Cutting Out the Middleman: OS-Level Support for X10 Activities

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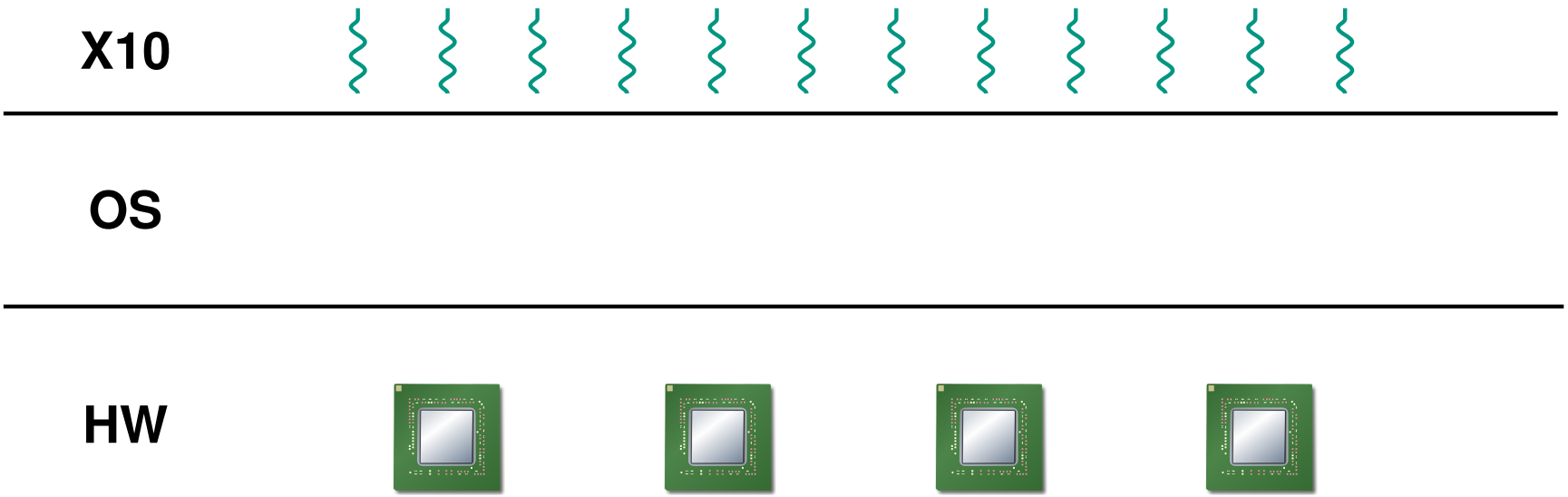
Ideal World



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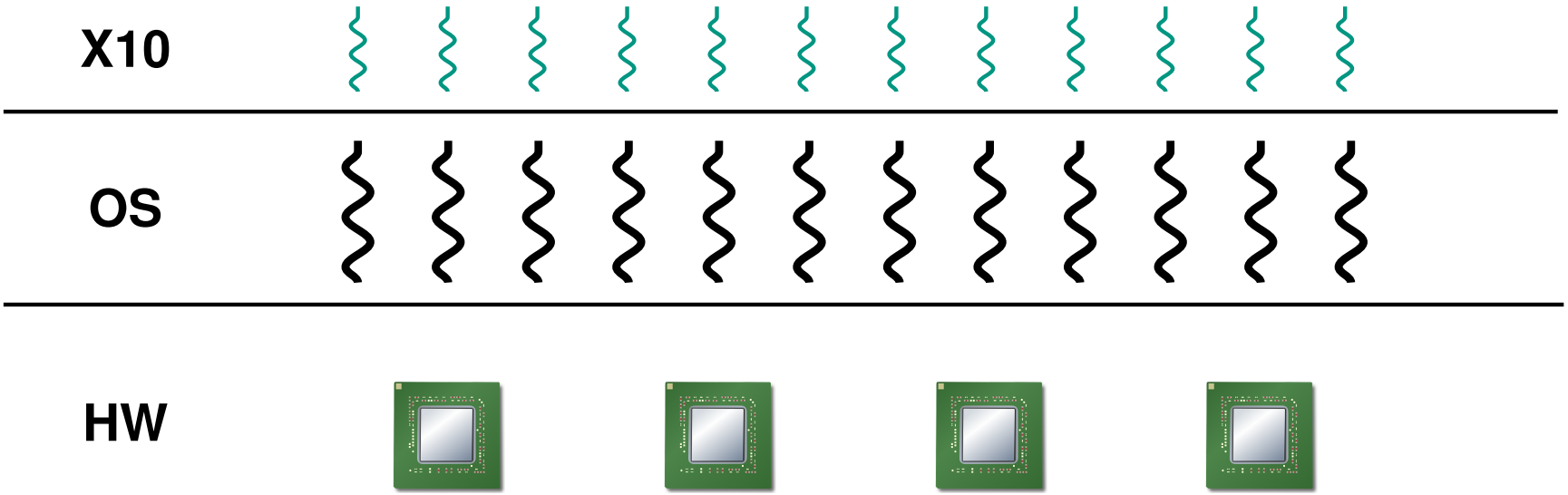

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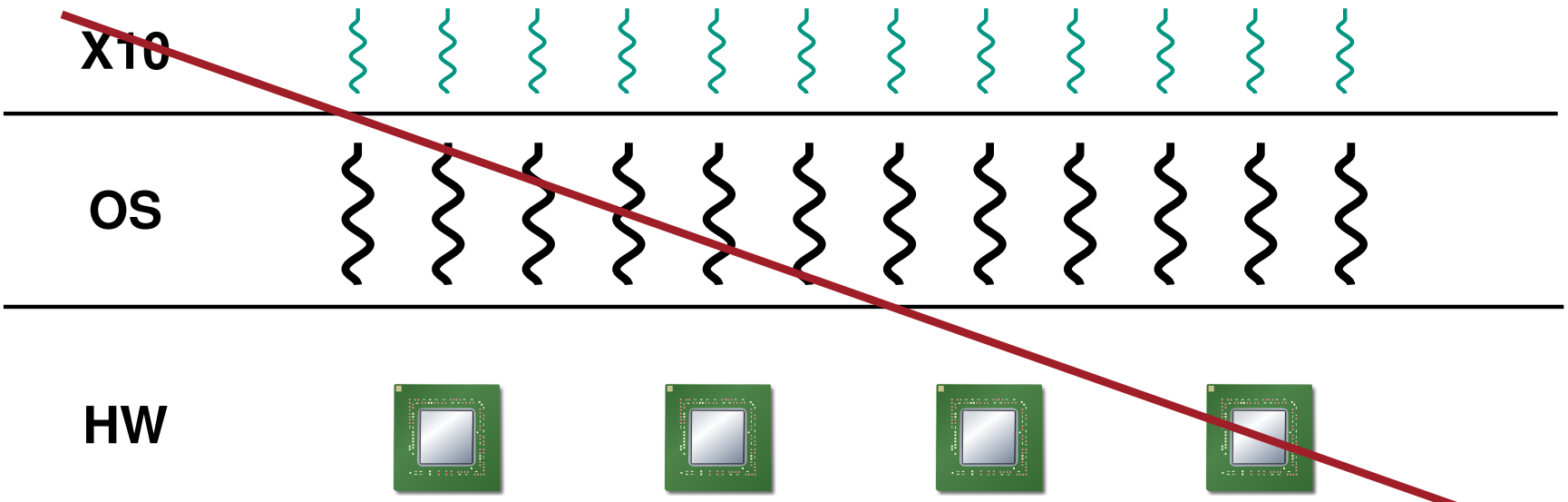
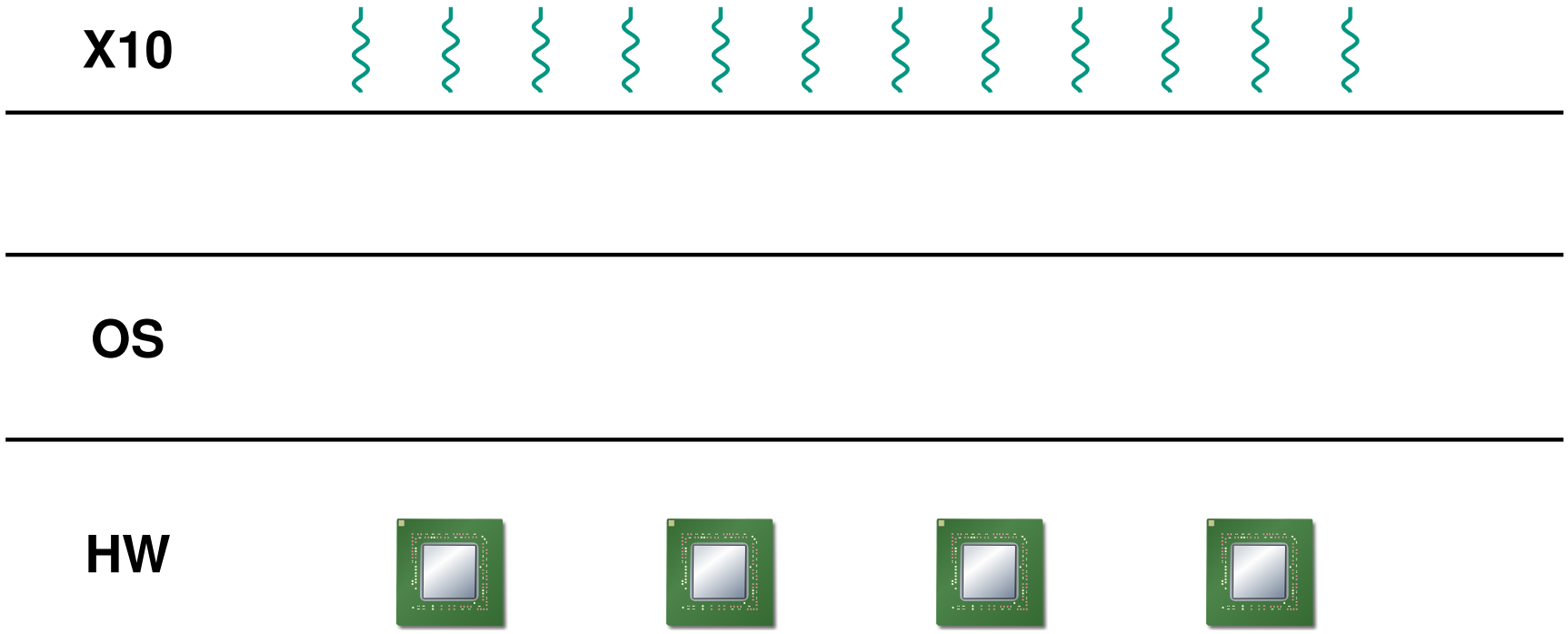


