

Embedded Networks



Jörg Kaiser

Institut for Distributed Systems (IVS)
Embedded systems and Operating Systems (EOS)

Summer Term 2009



Organization

Lecture: Prof. Dr. Jörg Kaiser
Institut für Verteilte Systeme (IVS)
Arbeitsgruppe Eingebettete Systeme und Betriebssysteme
kaiser@ivs.cs.uni-magdeburg.de

Secretary: Petra Duckstein / Dagmar Dörge
Bu29 / Room 405
duckstein@ivs.cs.uni-magdeburg.de

Exercises: Thomas Kiebel, Michael Schulze
Institut für Distributed Systems (IVS)
Department Embedded Systems and Operating Systems
mschulze@ivs.cs.uni-magdeburg.de



Organization

Lectures:	Wednesday	9:00 - 11:00	G22a-105
Exercises:	Wednesday	11.00 - 13:00	G29-334
	Wednesday	13:00 - 15:00	G29-334

Requirements:

Need: Vordiplom, Bachelor

Nice: VL Betriebssysteme 1,
VL Technische Informatik II,
VL Embedded Systems.

Creditpoints: 6 ECTS

Successful participation: Exercises, Exam

Course Category: Informatik II and III



Organization

- Exercises: Infos on the web.
- Slides on the web

http://ivs.cs.uni-magdeburg.de/eos/lehre/SS2008/vl_en/

- infos also available via UNIVIS

Participants must register on the web-page :

<http://eos.cs.uni-magdeburg.de/register/>



Literature:

Paulo Veríssimo, Luís Rodrigues:

Distributed Systems for System Architects

Kluwer Academic Publishers, Boston, January 2001

Hermann Kopetz:

Distributed Real-Time Systems

Kluwer Academic Publishers, 1997

Konrad Etschberger:

CAN - Controller Area Network, Grundlagen, Protokolle, Bausteine, Anwendungen

Carl Hanser Verlag, München, Wien, 1994

Sape Mullender (Hrsg.):

Distributed Systems

ACM Press, 1989

Further literature will be provided during the course.



On-line Documentation:

CAN: <http://www.can-cia.de>
Profibus: <http://profibus.com/downloads.html>
FIP: <http://worldfip.org/downloads>
LON: <http://echelon.com>

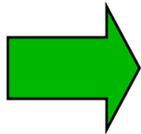


Embedded Networks or Communication networks to monitor and control the physical environment



Application Areas for Embedded Networks

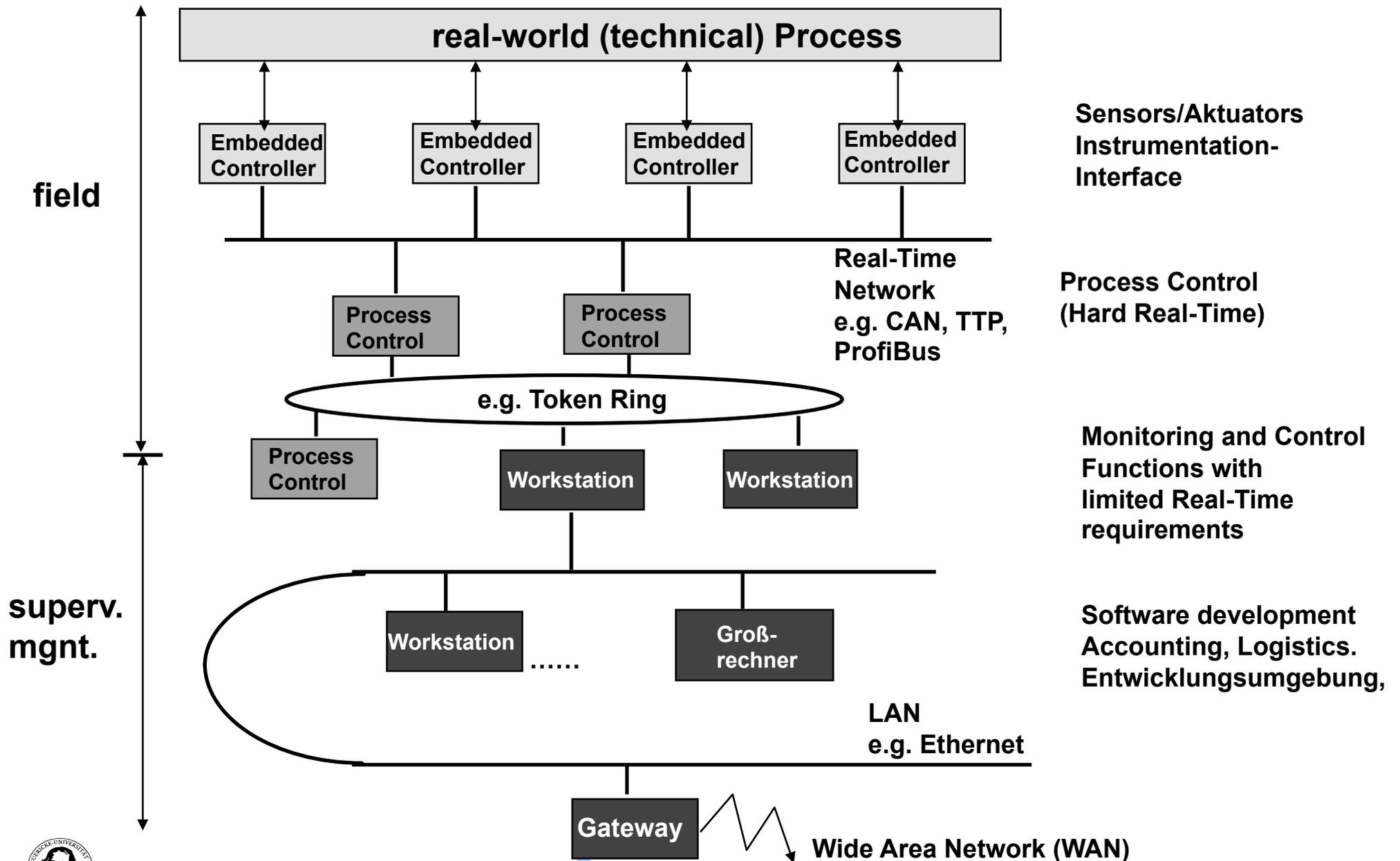
- **Industrial Automation**
- **Automotive**
- **Buildings**
- **Mechanical Engineering**



