Principles of Real-Time Programming

Embedded Systems Summer School in Salzburg

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UC Berkeley

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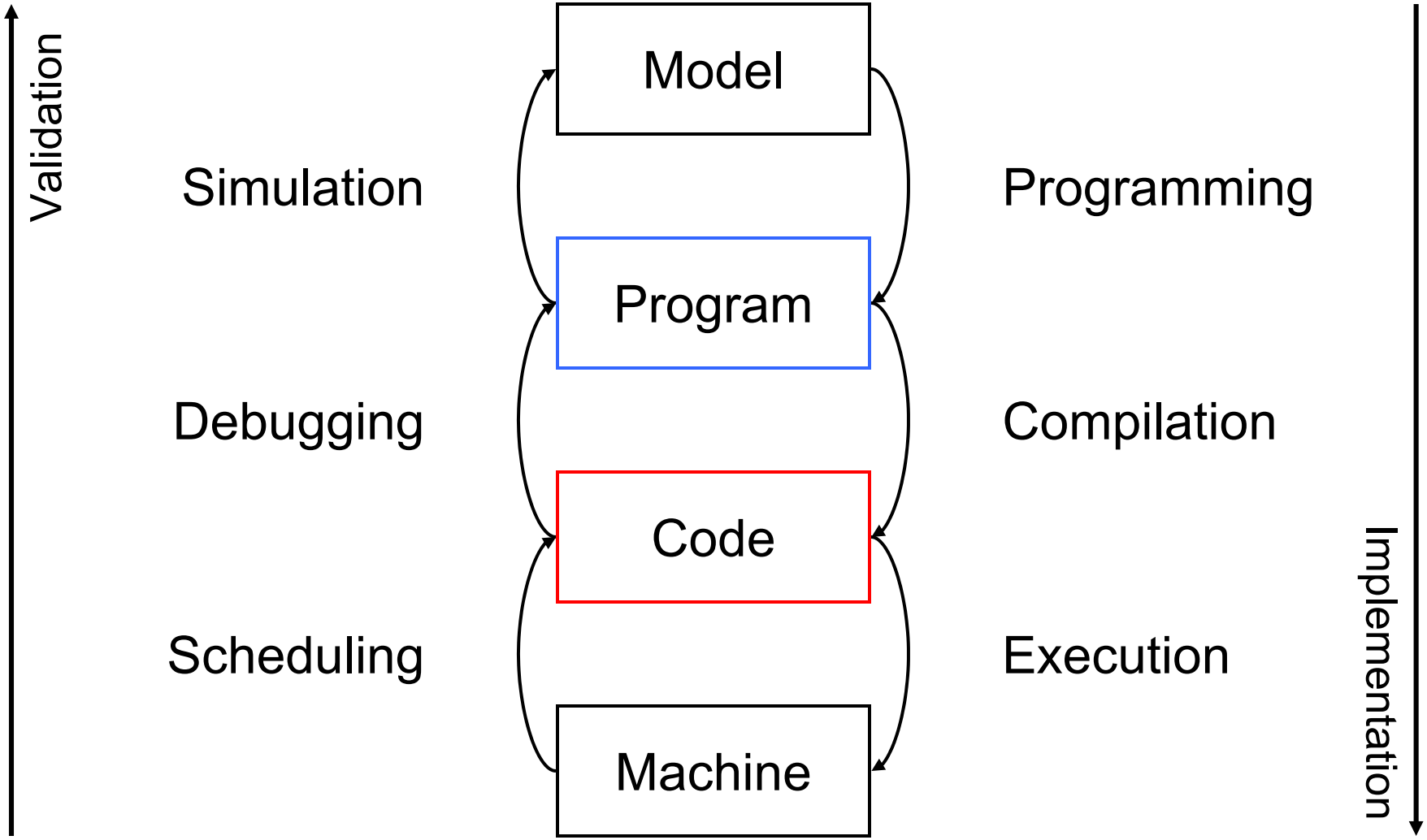
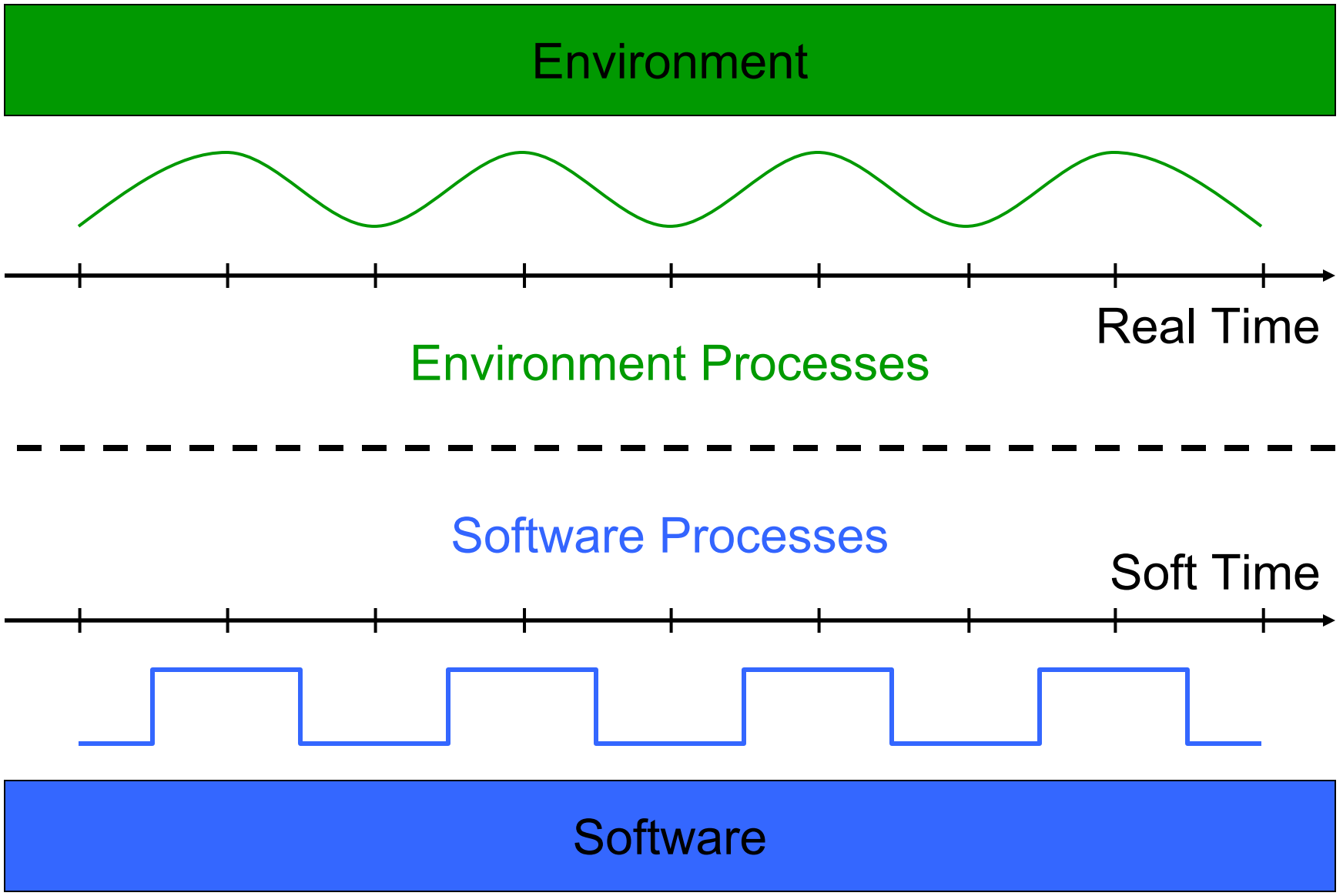
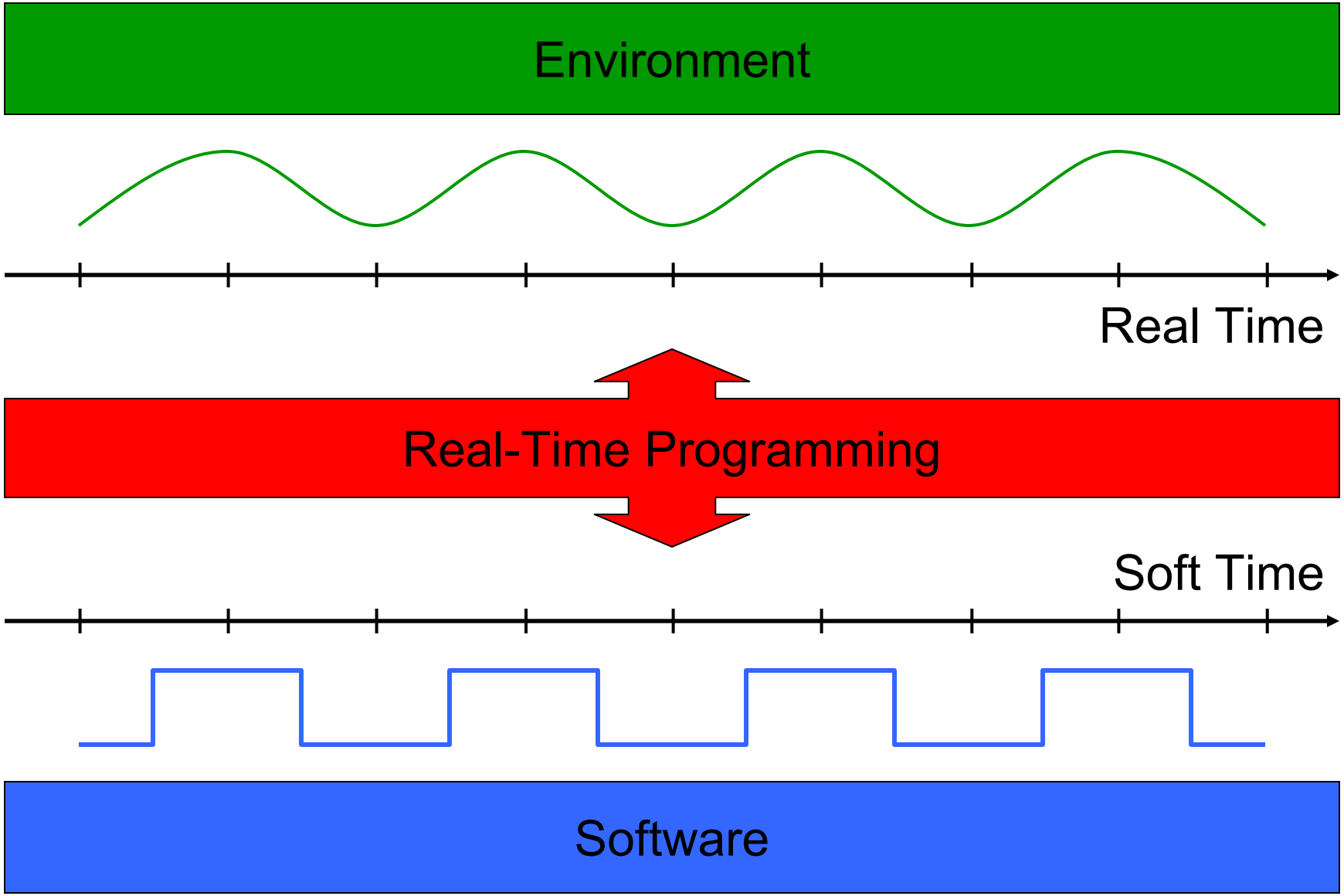
Real-Time Software Development



