Modeling of Time in Discrete-Event Simulation of Systems-on-Chip

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HELP ANR project

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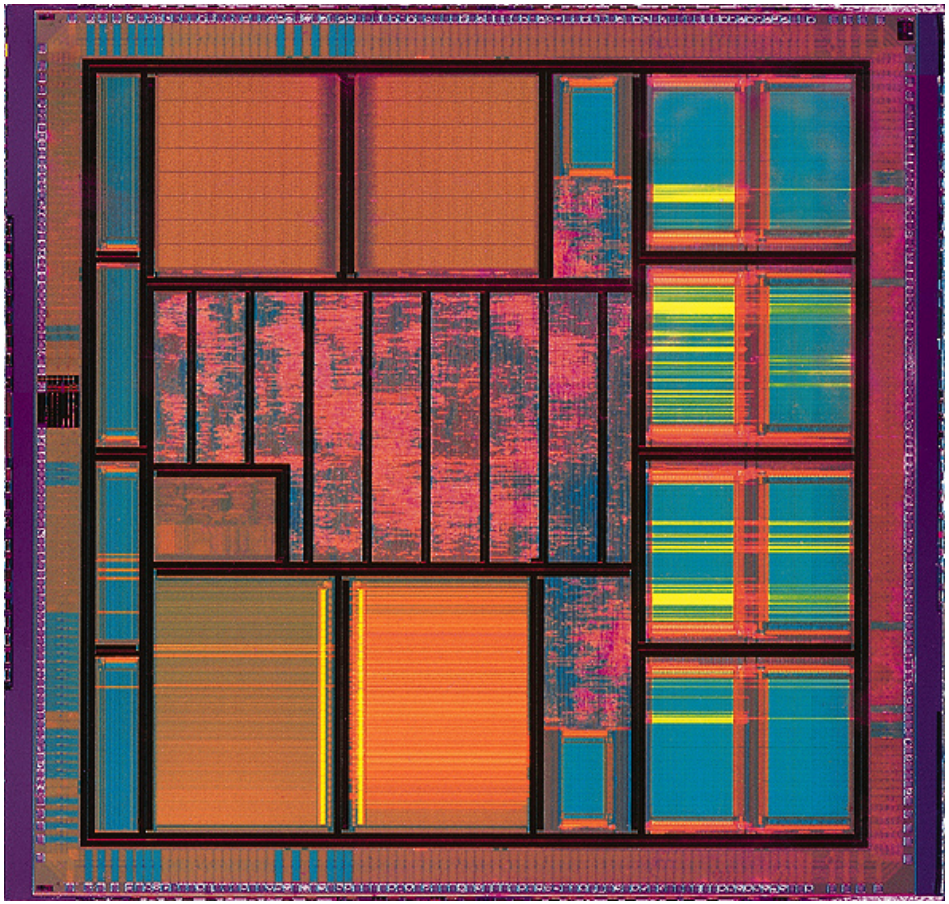
Outline

Outline

Modern Systems-on-a-Chip



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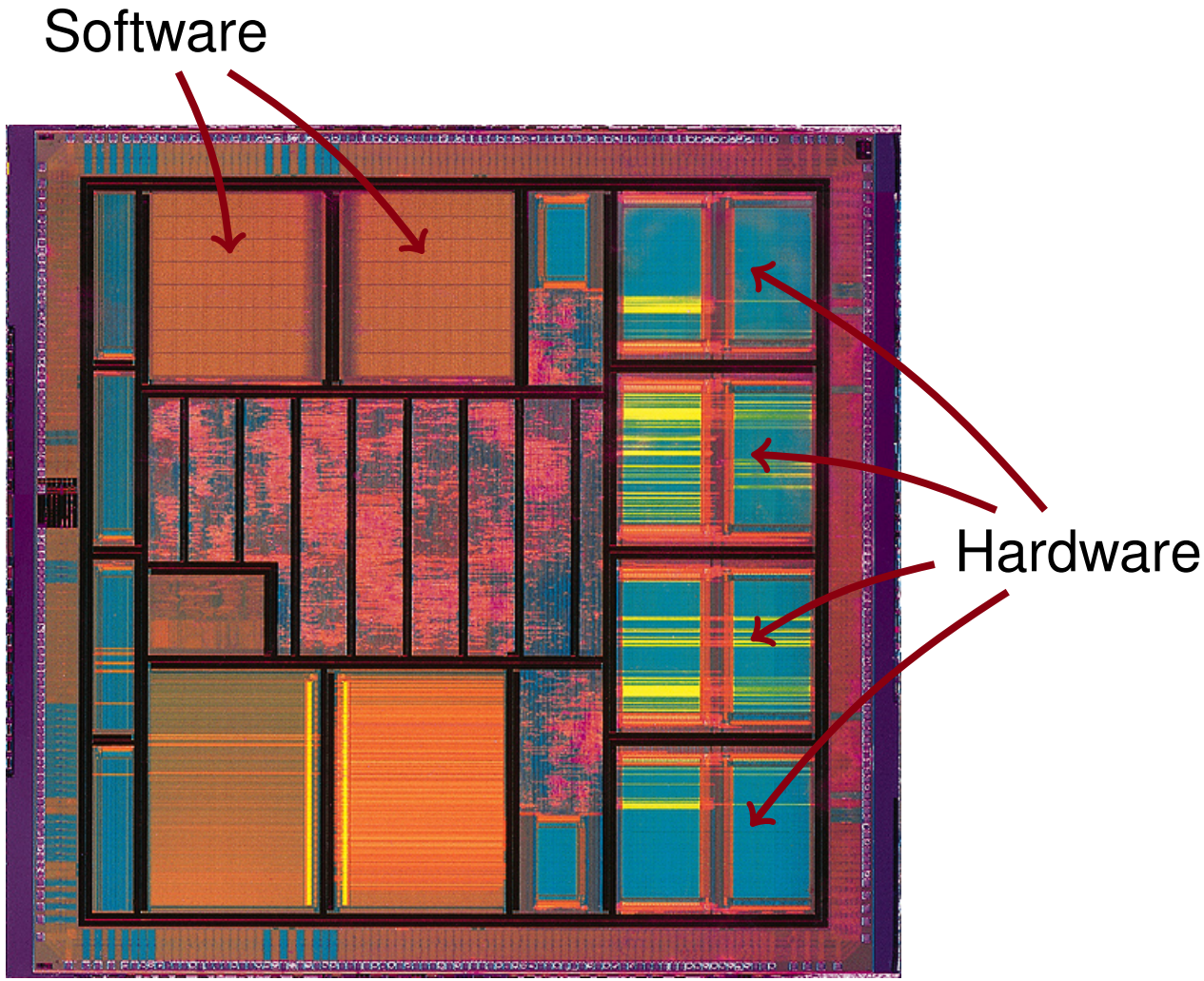

Transaction-Level Modeling

- (Fast) simulation essential in the design-flow
  - To write/debug software
  - To validate architectural choices
  - As reference for hardware verification

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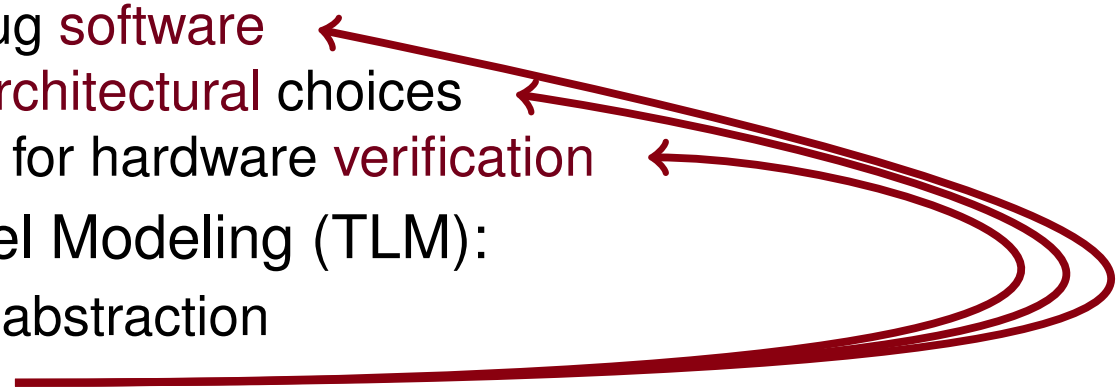

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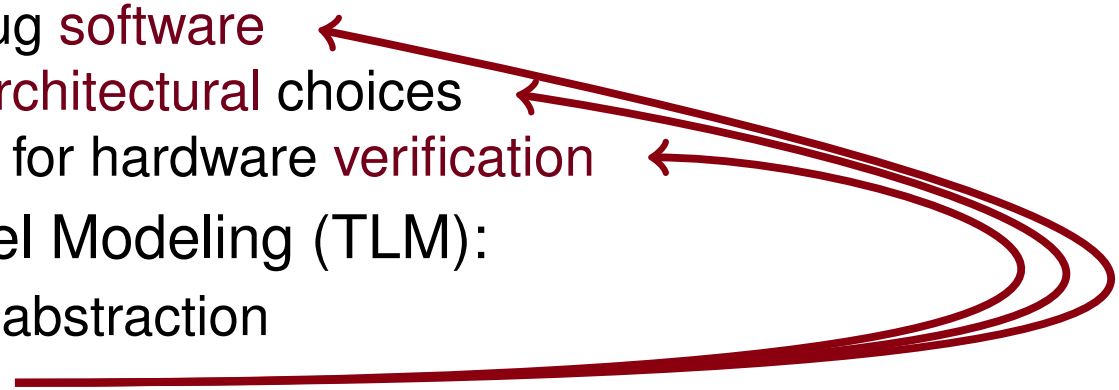
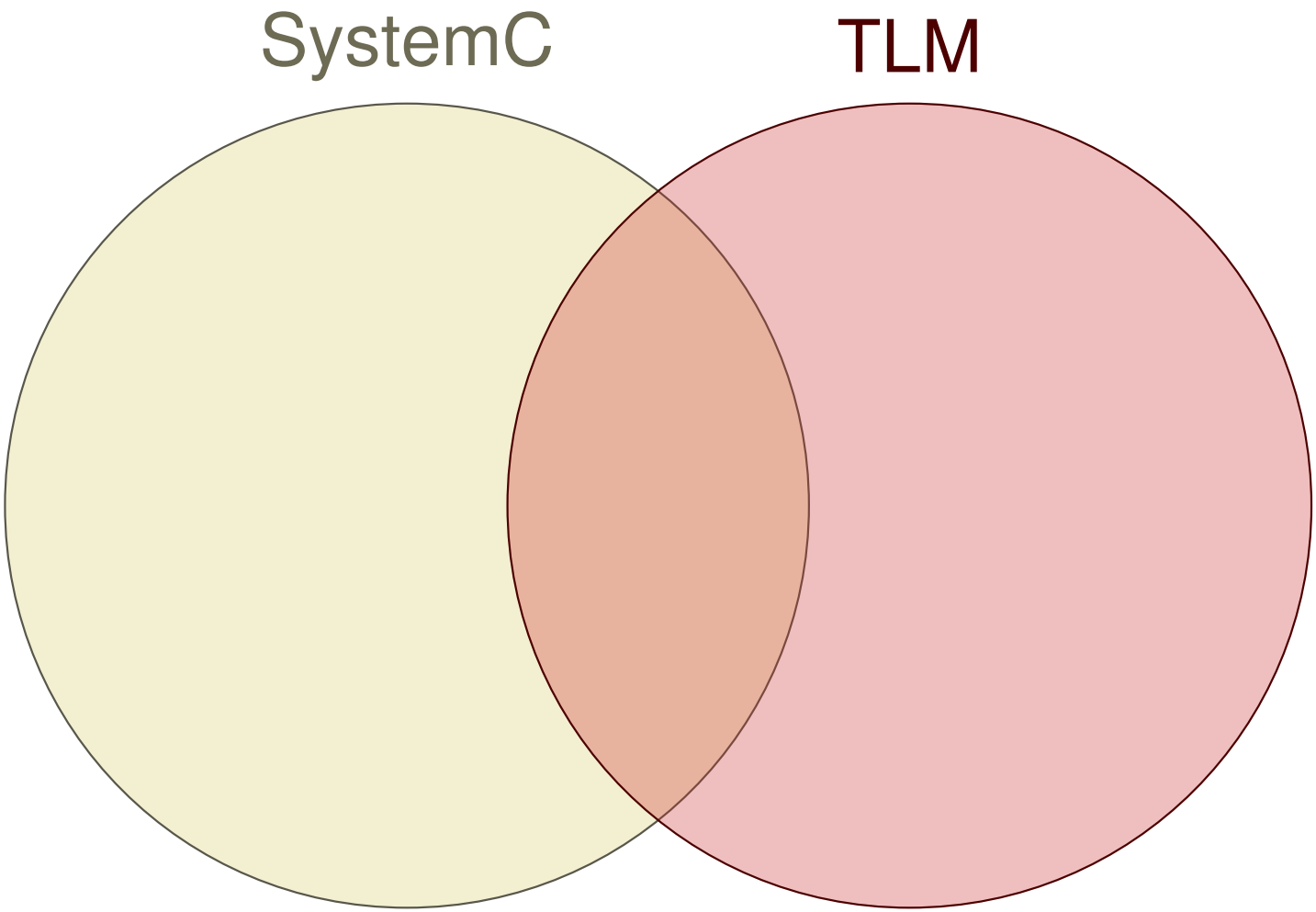


Industry Standard = SystemC/TLM

SystemC/TLM vs. “TLM Abstraction Level”



