Year 2 Review
Paris, November 8th and 9th, 2006

*Scientific Highlights :*

# Communication Centric Systems

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Technical University of Braunschweig

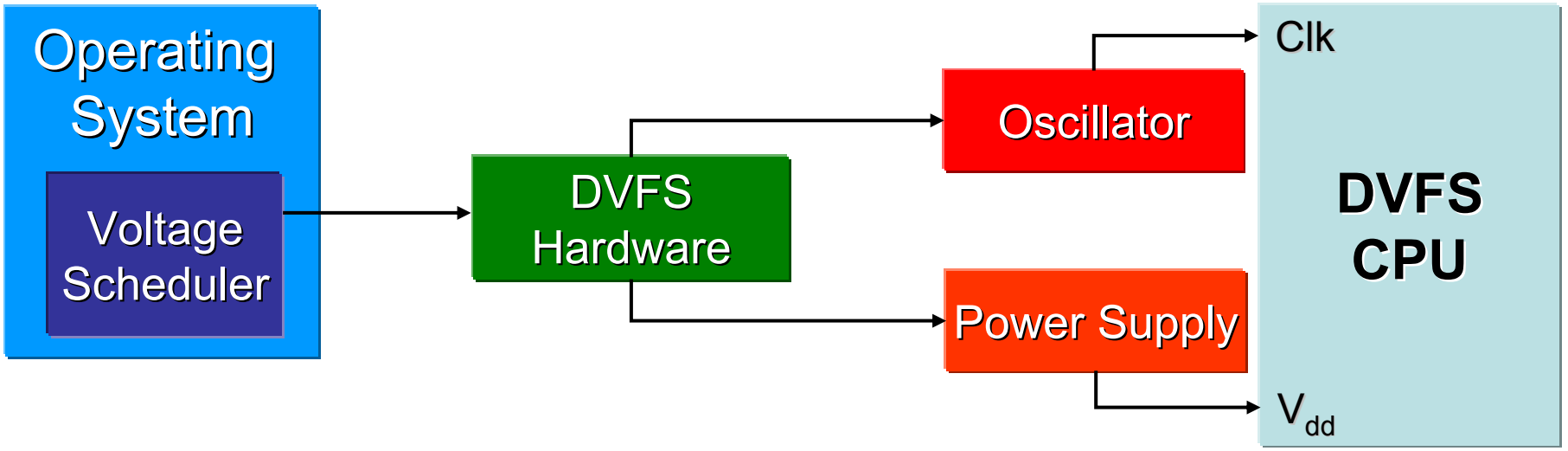
# Outline

1. Power optimization under timing constraints
   - Collaboration ARTIST 2 - University of Notre Dame, USA
   - Tool coupling
   - Case study: Mobile gaming platform
2. Automotive platform design
   - Collaboration ARTIST 2 - Startup Symtavision GmbH
   - Application 1: Engine ECU analysis
   - Application 2: CAN bus with gateway

# 1. Power Optimization under Timing Constraints

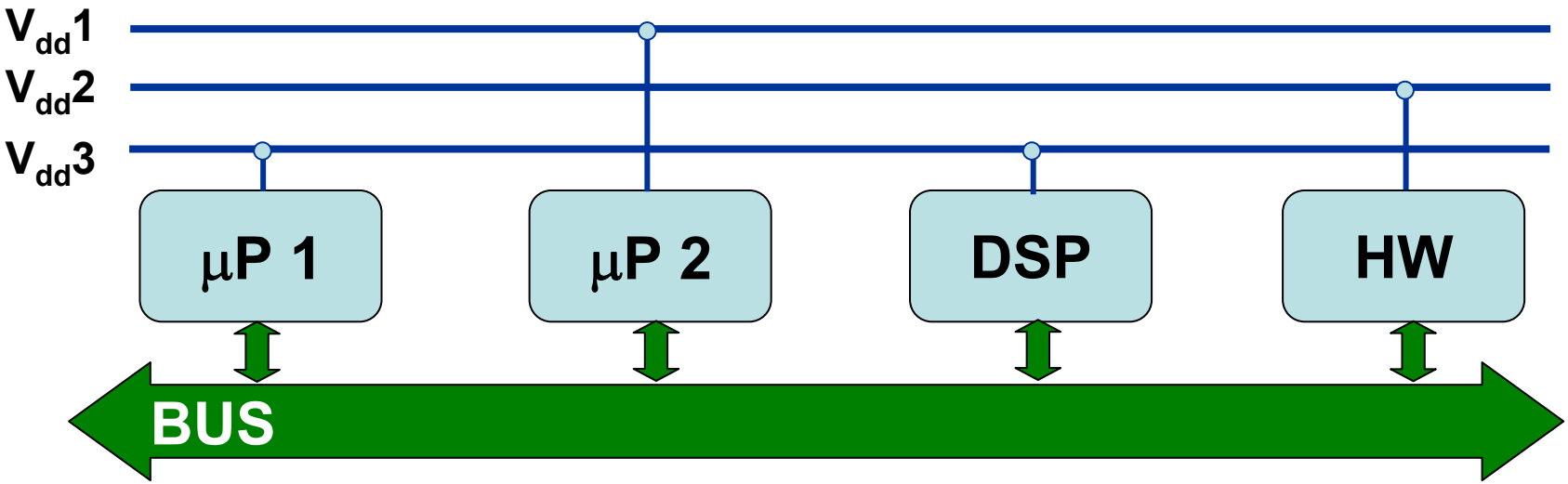
- Cooperation between University of Notre Dame and TU Braunschweig
- Two power optimization approaches
  - Given a set of tasks and their mapping to resources
  - Task level: determine the voltage/speed of each task that minimizes power (DVFS)
  - Resource level: determine the static voltage/speed of each resource that minimizes power (MV)
- Two optimization algorithms for each approach
  - Greedy Heuristic: uses sensitivity analysis of timing properties
  - Stochastic: uses evolutionary algorithms

# Dynamic Voltage and Frequency Scaling (DVFS)




- Change the CPU supply voltage and speed dynamically during runtime
- Increase energy efficiency by matching the CPU performance to the current workload
- Need a “good” voltage scheduler
- Require additional energy and time for transitions

# Multiple Supply Voltage (MV)

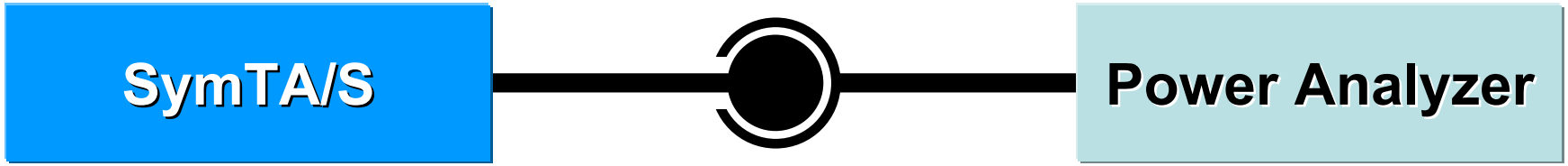



- Different supply voltages and operation modes
  - Each resource is assigned a fixed supply voltage and operation frequency at design time
  - Voltage selection according to performance requirement

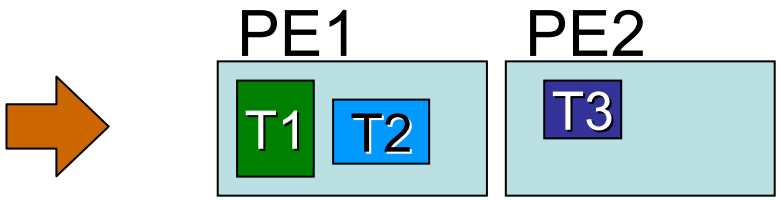
# Composition of timing and power analyses

