Principles of Real-Time Programming

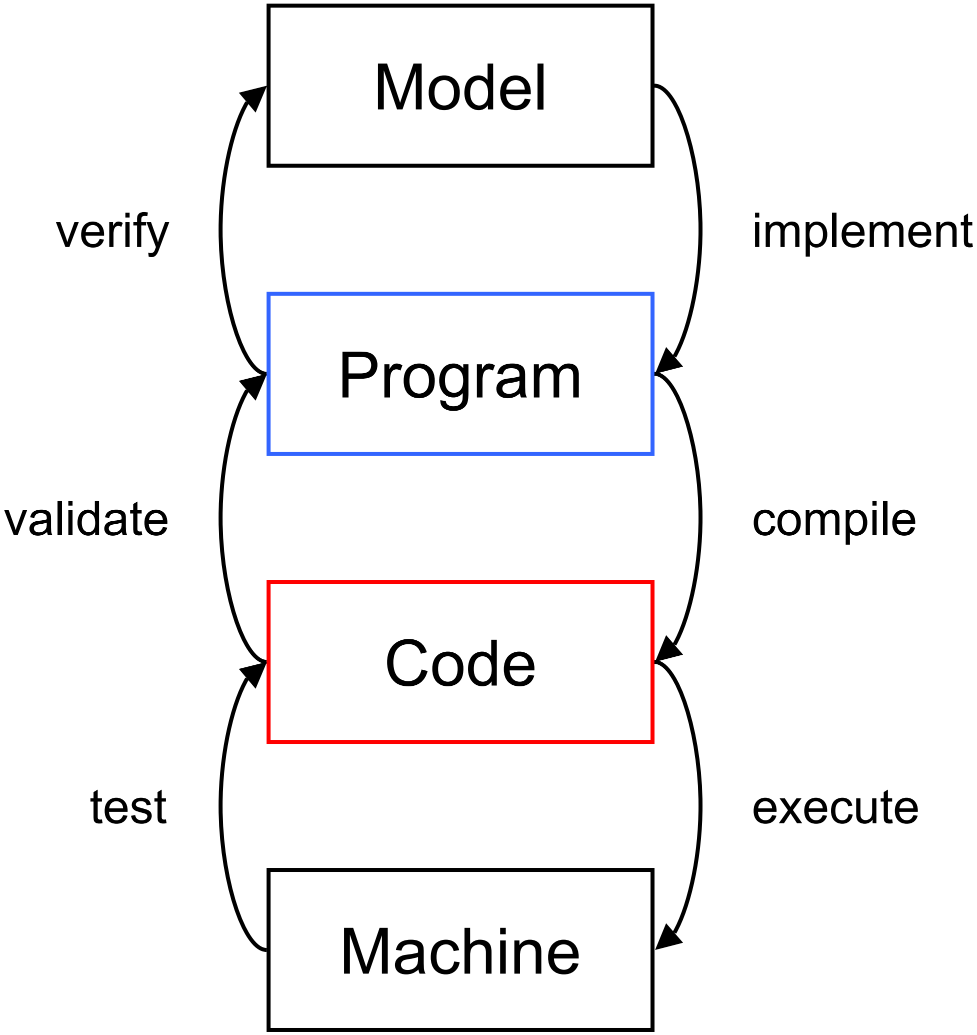
EMSOFT 2002

Christoph M. Kirsch

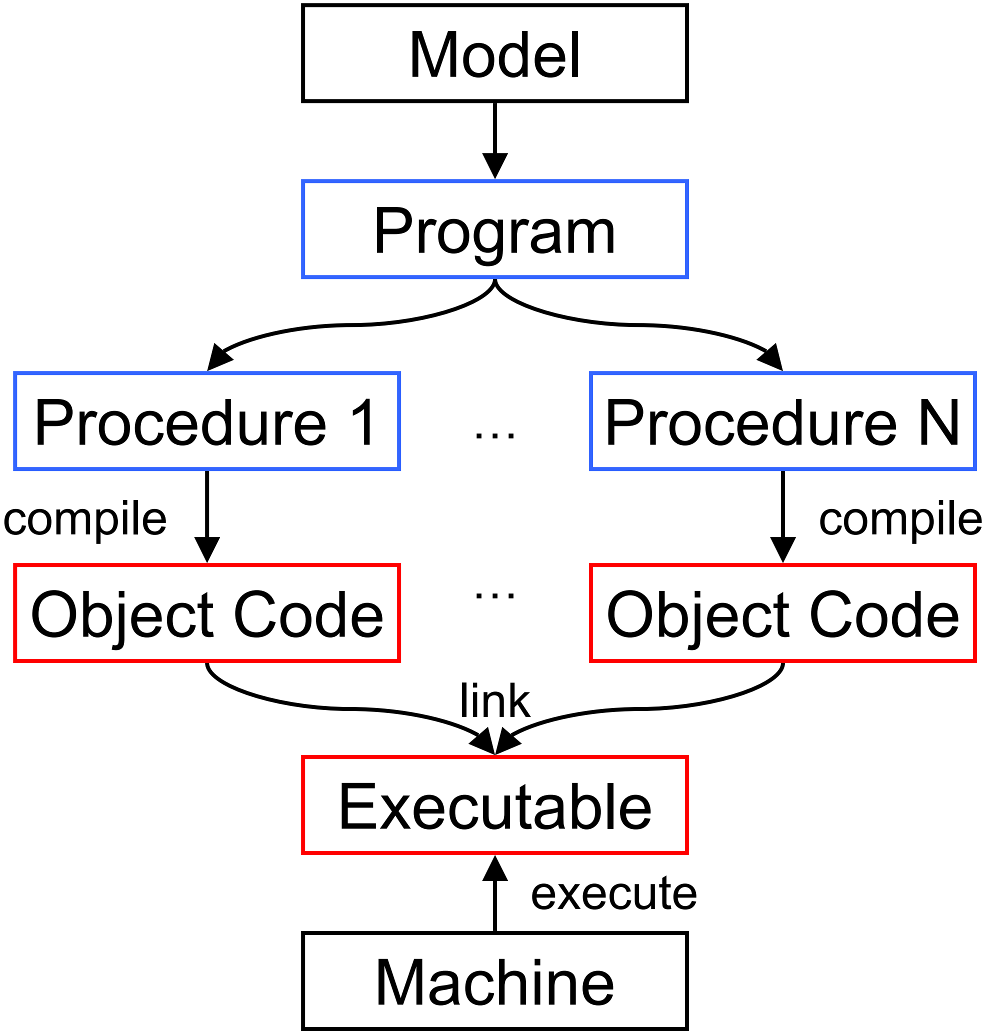
UC Berkeley

www.eecs.berkeley.edu/~cm

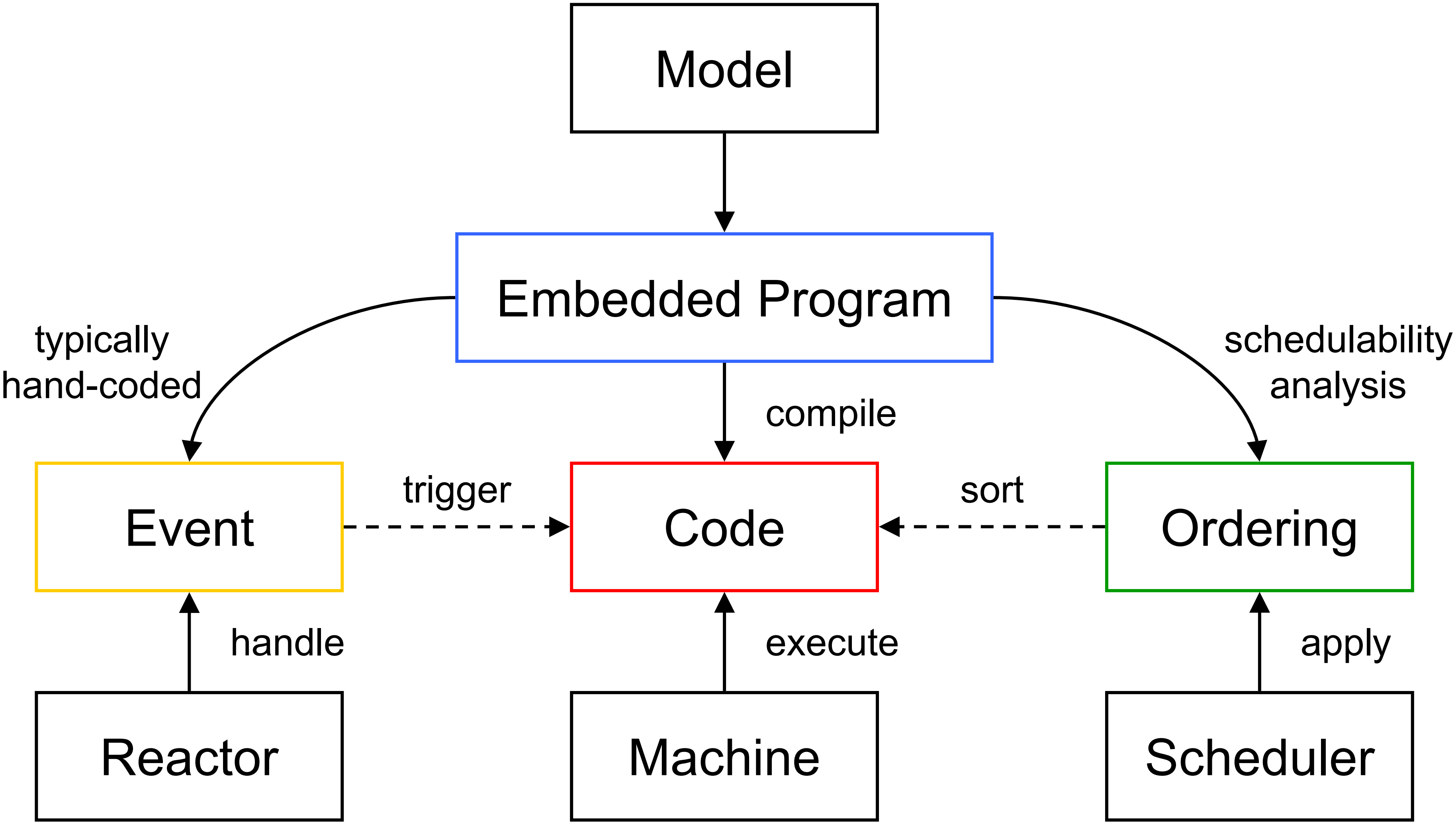
Sequential Programming