Current Practice



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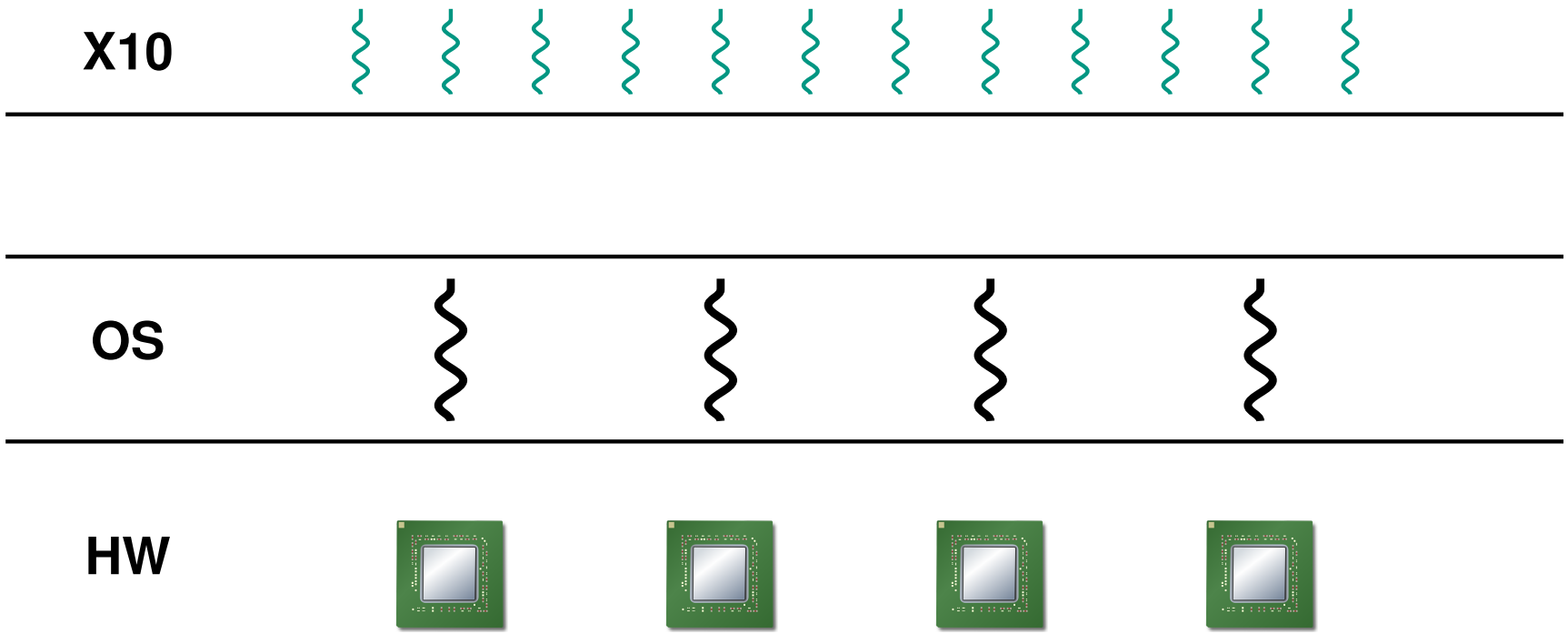

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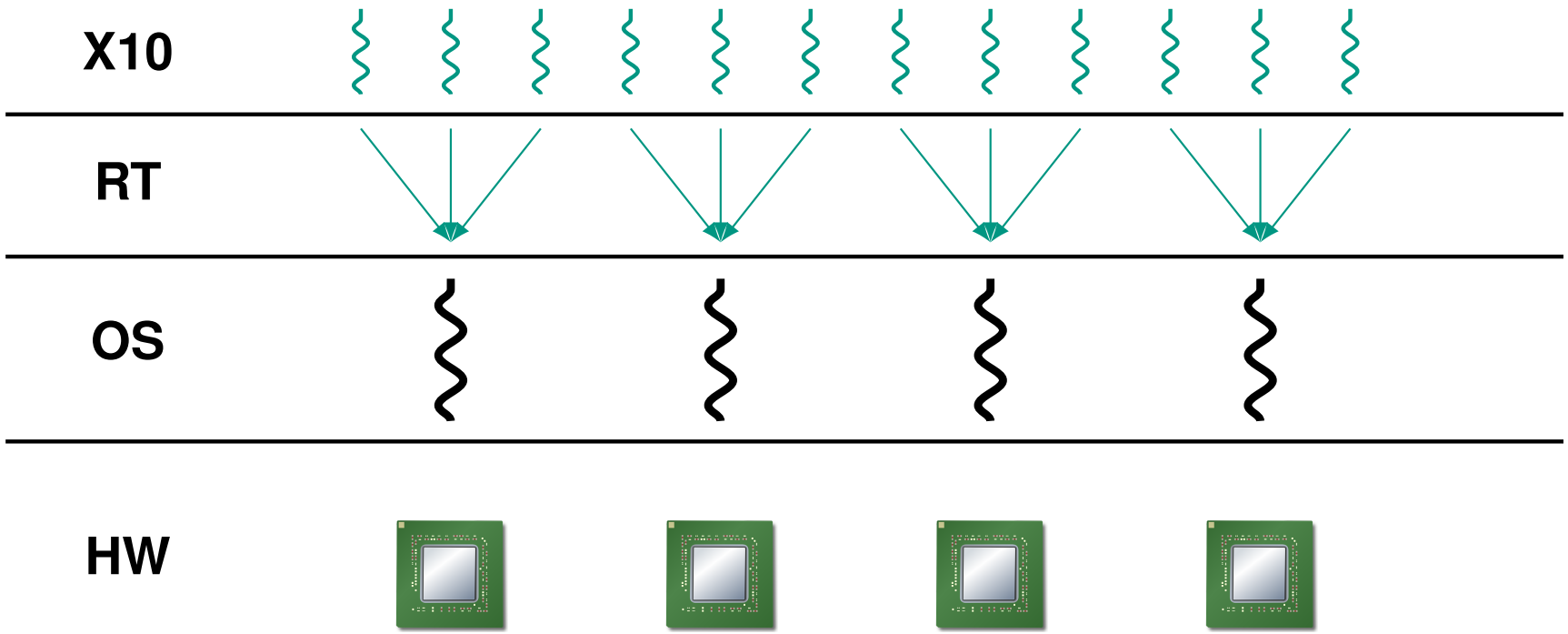