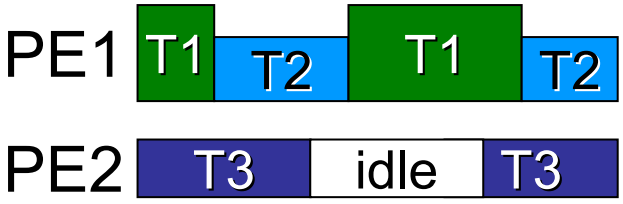
TU Braunschweig

Univ. of Notre Dame



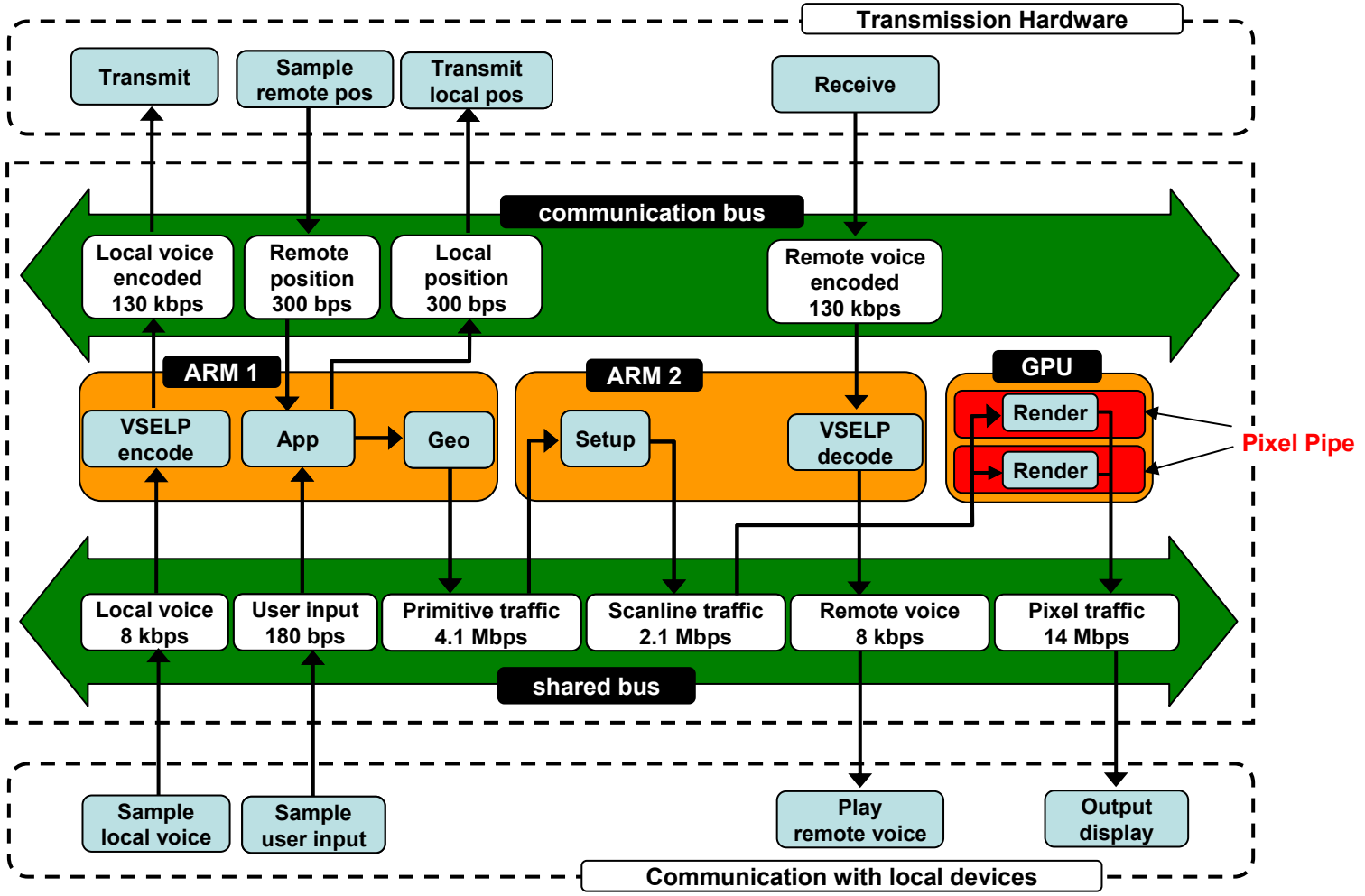

- System setup
  - Processor model selection
  - Task allocation + speed assignment
- Send worst case load execution trace
  - One trace per PE
  - One or more hyperperiods
- Return avg. power est. for WC trace
  - (Energy / Simulation time)



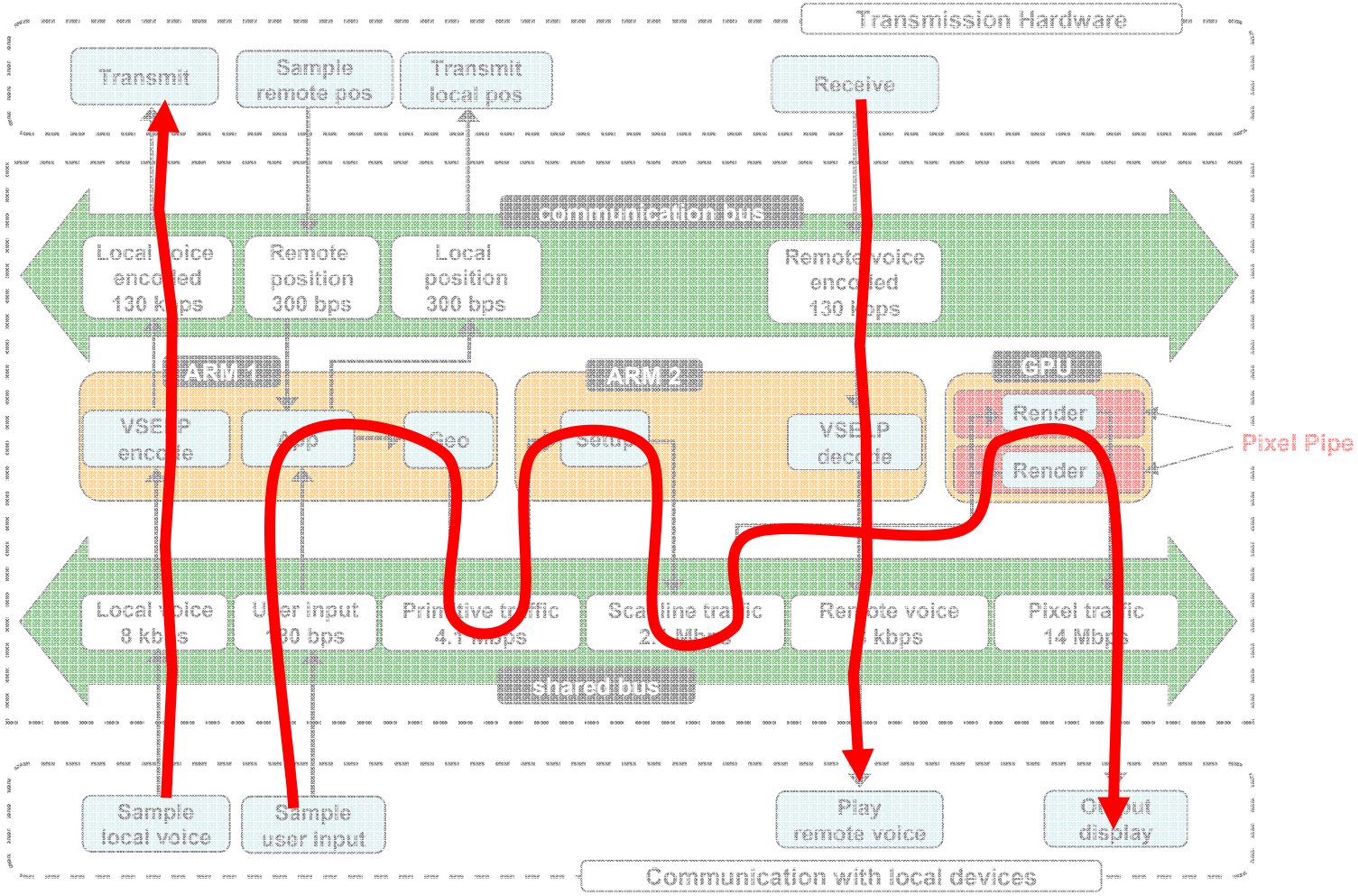




***322.054 mW***

# Case study: Mobile Gaming SoC



# Mobile Gaming SoC – Timing Constraints



# Greedy Heuristic: Results

## Task level (DVFS)

| *Task* | $sf_{init}$ | $sf_{opt}$ | *Mapping* |
|---|---|---|---|
| VSELP_ENCODE | 1.0 | 0.48 | ARM1 |
| SETUP | 1.0 | 0.75 | ARM2 |
| RENDER2 | 1.0 | 0.61 | PIXEL_PIPE2 |
| 3D_APP | 1.0 | 0.65 | ARM1 |
| VSELP_DECODE | 1.0 | 0.1 | ARM2 |
| RENDER1 | 1.0 | 0.61 | PIXEL_PIPE1 |

| *Resource* | $E_{init}$ | $E_{min}$ |
|---|---|---|
| ARM1 | 0.65 | 0.43 |
| ARM2 | 0.5 | 0.26 |
| PIXEL_PIPE1 | 1.0 | 0.23 |
| PIXEL_PIPE2 | 1.0 | 0.23 |
| COMM_BUS | 0.08 | 0.08 |
| SHARED_BUS | 0.28 | 0.28 |
| **Total Power** | **3.51** | **1.51** |

