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October 12th, 2003

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Operating System Support in the Hard Real-time Design Flow

12/10/2003

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ARTIST IST-2001-34820

http://www.artist-embedded.org/

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Hybrid & Embedded Software Systems

- Computational systems
  - but not first-and-foremost a computer
- Integral with physical processes
  - sensors, actuators
- Reactive
  - at the speed of the environment
- Heterogeneous
  - hardware/software, analog/digital, mixed architectures
- Networked
  - adaptive software, shared data, resource discovery

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Contents

- **Discussing Design Flow**
- **Models of Computation and Communication for OS or execution platforms**

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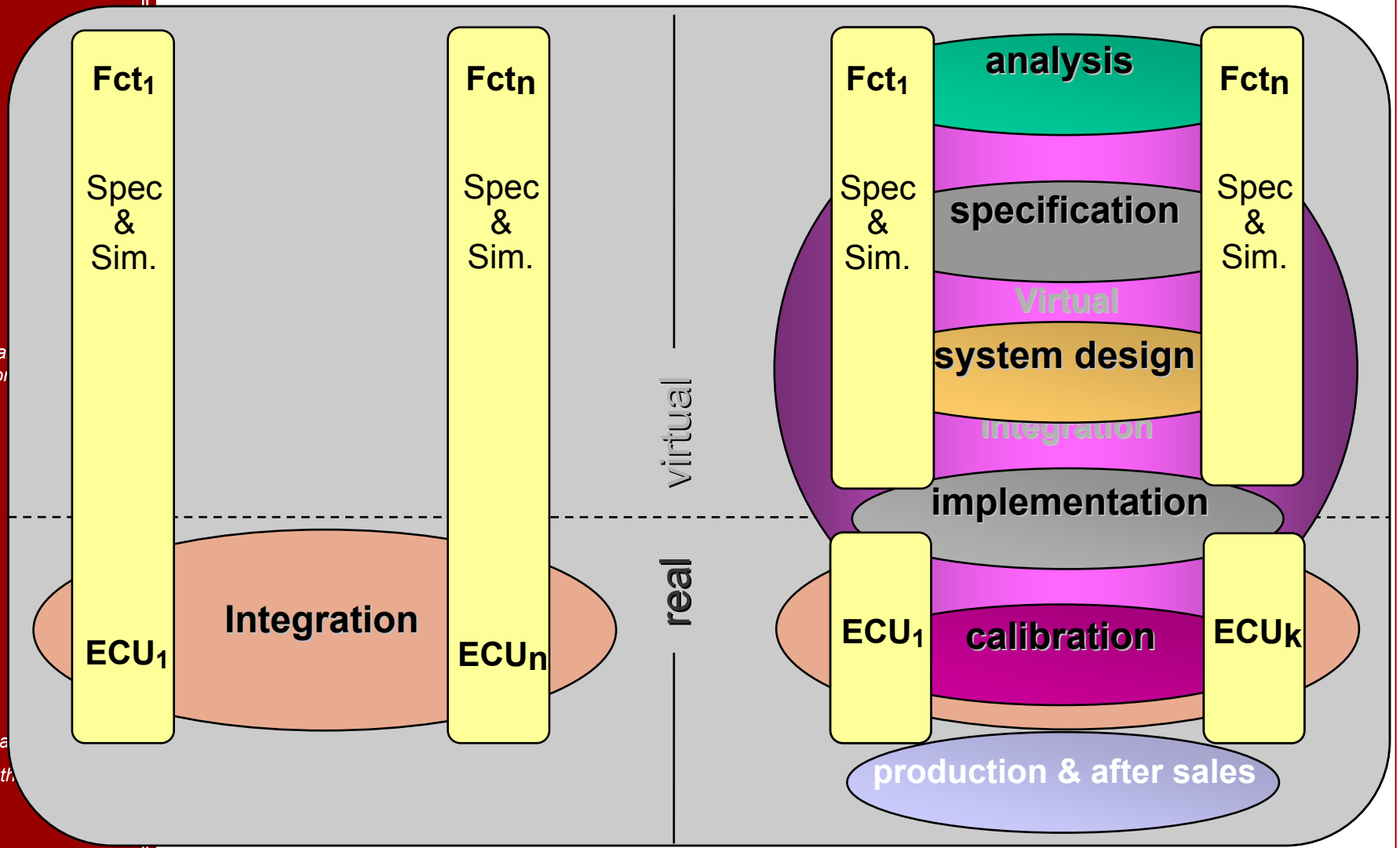
Design Flow (1)