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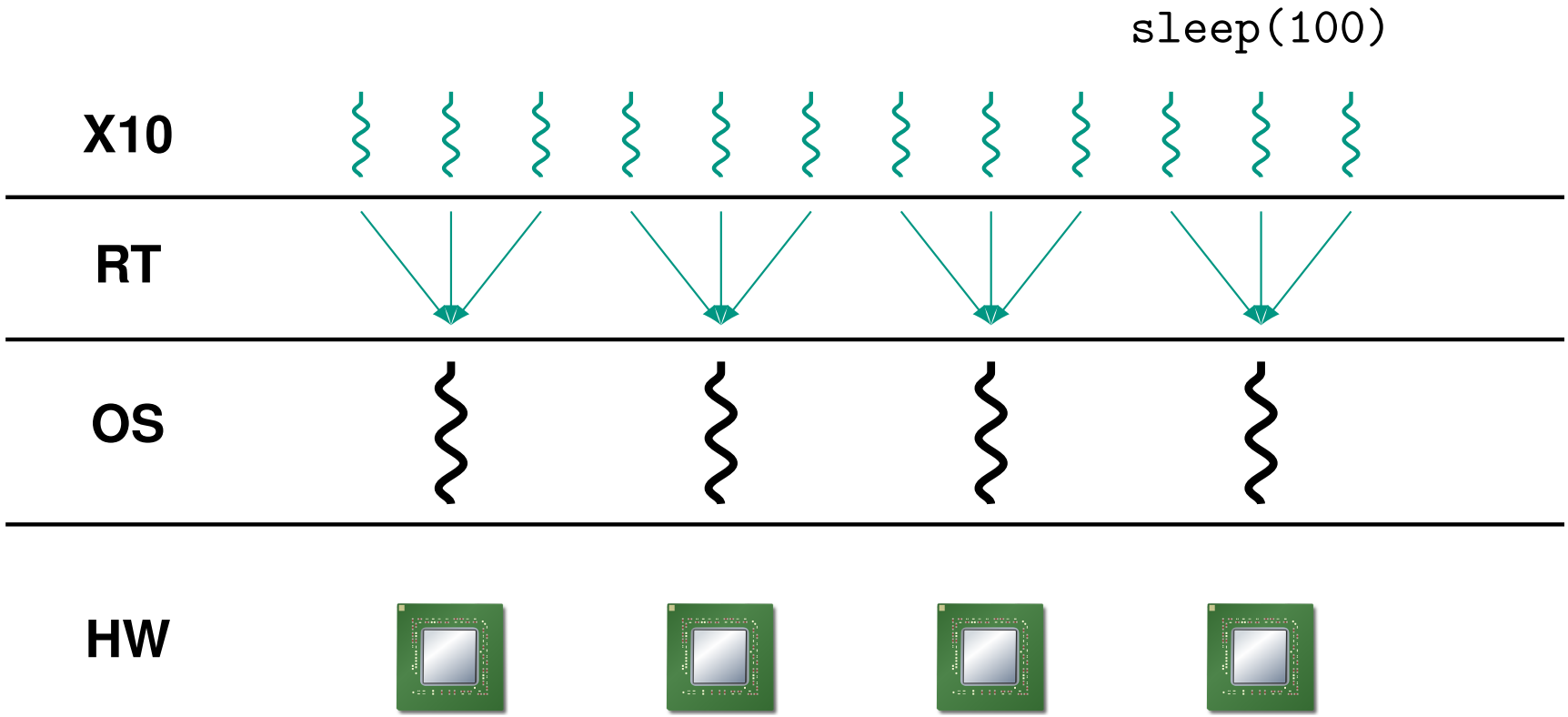

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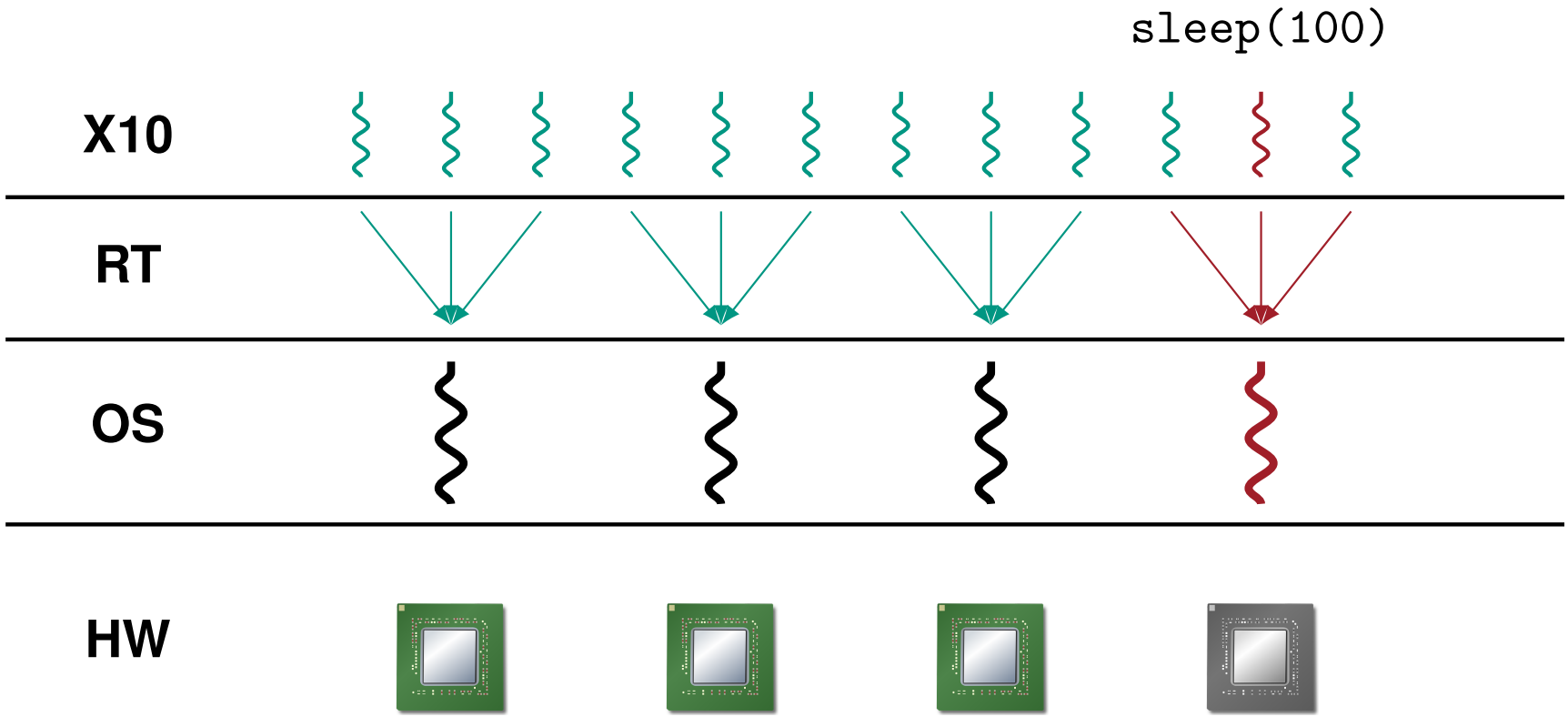
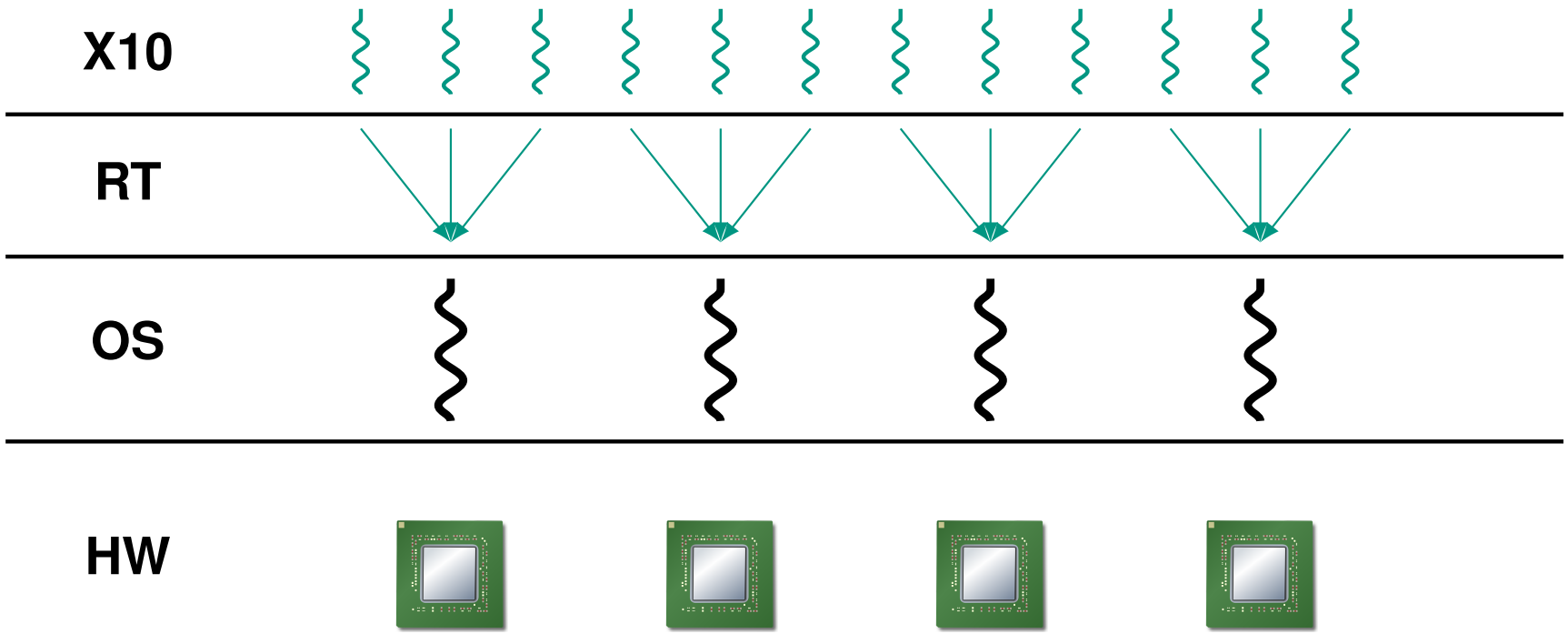


