Embedded Networks

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

Summer Term 2008

Organization

Lecture:

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Exercises:

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Department Embedded Systems and Operating Systems
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Organization

Lectures:	**Tuesday**	**9:00 - 11:00**	**G29-E037**
Exercises:	**Tuesday**	**15.00 - 17:00**	**G29-334**
	Wednesday	**9:00 - 11:00**	**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.

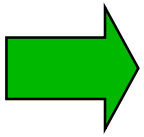
On-line Documentation:

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

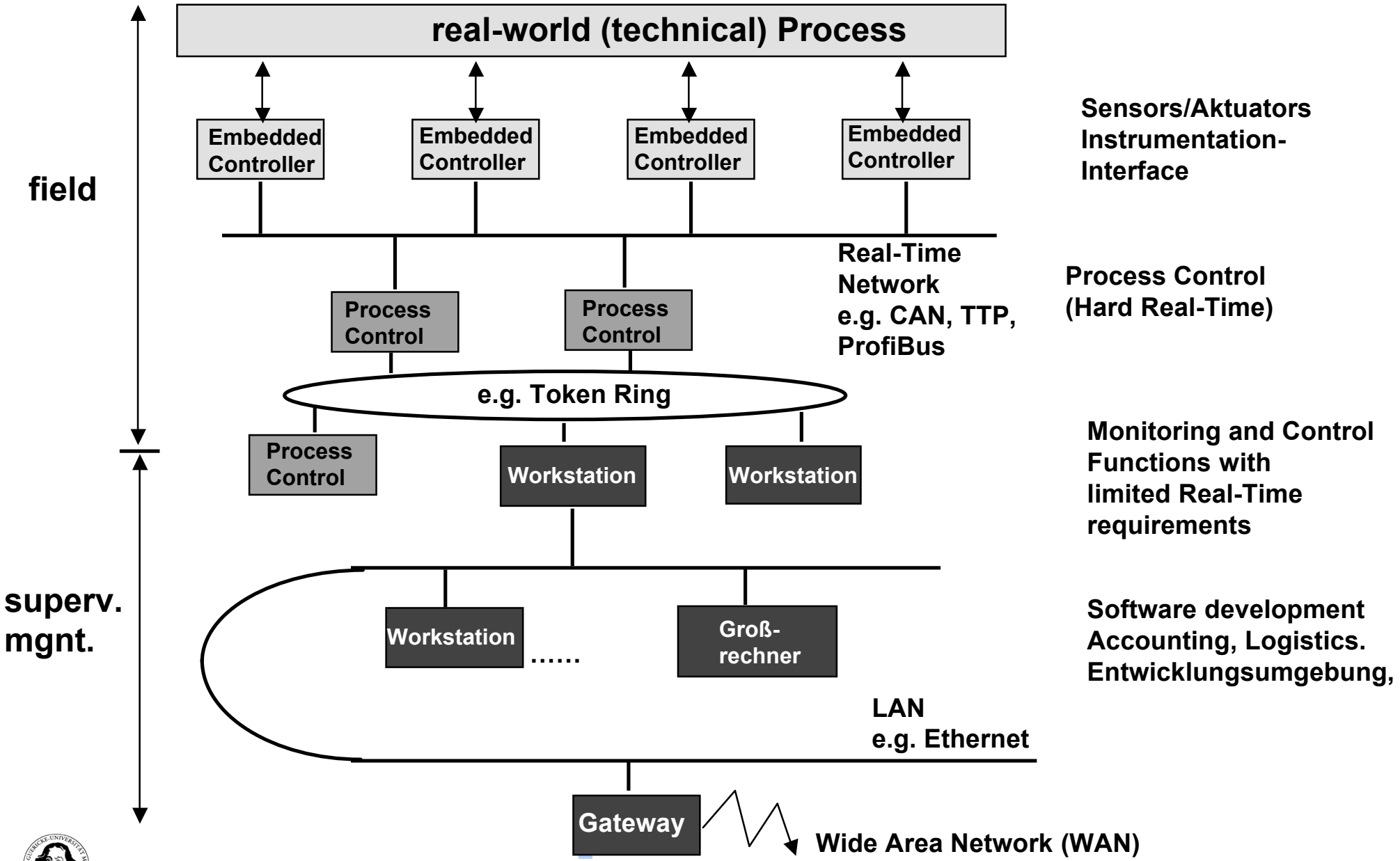
Application Areas for Embedded Networks

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



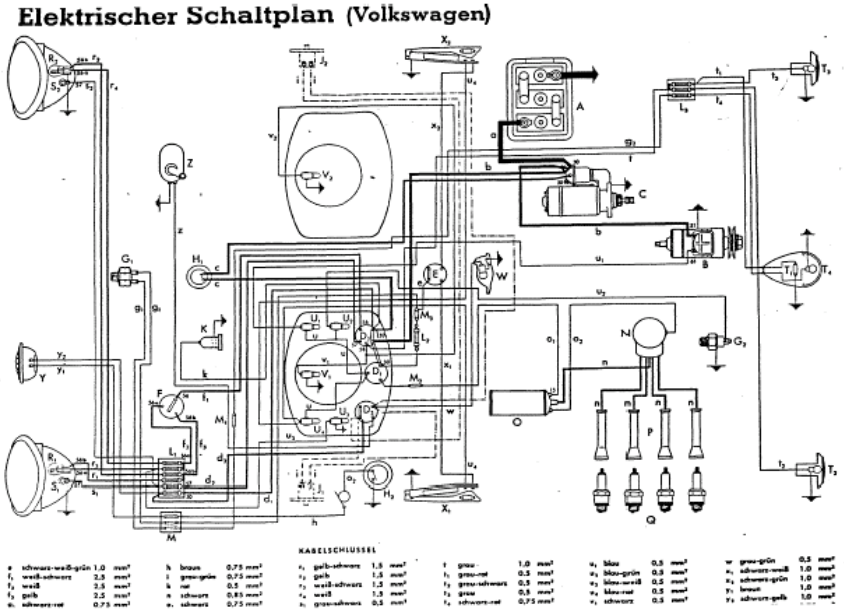
The Network is the Computer !

