COMMUNICATION CENTRIC DESIGN FOR COMPOSABILITY & DATA CONSISTENCY IN AUTOMOTIVE EMBEDDED SYSTEMS

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Communication Centric Design
Agenda

- Legacy: Automotive Embedded Systems
- Future execution platforms
- Challenges combining both worlds
- Conclusions

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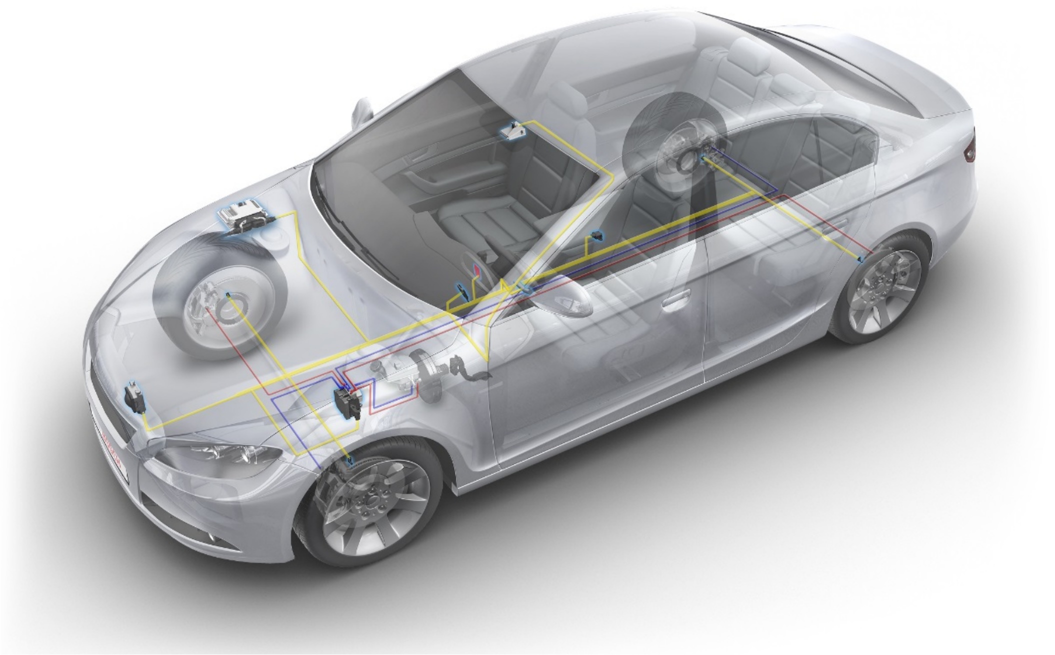
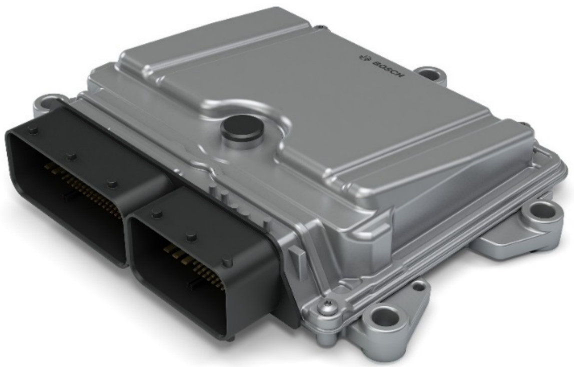
Legacy: Automotive Embedded Systems





In a modern car there are about 100 different ECUs interconnected over several busses and networks.

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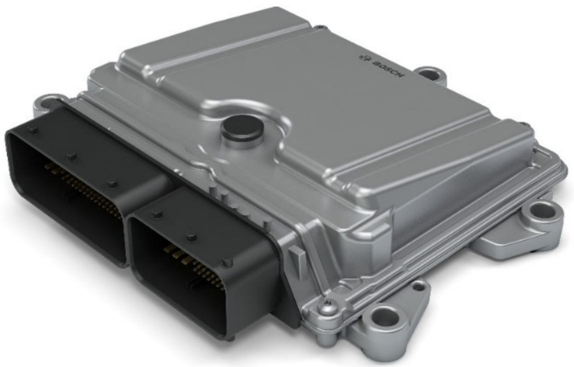
Legacy: Automotive Embedded Systems

Example – Engine Control

- Infineon AURIX
  - Up to 3 Cores
- Periodic & Angle-Synchronous Tasks
- Scheduled with Fixed Priority Preemptive Scheduling
- on an OSEK compliant Operating System



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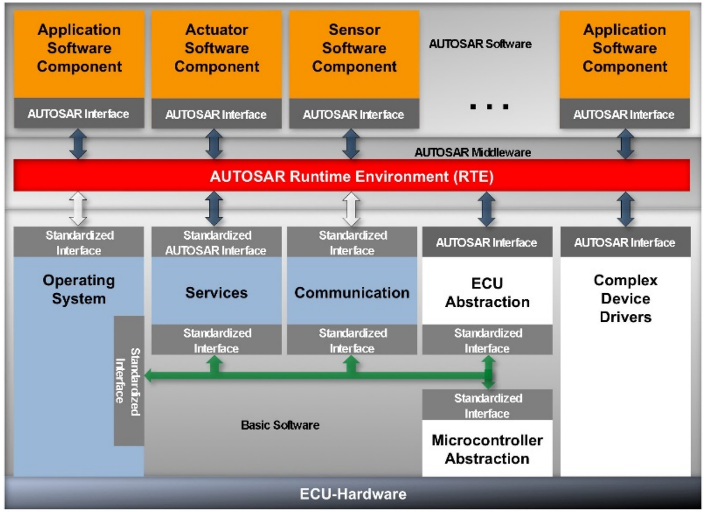
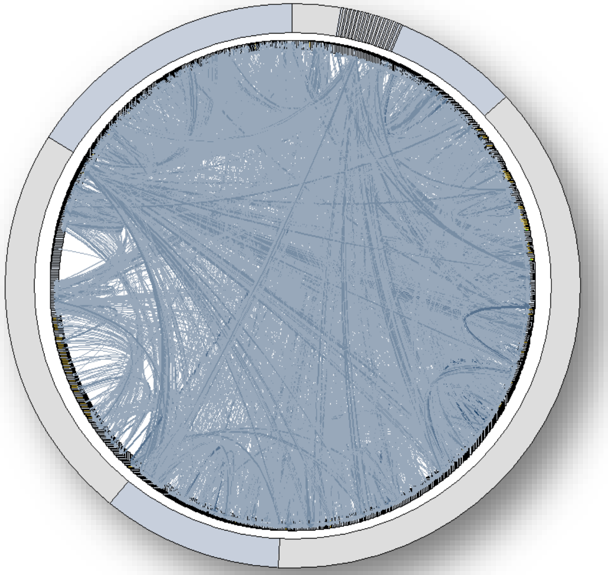
Software View