Workaround

```
class Runtime {
  public static def sleep(millis:Long) {
    Runtime.increaseParallelism();
    Thread.sleep(millis);
    Runtime.decreaseParallelism(1);
  }
}
```

Workaround in Action



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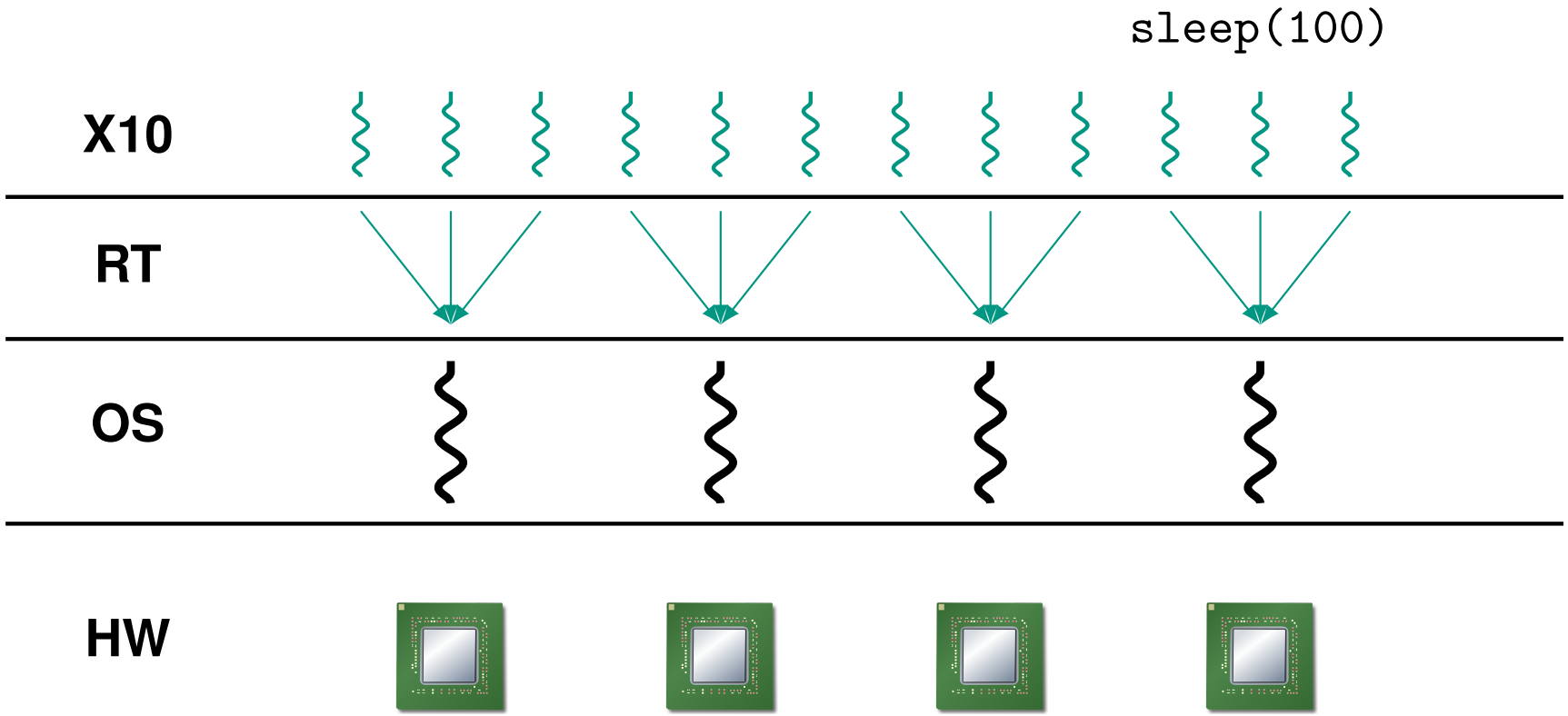

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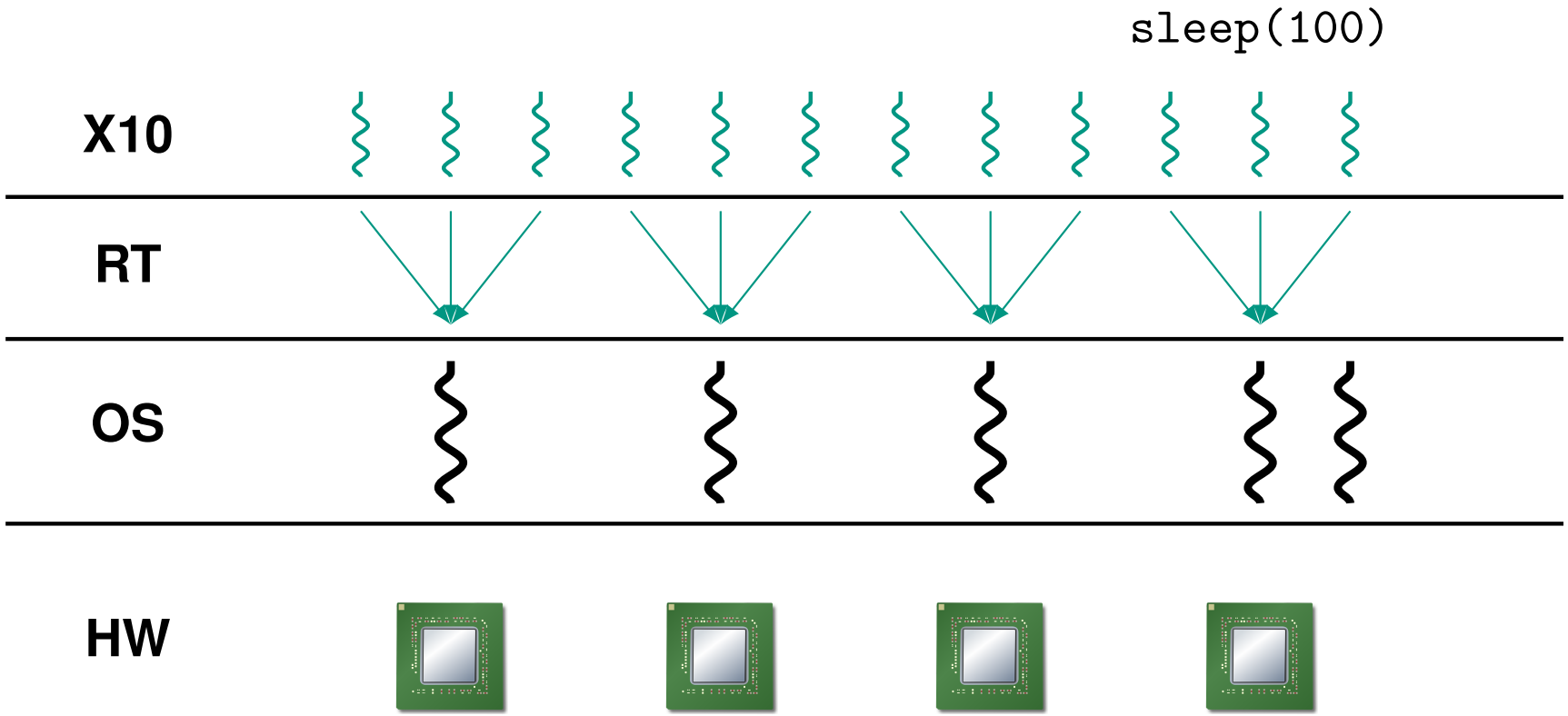

