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

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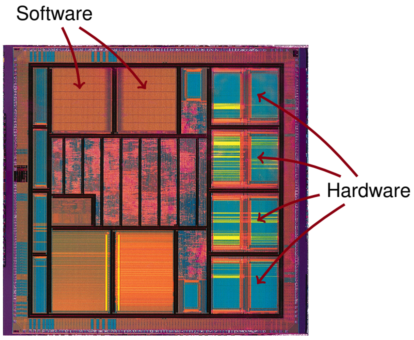
Outline

1. Transaction Level Modeling and jTLM
2. Time and Duration in jTLM
3. Applications
4. Implementation
5. Conclusion

Modern Systems-on-a-Chip

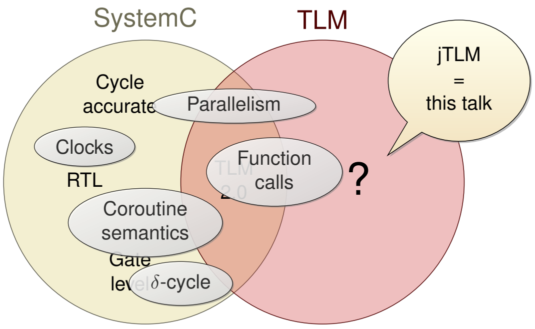


Transaction-Level Modeling

- (Fast) simulation essential in the design-flow
  - To write/debug software
  - To validate architectural choices
  - As reference for hardware verification
- Transaction-Level Modeling (TLM):
  - High level of abstraction
  - Suitable for

Industry Standard = SystemC/TLM

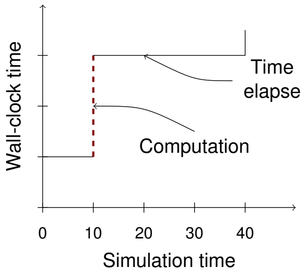
SystemC/TLM vs. "TLM Abstraction Level"



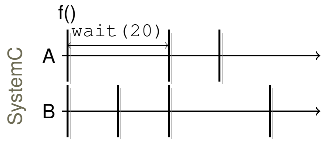
jTLM: goals and peculiarities

- 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

Simulation Time Vs Wall-Clock Time

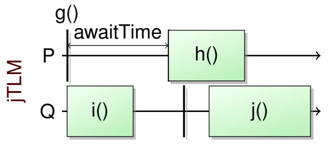


Time in SystemC and jTLM



Process A:

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

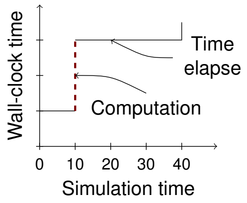


Process P:

```
g();
awaitTime(20);
consumesTime(15) {
  h();
}
```

Time *à la* SystemC: `awaitTime(T)`

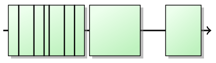
- By default, time does not pass ⇒ instantaneous tasks
- `awaitTime(T)`: let other processes execute for *T* time units



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

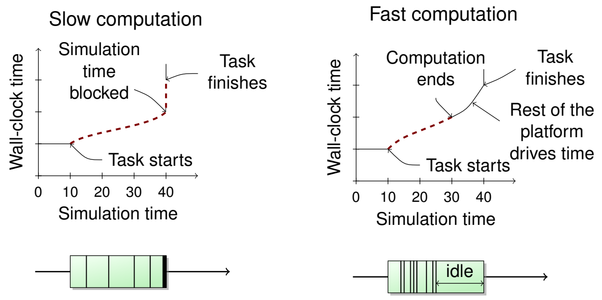
Task with Known Duration: `consumesTime(T)`

- 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)`



Exposing Bugs

Example bug: mis-placed synchronization:

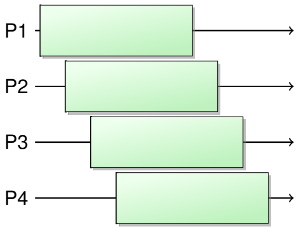
```
flag = true;          ||   while(!flag)
awaitTime(5);                  awaitTime(1);
writeIMG();                awaitTime(10);
awaitTime(10);             readIMG();
```

⇒ bug never seen in simulation

```
consumesTime(15) {    ||   while(!flag)
    flag = true;               awaitTime(1);
    writeIMG();            awaitTime(10);
}                          readIMG();
```

⇒ strictly more behaviors, including the buggy one

Parallelization

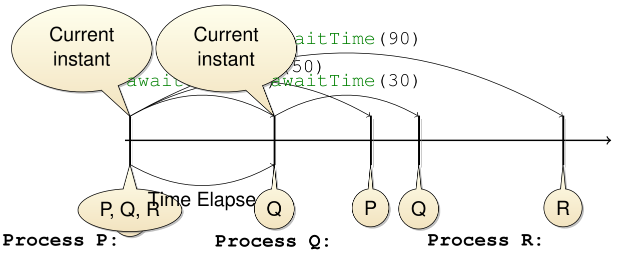


jTLM's Semantics

- Simultaneous tasks run in parallel
- Non-simultaneous tasks don't
- Overlapping tasks do

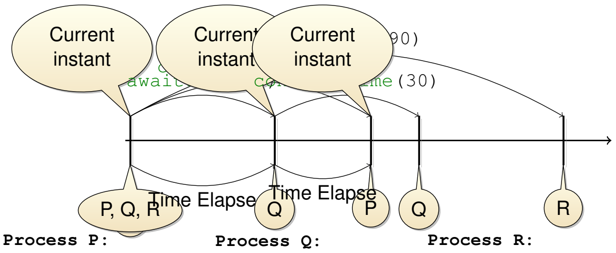
- Back to SystemC:
  - Parallelizing within δ-cycle = great if you have clocks
  - Simulation time is the bottleneck with quantitative/fuzzy time

Time Queue and `awaitTime(T)`



```
Process P:          Process Q:          Process R:
▶f();               ▶h();               ▶i();
▶awaitTime(50);     ▶awaitTime(30);     ▶awaitTime(90);
                    ▶g();
                    ▶awaitTime(30);
```

Time Queue and `consumesTime(T)`



```
Process P:          Process Q:          Process R:
▶f();               ▶i();               ▶l();
▶consumesTime(50){  ▶awaitTime(30);     ▶awaitTime(90);
▶  g();             ▶j();
▶}                  ▶consumesTime(30){
▶h();               ▶  k();
                    ▶}
```

Perspectives

- 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
- Perspectives
  - Adapt the ideas to SystemC (ongoing, not so hard)
  - Run-time Verification to explore schedules (science-fiction)
  - Open-Source Release?

Thank you! ⇝ Questions?