The Challenge of Mastering Parallelism in Real-Time Systems

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Storyline

1. Unstoppable Hardware Trends
2. Parallelism –
   A Challenge already Managed
3. Mastering Parallelism in
   Embedded Systems

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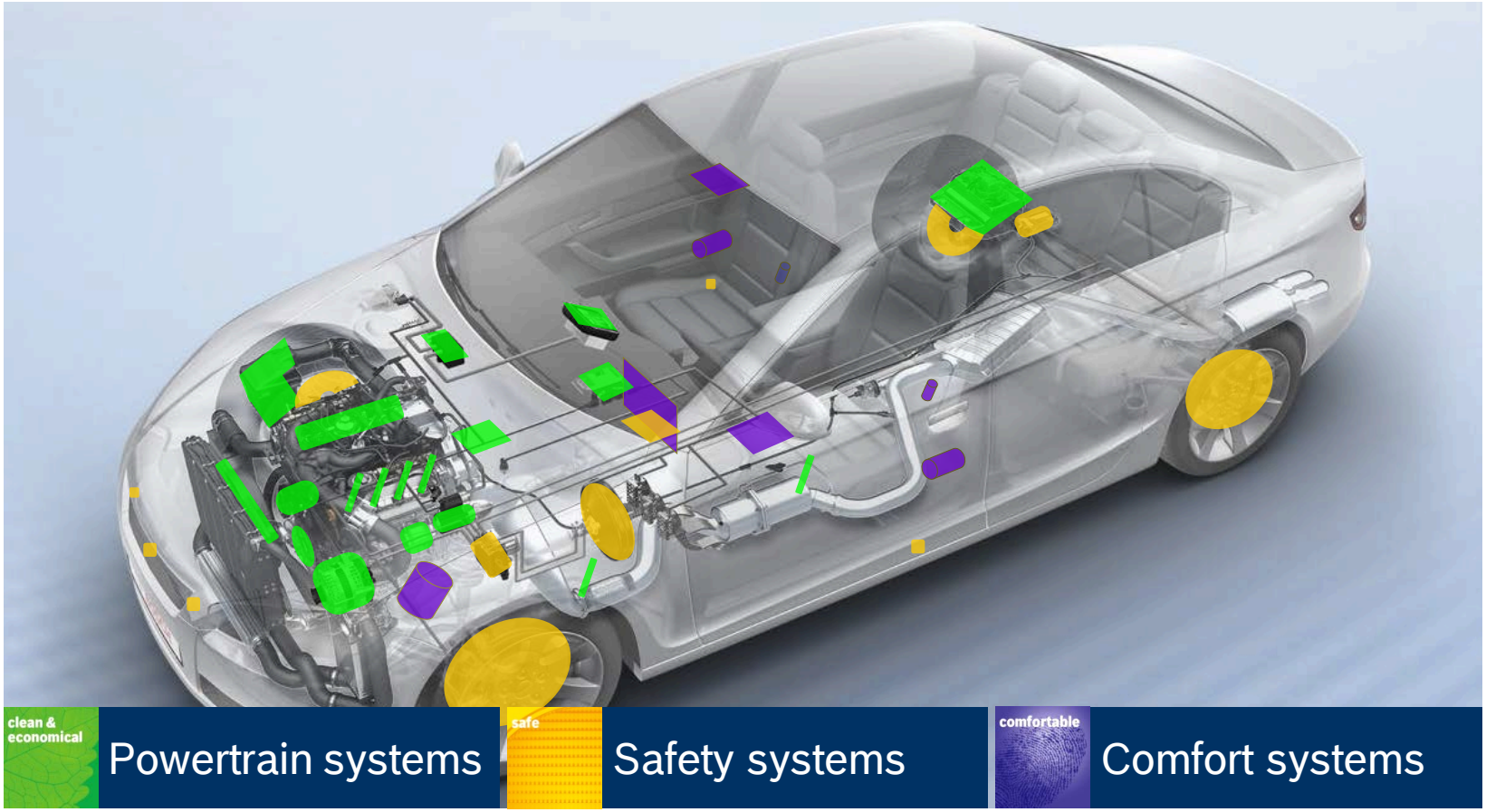
Automotive Technology: an overview



