Server-based scheduling in CAN

Subsystem integration of real-time systems

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PROGRESS
A national Swedish Strategic Research Centre

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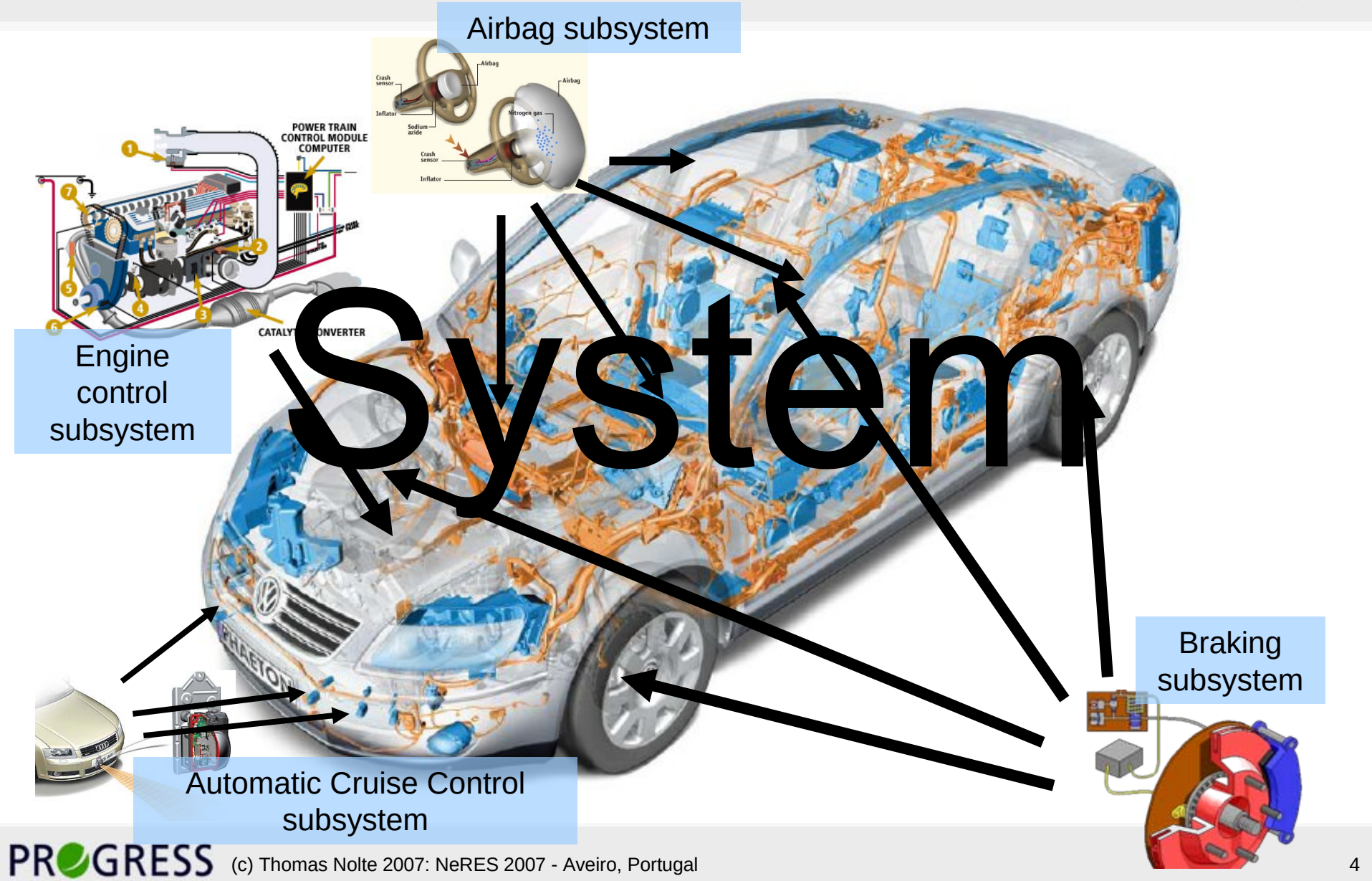
Outline

