

# Scheduling Analysis for Control Units and Networks

Torino  
June 09, 2011



Solutions for Complex  
Real-Time Systems

# Symtavigation – Who we are

## Company

- ▶ Founded 2005, 25 employees
- ▶ Based in Braunschweig, Germany
  - ▶ Munich branch, distributors in France, Italy, Japan, China, Korea. USA expansion in 2011

**Expertise: timing design and timing verification for embedded control units and networks**

## Solutions

- ▶ Tools: SymTA/S®, TraceAnalyzer™
- ▶ Standards-based tool-integration
- ▶ Methodology consulting and engineering services



Dr. Jersak  
CEO



Dr. Richter  
CTO



W. Ries  
CSO

**AUTOSAR**  
Development member



Founding member

# Our Customers

## OEMs & Suppliers

- Automotive
- Aerospace
- Transportation & Automation

## Use-Cases

- Architecture Design
- Network Optimization
- Software Integration
- Timing Verification



BMW Group



DAIMLER

VOLVO



DENSO

PSA PEUGEOT CITROËN



IVECO



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# Community Activities

## Collaborative Projects

SuReal



ALL|times



TIMMO2use



## Networking Events

SYMTA News Conference

since 2007

2010, 1st Symtavision Asia Conference  
2011, Conferences in F, IT, USA  
Real-Time Experts Road Shows