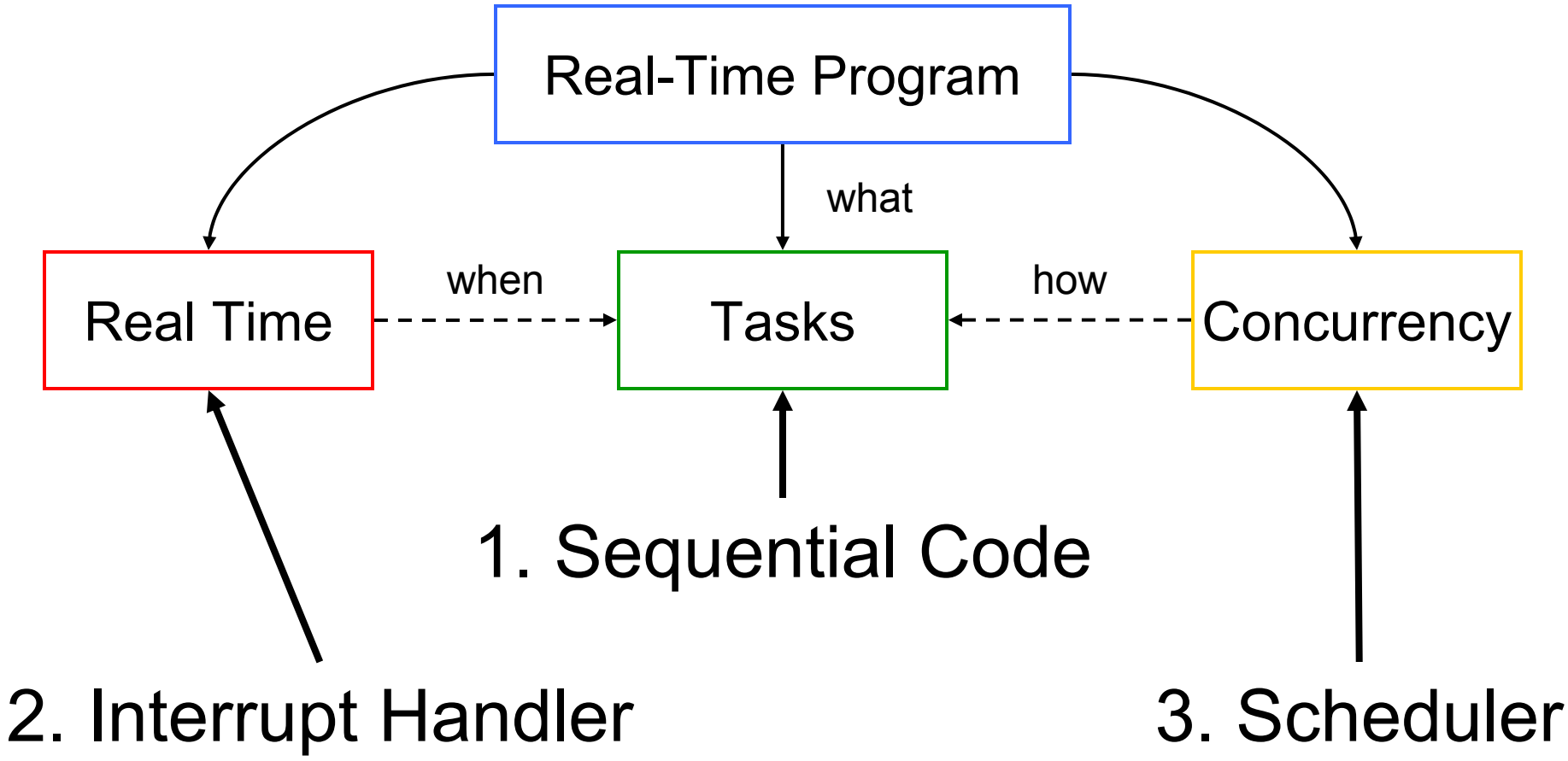
Real Time vs. Soft Time



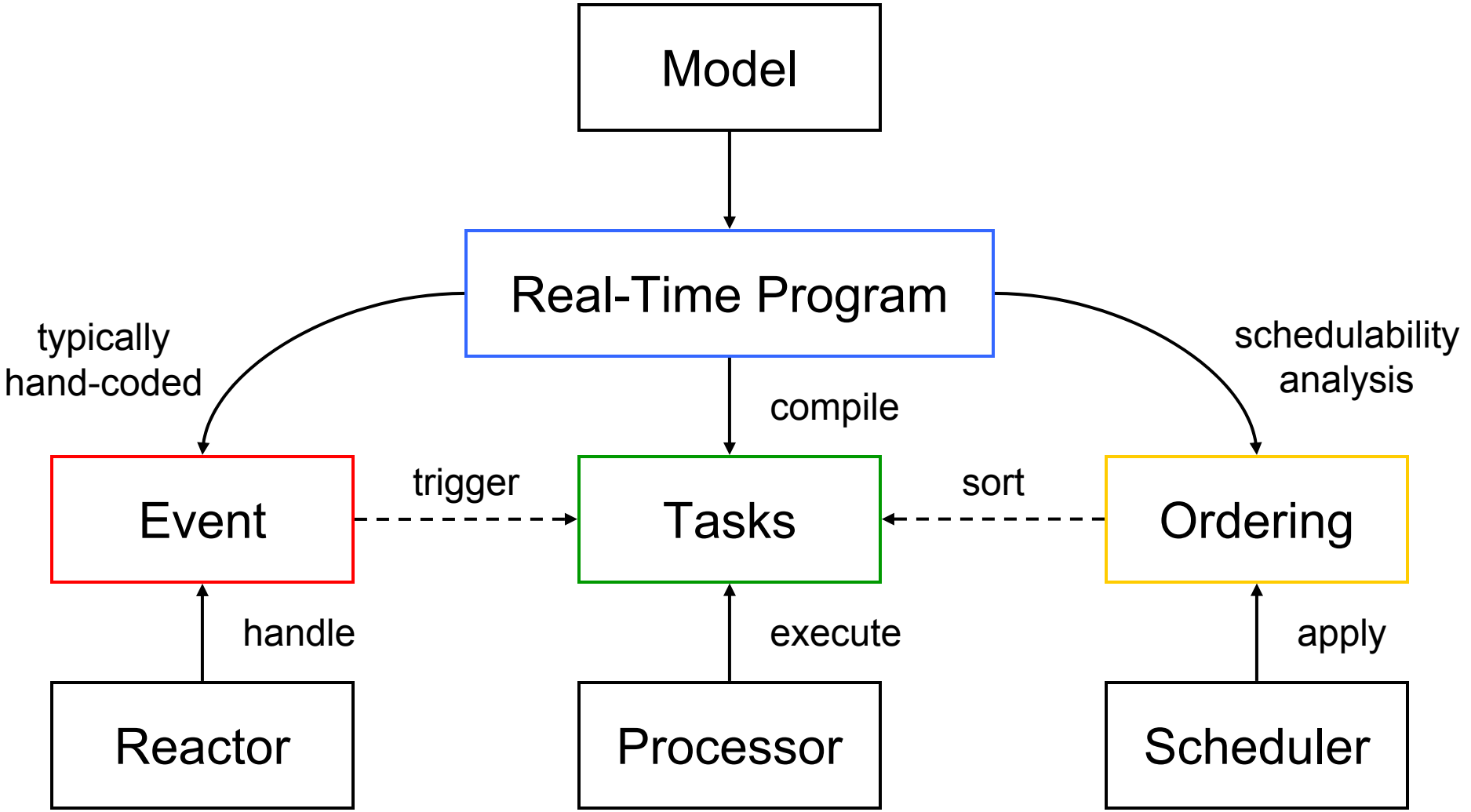
The Art of Real-Time Programming



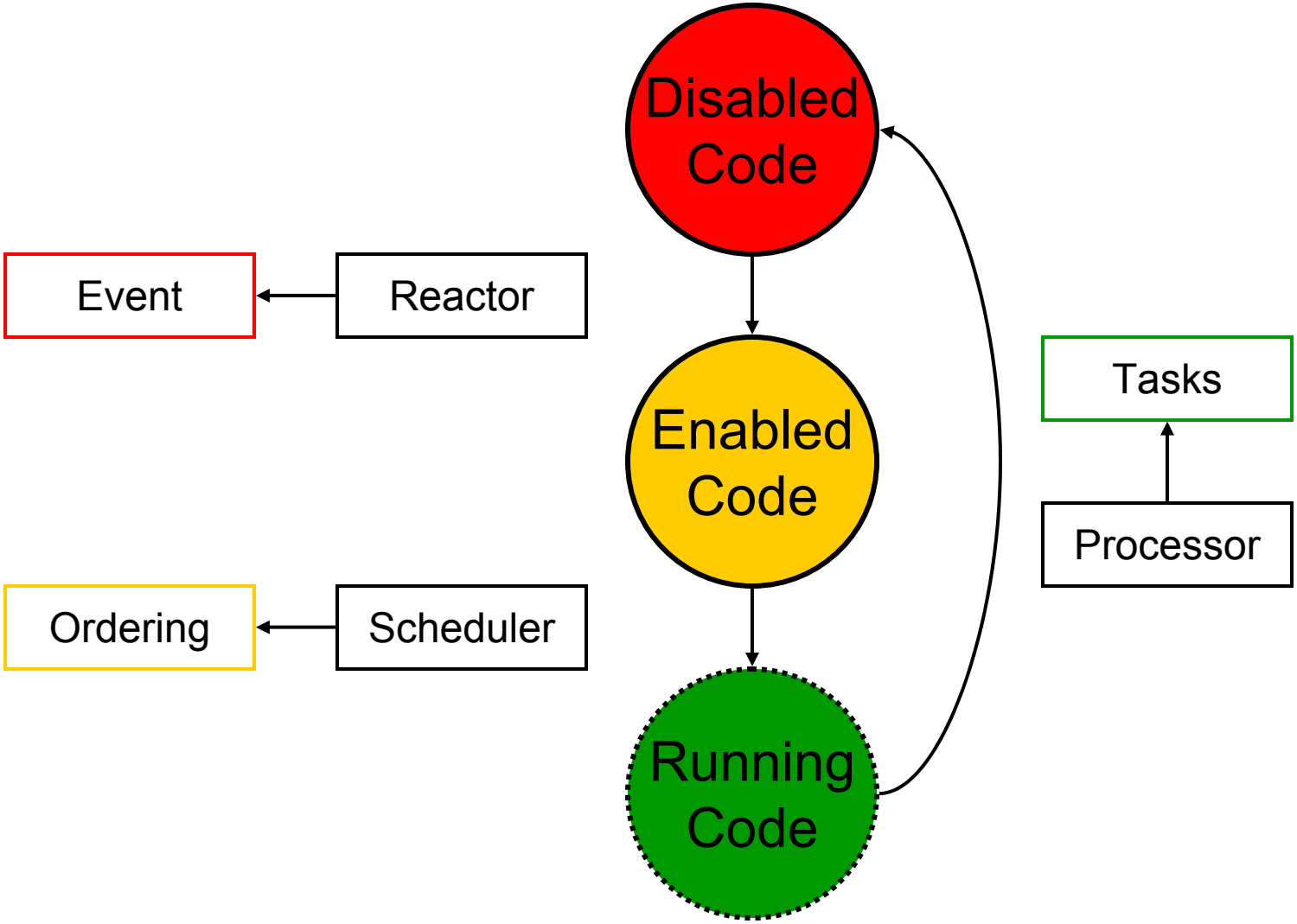
What is a Real-Time Program?