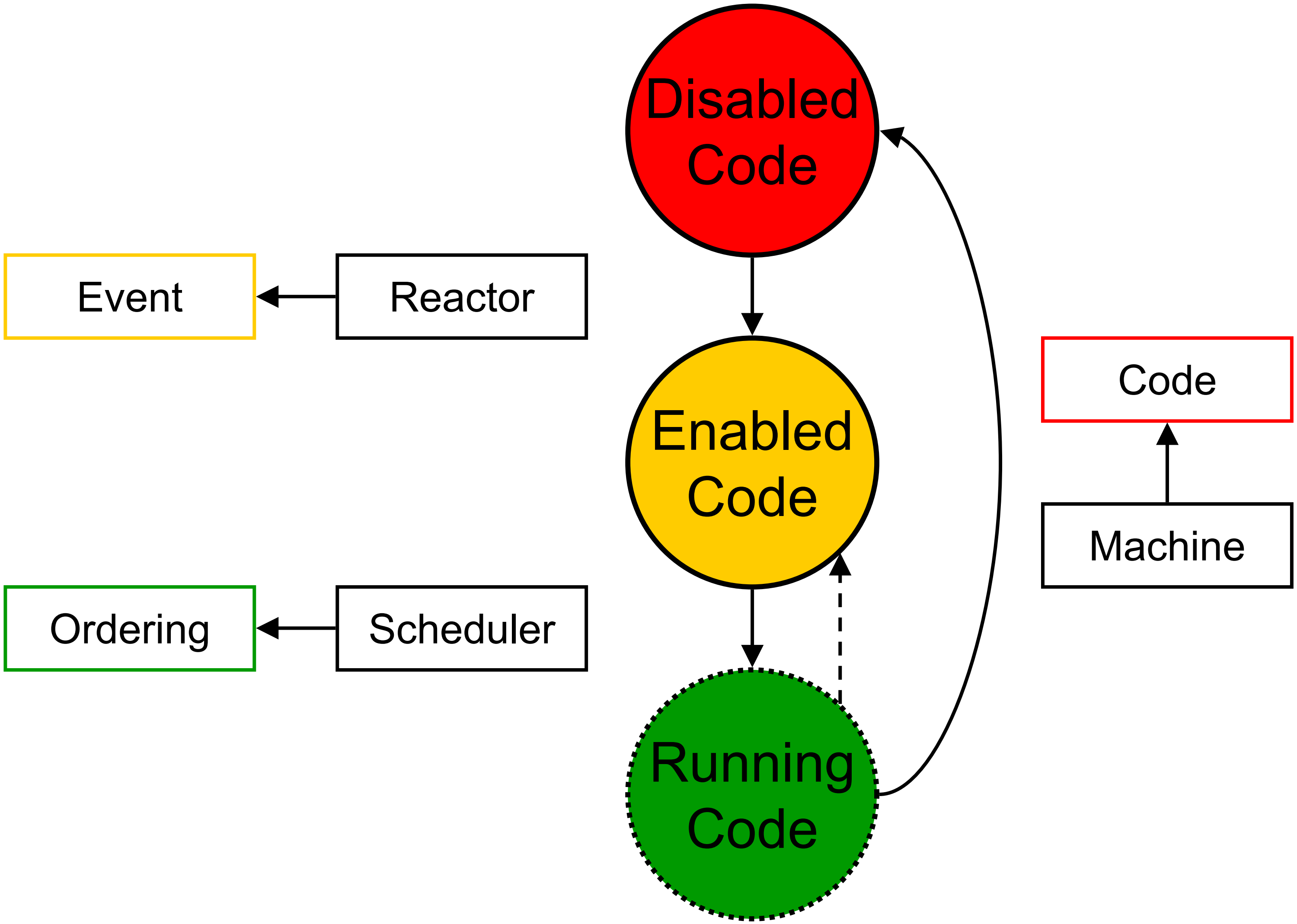
Composability and Type Safety



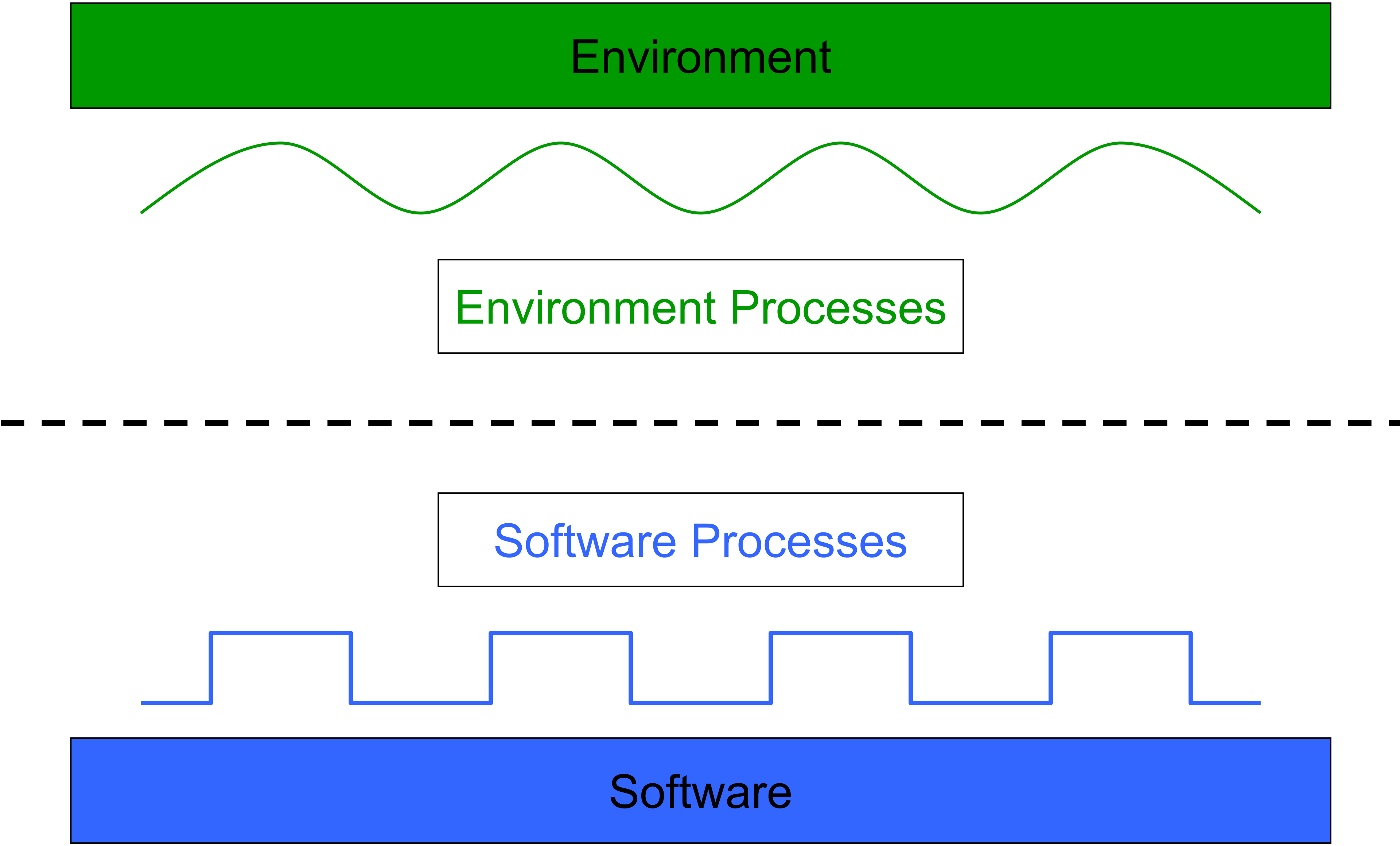
Embedded Programming



A Real-Time Process Model



Embedded Software



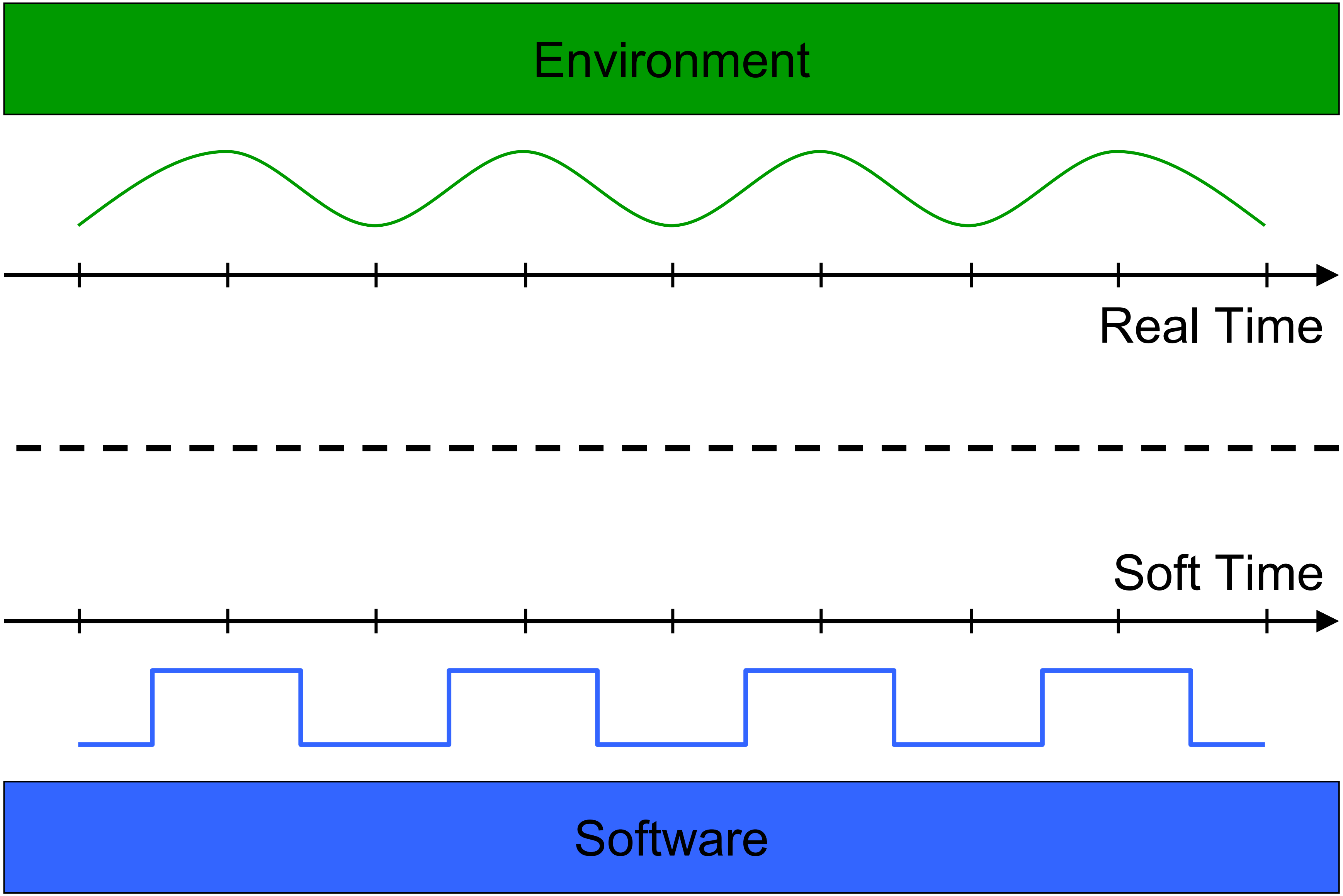
Environment

Environment Processes