now *tomorrow*

Source BMW

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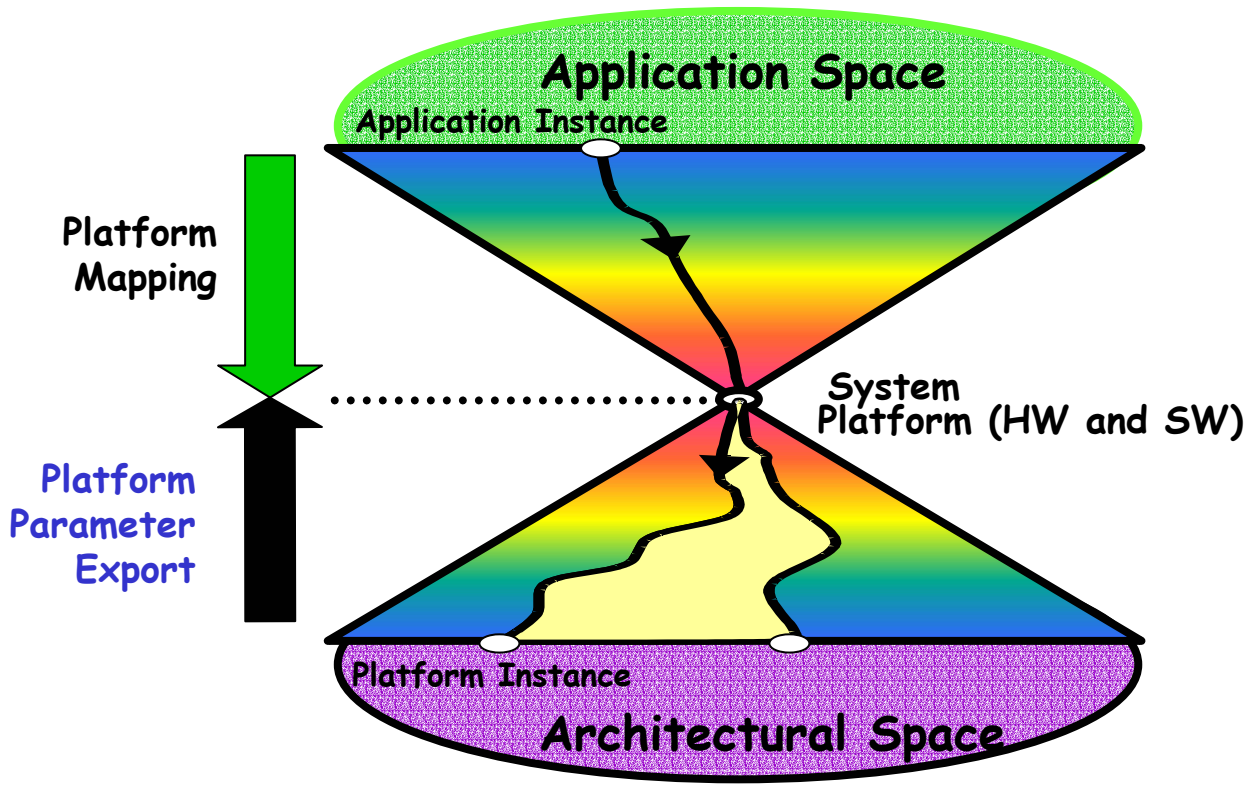
Design flow (2)