Embedded Networks in a CIM environment



Controlling a Car

Yesterday

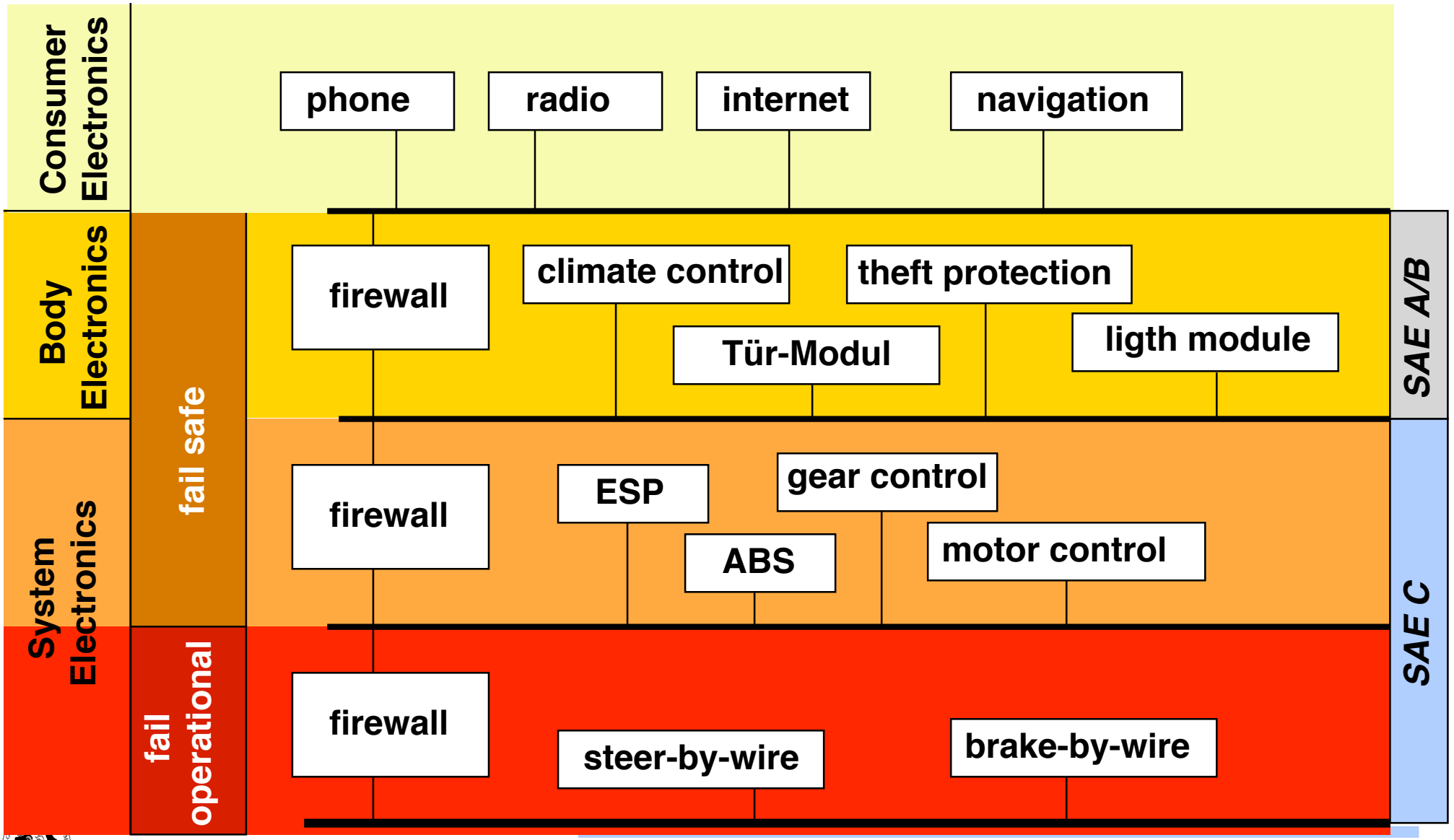


Today

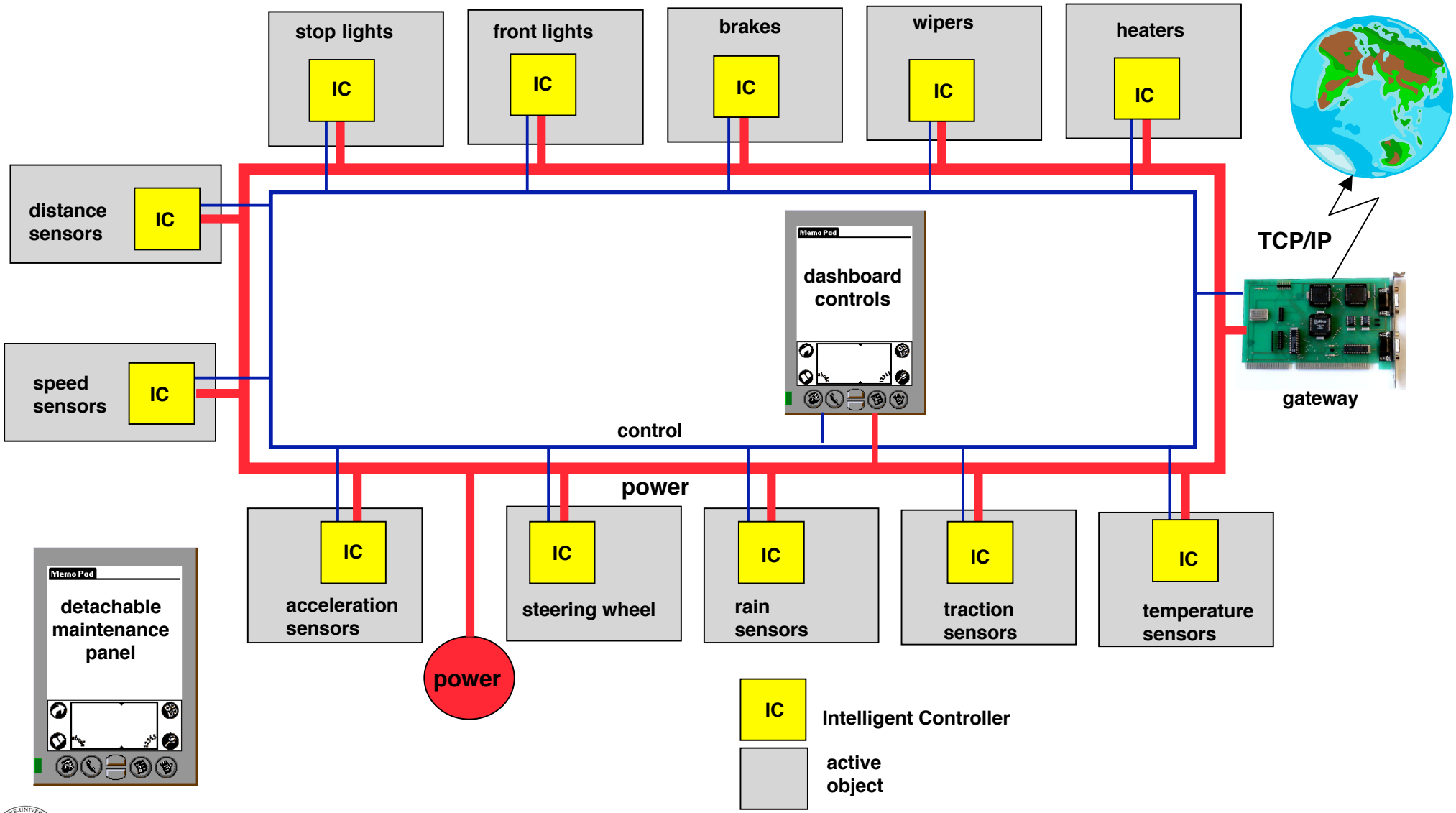
- 11.136 electrical parts
- 61 ECUs
- Optical bus for information and entertainment
- Sub networks based on proprietary serial bus
- 35 ECUs connected to 3 CAN-Busses
- 2500 signals in 250 CAN messges