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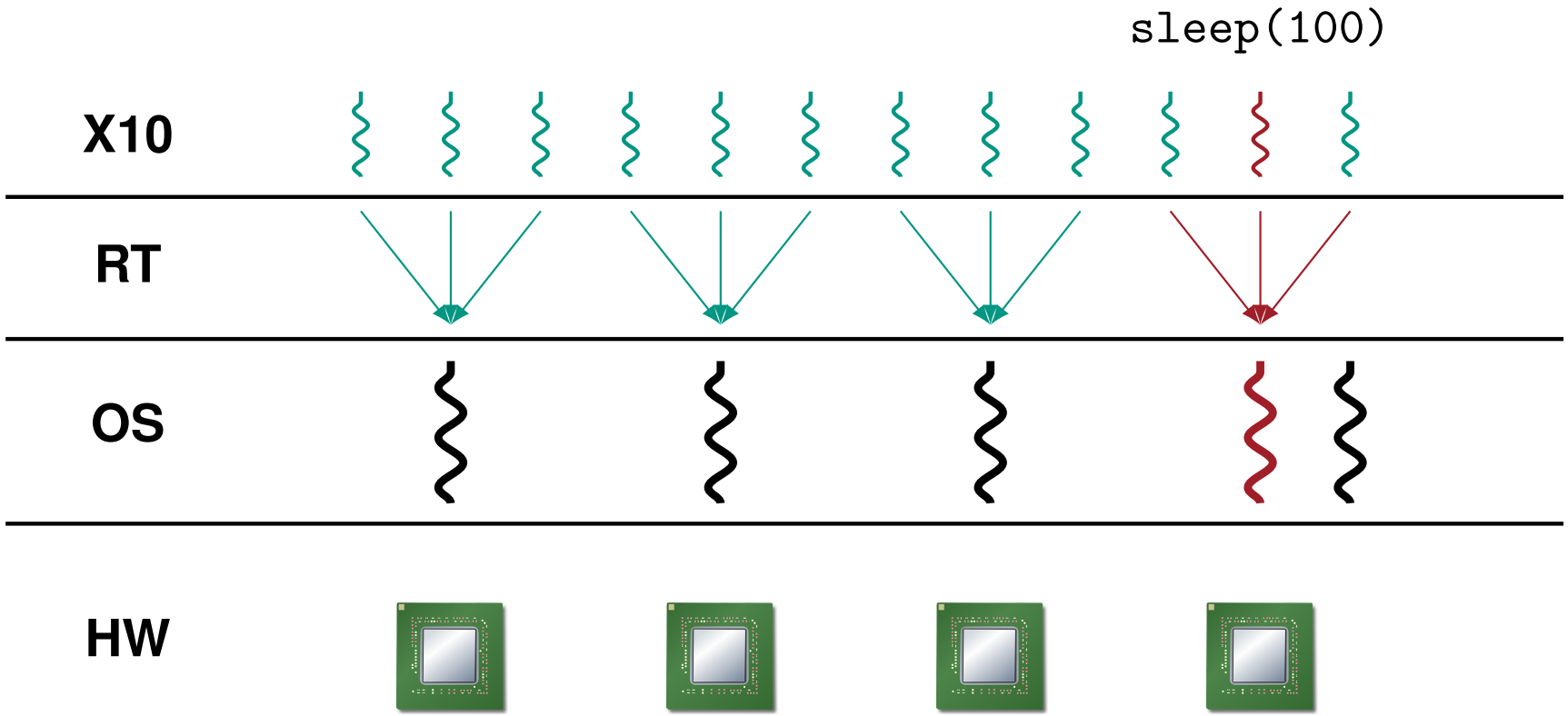

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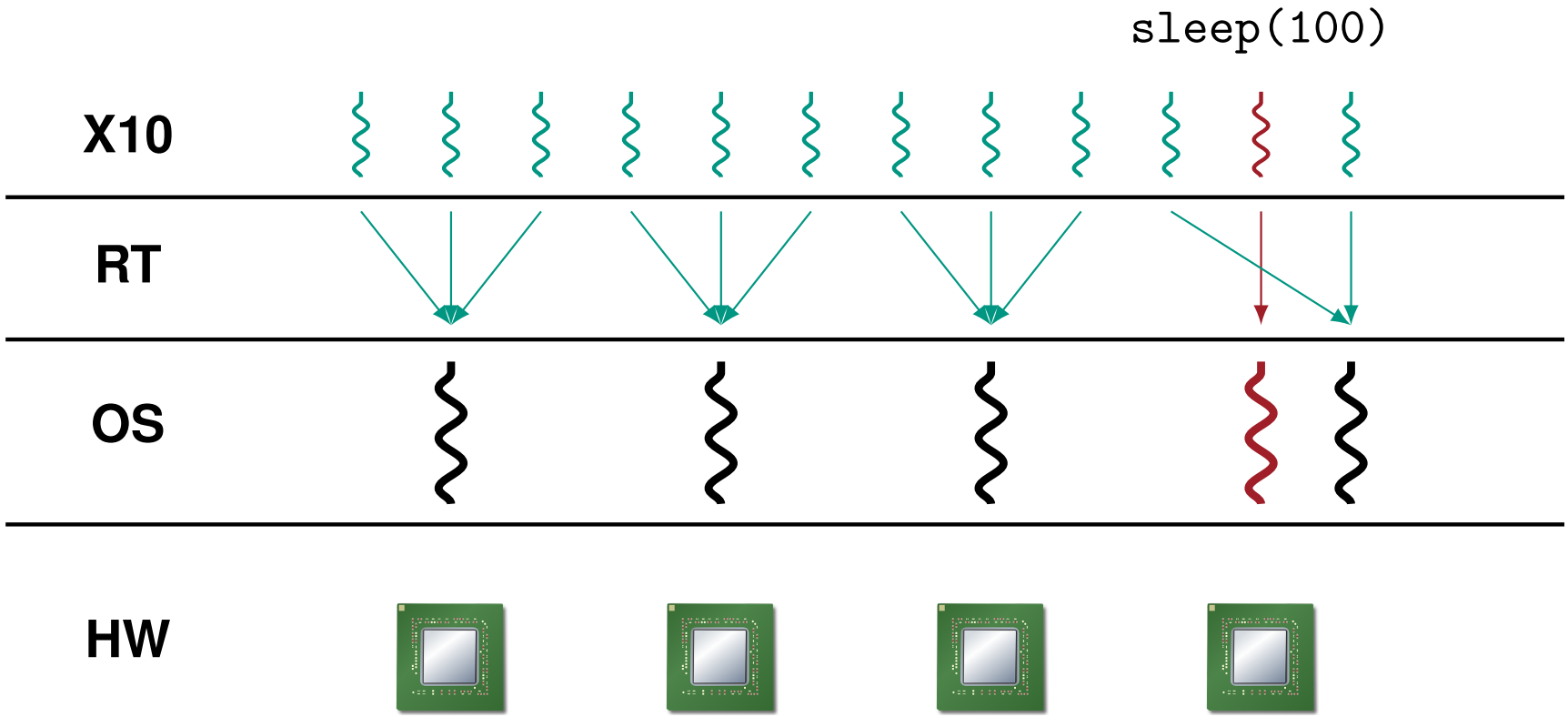

