

# Embedded Software Engineering

3 Unit Course, Winter 2010

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[www.cs.uni-salzburg.at/~ck/teaching/ESE-Winter-2010](http://www.cs.uni-salzburg.at/~ck/teaching/ESE-Winter-2010)

# It's significant

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

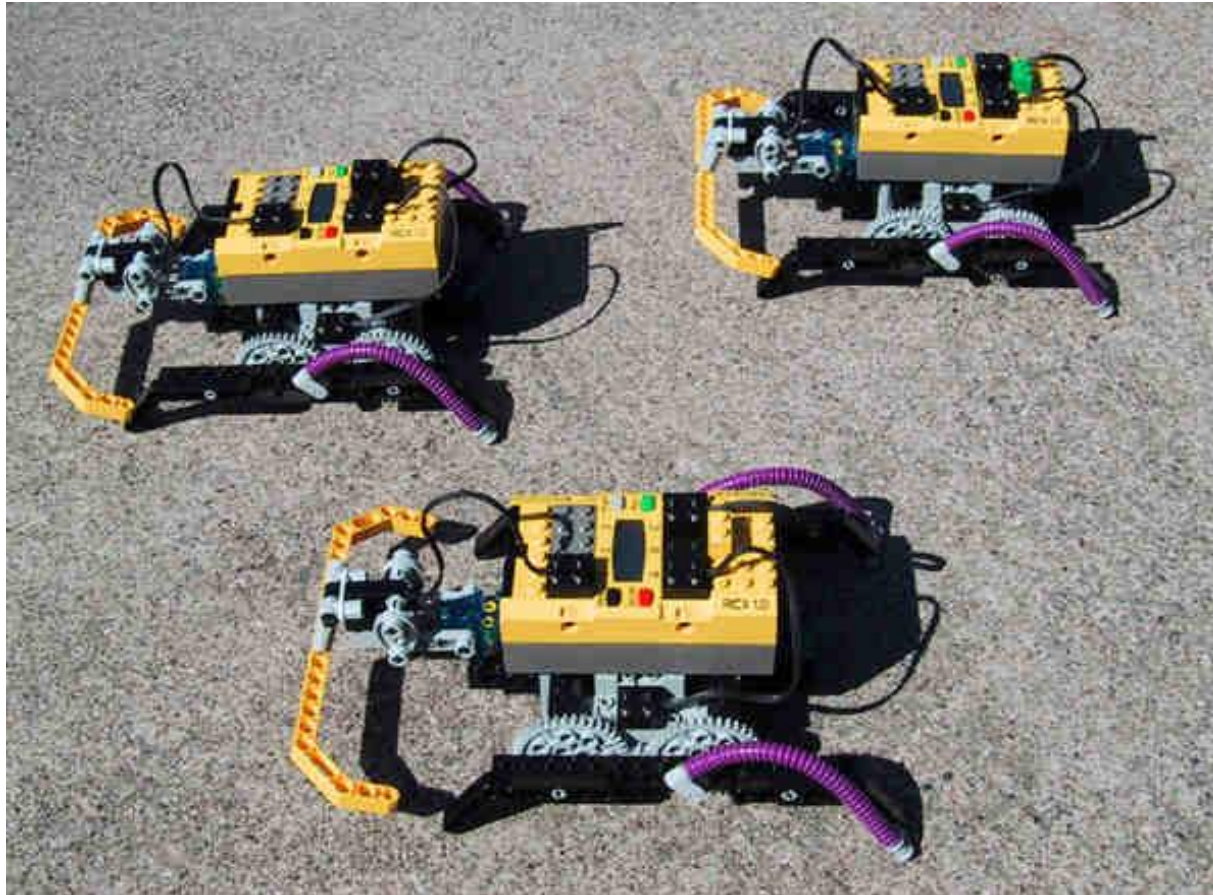
# It's risky

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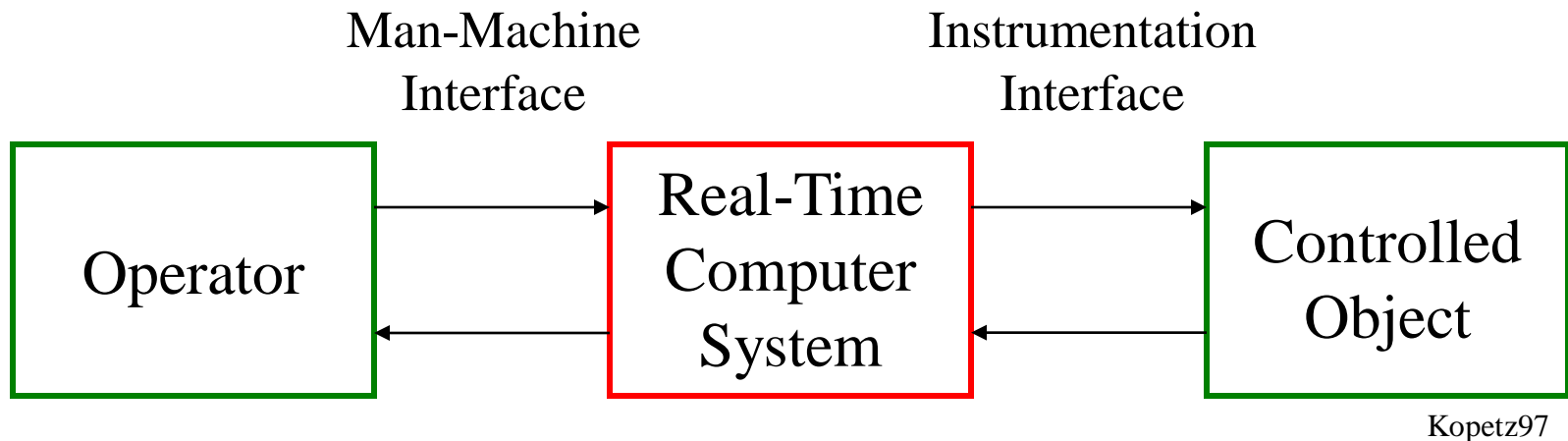
# It's fun

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# Problem

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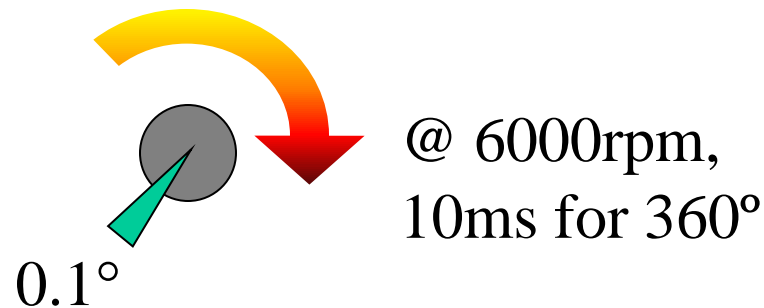


Methodologies for the implementation of  
embedded **real-time** applications

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

# Engine Controller

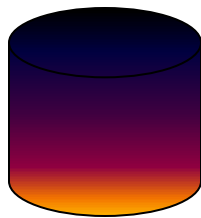
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- Temporal accuracy of  $3\mu\text{sec}$
- Up to 100 concurrent software tasks
- Hard real-time: no missed deadlines