- **Current art & practice**
  - V-lifecycle here too
  - Central role of scientific engineering tools
  - 1 function – 1 component – 1 ECU
  - Some rapid prototyping
  - Test, test, and test
- **Challenges**
  - Increasing complexity of the application space: more functions, interacting more, multiplexing, distributed systems
  - Safety critical nature of the designs
  - Interaction with the physical world
  - Complexity of the supply chains
  - Tools and methods from diverse skills

Design flow (3)

- **Objective**
  - Platform-based design: to reflect application space and execution space in the same domain, allows for flexible life-cycle (V, W, Y, T, OO,…)



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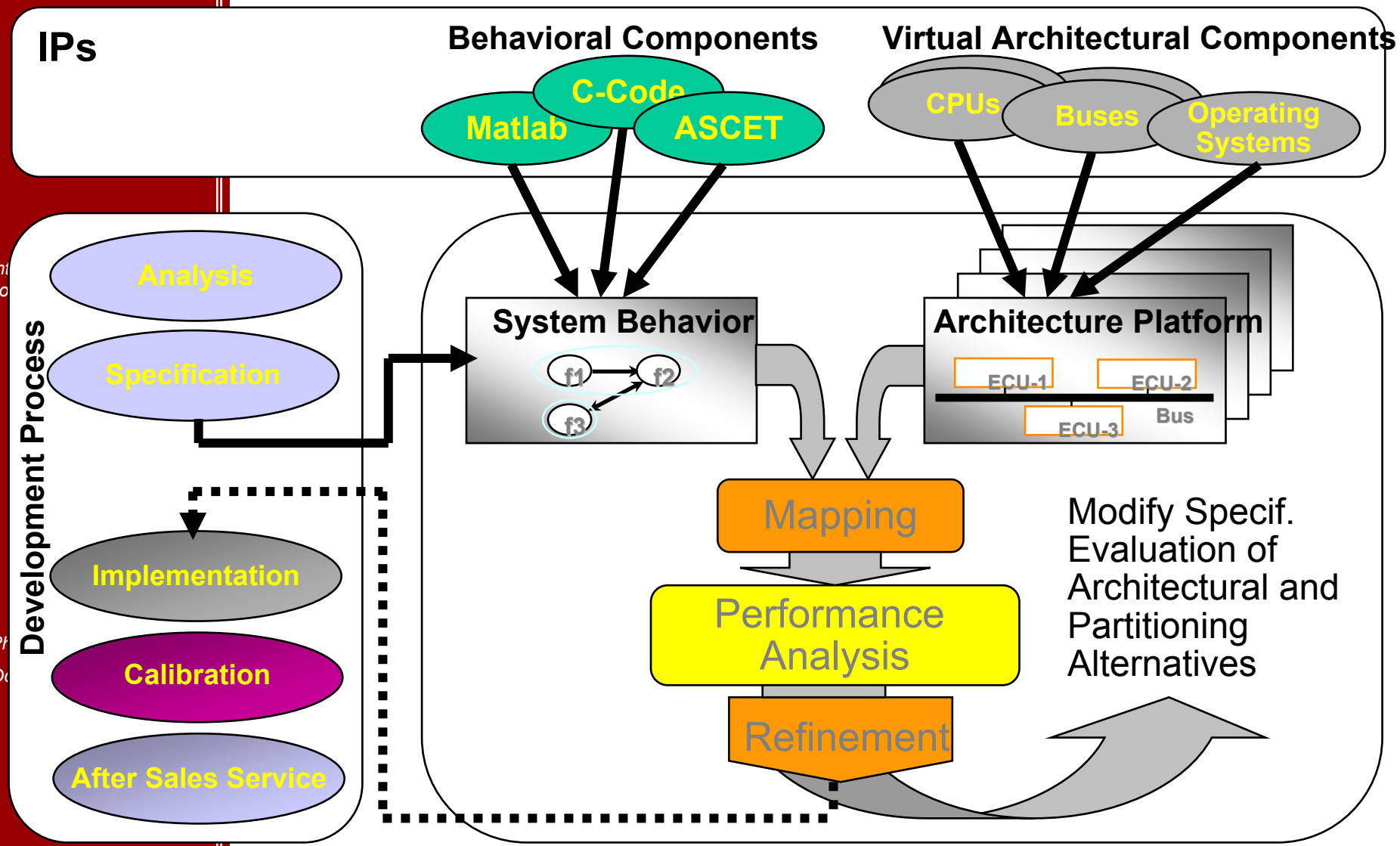
Design flow (4)



