Technische Universität Wien

# DECOS-TADE and DECOS-ISIS Collaborations

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# Overview

- Project Aims and Goals
  - Dependable Embedded Components and Systems (DECOS)
  - Timeliness-Assured Design Environment for Distributed Object-Based Embedded Computing (TADE)
  - Research at Institute for Software-Integrated Systems (ISIS)
- DECOS-TADE Collaboration
  - Technical Topics
  - Respective US-EU Roles and Contributions in the Project
  - Experience and Outlook
- DECOS-ISIS Collaboration
  - Technical Topics
  - Contributions
  - Preliminary Results

# Project Aims and Goals of DECOS Integrated Project

- Enabling technology to move from a federated distributed architecture to an integrated distributed architecture
- A system architecture that combines the complexity management advantages of the federated approach, but also realizes the functional integration and hardware benefits of an integrated system (Hammett, 2003)
- Reduce development, production and maintenance cost
- Increased dependability of embedded applications
- Technology invariant software interfaces
- Encapsulated communication and computational resources

# Project Aims and Goals of TADE

- Strengthen the technical foundation for enabling the system engineers to produce *guarantees* for timely service capabilities of various subsystems of distributed real-time embedded computing systems, especially on the basis of the recently established distributed real-time object-oriented programming methods and tools
- Develop an integrated tool-set named the *Timeliness-Assured Design Environment* (*TADE*), aimed for enabling major reduction in the system engineers' efforts in producing DREC systems with service time guarantees.

# Research at Institute for Software-Integrated Systems (ISIS) at Vanderbilt University

- Model-Integrated Computing
  - Specify integrated, multiple-view models
  - Model interpreters translate information in models to input languages of analysis tools
  - Automatic software synthesization
  - UML-based meta programming
- Model-Driven Architecture for Embedded Software

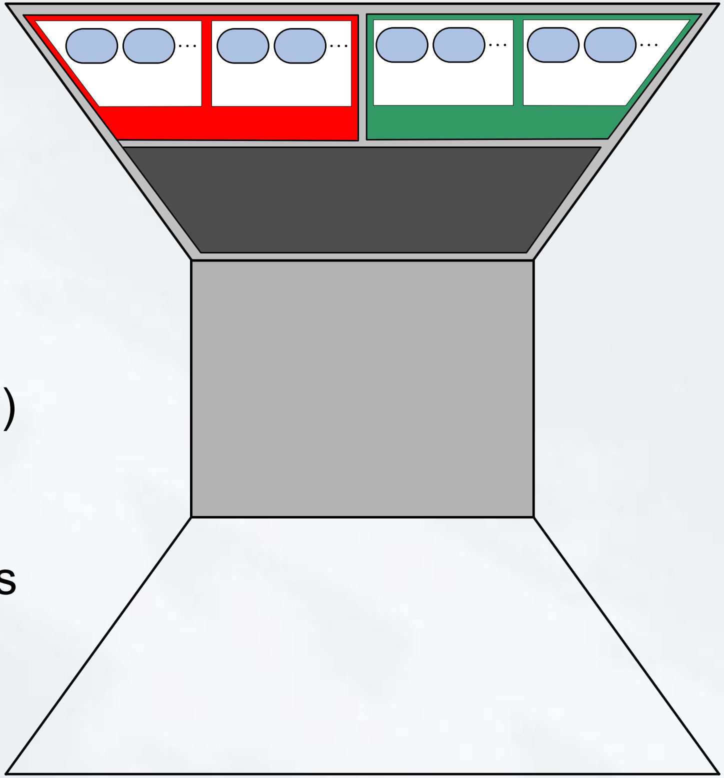
# Technical Topics of DECOS/TADE Collaboration

- Formalization of the structure of the real-time distributed component named TMO and the linking interface specification of DECOS jobs
- Collaborative work on the integration of event-triggered and time-triggered communication paradigms
- Comparison of commercial off-the-shelf platforms (common hardware and operating systems) as used in TADE with the introduced integrated DECOS platform
- Comparative studies of the TADE testbed and the DECOS test-bench, along with cooperative experiments
  - Performance measurements
  - Fault-injection experiments for evaluation of encapsulation of communication and computational resources
  - Validation of development tools