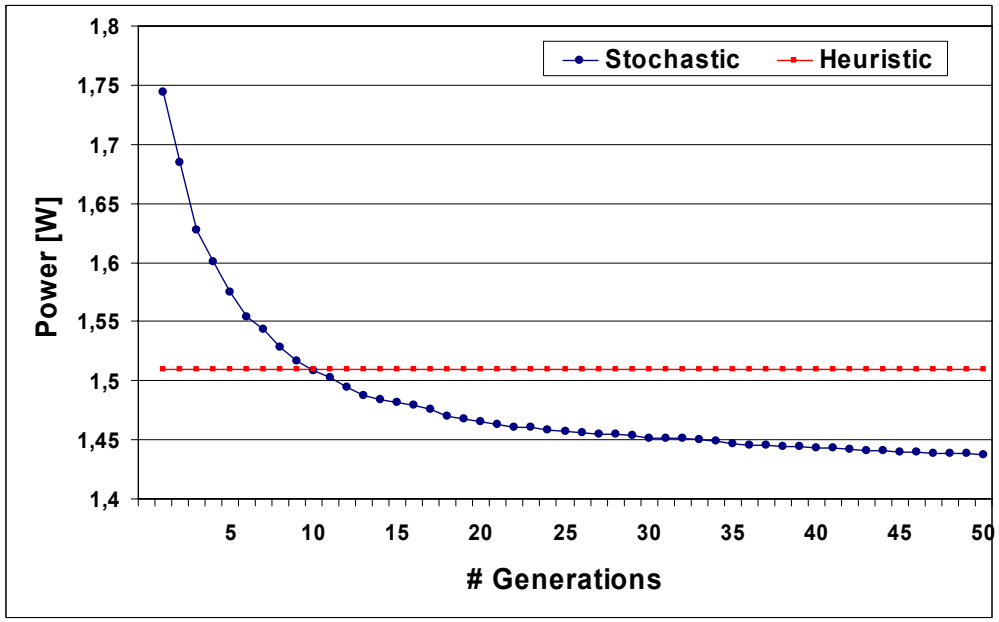
## Resource level (MV)

| *Resource* | $sf_{init}$ | $sf_{opt}$ | *Mapping* |
|---|---|---|---|
| ARM2 | 1.0 | 0.64 | [SETUP, VSELP_DECODE] |
| PIXEL_PIPE1 | 1.0 | 0.61 | [RENDER1] |
| PIXEL_PIPE2 | 1.0 | 0.61 | [RENDER2] |

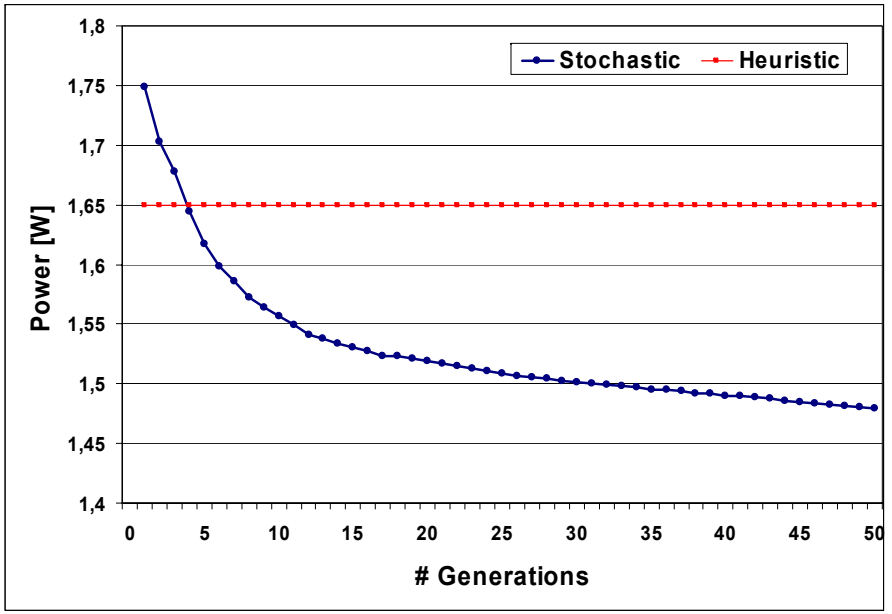
| *Resource* | $E_{init}$ | $E_{min}$ |
|---|---|---|
| ARM1 | 0.65 | 0.65 |
| ARM2 | 0.5 | 0.21 |
| PIXEL_PIPE1 | 1.0 | 0.23 |
| PIXEL_PIPE2 | 1.0 | 0.23 |
| COMM_BUS | 0.08 | 0.08 |
| SHARED_BUS | 0.28 | 0.25 |
| **Total Power** | **3.51** | **1.65** |