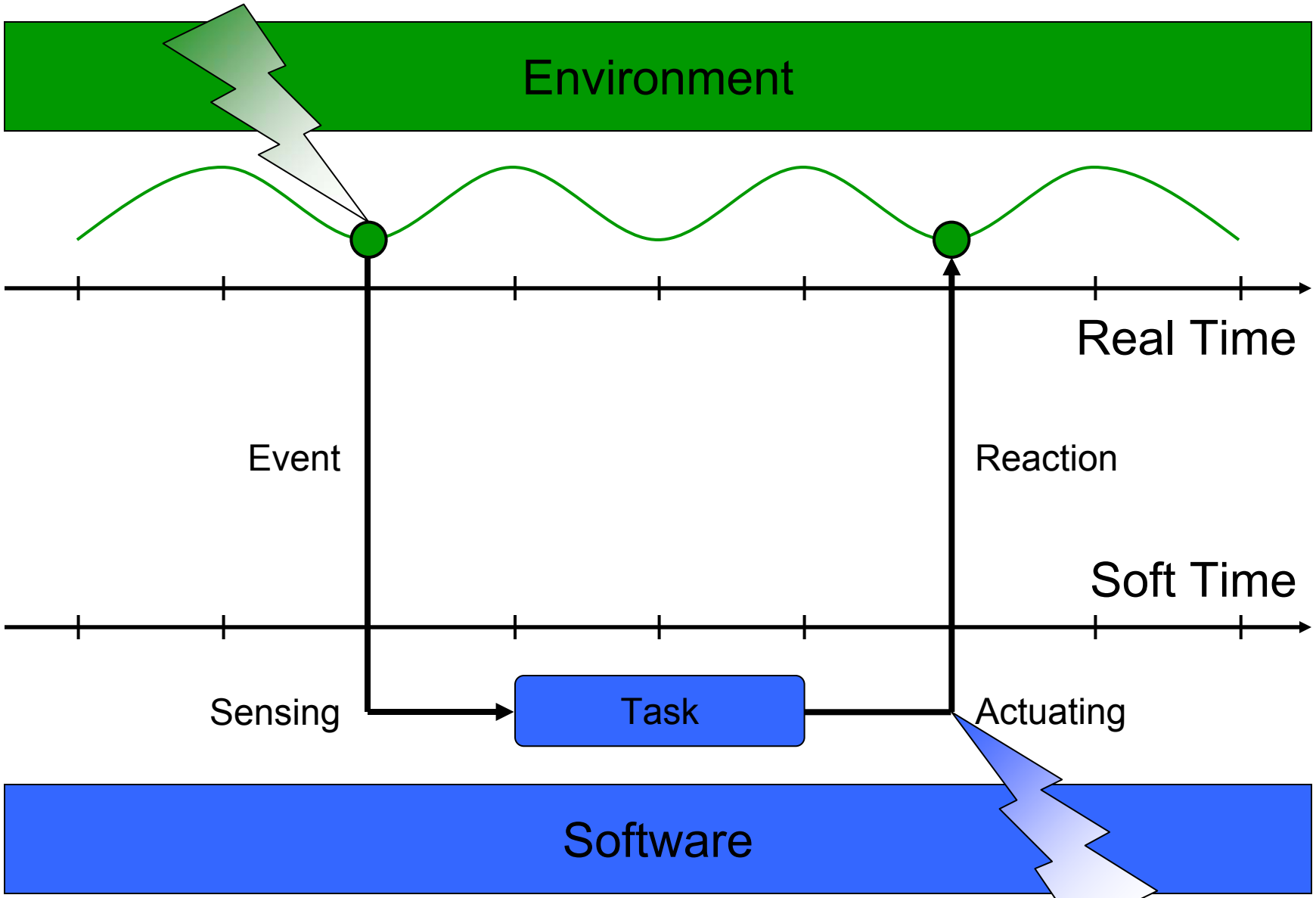
Real-Time Programming



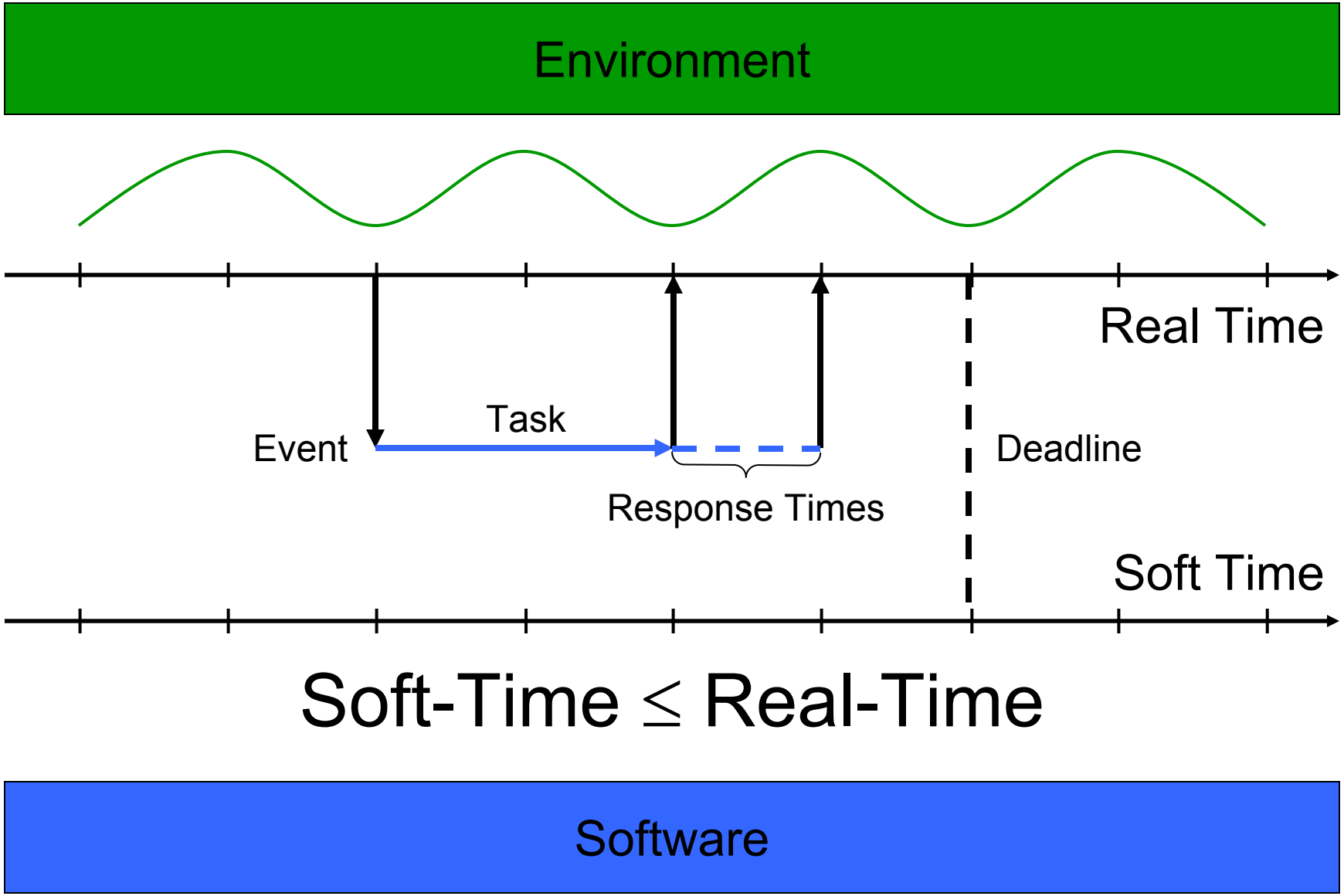
Triggering & Scheduling & Computing



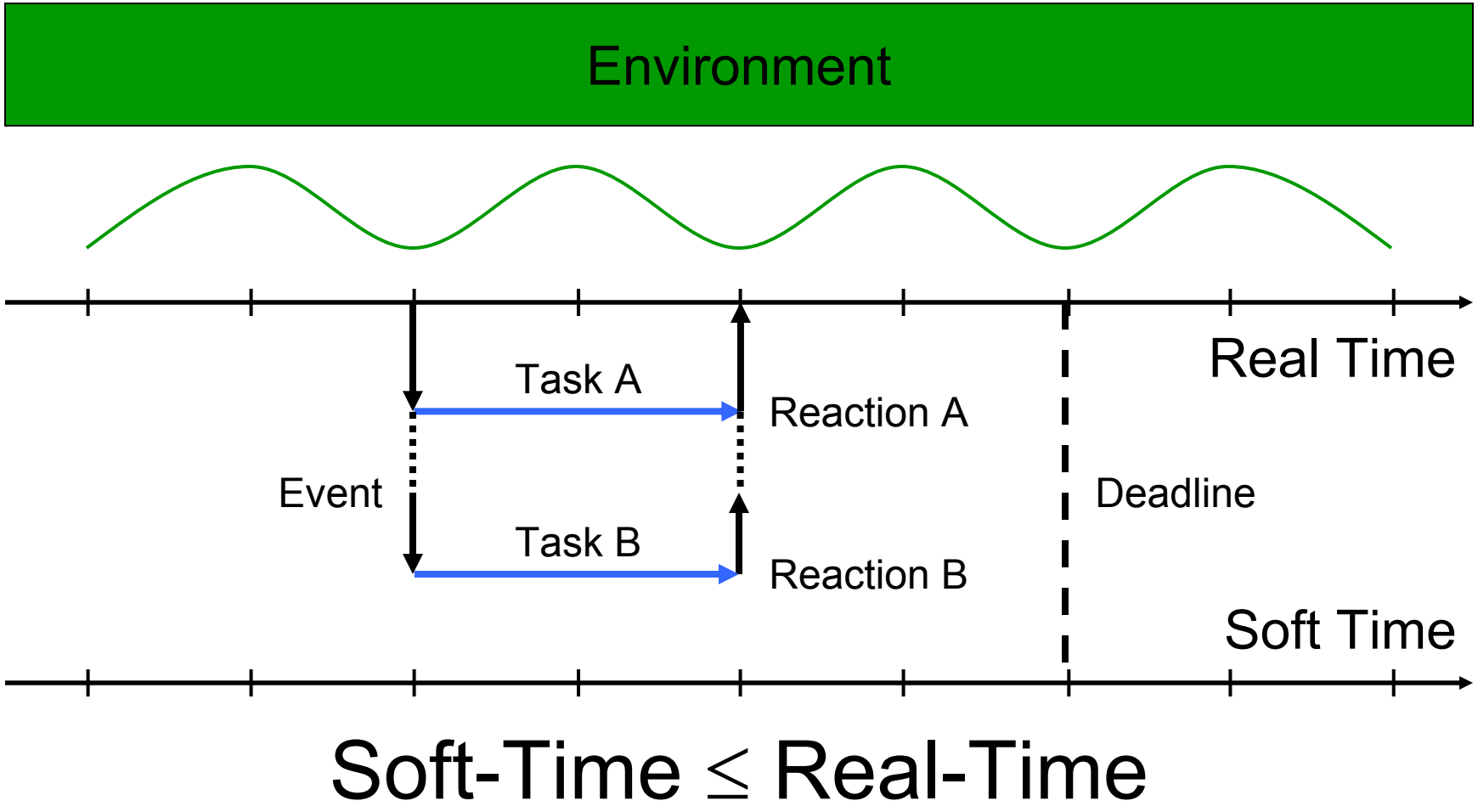
Sensing, Computing, Actuating



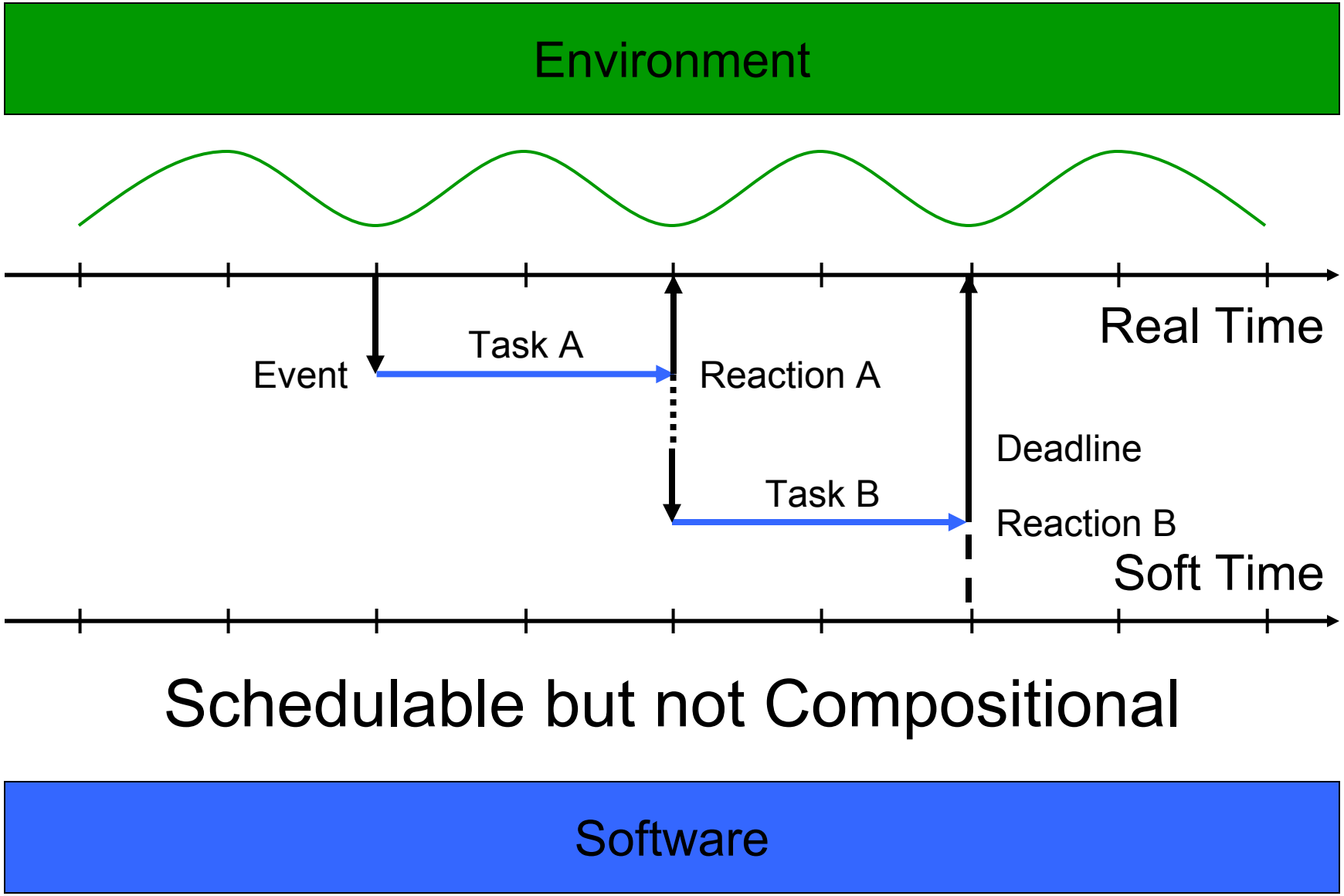
Scheduling Problem



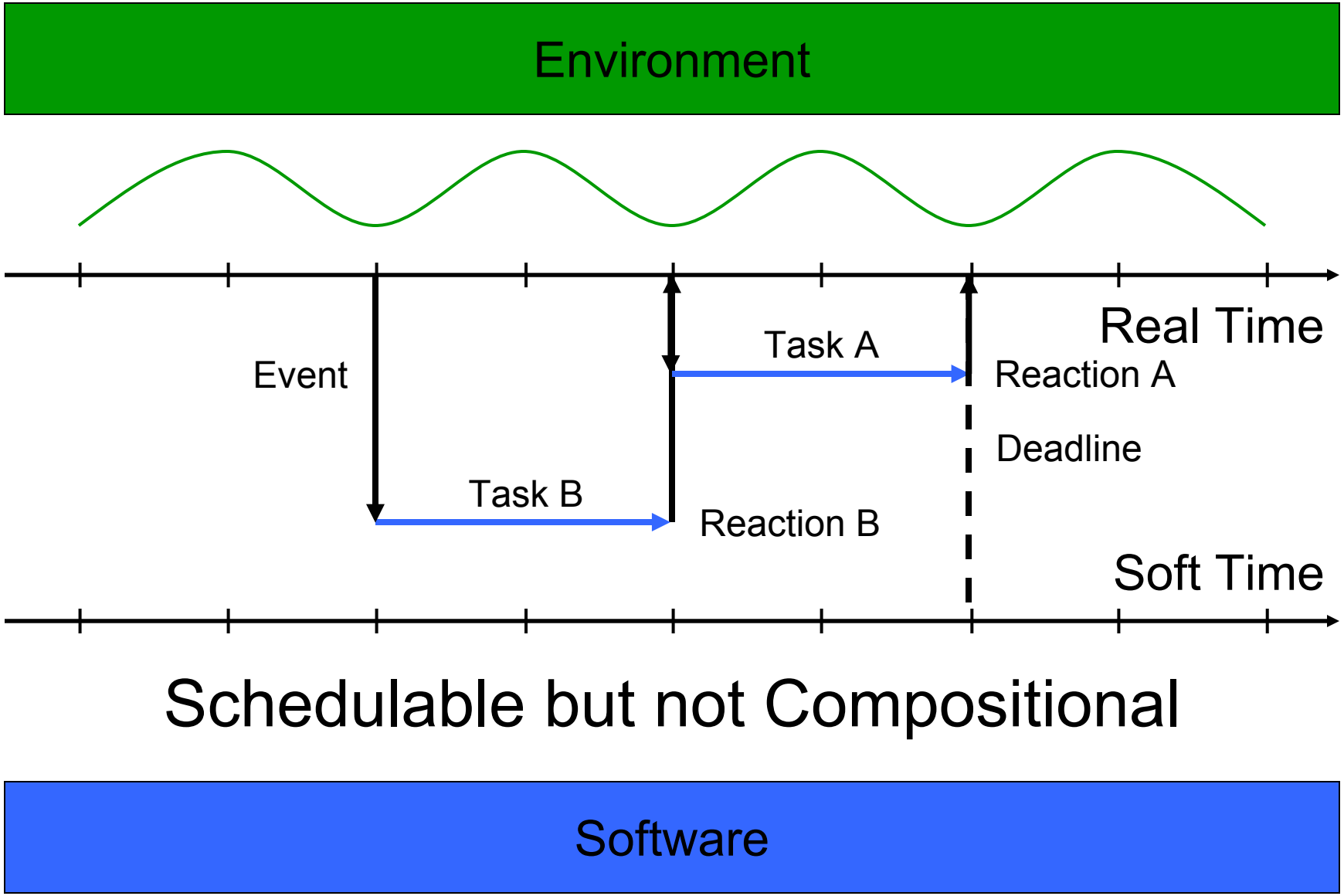
Concurrency



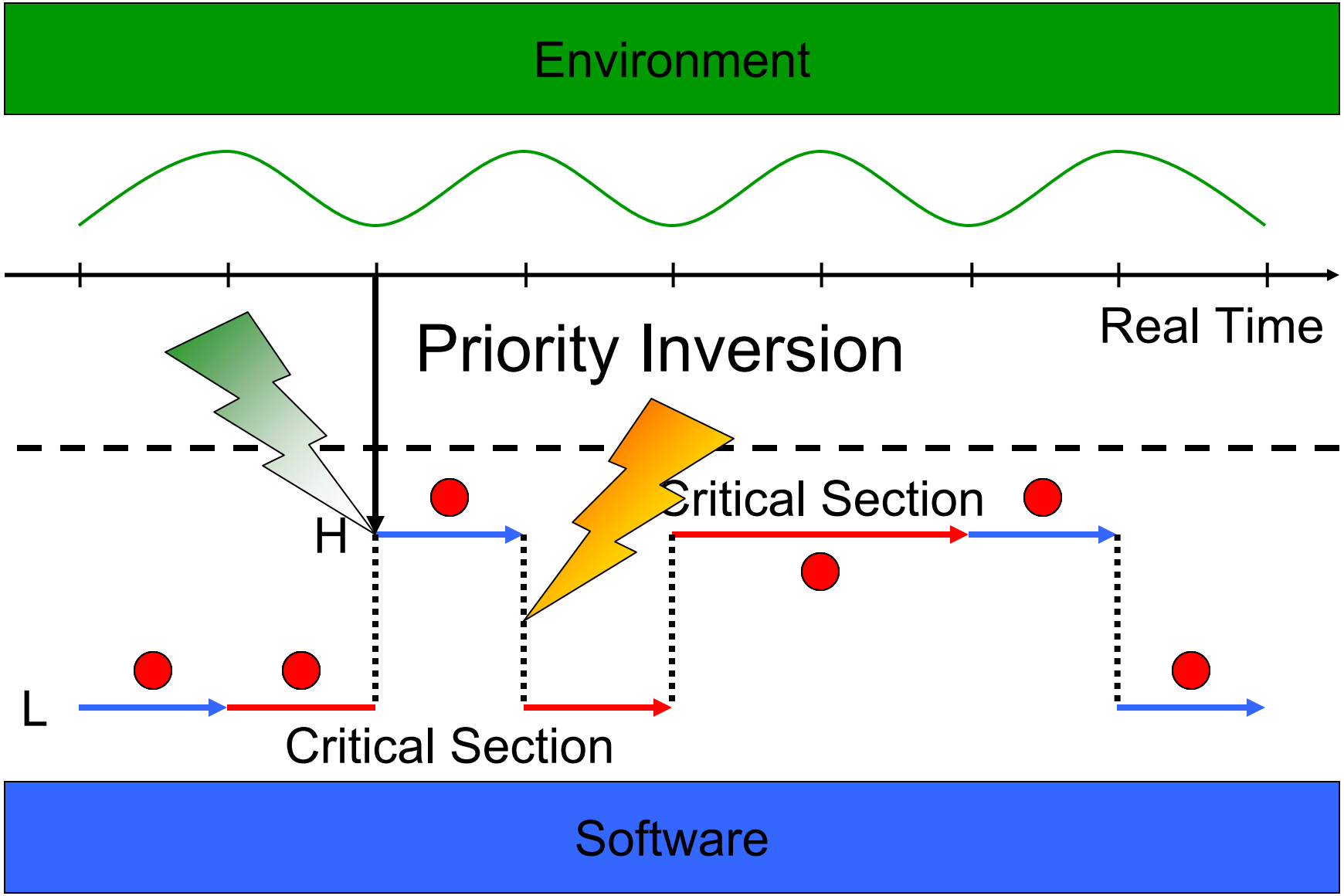
Problem: Time