## Standardization

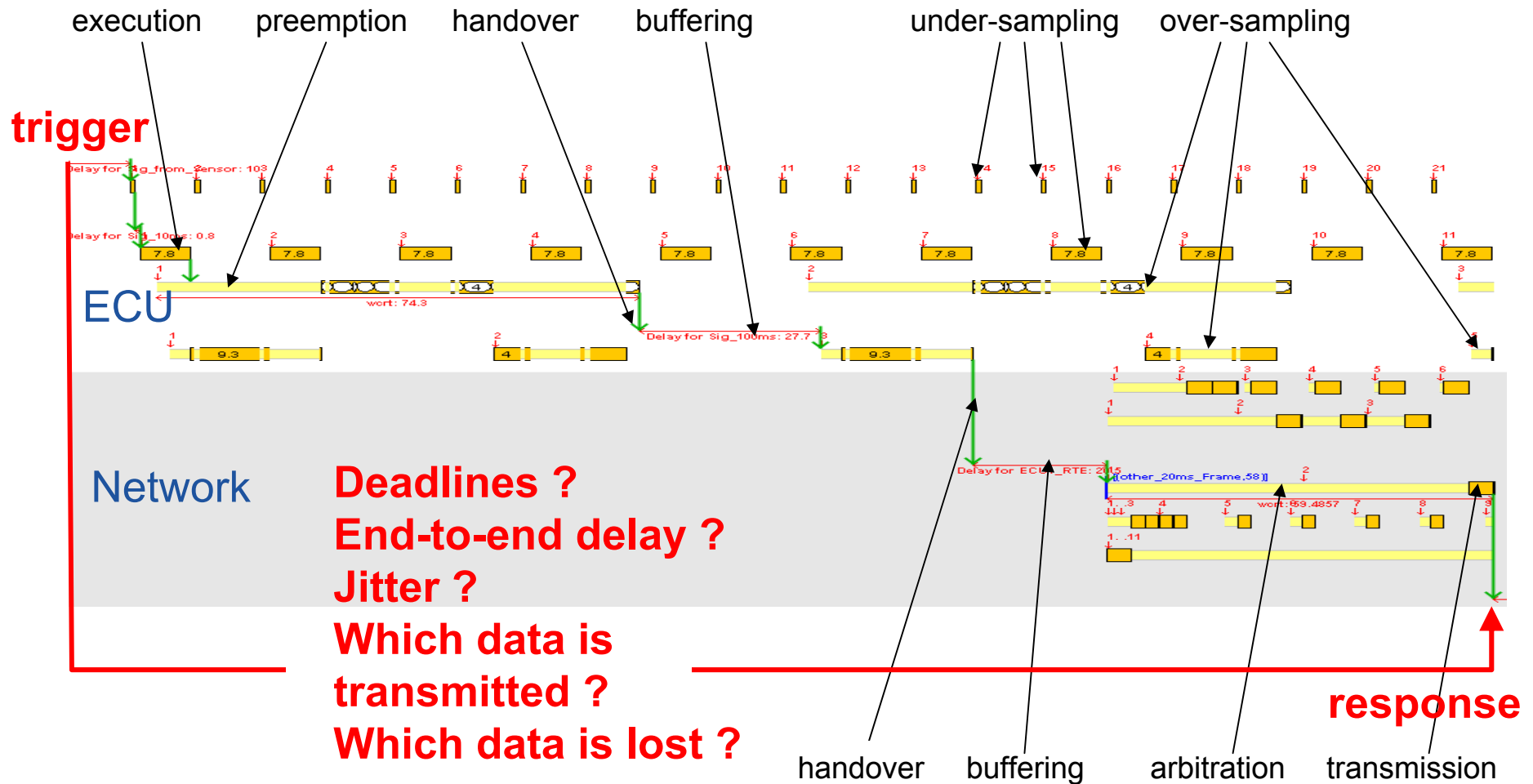
AUTOSAR

ISO 26262

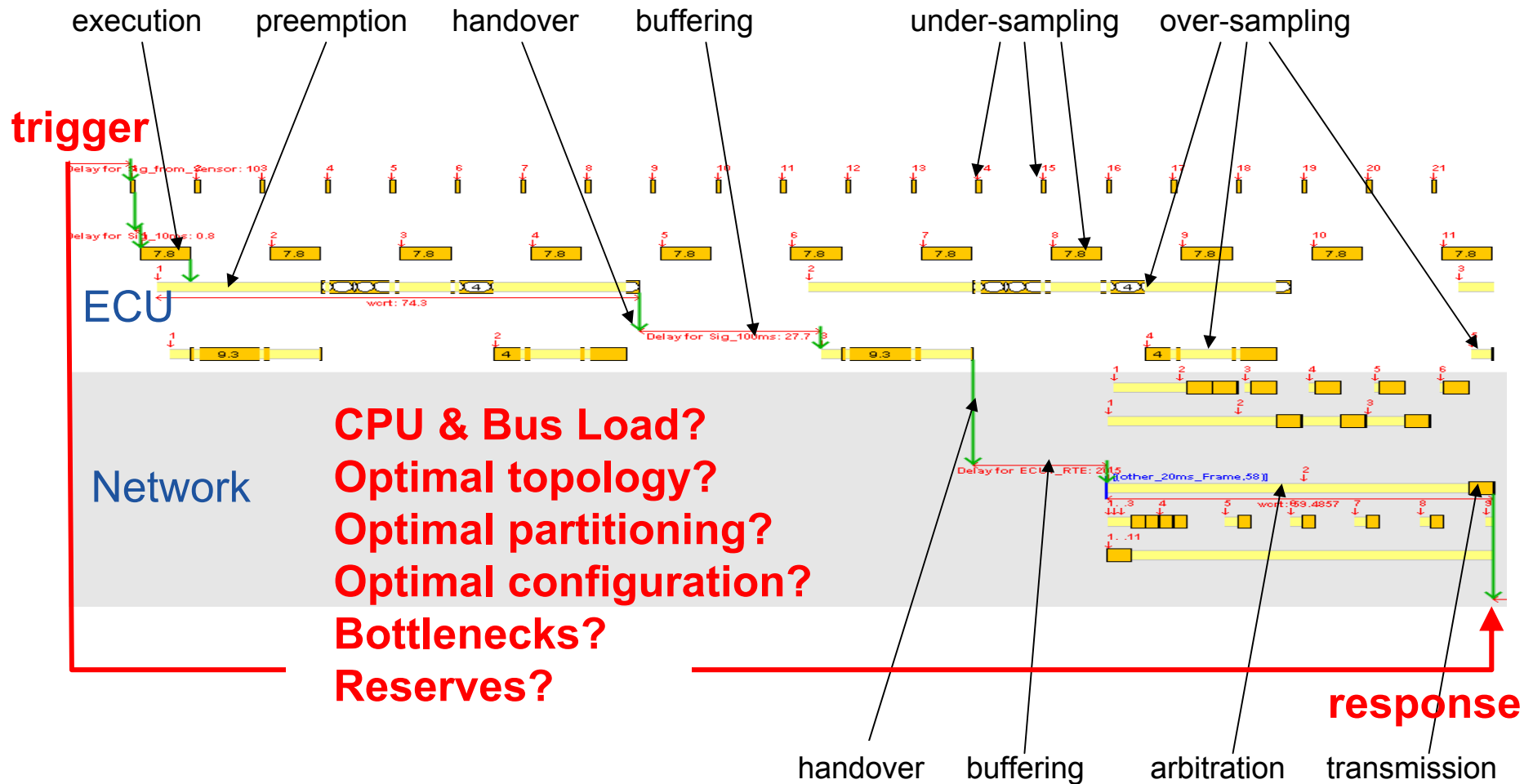
Common Trace Format



# Scheduling Analysis for Virtual Timing Verification



# Scheduling Analysis for Architecture Optimization



# Symtavision in the Development Cycle

## ❑ System design and