Design flow (5)

- **Consequences**
  - Regard:
    - specifications
    - IPs
    - executions infrastructures

    as equal citizens, when modeling is considered
  - Need to associate to OS, busses, execution platforms, etc., corresponding models of computation and communication (MoCC).

- **All this is necessary, but quite heterodox**

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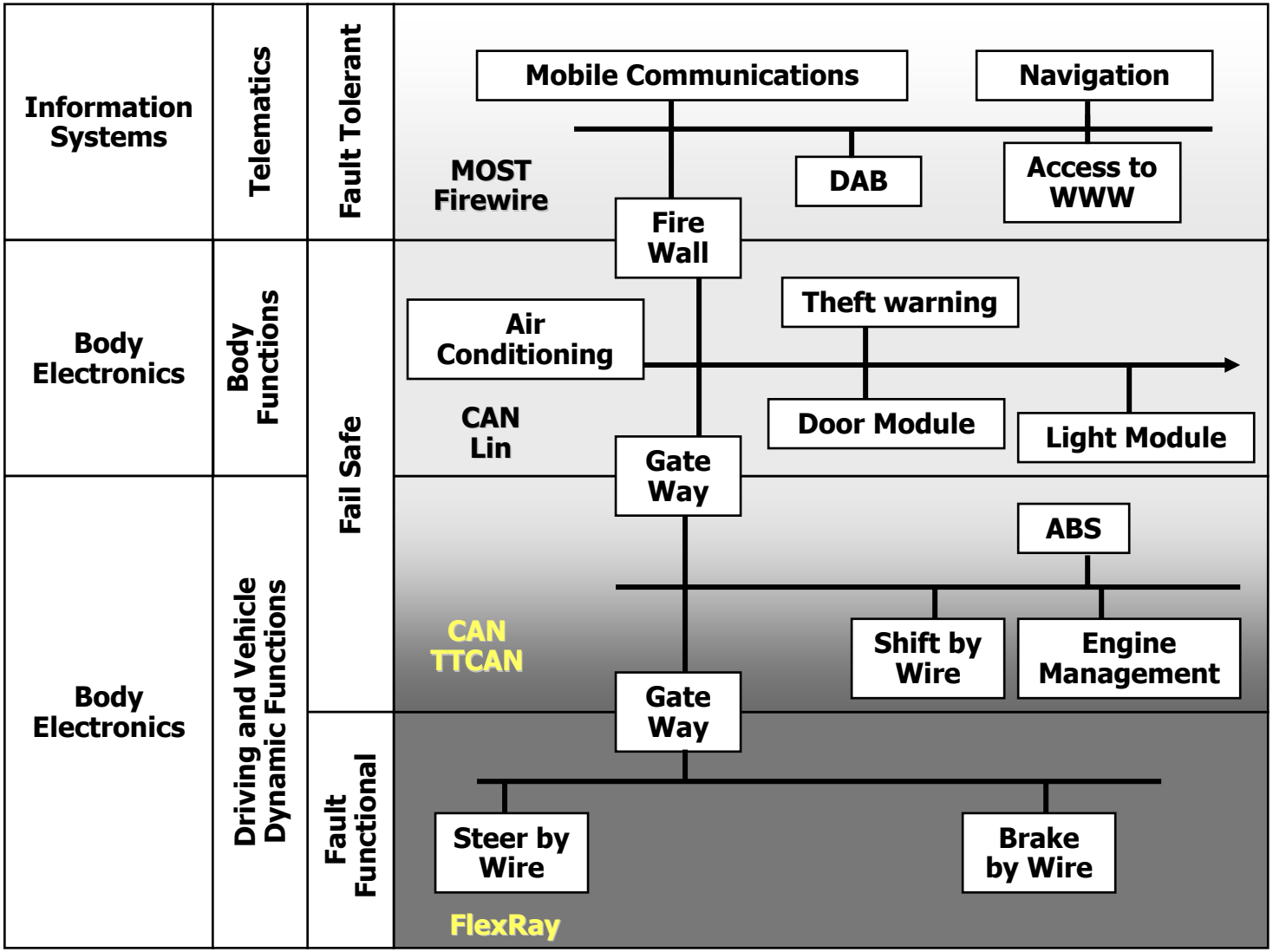
Electronics for the Car: heterogeneity