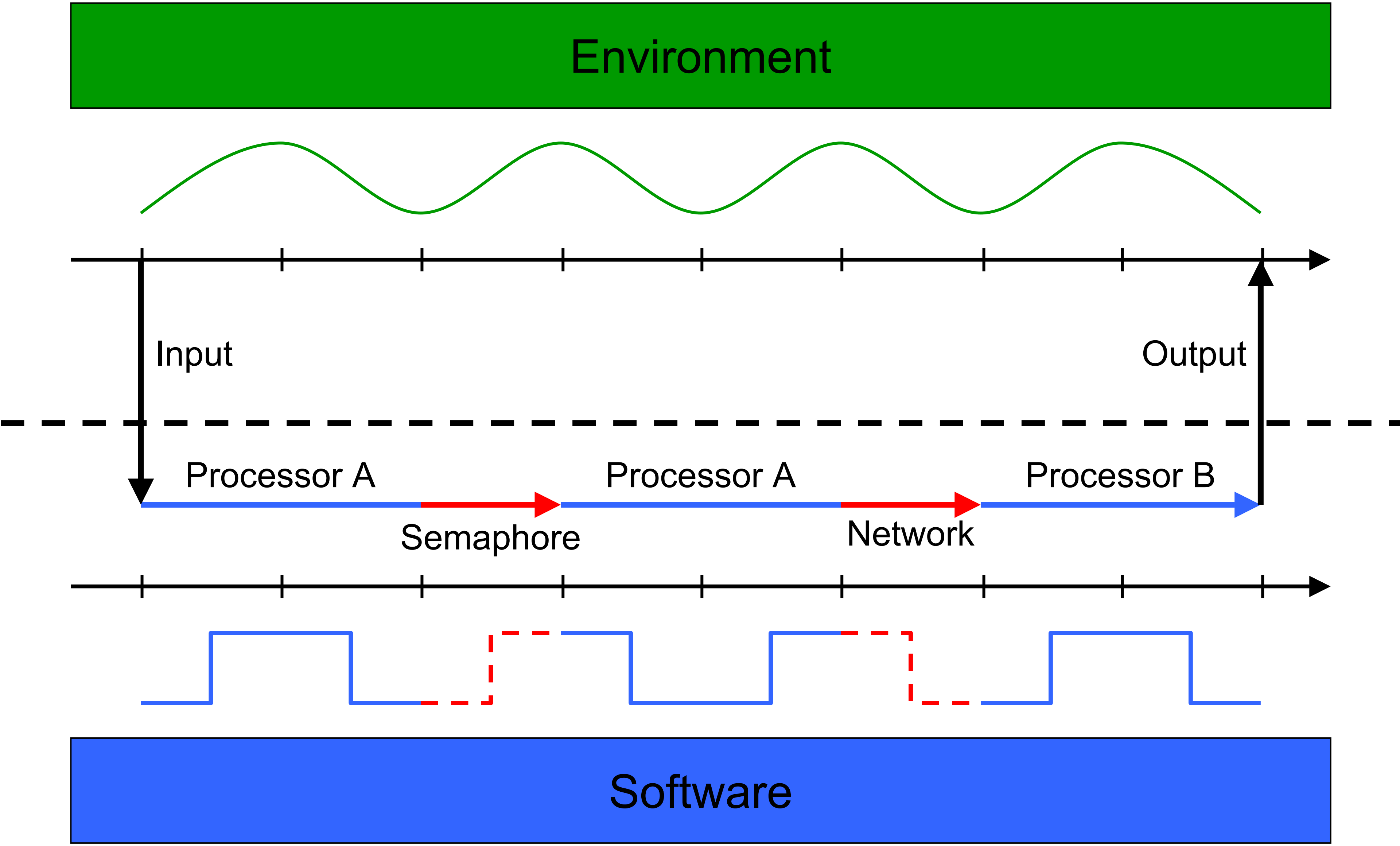
Software Processes

Software

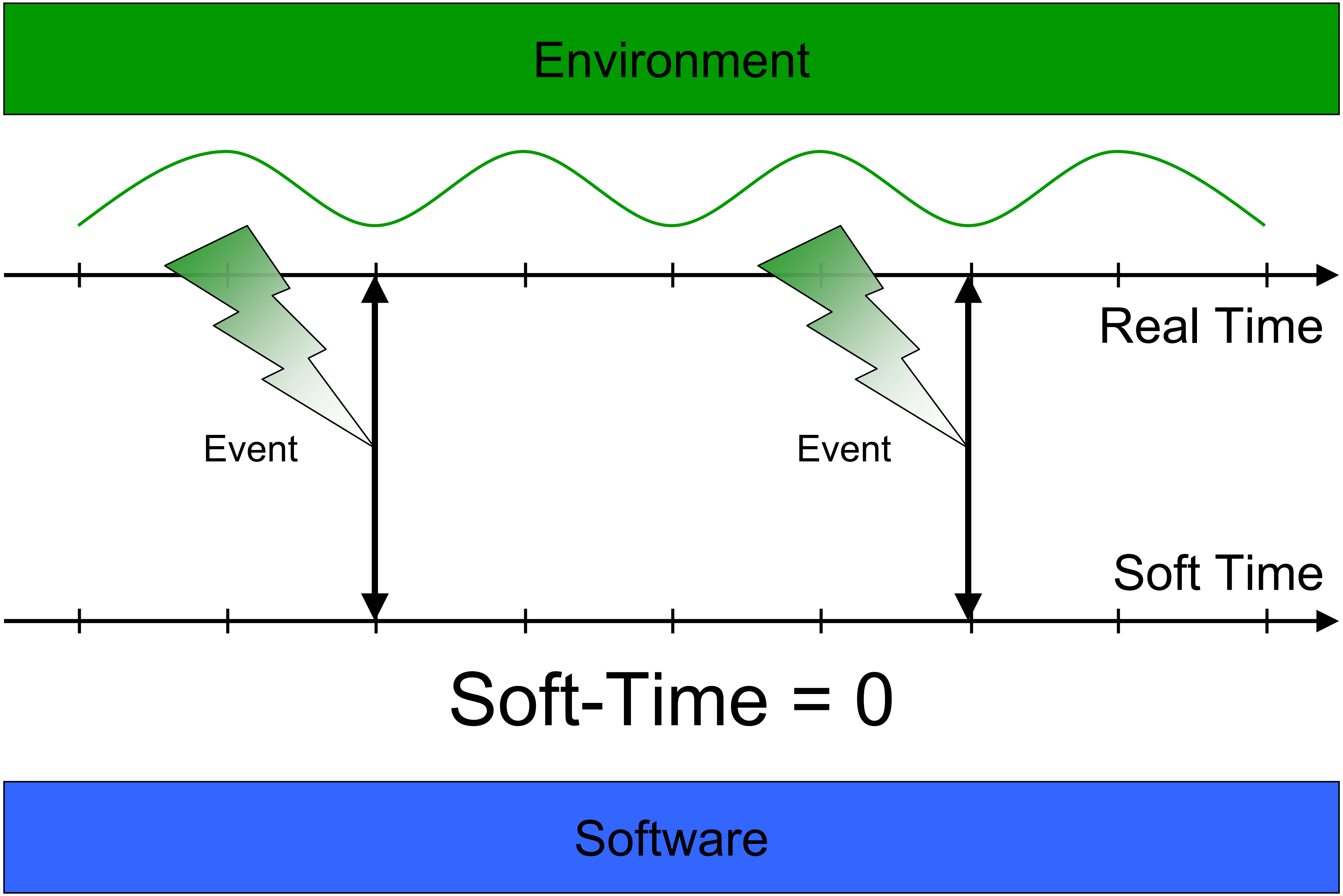
Real Time vs. Soft Time



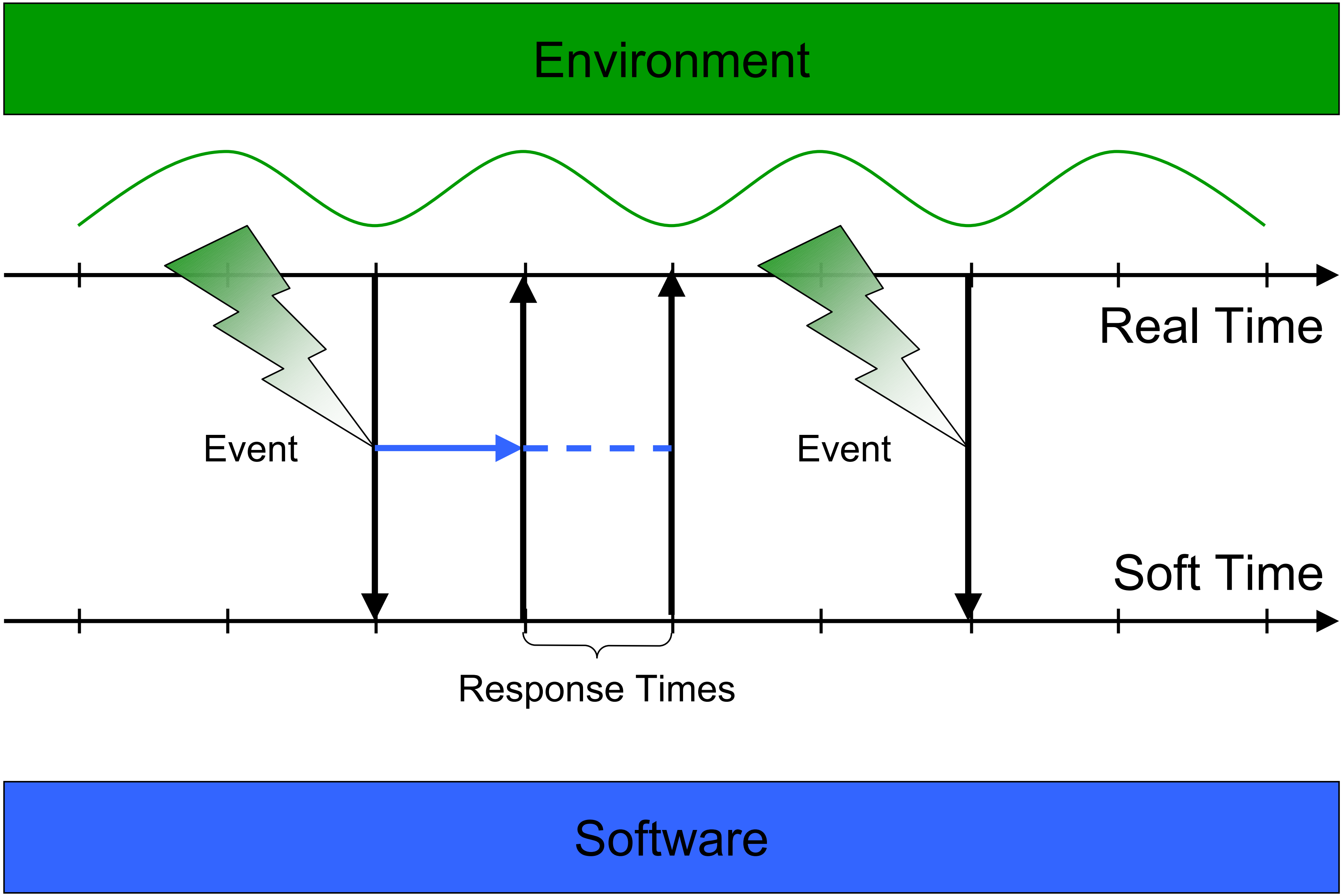
Soft Time


Environment
Input
Output
Processor A
Processor A
Processor B
Semaphore
Network
Software