virtual timing verification

- ❑ Architecture alternatives
- ❑ Cost effective real-time computation and communication
- ❑ Avoid late integration problems
  - deadline overruns, lost or inconsistent data, excessive jitter ...



## ❑ Software implementation and refinement

- ❑ Timing requirements and software budgets for suppliers
- ❑ Timing verification for each implementation step
- ❑ Early warning and remedy for impending timing problems



## ❑ System integration and verification

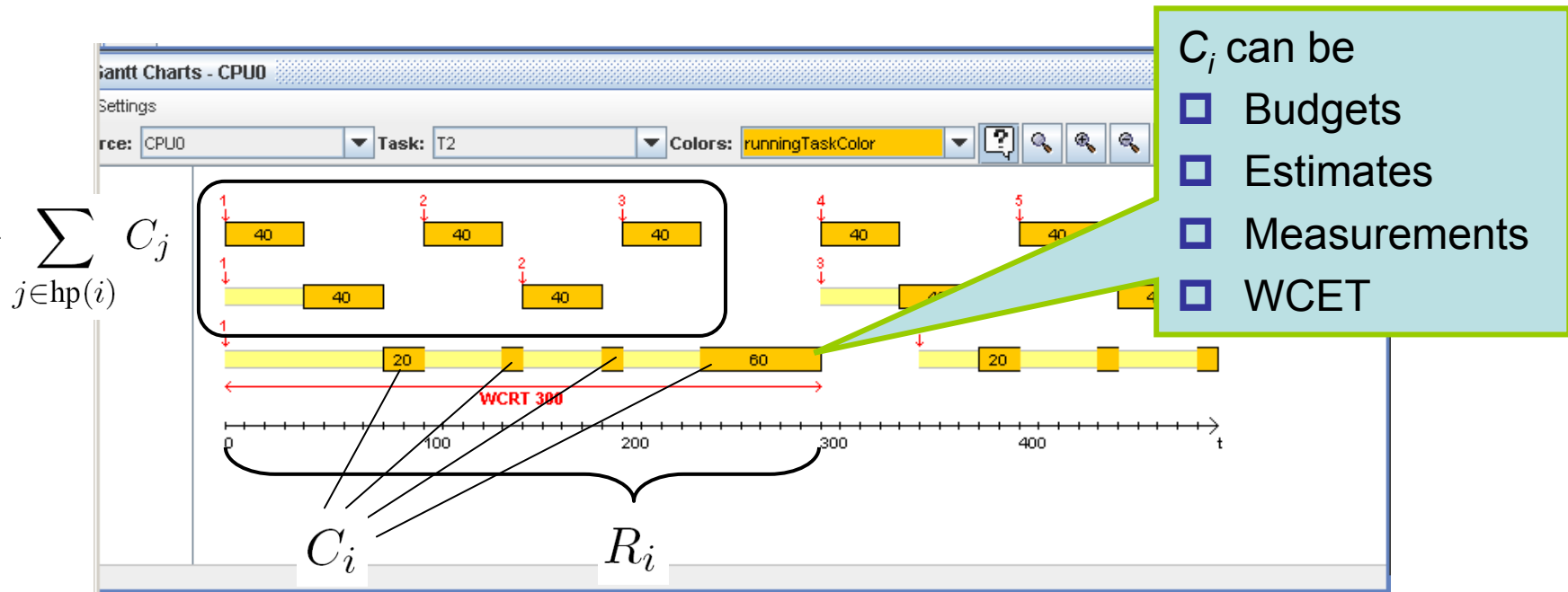
- ❑ Maximize system reliability
- ❑ Functional safety: system is free from unacceptable risk due to timing failures