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Execution platforms: MoCC (1)

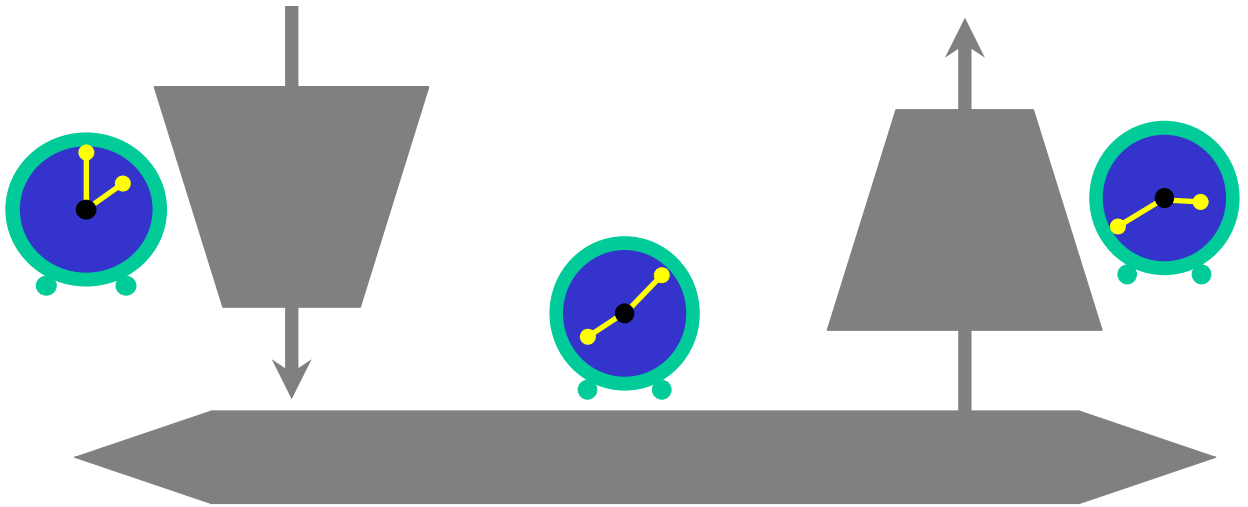
- **TTA**
  - Time-Triggered Architecture
  - TTP bus
  - Implements the strictly synchronous model (plus fault-tolerance & containment)
  - Execution platform MoCC matches specification MoCC – at least for synchronous languages

Execution platforms: MoCC (2)

- **GALS**
  - Globally Asynchronous Locally Synchronous
  - Popular in HW, but also relevant in SoC or SW systems
  - Computation occurs in synchronous clusters exchanging data via a set of communication media
  - Event Triggered, typically; blocking read

Execution platforms: MoCC (3)

- **LTTA**
  - Loosely Time-Triggered Architectures
  - More flexible, easily extensible
  - In principle less secure than TTA
  - Requires careful consideration within the design flow



Execution platforms: MoCC (4)

- **More…**
  - Specific system needs may require new execution architectures
  - Execution platforms are not selected according to a good matching with the design flow, other system considerations prevail (e.g., safety, or performance, or flexibility, or adaptivity, or…)