# Heuristic vs. Stochastic Approach

## Task level

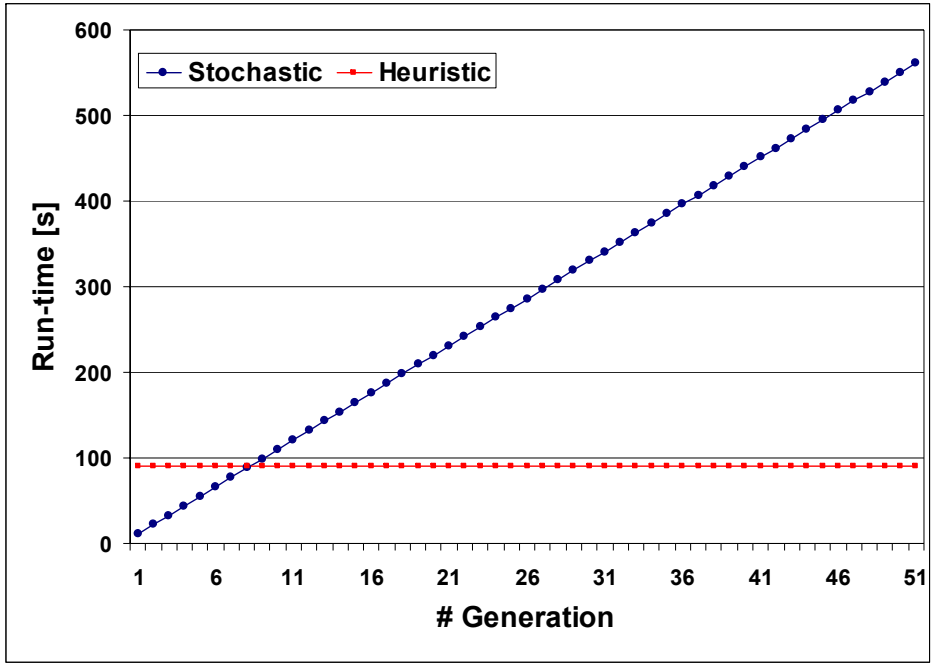



## Resource level

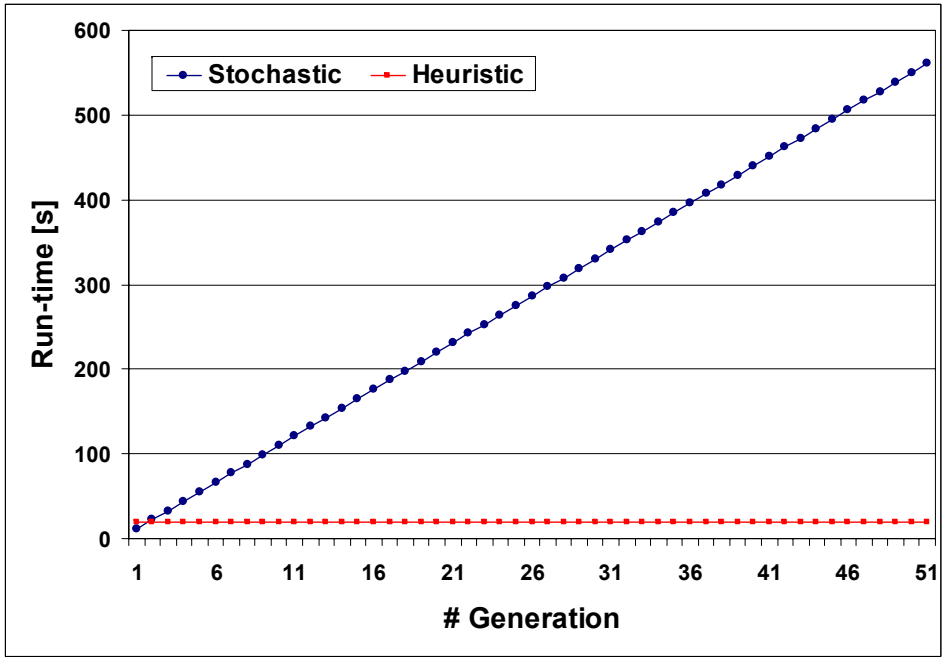


# Run-time – Heuristic and Stochastic Approach

## Task level




## Resource level



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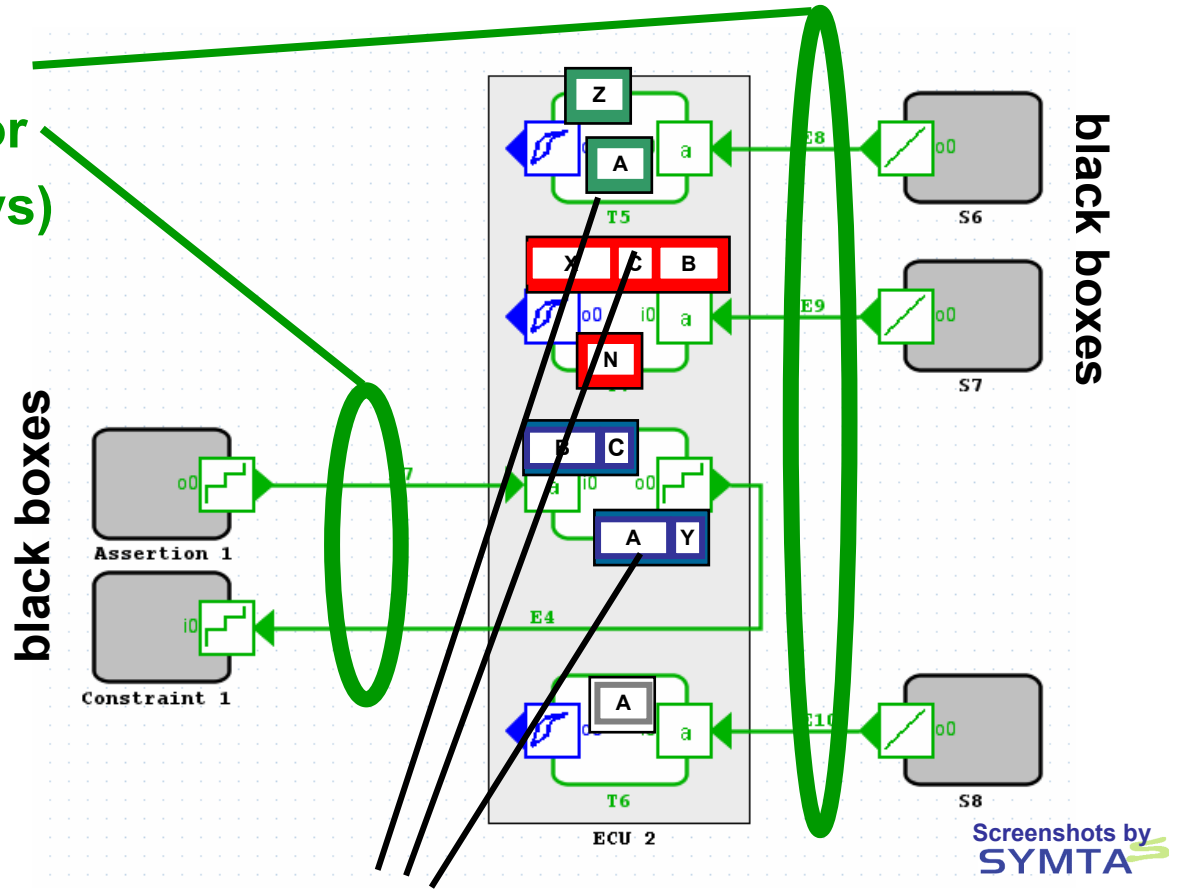
# 2. Automotive Platform Design

- SymTA/S tool of TU Braunschweig was extended to cover automotive platform details
  - techniques to model activation phases such as generated by time table based activations
  - detailed automotive OS, bus, and gateway models
  - import/export of automotive design data (design process integration)
  - extension work mostly by Symtavision w partial support of public funding
  - discussions w ETH and Linköping U

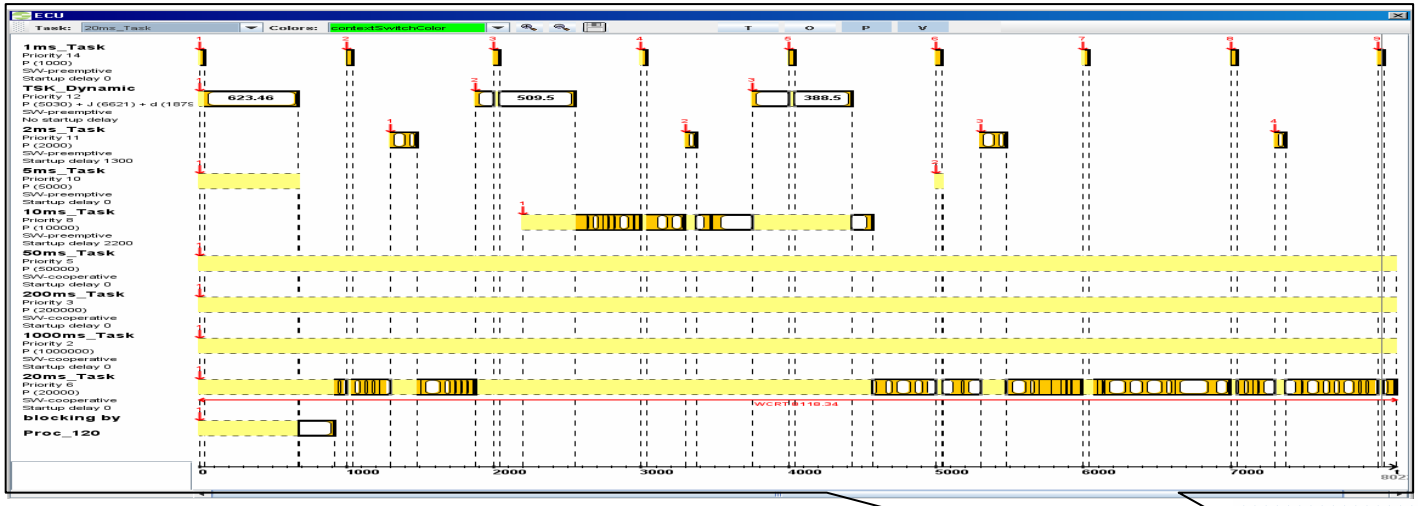
# Application 1 - Timing Analysis on ECU

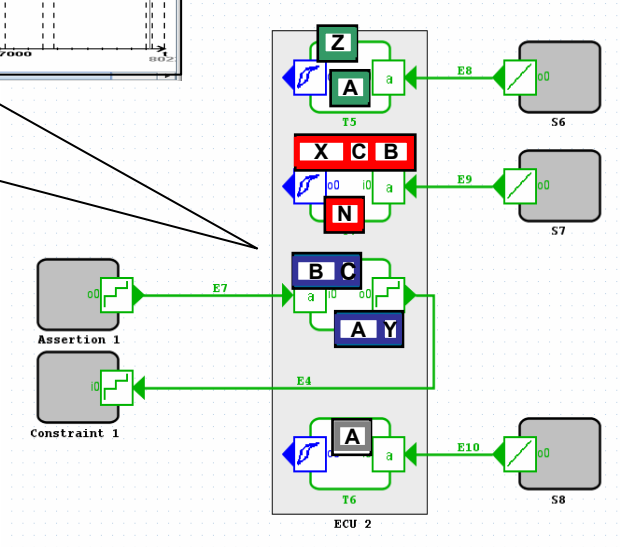
**interface captures dynamic I/O behavior (jitter, min/max delays)**