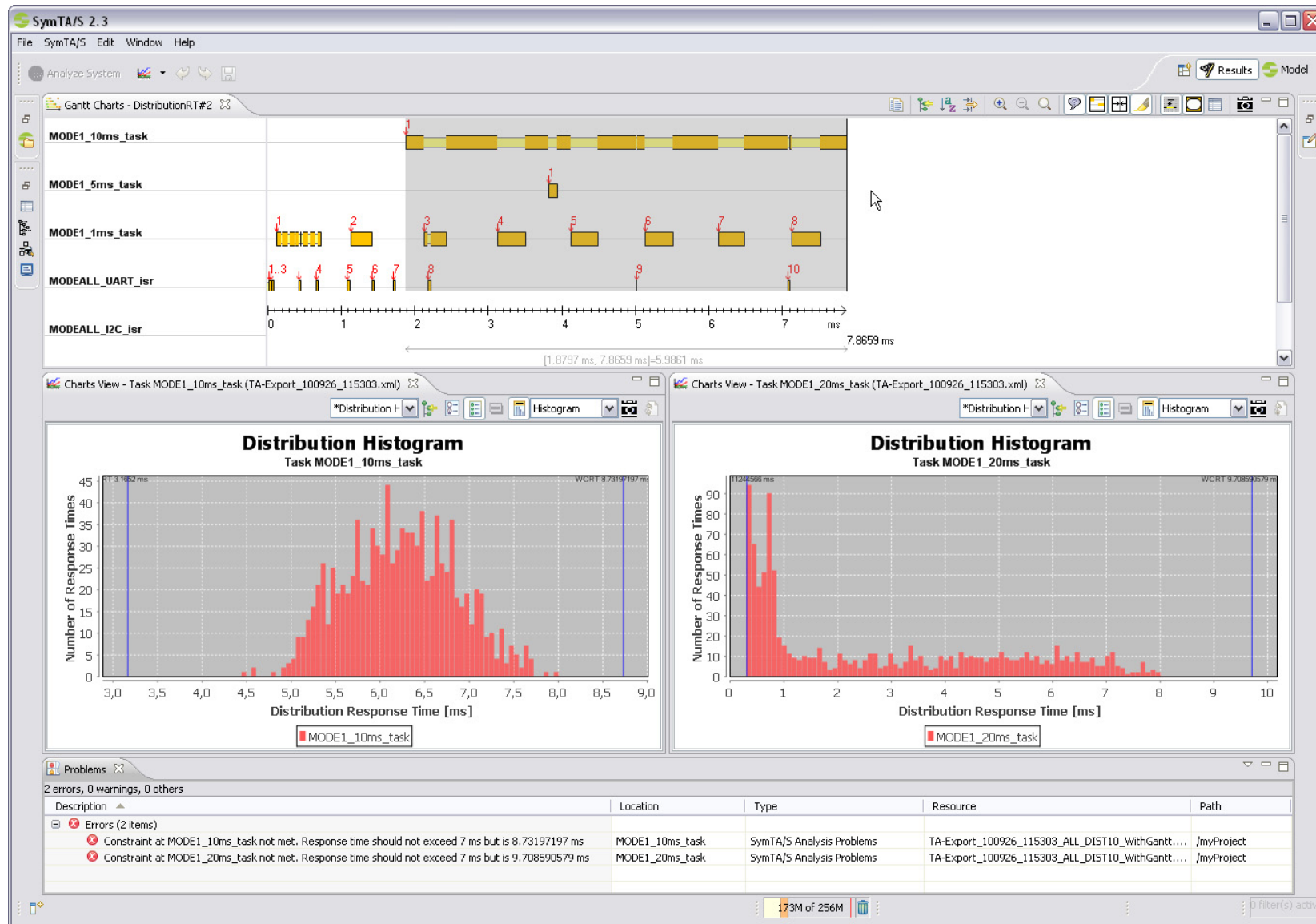
# Scheduling Analysis

$$R_i = C_i + \underbrace{\sum_{j \in \text{hp}(i)} C_j \left\lceil \frac{R_i}{T_j} \right\rceil}_{\text{interference term } I_i}$$

Worst-Case Response Time (WCRT)  $\uparrow$   
 code execution time  $\uparrow$



# Best-Case, Worst-Case and Distribution Analysis



# SymTA/S – Control-Unit Timing Perspective

The screenshot displays the SymTA/S 2.4 beta 3 interface with several key components:

- Project Explorer:** Lists files like 1\_RPM\_500.xml, 10\_RPM\_5000.xml, etc., and system components like SymtaSystem, Clocks, Cores, and Runnables.
- Spreadsheet:** Shows a table of core loads and a line chart comparing 'load Core1' and 'load Core2' across RPM values from 500 to 6000.
- Charts View - Core Core2:** Two pie charts showing load distribution. The top chart (RPM\_3000.xml) shows a total load of 97.88% with RPM\_2 at 36%. The bottom chart (RPM\_2-R2) shows a total load of 107.551% with RPM\_2 at 41.999%.
- Gantt Charts - RPM\_2-R2:** A timing diagram showing the execution of tasks RPM\_1, RPM\_2, OS2\_1ms, OS2\_Tick, INT\_1, and RPM-Tick over a 7ms period.



# SymTA/S – Network Timing Perspective

The screenshot displays the SymTA/S 2.4 software interface with several key components:

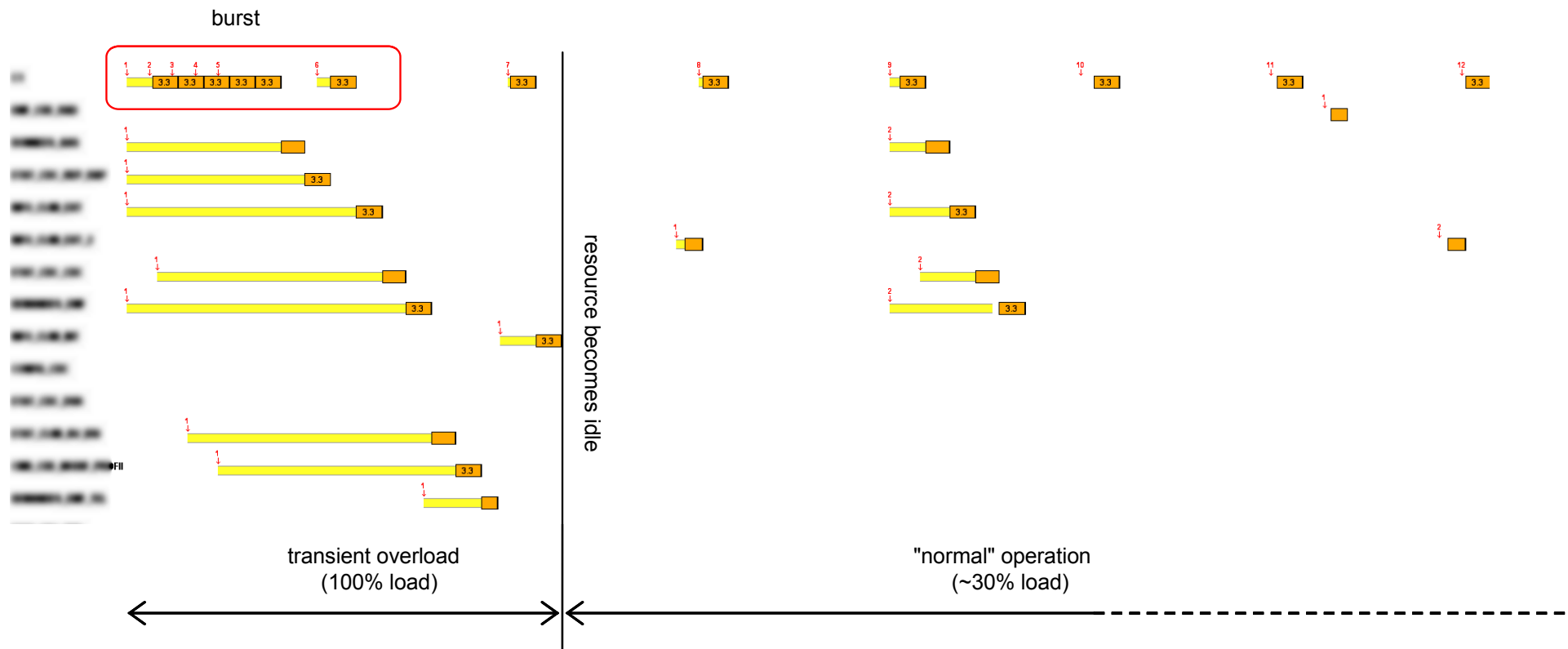
- Hierarchical system structure:** A tree view on the left showing the system hierarchy, including Buses (4), COM Layers (10), Cores (7), and ECU1 through ECU7.
- List of all Paths:** A table showing the following data:
 

| Element | Name     | Parents | Path        | Semantic       | Has Initial Delay | Analyse | Extended Results | Worst Case Analysis | All |
|---------|----------|---------|-------------|----------------|-------------------|---------|------------------|---------------------|-----|
| 1       | Path1    | Path1   | SymtaSystem | MaxAgeSemantic | false             | true    | false            | FullOffset          | All |
| 2       | Path2    | Path2   | SymtaSystem | MaxAgeSemantic | false             | true    | false            | FullOffset          | All |
| 3       | Path3    | Path3   | SymtaSystem | MaxAgeSemantic | false             | true    | false            | FullOffset          | All |
| 4       | Path4    | Path4   | SymtaSystem | MaxAgeSemantic | false             | true    | false            | FullOffset          | All |
| 5       | Path5    | Path5   | SymtaSystem | MaxAgeSemantic | false             | true    | false            | FullOffset          | All |
| 6       | new Path | <empty> |             |                |                   |         |                  | FullOffset          | All |
- List of all Software Components:** A table showing the following data:
 

| Element | Name | Parents |
|---------|------|---------|
| 1       | SWC1 | <empty> |
| 2       | SWC2 | <empty> |
| 3       | SWC3 | <empty> |
| 4       | SWC4 | <empty> |
| 5       | SWC5 | <empty> |
| 6       | SWC6 | <empty> |
- Path Graph - Path2:** A flow diagram showing the signal path from Start through Core1, Core4, Core5, and Core6, involving SWC2, SWC1, SWC4, and SWC6, ending at End.
- System Graph - Symta System:** A network topology diagram showing ECU1 through ECU7 connected via various COM layers (COM1 to COM10) and buses (Bus1 to Bus4).

