warning

variable message sign

Special protocols for speedy transport

With over 220 million registered vehicles, Europe has the highest vehicle density in the world. This means over 220 million cars and trucks, all exchanging traffic data in the future cellular communication network with 55.5 million in Germany alone.

A completely new task for the cellular communication market

With this many communicating participants, a powerful communication network is required that must be capable of mastering a completely innovative task: The transmission of traffic data between vehicles, traffic guidance systems, and telematic service providers – messages needs to be rapid, specifically targeted and ordered by priority. To this end, an adapted communication protocol will be developed in the research project CoCar under the leadership of the Vodafone Group Research & Development: a medium to transmit data within a fraction of a second, with precisely specified data formats and communication protocols, and with information filtered by priority.

The protocol will allow a structured and systematic flow of information, which is the key to coordination of vehicle assistance, traffic guidance, traffic service centers and cellular networks. In addition, the protocol will have an important function at the interface of the automobile and telecommunication industries: It will enable data exchange among vehicles and distinct generations of cellular communications and between different assistance and traffic guidance systems. The protocol runs in the background and connects all system components – regardless of vehicle type, level of technological progress in the cellular network, and specifications of the traffic infrastructure. In this way, the researchers are providing for long-term implementation of cellular communication technologies.

55,511,374

vehicles

were registered

in Germany

as of January 1, 2007

Thus, cellular communication faces new challenges: Up to now, the technology was used mainly for telephone conversations, transmission of short text messages, and for downloading large quantities of data from the internet. These transmission processes involve sending large quantities of data continuously over a relatively long period of time. In contrast, telematics applications require consolidation and high speed transmission of an enormous number of small data packets at high reliability.

In order to provide rapid processing, the information is coded to reduce the messages to their core content. In addition, each message is assigned a sending order priority. Processes involving reactions within seconds have top priority – for example a suddenly formed jam or an icy road segment. The second priority level comprises traffic flow and vehicle density data as processed in strategic route guidance.