AUTOSAR – Layered Architecture



Runnable Communication Graph

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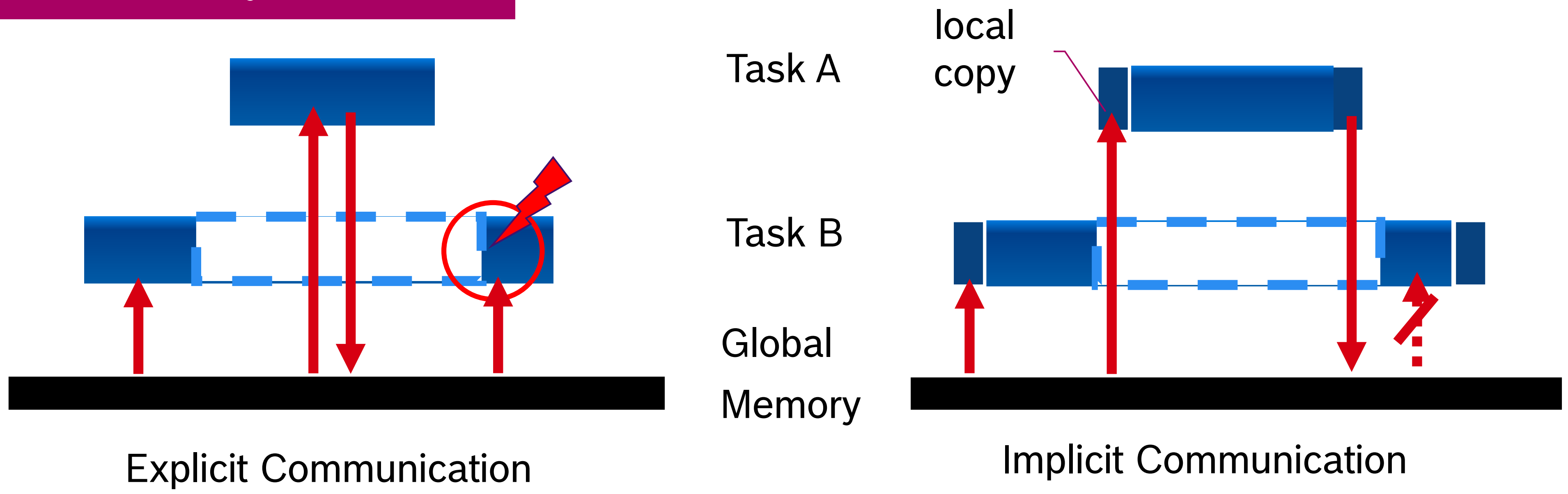
Data consistency mechanisms



To avoid data inconsistencies during execution, efficient mechanisms have to be introduced

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- Intelligent mobility systems of the future
- **Future execution platforms**
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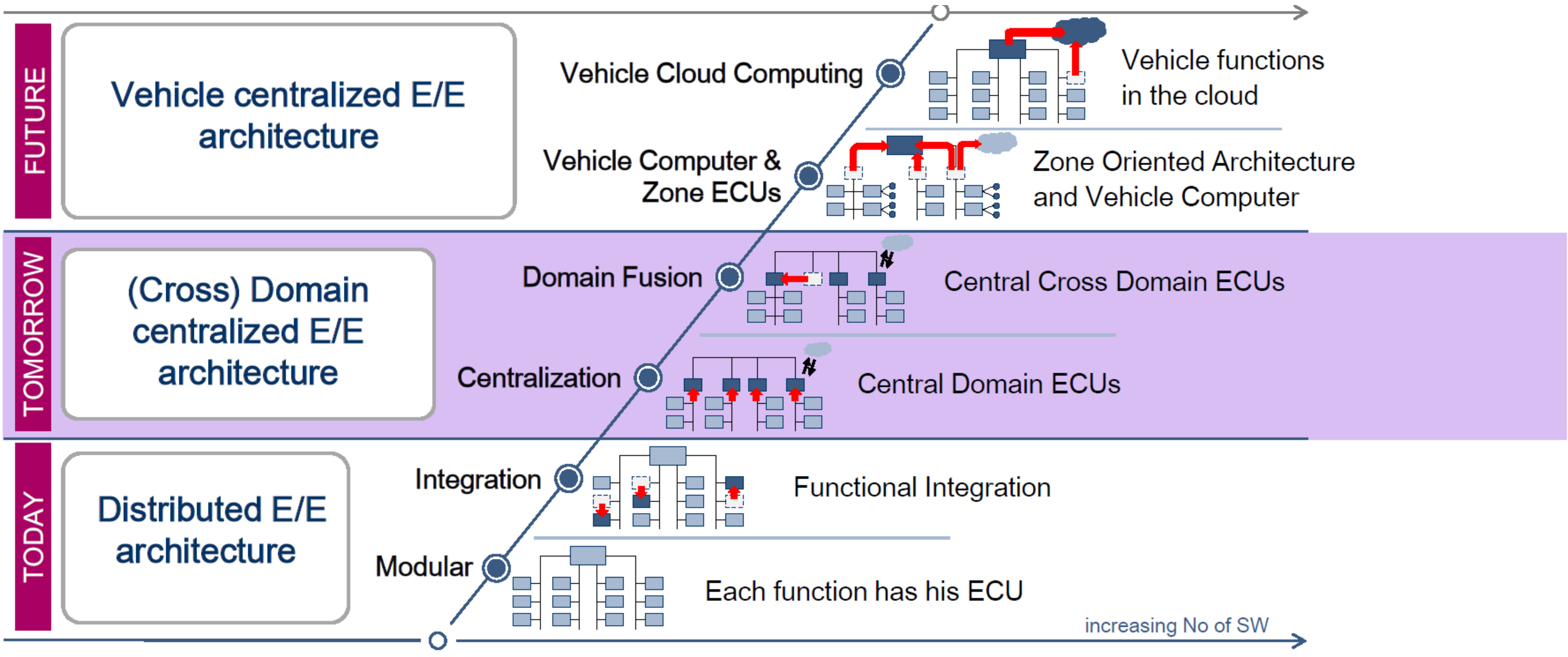
Future E/E-Architectures