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- Discussing Design Flow
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- **Should Mrs Design_Flow marry Mr RTOS, or alternatively should Mr RTOS marry Mrs Design_Flow?**

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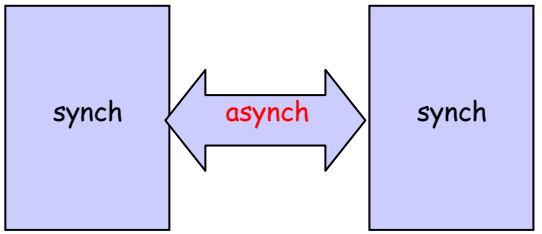
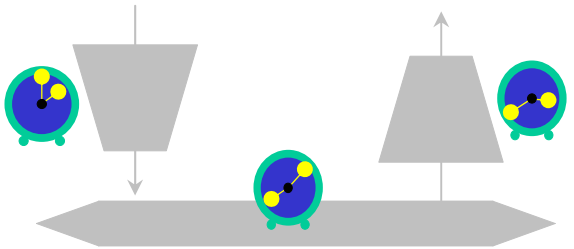
Who marries whom?

- Should the RTOS adjust to the design flow and fit to a “nice” MoCC?
  - Only TTA allowed?
  - Only hard-core GALS?
  - Only…
- Would facilitate mapping of the design down to the execution platform
- But off-the-shelf RTOS and standard busses & protocols are there
- And the beauty of an RTOS is not created for appealing to Mrs Design_Flow
- Should the design flow adjust to the available RTOS or execution platform?
- Requires to abstract any given particular execution platform into a usable MoCC
- Requires to develop automatic deployment techniques for the resulting MoCCs

Both approaches have their advantages, but the 2nd one is more pragmatic

One approach under study at ARTIST-HRT





- Develop automatic deployment techniques, from Matlab/Simulink or synchronous MoCC, to GALS
- Requires that blocks can be automatically encapsulated with propers wrappers to ensure correct deployment
- Show how to (mildly) adapt LTTA so it can be seen as hard-core GALS

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HRT study

- MoCC for heterogeneous systems
- Generating adaptors for correct-by-construction assembly of partial designs
- Generating adaptors for correct-by-construction deployment