Sample protocol

```
<tpeg_message>
  <originator country='DE' originator_name='CoCar'/>
  <summary xml:lang='en'>Thick fog on the A8 between Irschenberg and Chiemsee
    interchanges affecting both inbound and outbound traffic.</summary>
  <road_traffic_message message_id='12345' version_number='3'
    message_generation_time='2007-09-16T07:59:29+1' start_time='2004-09-16T07:59:29+1'
    severity_factor='&rtm31_4;'>
    <location_container language="&loc41_40;">
      <location_coordinates location_type="&loc1_3;">
      <WGS84 latitude="47.828" longitude="11.915"/>
      <location_descriptor descriptor_type="&loc3_7;" descriptor="A8:E45/>
      <location_descriptor descriptor_type="&loc3_24;" descriptor="Irschenberg"/>
      <location_descriptor descriptor_type="&loc3_25;" descriptor="Rosenheim"/>
      <location_descriptor descriptor_type="&loc3_26;" descriptor="Bayern"/>
      <location_descriptor descriptor_type="&loc3_27;" descriptor="Deutschland"/>
      <WGS84 latitude="47.834" longitude="12.396"/>
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      <location_descriptor descriptor_type="&loc3_26;" descriptor="Bayern"/>
      <location_descriptor descriptor_type="&loc3_27;" descriptor="Deutschland"/>
      <direction direction_type="&loc2_2;"/>
      </location_coordinates>
    </location_container>
    <network_conditions>
      <restriction restriction="&rtm49_255;"/>
    </network_conditions>
  </road_traffic_message>
</tpeg_message>
```
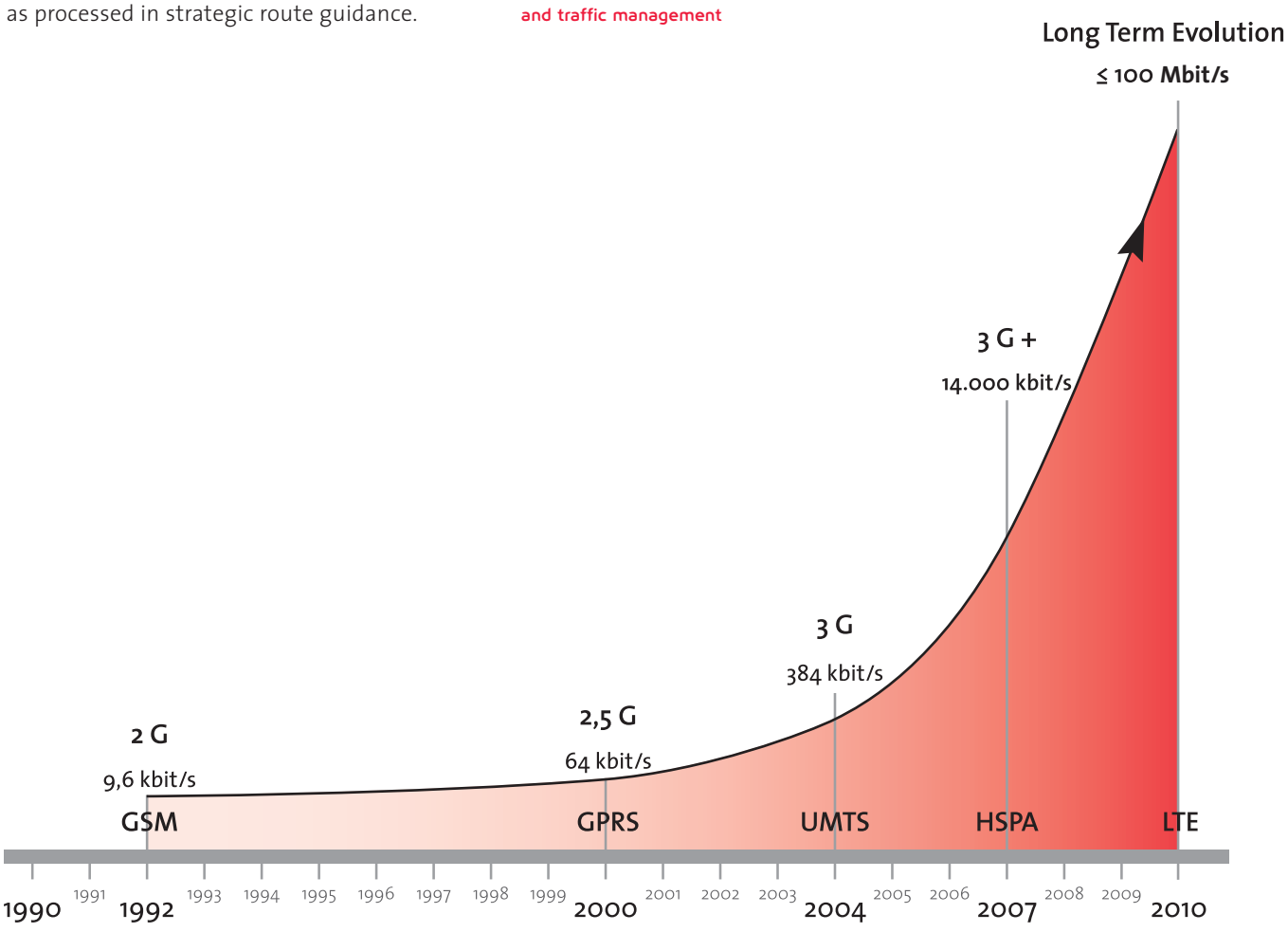

The protocol links on-board computers, assistance systems, cellular networks, and traffic management