The Network is the Computer !

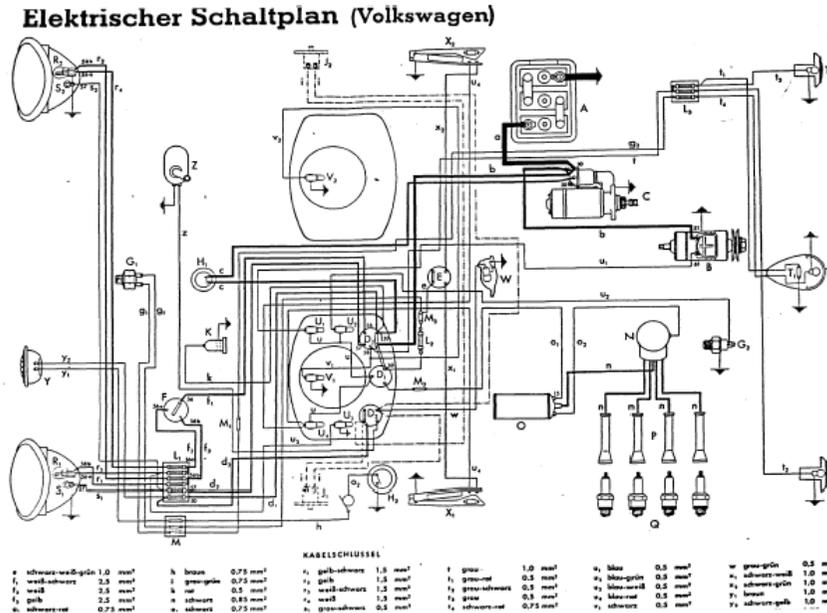


Embedded Networks in a CIM environment



Controlling a Car

Yesterday



Today

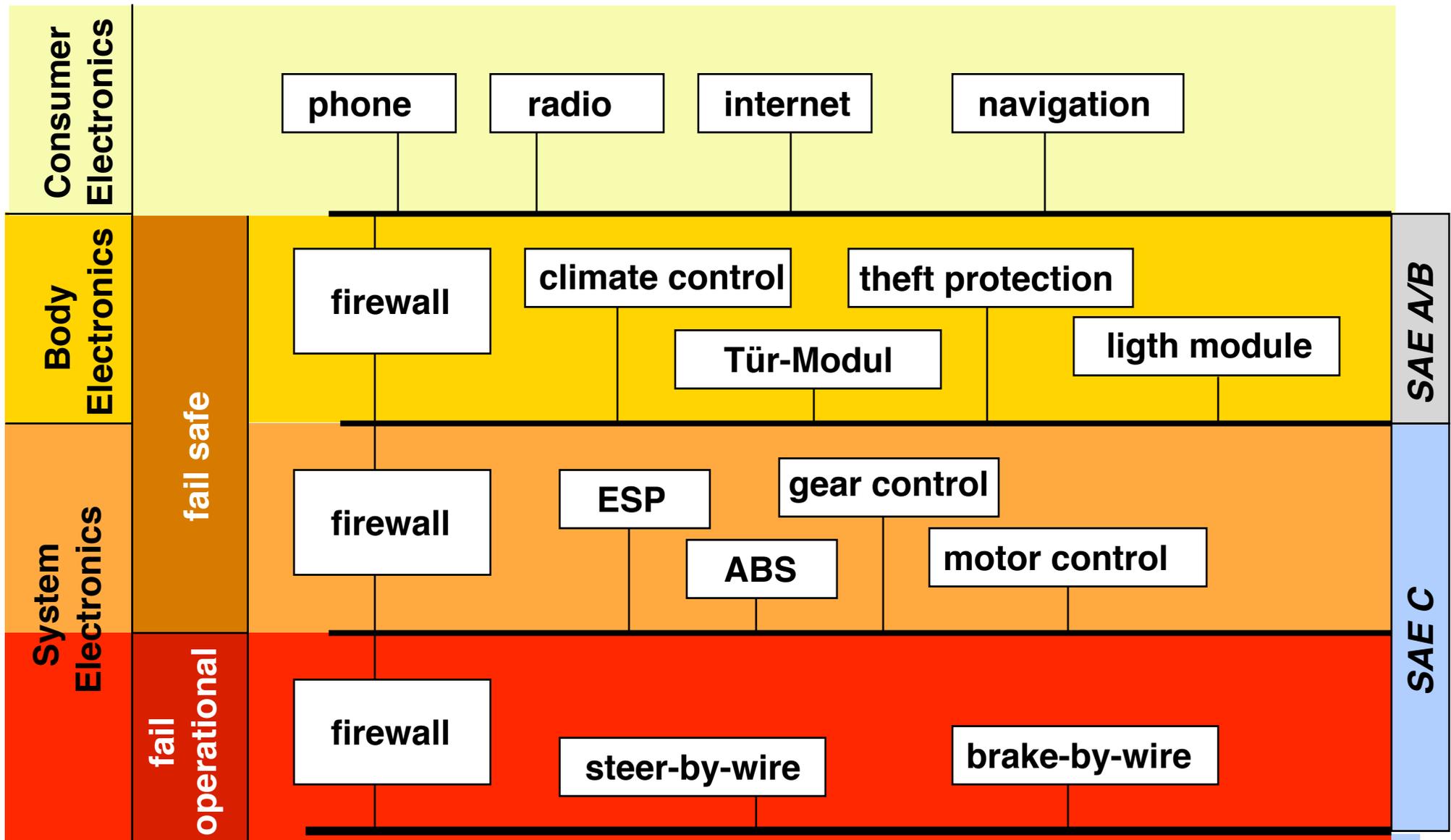


- 11.136 electrical parts
- 61 ECUs
- Optical bus for information and entertainment
- Sub networks based on proprietary serial bus
- 35 ECUs connected to 3 CAN-Busses
- 2500 signals in 250 CAN messages