**preemptive and cooperative tasks**

# Analysis Challenges




- complicated preemption and cooperation scheme
- task chaining
- high accuracy

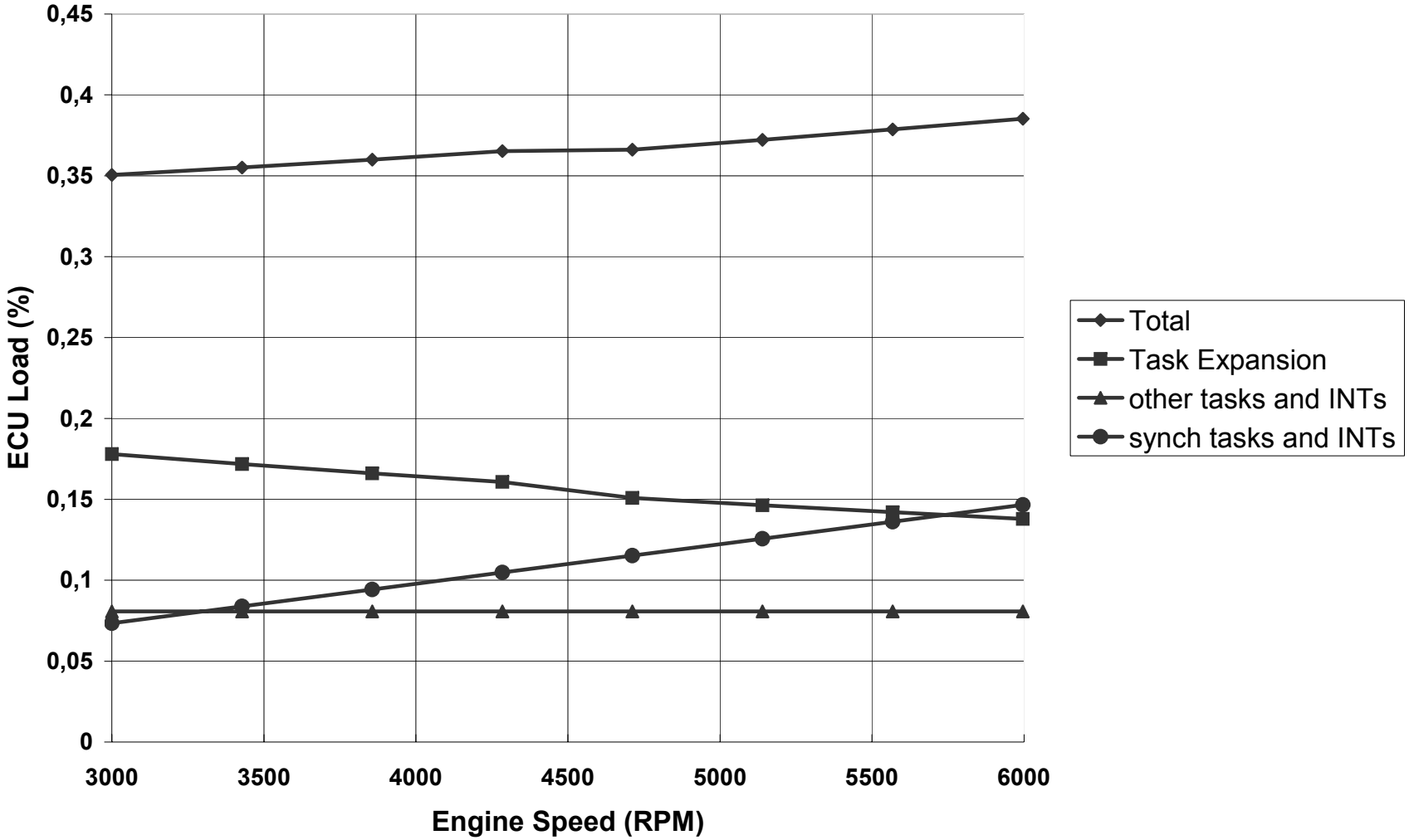
# Design task

- Engine ECU with periodic and engine-synchronous tasks
- Specialties
  - load of engine-synch. tasks increases with engine speed
  - compensation by application level „task expansion“ mechanisms
- Accuracy issues
  - chained task activations w/ preemptive & cooperative tasks
  - alternating task executions (mutex)

Goals

- automatic analysis of multiple „points of interest“ (RPM curve)
- support test development by identifying corner cases
- consideration of platforms (4-, 6-, 8- cylinder engine)