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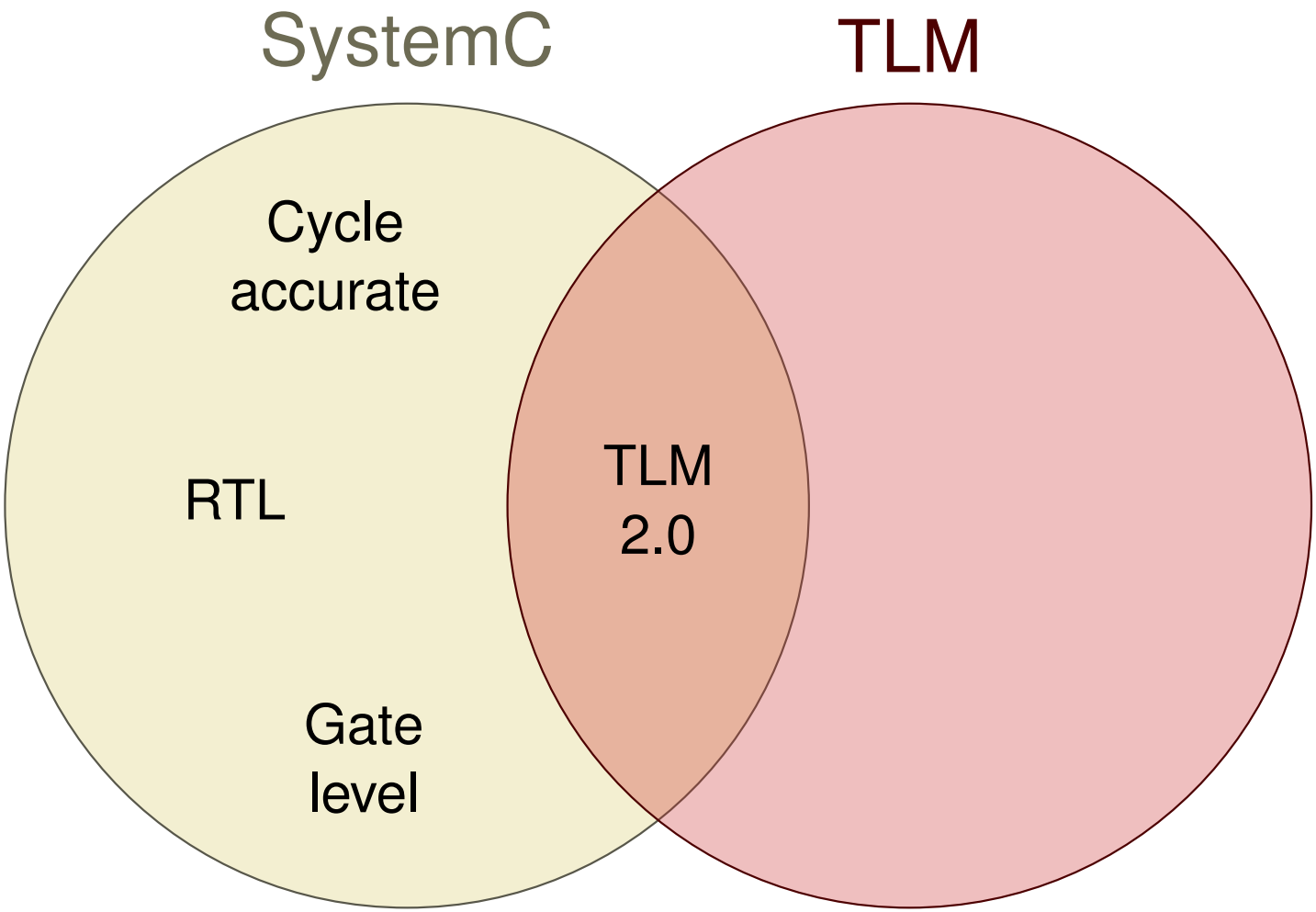

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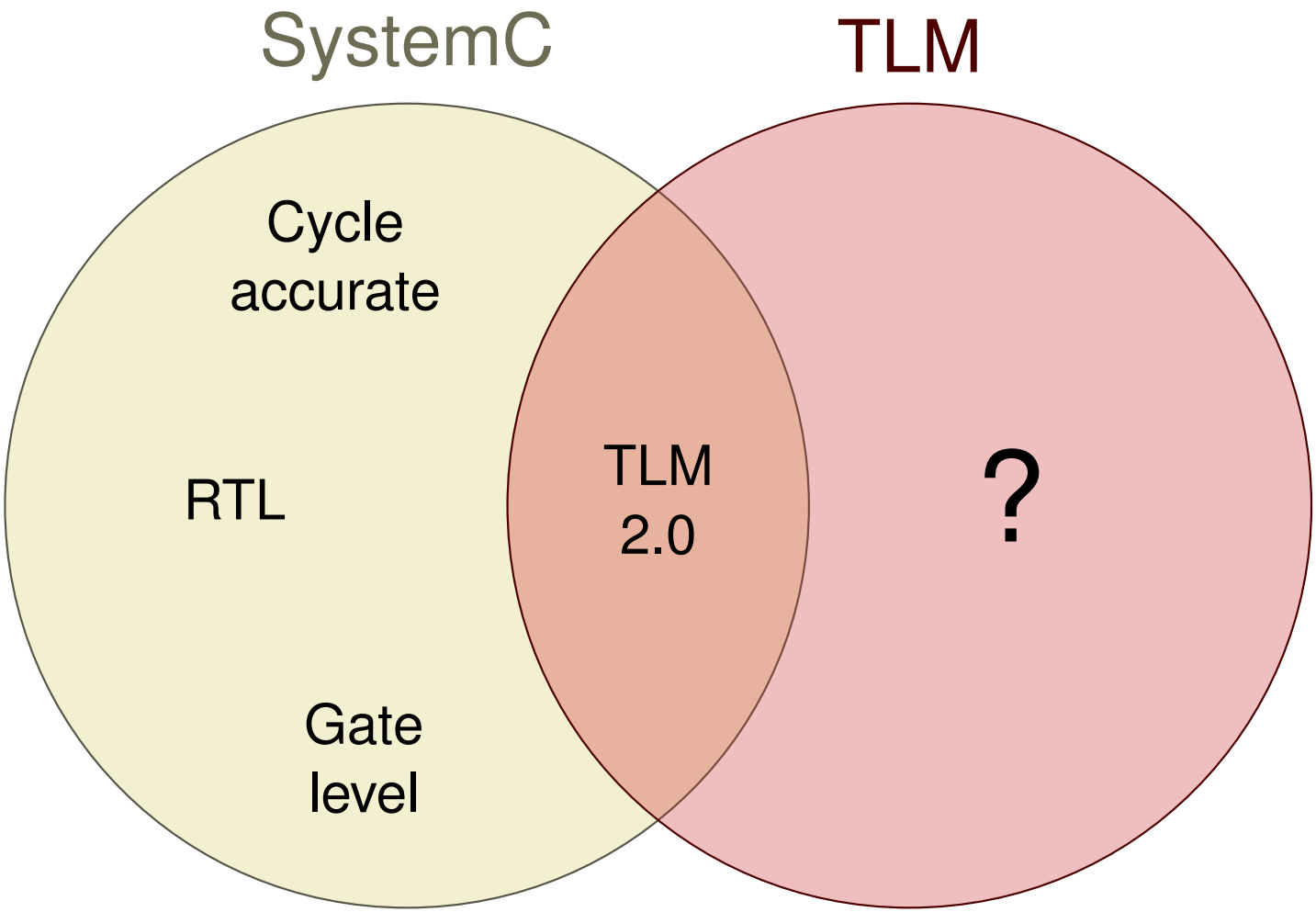

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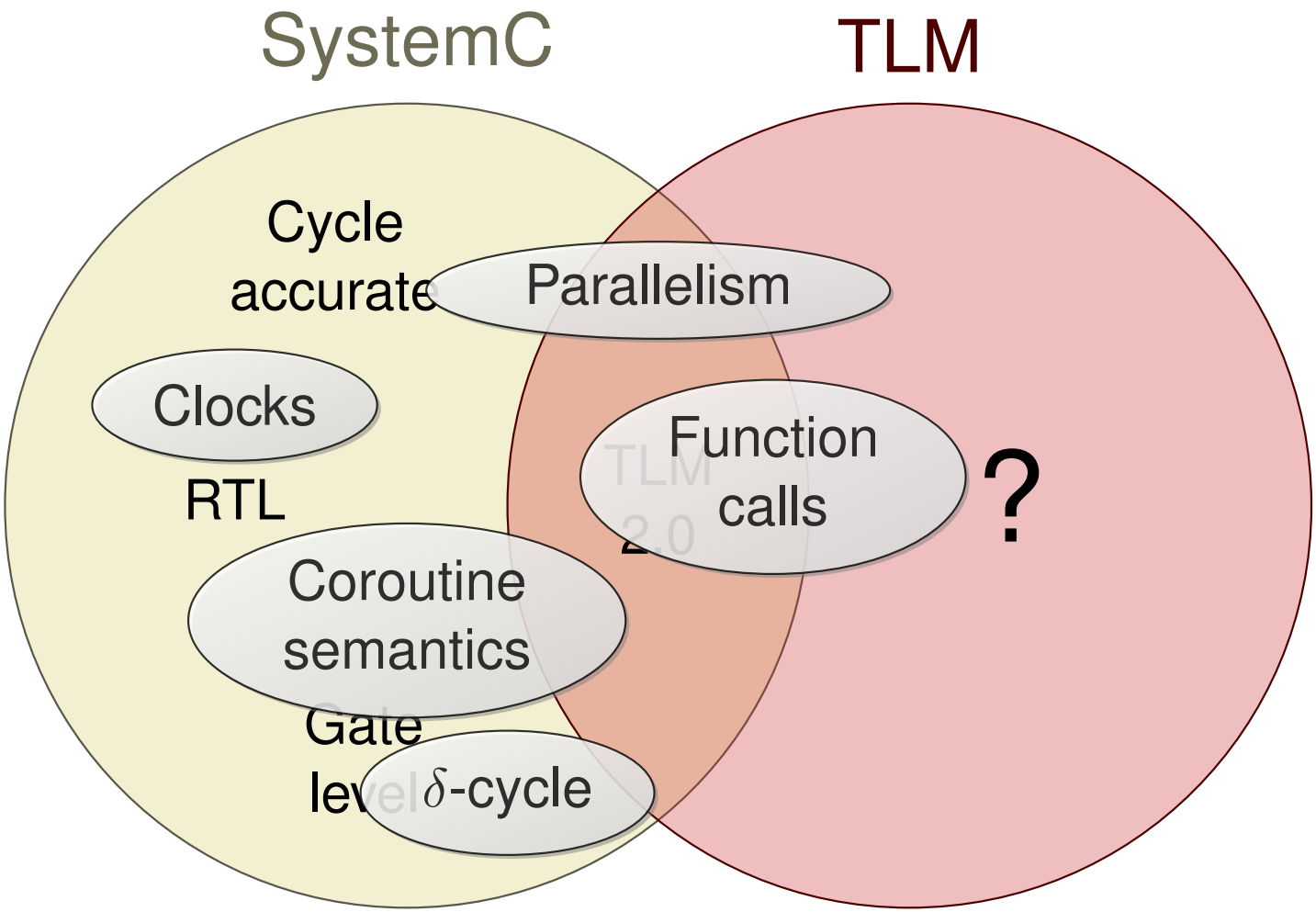

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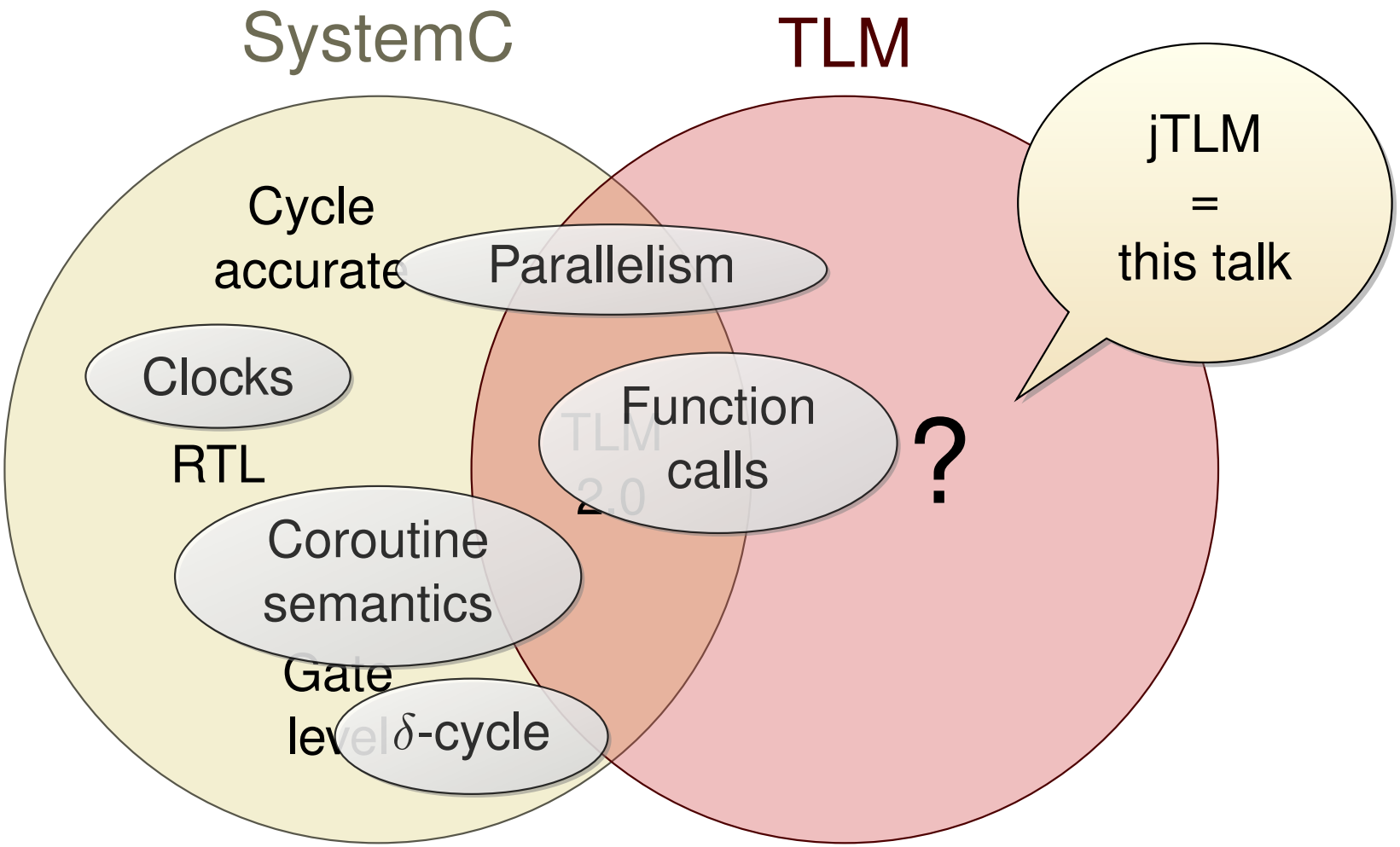
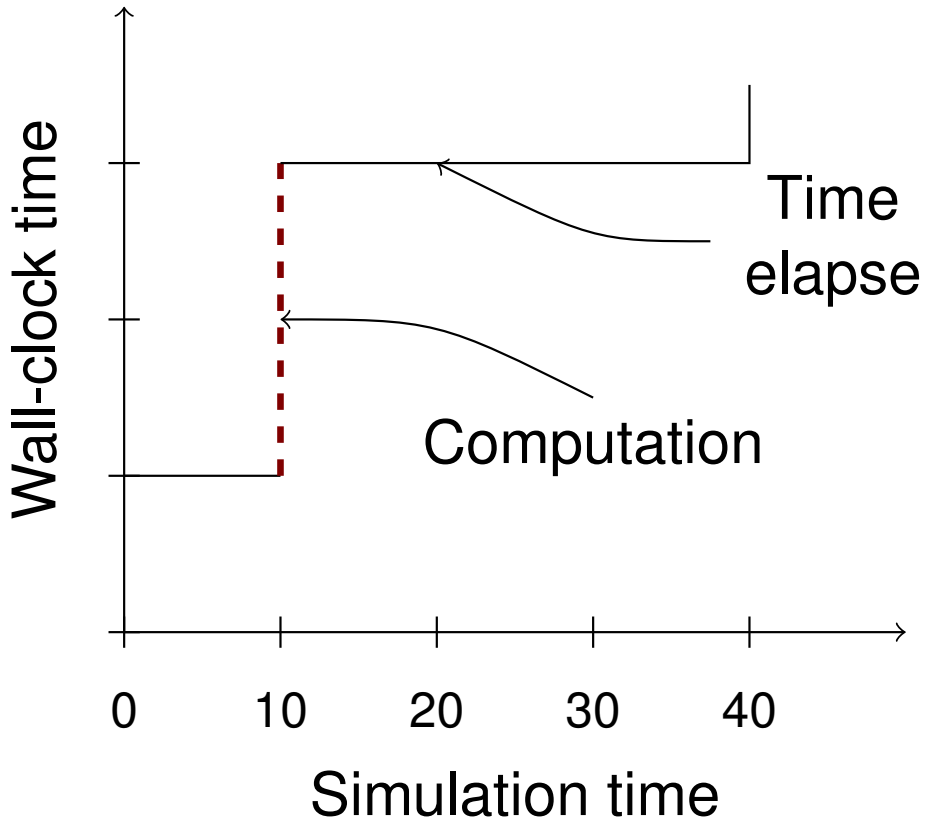


