

# Embedded Software Engineering

3 Unit Course, Winter 2004

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[www.cs.uni-salzburg.at/~ck/teaching/ESE-Winter-2004](http://www.cs.uni-salzburg.at/~ck/teaching/ESE-Winter-2004)

# It's significant

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\$4 billion development effort  
> 50% system integration & validation cost

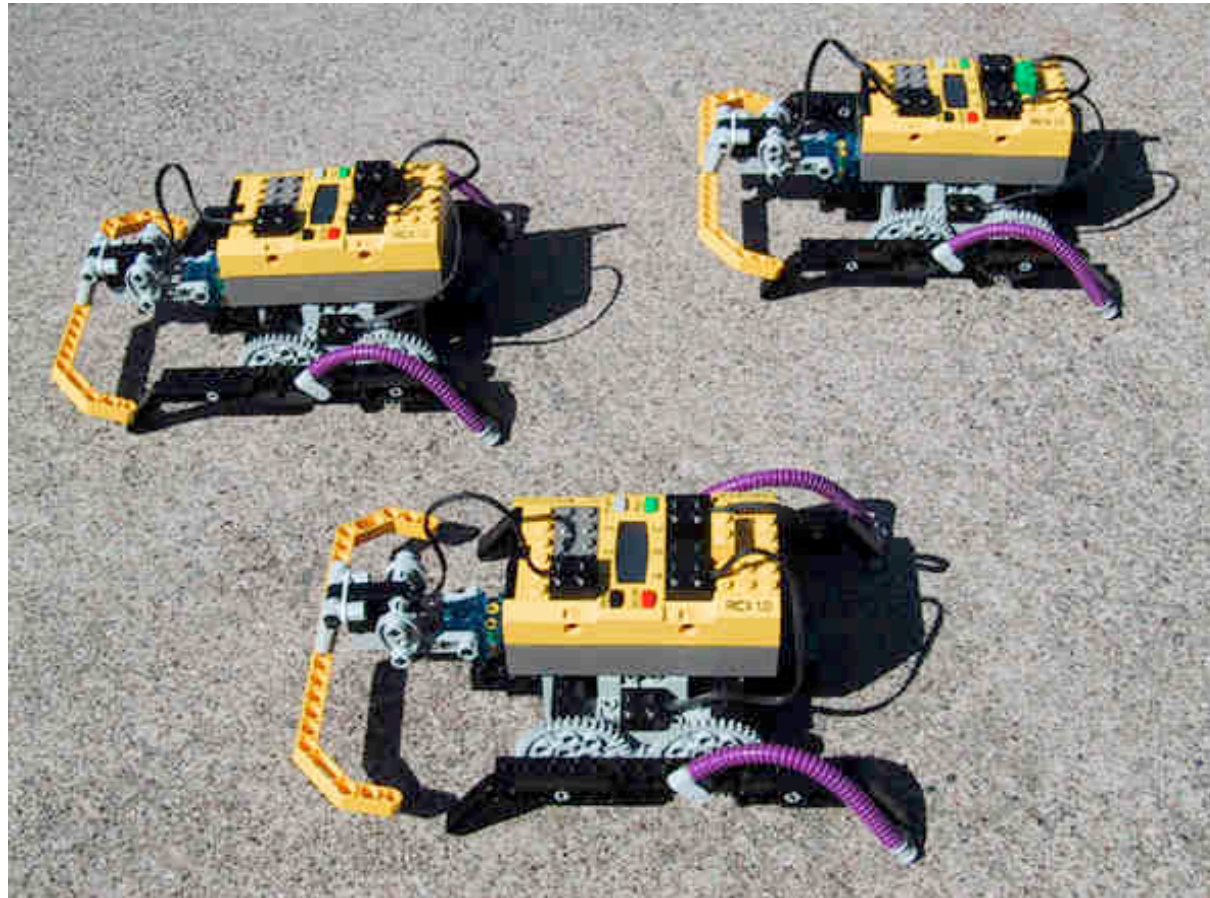
# It's risky

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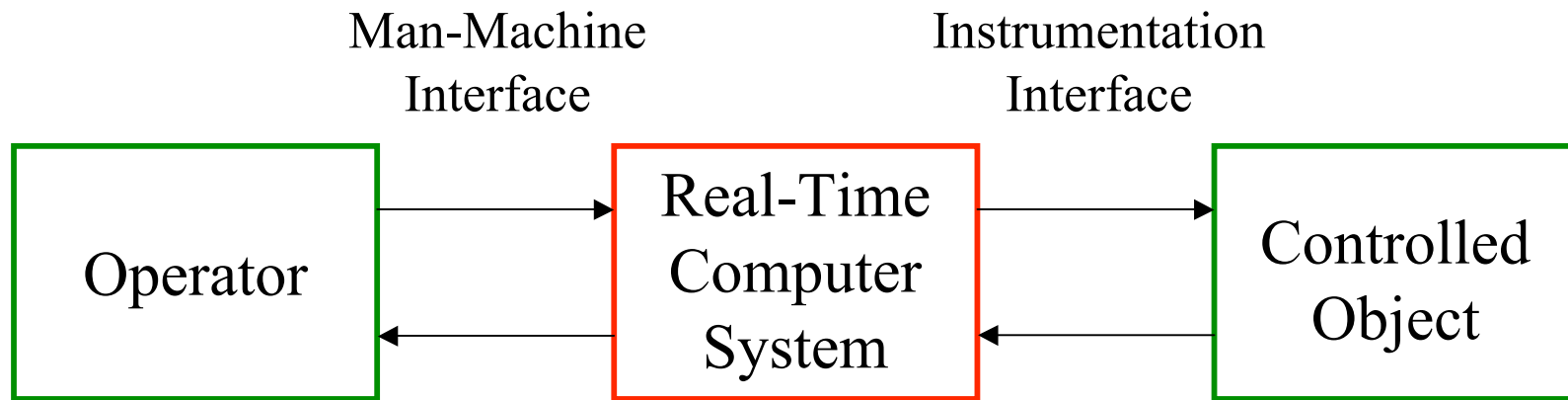
# It's fun

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# Problem

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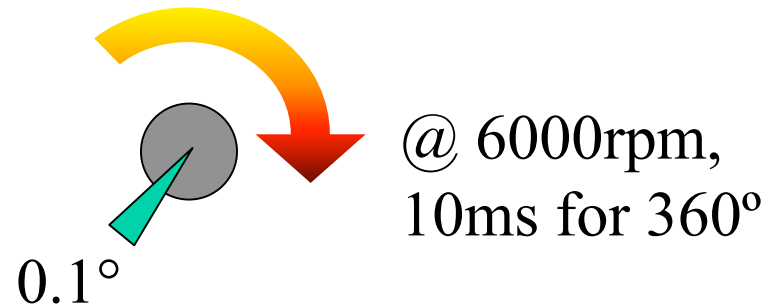
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Methodologies for the implementation of  
embedded **real-time** applications

- Methodology: **tool-supported, abstract, compositional**
- Implementation: **compositional, scalable, dependable**

# Engine Controller

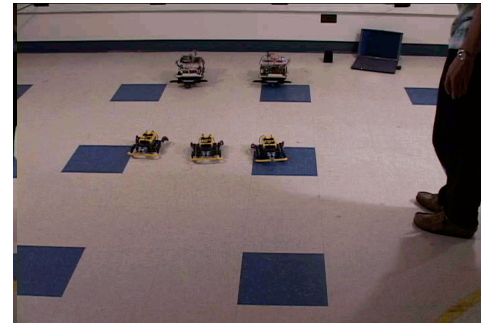
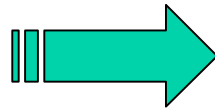
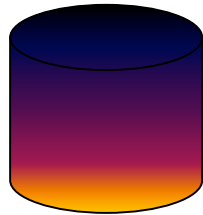
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- Temporal accuracy of  $3\mu\text{sec}$
- Up to 100 concurrent software tasks
- Hard real-time: no missed deadlines

# Video Streaming

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- 25 frames/sec
- Dynamic resource allocation
- Soft real-time: degraded QoS