# Contribution of TADE: Time-Triggered Message-Triggered Object (TMO) Model

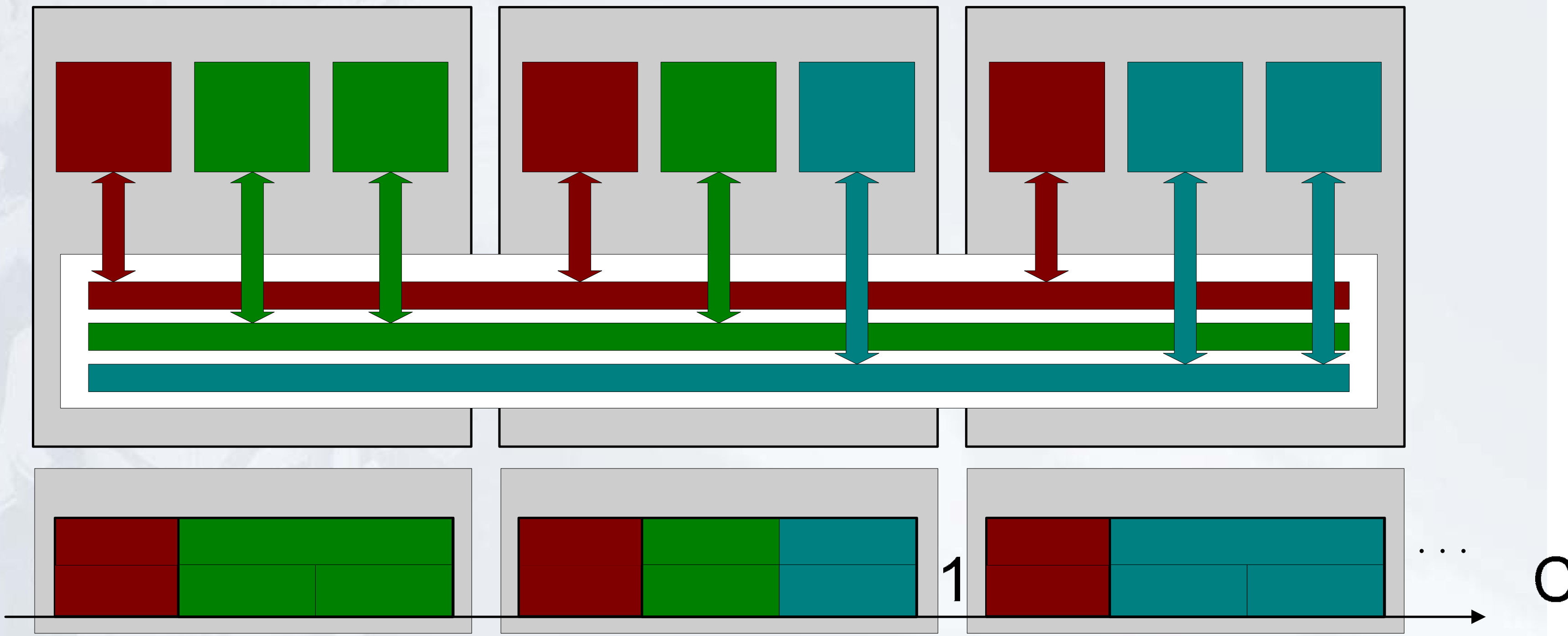
- Powerful extension of conventional distributed object computing
  - Globally referenced time base
  - Distributed object computing
  - Spontaneous methods
  - Basic concurrency constraint
  - Guaranteed completion time and deadline for result arrival
- Tools and methods for composition of real-time distributed object programs
- Execution engines on several major platforms (e.g., Windows, Linux)