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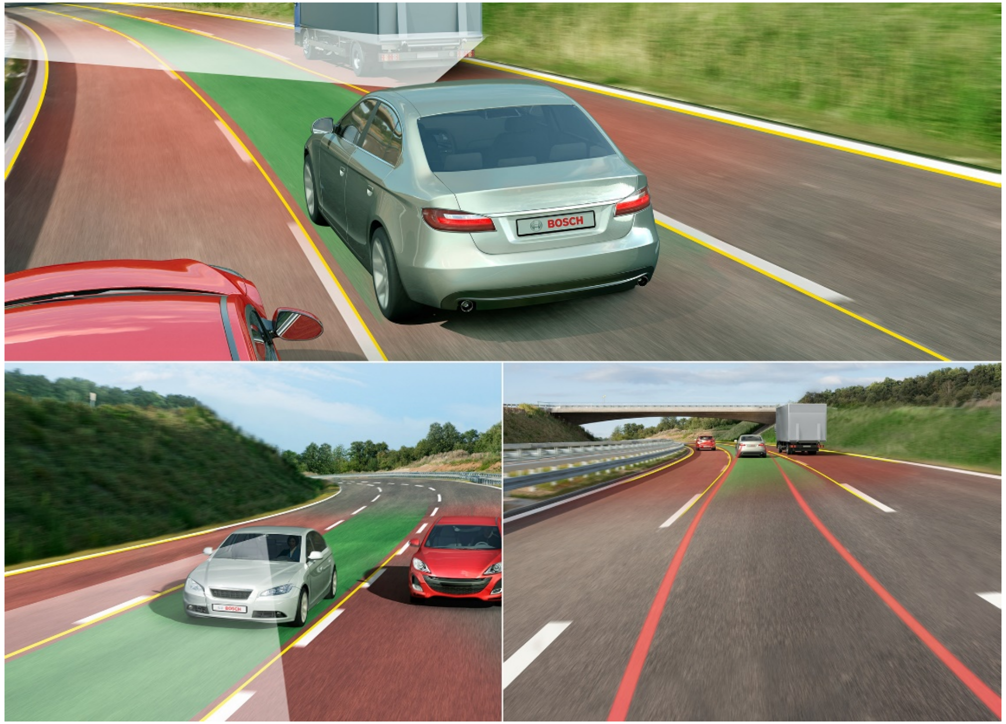
Future execution platforms

Hardware availability:

- Increasing autonomy requires fail operational or at least fail degraded systems
- It can no longer be assumed that the driver can maintain controllability of the vehicle in the case of loss of function
  - E.g. In case of failure, braking system needs to be able to warn driver/occupant and ensure a safe stop
- Detecting errors and resetting/turning off system is no longer a plausible safety concept

➔ Demand for demonstrating the absolute failure rates of hardware will increase



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Future execution platforms

Software Reliability:

- Systematic faults covered by development process
- For consolidation of functions onto one common ECU, Freedom from Interference has to be shown
  - Spatial Isolation
  - Temporal Isolation
- Hypervisors are used for isolation
  - Spatial Isolation ✓
  - Temporal Isolation ✗

➔ Current Hypervisors are not sufficient to guarantee temporal isolation ***efficiently***