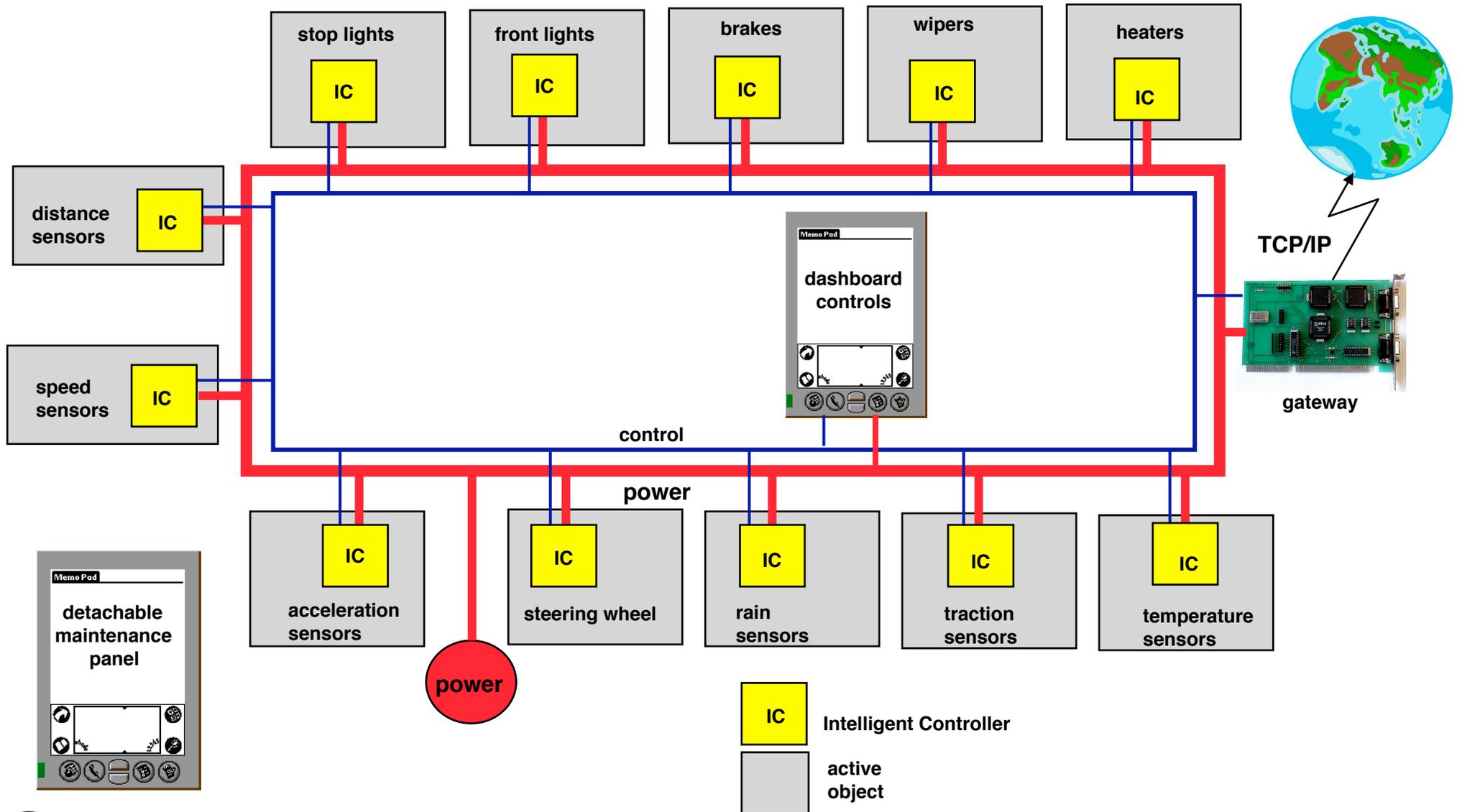


Levels of Communication in a CAR

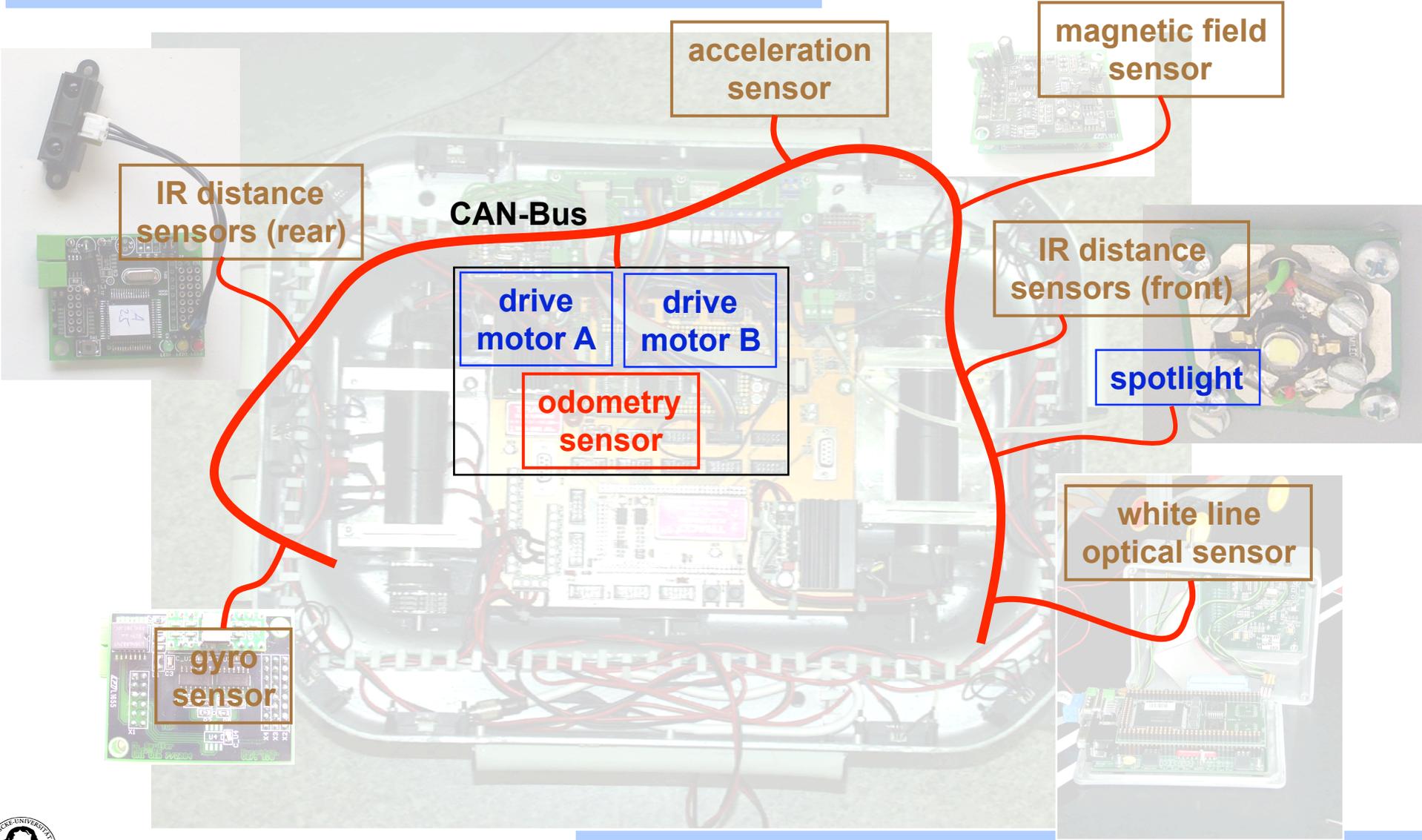
T. Führer, B. Müller, W. Dieterle, F. Hartwich, R. Hugel, M. Walther:
 „Time Triggered Communication on CAN“



Future: Distributed Cooperative Control



Distributed Control with Co-operating Smart Components



Requirement: Predictability of Communication !

Sources of Unpredictability ?