- Subsystem integration
- What we do
- Server-CAN
- Current status

Integration of embedded systems

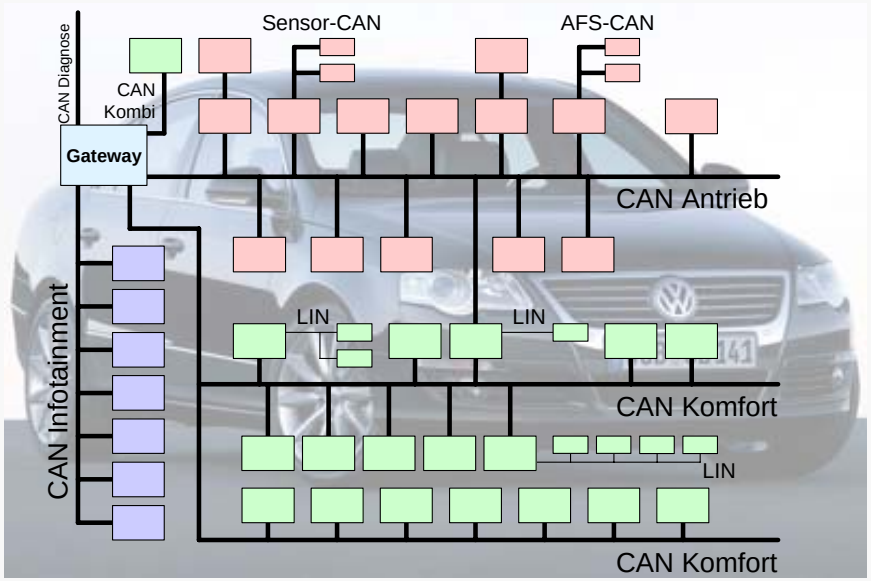
1. Hardware level integration
   - Standardized hardware interfaces
   - Integration takes place at network level, e.g., integrating black box Electronic Control Units (ECUs)
2. Software level integration
   - Black or white box software components
   - Integration is performed by synthesis towards a common (standardized) software platform
3. Model level integration
   - Models are developed and integrated throughout the development

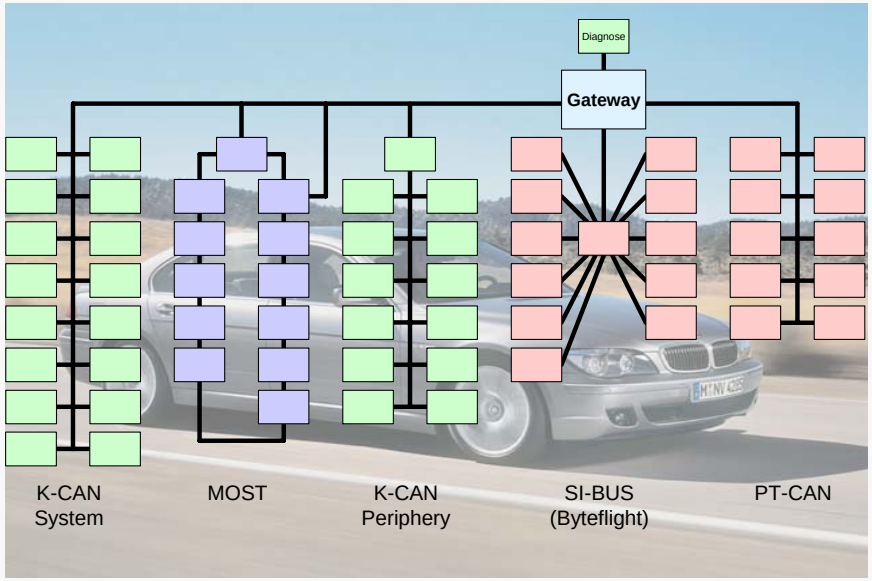
Terminology: System vs. subsystem



Motivating trends

- Example network architectures





- Reduce the number of Electronic Control Units (ECUs)
  - Trend: fewer and more powerful
- Integrate functions (software) on a common architecture
  - Trend: AUTOSAR

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SSI – SubSystem Integration

- Project within PROGRESS (www.mrtc.mdh.se/progress)
- Members

Moris Behnam,
phd student

Insik Shin
postdoc

Thomas Nolte
senior researcher
project leader

Mikael Nolin
senior researcher

- We focus on achieving predictable execution of a subsystem's software
  - integration of real-time systems
- Our goals are
  - the integration of subsystems should be less complicated
  - it should be possible to develop subsystems independently

Research problems outlined

Integrating subsystems generates temporal interference

- Network level challenges
  - Temporal interference between subsystems
    - Tool enabled integration
      - Takes underlying technology and produce (synthesize) an integrated solution
    - Standards enabled integration
      - The use the underlying technology in a specified way guarantees an integrated solution
    - Middleware enabled integration
      - Removal of dependencies inherent in the underlying technology, simplifying an integrated solution
- Node level challenges
  - Temporal interference between subsystems
    - Hierarchical scheduling
  - Logical resource sharing between subsystems
    - Synchronization protocol