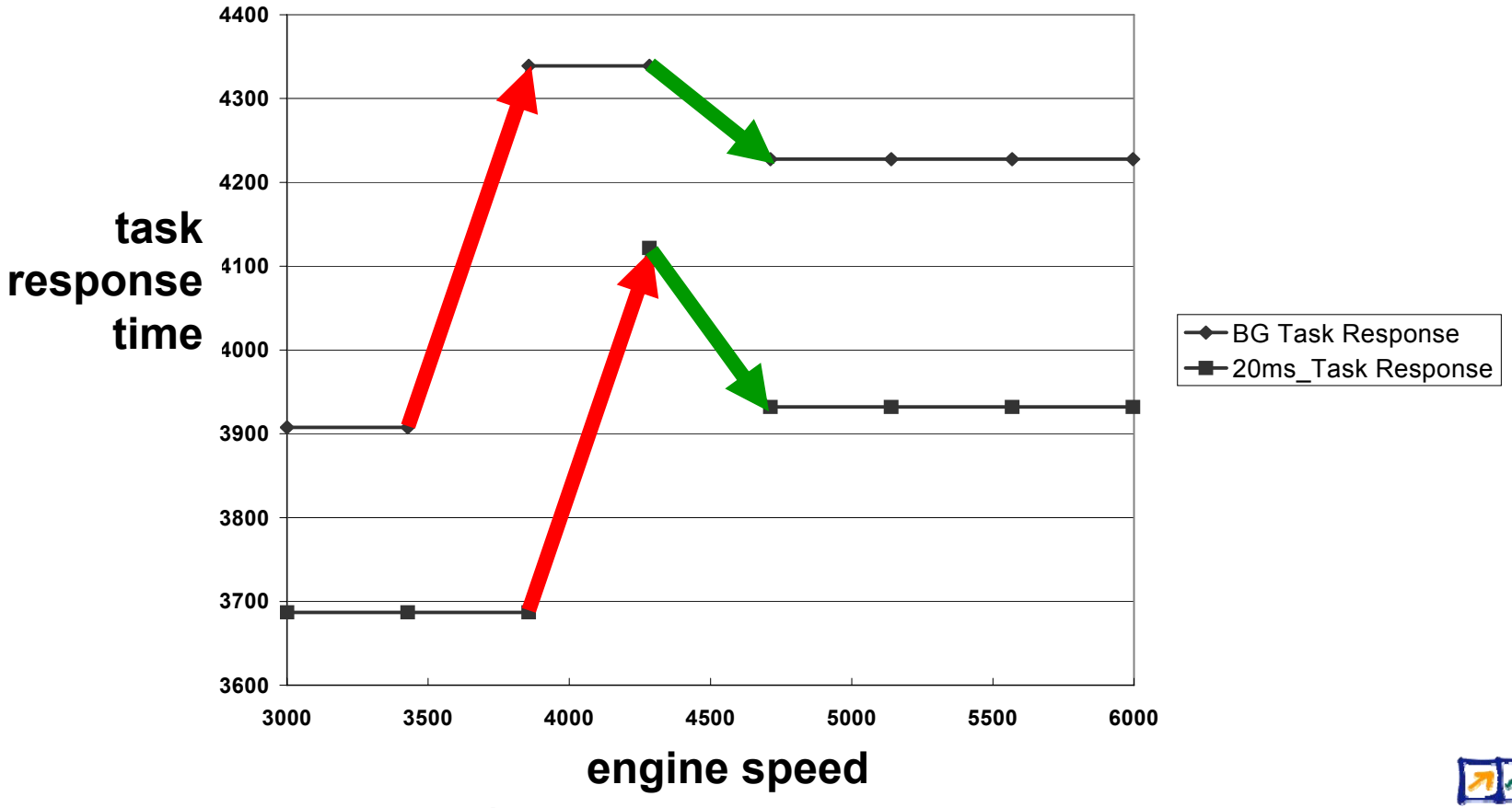
# Results I – Characteristic Load Curve



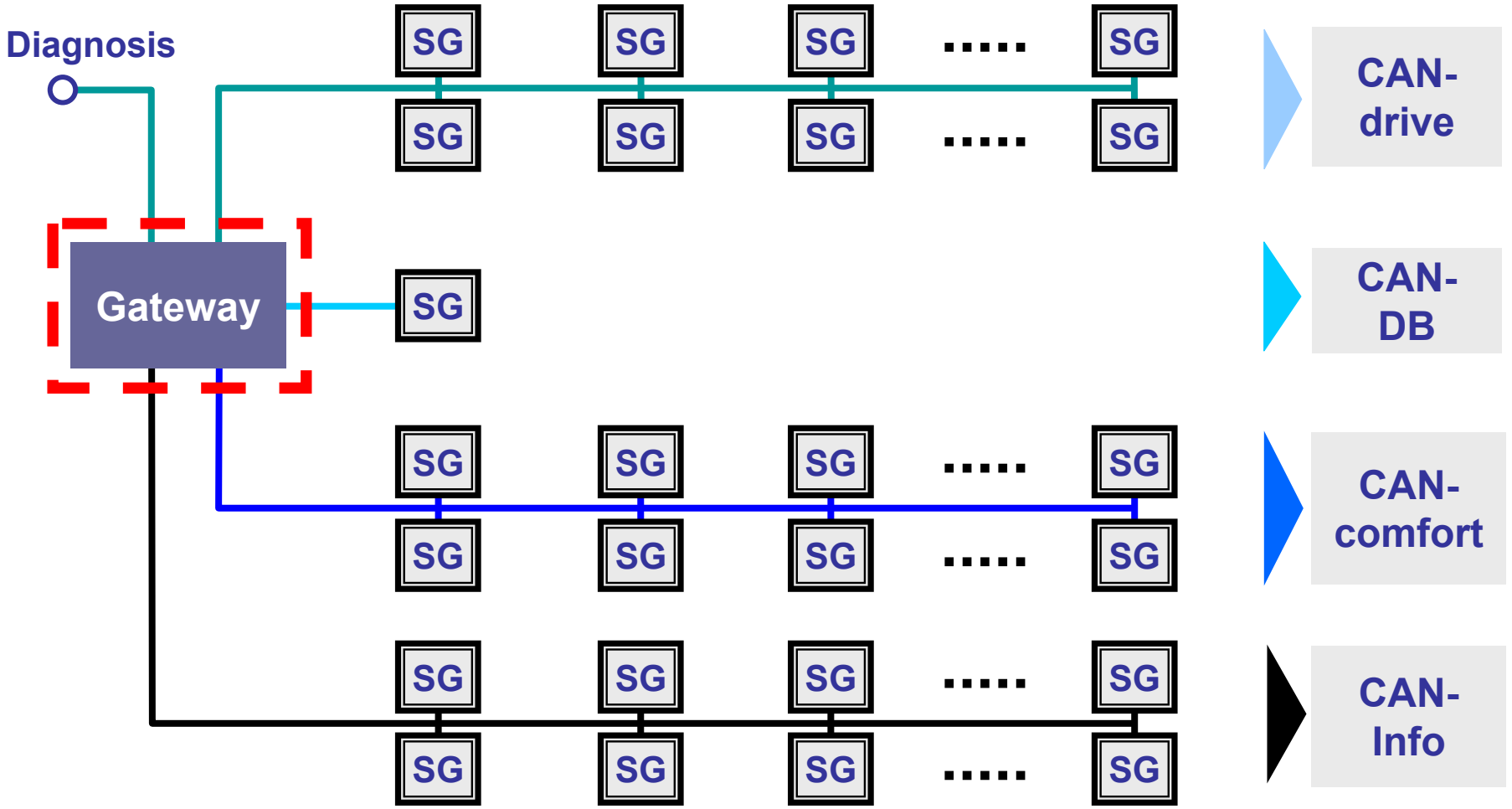
# Results II – Detecting "Anomalies"

**Additional preemption by RPM-synchronous tasks (increases task interference)**

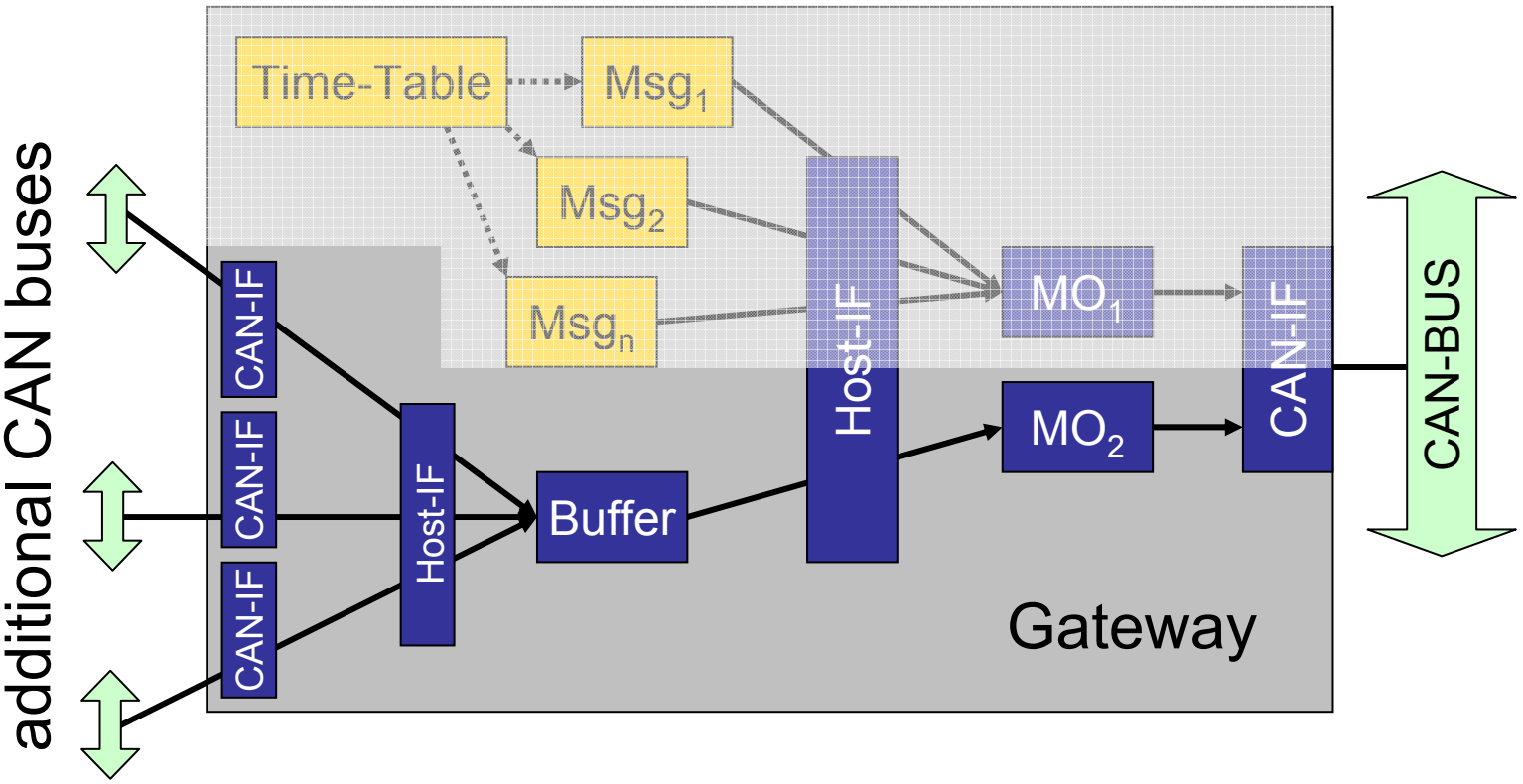
**Task cut-off (reduces core execution time)**