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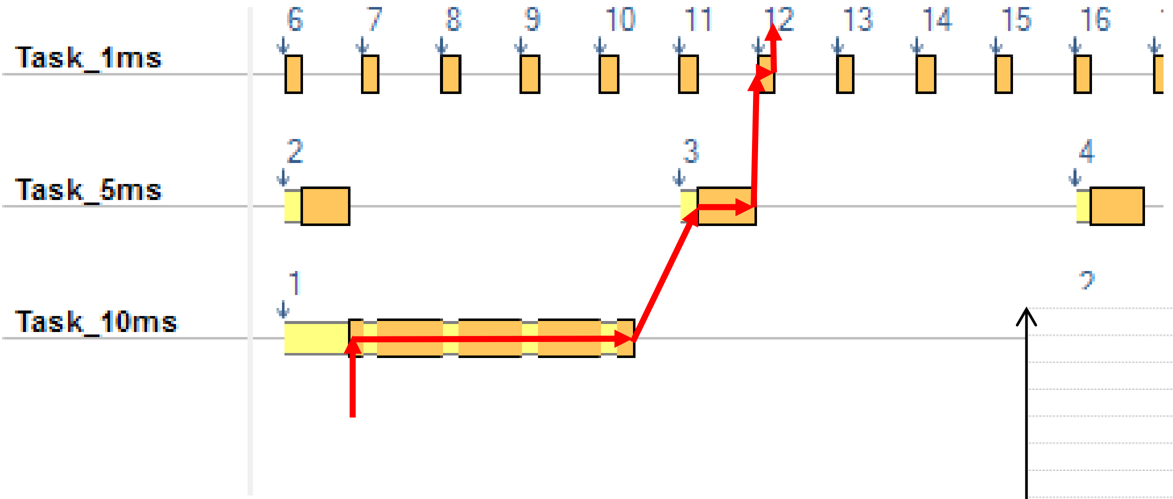
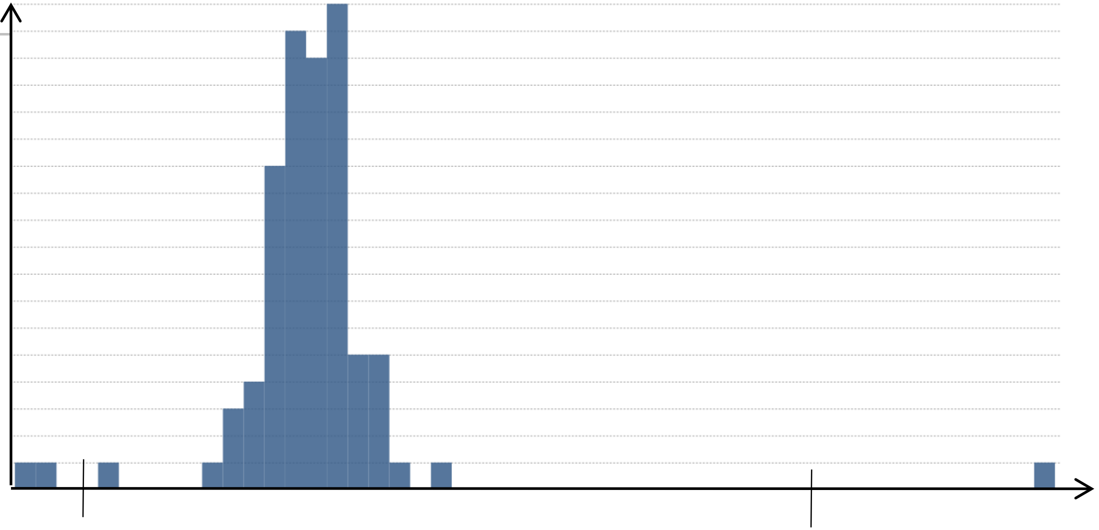
Consolidation of ECUs – Single Application





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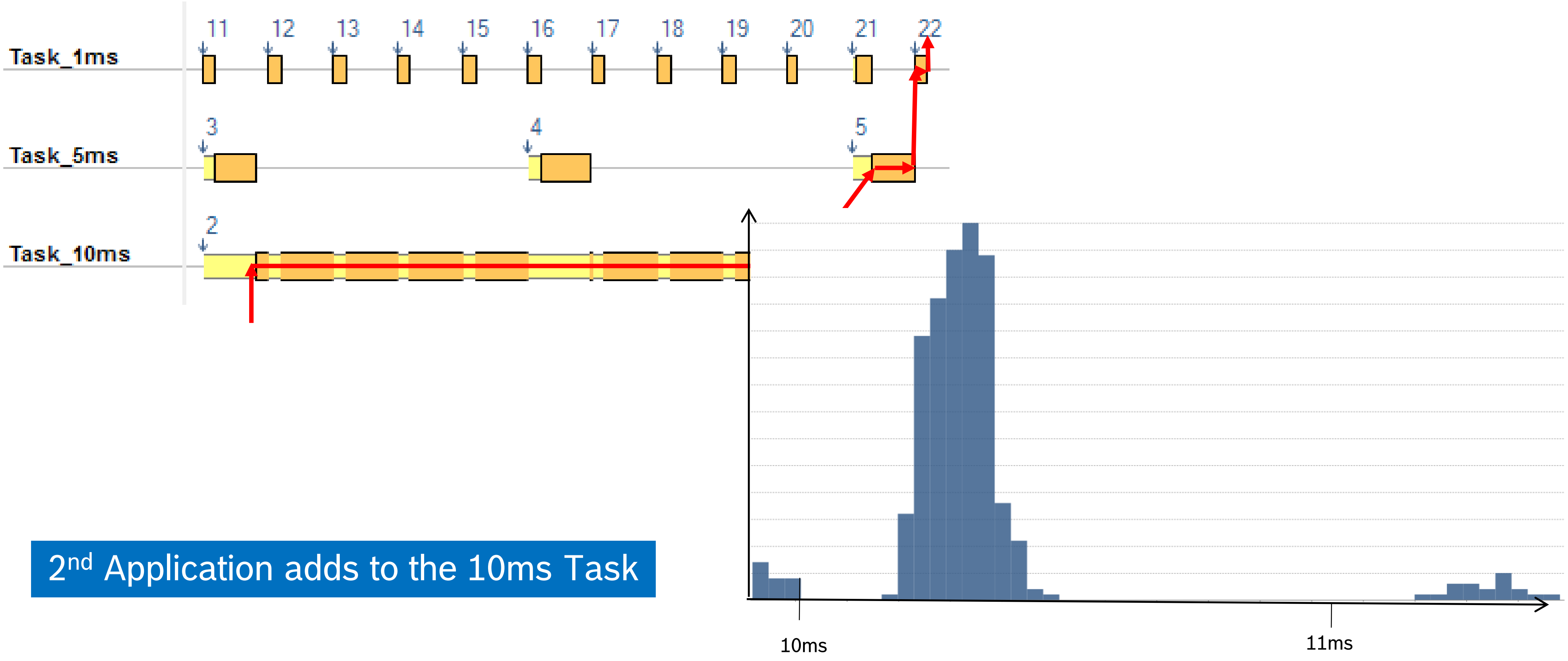
Consolidation of ECUs – Two Applications