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Engine Control Domain

- Engine Control Unit for Diesel and Gasoline Engines
- **Challenges**: Real-Time computation of several injections for up to 12 cylinders @ 8,000 RPM, reading and processing of up to 50 sensor signals, ...
- **Hardware**: typically 1-2 MB internal flash (optional 2-4 MB external flash), 64-144 kByte internal data-RAM, CAN, TT-CAN, Flexray, up to 48 A/D converters
- **Software**: > 500,000 LOC,
  > 1,000 components,
  > 2000 variant points

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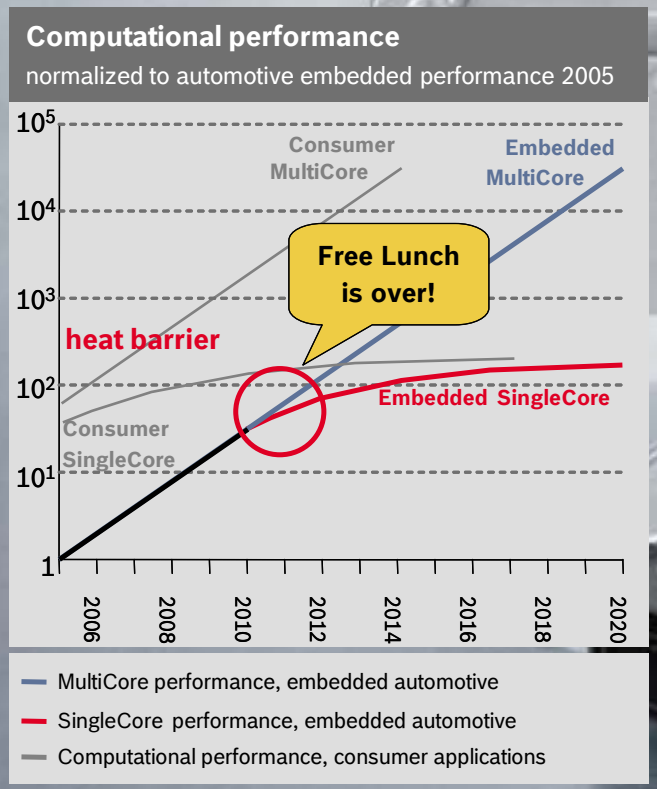
Drivers for parallelism in embedded Micro-Controllers



The Limits

Serial computing in embedded systems is hitting technological limits

- Power wall
- ILP wall (Instruction Level Parallelism)
- Memory bandwidth wall

The Future

- Multi-Core µCs are already present in automotive embedded systems
- Higher performance only via Many-Core µCs and Multi-Processor architectures