Levels of Communication in a CAR

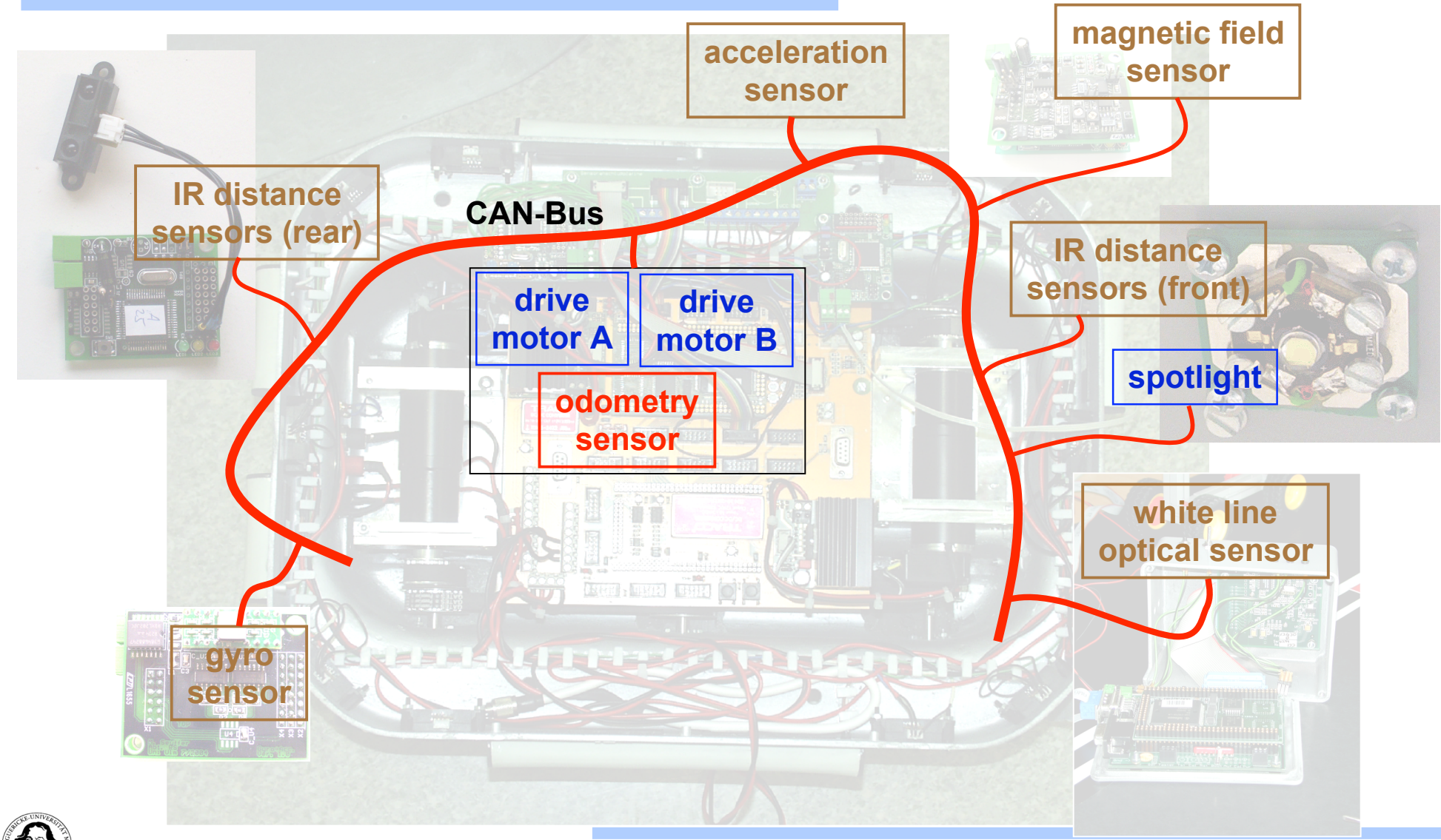
T. Führer, B. Müller, W. Dieterle, F. Hartwich, R. Hugel, M. Walther:
„Time Triggered Communication on CAN“