Sources of Unpredictability

Network is a shared medium

→ Arbitration, Collisions

Sender and Receiver must run in Sync

→ bounded buffers, lost messages

Transmission Errors

→ re-send

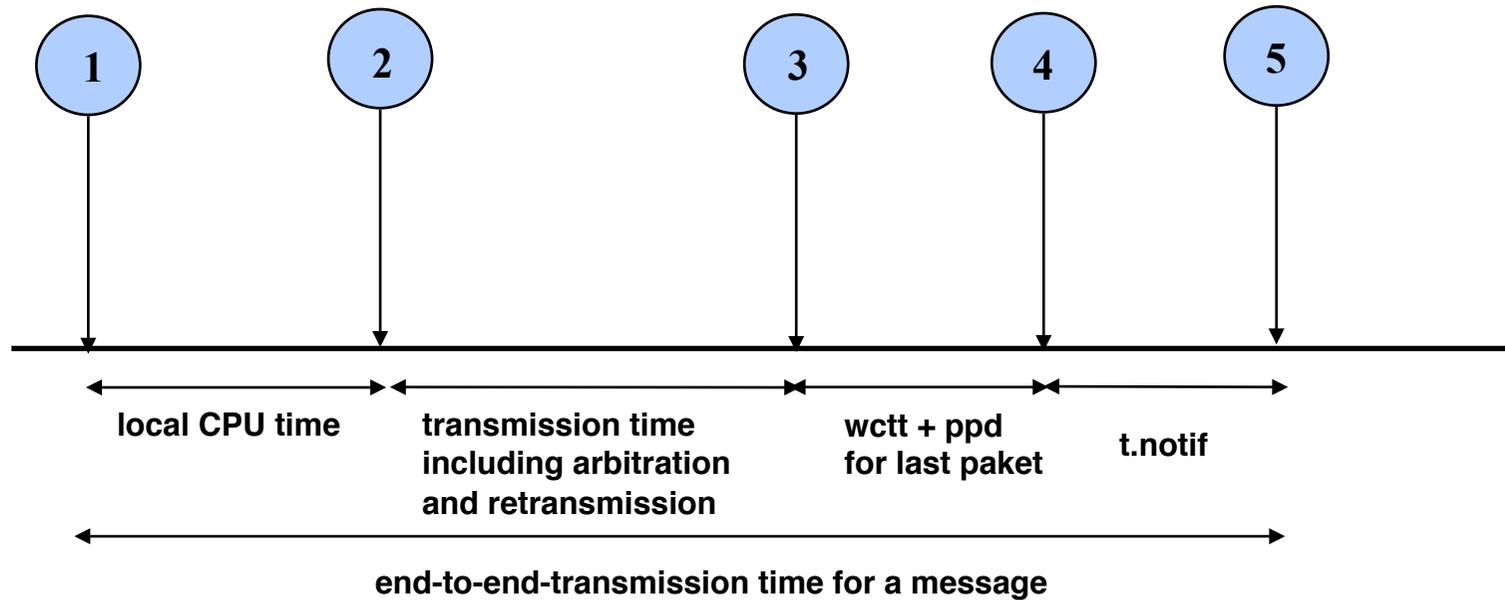


Requirements for a predictable communication system

- **bounded, predictable transmission times**
- **execution time for protocol stack is bounded and small**
- **variations of the execution time (Delay Jitter) is small**
- **error detection in sender and receiver**
- **error detection with minimal latency**
- **no thrashing under high load conditions (constant throughput)**
- **support for multicast communication**
- **support for many-to-many communication**
- **Composability**



End-to-End communication costs



1. Send-task becomes ready
2. Latest point in time when the message is in the ordered transmission queue (OQ).