# Real-Time Systems

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Characteristics	Hard	Soft
Response time	Hard-required	Soft-desired
Peak-load performance	Predictable	Degraded
Control of pace	Environment	Computer
Redundancy	Active	Checkpoint
Error detection	Autonomous	User assisted

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# Mechatronics

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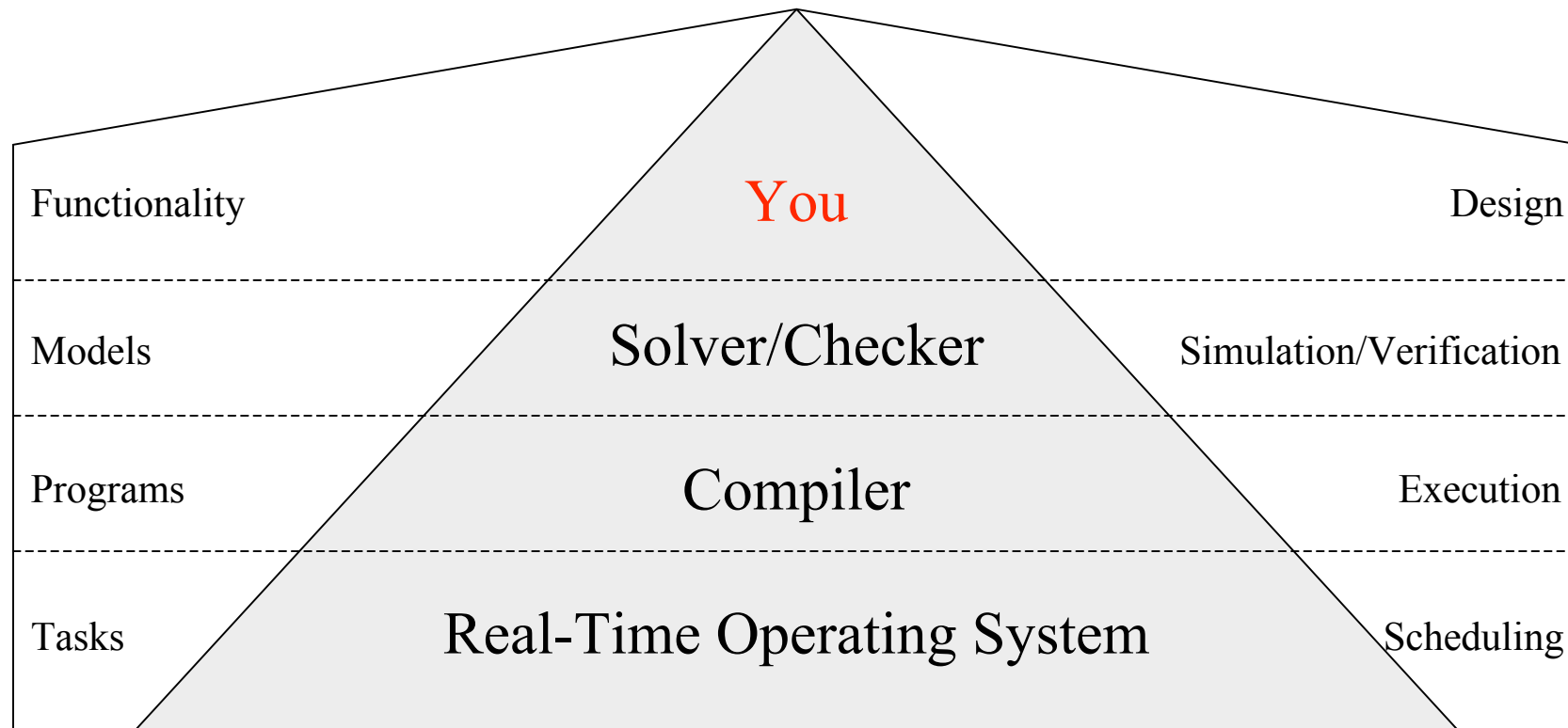
Fly-by-wire