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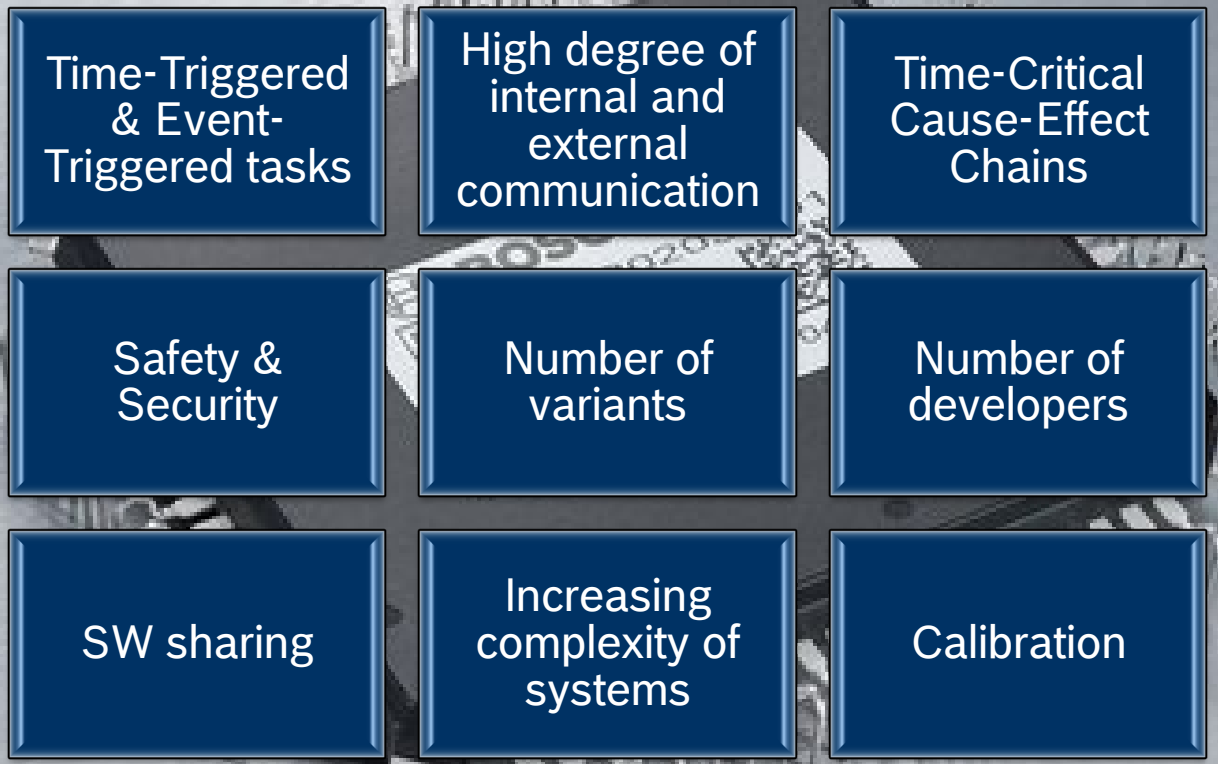
Generic View: The System Setup



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Parallelism – A Challenge Already Mastered

- The usual statement when it comes to parallelism

“People can work only sequentially, at least when considering complex tasks”

- That is true!

“Nevertheless, we are experiencing parallelism in our daily lives!”

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Parallelism in Our Daily Lives

- Traffic
- Orchestras
- Team Sports
- Production Lines
- Fire Fighters
- Project Work
- … and many more!

… and we have intuitively learned to manage parallelism!