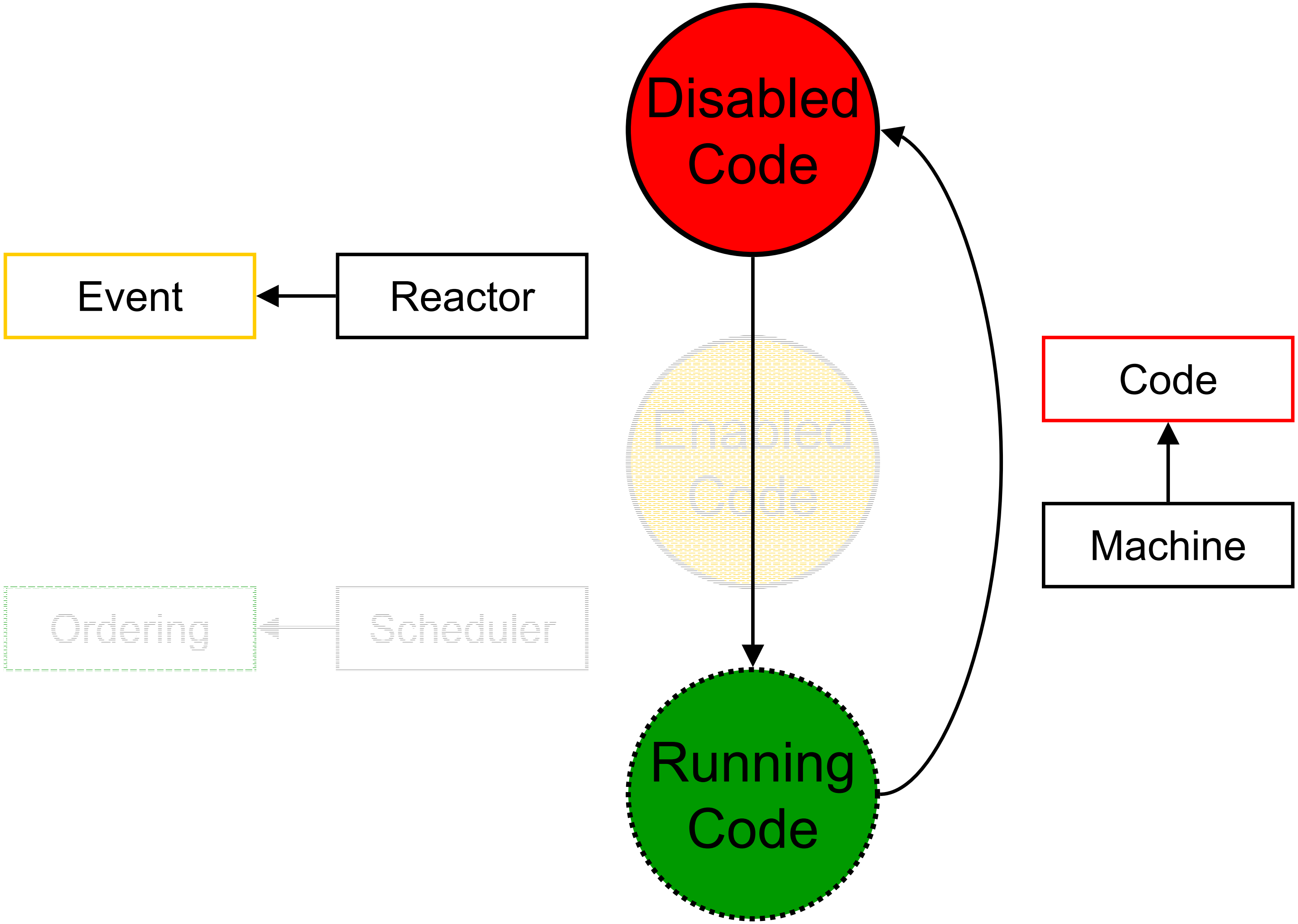
The Synchronous Model



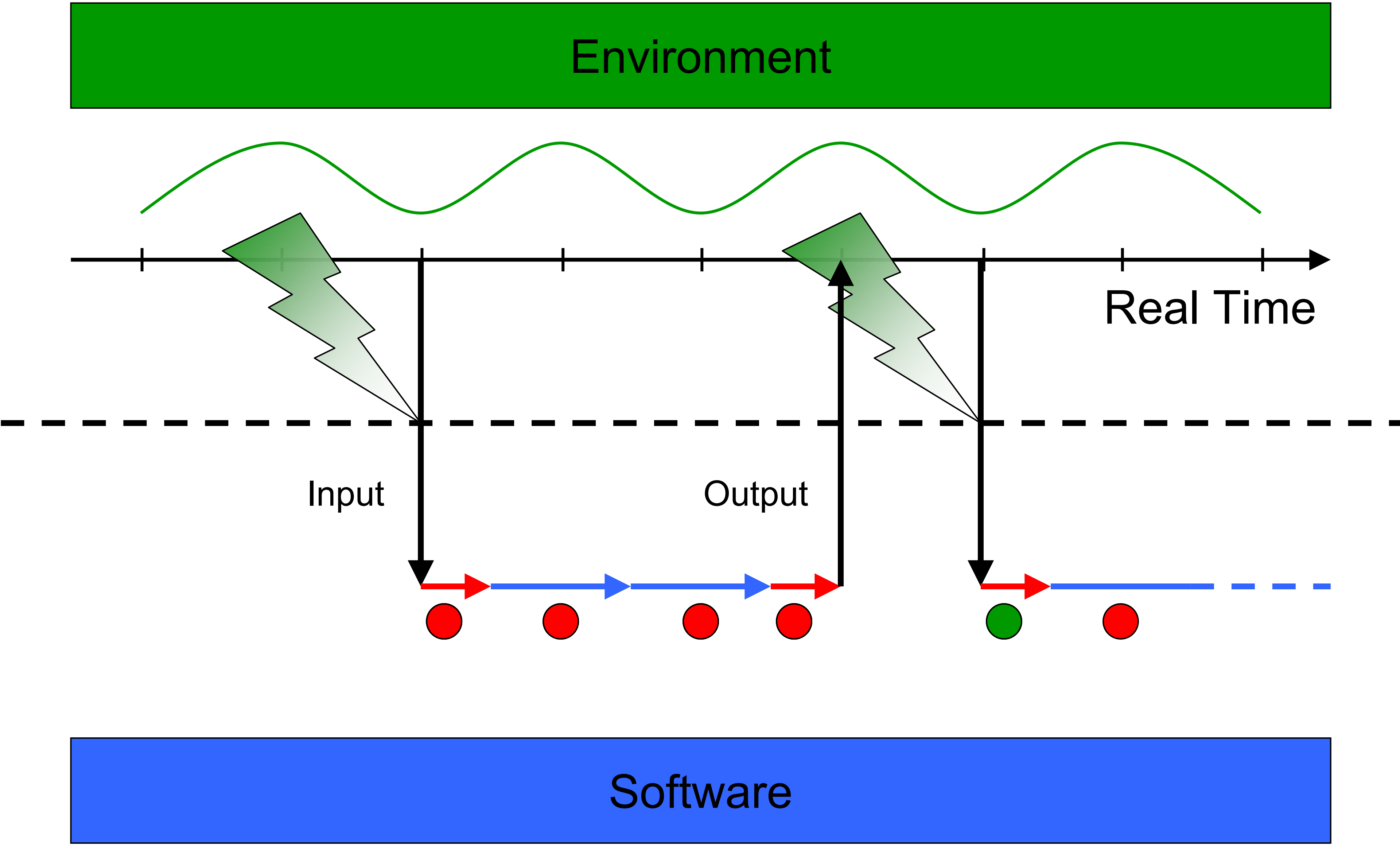
A Synchronous Implementation



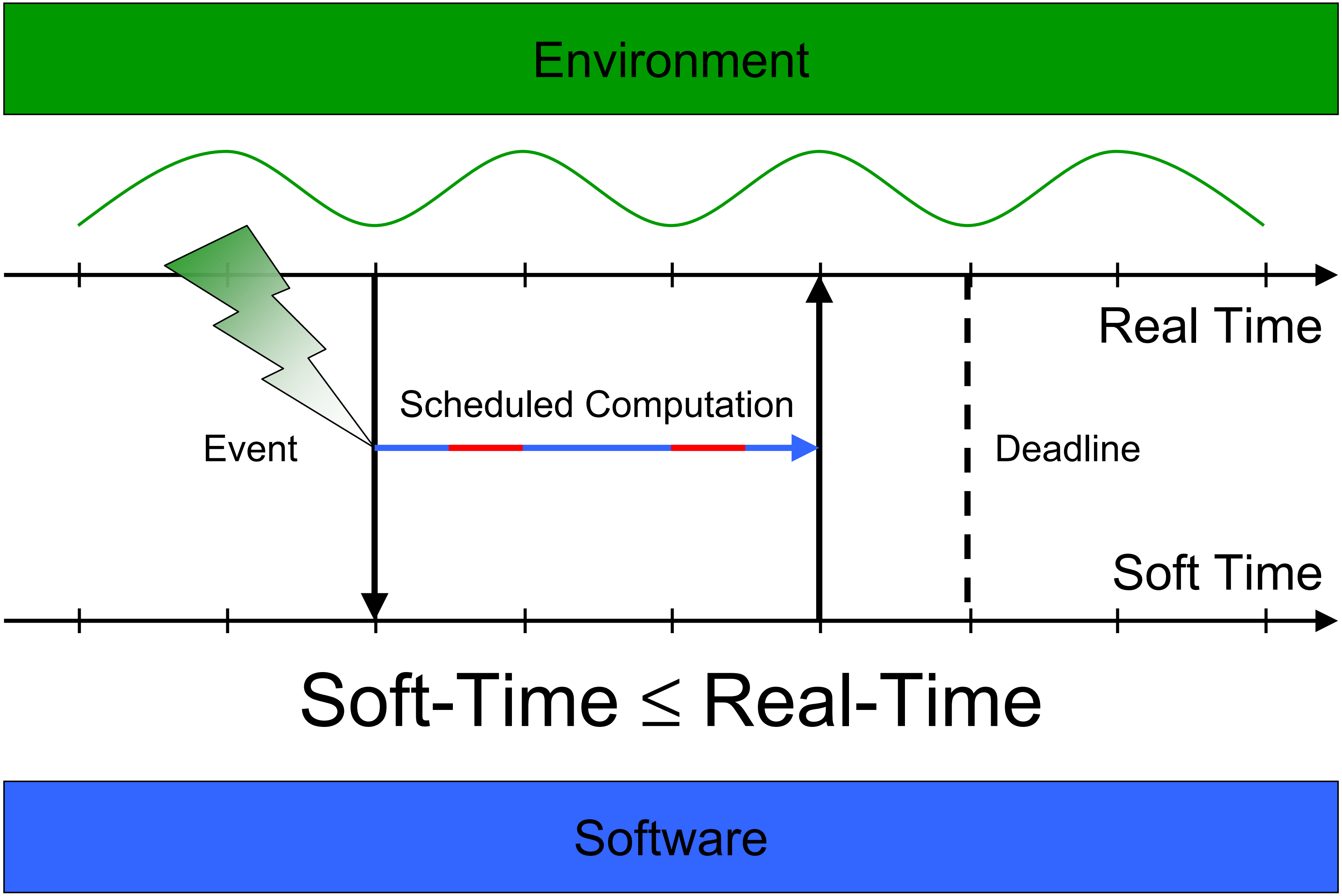
Event Safety



Synchrony

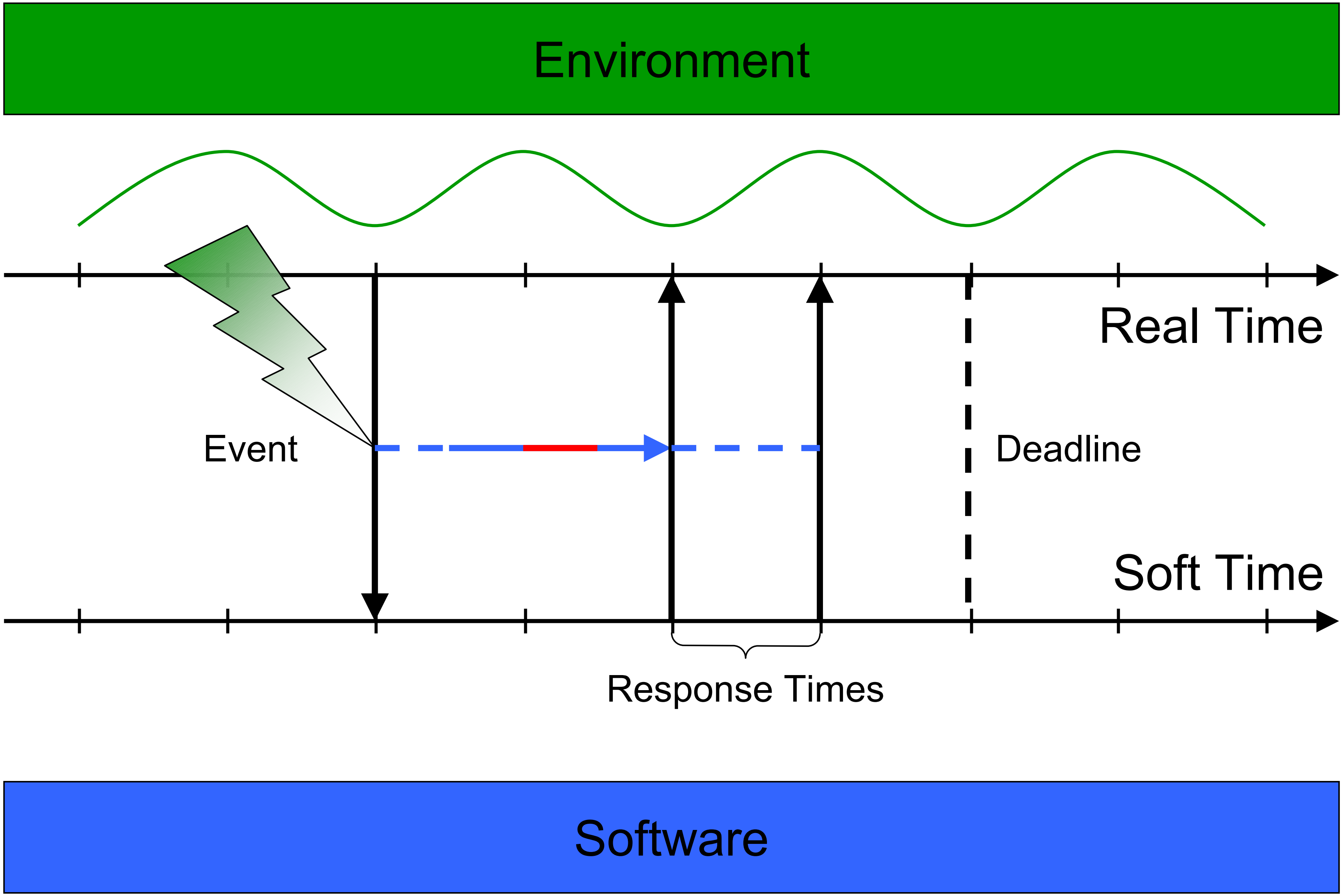


The Scheduled Model