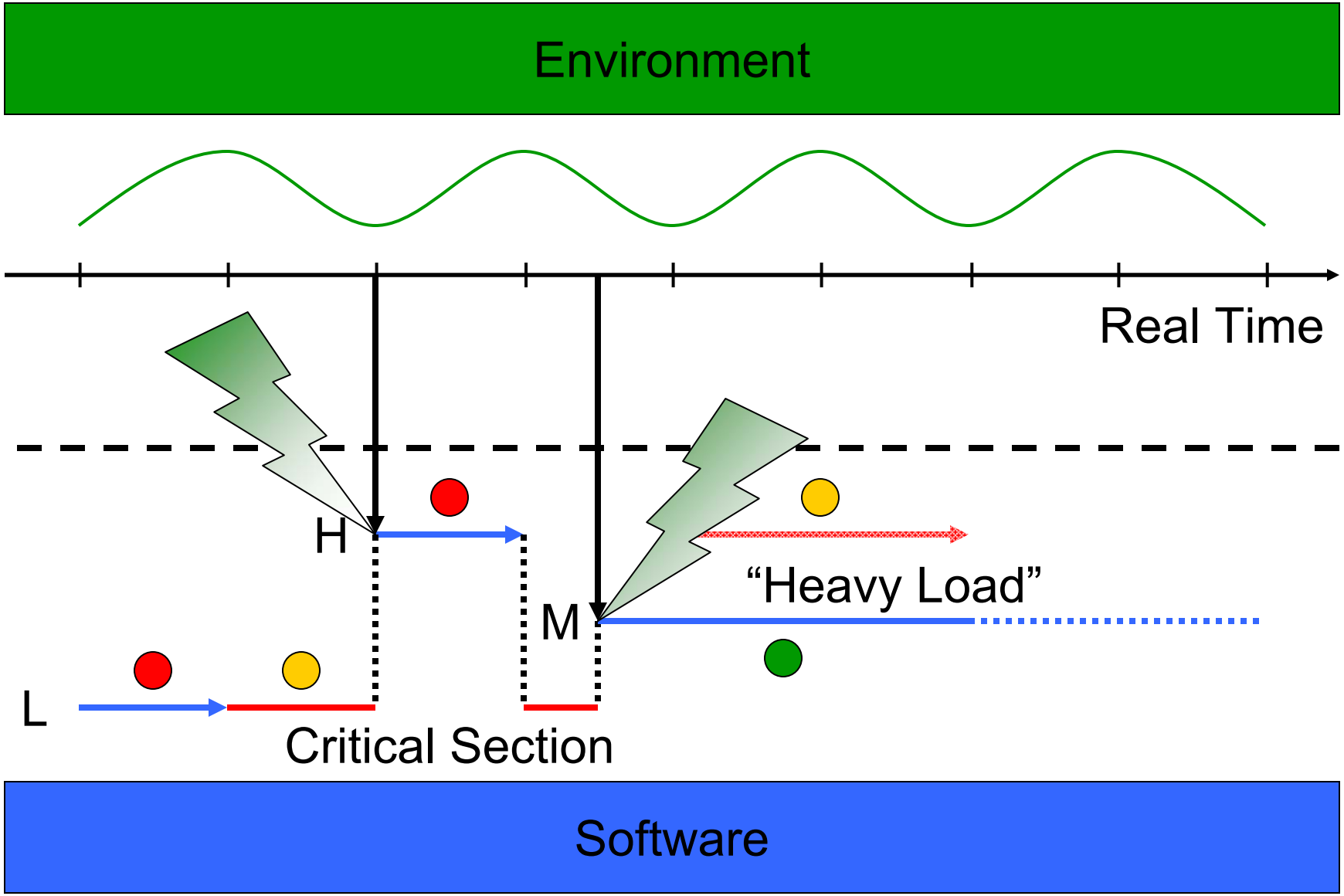
Problem: Value



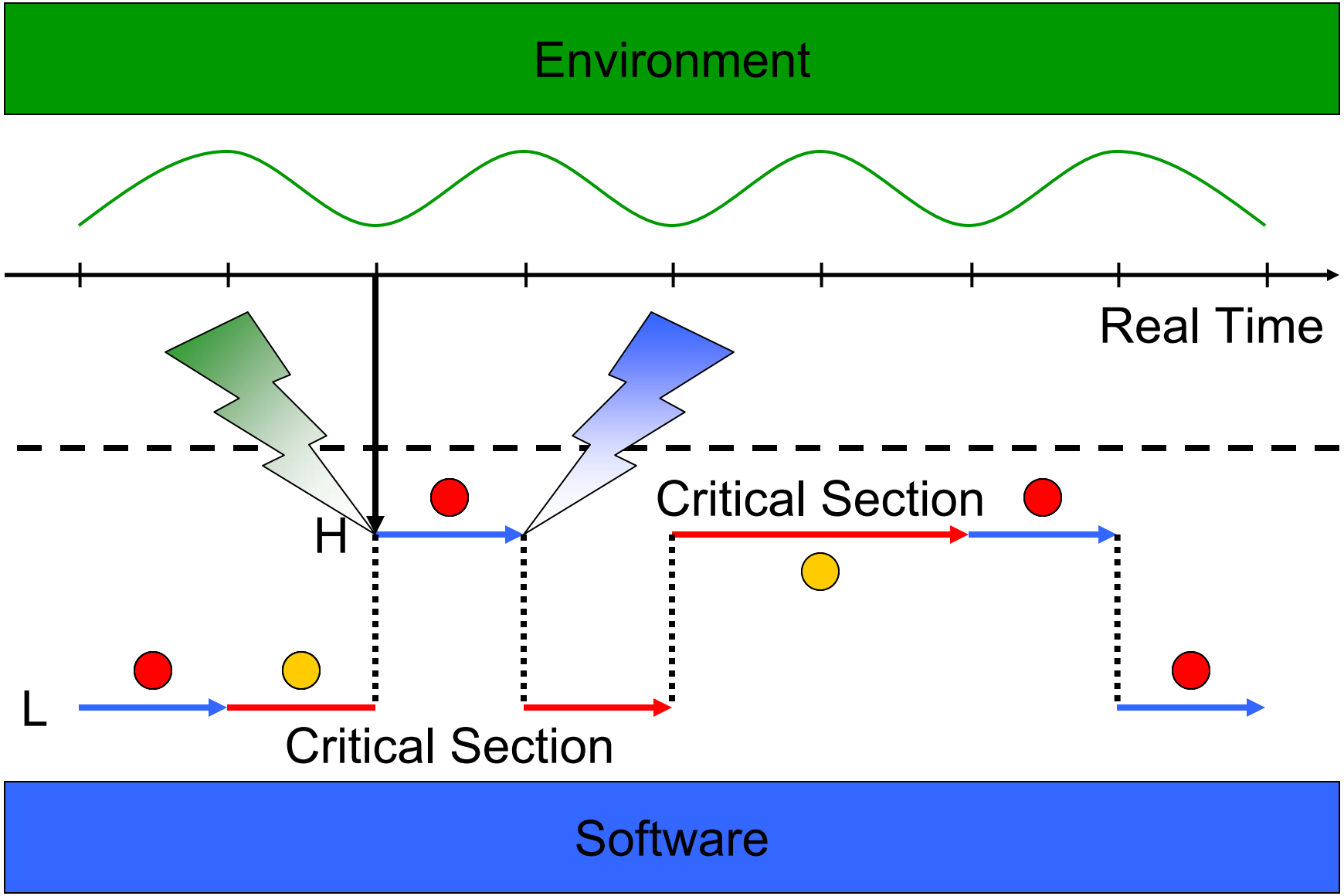
Problem: Unbounded Soft Time



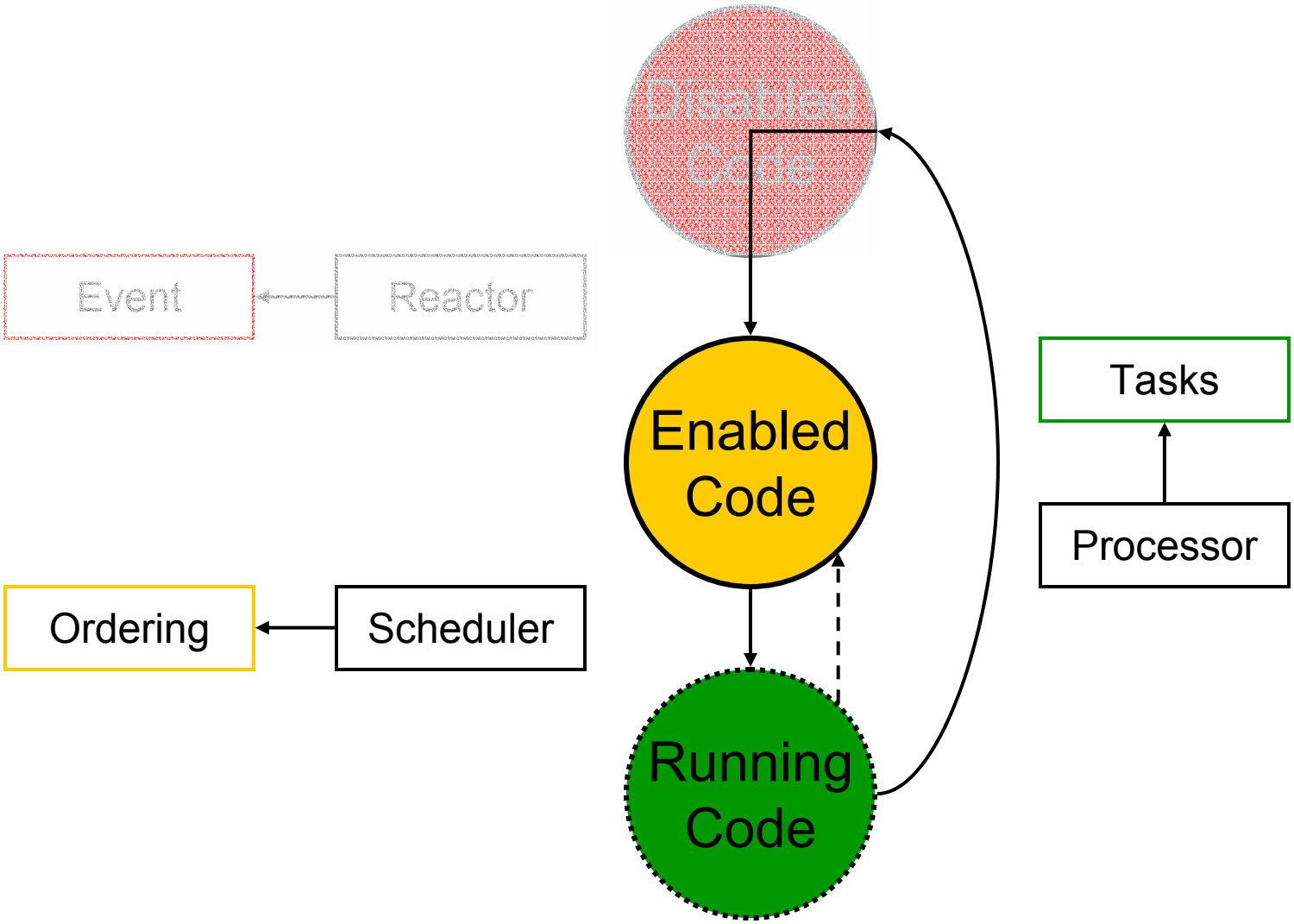
Problem: Unbounded Soft Time



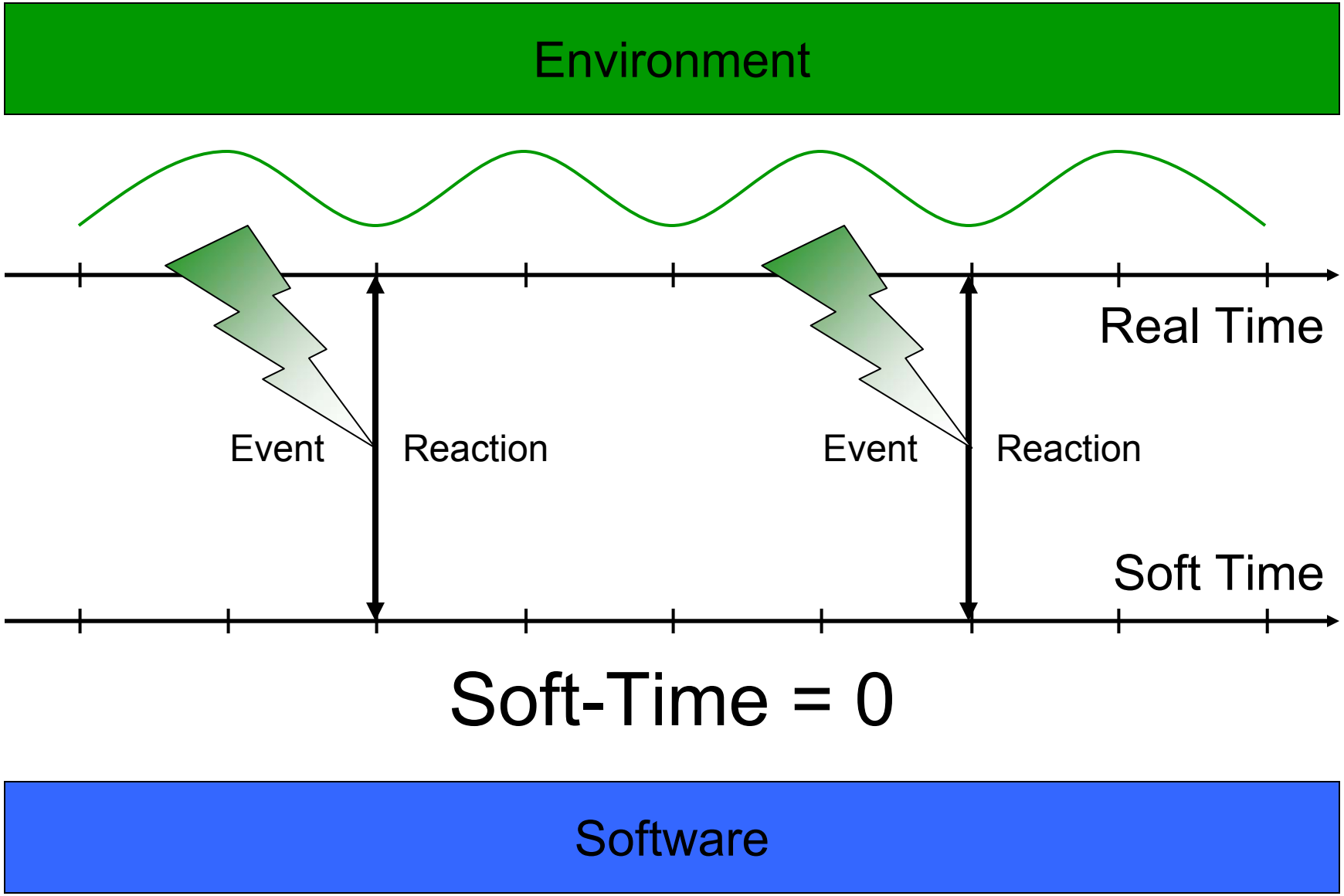
Analysis


Environment
Real Time
H
Critical Section
L
Critical Section
Software

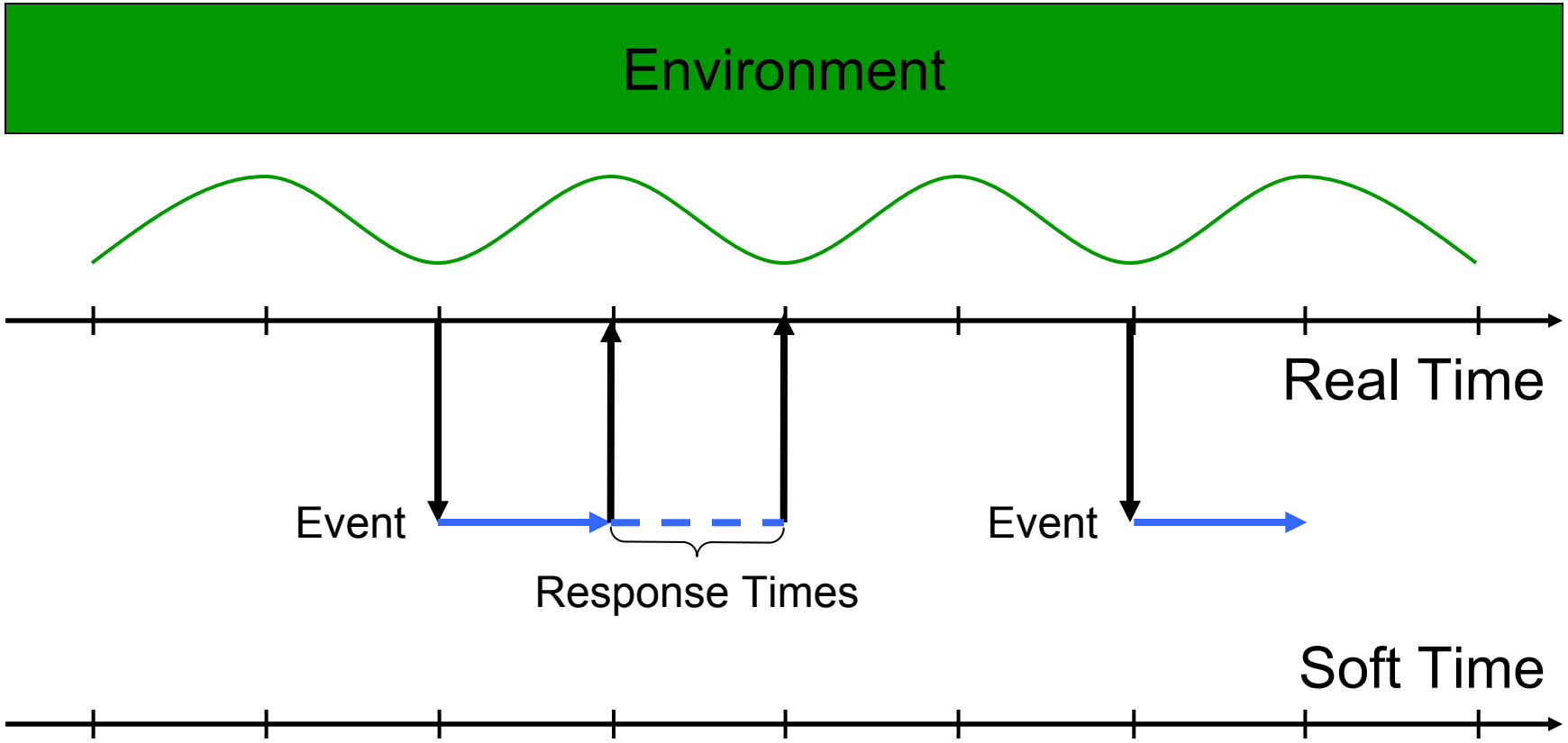
Trivial Reactor, Complex Scheduler