# 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

Kopetz97



# Mechatronics

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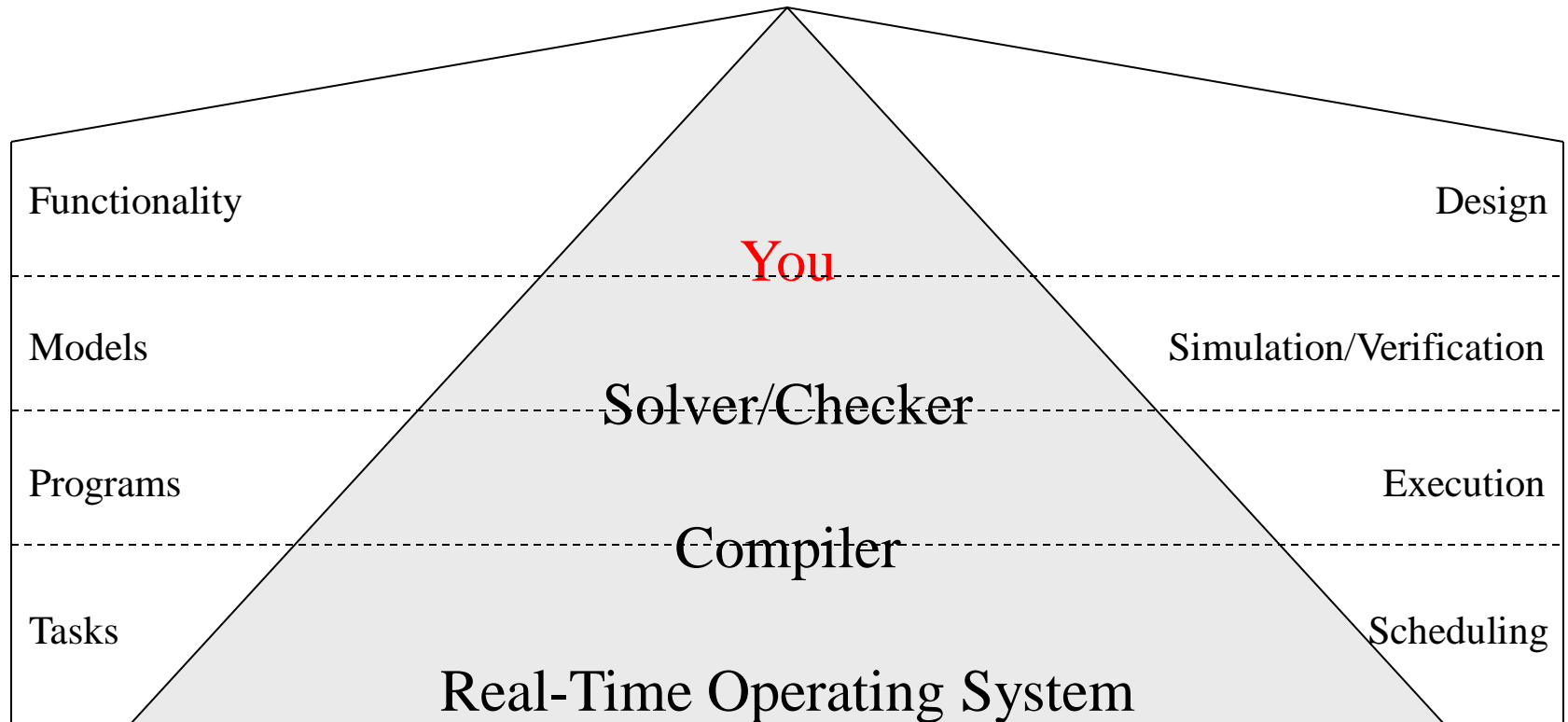
Fly-by-wire