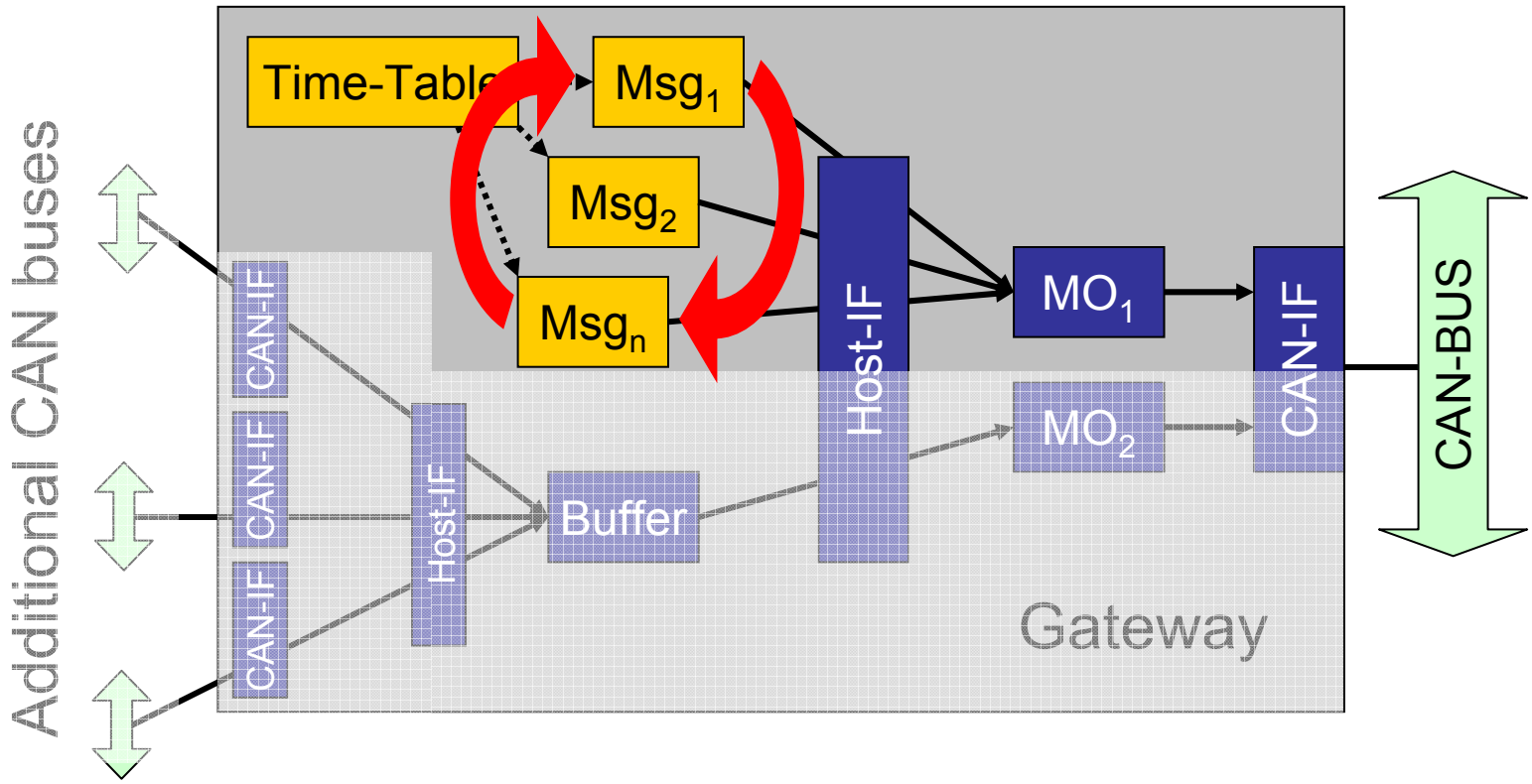
# Application 2: CAN Bus with Gateway



# Gateway


Time-Table
Msg1
Msg2
Msgn
Host-IF
MO1
CAN-IF
CAN-BUS
additional CAN buses
CAN-IF
CAN-IF
CAN-IF
Host-IF
Buffer
Host-IF
MO2
CAN-IF
Gateway

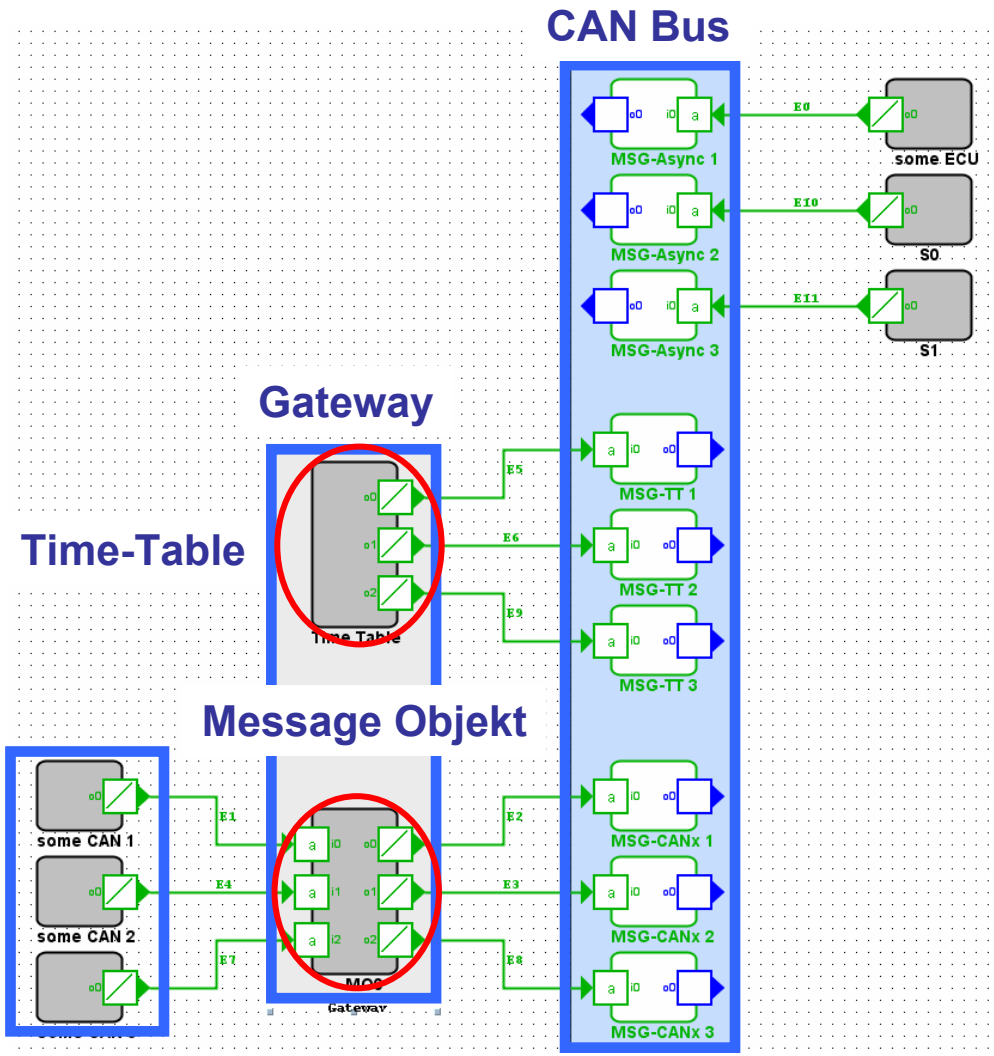
# Time-Table Driven Messages



# Analysis Challenges

- CAN-Bus
  - CAN protocol
  - Error models
- Gateway
  - Consideration of timing dependencies between time table generated messages (traffic shaping)
  - Shared, priority-ordered send buffer
  - Shared message objects (CAN Controller)