jTLM: goals and peculiarities

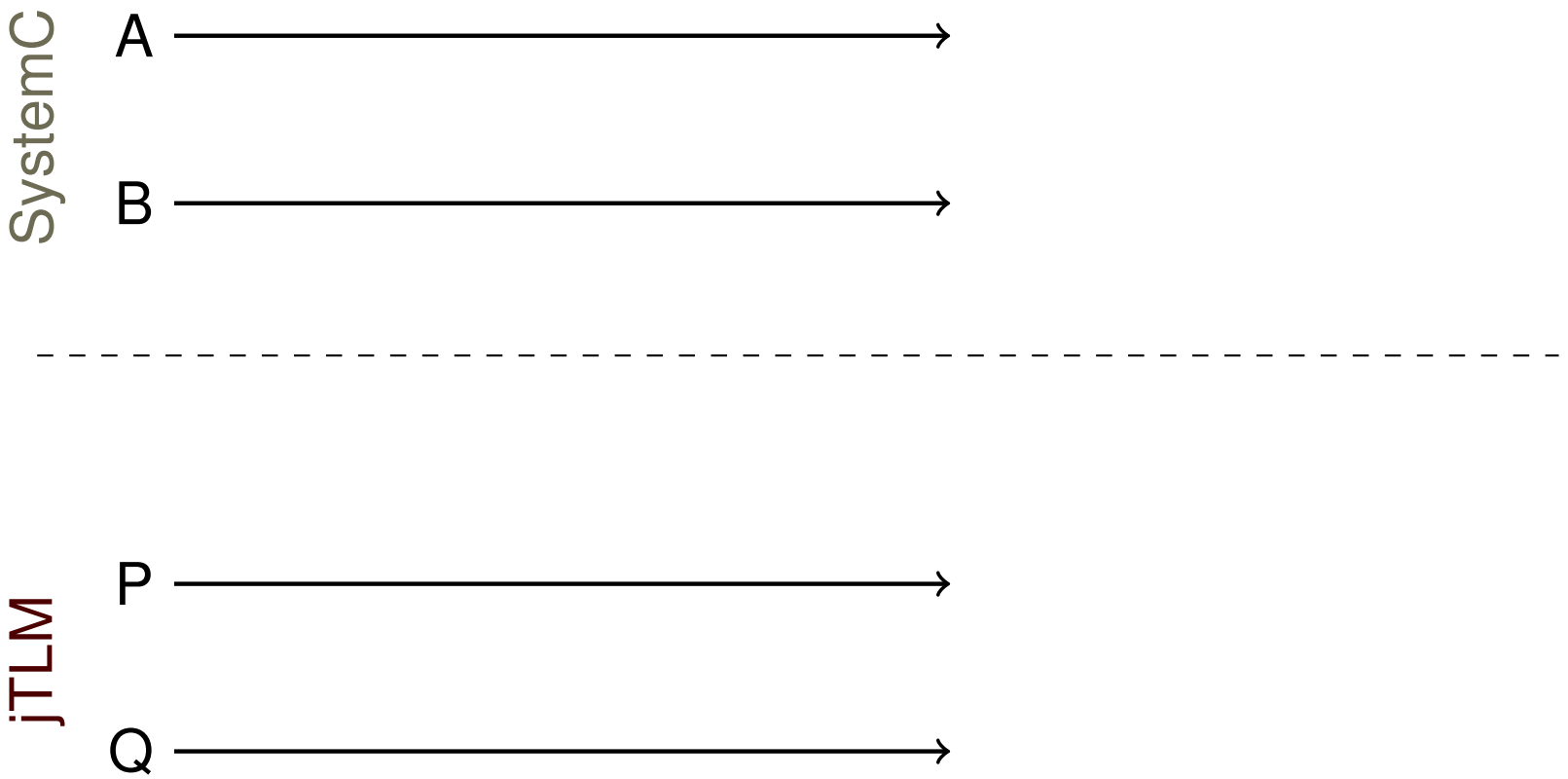
- jTLM's goal: define "TLM" independently of SystemC
  - Not cooperative (true parallelism)
  - Not C++ (Java)
  - No δ-cycle
- Interesting features
  - Small and simple code ($\approx$ 500 LOC)
  - Nice experimentation platform
- Not meant for production

Outline

Simulation Time Vs Wall-Clock Time



Time in SystemC and jTLM



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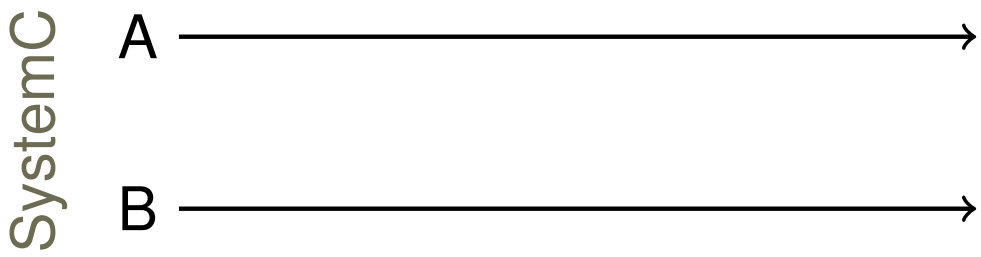

Process A:

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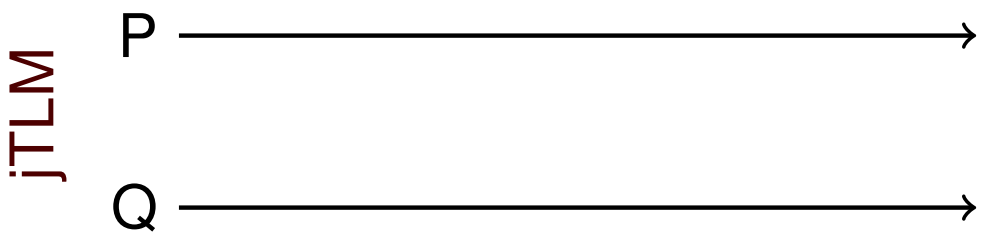
f();
//time taken by f
wait(20, SC_NS);
```



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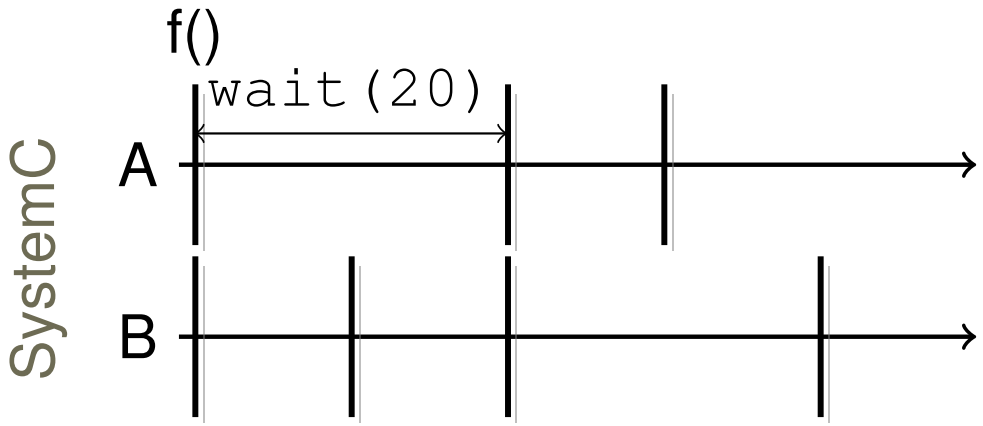

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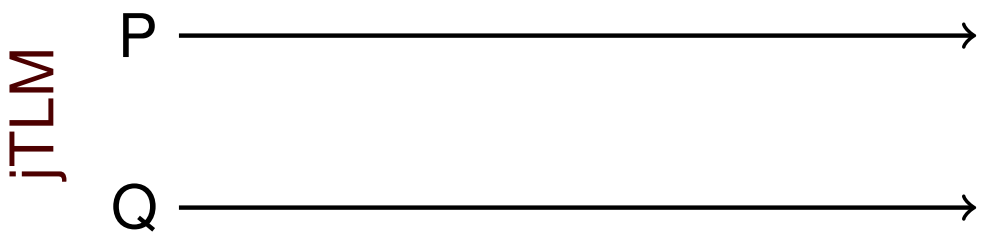

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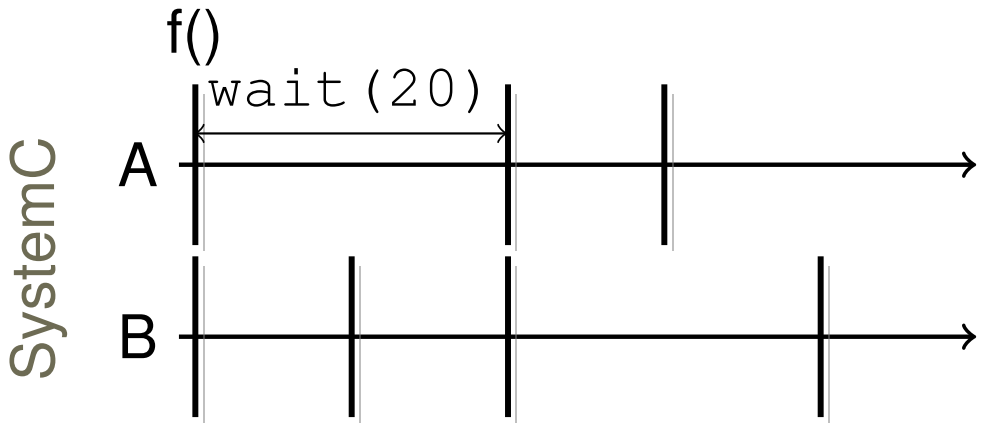

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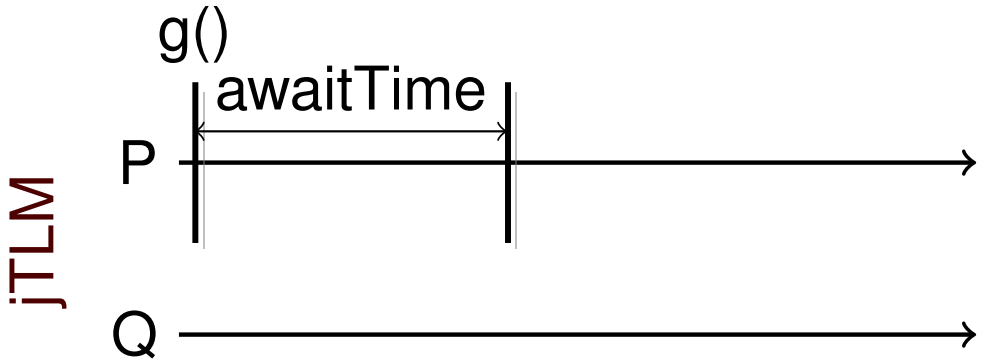

Process P:

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g();
awaitTime(20);
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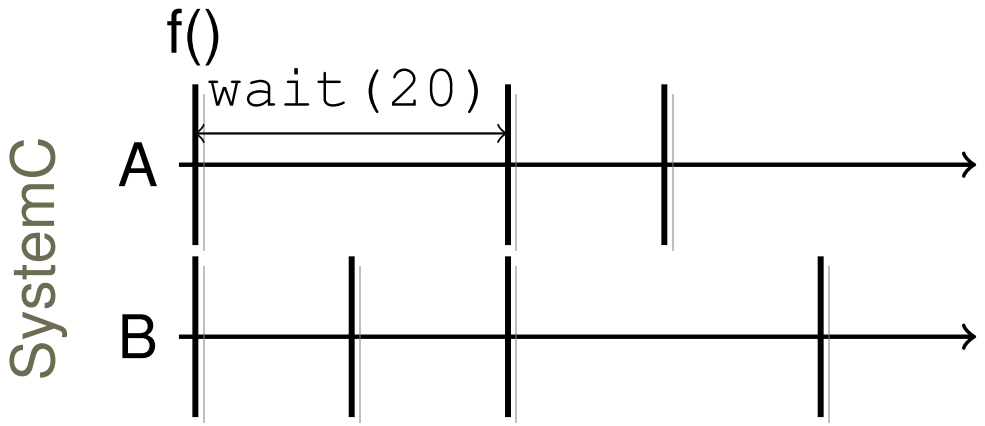
Time in SystemC and jTLM



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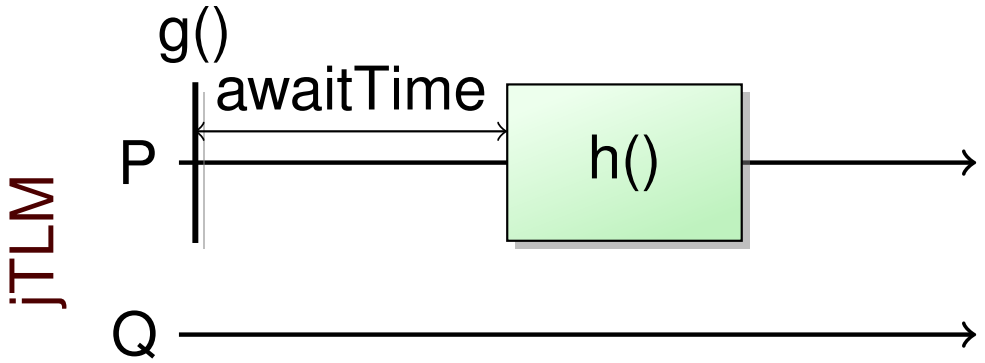

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g();
awaitTime(20);
consumesTime(15) {
  h();
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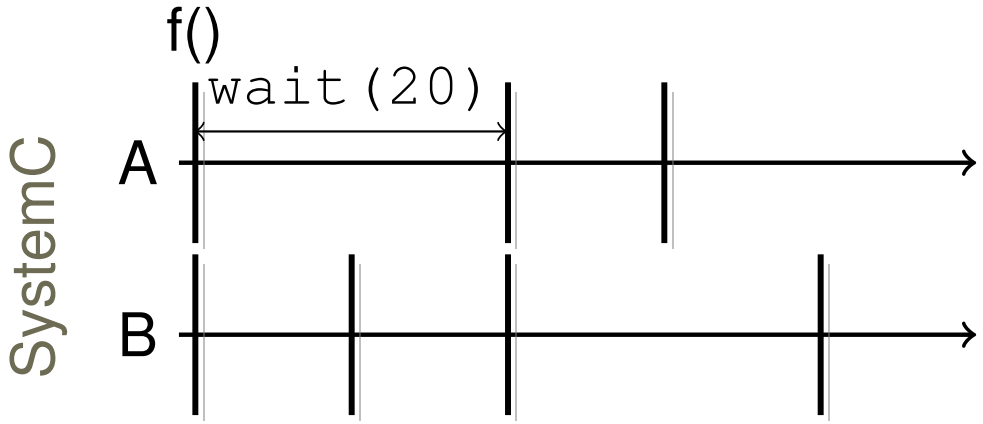
Time in SystemC and jTLM



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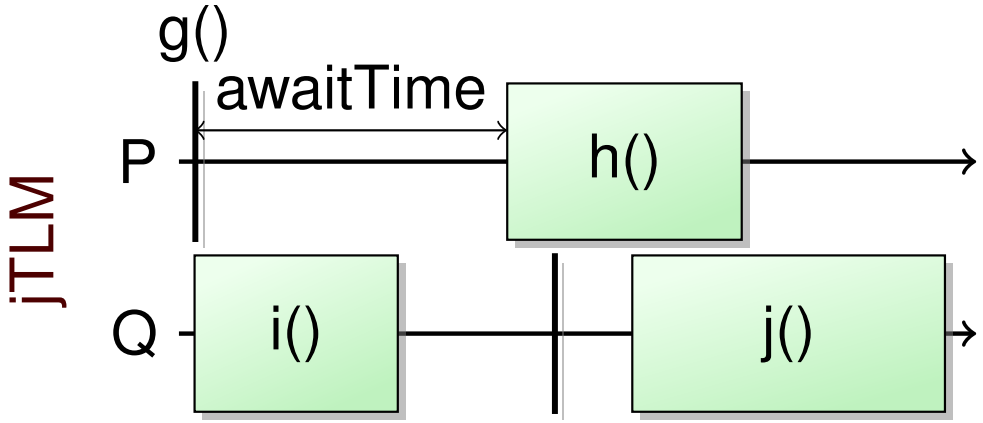

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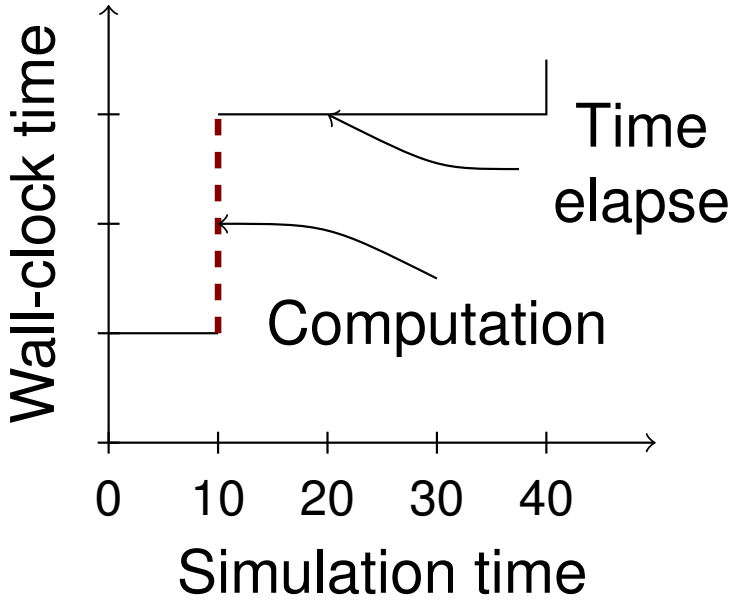
Time *à la* SystemC: `awaitTime(T)`

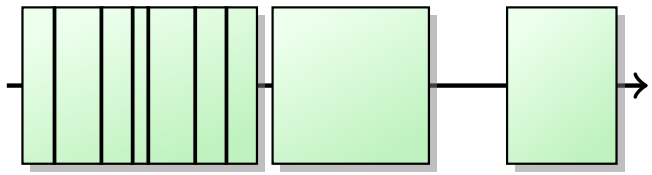
- By default, time does not pass
  $\Rightarrow$ instantaneous tasks
- `awaitTime(T)` :
  let other processes execute
  for T time units