The Synchronous Model



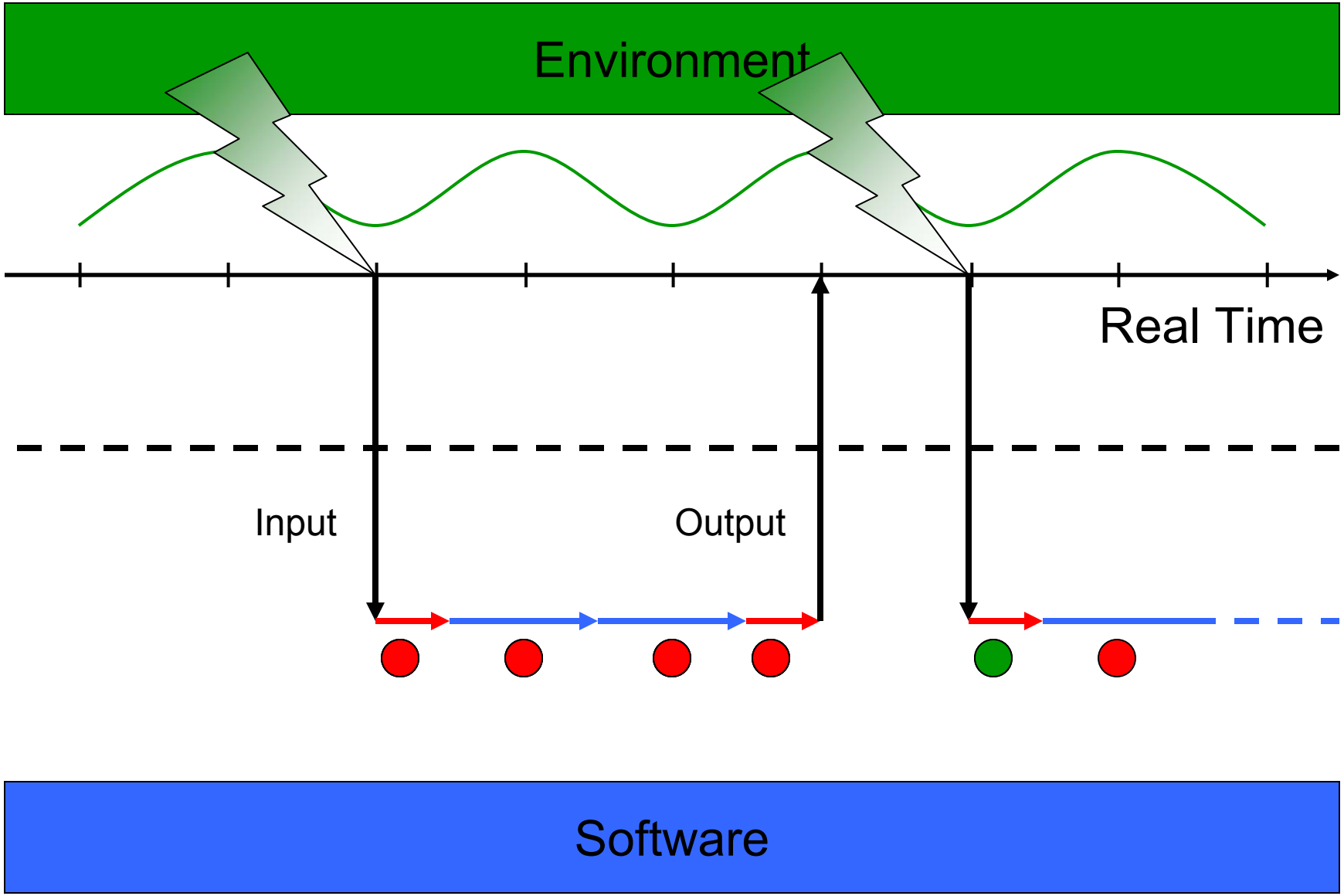
A Synchronous Implementation



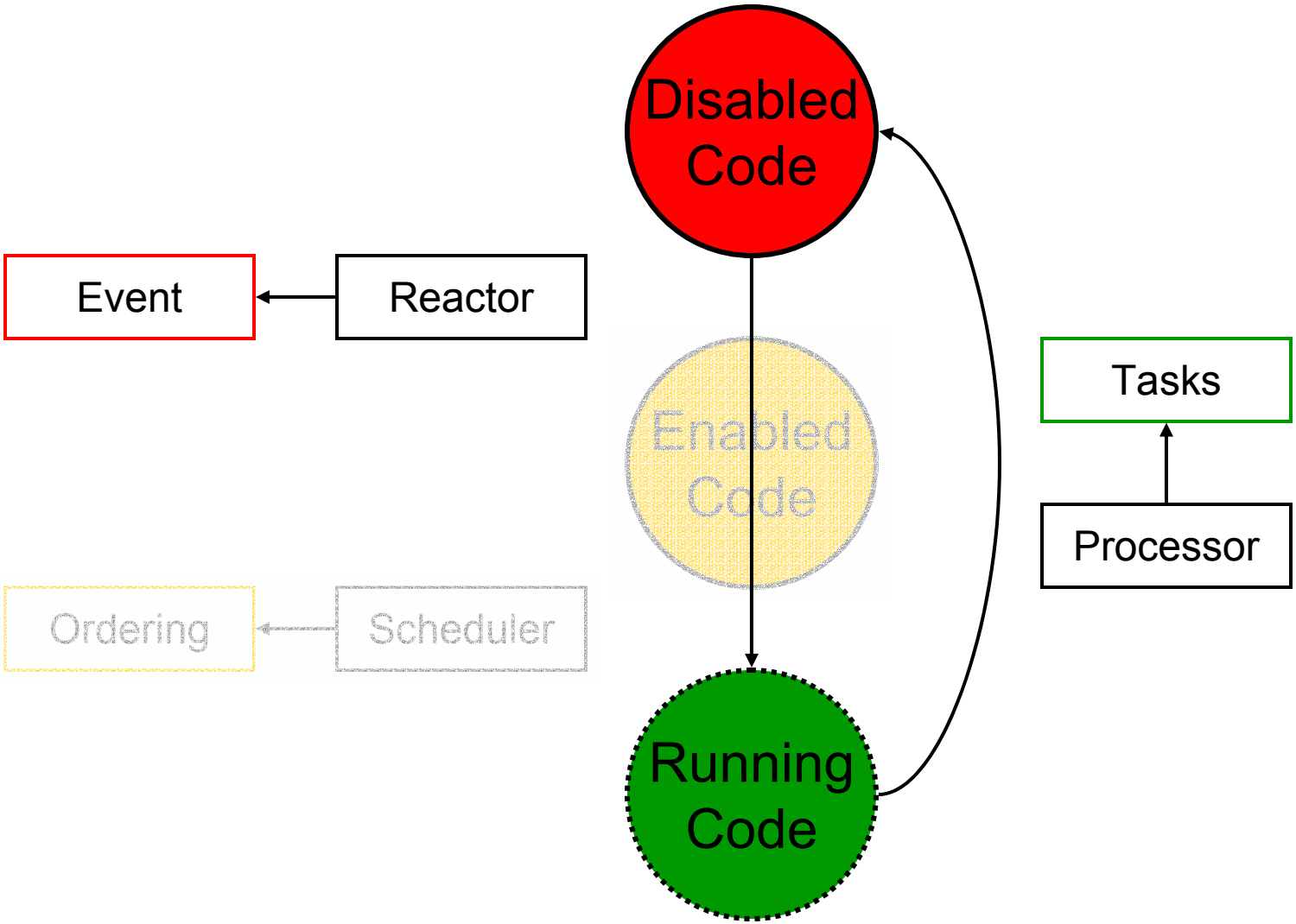
Synchronous but not Compositional

Software

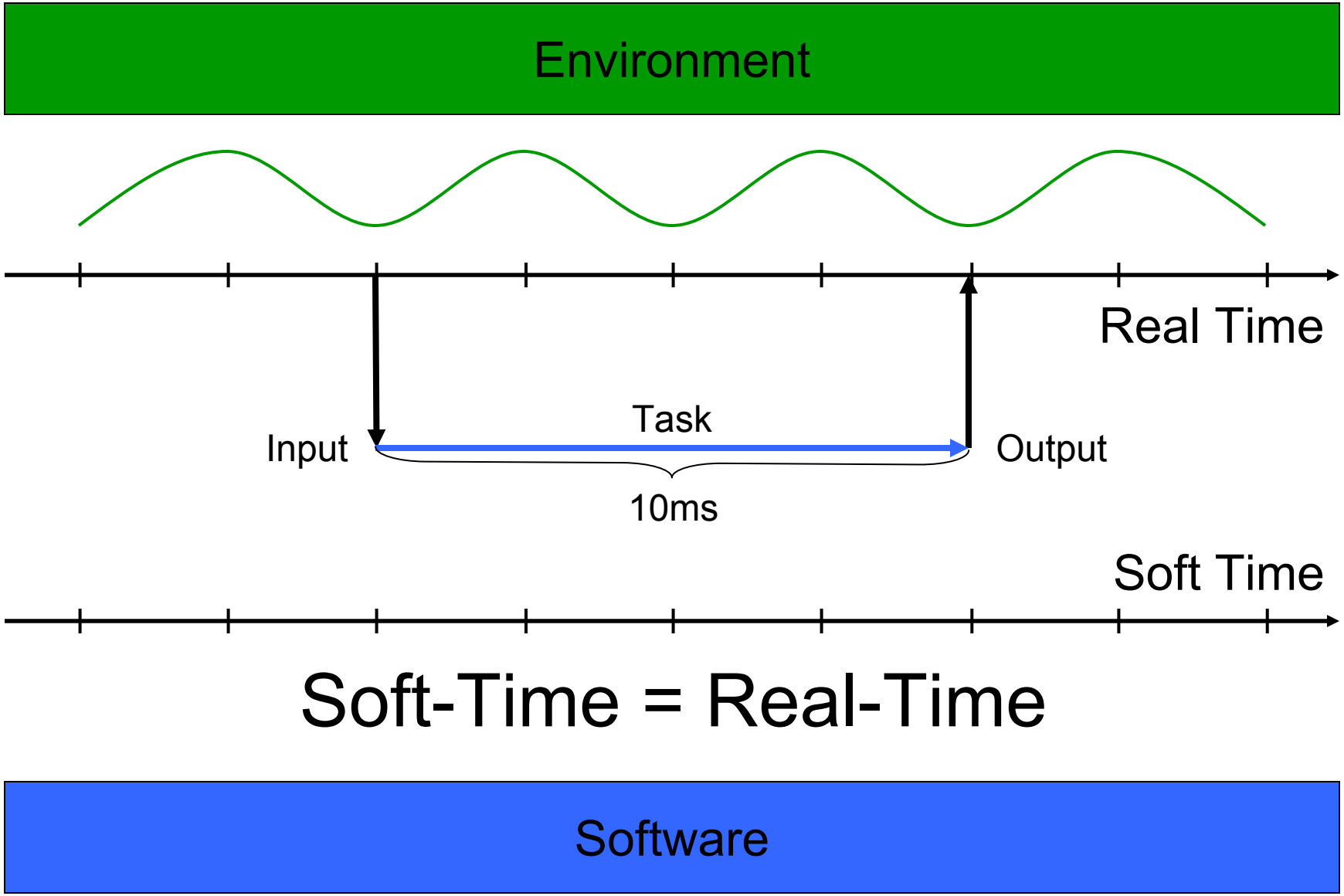
Synchrony



Complex Reactor, Trivial Scheduler



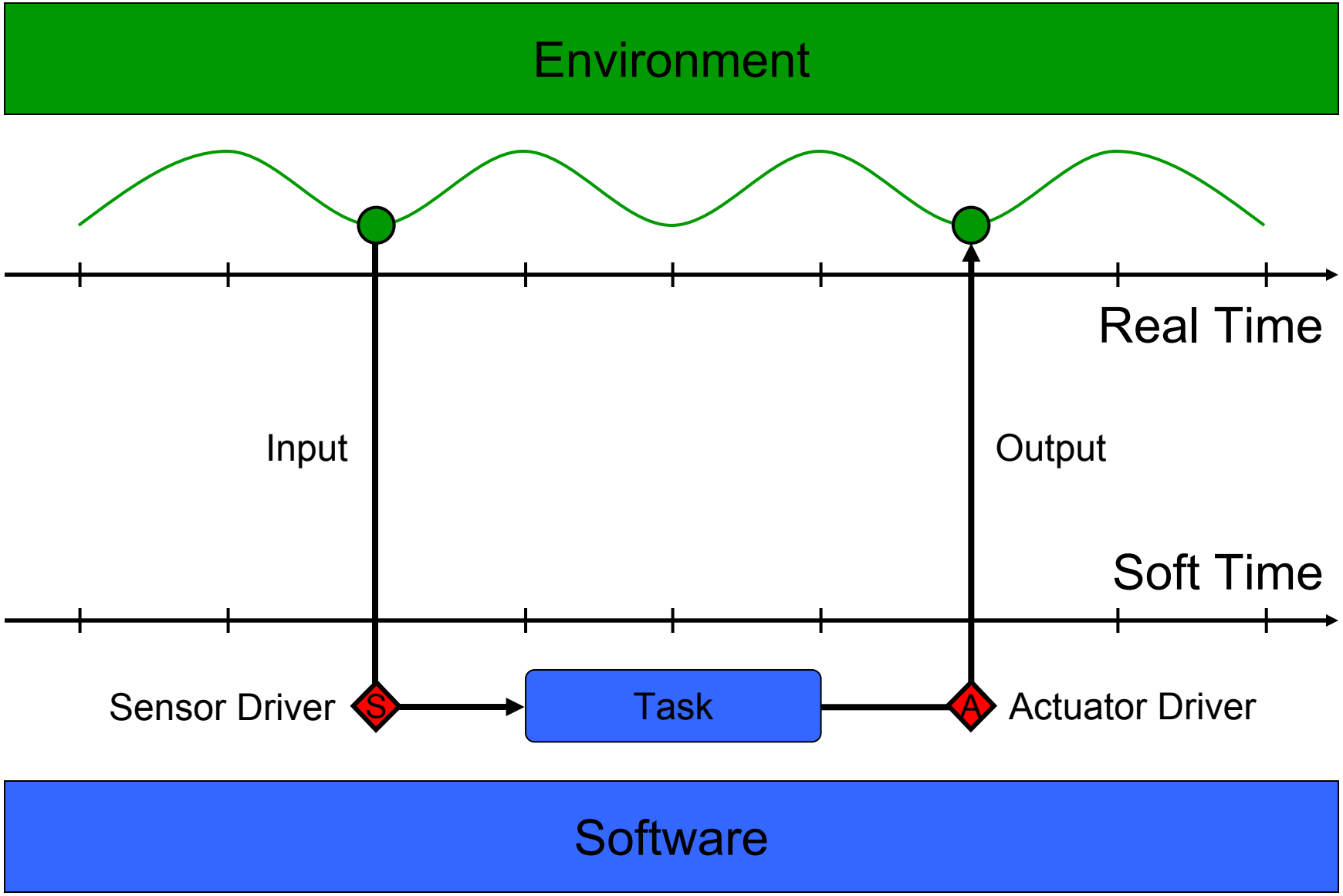
Programming Abstraction



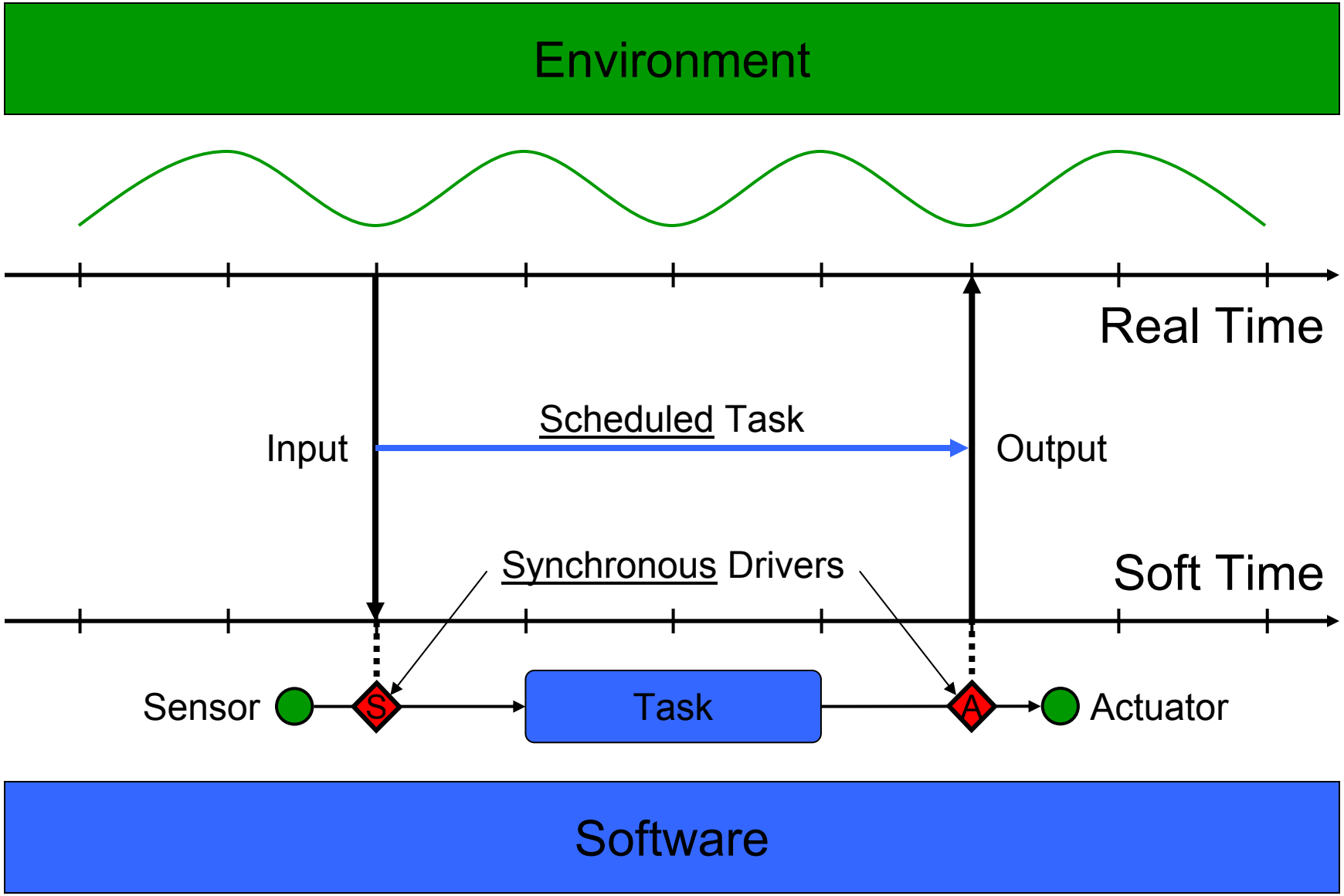
Soft-Time = Real-Time

Software