2nd Application adds to the 10ms Task

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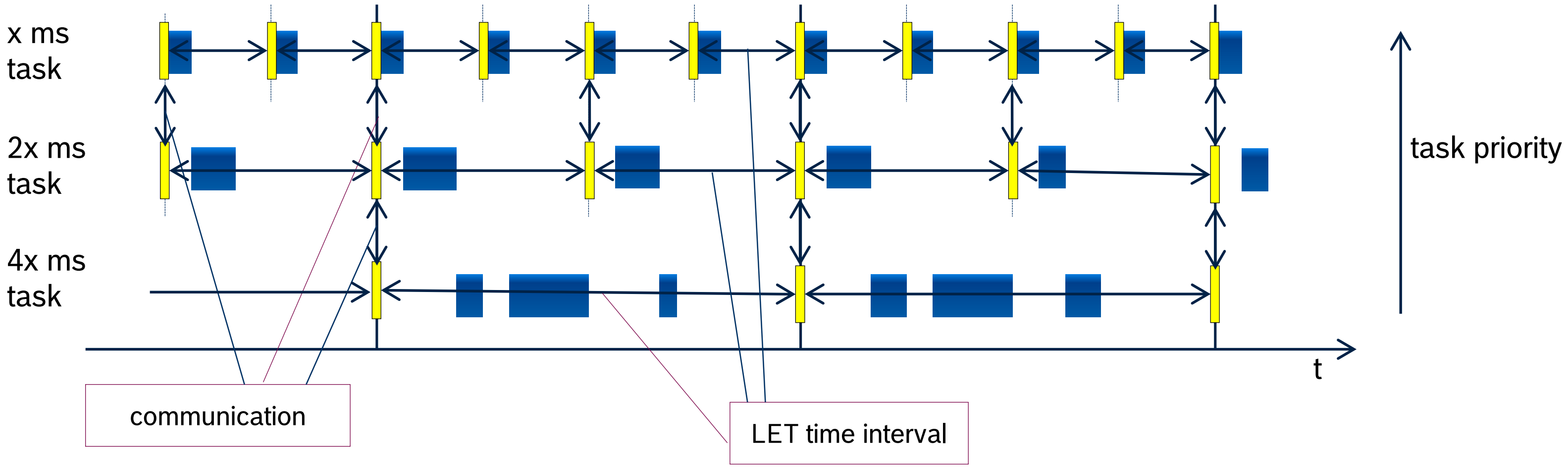
Timed Communication – Theory

- Tasks behave according to a Logical Execution Time (LET)
  - Inputs are (logically) read at beginning of time interval
  - Outputs are (logically) written at end of time interval
  - Independent of when task actually runs within interval



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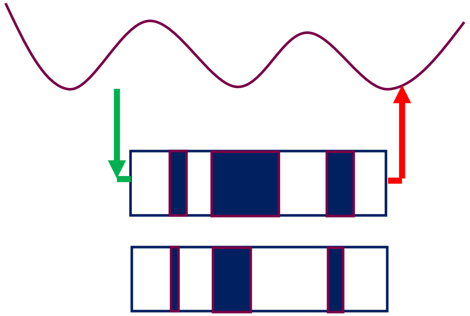
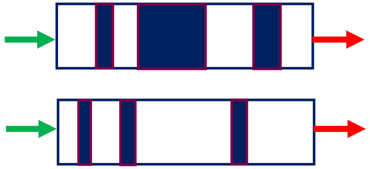
Portability, Integratability, Interoperability

Replaceability / Portability



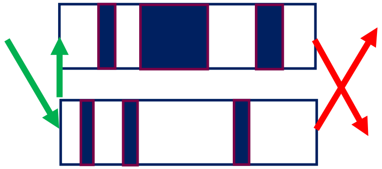
Same behavior at different CPU speed

Integratability/ Extensibility



Integration without side effects

Interoperability



Verifiability by deterministic communication

© Tom Henzinger et al., IST Austria

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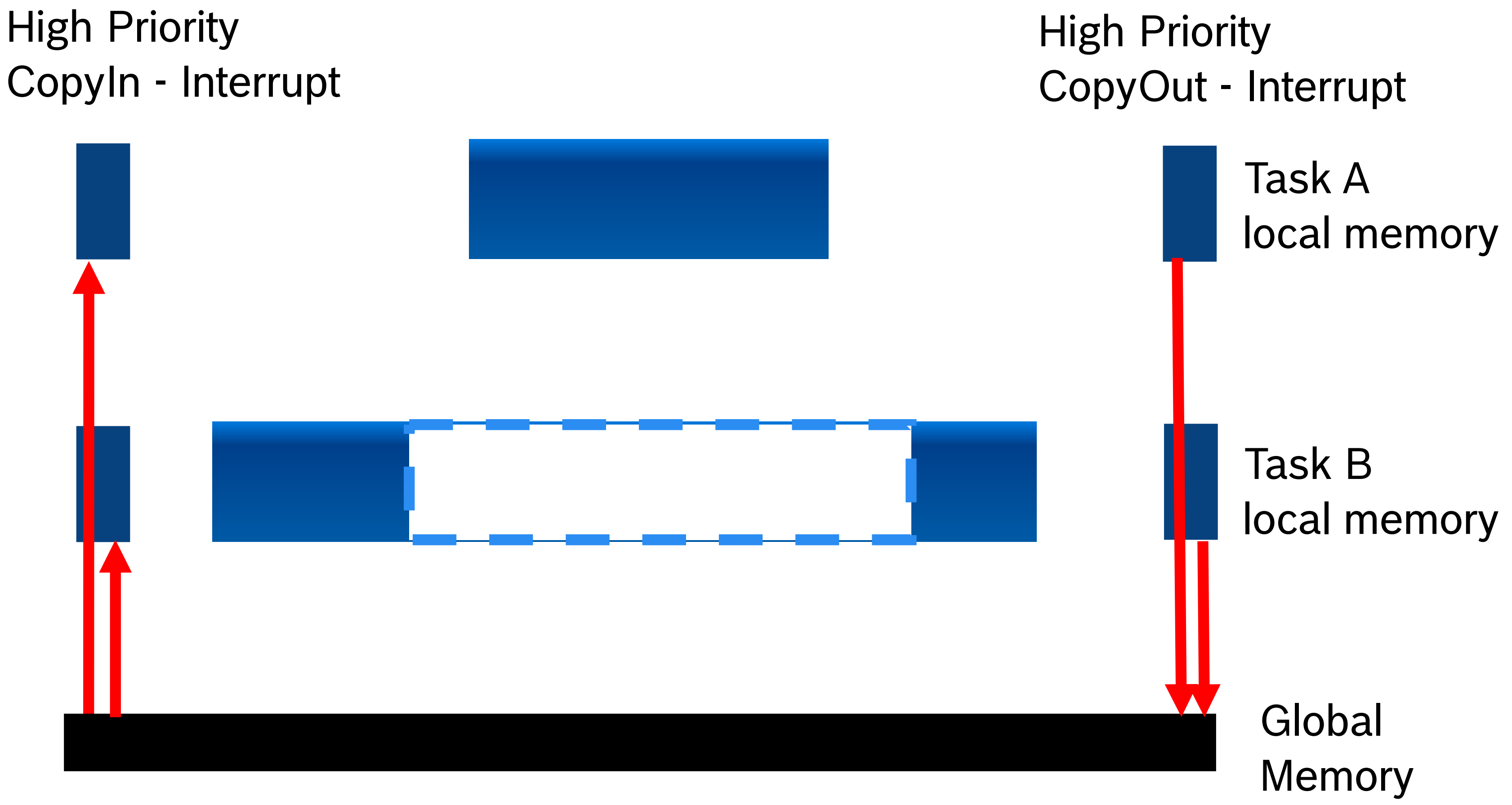
Timed Communication - Implementation