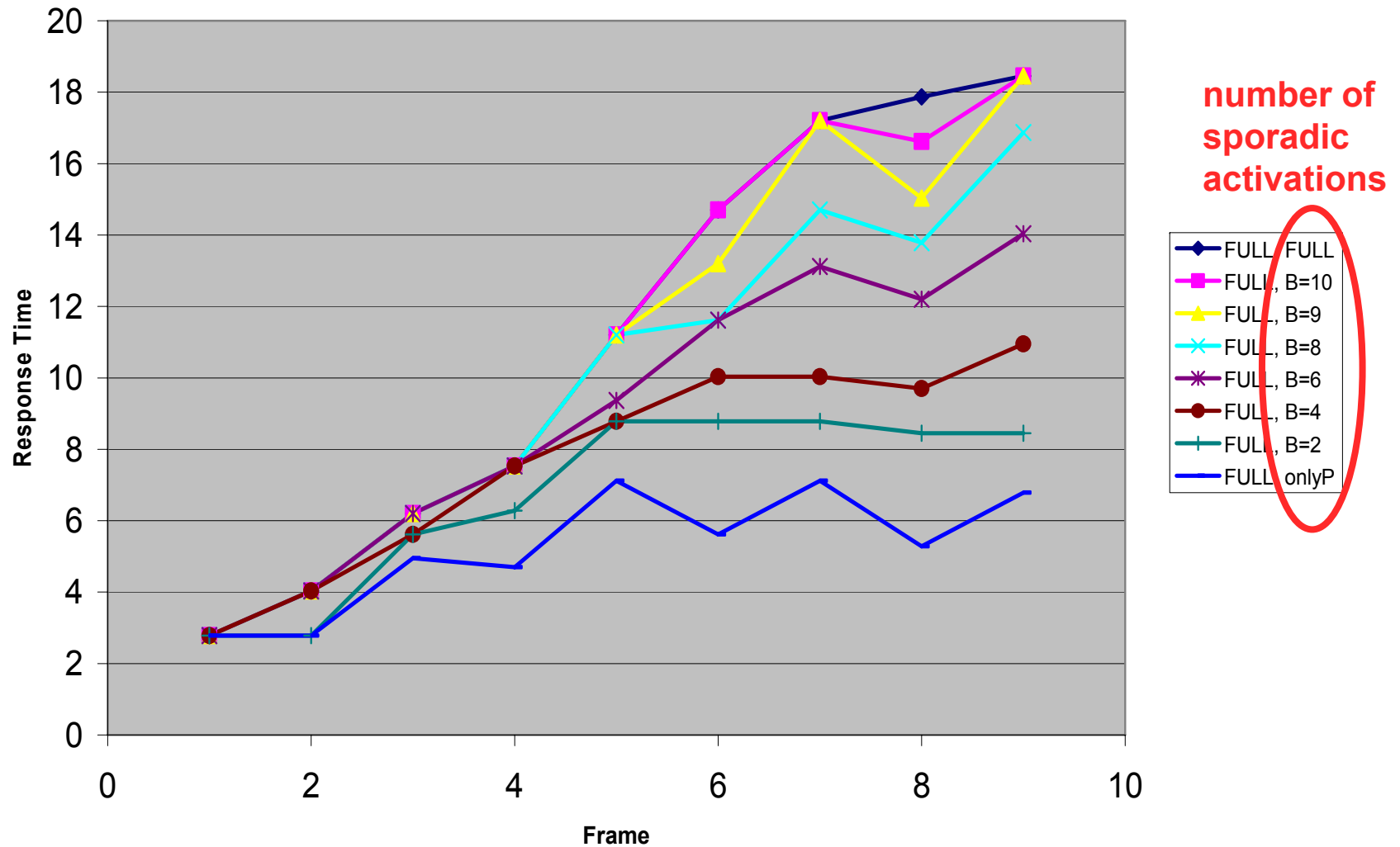
# Example: transient CAN bus load analysis

- ❑ Varying loads must be considered (see below) – in the body domain, most of the load is sporadic!
- ❑ Dynamic interdependencies affect end-to-end timing