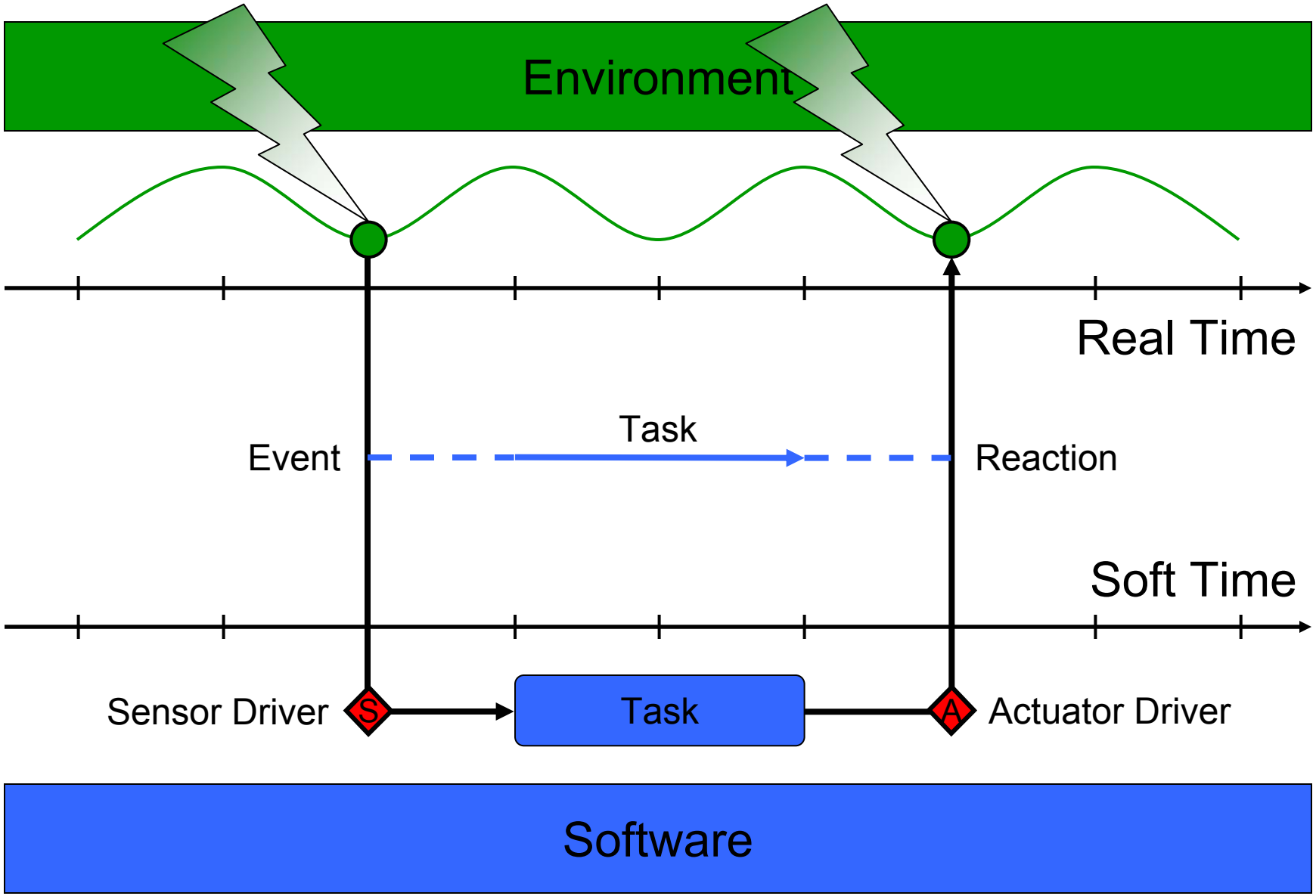
Driver vs. Task



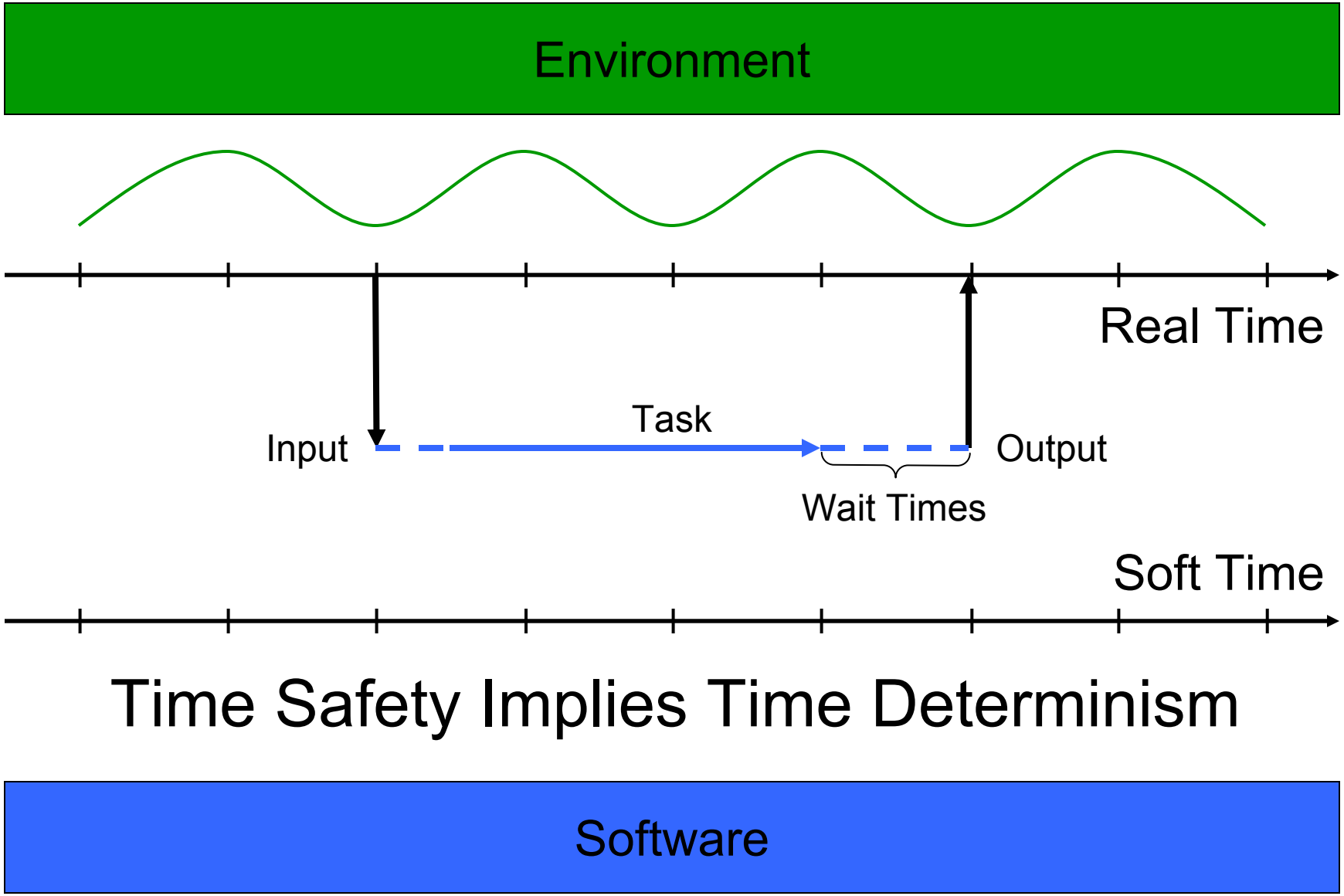
Synchronous vs. Scheduled Computation



Environment-triggered Programs

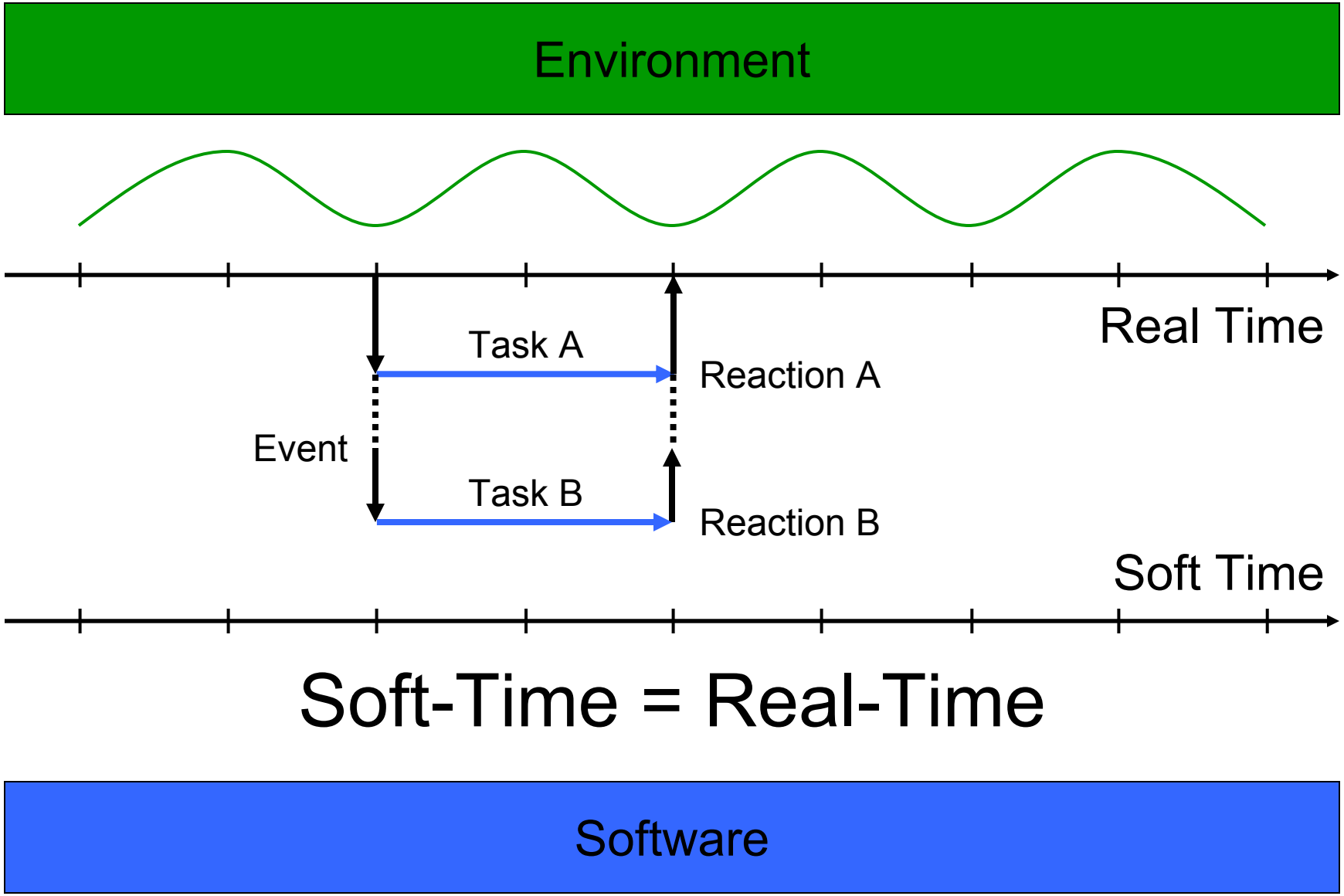


A Time-Safe Implementation

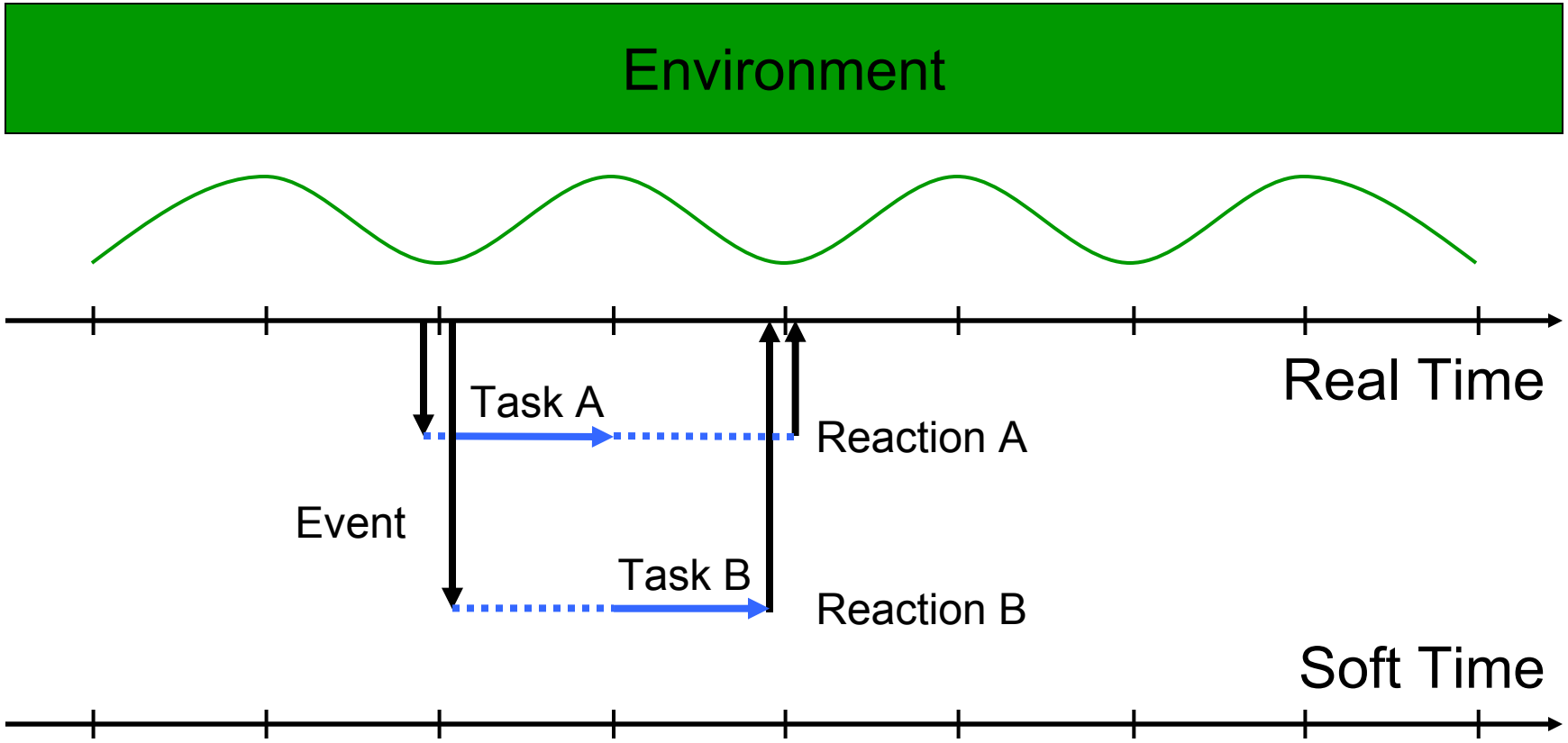


Time Safety Implies Time Determinism

Parallel Composition



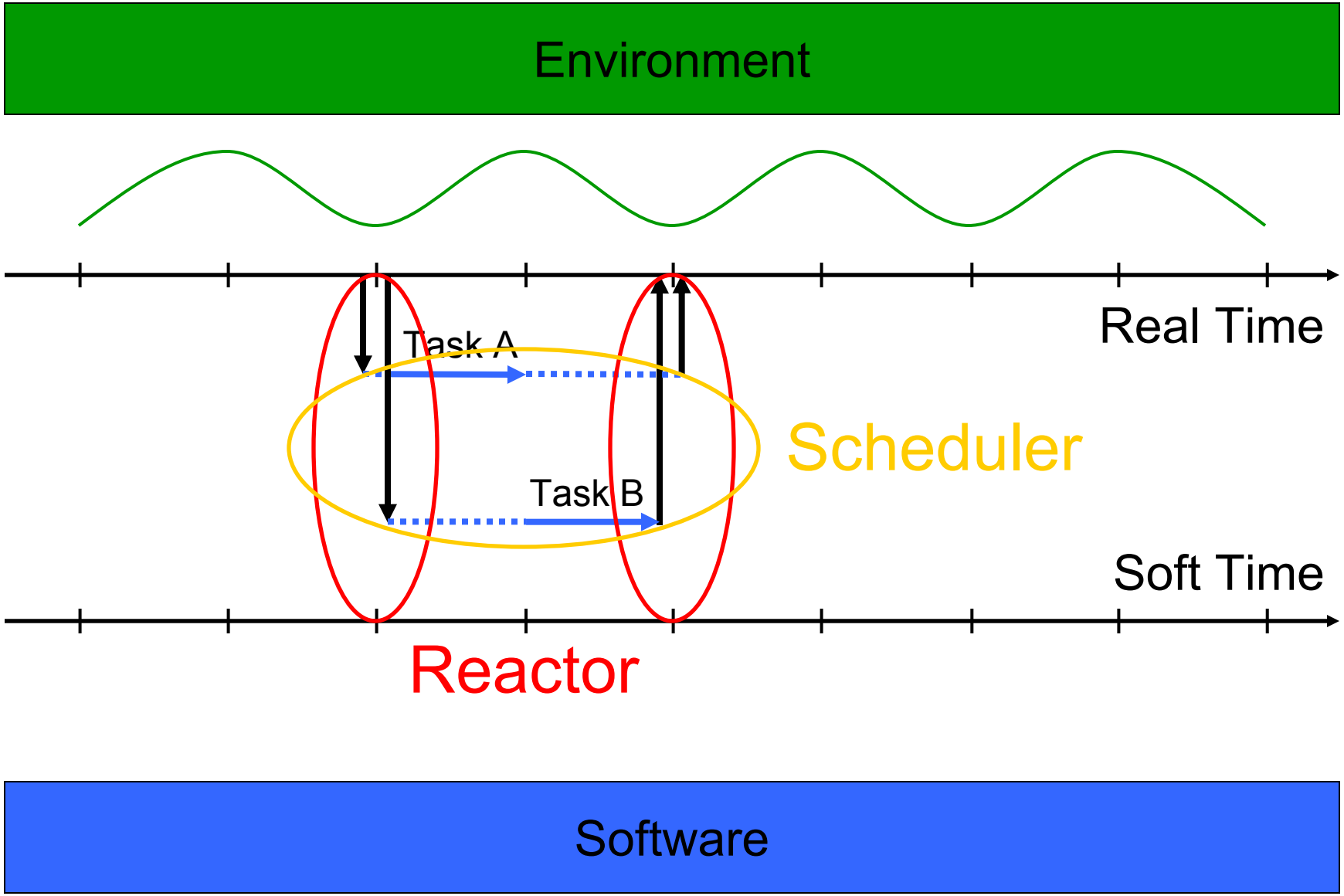
Implementation