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

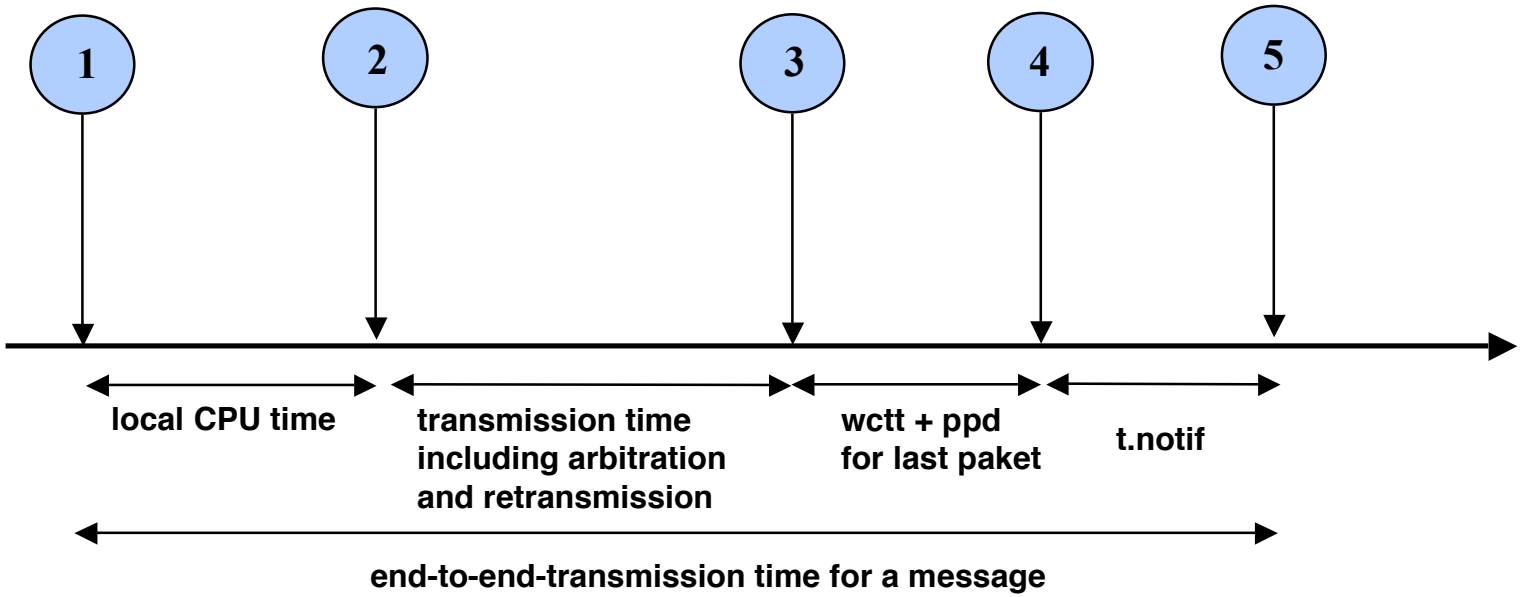
Transmission Errors

→ 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