Server-CAN

Server-CAN

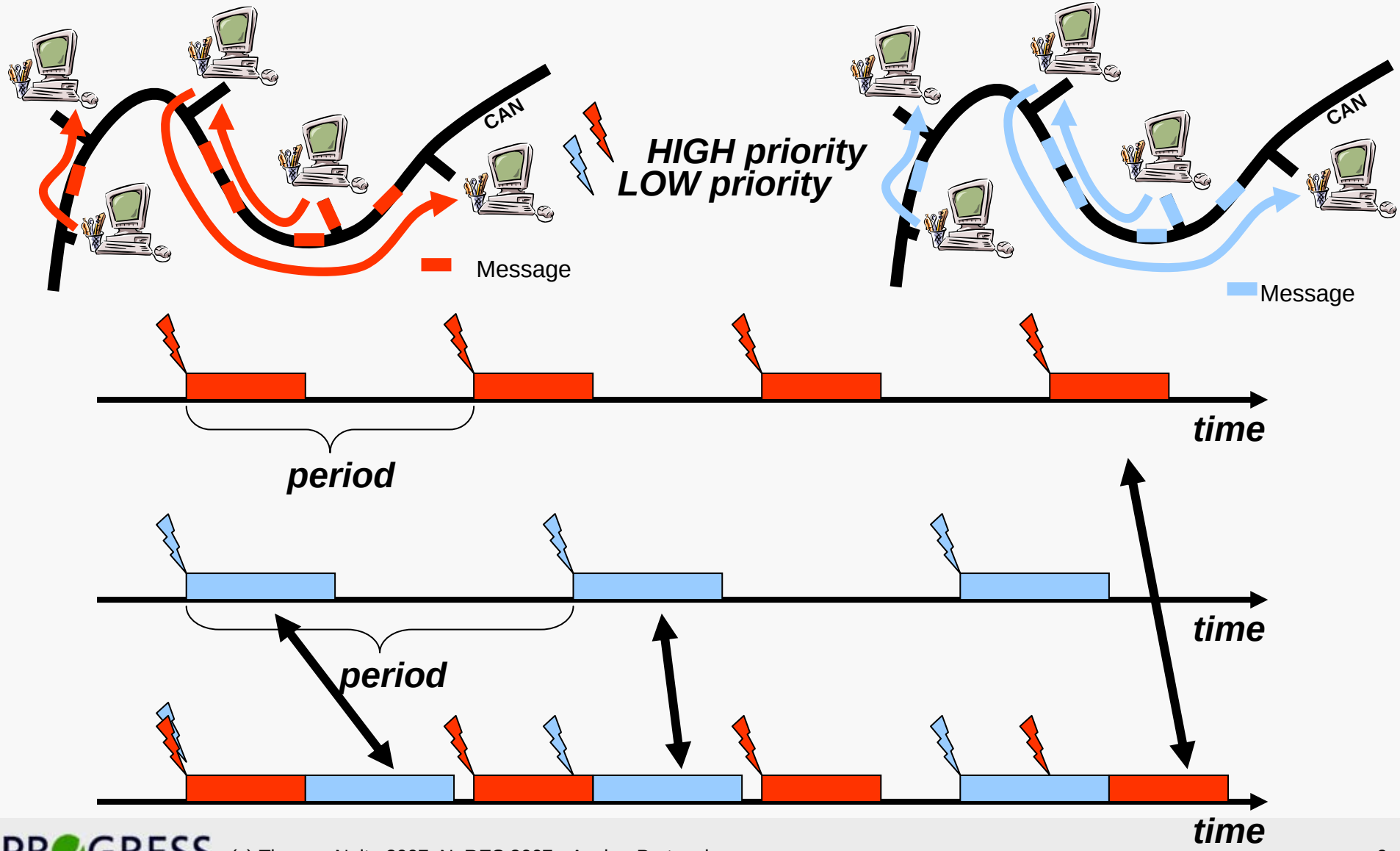
What is it?