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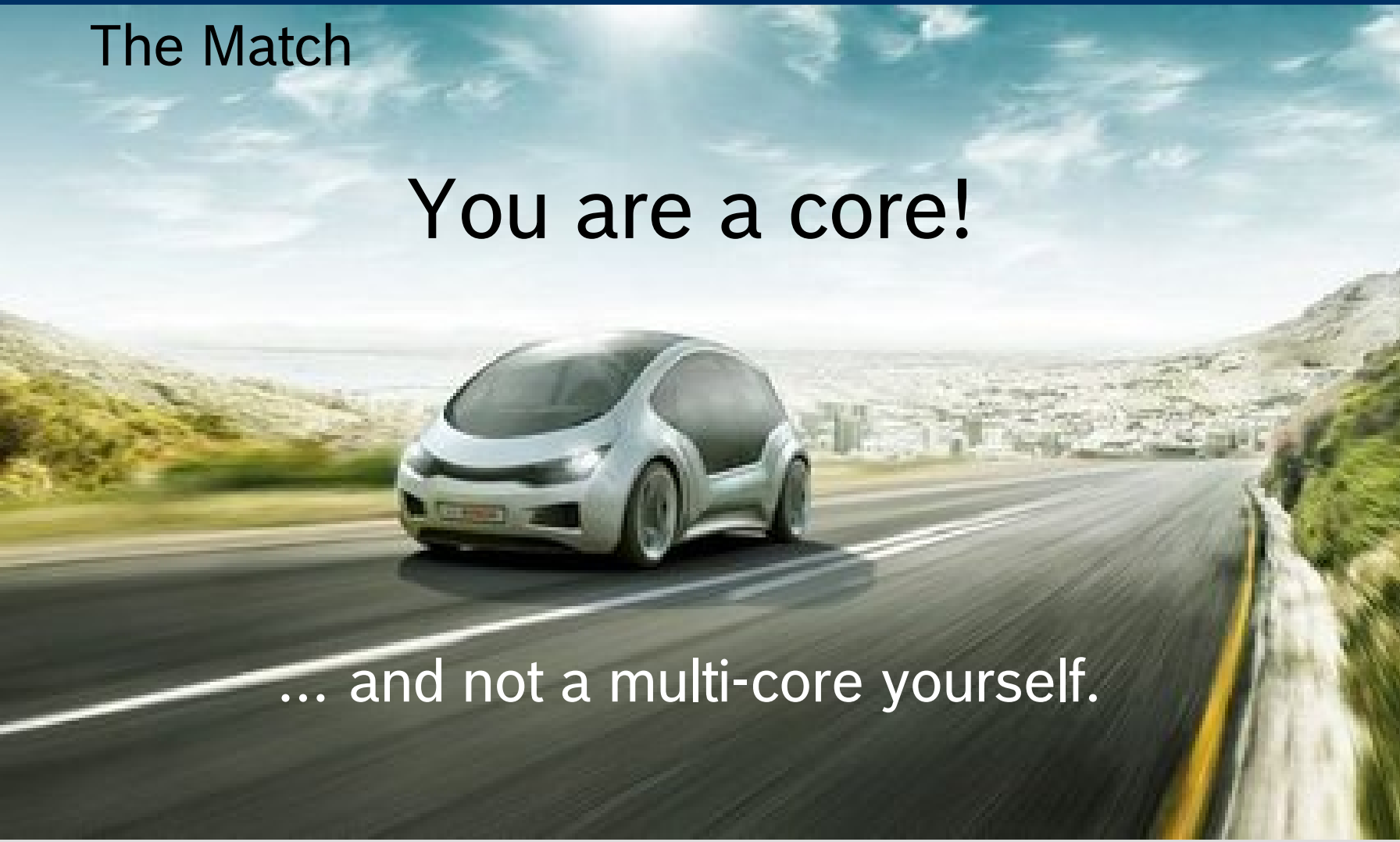
The Match



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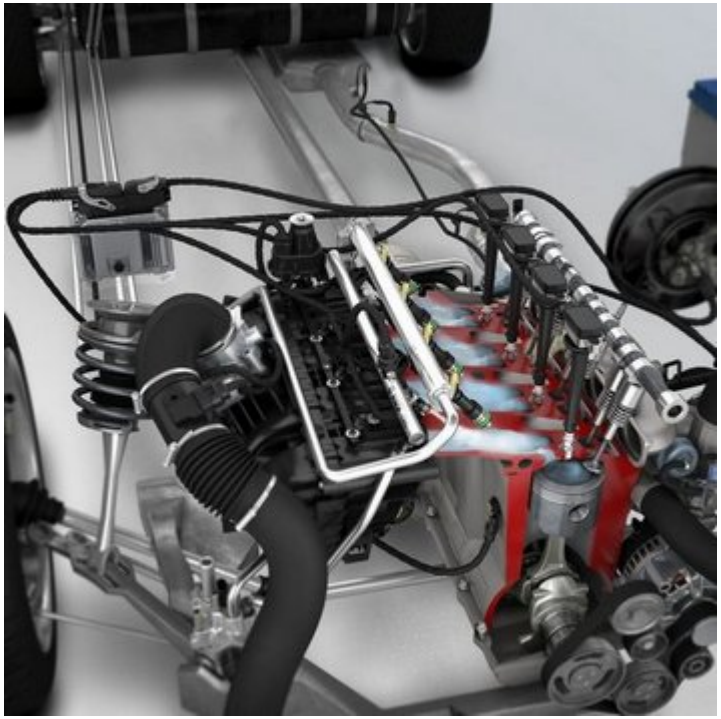
An Example: Engine Control