```
f(); // instantaneous
awaitTime(20);
```

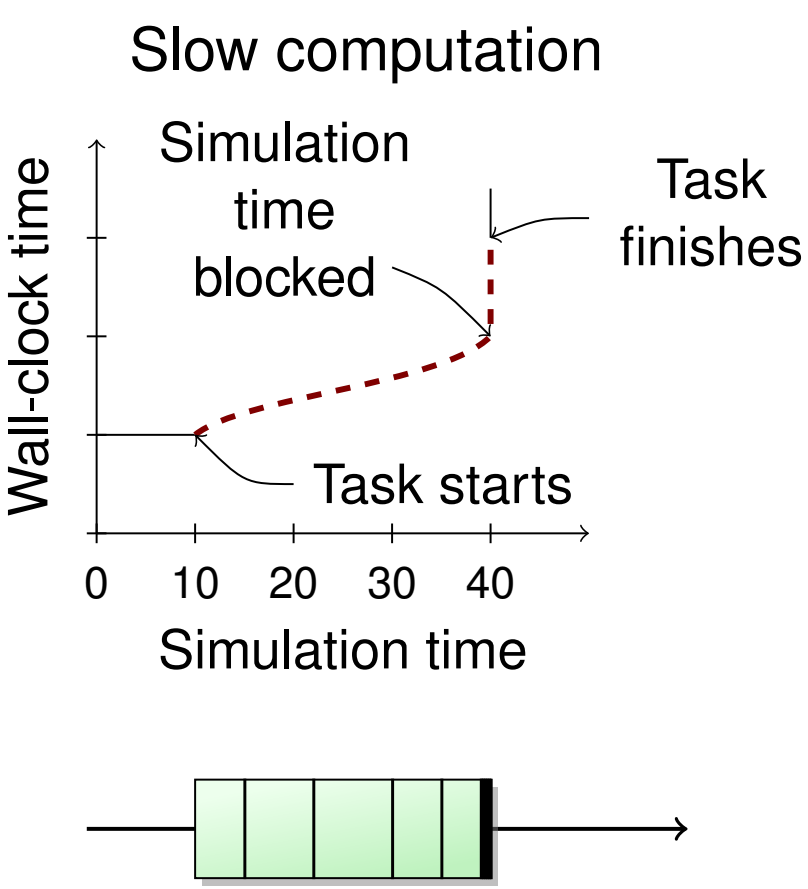
Task with Known Duration: `consumesTime(T)`

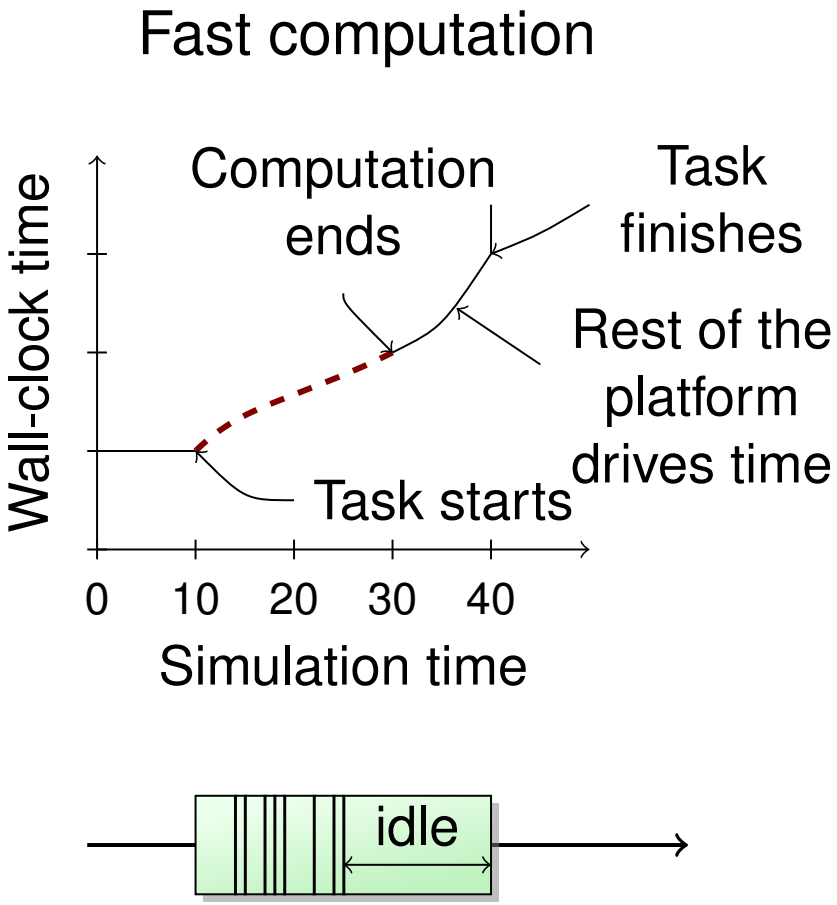
- Semantics:
  - Start and end dates known
  - Actions contained in task spread in between
- Advantages:
  - Model closer to actual system
  - Less bugs hidden
  - Better parallelization



```
consumesTime(15) {
    f1();
    f2();
    f3();
}
consumesTime(10) {
    g();
}
```

Execution of `consumesTime(T)`





Outline

Exposing Bugs

Example bug: mis-placed synchronization:

```
flag = true;
awaitTime(5);
writeIMG();
awaitTime(10);
```

||

```
while(!flag)
    awaitTime(1);
awaitTime(10);
readIMG();
```

$\Rightarrow$ bug never seen in simulation

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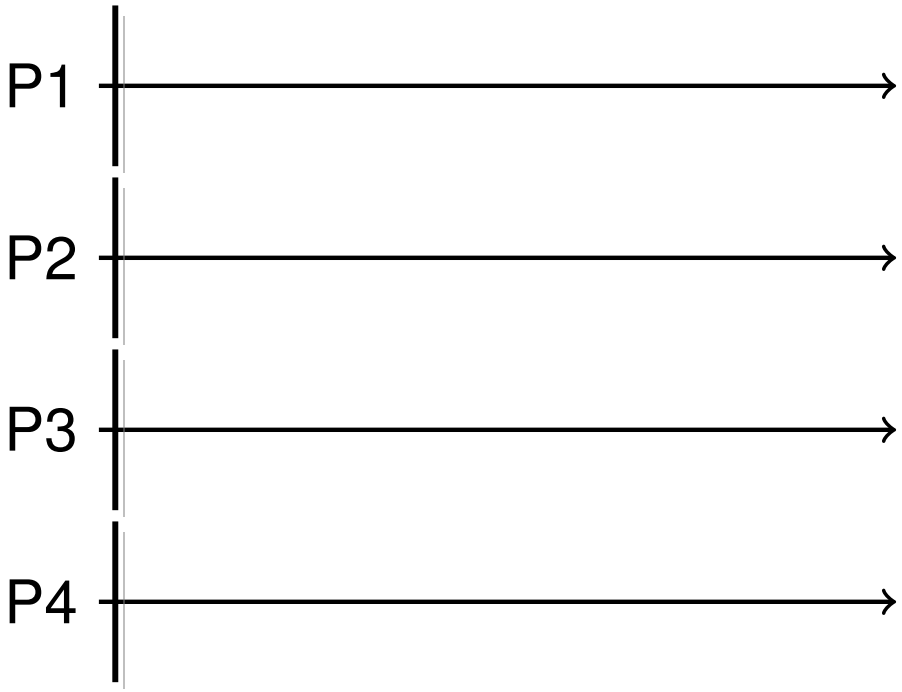
⇒ strictly more behaviors, including the buggy one

Parallelization



jTLM's Semantics

- Simultaneous tasks run in parallel

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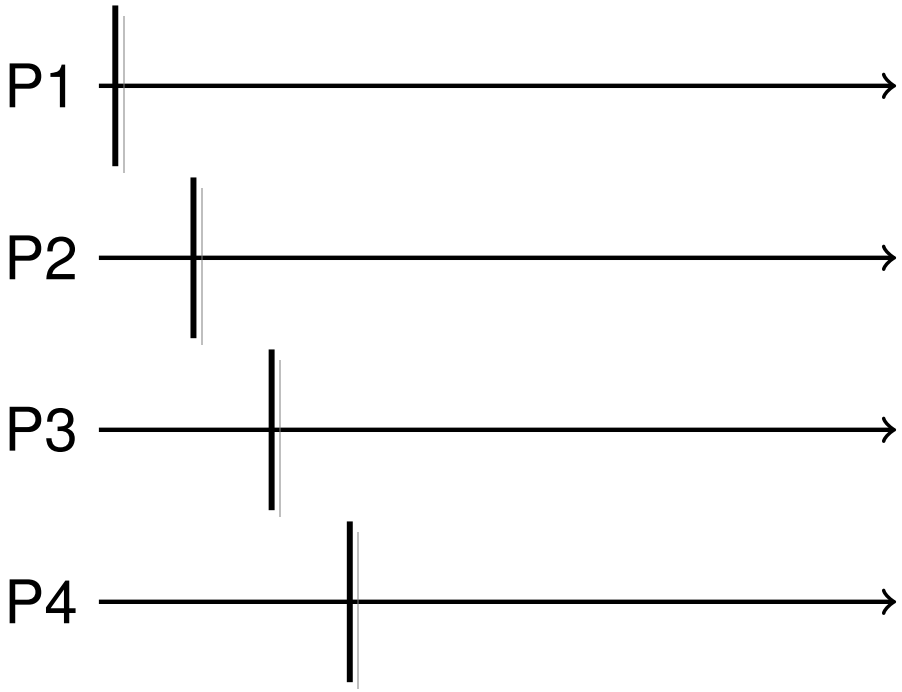

jTLM's Semantics

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- Non-simultaneous tasks don't

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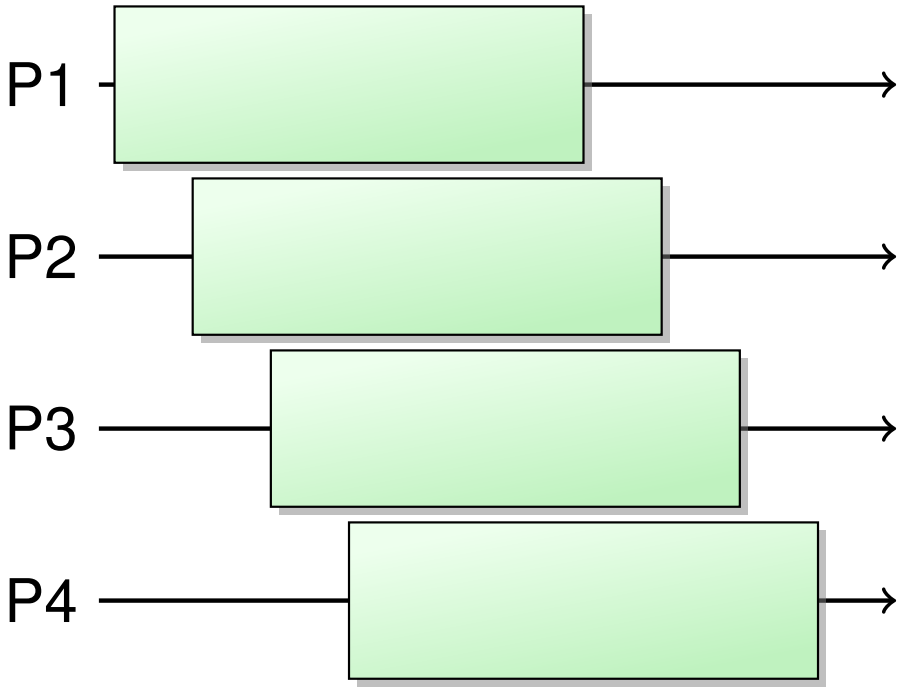

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- Overlapping tasks do

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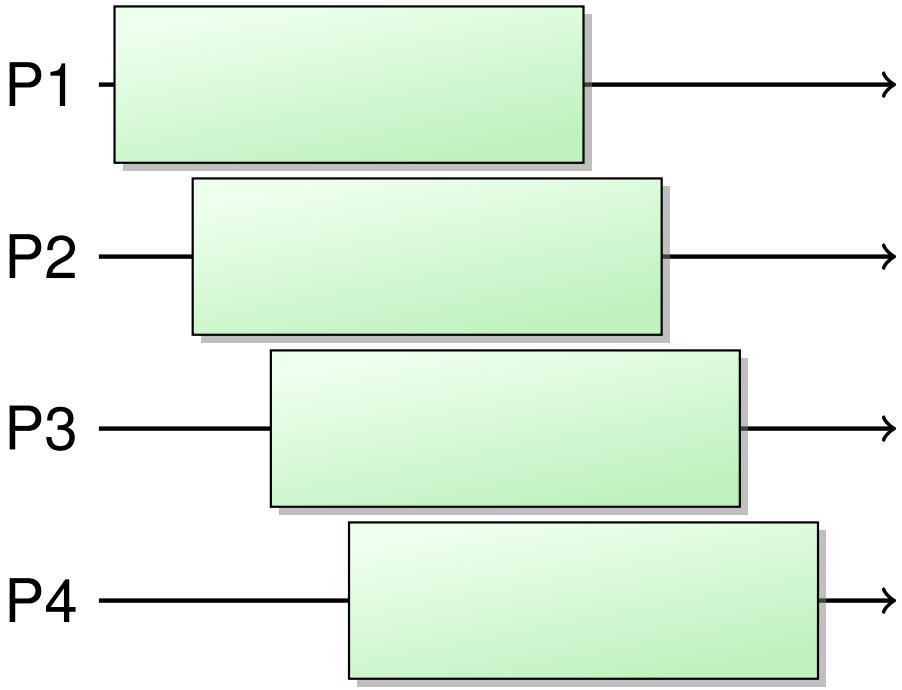

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- Back to SystemC:
  - Parallelizing within δ-cycle = great if you have clocks
  - Simulation time is the bottleneck with quantitative/fuzzy time

Outline

Time Queue and `awaitTime(T)`

Process P:

```
►f();
 awaitTime(50);
```

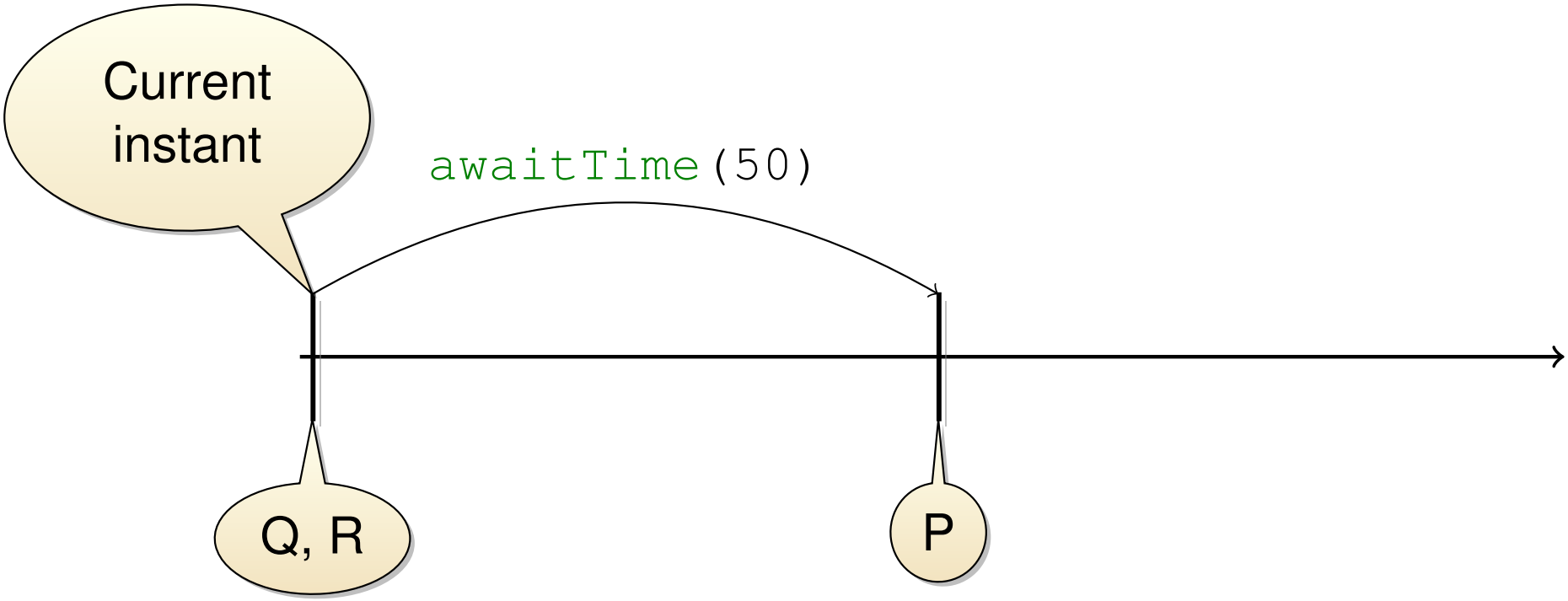
Process Q:

```
►h();
 awaitTime(30);
 g();
 awaitTime(30);
```

Process R:

```
►i();
 awaitTime(90);
```

Time Queue and `awaitTime(T)`



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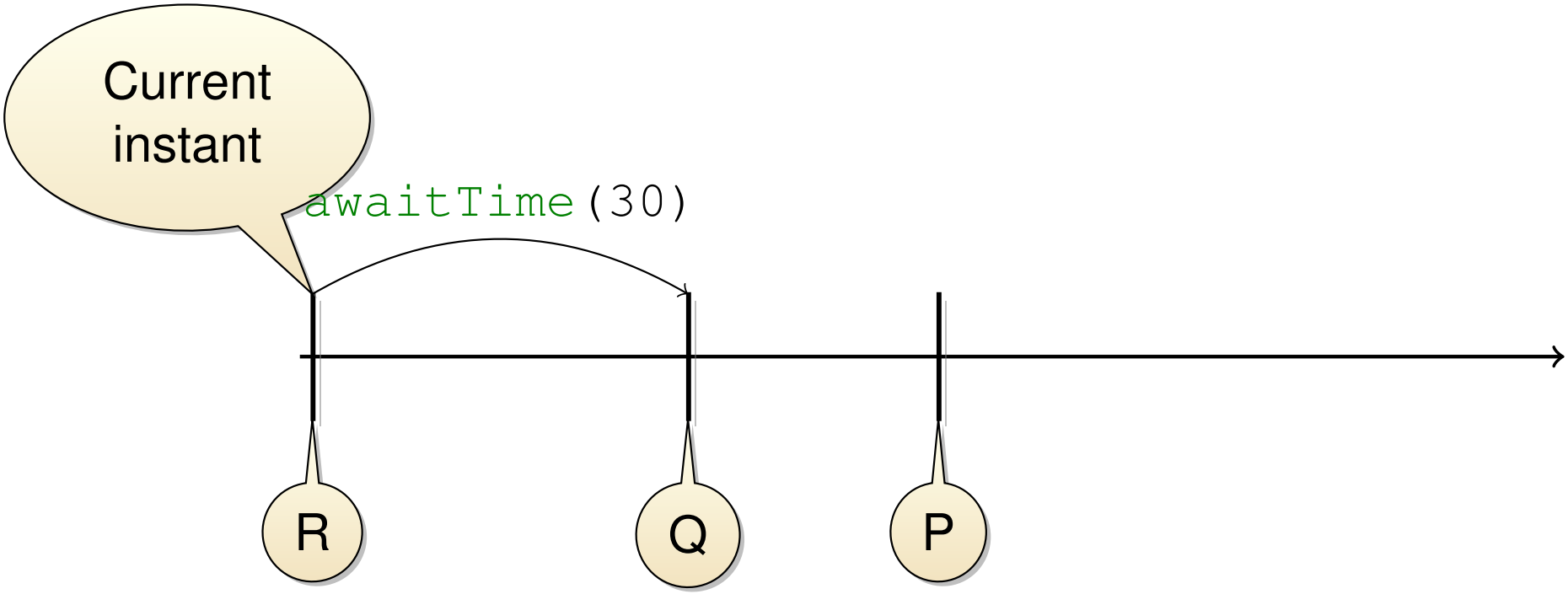

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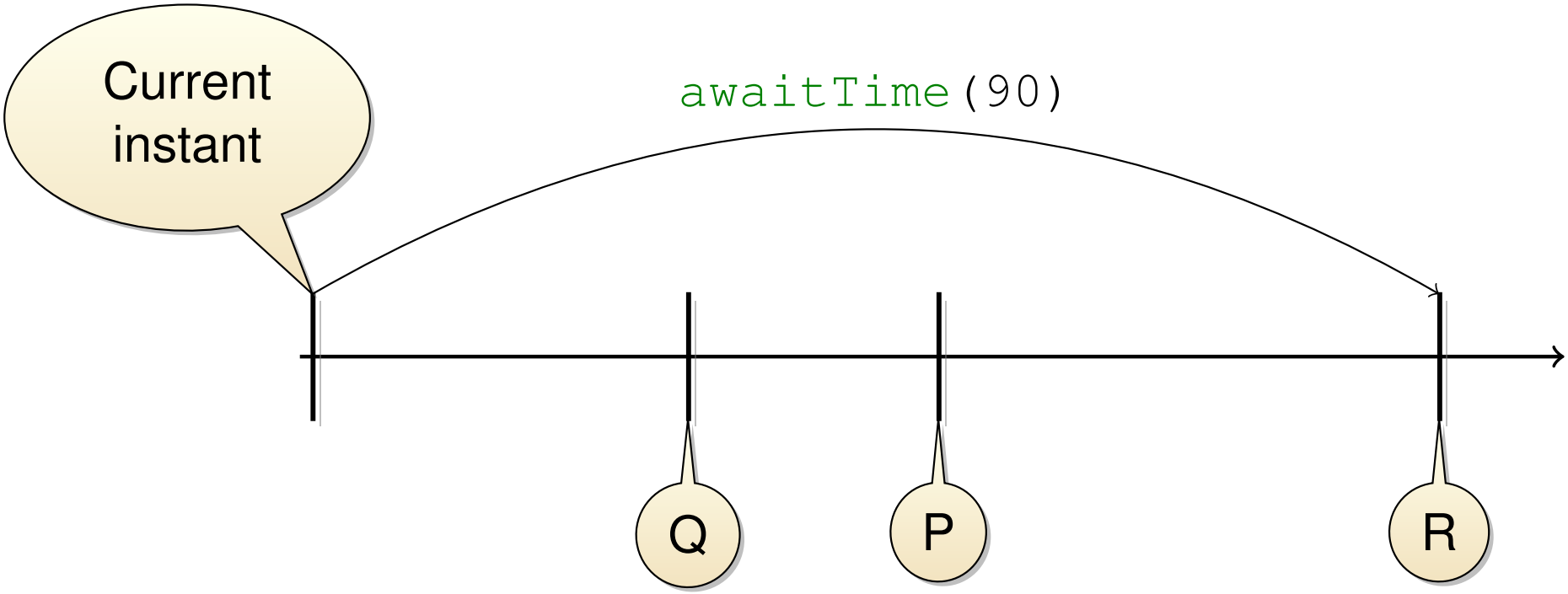

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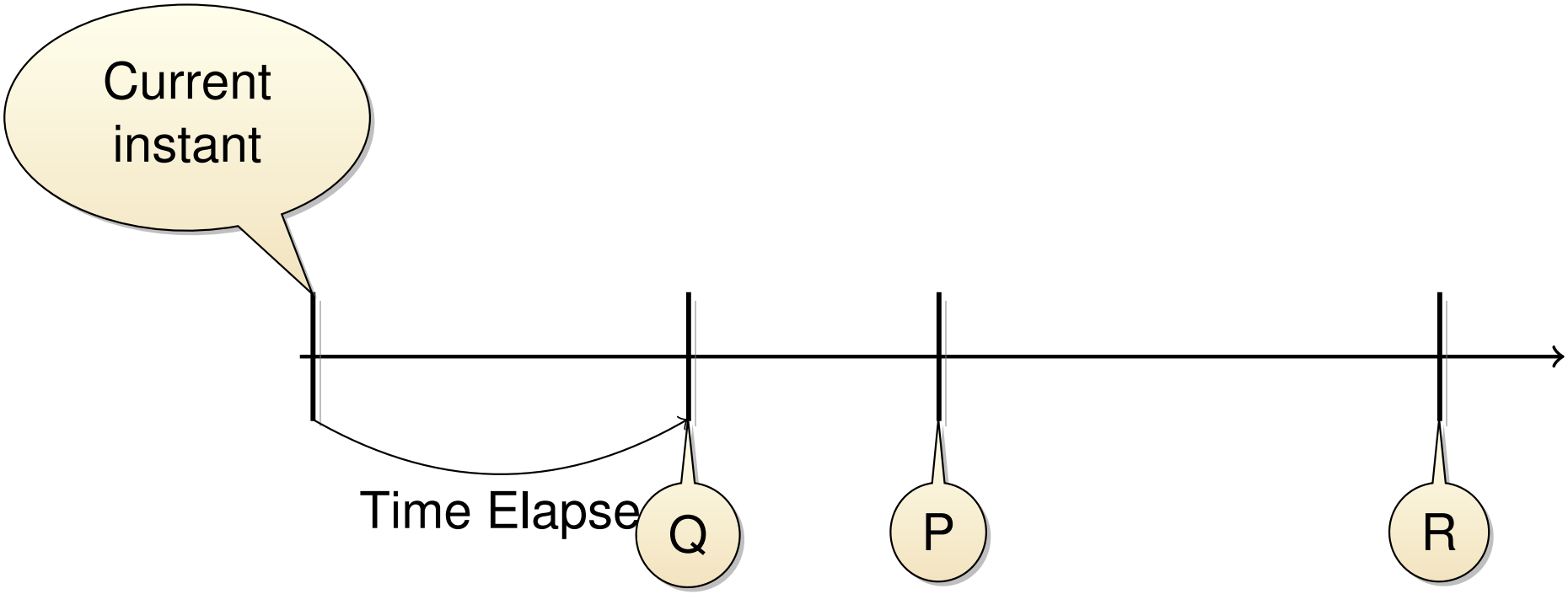

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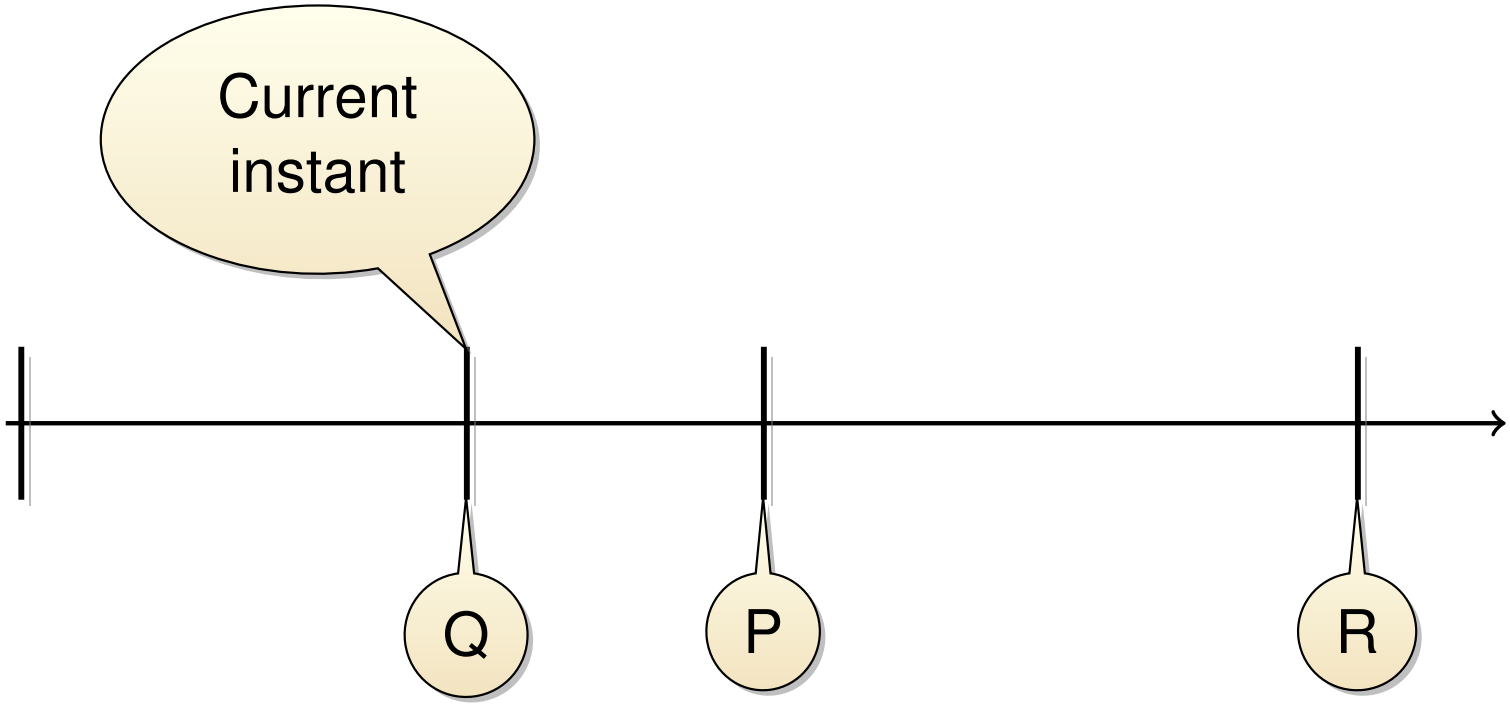

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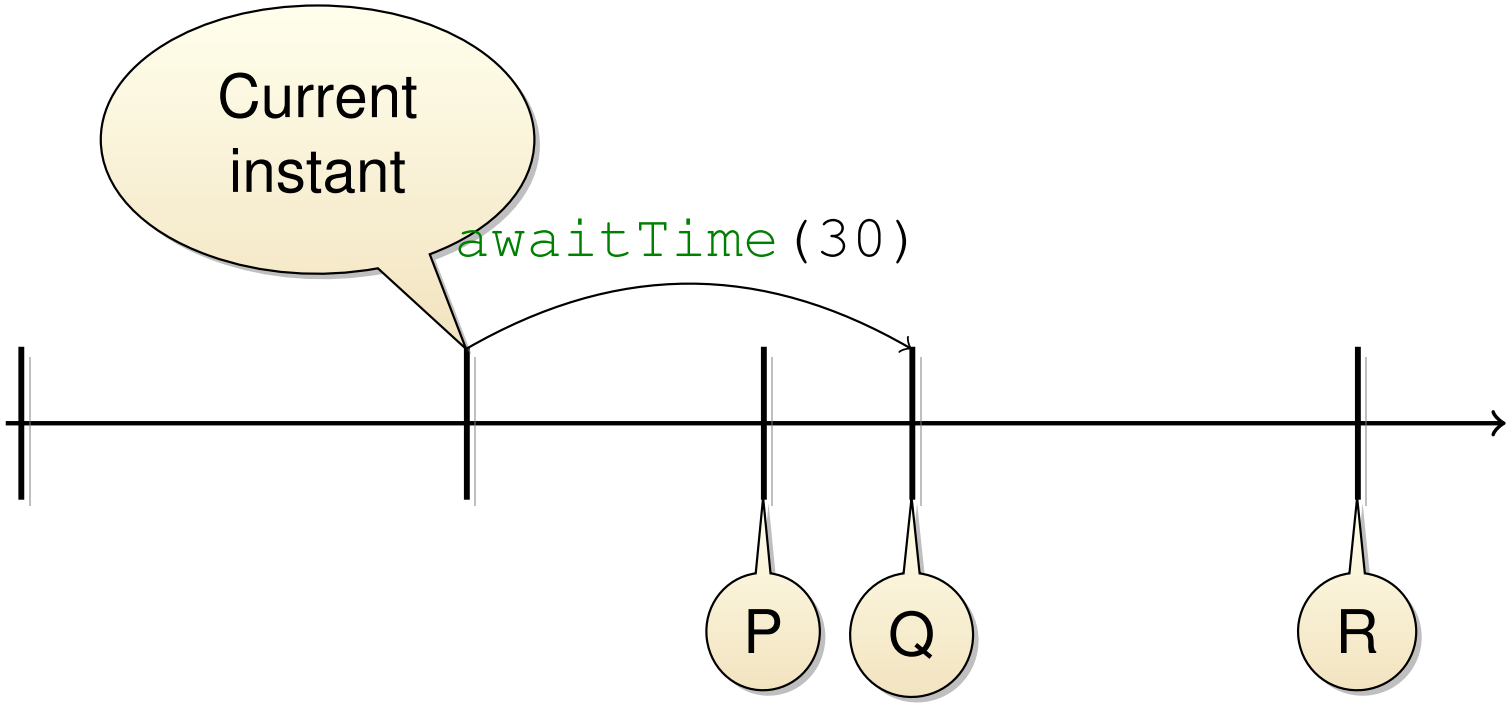

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Time Queue and `consumesTime(T)`

What about `consumesTime(T)` ?