Drive-by-wire

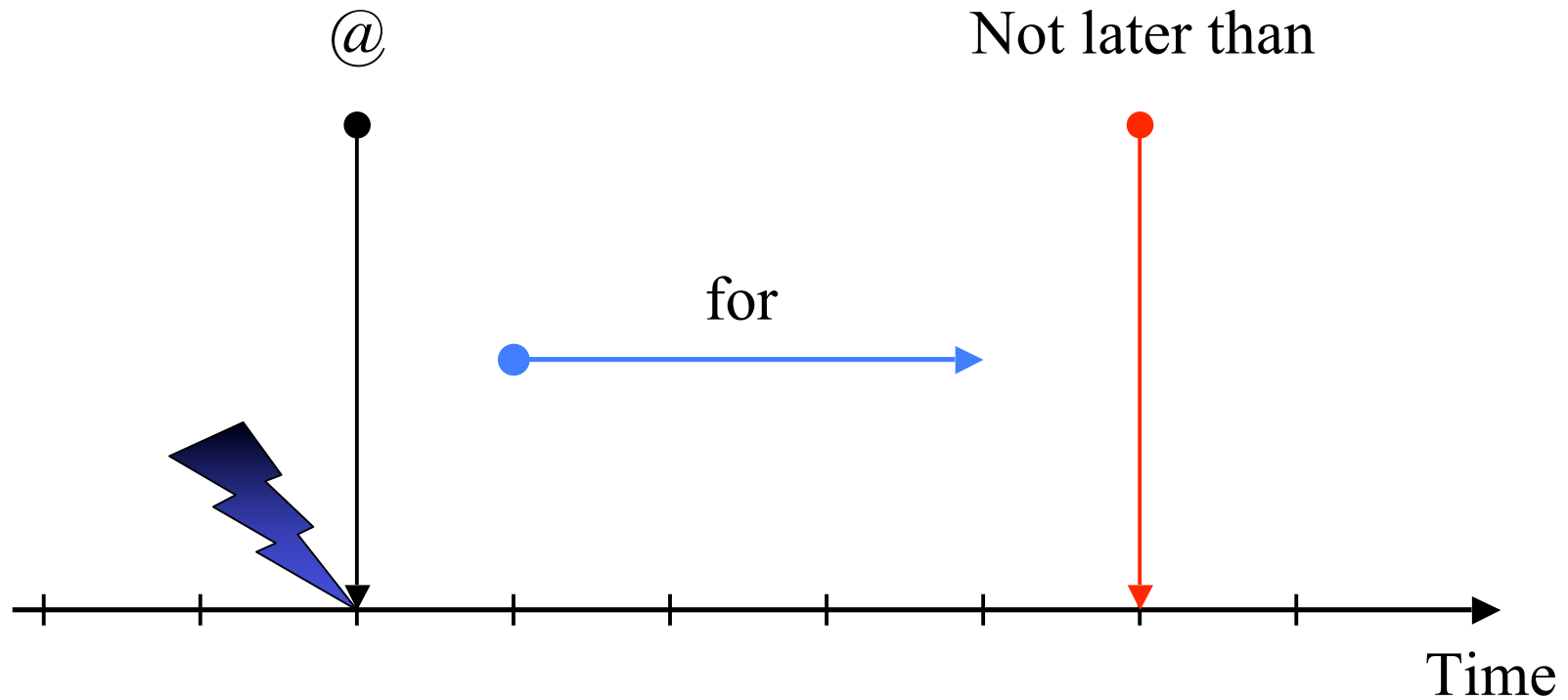
# Embedded Software Engineering

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