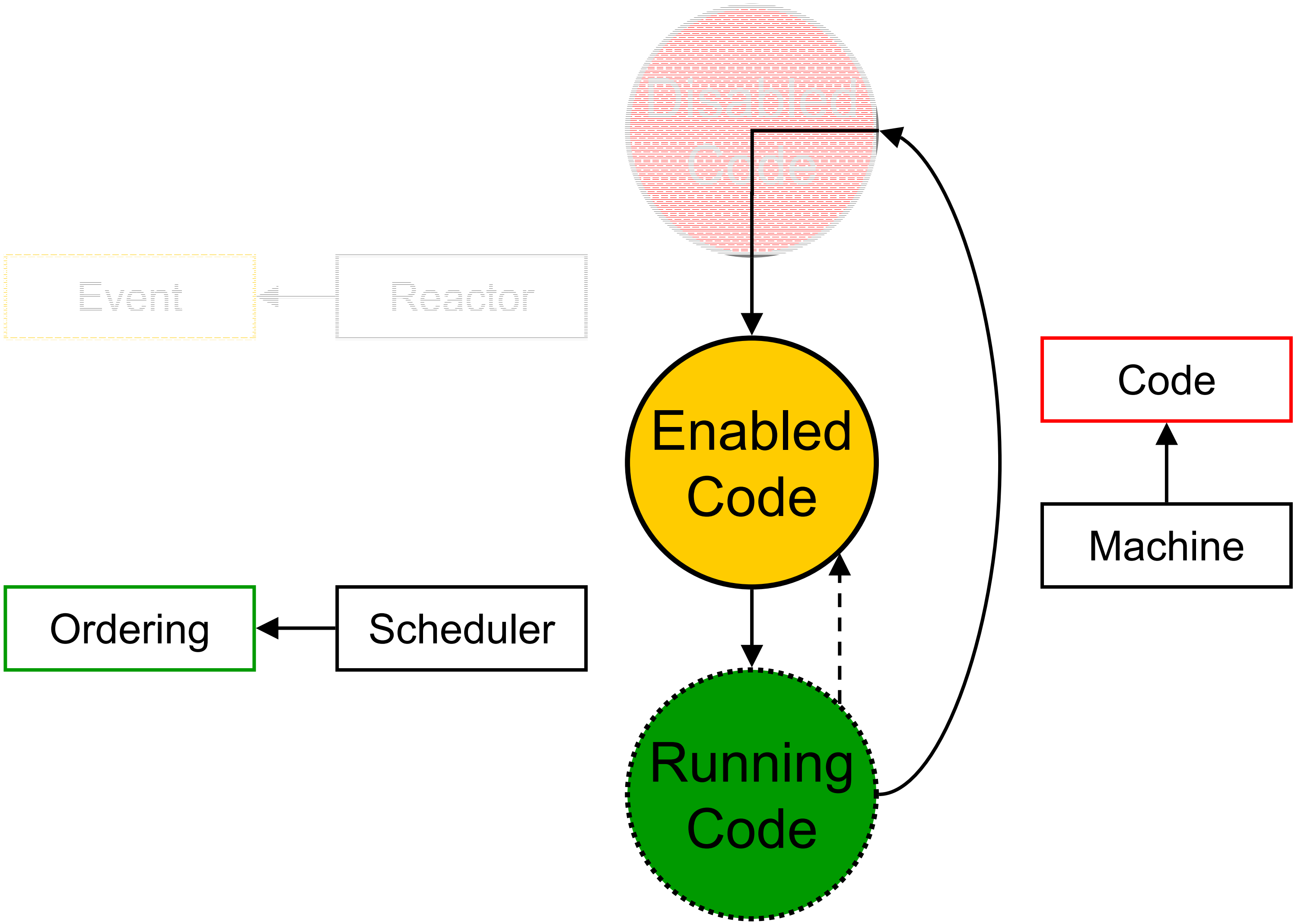


Soft-Time ≤ Real-Time

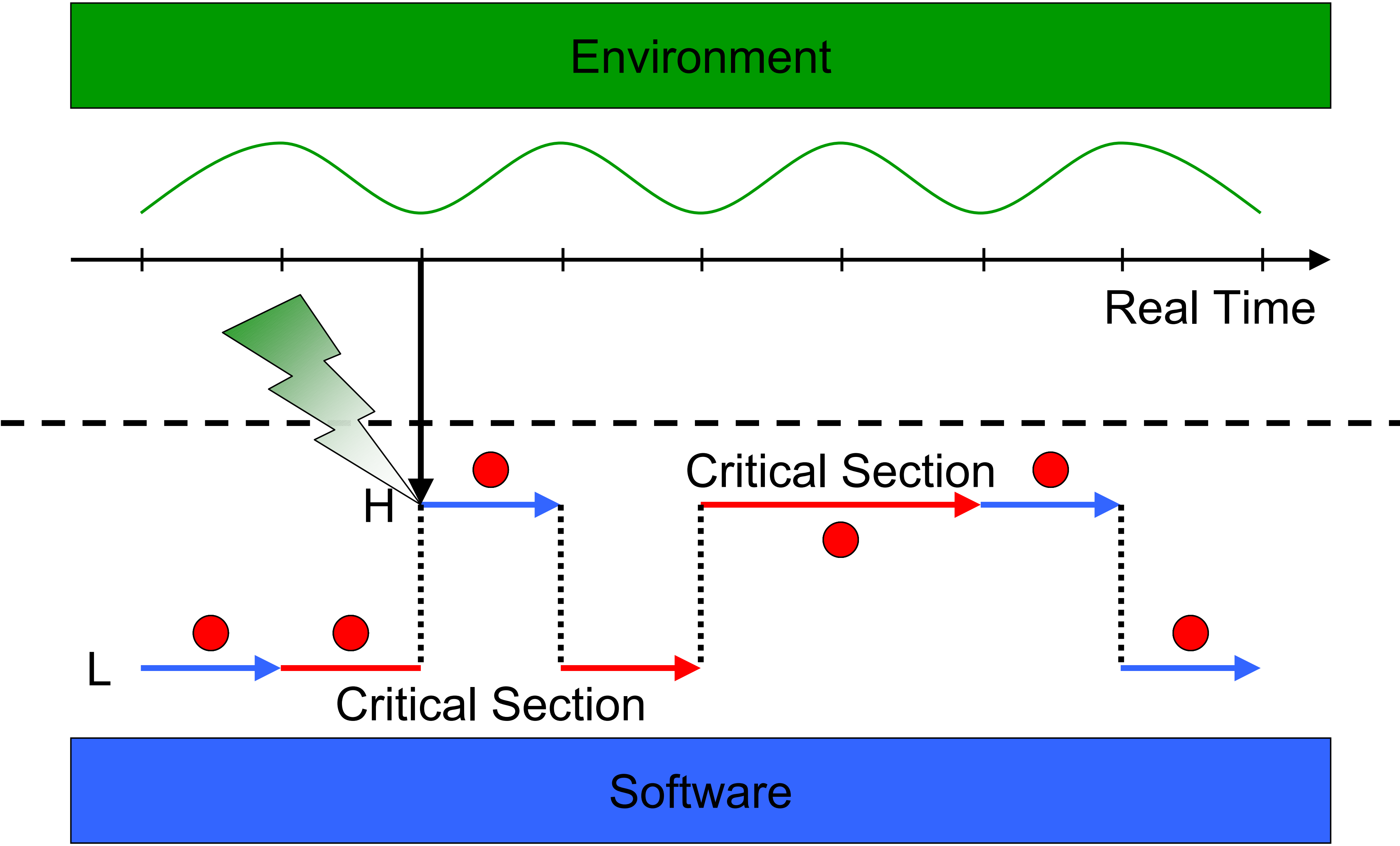
A Scheduled Implementation



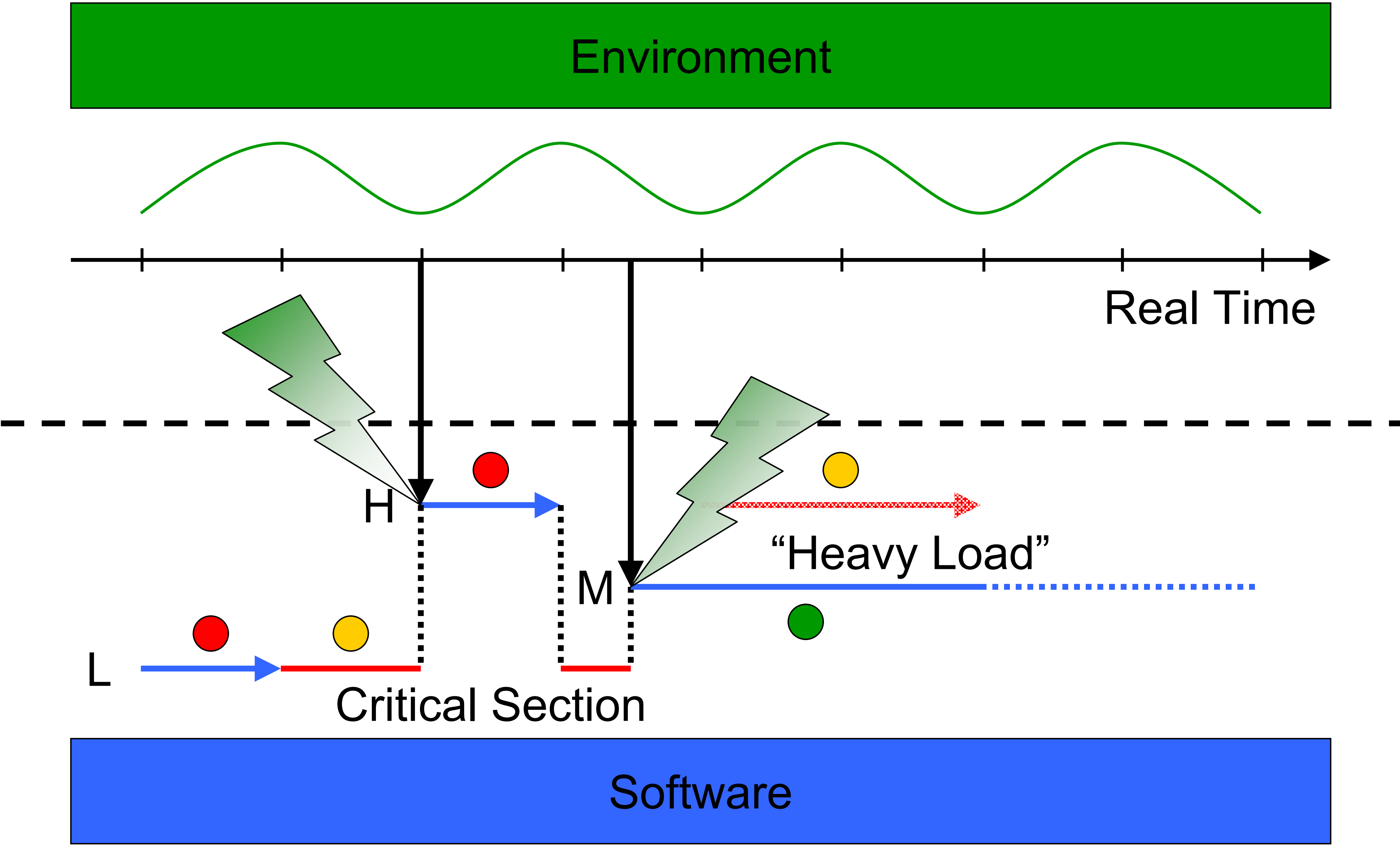
Space Safety



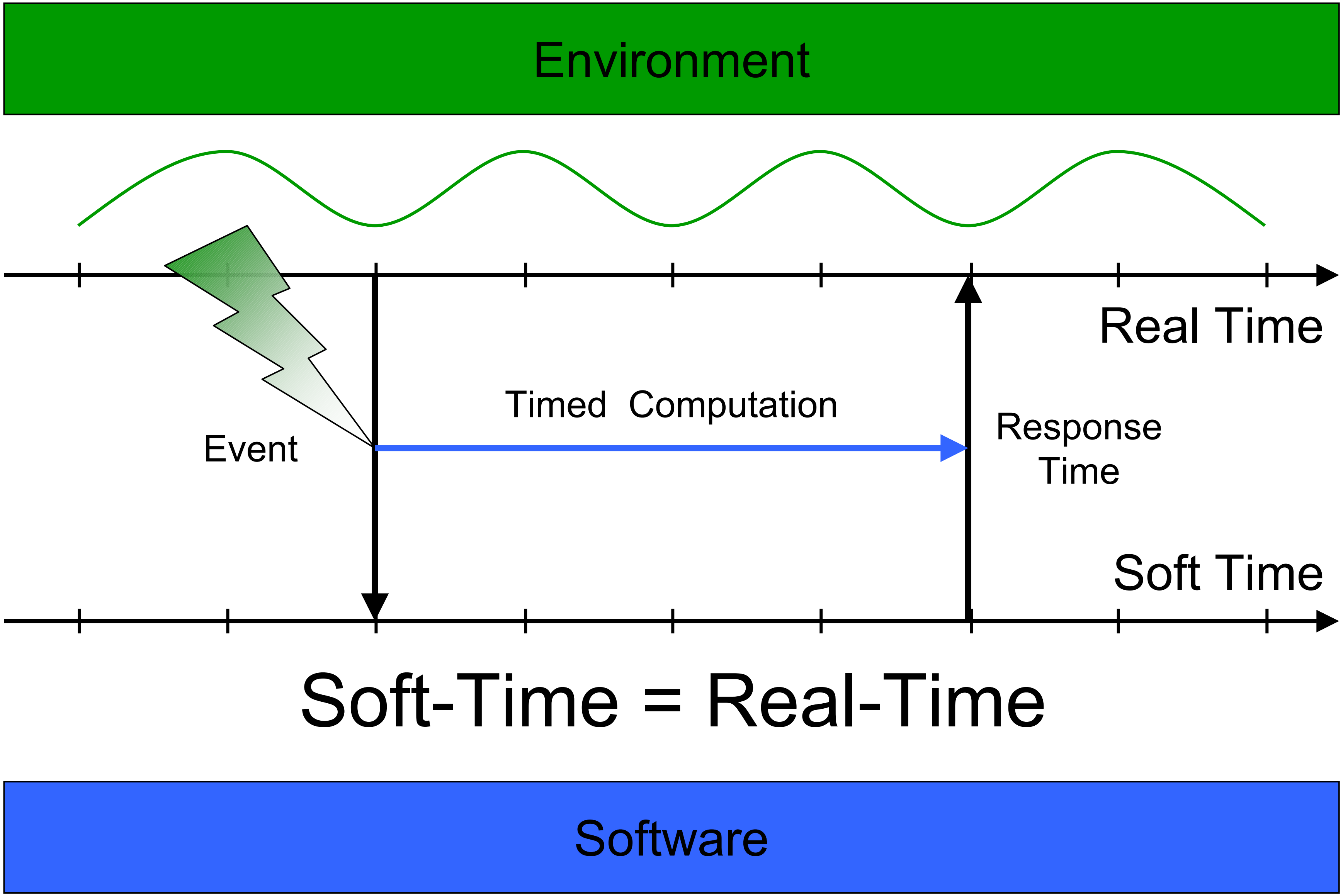
Priority Inversion



Unbounded Soft Time