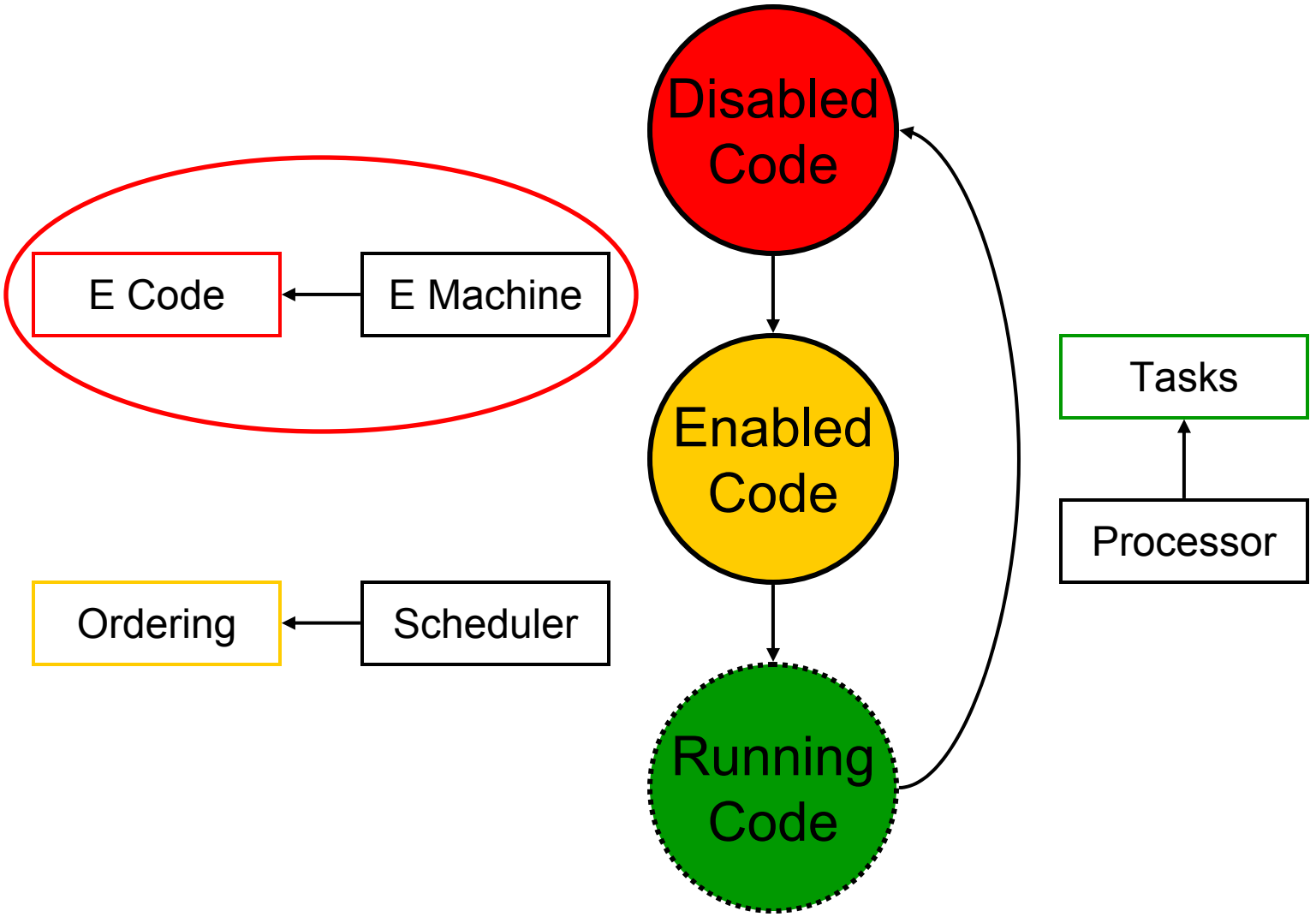
Compositional wrt. Time Determinism

Software

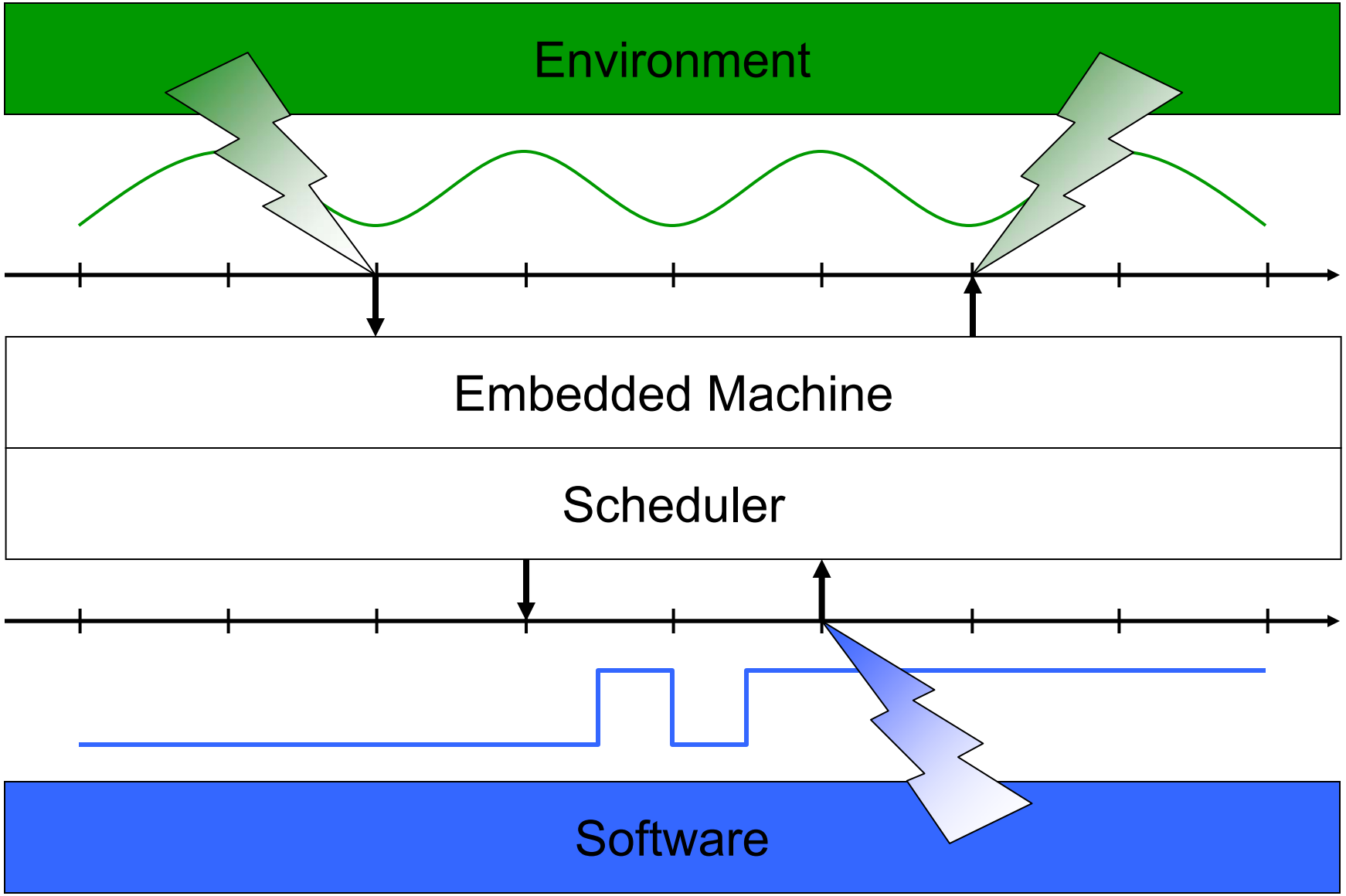
Let's Program



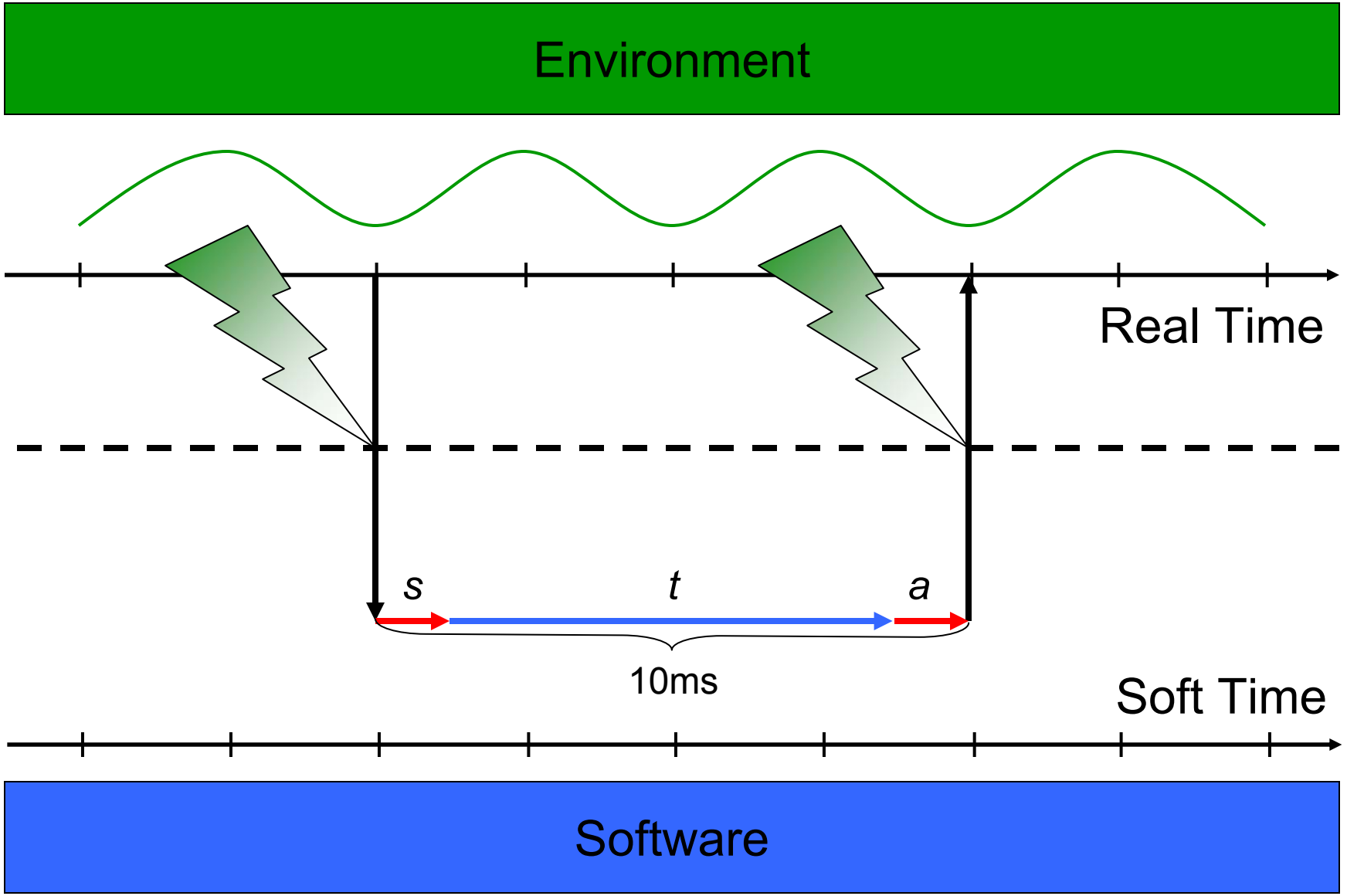
The Embedded Machine



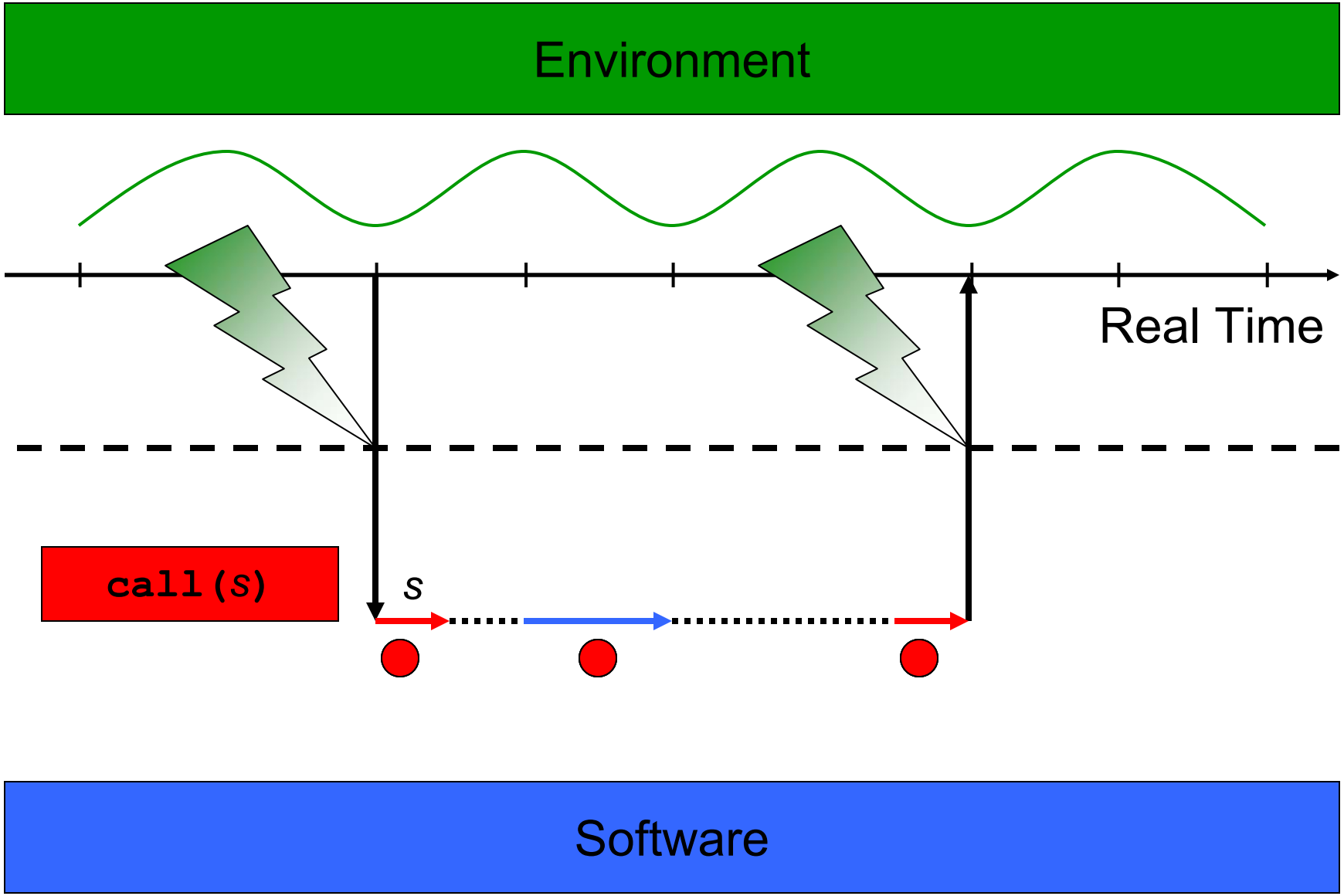
Reactivity and Proactivity



Example



E Code



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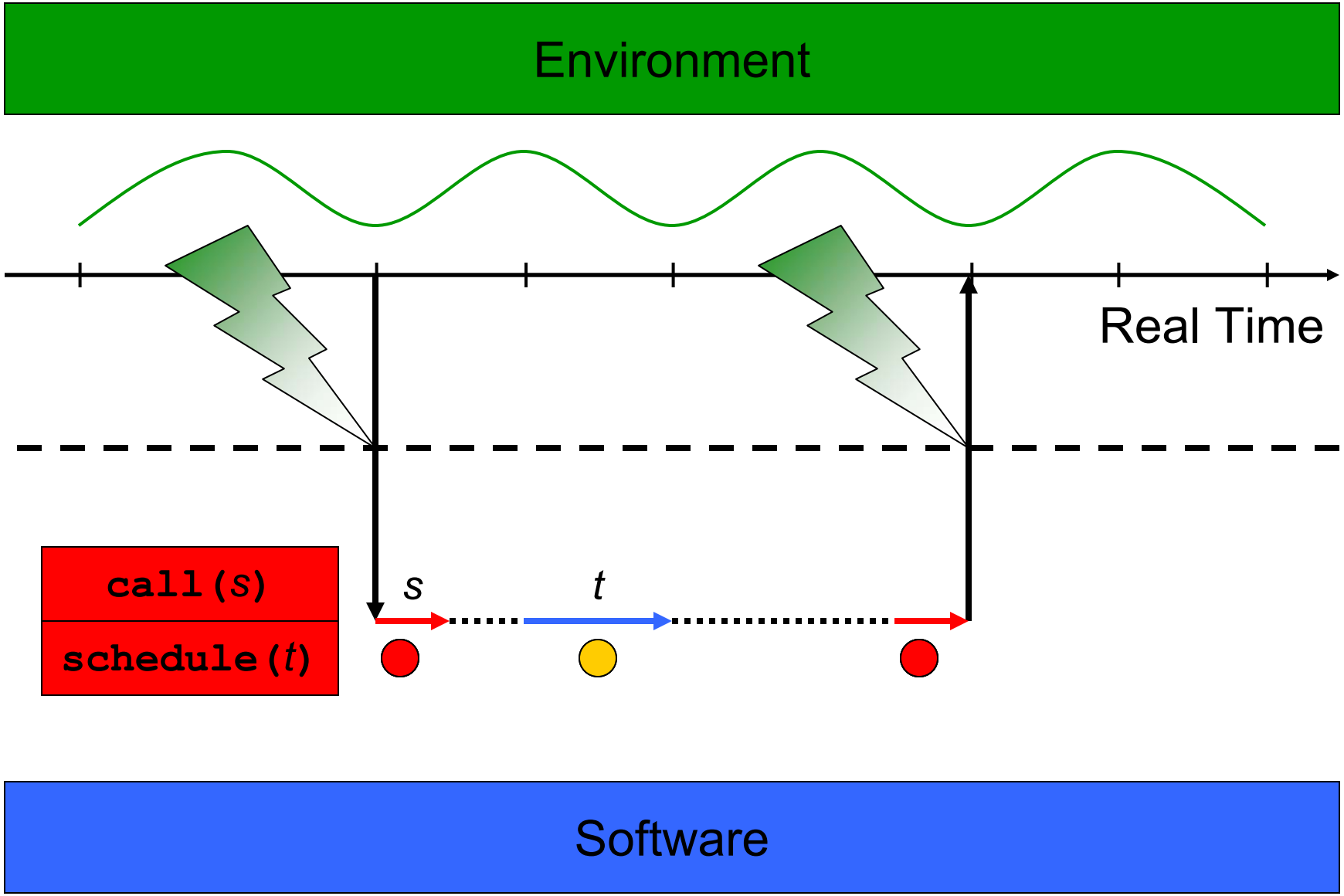