- Inherent Parallelism from Physics
  - Air System
  - Turbo system
  - Injection system
  - Exhaust system
  - Idle controller
  - Diagnosis
  - Monitoring
  - ...
- Today these systems are intertwined into sequential execution tasks
- Difference to real-life projects
  - Execution can be rehashed and rehashed and ....



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Parallel Environment

Injection System | Vehicle dynamics | Air System | . . . | Diagnostics

Sequential

Today

Parallel Design

Necessary Paradigm Shift

Parallel

Vehicle Dynamics

Injection System

Air System

Diagnostics

Future

Source: Bosch Mediaspace

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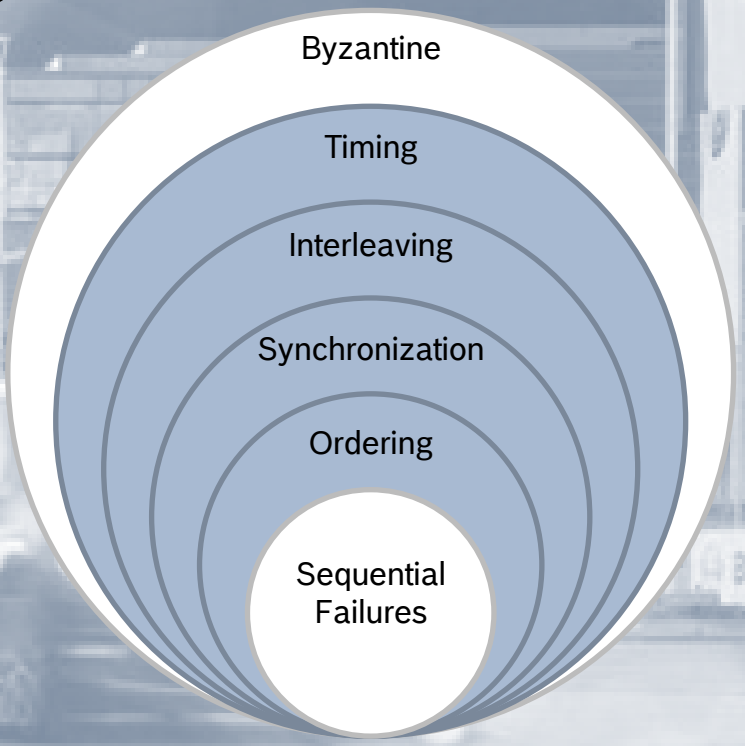
The Different Failure Modes