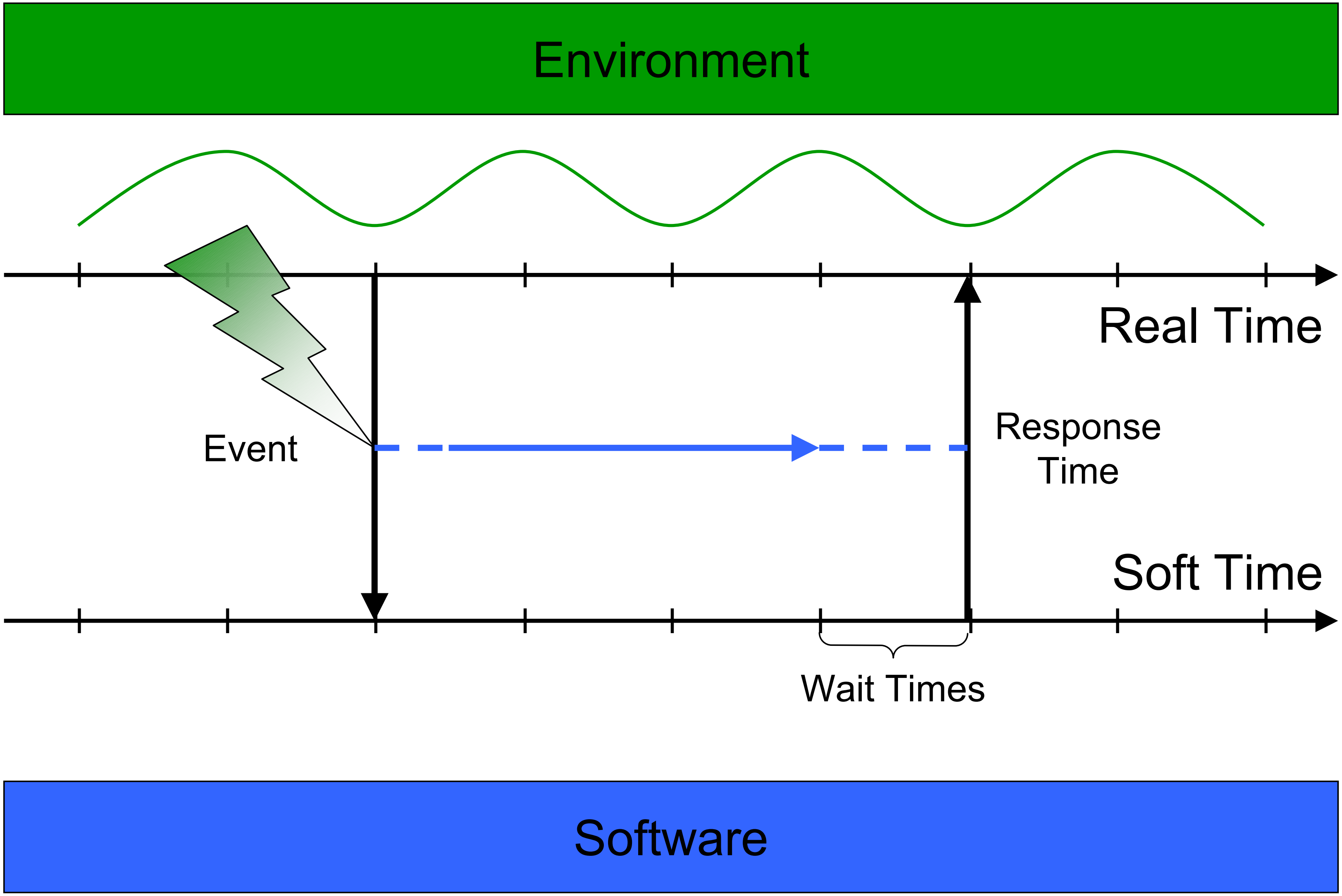


The Timed Model

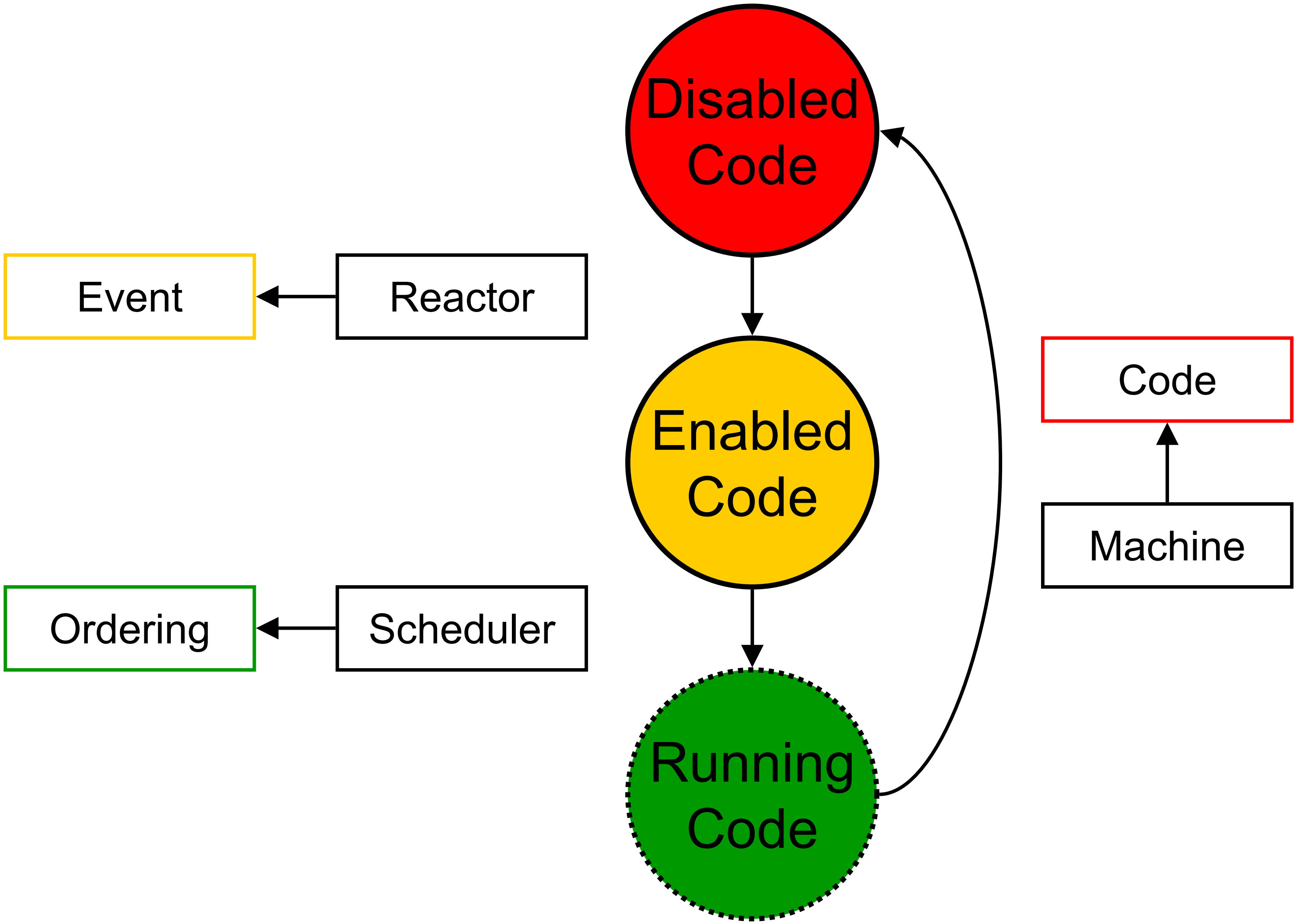


Soft-Time = Real-Time

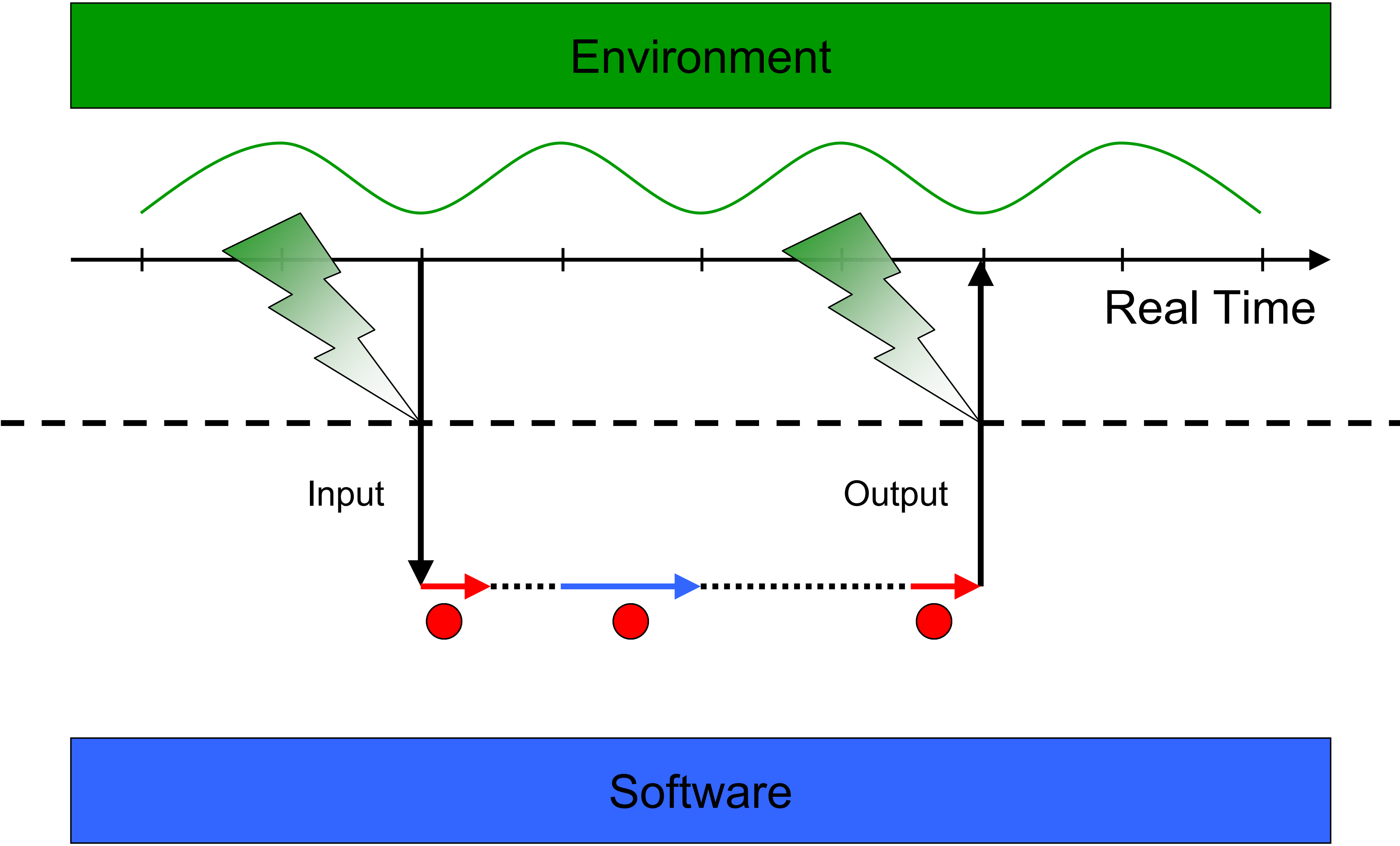
A Timed Implementation



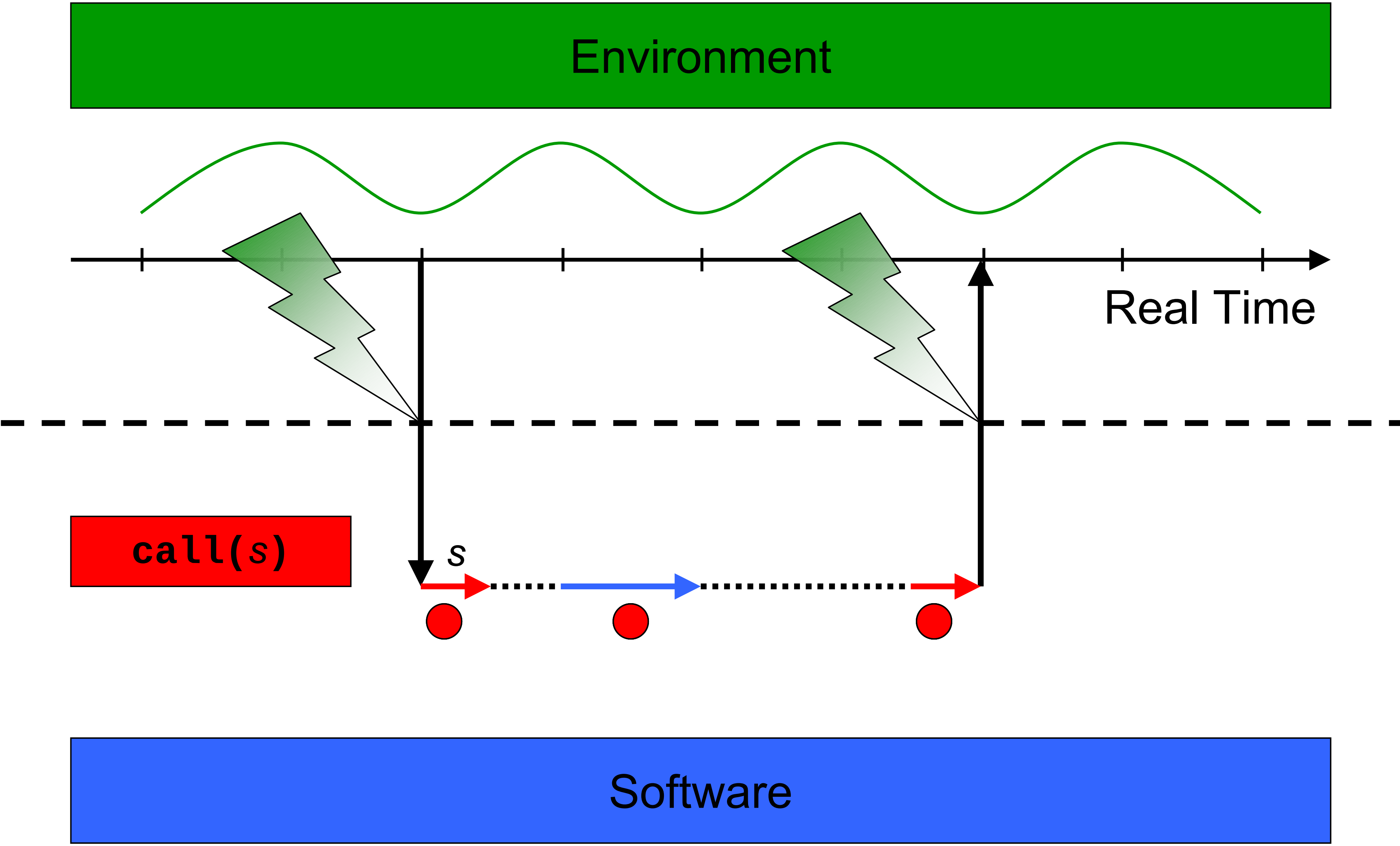
Time Safety


Disabled Code
Event
Reactor
Enabled Code