3. All pakets of message m in OQ are put to the network medium.
Transmission of last paket starts.
wctt: worst case transmit time
ppd: physical propagation delay
4. Last paket of m reaches the Communication Controller of receiptient.
5. "Paket received" interrupt is triggered.
t.notif: worst case delay between successful reception of the paket (in the CC) and notification of the task.
Receive task will become ready at this instant..



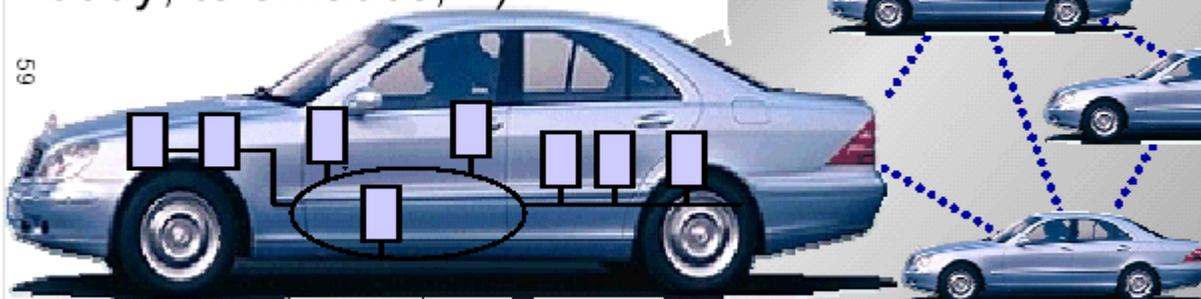


Vehicles become a means of communication with ...

... connectivity to service centers



... connectivity within vehicle internal domains (engine, body, telematics,...)



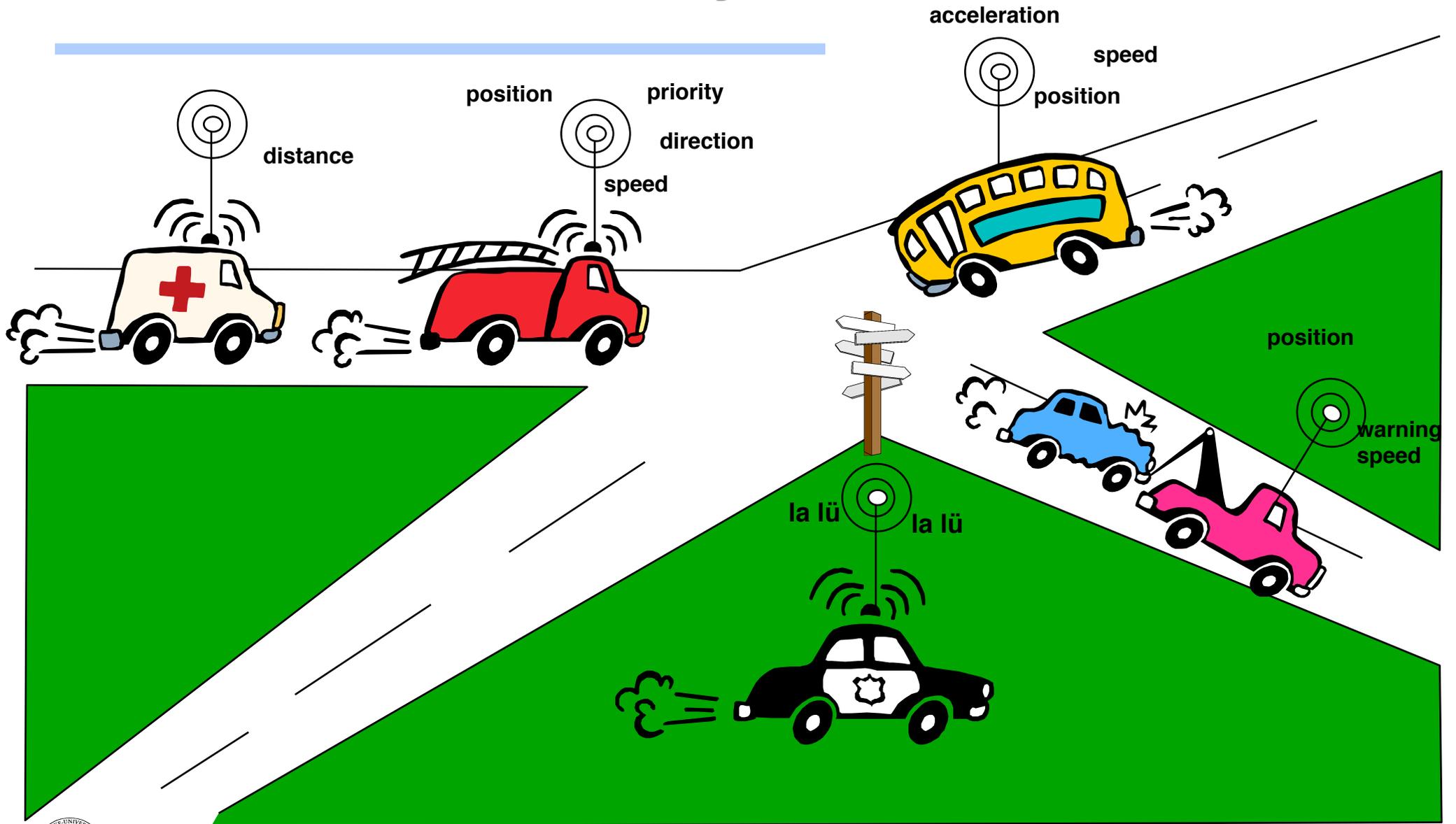
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... connectivity top other vehicles