- Server-based scheduler
  - Developed for CAN
- Dynamic priority bandwidth conserving version of PS and TBS
  - Periodic Server-Scheduled CAN (PS^2-CAN)
  - Simple Server-Scheduled CAN (S^3-CAN)

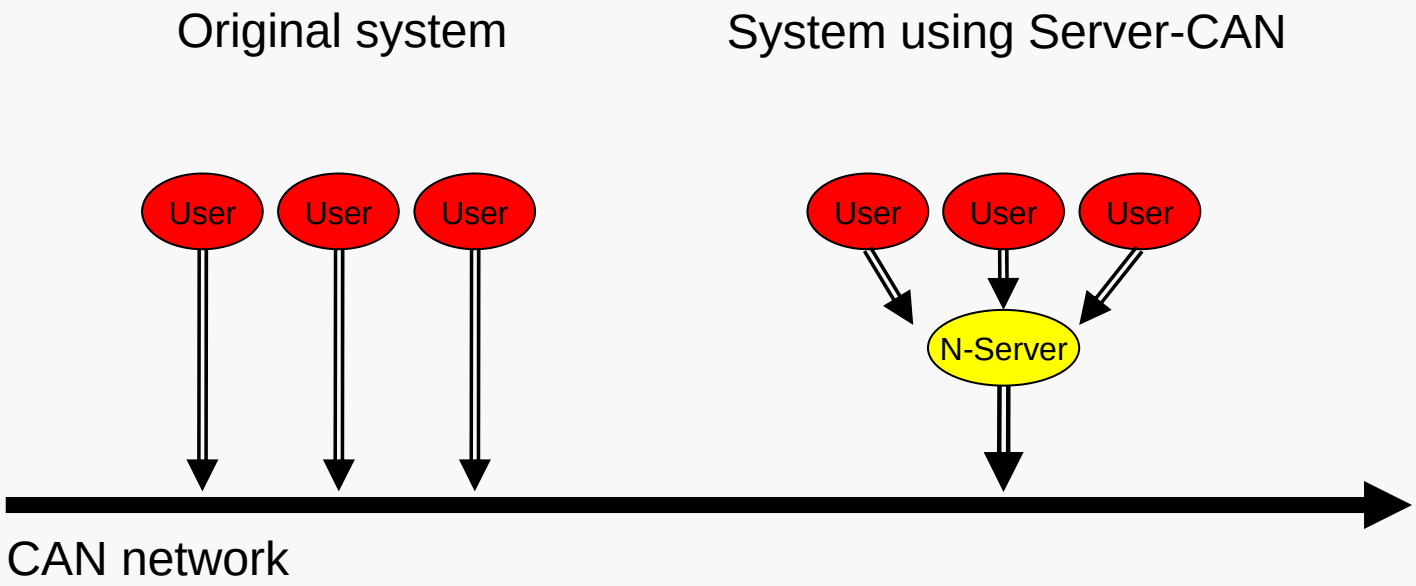
Properties

- Real-time guarantees
- Decouples message ID from priority
- Allows for independent development of subsystems
  - Freedom in ID usage
- Allows for dynamic system reconfiguration
  - Admission control

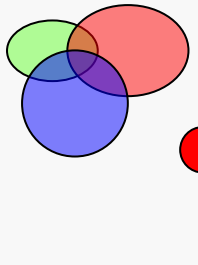
Integration, what is the problem?