Time Queue and `consumesTime(T)`

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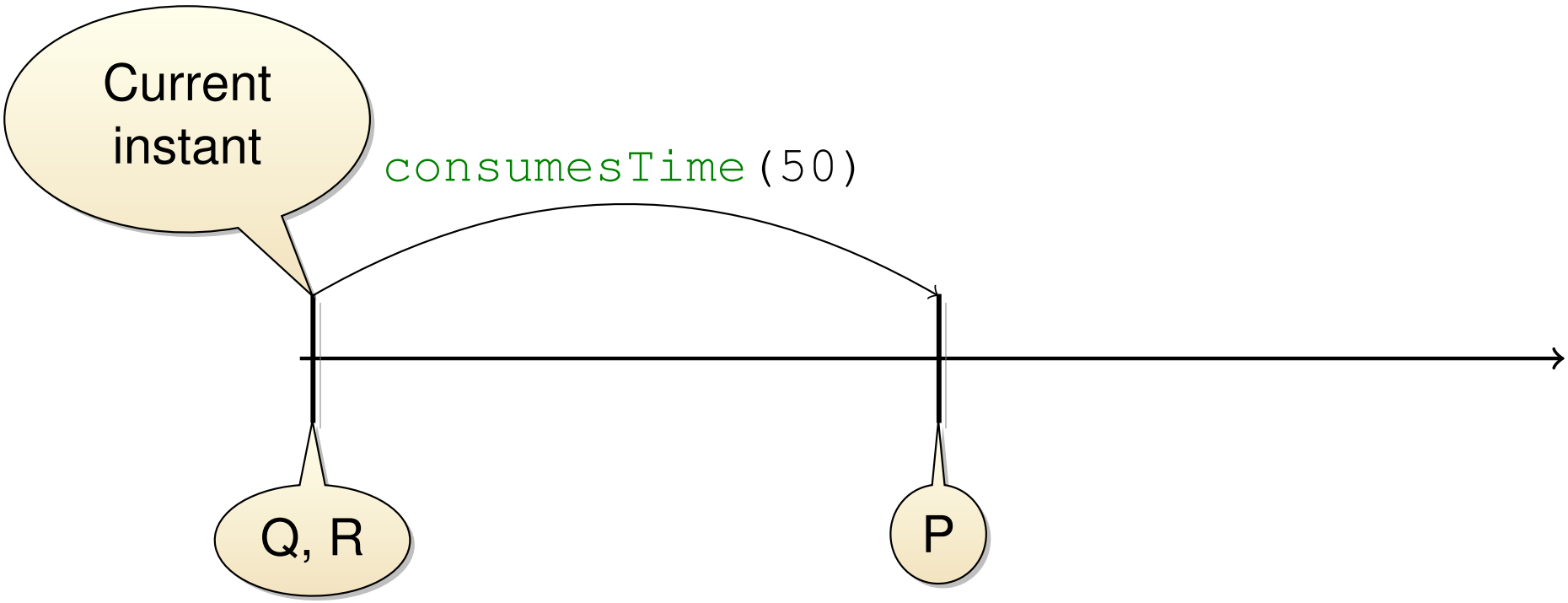

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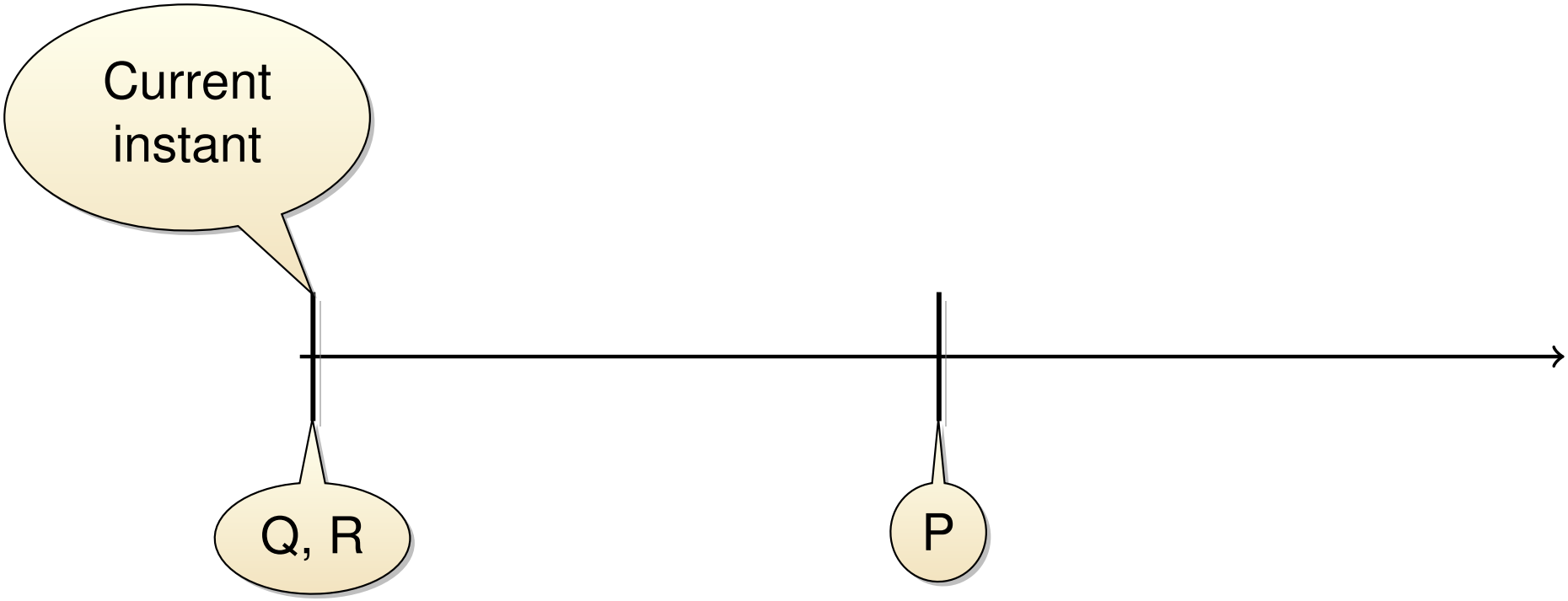

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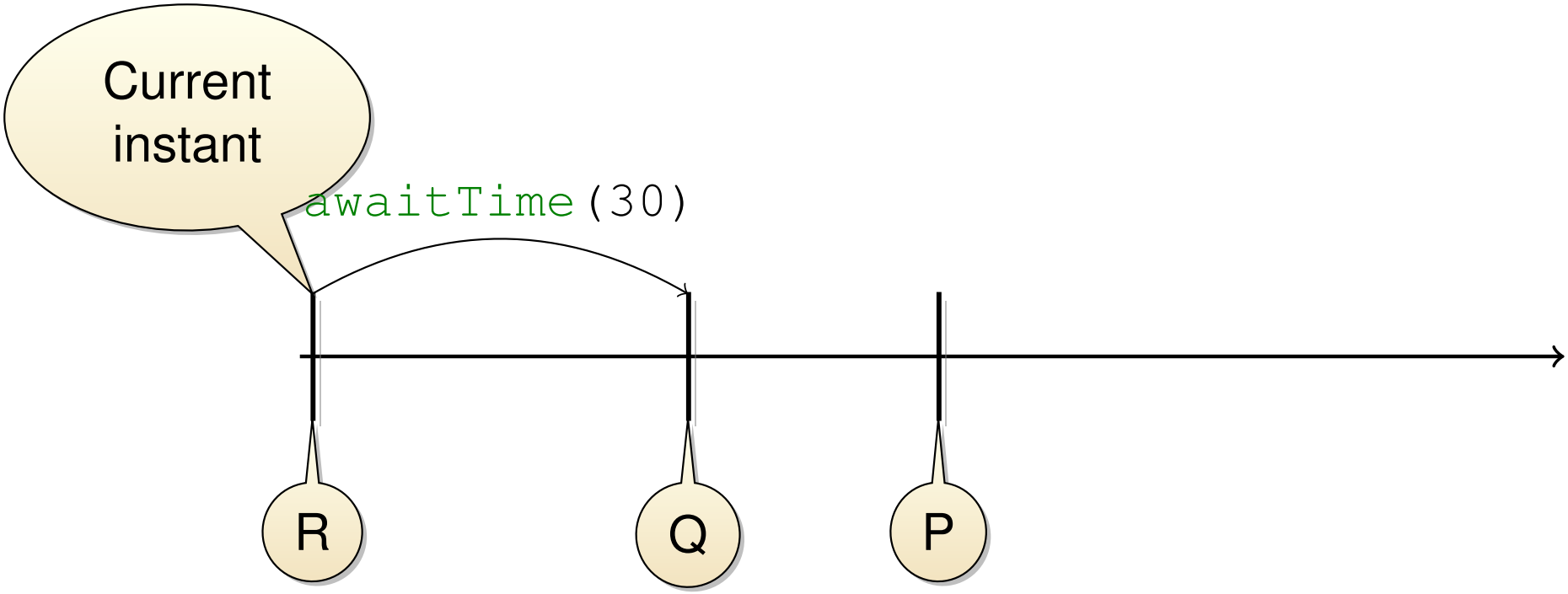

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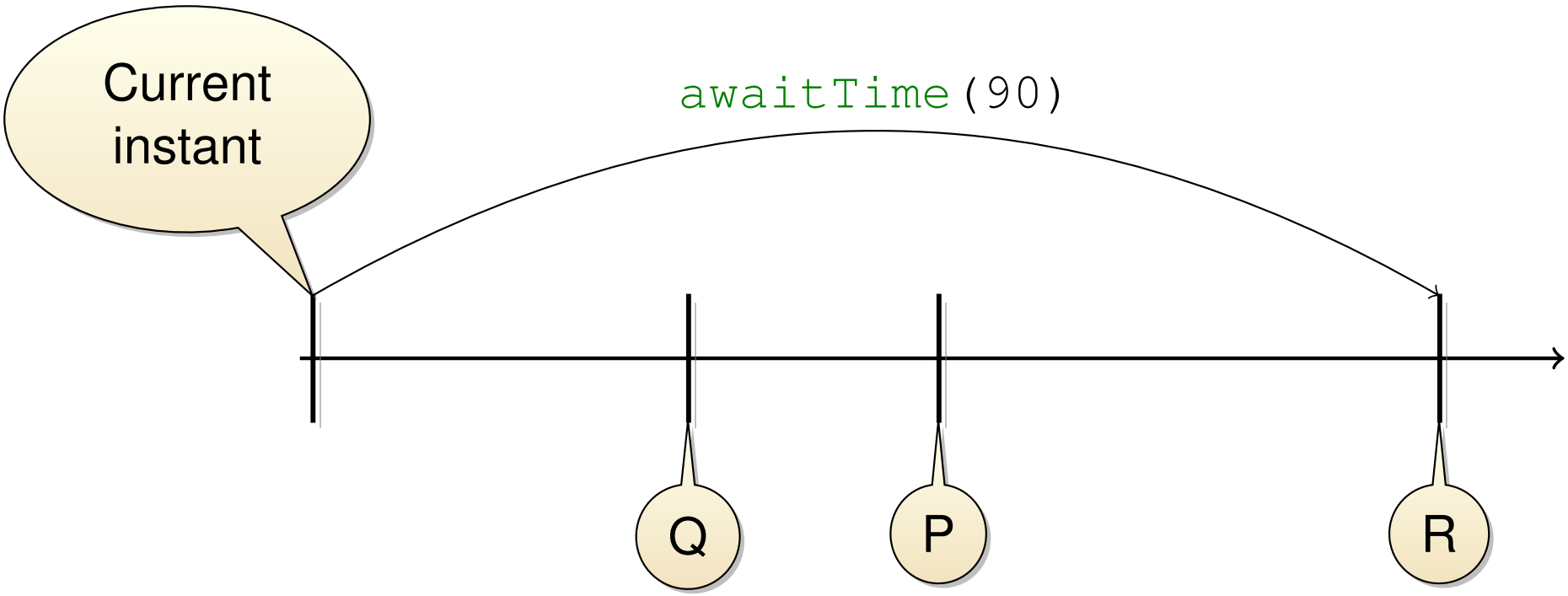

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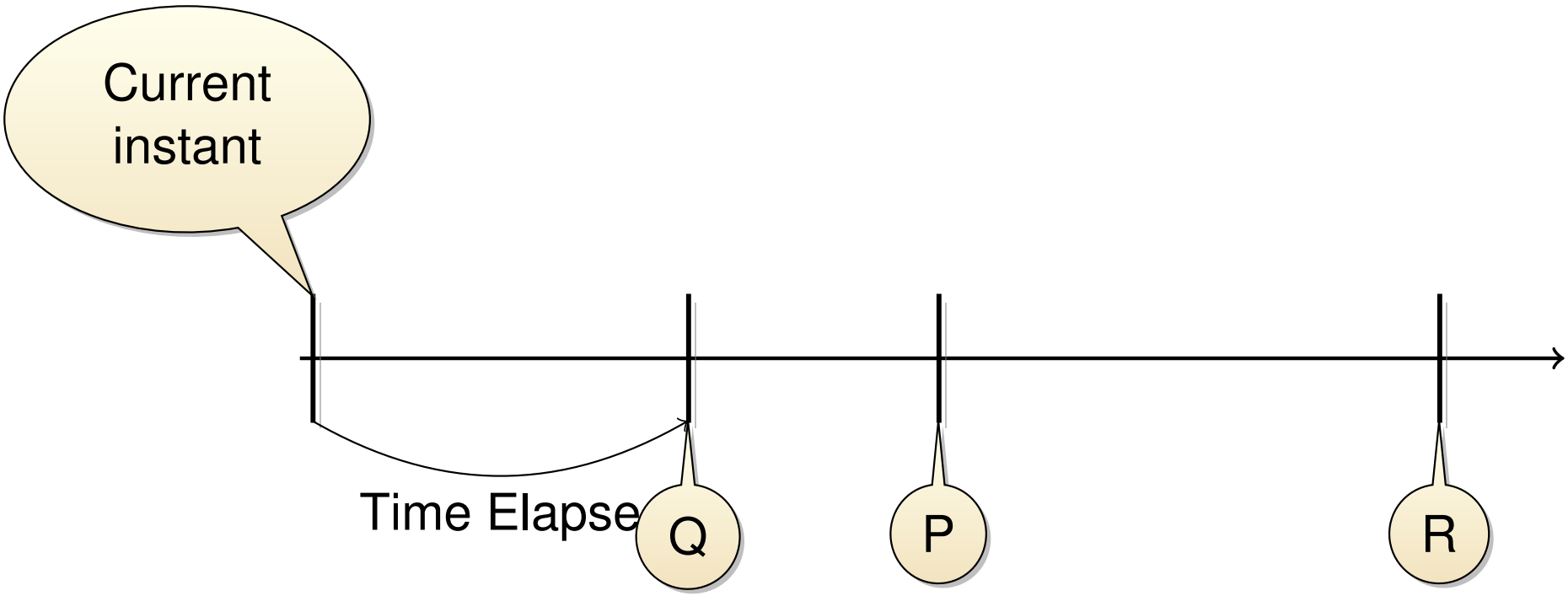

Process P:

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  f();
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►   g();
  }
  h();
```