Motivation

Problems with user-level scheduling approach:

- Complexity: interplay between two schedulers
- Performance: starting/stopping kernel-level threads is expensive
- Bugs: what if starting/stopping is forgotten? (e.g., user code)

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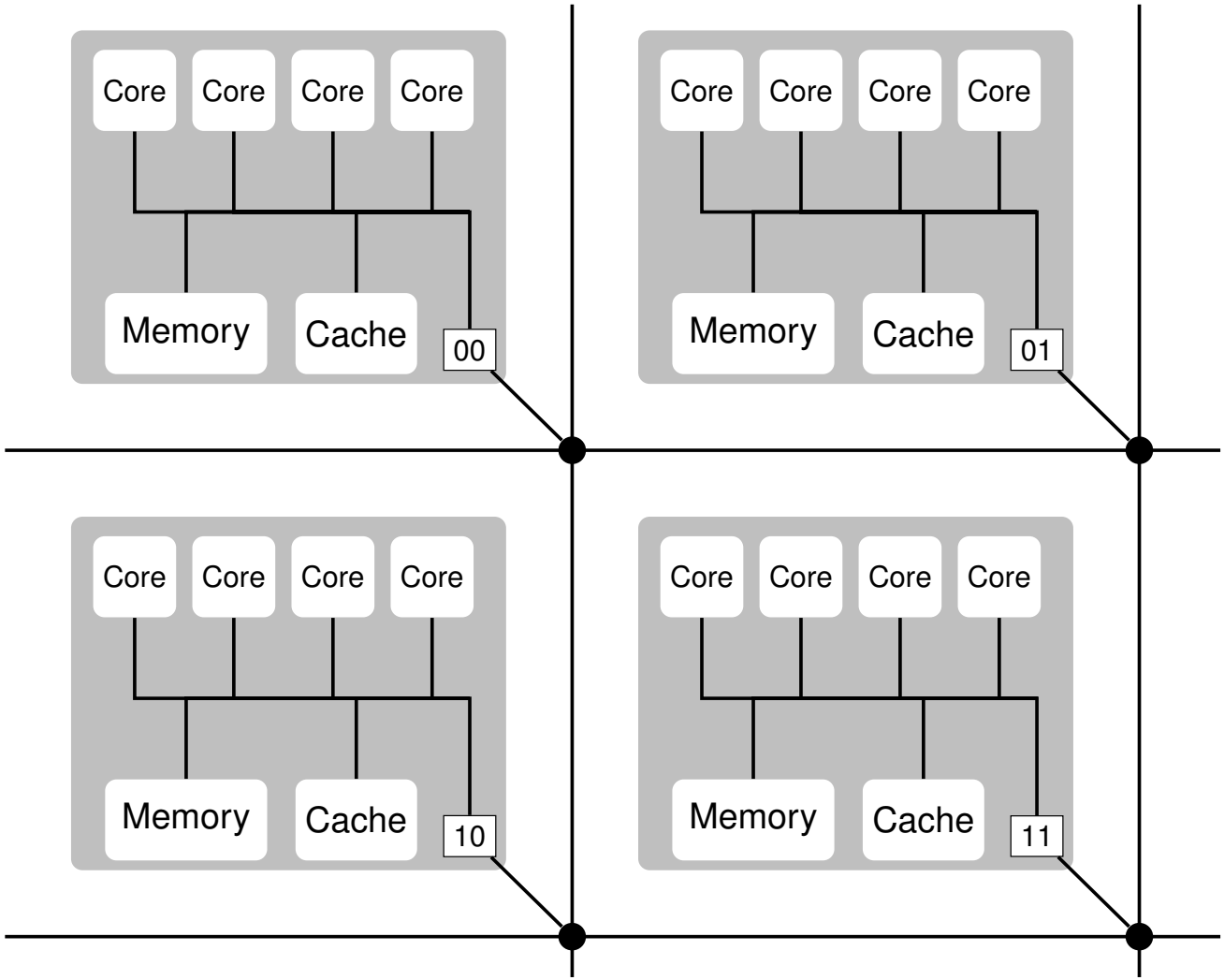
In this talk:

- How we directly mapped activities to OS primitives
  - Context: many-core hardware architecture
- How this simplifies runtime system and OS
- Initial evaluation of system efficiency

Tiled Many-Core Architectures



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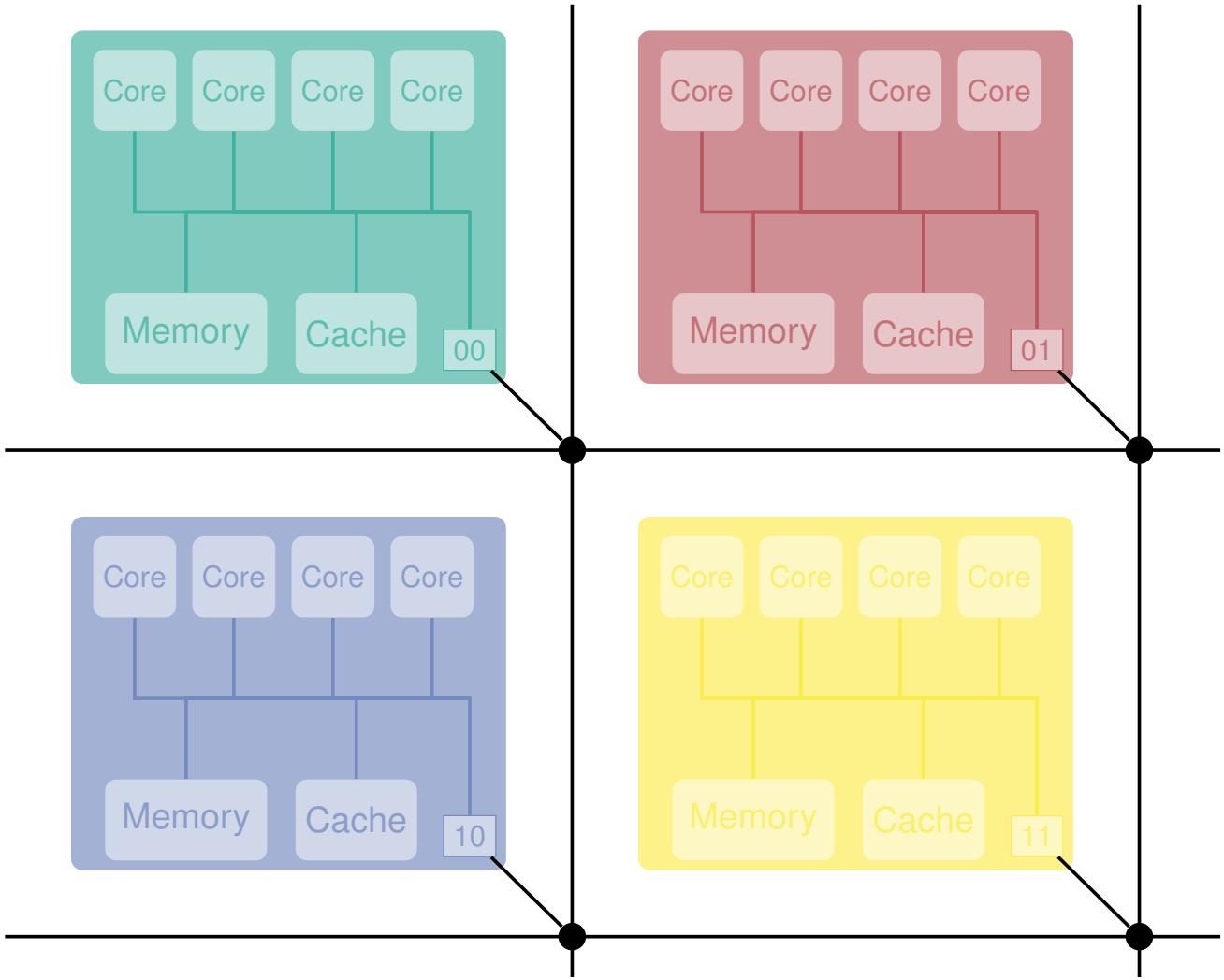