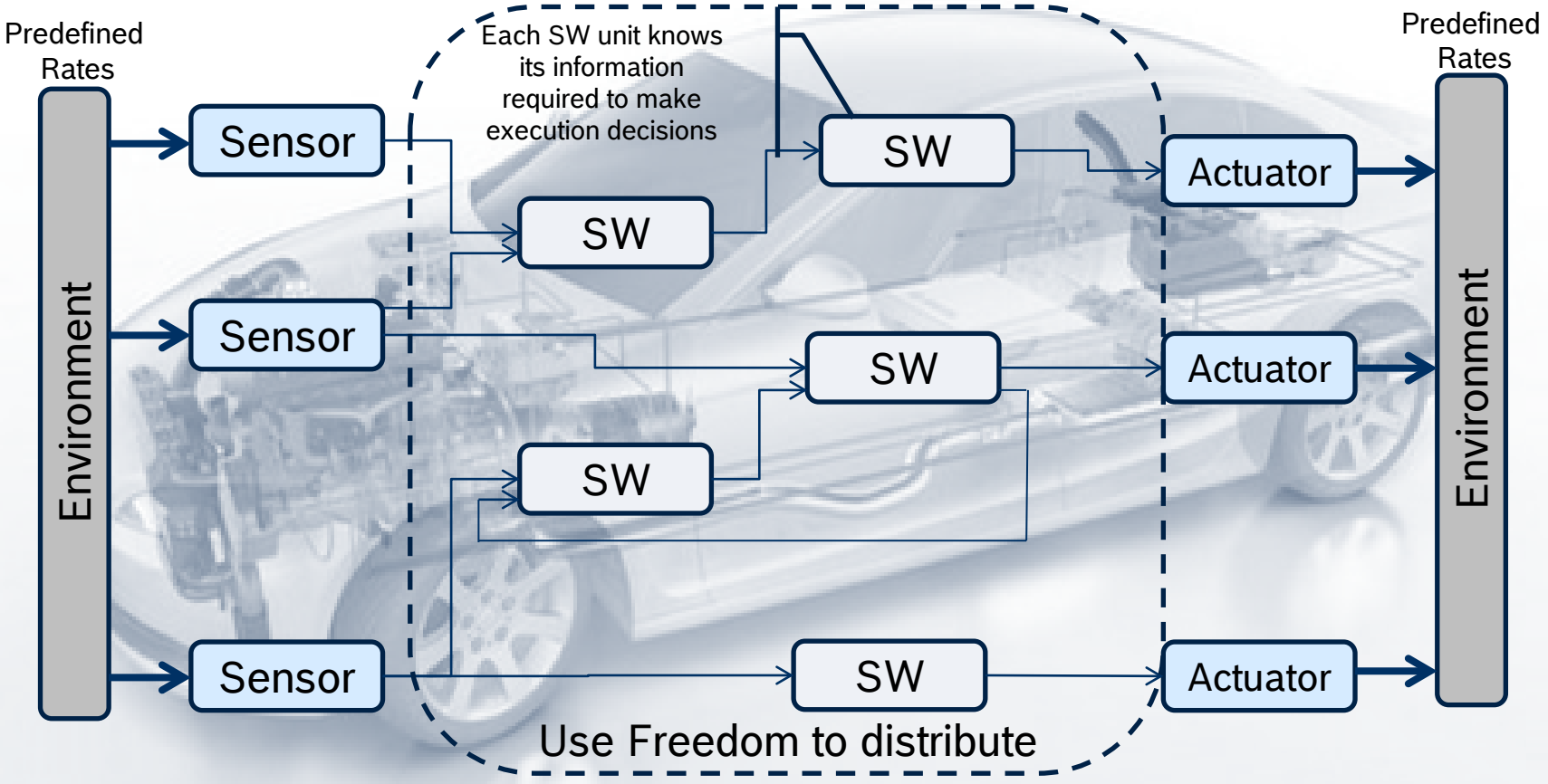
- Sequential failure modes
  - Remain same for parallel systems
  - Established methods are sufficient
- Concurrency-related failure modes
  - Are present in preemptive systems already
  - Probabilities change in parallelized systems
  - Intrusive debugging mechanisms change real-time behaviors
  - Debugging of several cores extremely difficult



The failure modes

From: Henrik Thane, Monitoring, Testing and Debugging of Distributed Real-Time Systems, Doctoral Thesis
Mechatronics Laboratory, Department of Machine Design Royal Institute of Technology, KTH S-100 44 Stockholm, Sweden

Correct System Execution for any Distribution



Paradigm: Independent of the chosen distribution, the system should behave the same way