Process Q:

```
  i();
►awaitTime(30);
  j();
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  }
```

Process R:

```
  l();
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```

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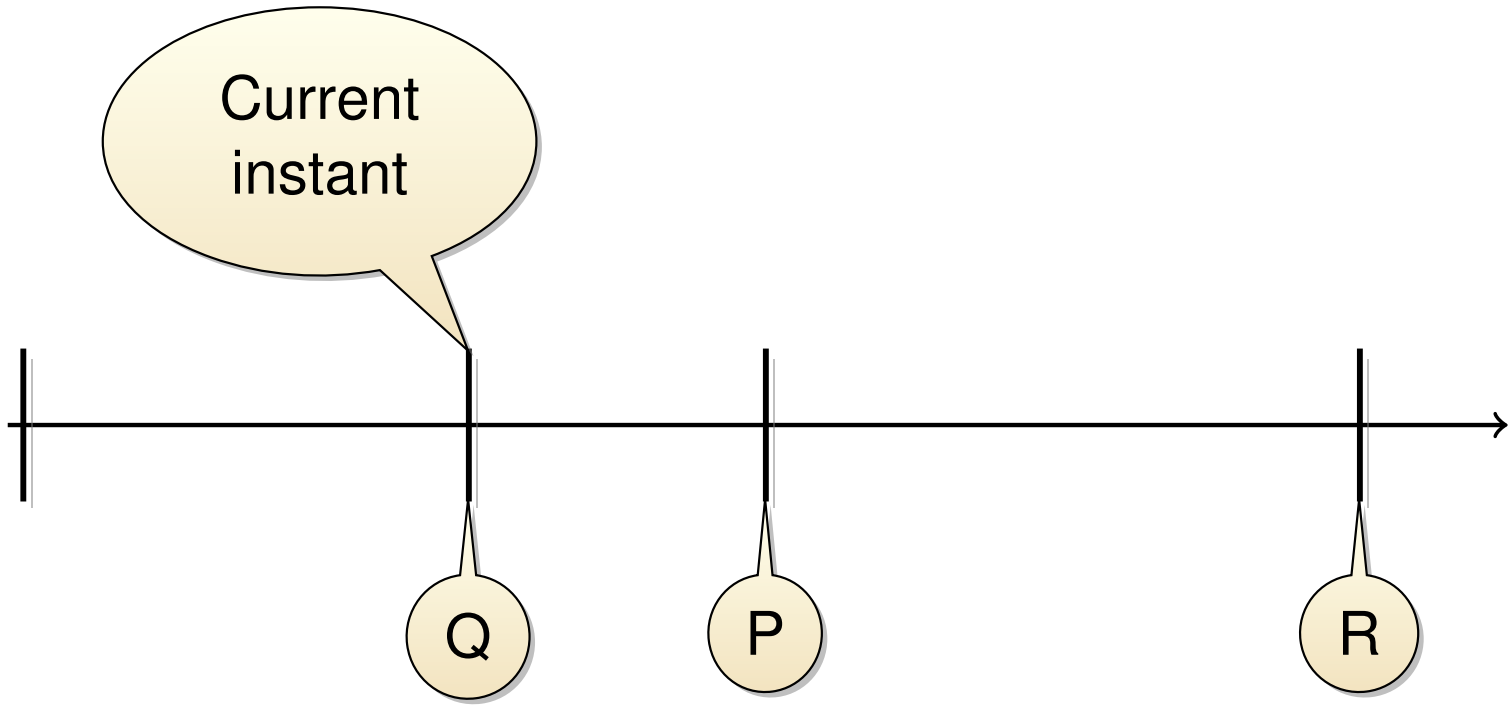

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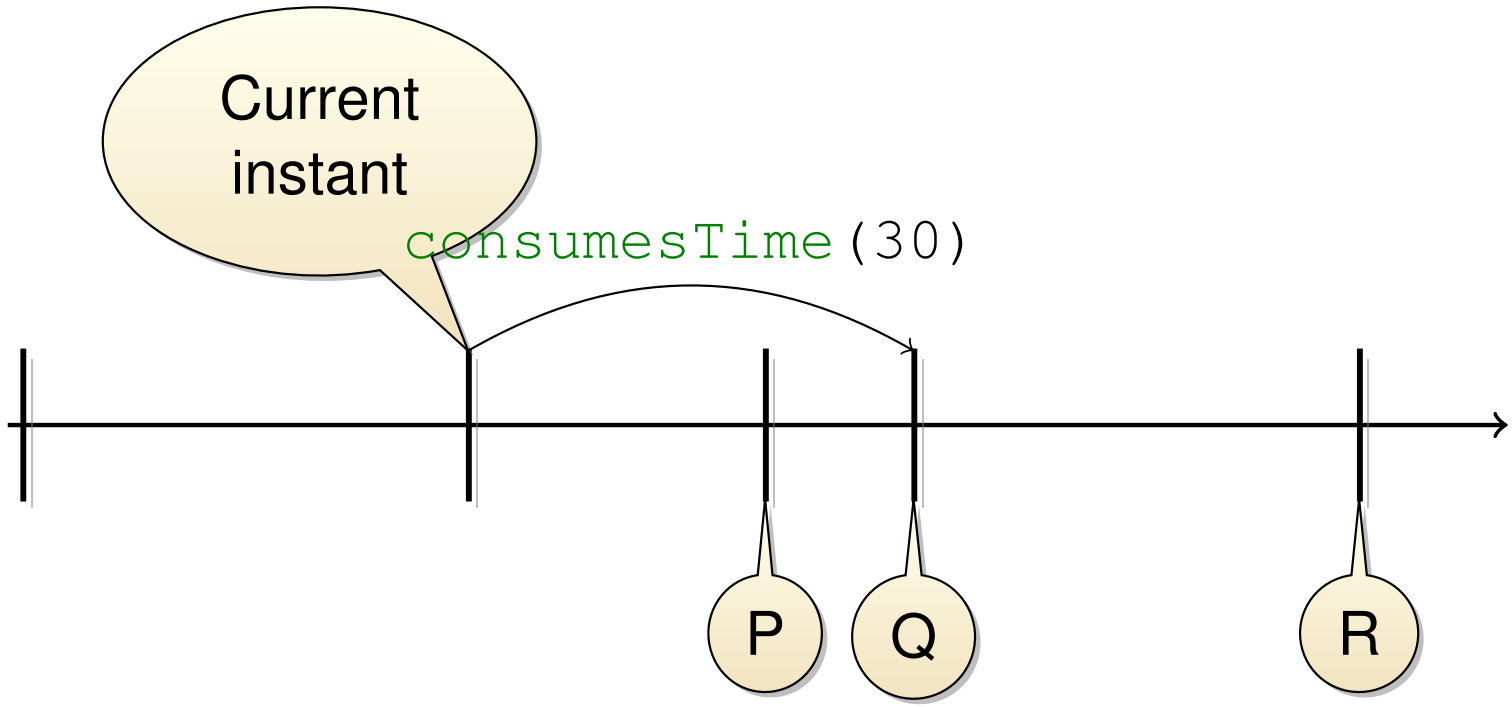

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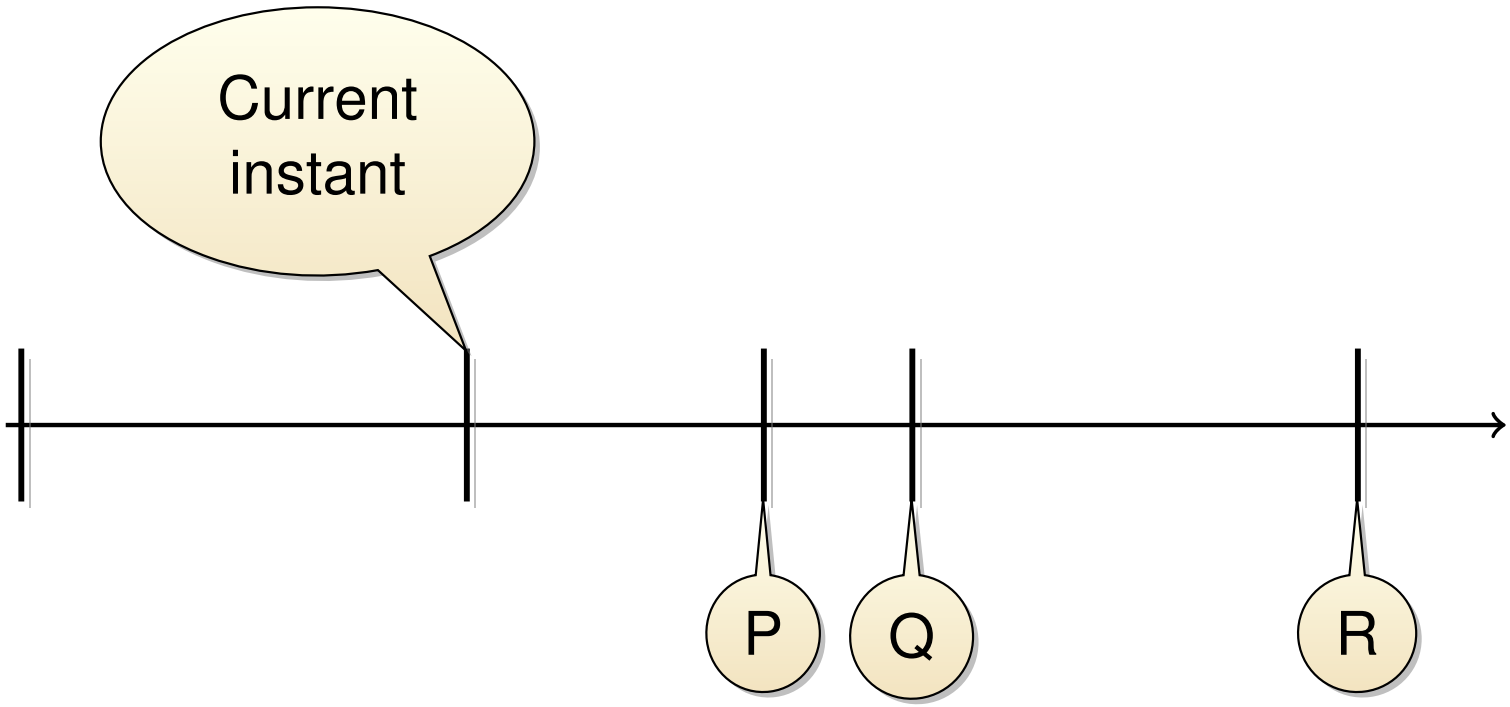

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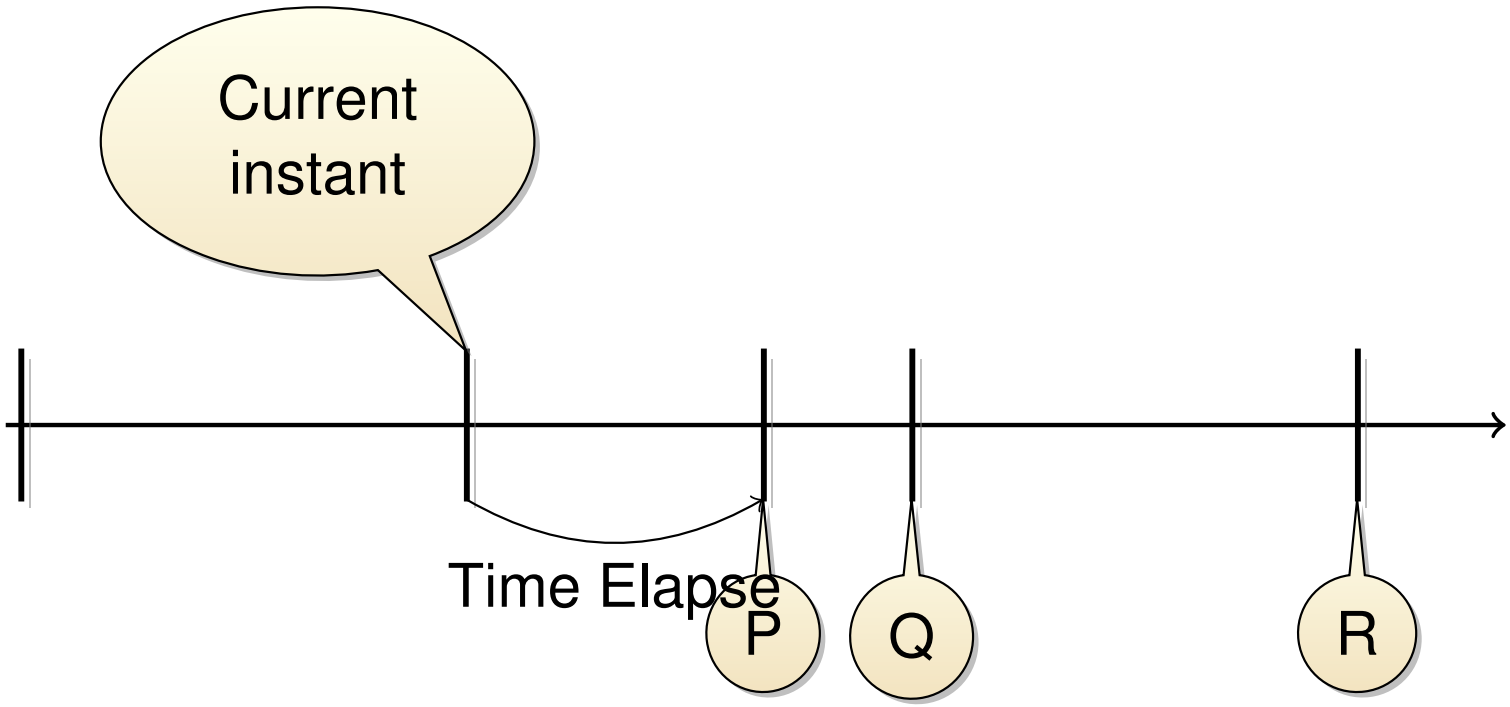

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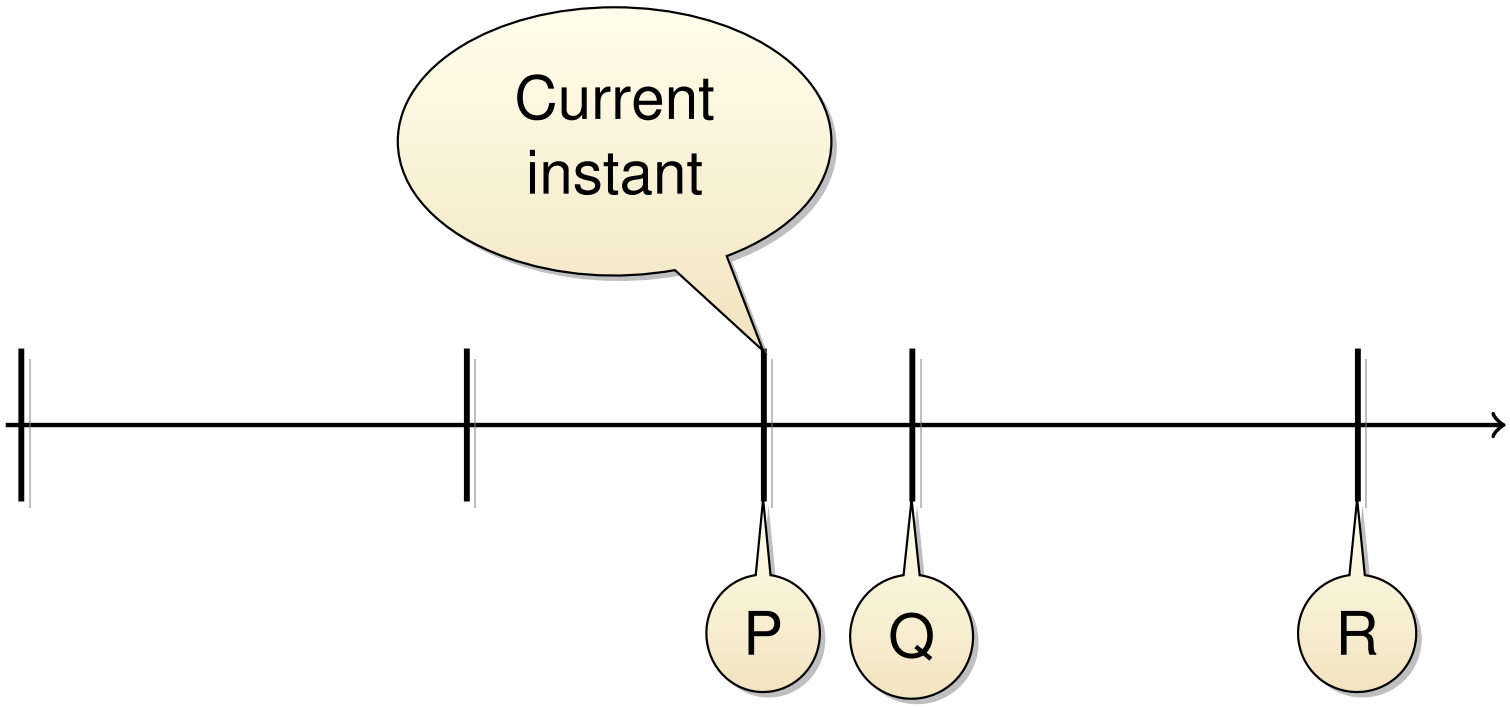

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- Summary
  - Tasks with duration
  - Exhibit more behaviors/bugs
  - Better parallelization
- Skipped from the talk (cf. paper)
  - Tasks with a priori unknown duration
  - jTLM's cooperative mode
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  - Adapt the ideas to SystemC (ongoing, not so hard)
  - Run-time Verification to explore schedules (science-fiction)
  - Open-Source Release?

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Thank you! $\rightsquigarrow$ Questions?