# Real-Time

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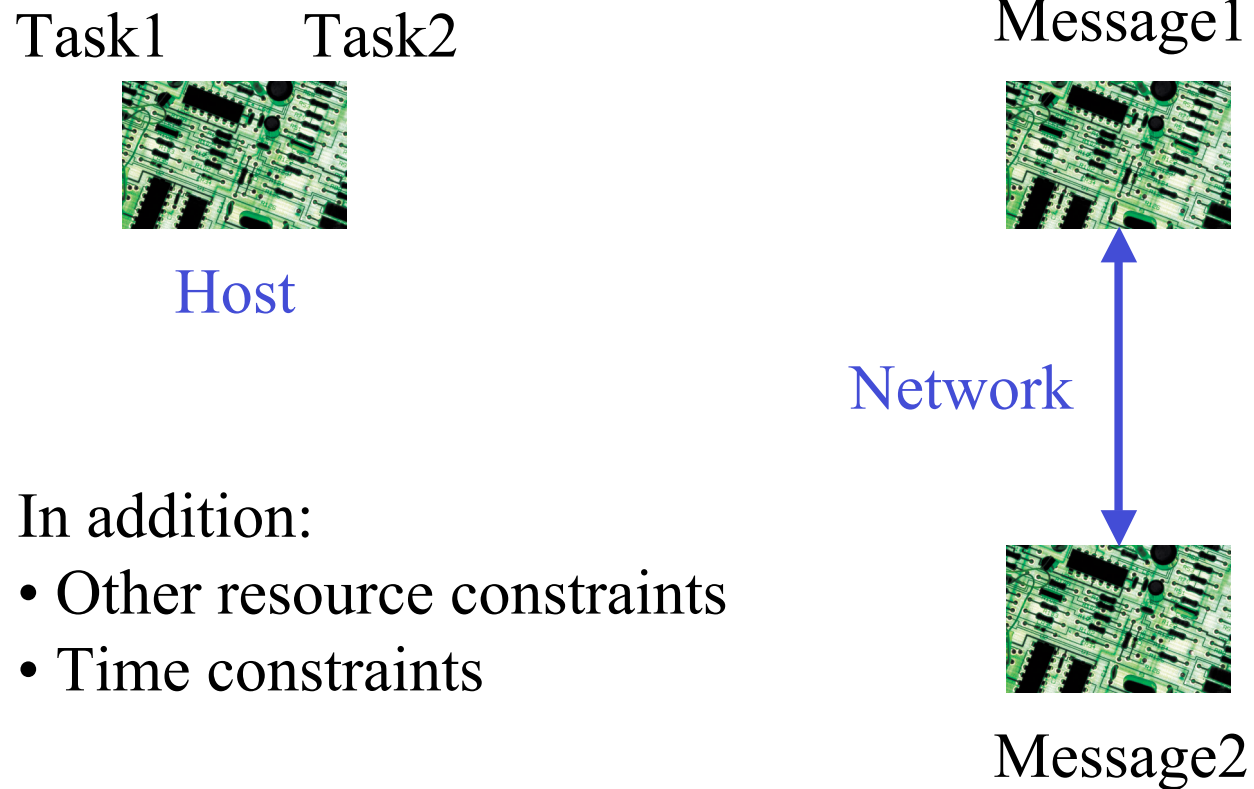
● → Time-instant