Drive-by-wire

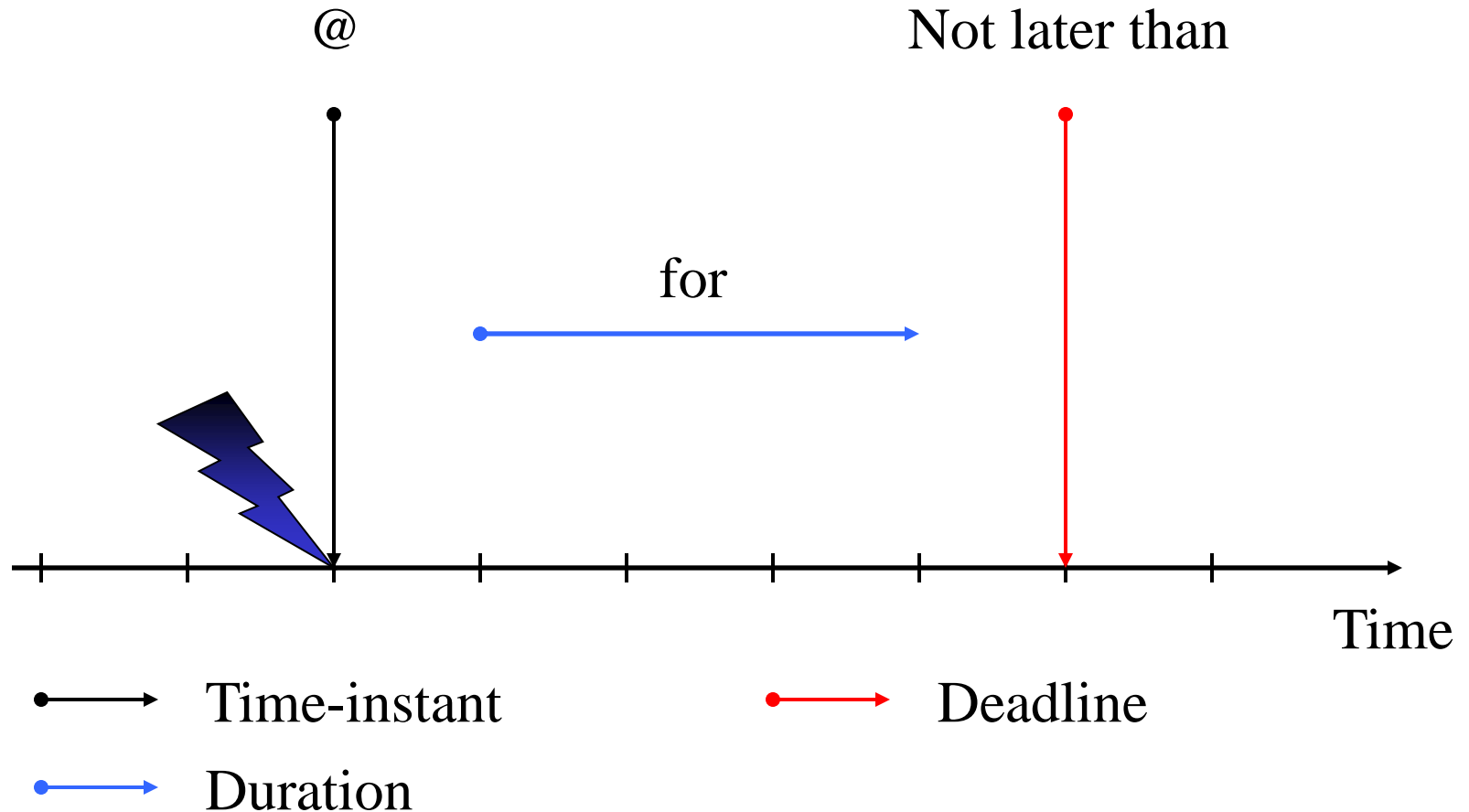
# Embedded Software Engineering

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# Real Time

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# Concurrency

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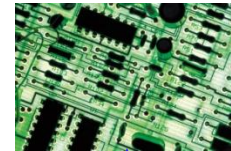
Task1

Task2



Host

Message1



Network



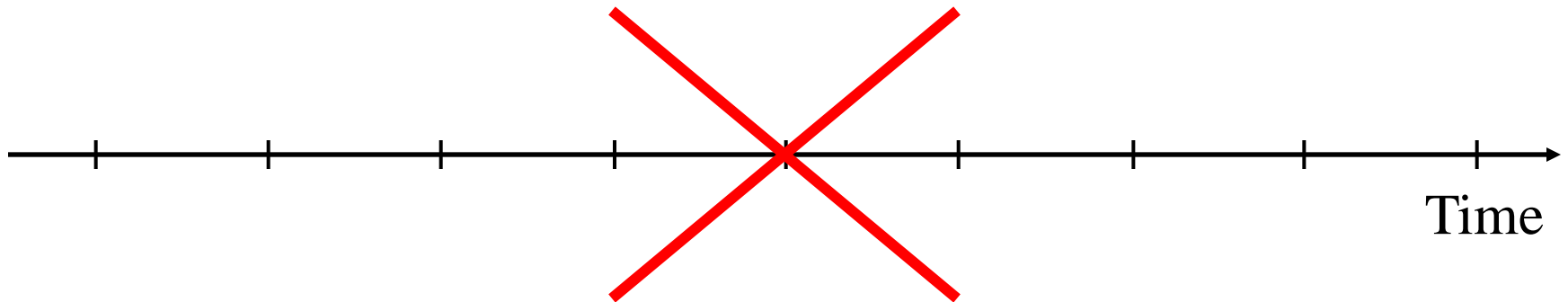
Message2

In addition:

- Other resource constraints
- Time constraints

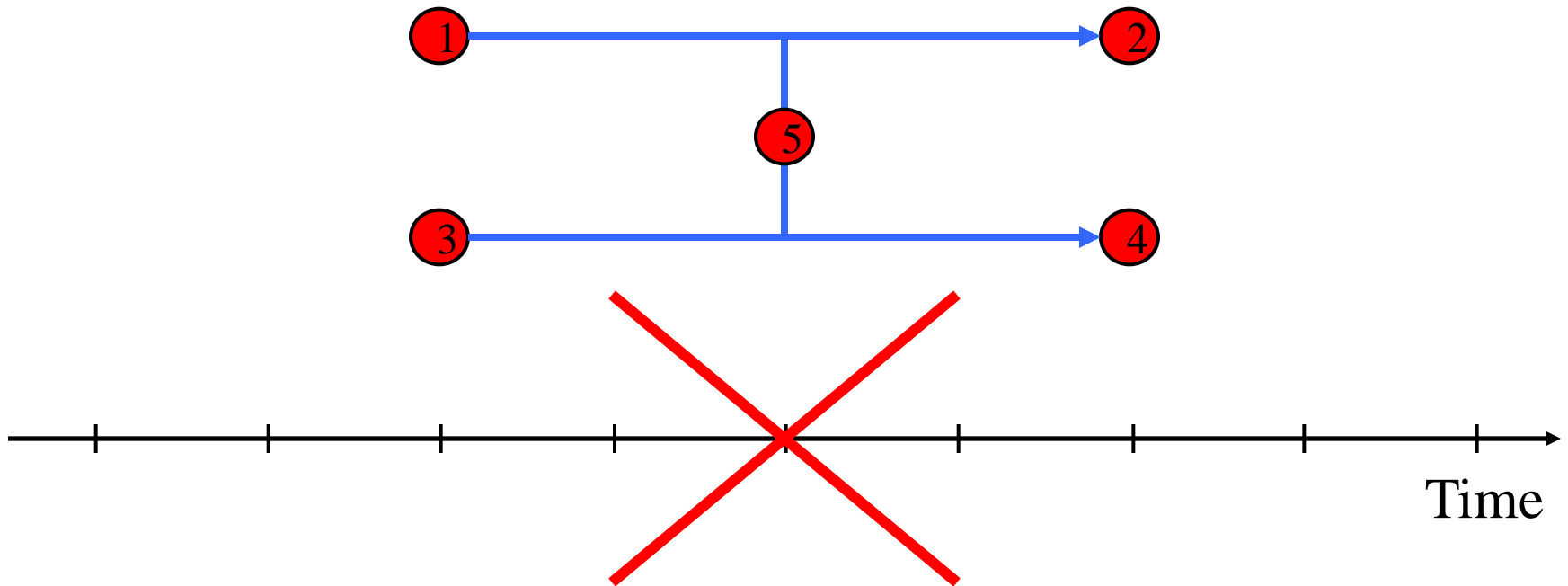
# Sequential Programming

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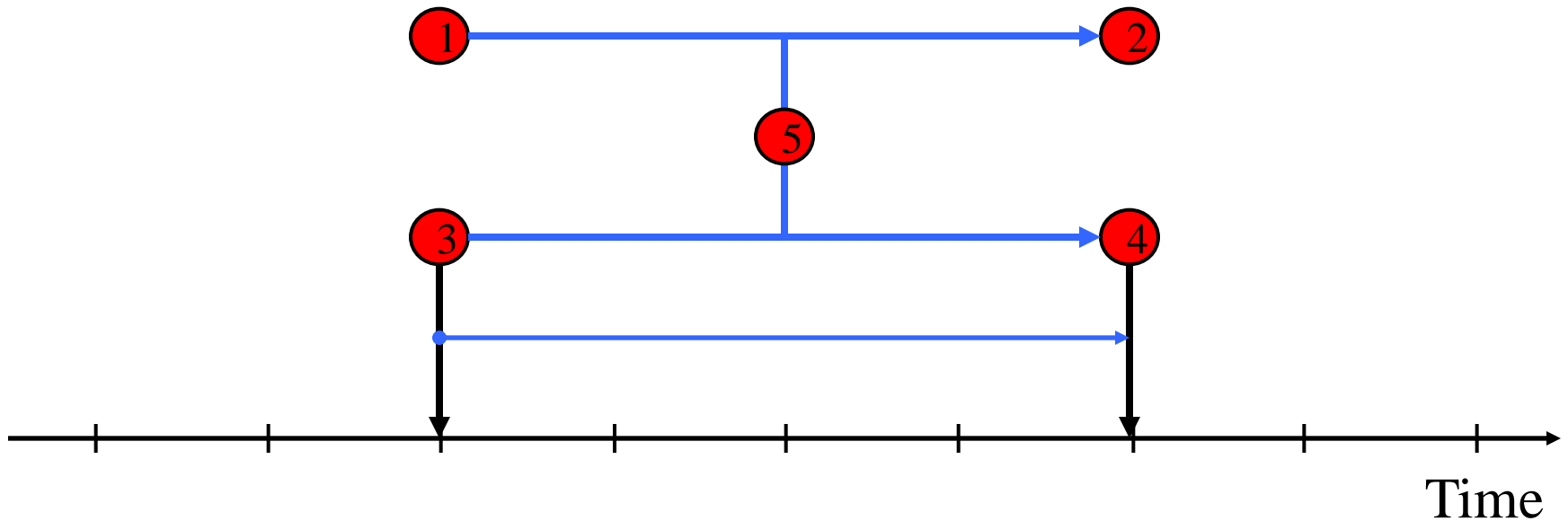
# Multiprogramming