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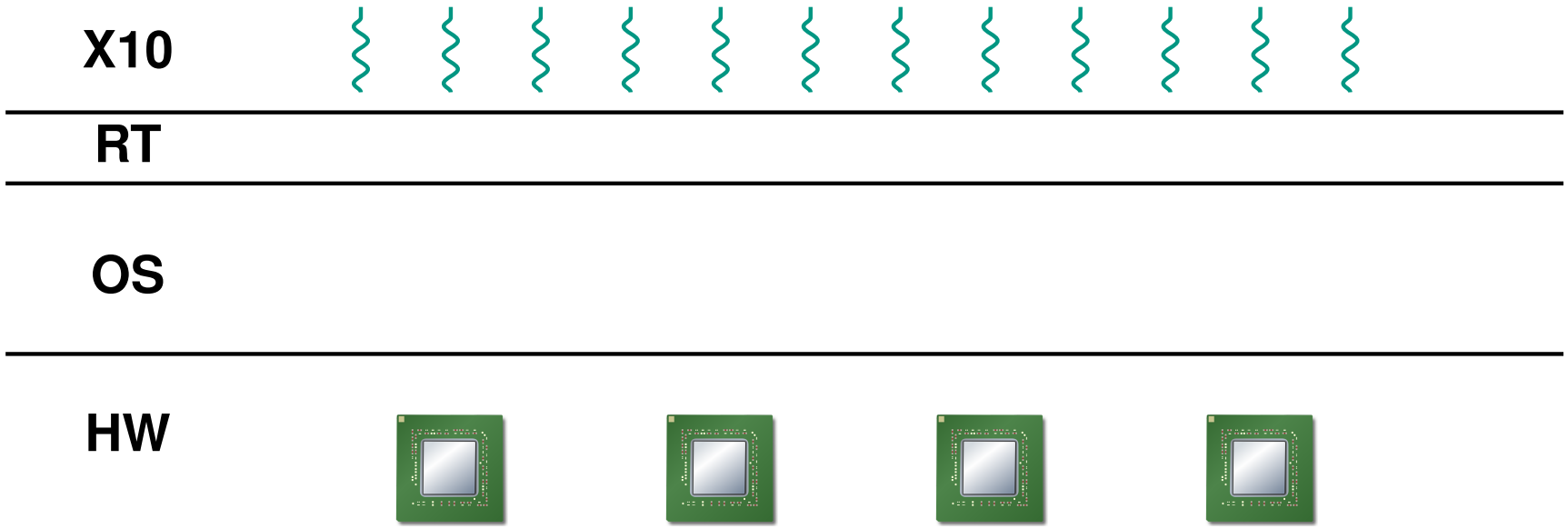
⇒ Very lightweight threads called ***i*-lets**

Async



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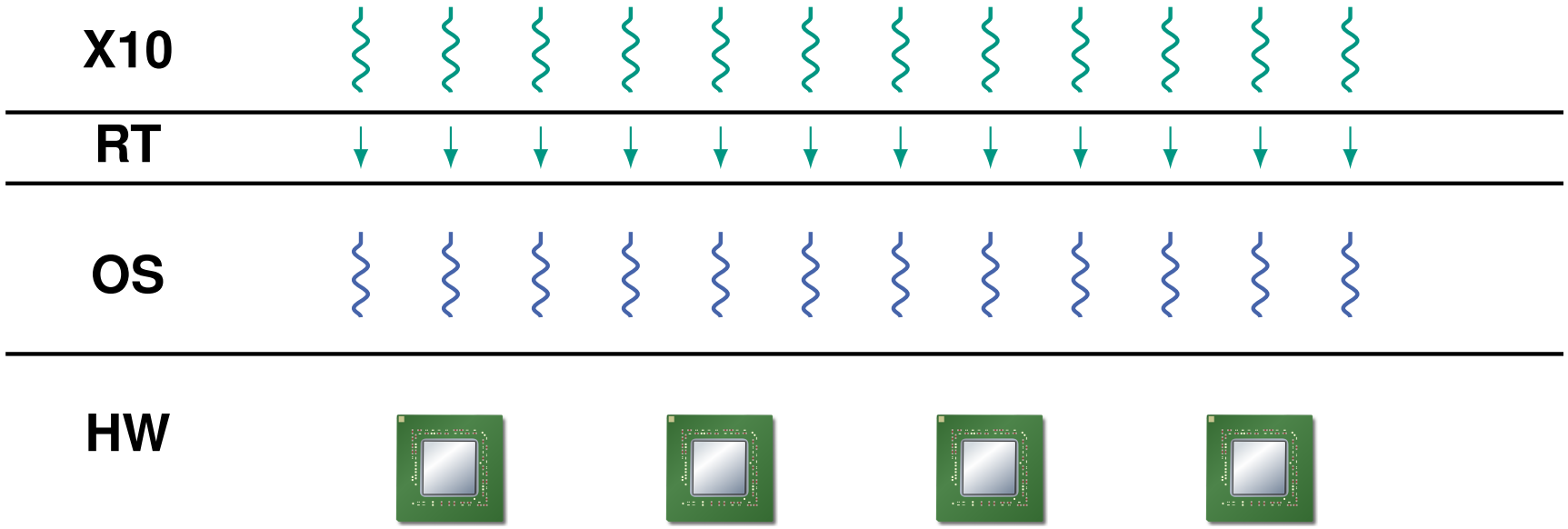

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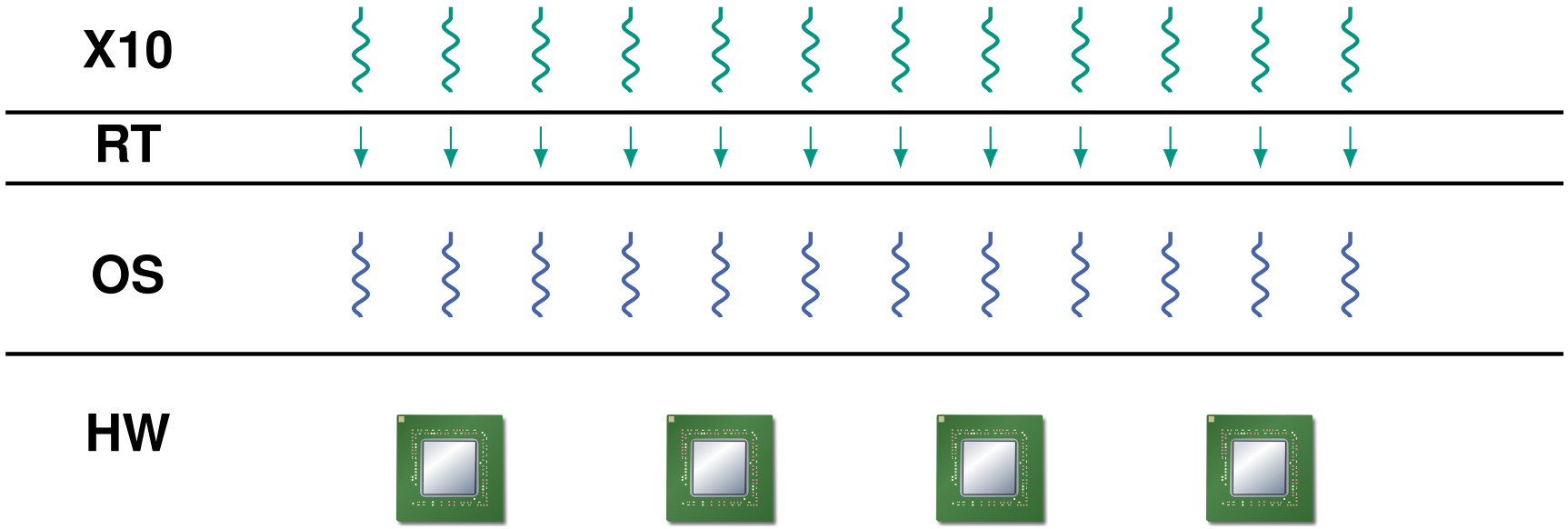