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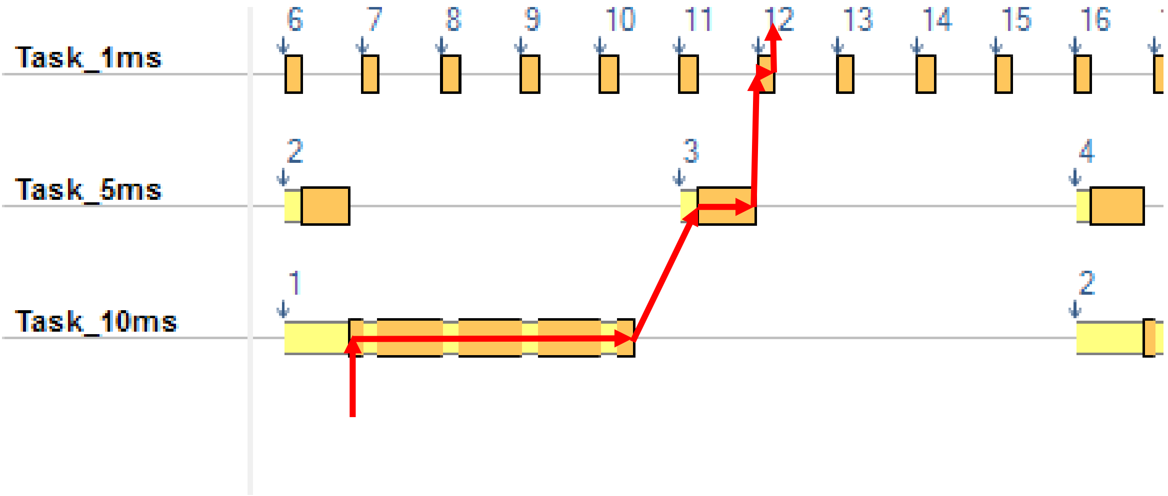
Transformation



The following experiments were conducted with SymTA/S. Details on how the transformation of existing applications to logical execution time for analysis can be done, will be presented at **ECRTS ’17**.

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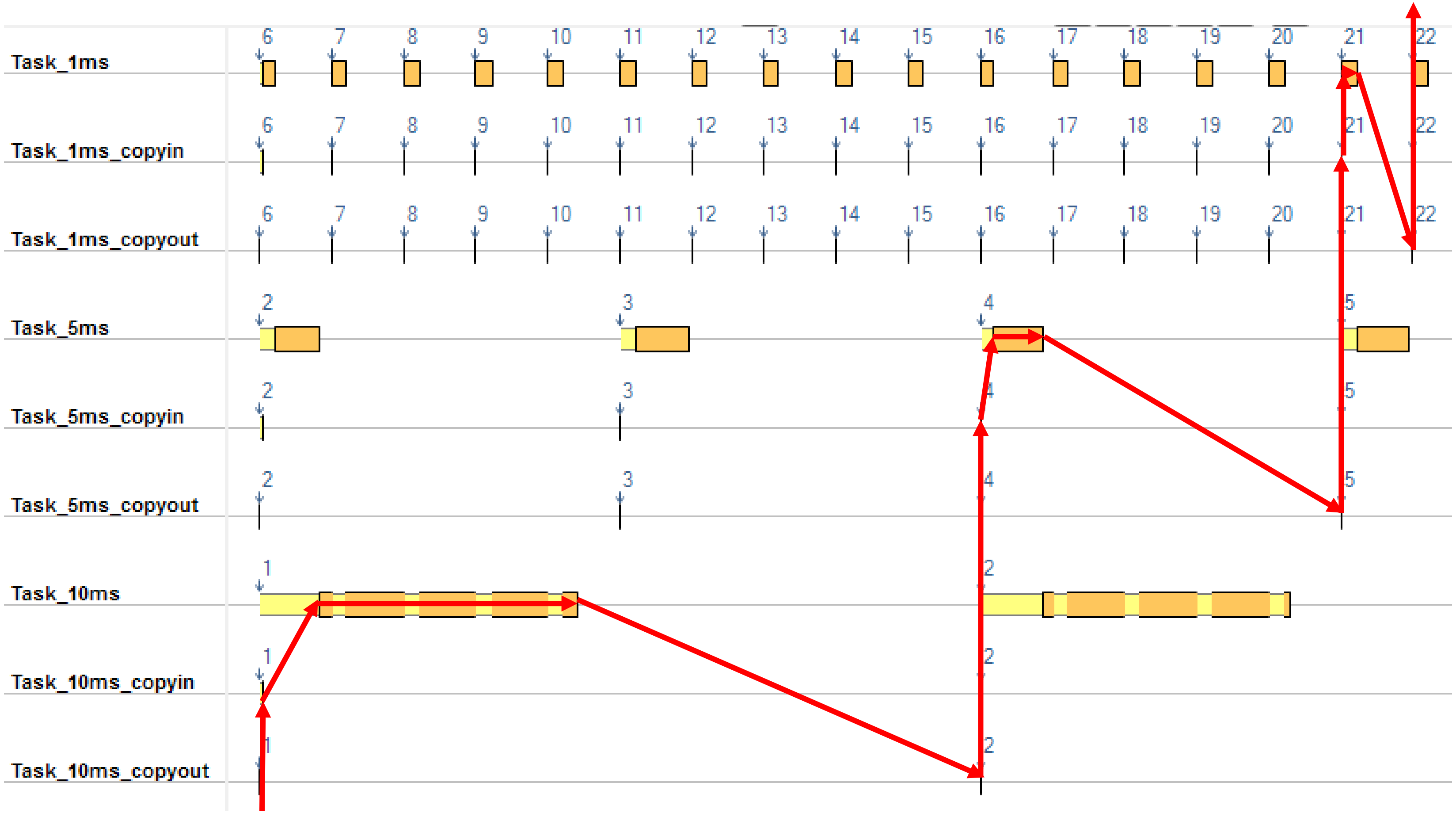
Transformation