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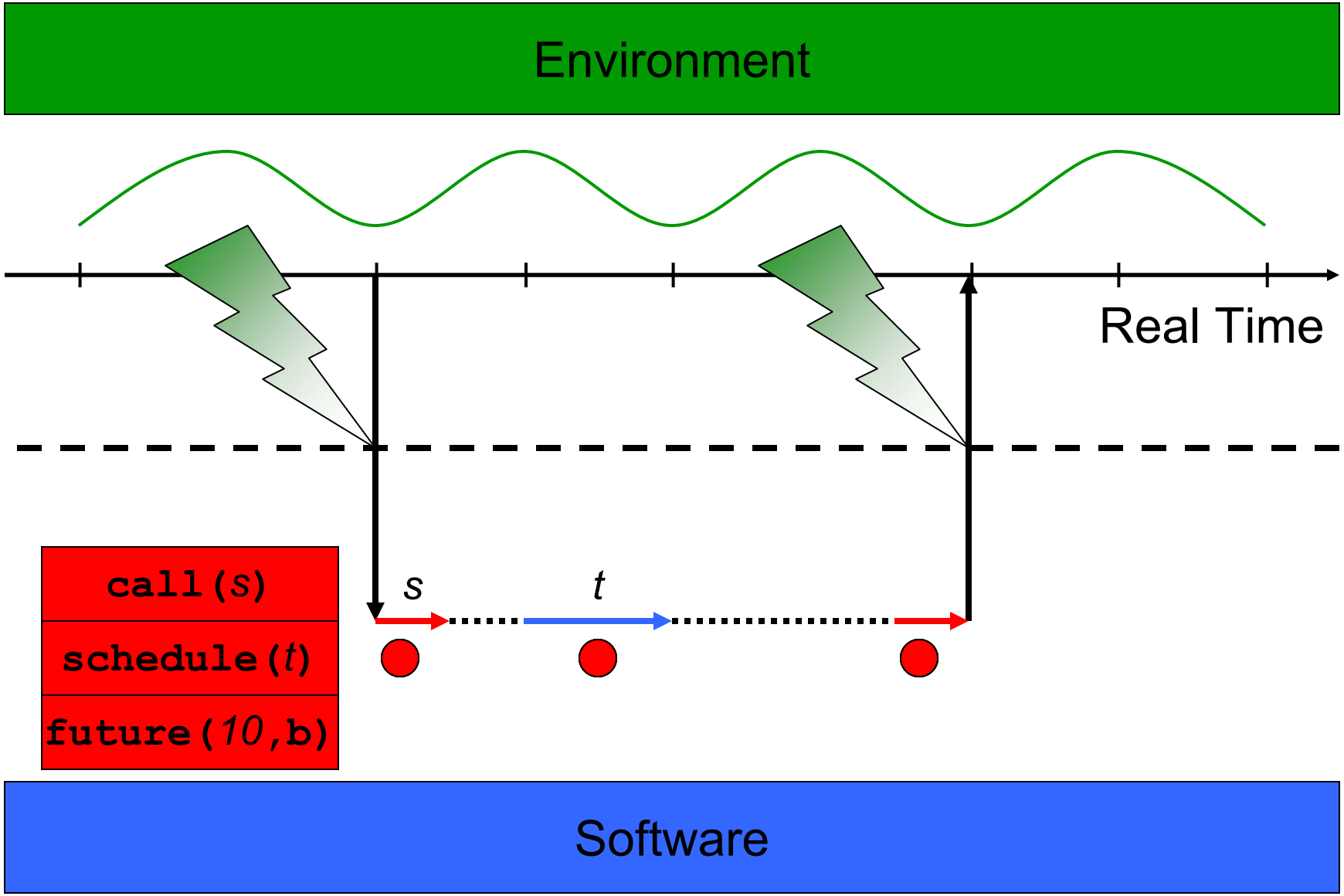
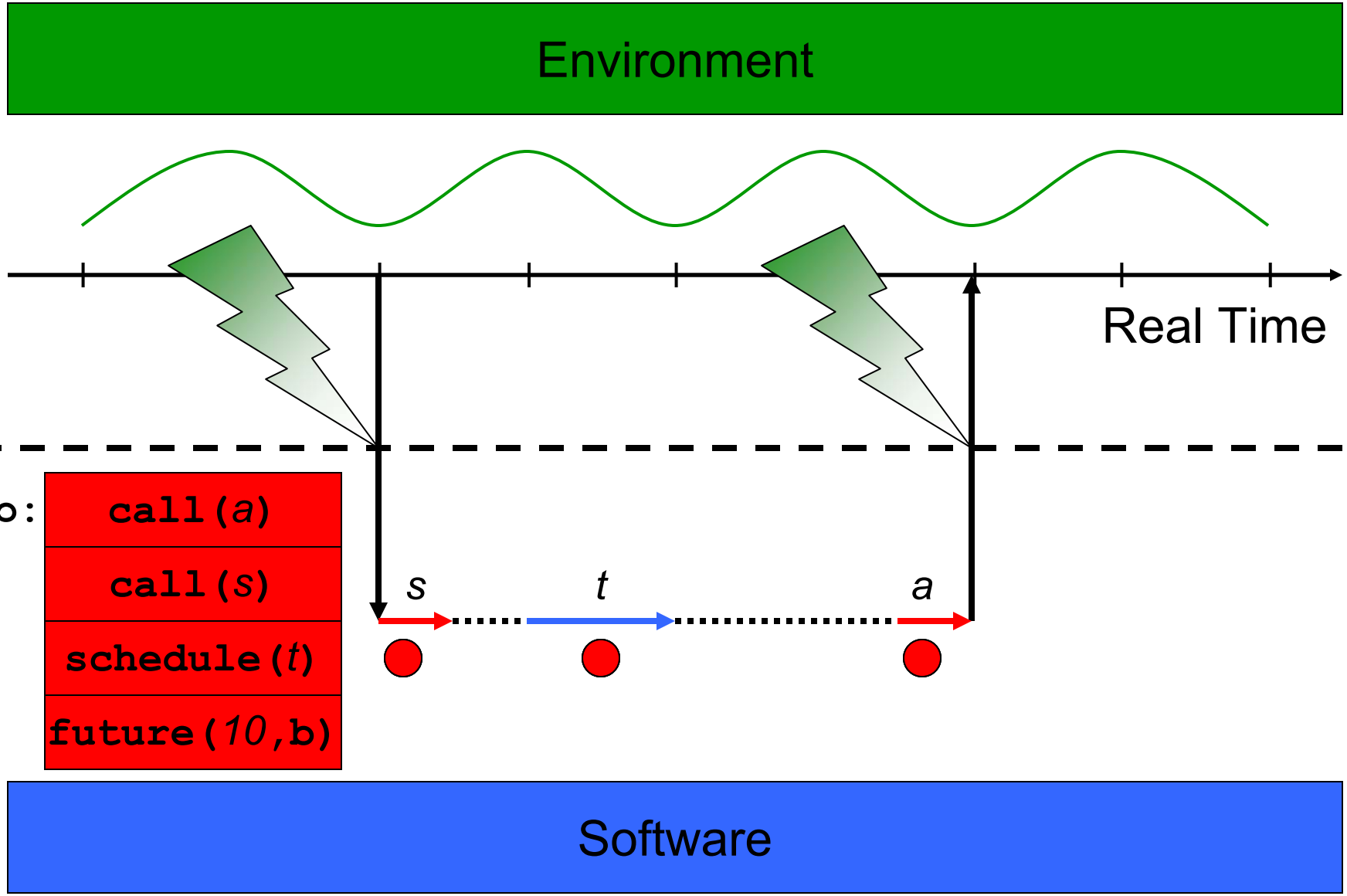
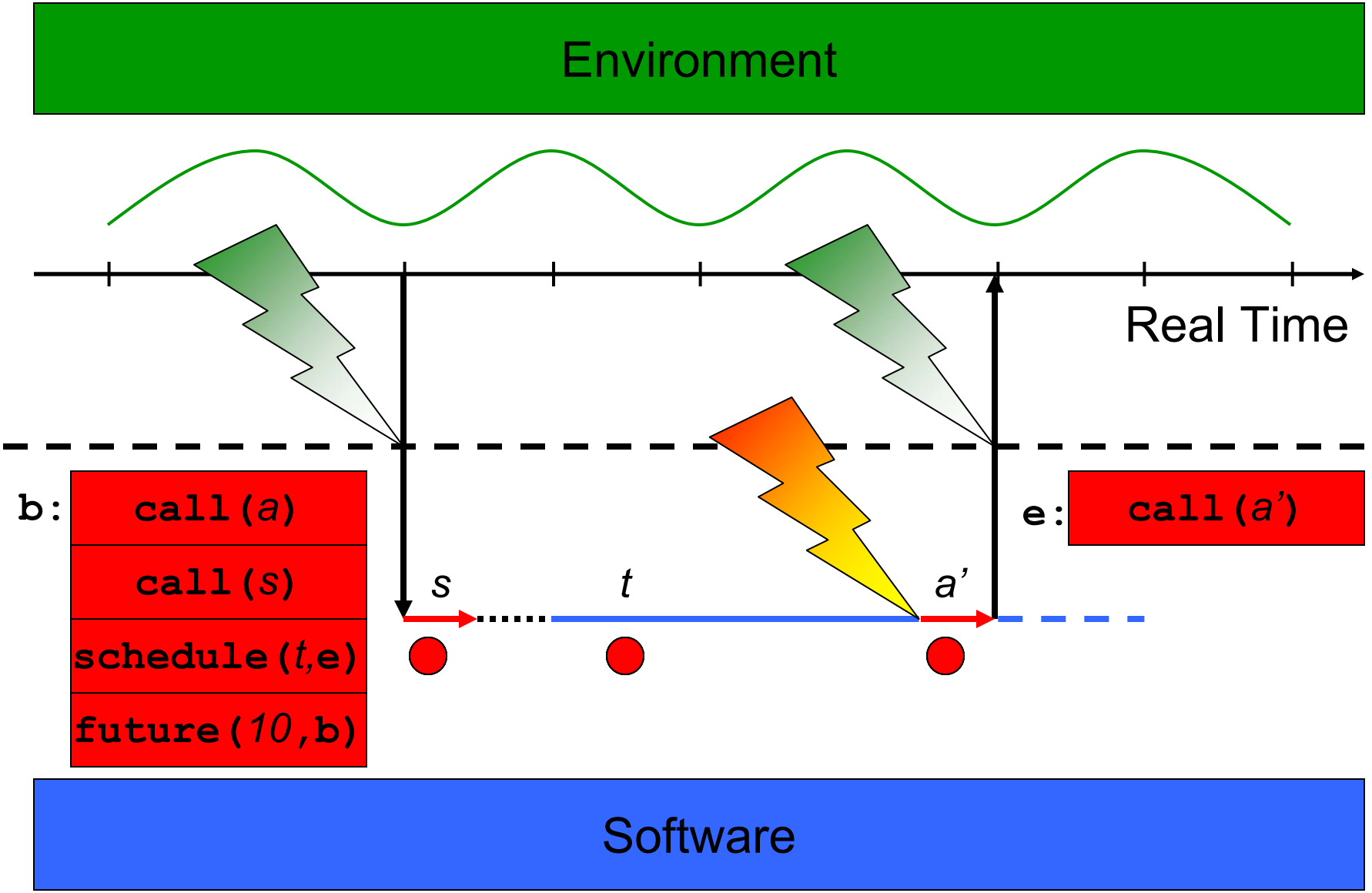

Environment
Real Time
call(s)
schedule(t)
future(10,b)
s
t
Software

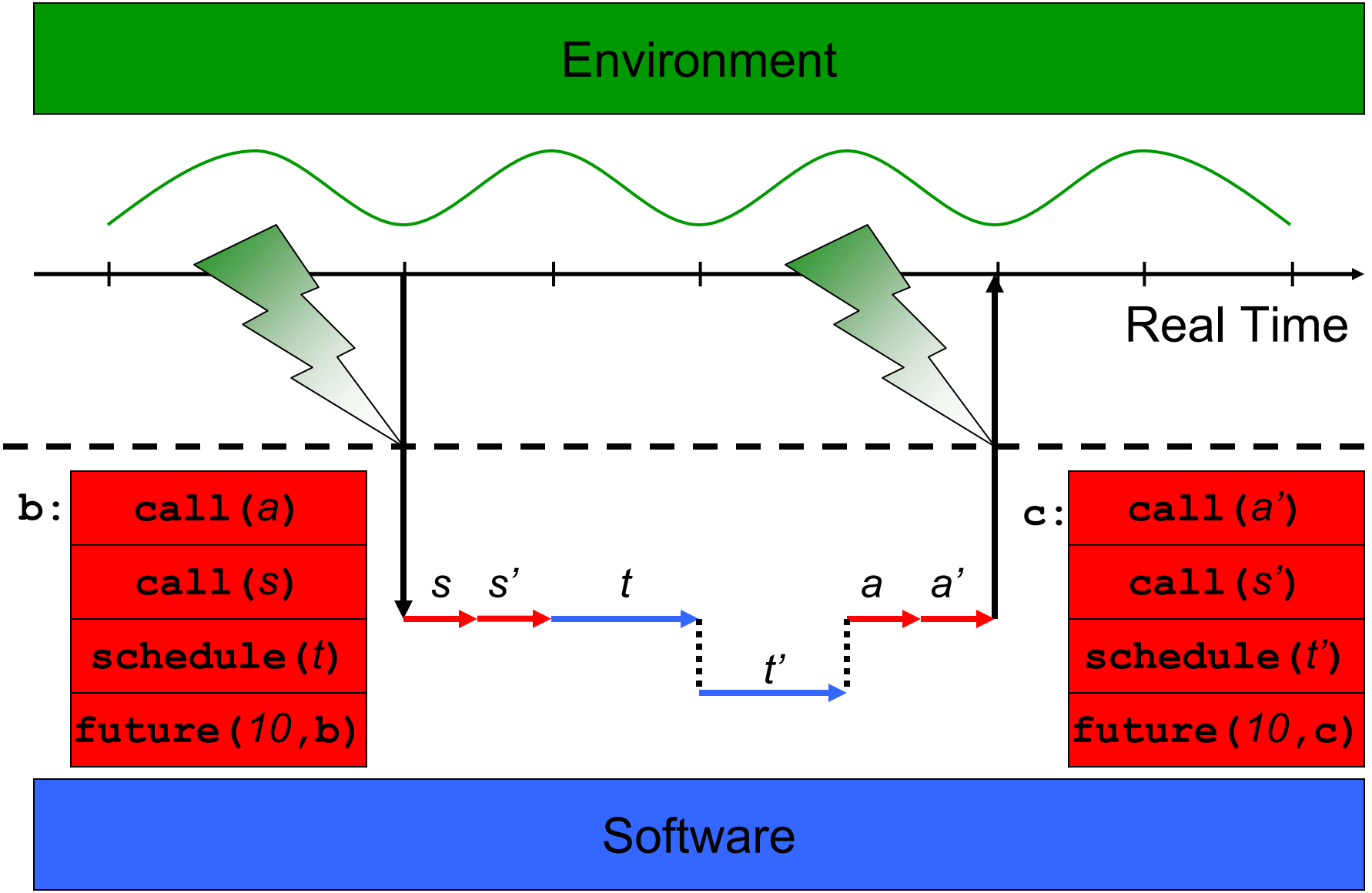
E Code


Environment
Real Time
b:
call(a)
call(s)
schedule(t)
future(10,b)
s
t
a
Software

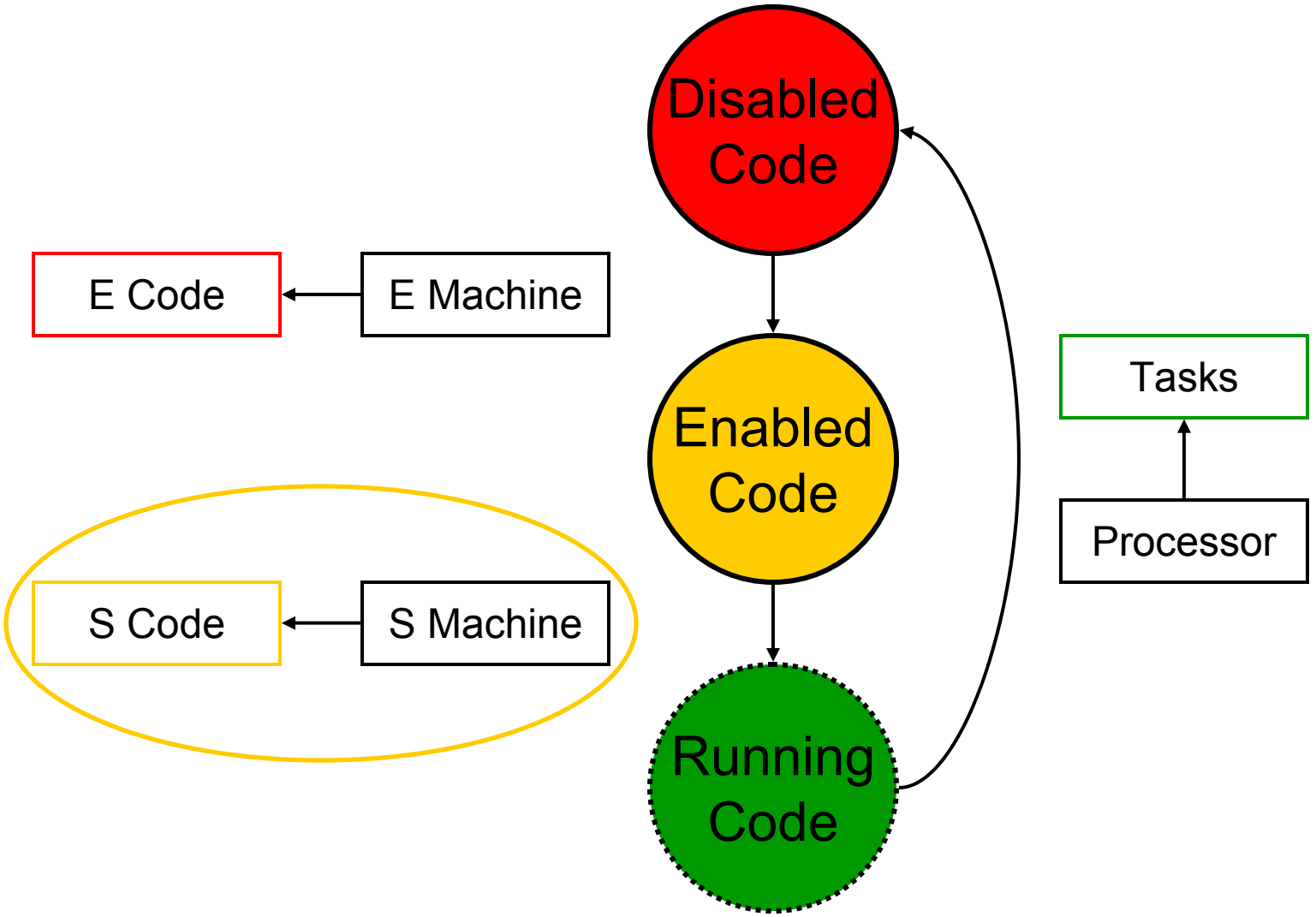
Time Safety or Runtime Exception



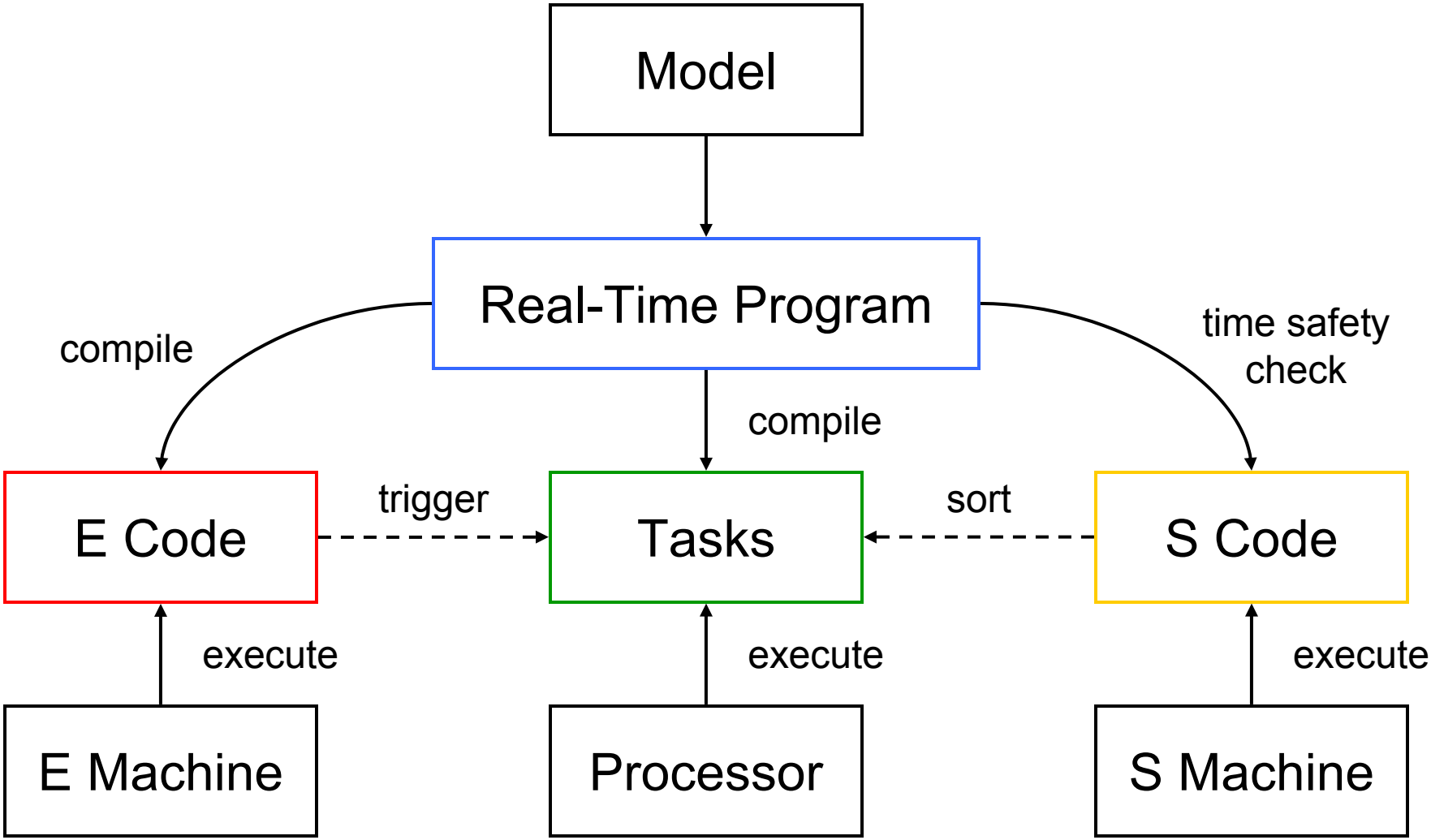
Compositionality and Time Safety



The Scheduling Machine: EMSOFT 2003 in Philadelphia



Summary


Model
Real-Time Program
compile
compile
time safety check
E Code
trigger
Tasks
sort
S Code
execute
execute
execute
E Machine
Processor
S Machine