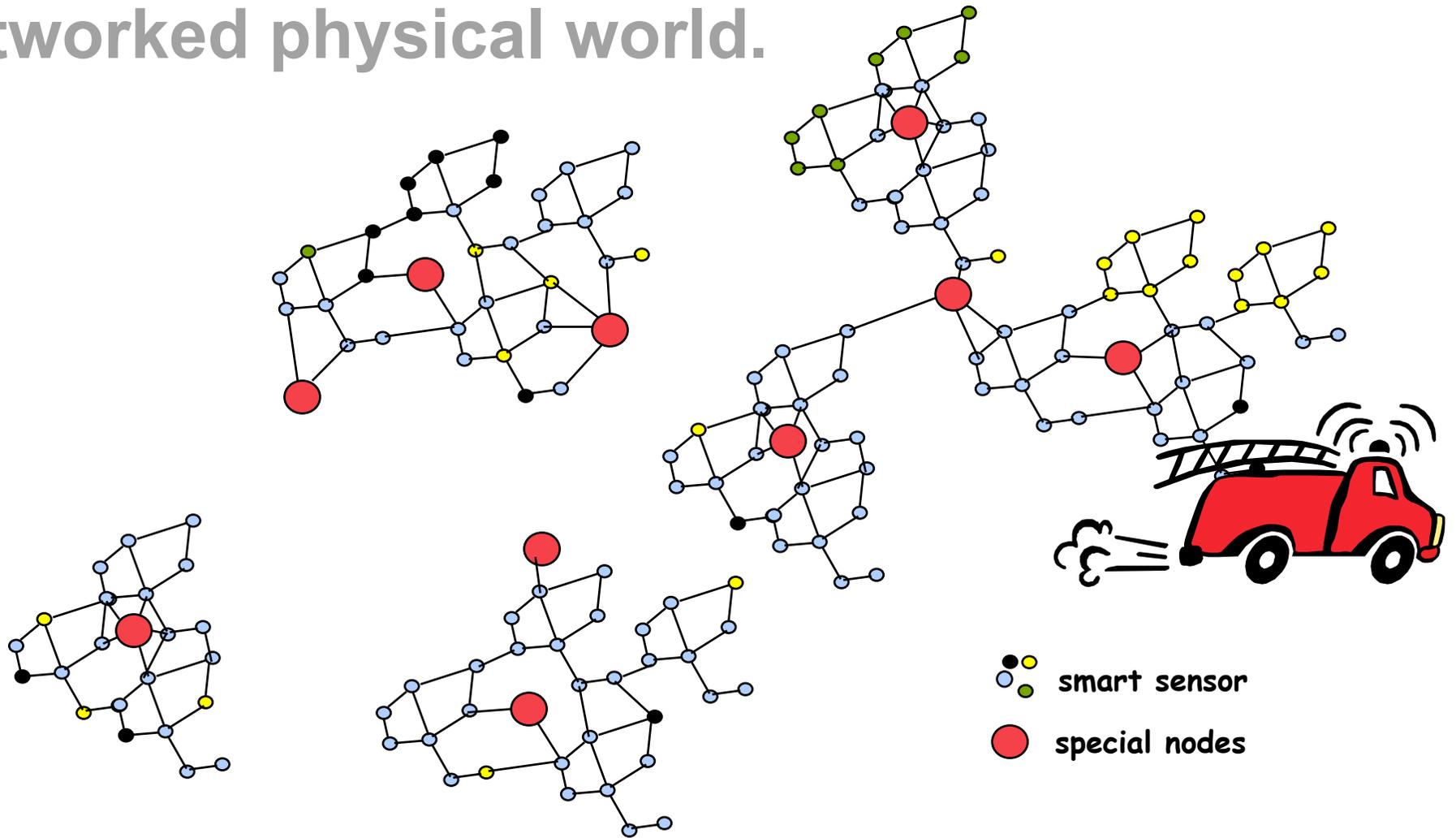
... connectivity to (public) infrastructure