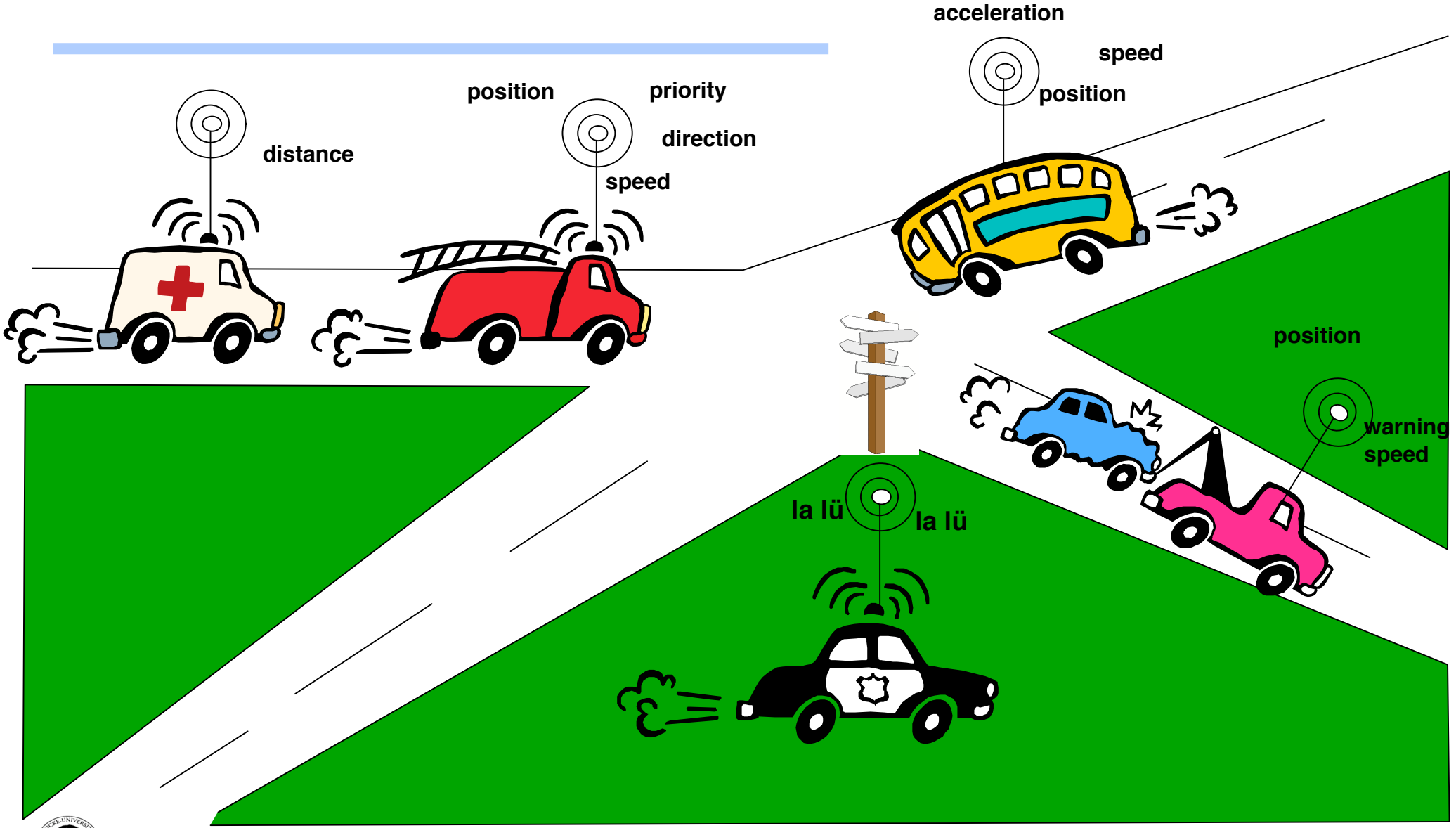
2. Latest point in time when the message is in the ordered transmission queue (OQ).