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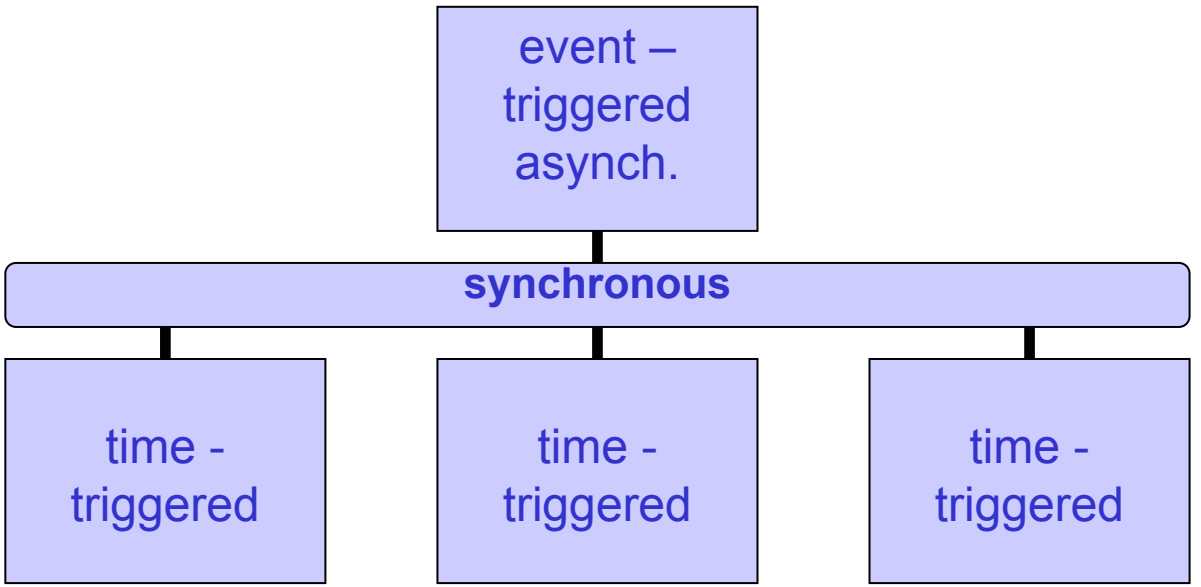
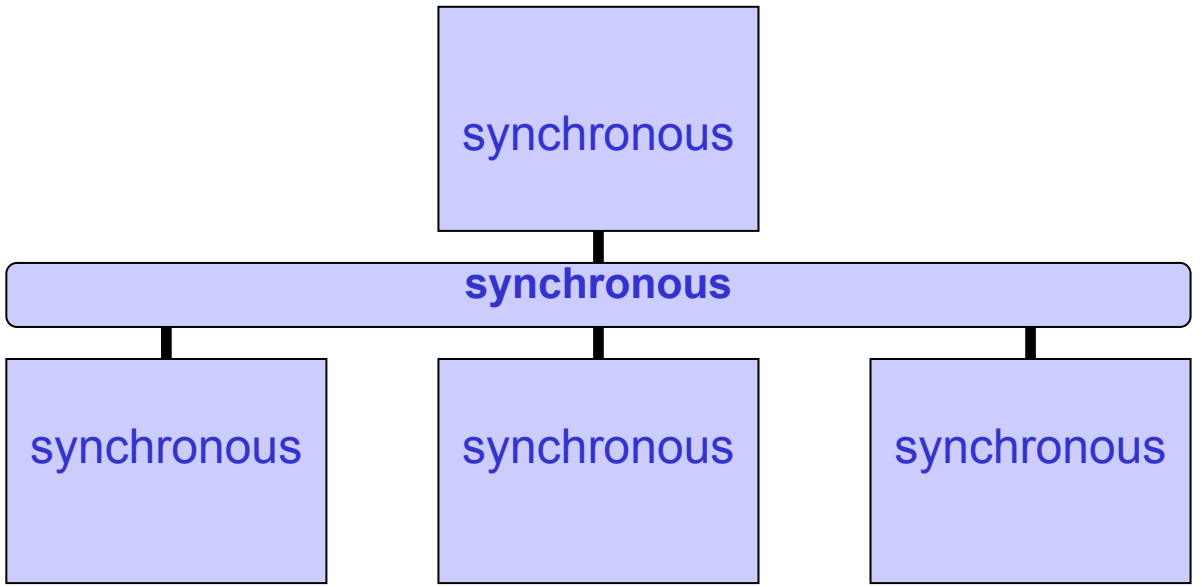
HRT study: heterogeneous MoCCs



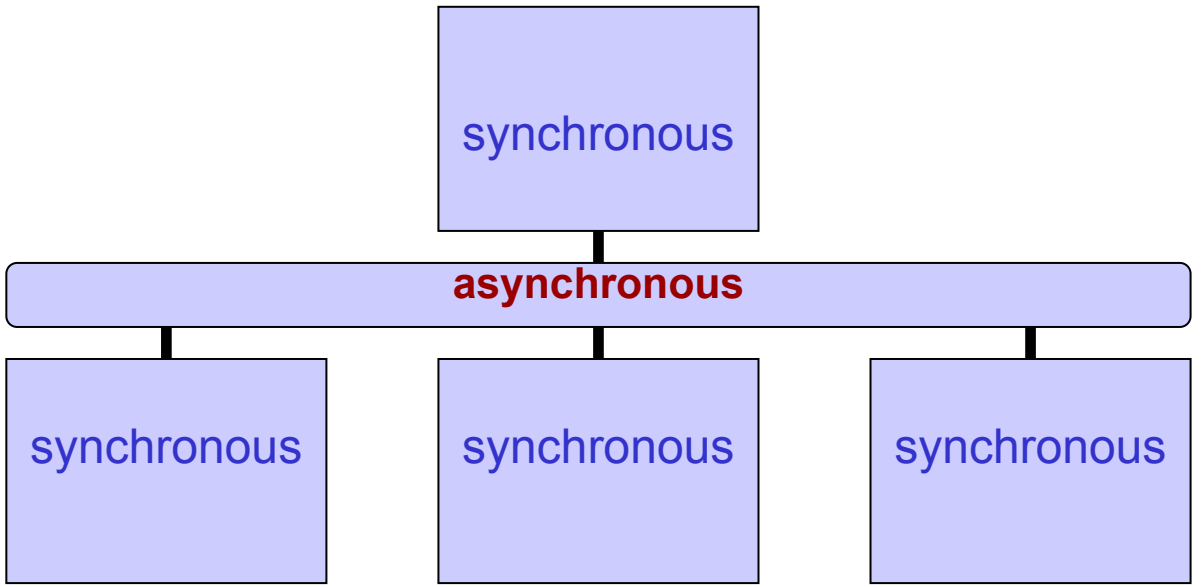
- How to define heterogenous parallel composition?