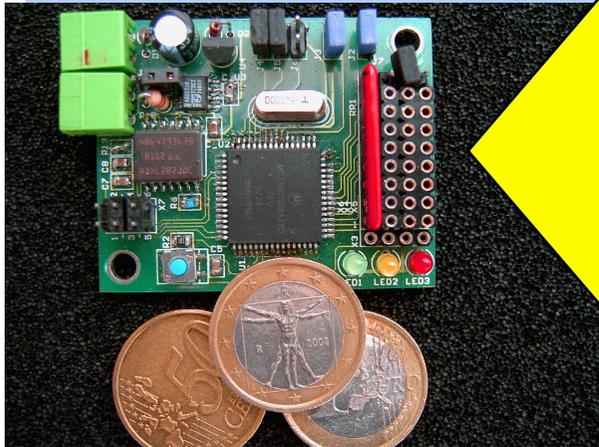
Autonomous sentient systems



"Embedded Everywhere": A networked physical world.



Hardware for Sensornets "Smart Dust"



tiny-board, CORE, Ulm

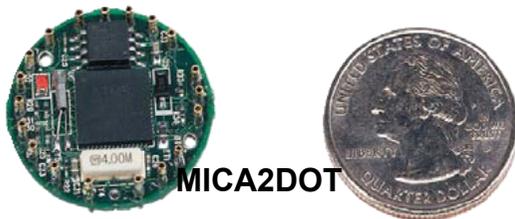
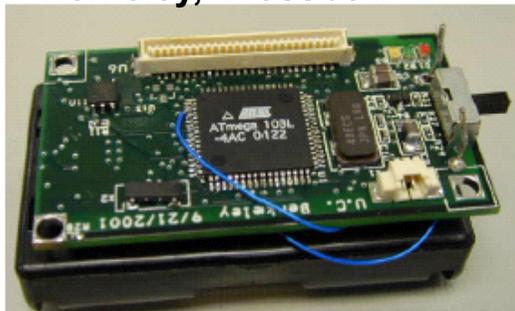
Developed Sensors at CORE

- infrared motion detector
- infrared distance sensor
- acceleration sensor
- embedded gyro
- weather station
- magnetic field detector
- in-house location system

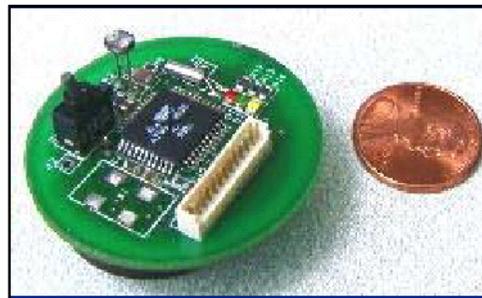


68HC11 CAN-Sensor Boards, CORE, Ulm

a mica mote,
Berkeley, Crossbow



MICA2DOT

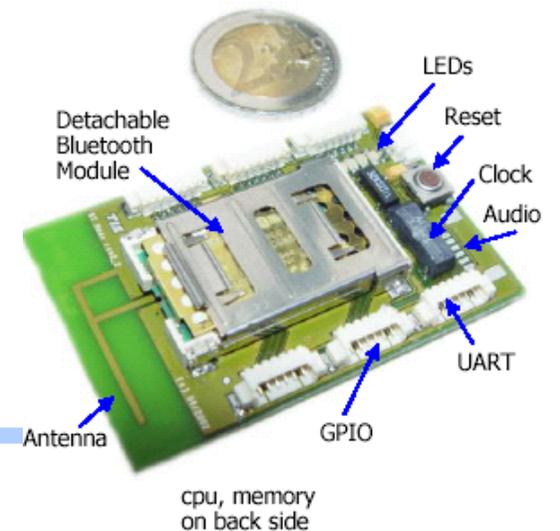


WeC „Smart Rock“ UCB



The EYES prototype

Smart-its: ETH Zurich,



cpu, memory
on back side

Tiny Properties

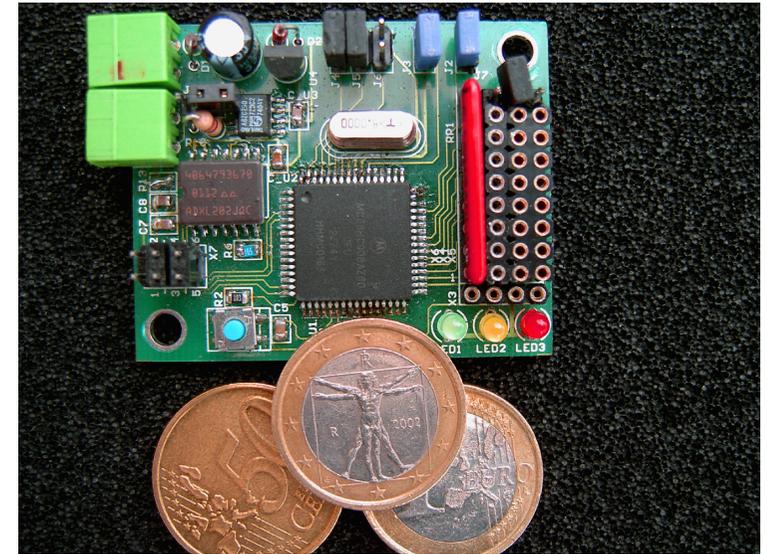
**Designed for experimentation:
Basic Board + Piggyback extension**

Basic board:

- Processor 68HC908AZ60 (60k Flash, 2k RAM)**
- Power regulator (linear or switched) 6-14 V**
- LEDs for checks, configuration jumpers**
- CAN-Bus Network Interface**
- Sockets for AD, C&C, digital I/O**
- Sockets for asynch.and synch serial comms.**

Power consumption:

- Processor ~ 250 mW @ 16MHz**
- Radio link (Easy Radio, 19kbit/sec): ~150mW(transmit), ~75mW(idle)**
- 9V Block (565 mAh): ~ 8h@continuous operation, ~30 days@10ms/sec**



AVR Properties

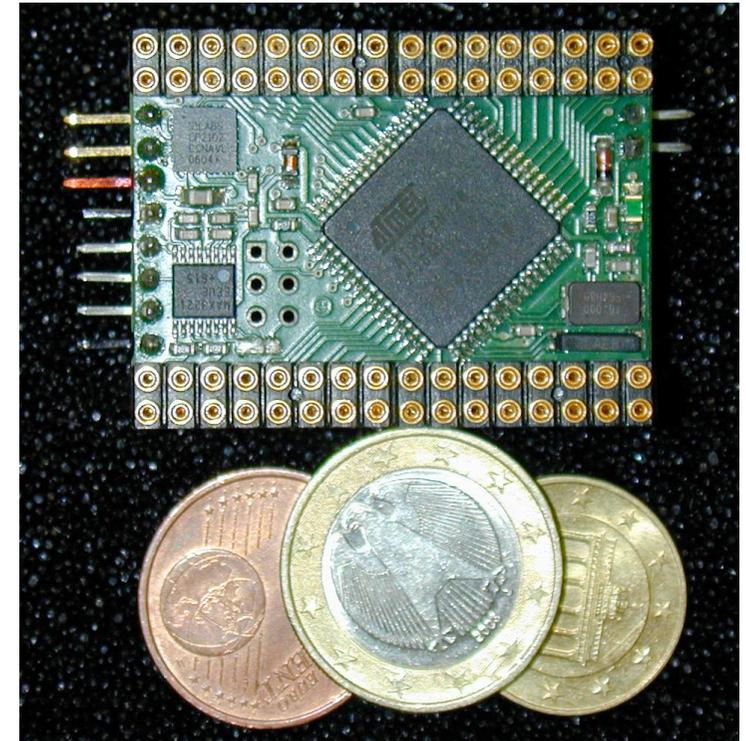
Designed for experimentation:
Basic Board + Piggyback extension

Basic board:

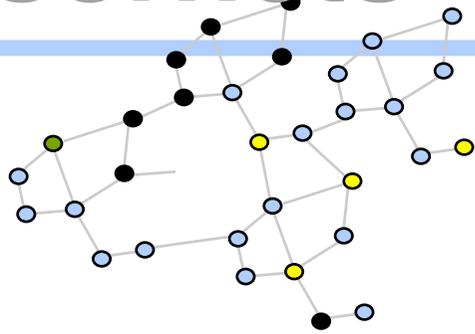
- Processor Atmel AVR AT90CAN128 (128k Flash, 4k RAM)
- Power regulator (linear or switched) 2.7-24 V
- LEDs for checks, configuration jumpers
- CAN-Bus Network Interface
- Sockets for AD, C&C, digital I/O
- Sockets for asynch. and synch serial comms.

Power consumption:

- Processor ~ 160 mW @ 16MHz and 5V
- Radio link (ZigBee, 250Kbps)
- 9V Block (565 mAh): ~17,5h@continuous operation, ~70 days@10ms/sec



Sensornets



Components:

- heterogeneous Sensors
- stationary and mobile entities
- very large number of components
- through away product (in the true sens of the word)
- life time = battery life time
- constraints in performance and memory

Behaviour:

- spontaneous behaviour
- not always active
- division of labour required

Network:

- bandwidth constraints
- Multi-hop
- Aging of information
- Quality of dissemination



Networks

- ➔ **wireless communication with low bandwidth**
- ➔ **(still) no standards**
- ➔ **alternation of sleep and active times is a challenge for MAC protocols**
- ➔ **inherently multi-hop**
- ➔ **address- , contents- und location-based routing**



embedded networks: fieldbusses vs. sensornets

common properties:

- ➔ **communicate information to perceive and control the physical environment,**
- ➔ **transferred information is subject to aging,**
- ➔ **meeting individual timing constraints is more important than throughput,**
- ➔ **considers trade-offs concerning energy consumption, bandwidth, reliability and priority of message traffic.**

major differences:

	fieldbusses	sensornets
number of nodes	low to moderate	very large (in theory)
safety	very high to moderate	low
predictability	very high	low to moderate
number of hops	1 to few	many
indiv. failure probability	very high to moderate	very low



Embedded Networks

- o **Introduction**
- o **Models of communication**
- o **Dependability and fault-tolerance**
 - * **Attributes and measures of Dependability**
 - * **Basic techniques of Fault-Tolerance**
- o **Time, Order and Clock synchronization**
- o **The physical network layer**
- o **Protocols for timely and reliable communication**
 - * **Introduction, problem analysis and categories**
 - * **Interbus-S, ProfiBus, WorldFip,**
 - * **Controller Area Network (CAN-Bus)**
 - * **Time Triggered Protokoll (TTP/C)**
 - * **Real-Time CSMA-Networks (VTCSMA)**
 - * **Lon (Echelon)**
 - * **Token protocols**
- o **Sensornets**
 - * **Requirements for sensor nets**
 - * **Protokols for wireless communication**
 - * **Energy-efficient MAC-protocols**