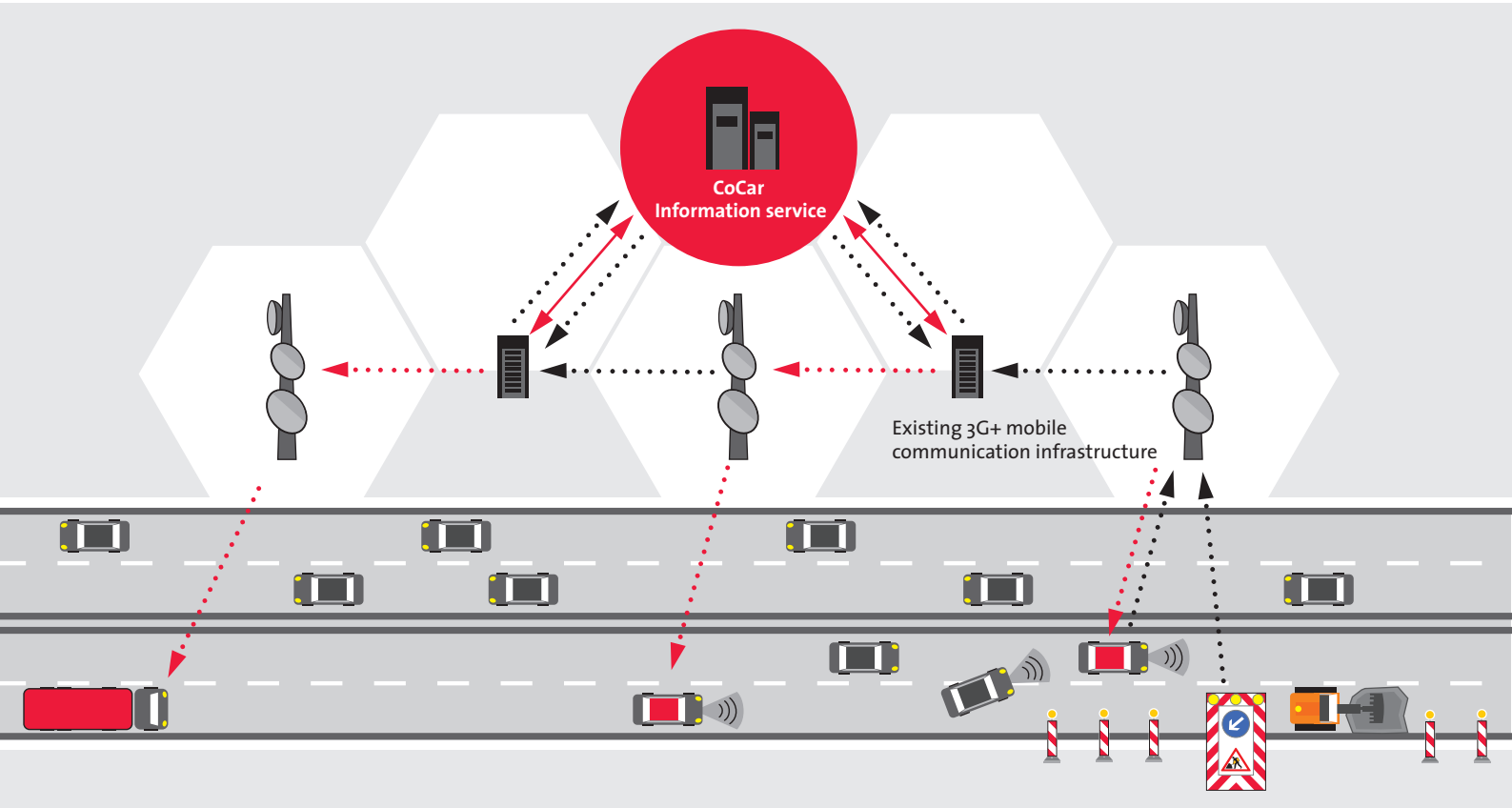
The challenge: moving road works

No report card without exams – testing is as essential for cellular communication technologies as in any other area. Prototypes of the systems developed in CoCar will demonstrate their suitability for implementation in real traffic. The exam topic is, "warning – moving road works".