● → Deadline

● → Duration

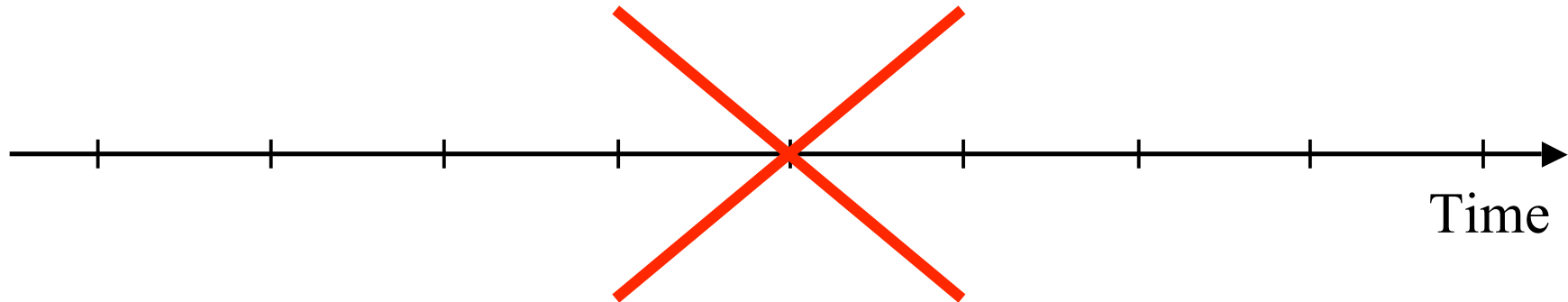
# Concurrency

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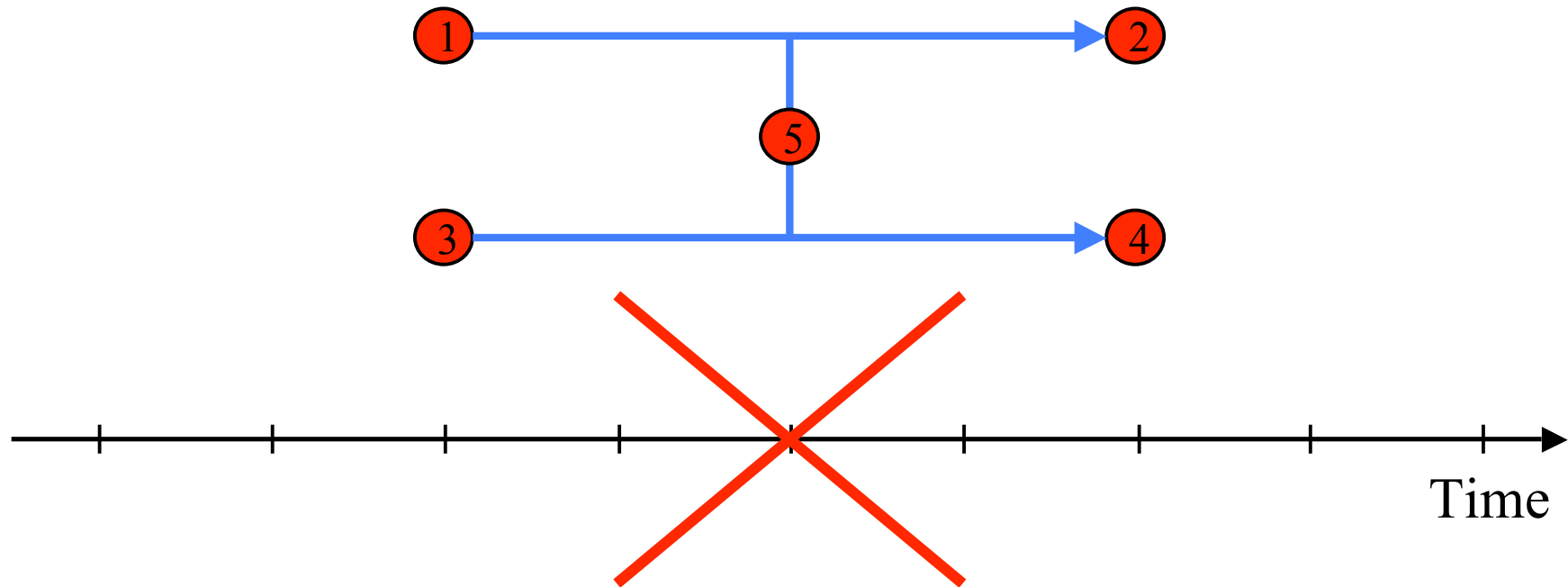
# Sequential Programming