Users and N-Server



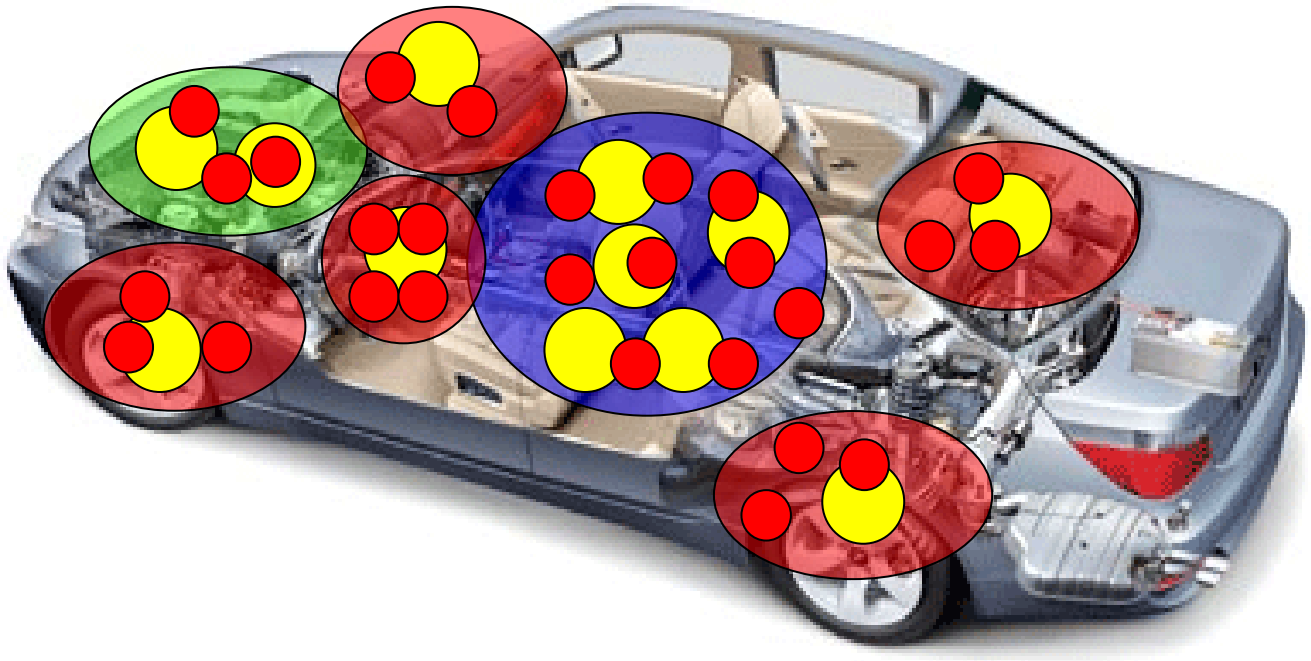
The Server-CAN concept



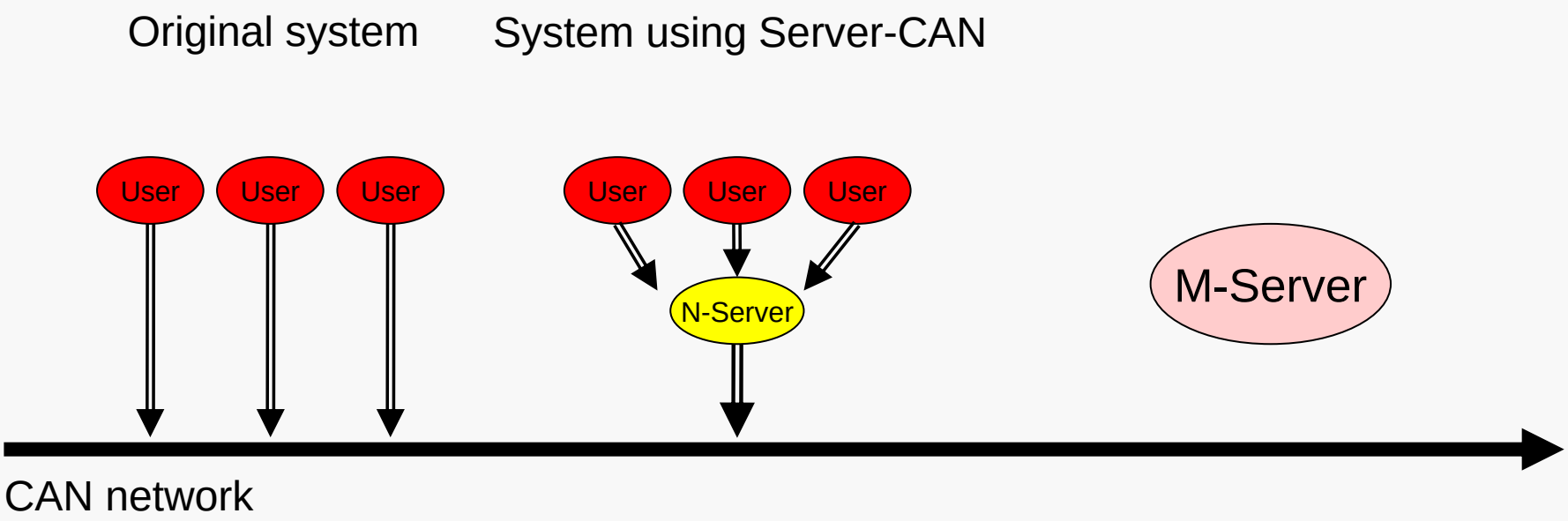
Applications: message transmitters

Message transmitters: users

Network access servers: N-Servers



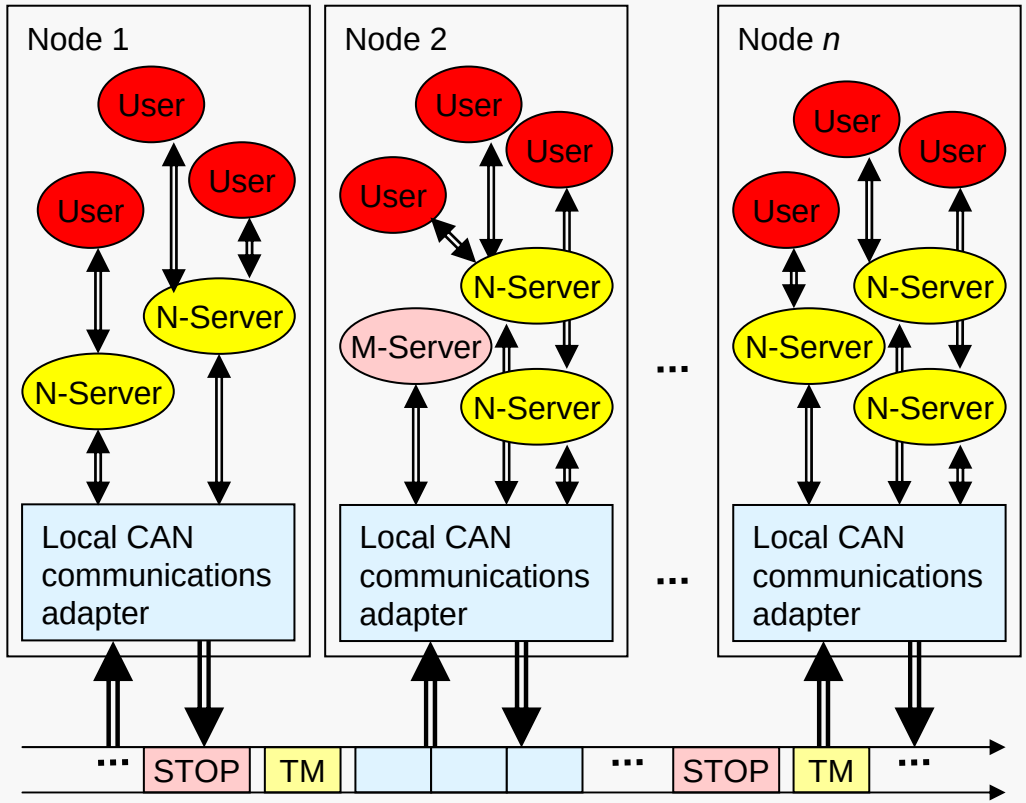
The M-Server



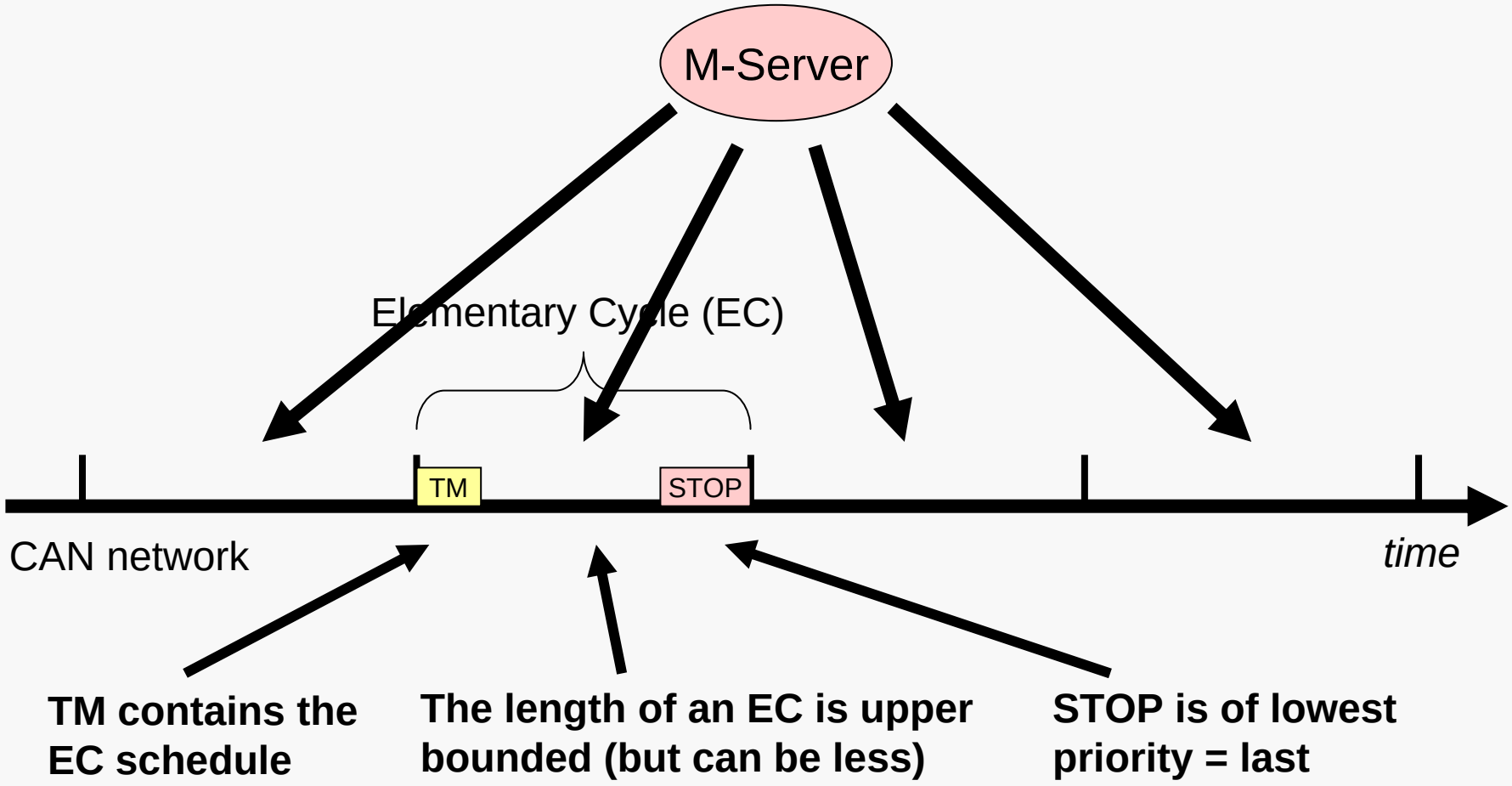
We have control over the N-Server…

…thanks to the system scheduler: the **M-Server**

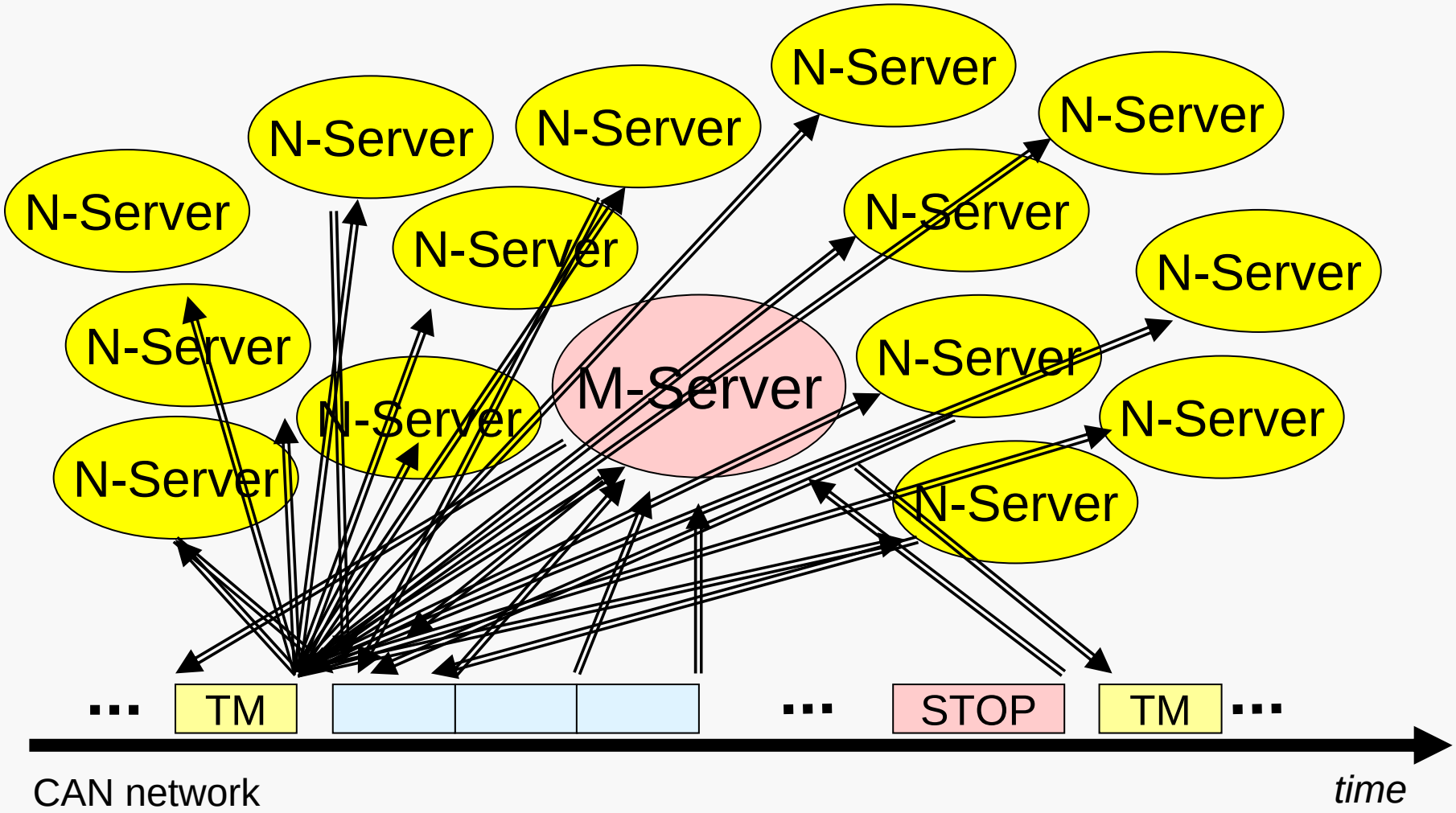
The Server-CAN architecture



Scheduling

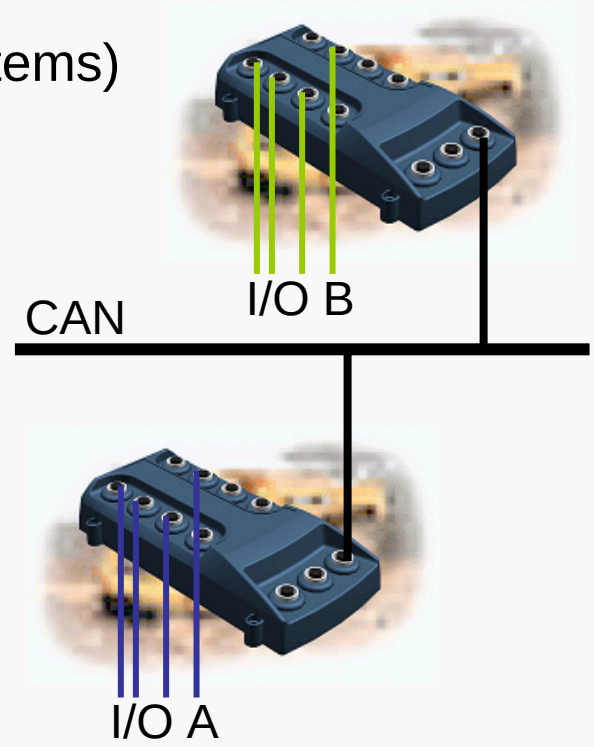