# Contribution of DECOS



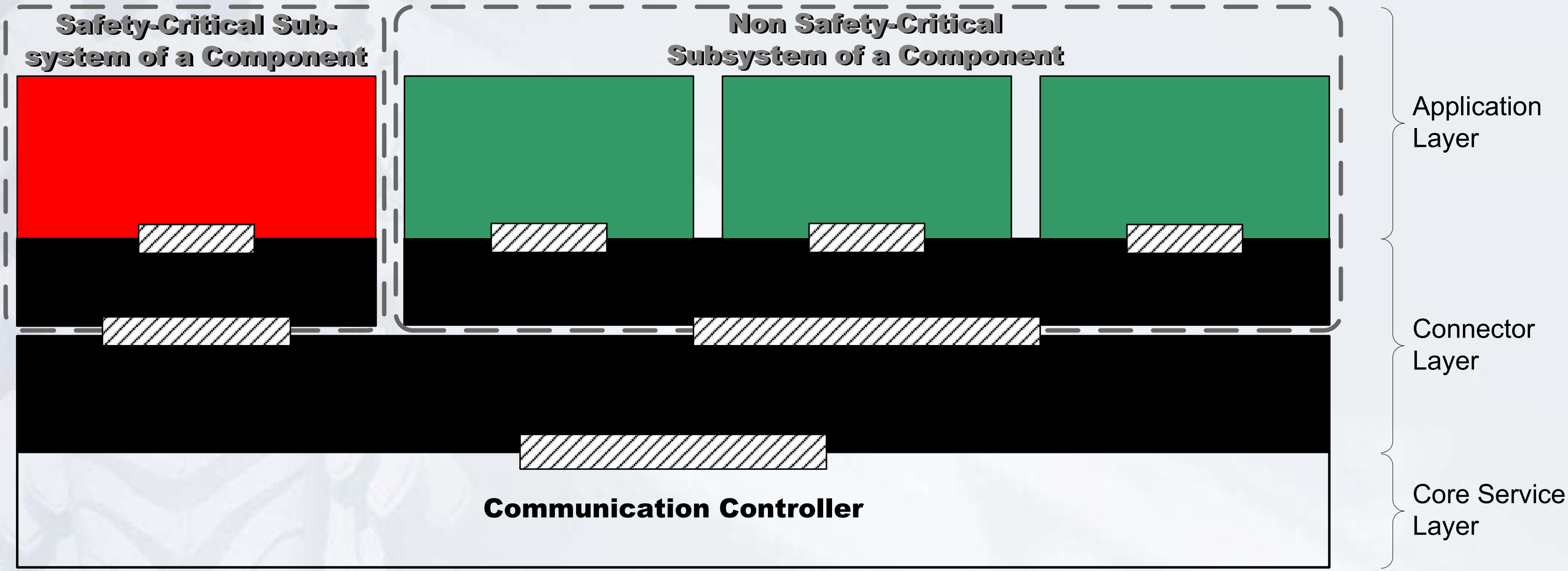

- Design methodology with tool support based on the Model Driven Architecture (MDA)
  - Meta-models constrain the development process
  - Formal specification of linking interfaces (value, time, dependability)
  - Tools facilitate refinement of models
- Generic architectural services as a validated stable base line for applications
- Encapsulated of communication and computational resources

# Virtual Networks in DECOS




Job 1 Job 1 Job 2 Job 2

# DECOS Integrated Component Model




- Horizontal and vertifical partitioning
- Safety-critical and non safety-critical subsystem

# Collaboration Results: TMO on top of a Time-Triggered Core Architecture (1)

- TMO execution engine for a time-triggered core architecture
- Implementation of a Kernel Abstraction Layer (KAL) that maps TMO middleware onto the DECOS core architectural services (C1-C4)
- Integrated DECOS architecture is enriched with support for application subsystems based on distributed object computing
  - Support for realization of DECOS jobs as TMOs
  - Exploitation of encapsulated event-triggered and time-triggered virtual networks for method invocations and multicast communication channels

# Collaboration Results: TMO on top of a Time-Triggered Core Architecture (2)

- TMO with improved temporal performance
  - Global time base with a precision of 5 μs
  - Minimization of communication jitter by devising conflict-free time-triggered schedules at design time for both processing activities (e.g., spontaneous methods) and communication activities (e.g., messages for remote method invocations and those exchanged via multicast channels)
- TMO with improved dependability
  - Improved reliability of application TMOs through the fault-tolerance mechanisms of the underlying services (i.e., fault-tolerant communication service, fault-tolerant clock synchronization, fault isolation between components).
  - Basis for building fault-tolerant TMO applications with active redundancy at relative ease (e.g., Triple Modular Redundancy)

# Outlook of TADE/DECOS Collaboration

- Measurements of the temporal performance of the TMO execution engine developed within the TADE/DECOS collaboration
- Realization of a multimedia application as a demonstrator based on the newly developed TMO execution engine
- Enhancement of the linking interface specification framework based on the component formalization efforts of TADE
- Comparative studies of the TADE testbed and the DECOS test-bench
- TMO based on a Time-Triggered Ethernet Platform

# Technical Topics of DECOS-Vanderbilt Collaboration

- Model Integrated Computing for DECOS
- Case study: Meta-modeling of sensor DAS
- Interpreters for exporting information to other tools (compiler, scheduling tools, etc.)
- Model transformation tools support export to other model-based tools (e.g. MATLAB)

# Contributions

- Contribution of DECOS
  - Generic architectural services
  - Virtual networks with predefined temporal properties
  - Design methodology for development process
  - Implementation platform
- Contribution of ISIS
  - Metamodeling methodology
  - Tool integration platform and methodology
  - Generic Modeling Environment (GME)
  - Model Transformation Tool (GReAT)
  - Design Space Exploration Tool (DESERT)

# Collaboration Results

- Generic modeling of a sensor DAS using GME from ISIS
- Modeling of a particular sensor DAS using GME
- Approach allows for a separation of concerns between system designer and component implementer in practice

# Outlook on DECOS-ISIS Cooperation

- Implementation of model interpreter
- Modeling of case study that exists in real hardware
- Integration of model transformation tool
- Integration of design space exploration tool