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

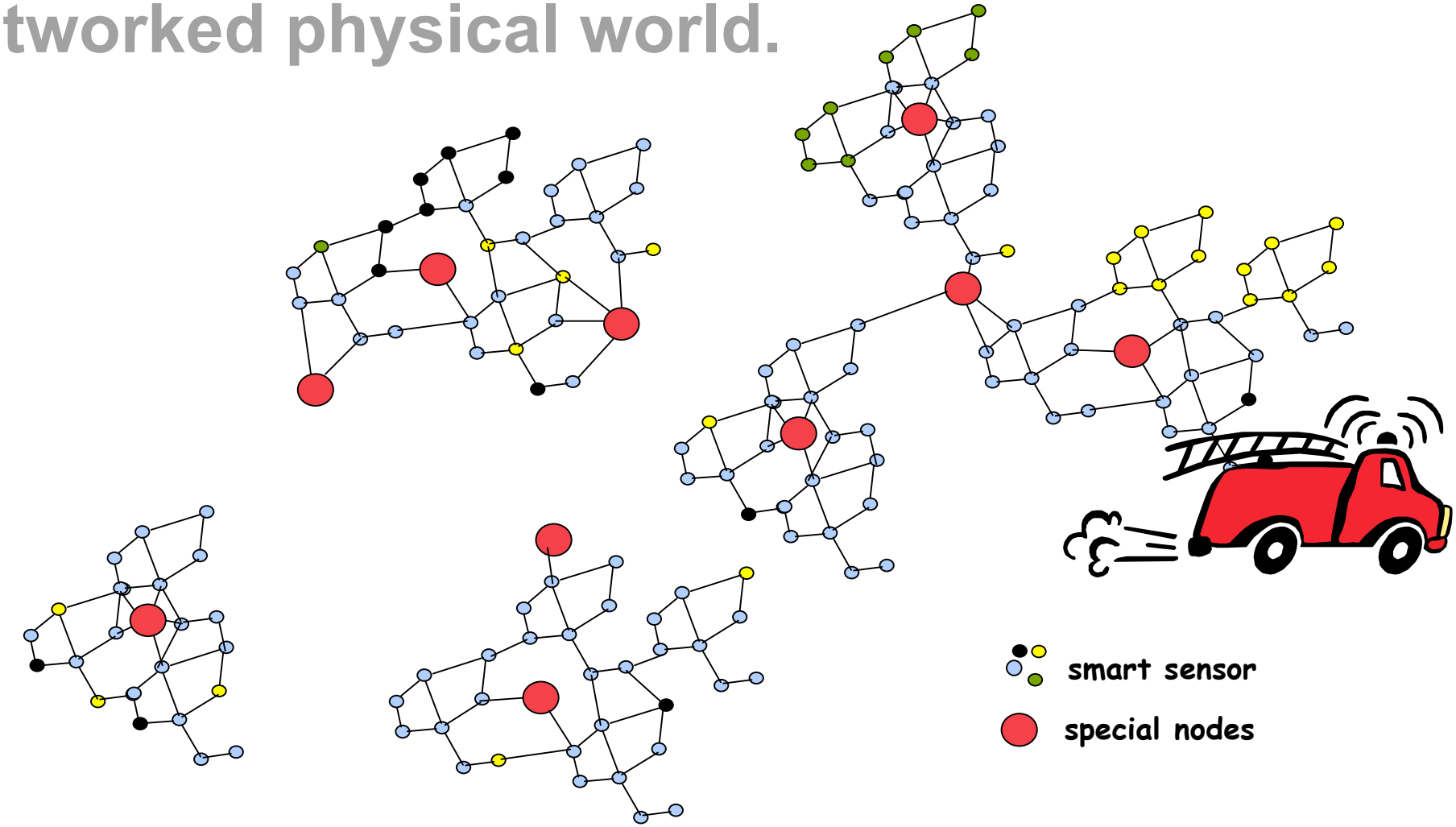
4. Last paket of m reaches the Communication Controller of receipient.

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 time instant..

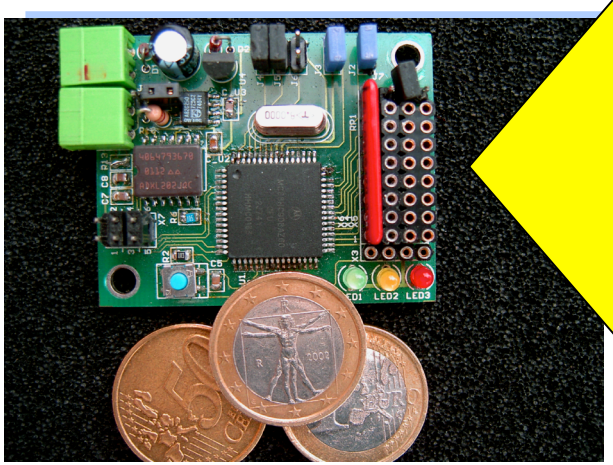
Autonomous sentient systems



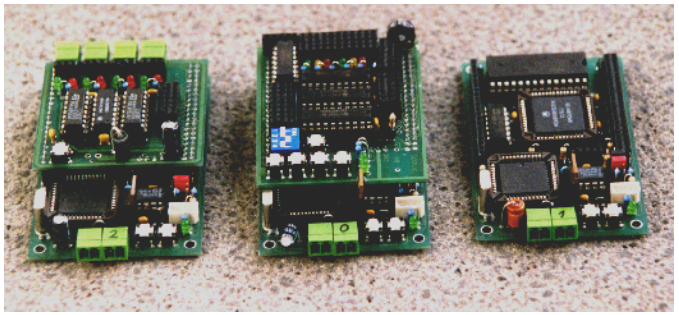
"Embedded Everywhere": A networked physical world.