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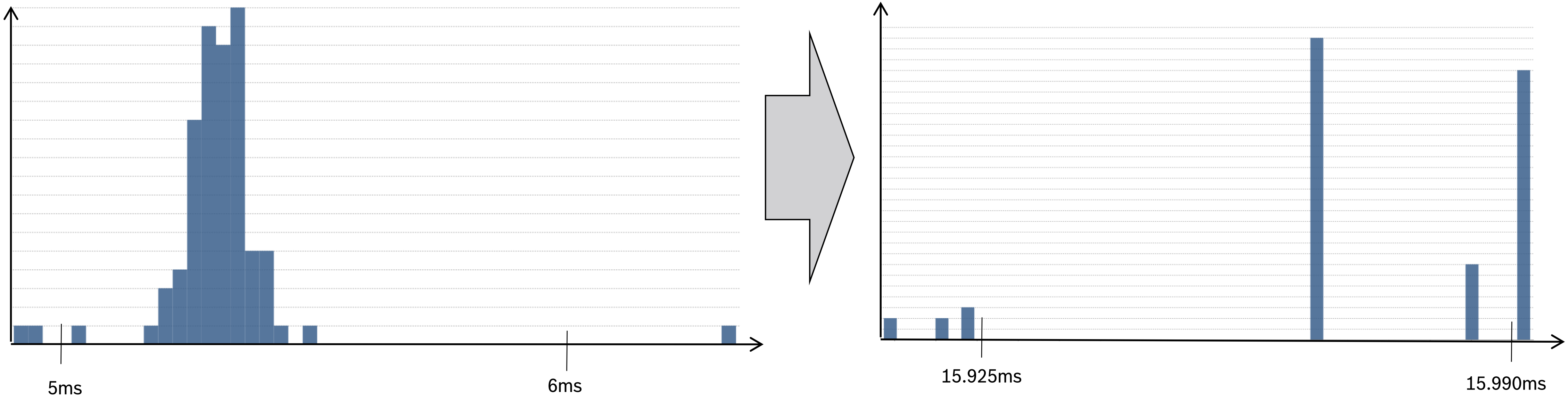
Logical Execution Time – Single Application



With LET-Semantics, the latency of the given communication path increases

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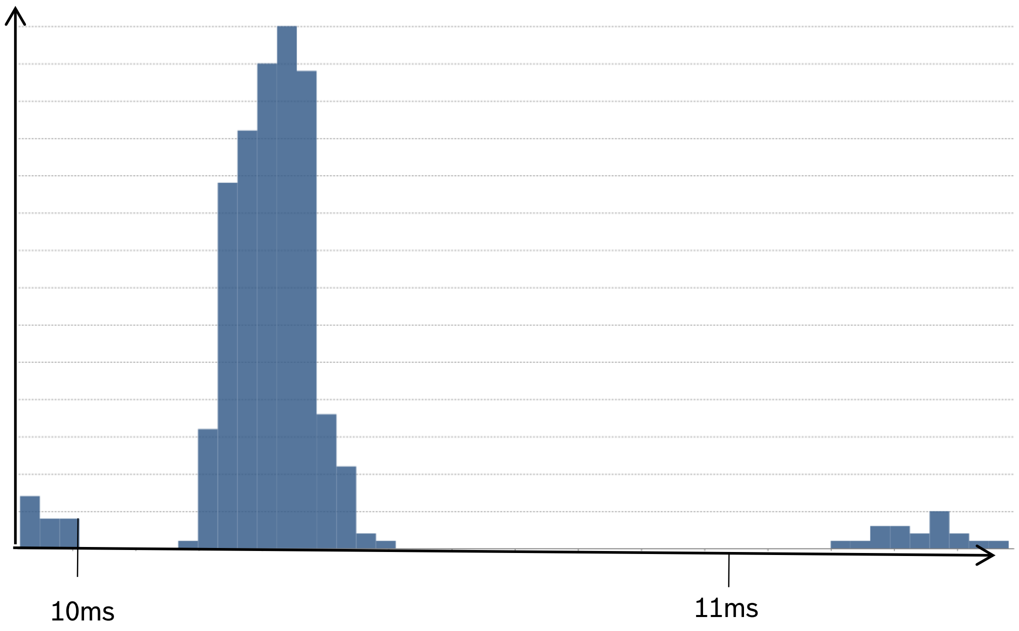
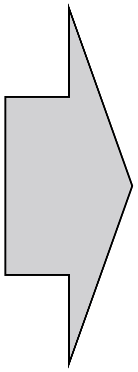
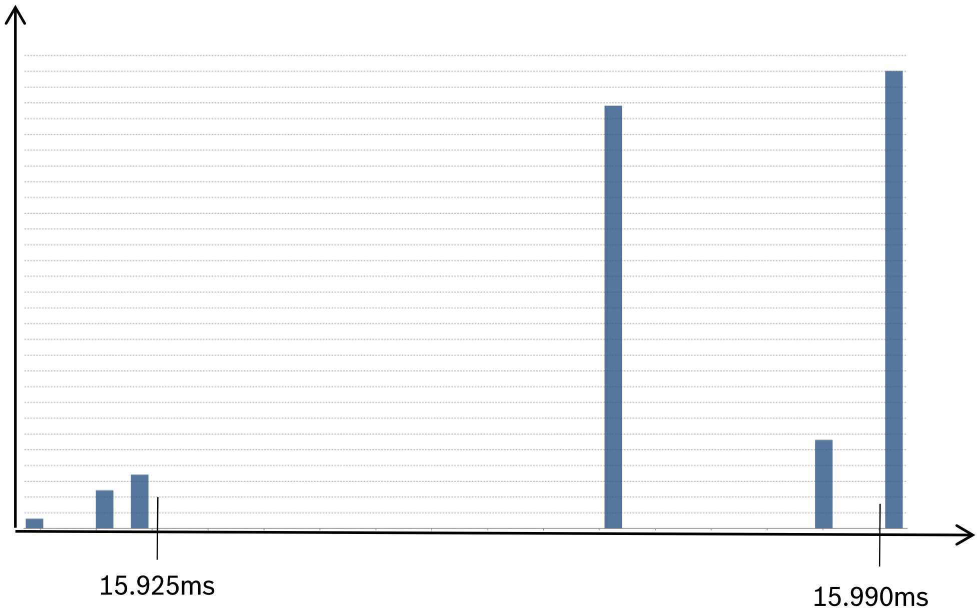
Logical Execution Time – Two Applications