# System Setup



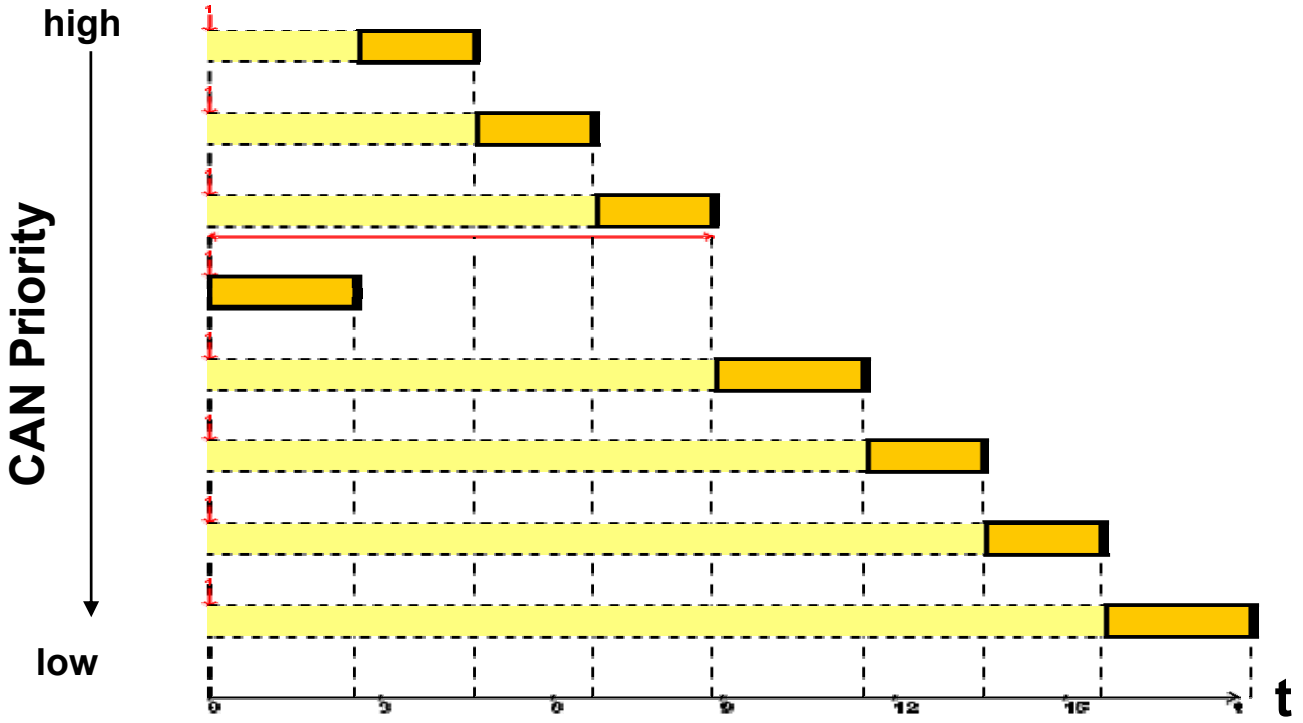

asynchronous senders

messages from other CAN buses

# Timing Influences I

Simplification: NO Time-Table and NO shared Message Object

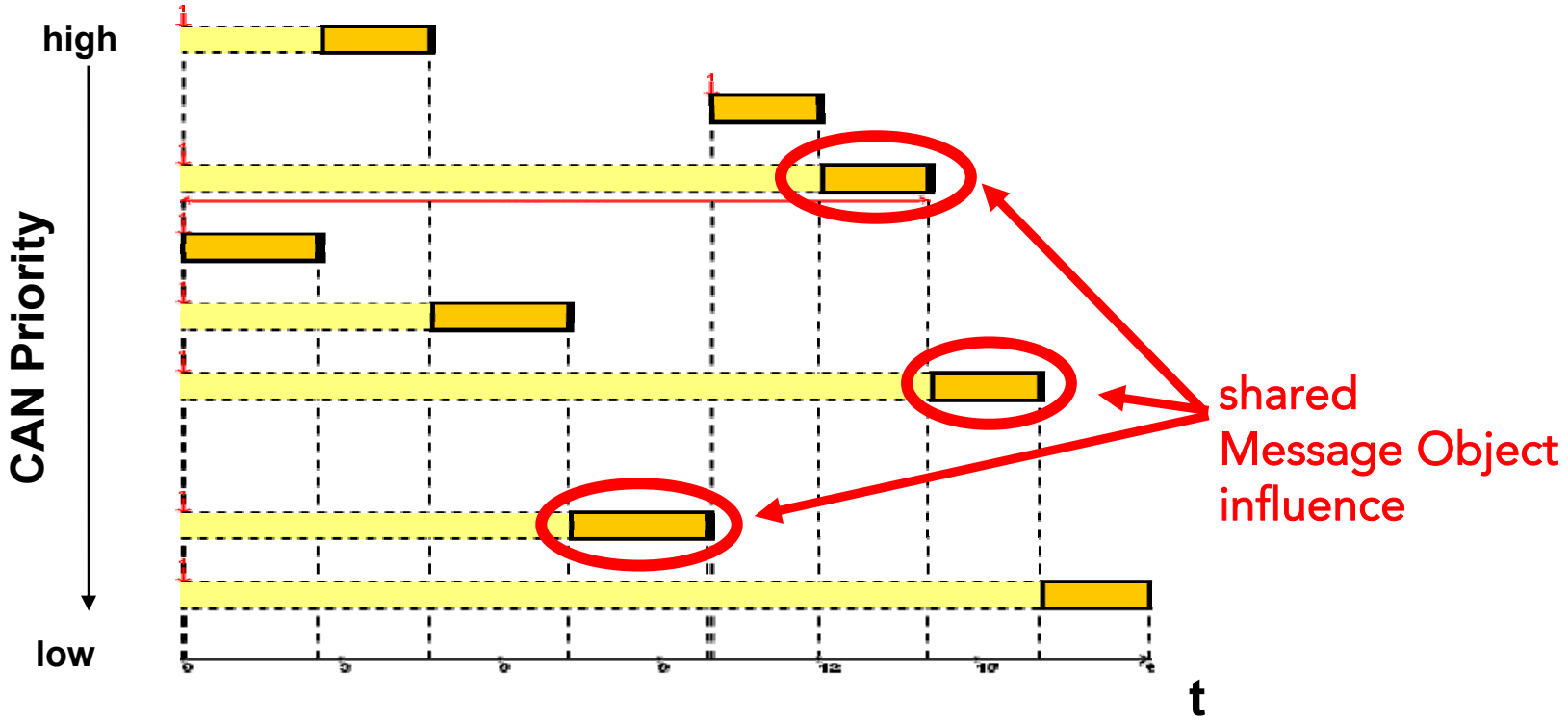
- Behavior according to message priorities with one blocking lower priority message in the worst-case
- Can be easily predicted



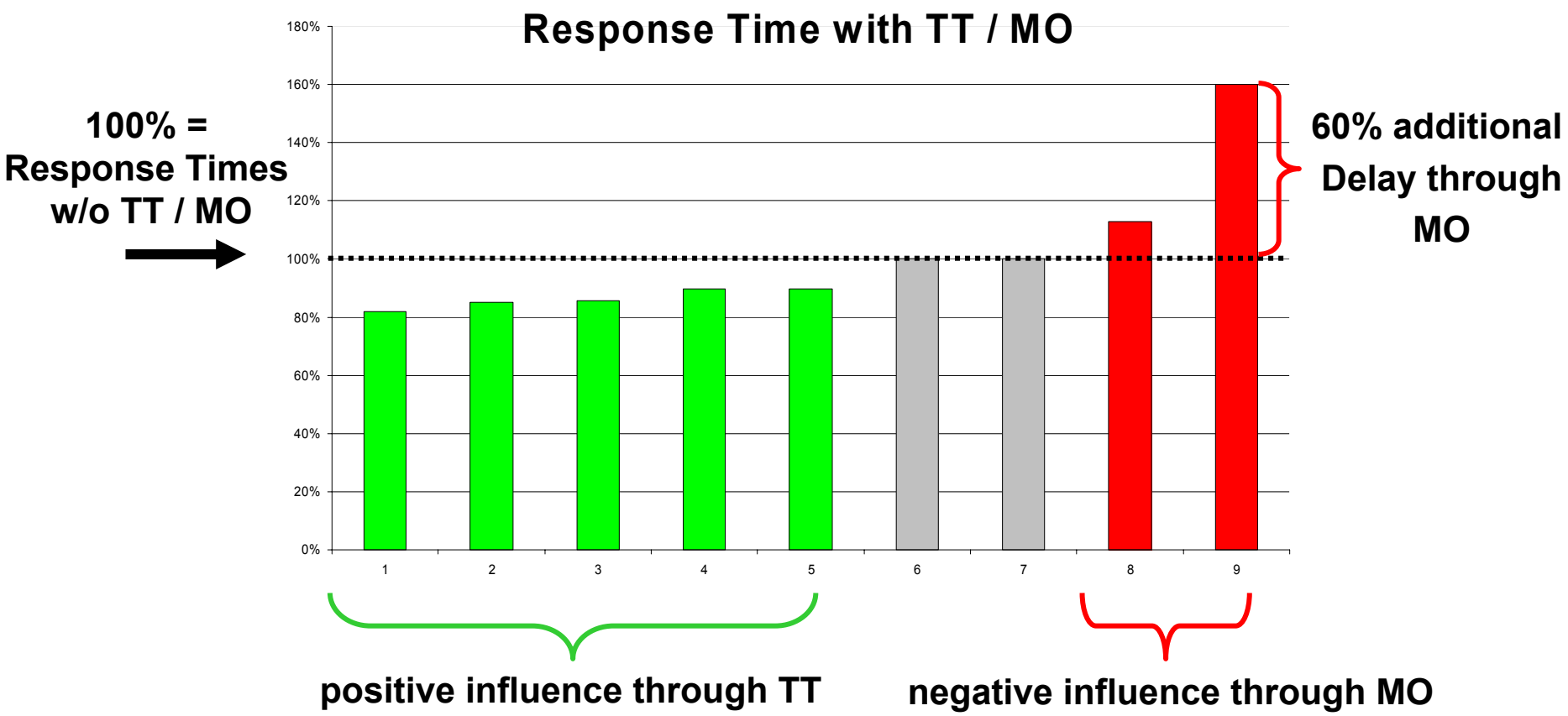
# Timing Influences II

## Detail: WITH Time-Table and WITH shared Message Object

- Complex, non-intuitive communication pattern
- Many blocking messages



# Influence on Response Times



# Conclusion

- collaboration of ARTIST 2 w international leading research institutions and industry leads to world leading practical solutions
- collaboration and meetings in ARTIST 2 instrumental for success
- tool status
  - evaluated and introduced by automotive manufacturers and suppliers world wide
  - already used for new car model design at one manufacturer – feedback with top quality ratings