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# Real-Time Programming

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# Embedded Software



The diagram illustrates the layers of embedded software. At the top is a green bar labeled 'Environment'. Below it is a green wavy line. In the center is a white box labeled 'Environment Processes'. A horizontal dashed line separates this from another white box labeled 'Software Processes' below it. At the bottom is a blue bar labeled 'Software'. A blue square wave line is positioned above the 'Software' bar.

Environment

Environment Processes

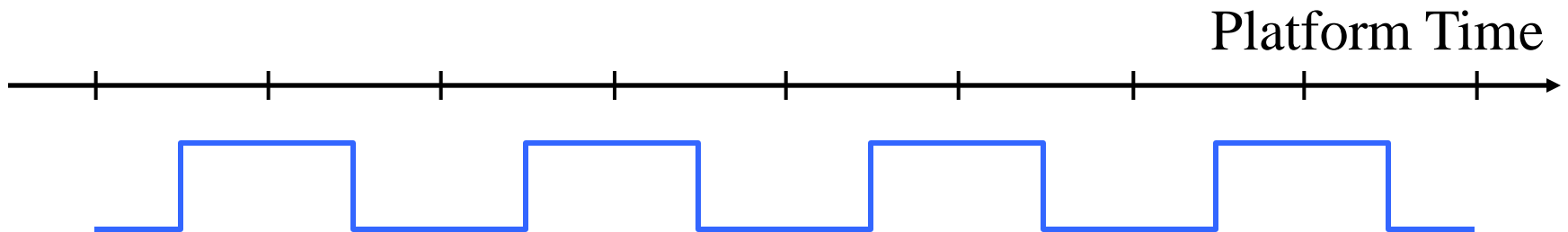
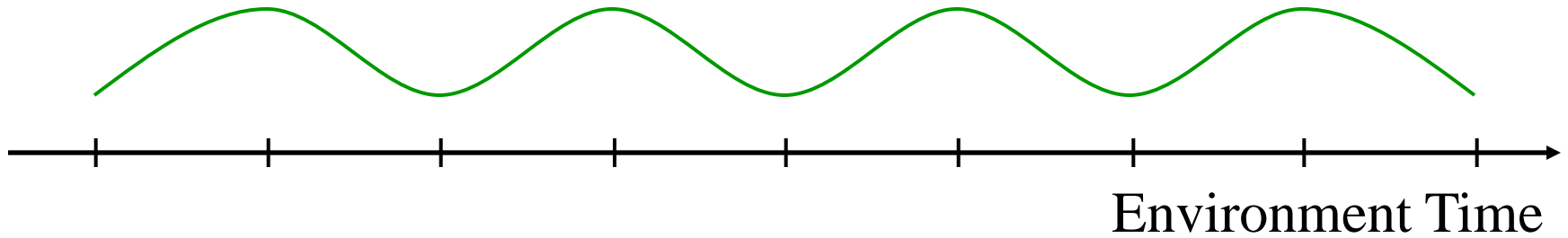
Software Processes

Software

# Environment vs. Platform Time



Environment



Software

# The Art of Embedded Programming