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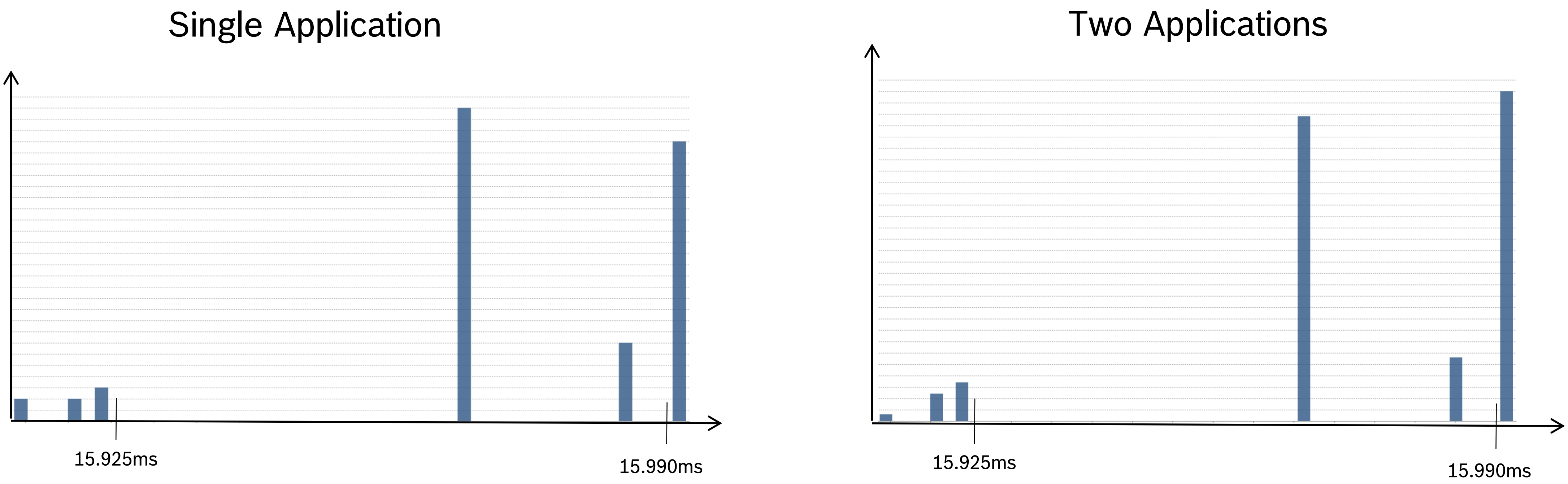
Logical Execution Time - Composability



Latency is (almost) constant during addition of new applications or functions

This also holds when moving a task to another core of when migrating to new hardware

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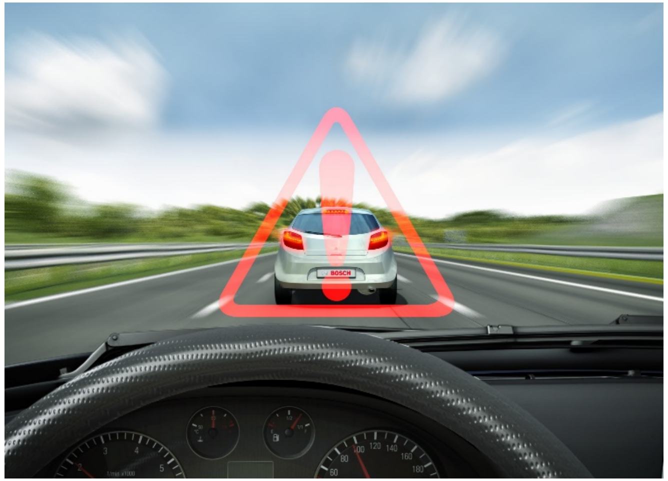

Future E/E-Architectures, will consist of centralized control units handling cross-domain functions. For safe integration, enhanced mechanisms are needed that ensure freedom from interference.

For spatial separation Hypervisors are used to guarantee independence, but are inefficient in the time domain.

The concept of Logical Execution Time ensures composability in the time-domain thus also giving independence.