HRT study: correct-by-construction mapping



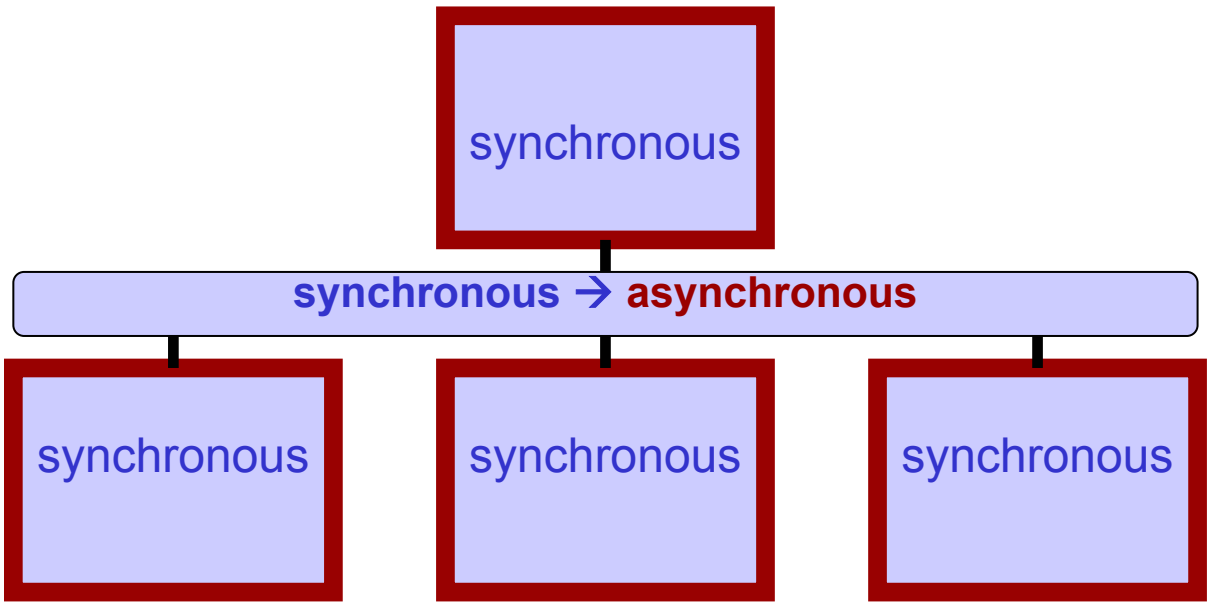
- How to move correctly, from a synchronous spec,

HRT study: correct-by-construction mapping



- How to move correctly, from a synchronous spec,
- … to a GALS deployment?
- Provide an algebraic characterization

HRT study: correct-by-construction mapping



- How to move correctly, from a synchronous spec,
- … to a GALS deployment?
- Provide an algebraic characterization
- And use it to generate wrappers