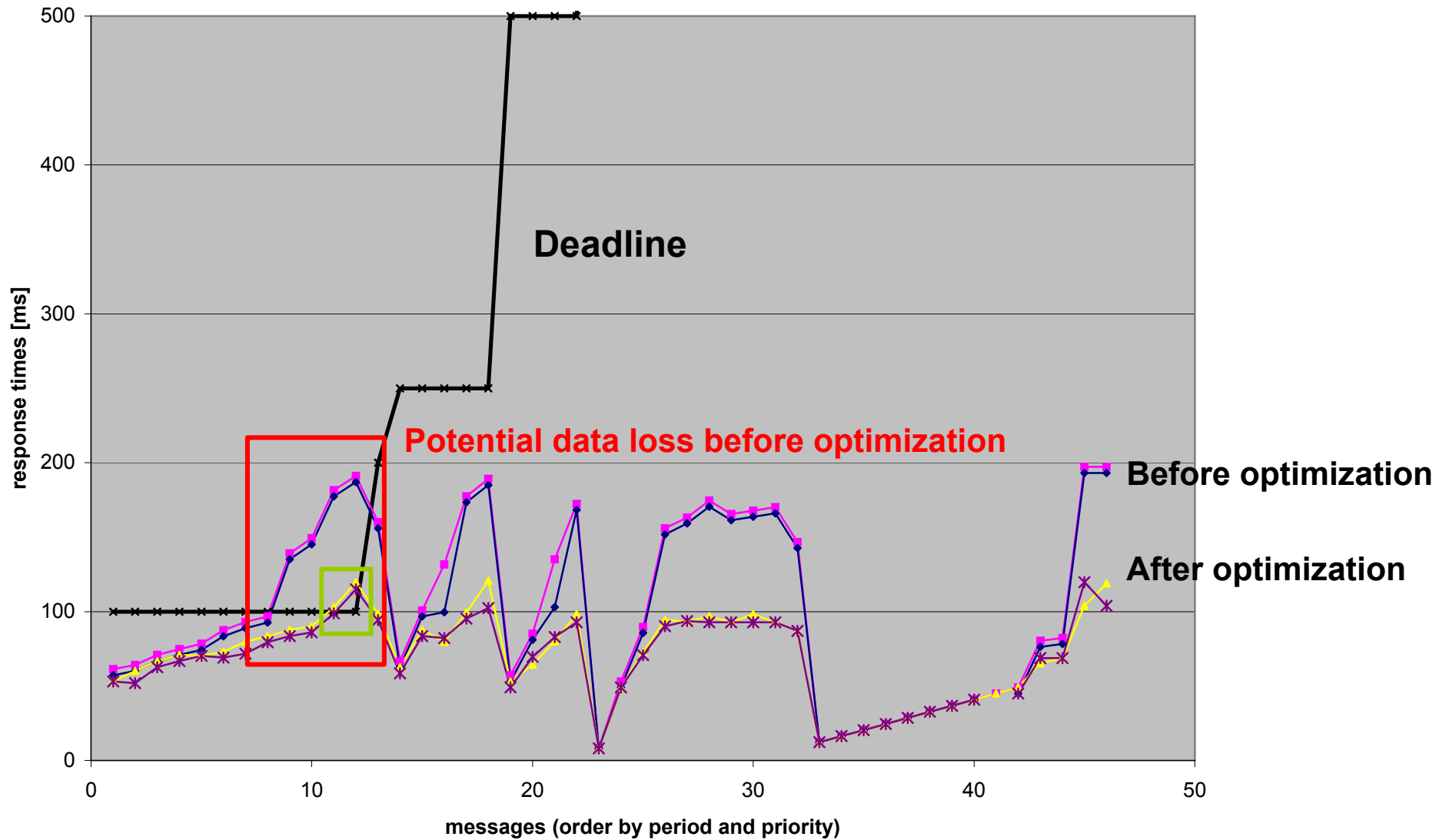


# Response Times at Different Dynamic Loads

## Response Time Profiles



# CAN bus offset optimization



**Thank You!**



**SYMITA VISION**