Hardware for Sensornets "Smart Dust"

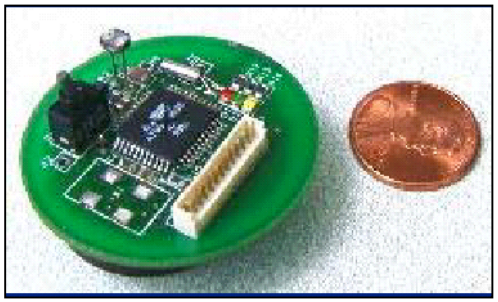


Developed Sensors at CORE
- infrared motion detector
- infrared distance sensor
- acceleration sensor
- embedded gyro
- weather station
- magnetic field detector
- in-house location system



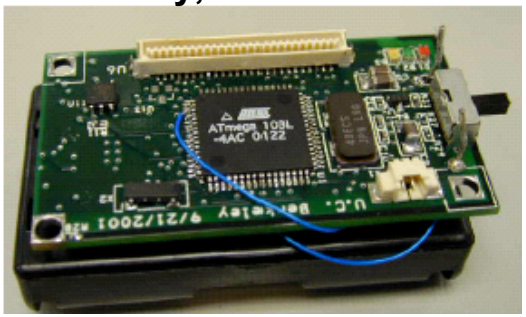
68HC11 CAN-Sensor Boards, CORE, Ulm

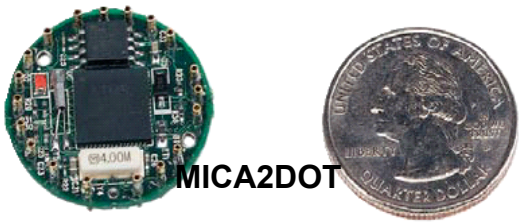
tiny-board, CORE, Ulm



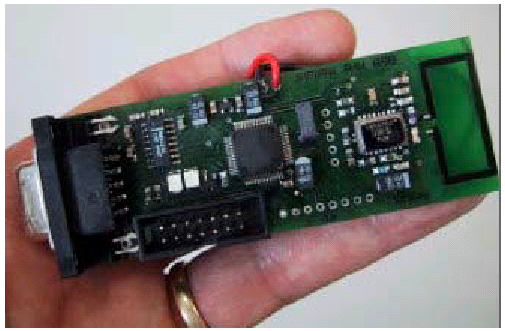
WeC „Smart Rock“ UCB

a mica mote,
Berkeley, Crossbow



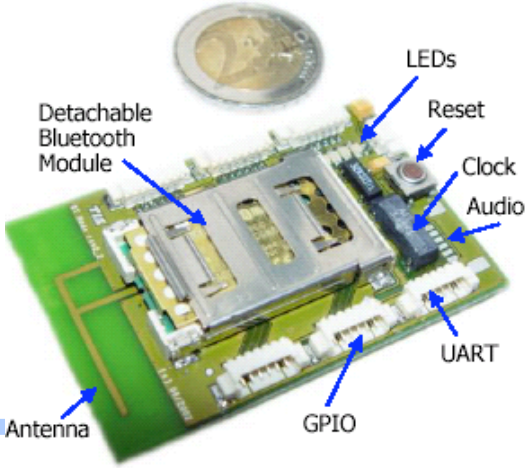


MICA2DOT



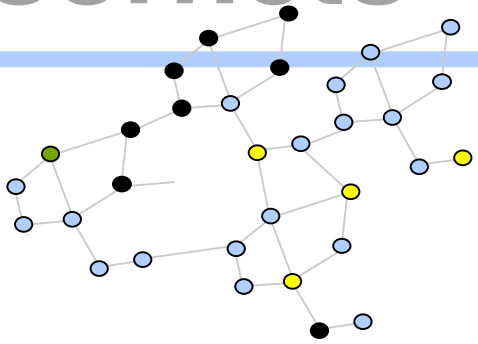
The EYES prototype

Smart-its: ETH Zurich,



cpu, memory
on back side

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:

- sponteneous 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,**
- **transfered information is subject to aging,**
- **meeting indivudual 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

- Introduction
- Models of communication
- Dependability and fault-tolerance
  - * Attributes and measures of Dependability
  - * Basic techniques of Fault-Tolerance
- Time, Order and Clock synchronization
- The physical network layer
- 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
- Sensornets
  - * Requirements for sensor nets
  - * Protokols for wireless communication
  - * Energy-efficient MAC-protocols