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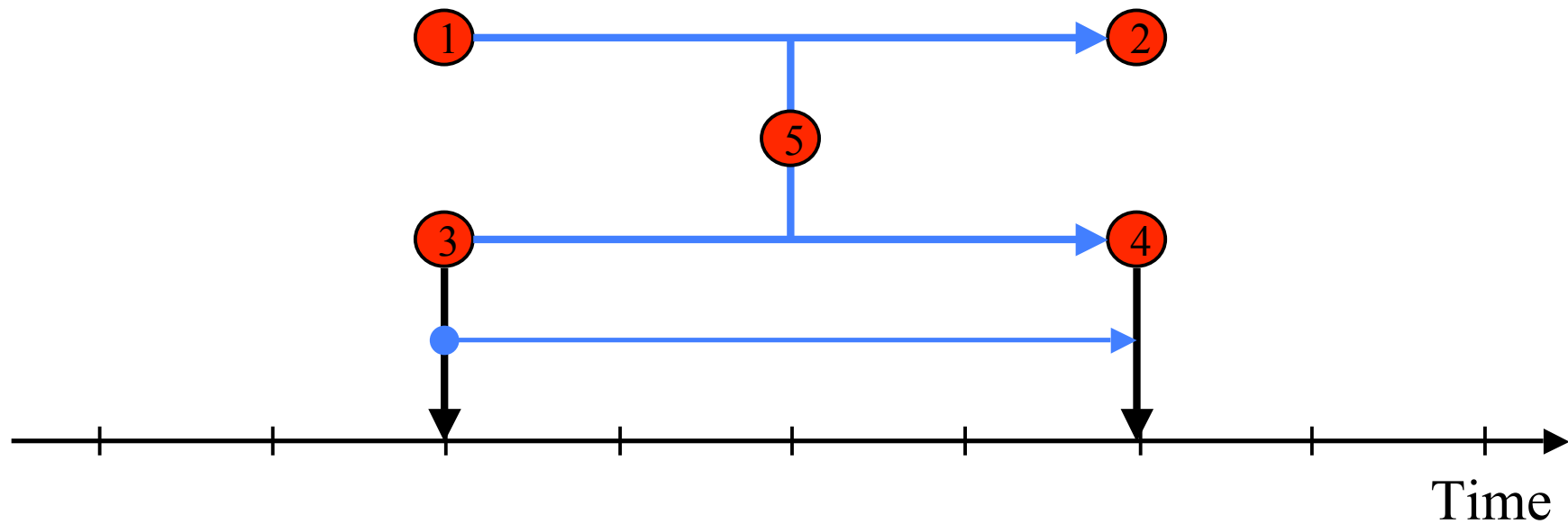
# Multiprogramming

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# Real-Time Programming

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# Embedded Software



Environment



Environment Processes



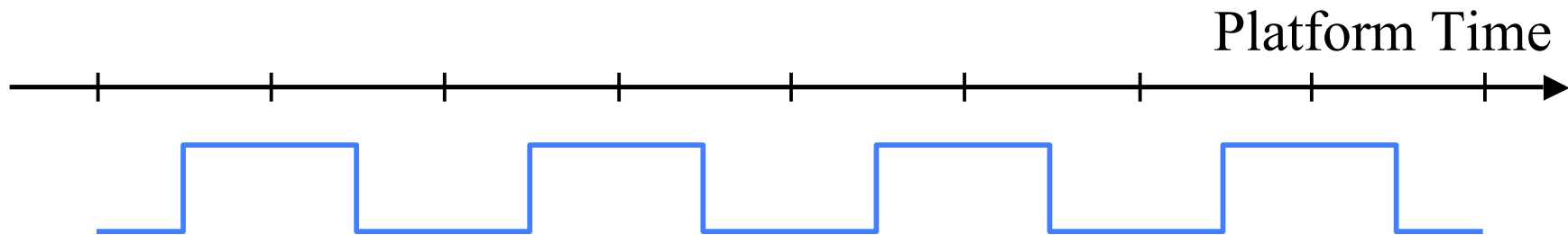
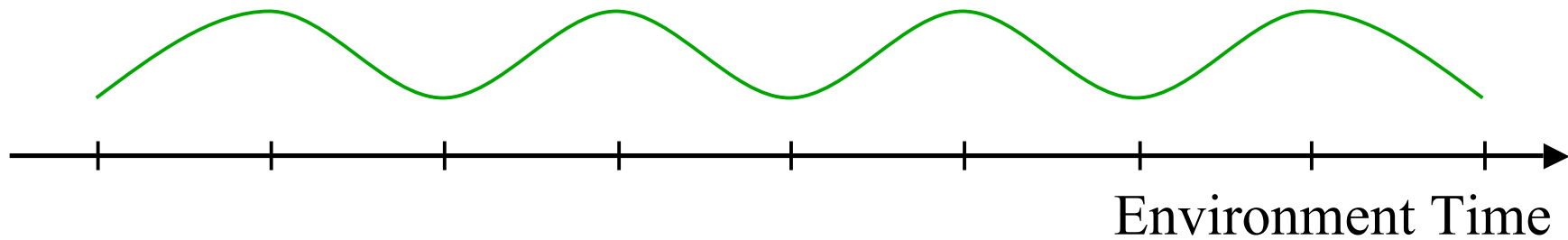
Software Processes



Software



# Environment vs. Platform Time



# The Art of Embedded Programming