M-Server
Elementary Cycle (EC)
TM
STOP
CAN network
time
TM contains the EC schedule
The length of an EC is upper bounded (but can be less)
STOP is of lowest priority = last

Scheduling example



Current status

- SAVE demonstrator project
  - Server-CAN implementation
  - + many more subprojects
- Platform
  - CrossFire ECU (CC-Systems)
  - CCSimTech simulation technique
- Application
  - Individual case studies
  - Real application from industrial partners



The SAVE Project

”The goal of SAVE is to establish an engineering discipline for systematic development of component-based software for safety-critical embedded vehicular systems”

6 year program

Stiftelsen för Strategisk Forskning

Supporting industries: ABB ATP/Robotics, Bombardier, CR&T, Saab, Scania, Volvo Car and Volvo TD

Mälardalen University - RTS Design Lab - SE Lab	Linköping University - RTS Lab	Uppsala University - UppAal grp	Royal Institute Of Technology - Damek KTH

Resources

- The MRTC web page contains most publications related to SAVE, PROGRESS and Server-CAN
  - http://mrtc.mdh.se
- For an overview of automotive systems, and technical details of Server-CAN, see my thesis
  - T. Nolte, ”**Share-Driven Scheduling of Embedded Networks**”
  - http://www.diva-portal.org/mdh/abstract.xsql?dbid=134
- On integration of embedded control systems, see
  - D. Chen, M. Törngren, J. Shi, S. Gerard, H. Lönn, D. Servat, M. Strömberg, K.-E. Årzen,
    ”**Model Integration in the development of Embedded Control Systems – a characterization of current research efforts**”