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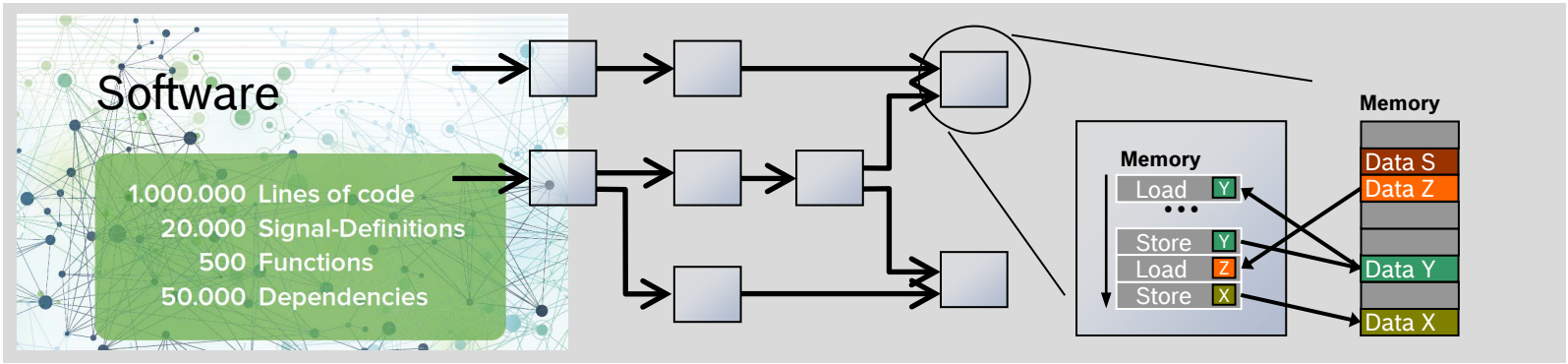
The Challenges of Parallelism



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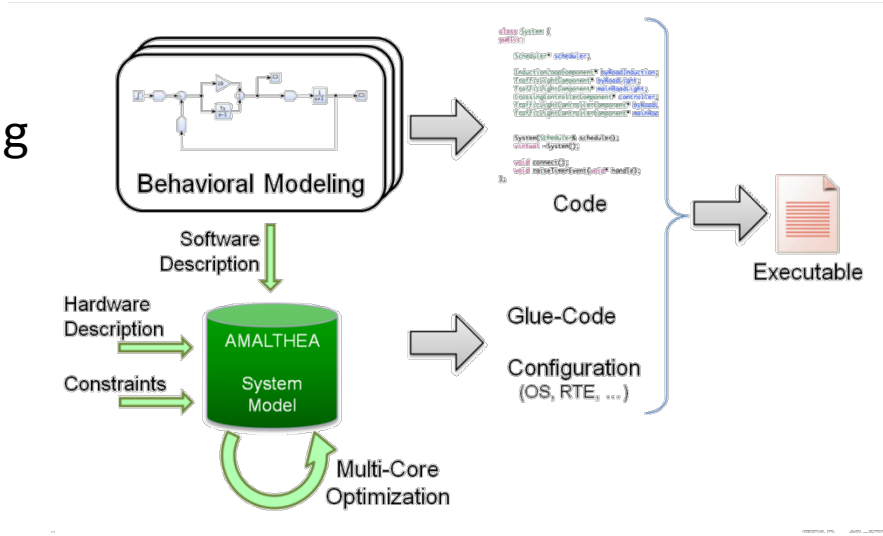
Publicly funded Project: Amalthea

Project Goals

- Efficient Multi-Core development
  - Methodological framework
  - High quality parallel processing
- AUTOSAR compatibility
- Support for product line engineering
- Continuous tool chain platform
  - Open source
  - Eclipse based
  - Open for third party products



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Summary

- Change in System set-up
  - Formerly: Compile and Test
  - Future: Plan and Compile

- Will have high effects on
  - Developers
  - Tools and tool chains
  - Standards
  - Collaborations

- Bosch as automotive TIER1 works in collaborations with industrial partners and universities on necessary technological steps!

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Thank you for your attention.

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