"Moving road works ahead", warns the display symbol in the vehicle cockpit. This typical traffic situation will serve to test the use of newly developed cellular communication technologies in traffic by mid-2009. During this last phase of the research project CoCar, the engineers – led by Volkswagen AG and working together with Daimler AG and MAN Nutzfahrzeuge AG – will demonstrate that the technologies provide an innovative future basis for routinely exchanging traffic data.

Experiencing inter-vehicle interactions

The exemplary application "Traffic hazard: road works warning" is designed to encourage further development of cellular communication based technologies – with a focus on implementing these technologies as communication systems for automotive safety assistance and traffic management. Research and development departments of automobile and truck manufacturers, specialists in traffic service centers, as well as cellular network operators will be able to experience the systems live, observing interactions between different vehicles and visualizing new potential innovations. With this procedure, the partners in CoCar will determine the technical demands on cellular communication systems posed by advanced driver assistance, traffic information, and traffic management.



In Germany road works cause

81,300,000

hours of delays yearly

Moreover, the engineers will also take vehicles into account that do not have access to on-board sensors for the vehicle environment, but need to be informed of the current traffic state by external sources.

The basis for the technology demonstration is a test infrastructure. There, the newly developed systems required for car communication will all be implemented as prototypes: components for the functional extension of the cellular network, as well as elements for linking to traffic service centers, automotive driver assistance systems and on-board computers. This so-called "end-to-end architecture" covers the complete data transmission chain: The vehicles send their own detector data to traffic information centers. There, the messages are processed and transmitted to all vehicles located on the corresponding roadway segment.

This information chain will be closely implemented in the demonstrator "Traffic hazard: road works warning", with the help of three vehicles – a Volkswagen, a Mercedes-Benz and a MAN truck. A moving road works vehicle sends periodic position updates at brief intervals to a traffic service center. This center informs upstream vehicles approaching the road works site. If the warning proves to be relevant for the affected vehicles, a moving triangle appears on the display and reports "moving road works ahead".

Encouraging further development of mobile communication based technologies

Vision - cellular communication prospects.

In the near future, vehicles will log into cellular networks autonomously and automatically. After downloading current traffic state information, they will warn the driver of local hazards such as obstacles. Concurrently, they will be integrated into powerful traffic management systems, continuously exchanging data on traffic flow and road conditions.

By means of cellular communication, this vision is soon to become reality in Germany and perhaps even in the entire European roadway network. The key requirements are novel trend-setting cellular communication technologies – as investigated in the Aktiv research initiative. Thus, cellular communication research has been targeted in the project CoCar, because of the immense innovation potential of this versatile technology for future generations of advanced driver assistance and driver information systems and for efficient solutions in traffic management.

In order to exploit thoroughly the economic and research opportunities offered by cellular communications technologies, Aktiv is connecting different branches of industry: telecommunication network operators and terminal device manufacturers, automobile manufacturers and their suppliers, as well as traffic service providers. This interdisciplinary approach will open up entirely novel fields of application and models for global operation in cellular communications, with definite economic prospects. cellular communication will result in establishing safety assistance and services for the stakeholders in traffic. The partners enjoy the advantage of the excellent existing cellular infrastructure, which provides stable cellular communication coverage throughout Europe.

With the development of cellular communication technologies for implementation in traffic, CoCar is enabling novel applications that previously were considered as a technical vacuum. CoCar will establish new economic and scientific standards in cellular communication and enhance the role of Germany as a leading technology country.

Small data packets - high performance

These data packets are small; traffic warnings comprise only a few hundred bytes. However, these data packets will occur in large numbers: In congested traffic, the vehicle density can considerably exceed 100 vehicles per lane and kilometer.

It takes powerful cellular networks to transmit such a large number of data packets – sufficiently quickly. Third-generation cellular communication devices (3G+) currently provide the top performance attributes, with latencies of below one second and a data rate of up to 14 Mbit per second.

CoCar will investigate the capacity of the cellular communication systems for driver assistance and traffic management applications. Potential extensions for future systems will be recommended and the implementation of such systems will be evaluated.

Further information is available from the Aktiv office.

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