Code
Machine
Ordering
Scheduler
Running Code

Software vs. Environment Event



E Code



Environment

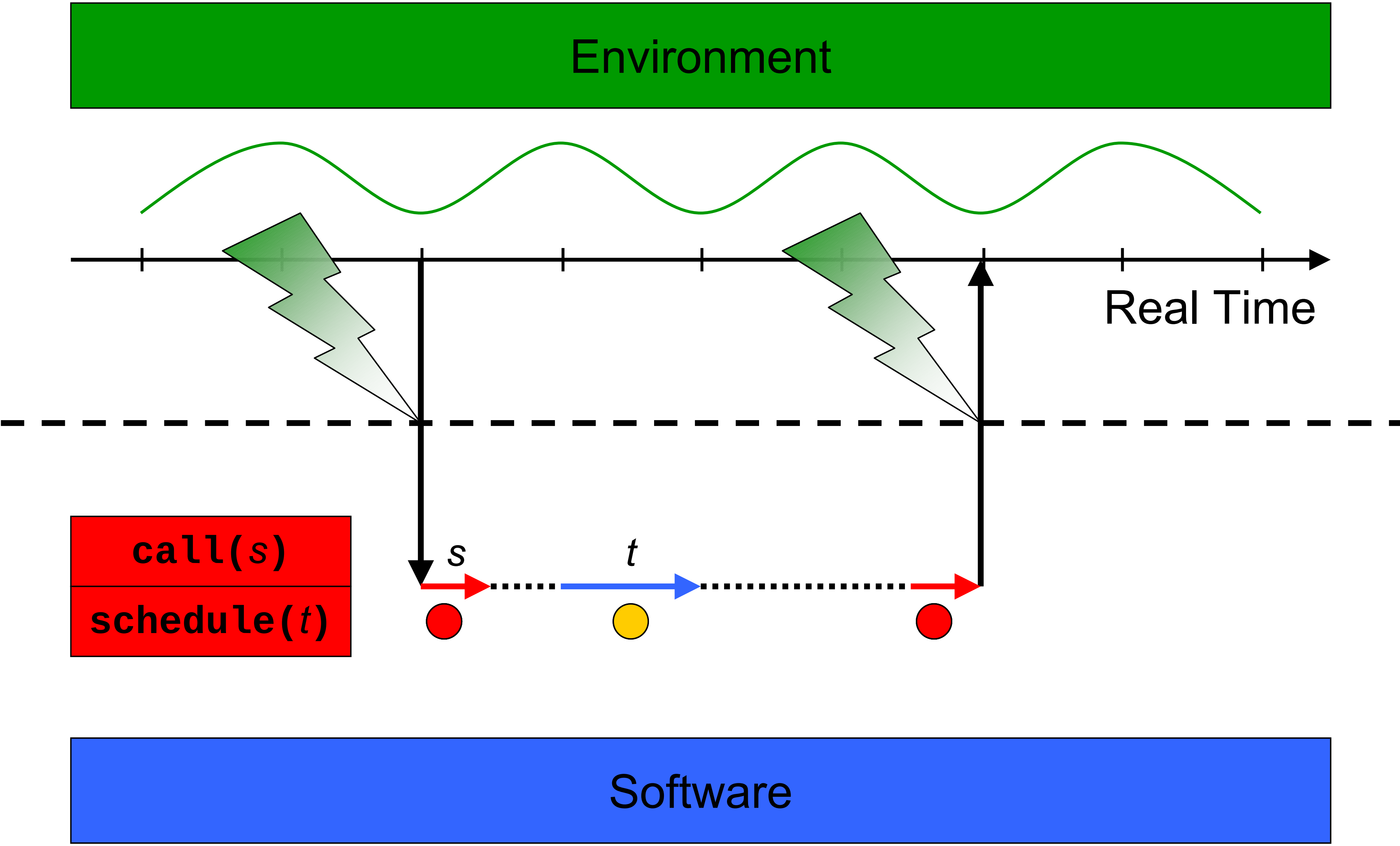
Real Time

call(*s*)

s

Software

E Code



Environment

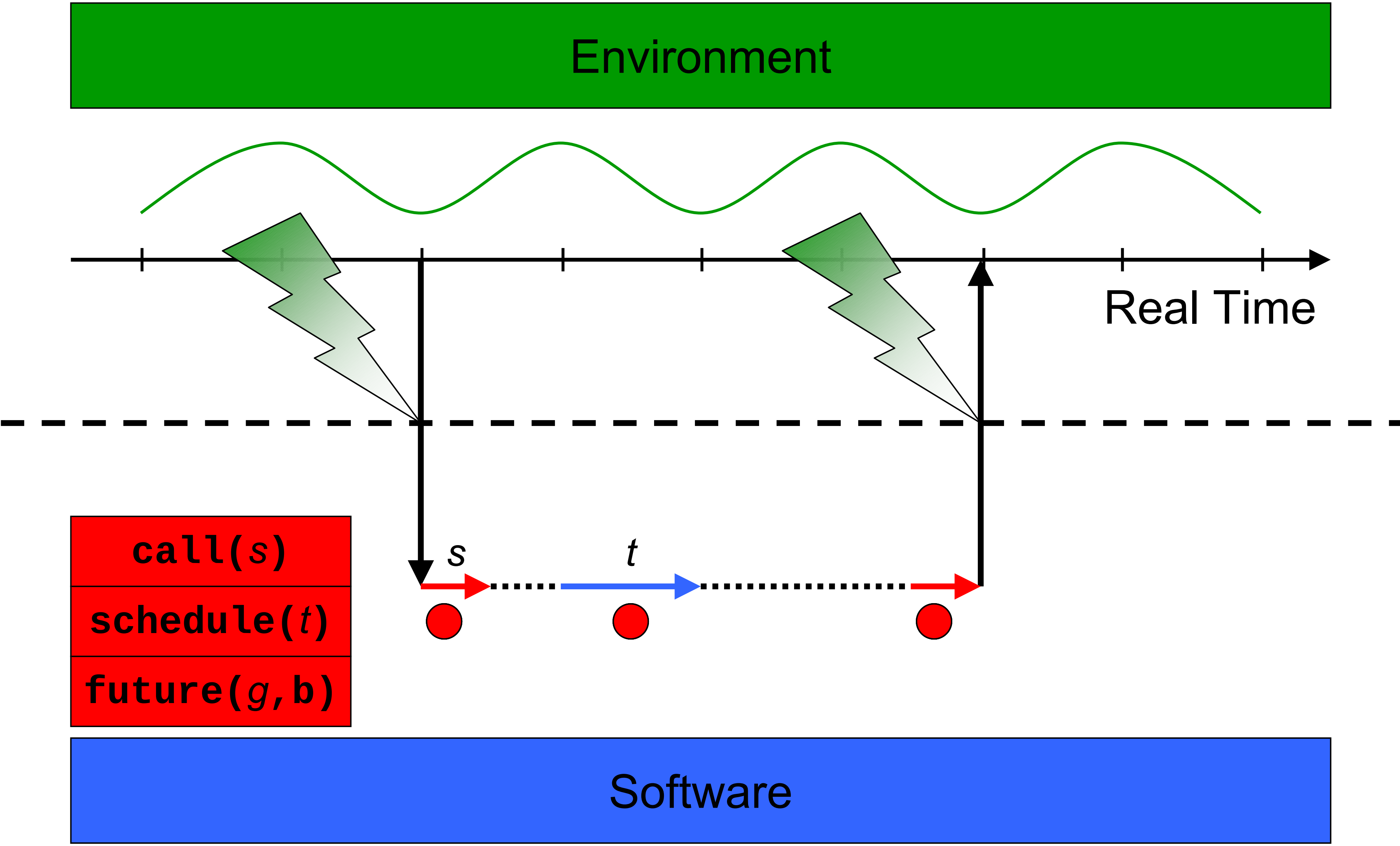
Real Time

call(*s*)

schedule(*t*)

Software

E Code



Environment

Real Time

s

t

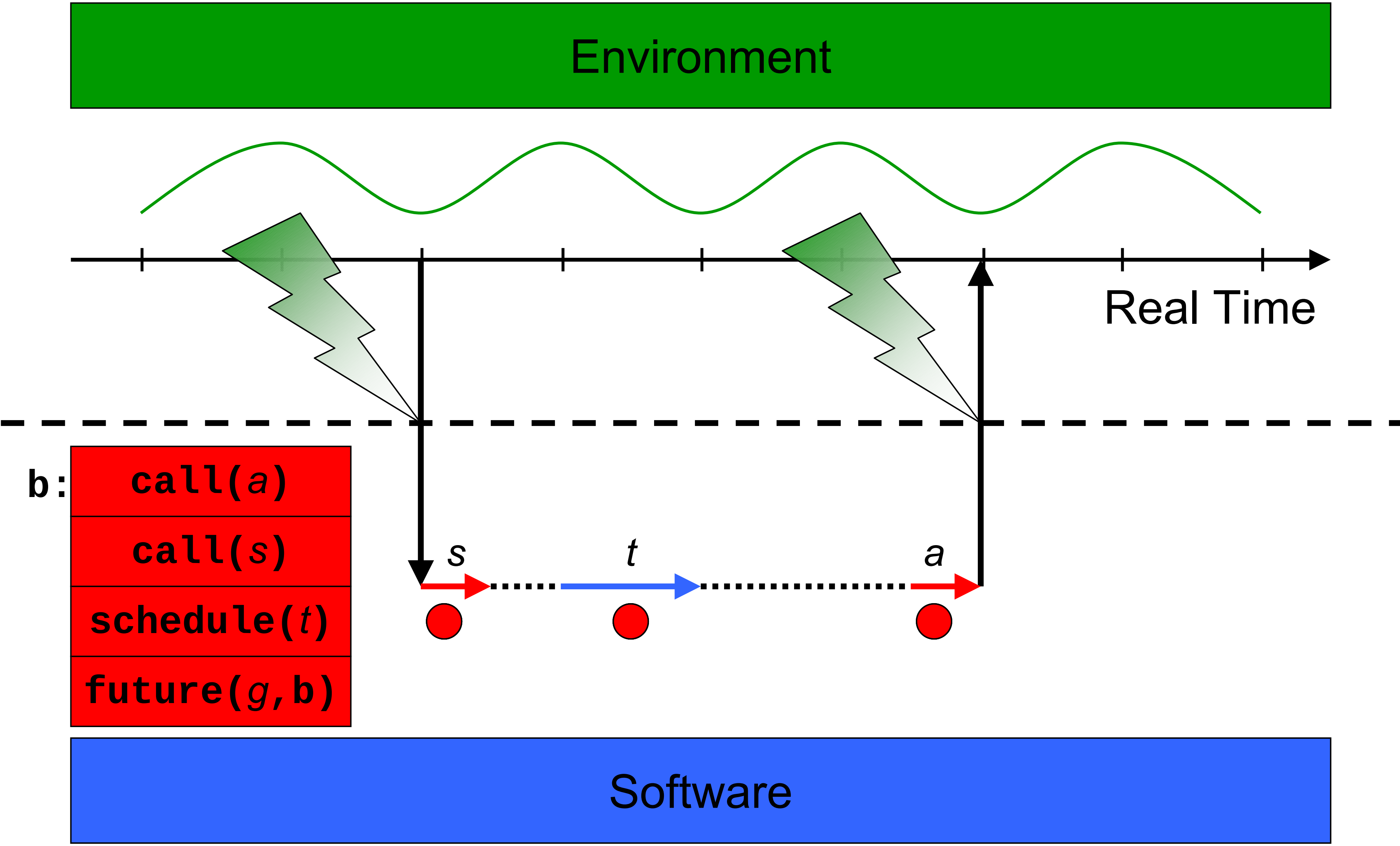
call(*s*)

schedule(*t*)

future(*g*,b)

Software

E Code



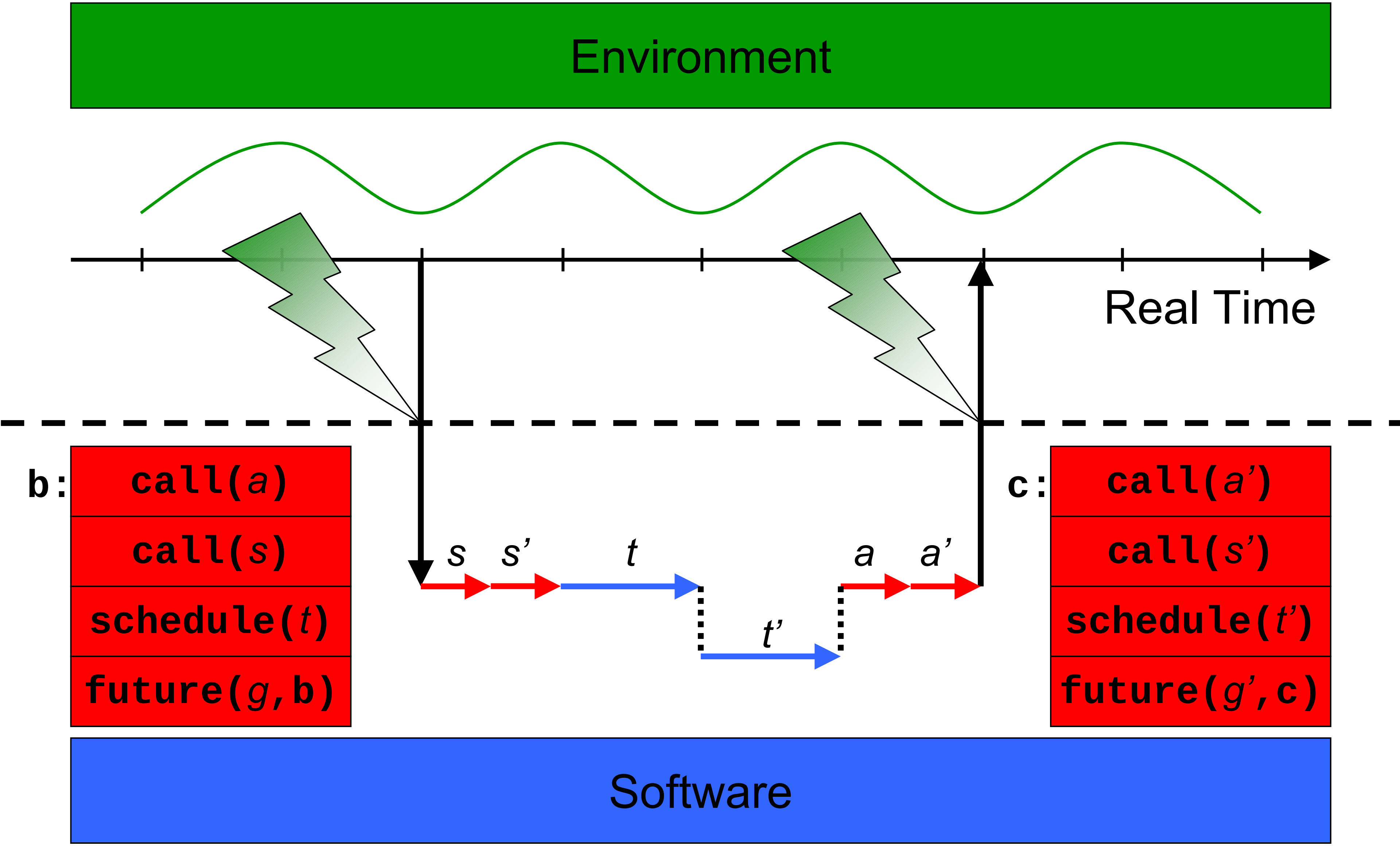
Environment

Real Time

```
b: call(a)
   call(s)
   schedule(t)
   future(g,b)
```

Software

Composability and Time Safety



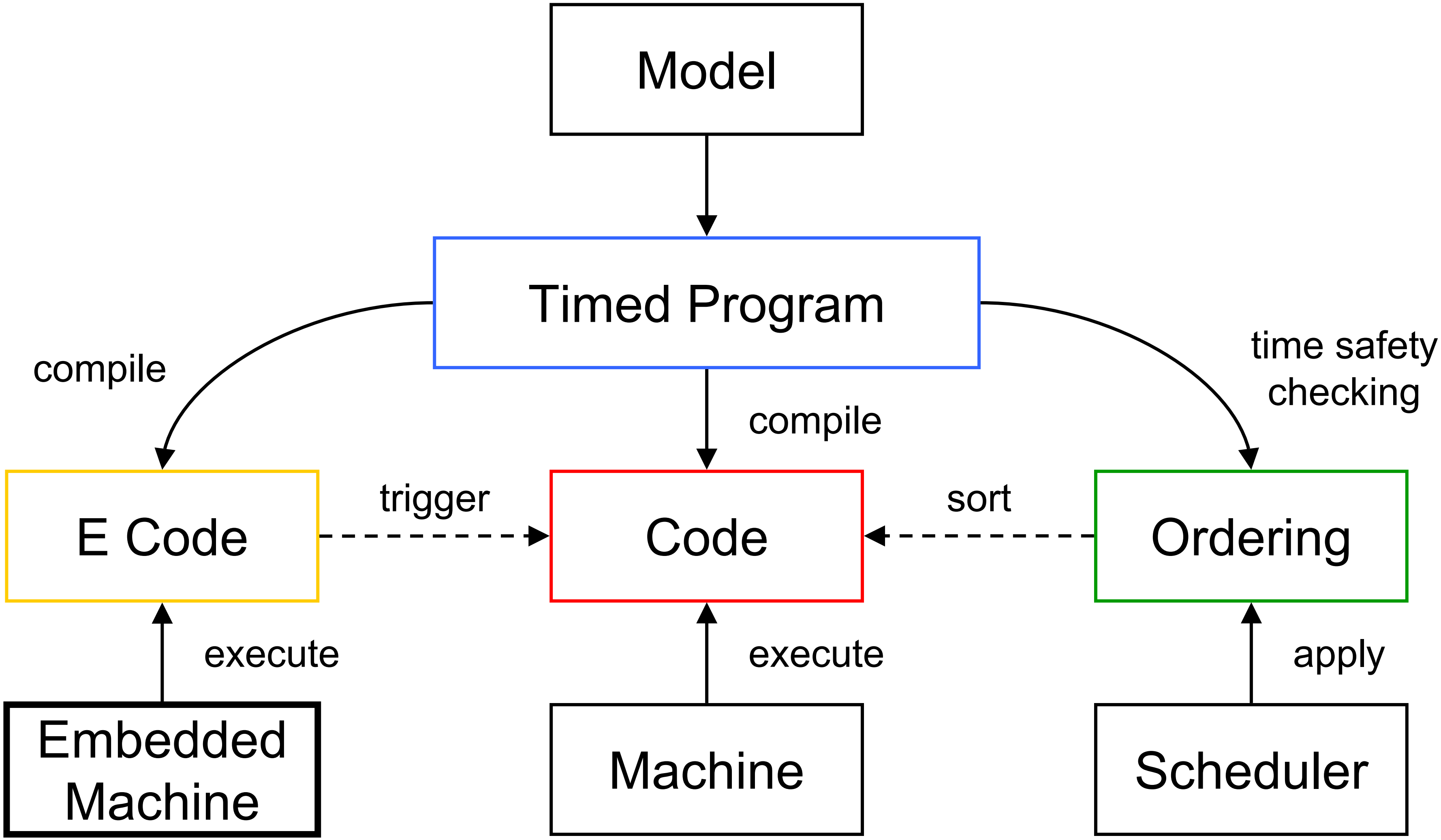
b:

```
call(a)
call(s)
schedule(t)
future(g,b)
```

c:

```
call(a')
call(s')
schedule(t')
future(g',c)
```

The Embedded Machine



Credits

- Synchronous Programming:
    - Esterel
    - Lustre
    - Signal
    - and many more

- Scheduled Programming:
    - Real-Time Operating Systems
    - Real-Time Scheduling Theory
    - Real-Time Communication Protocols

- Classical Compiler Technology:
    - Modular/Incremental Compilation
    - Abstract Machines