- Each activity corresponds to exactly one *i*-let
- Very thin runtime system, no user-level scheduler
- Blocking calls unproblematic, no workaround needed

Remote *i*-let spawning

Karlsruhe Institute of Technology

```
spawn_ilet(place_id, ilet)
```

- Start an *i*-let on a different place
- Asynchronous

Small At Async Statement: `at (B) async S`

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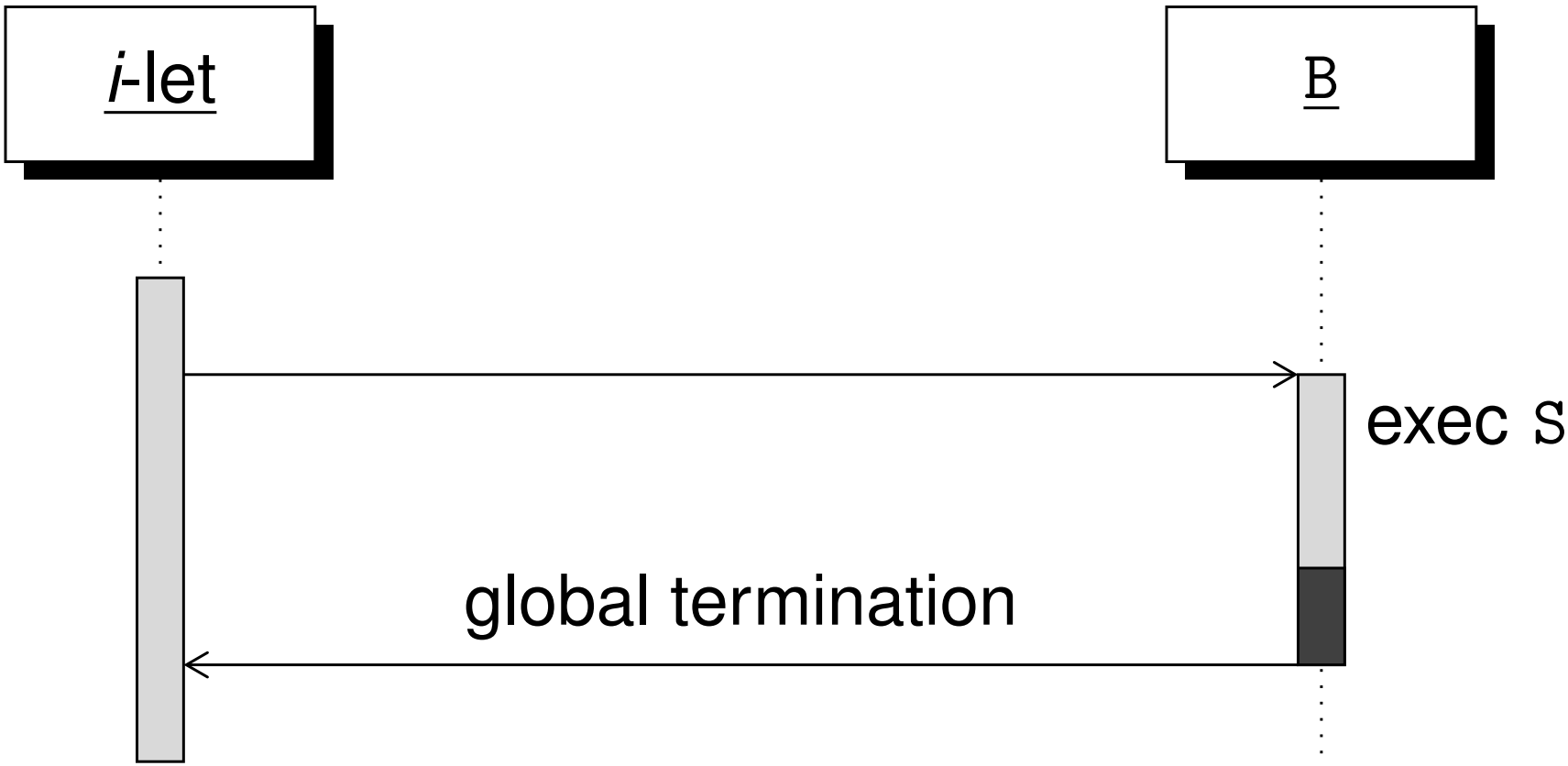

Push DMA Transfer

```
push_dma(place_id, data, length, sender_ilet, receiver_ilet)
```

- Copy memory block to different place
- Specify actions to be executed when transfer is finished
- Asynchronous, HW support

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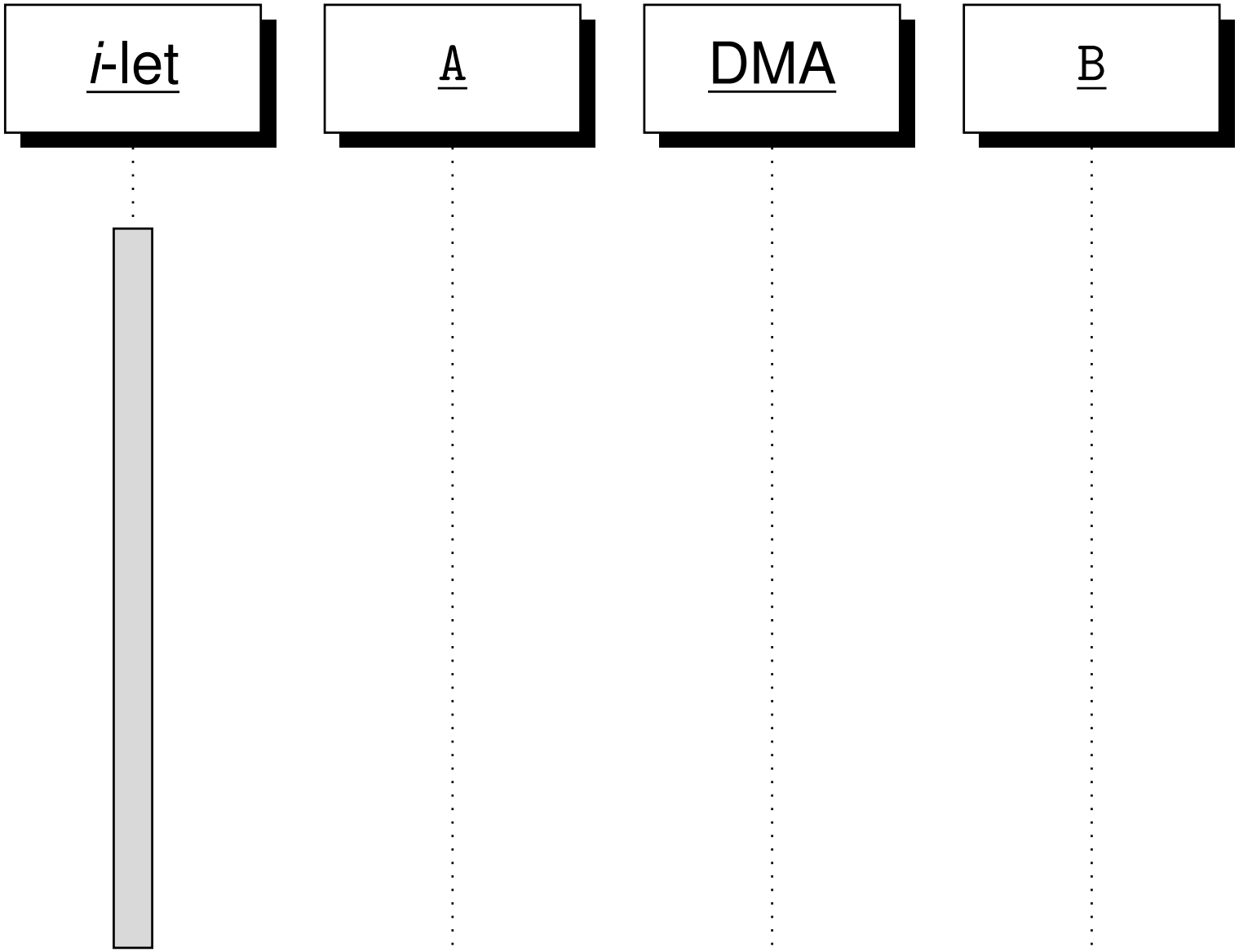

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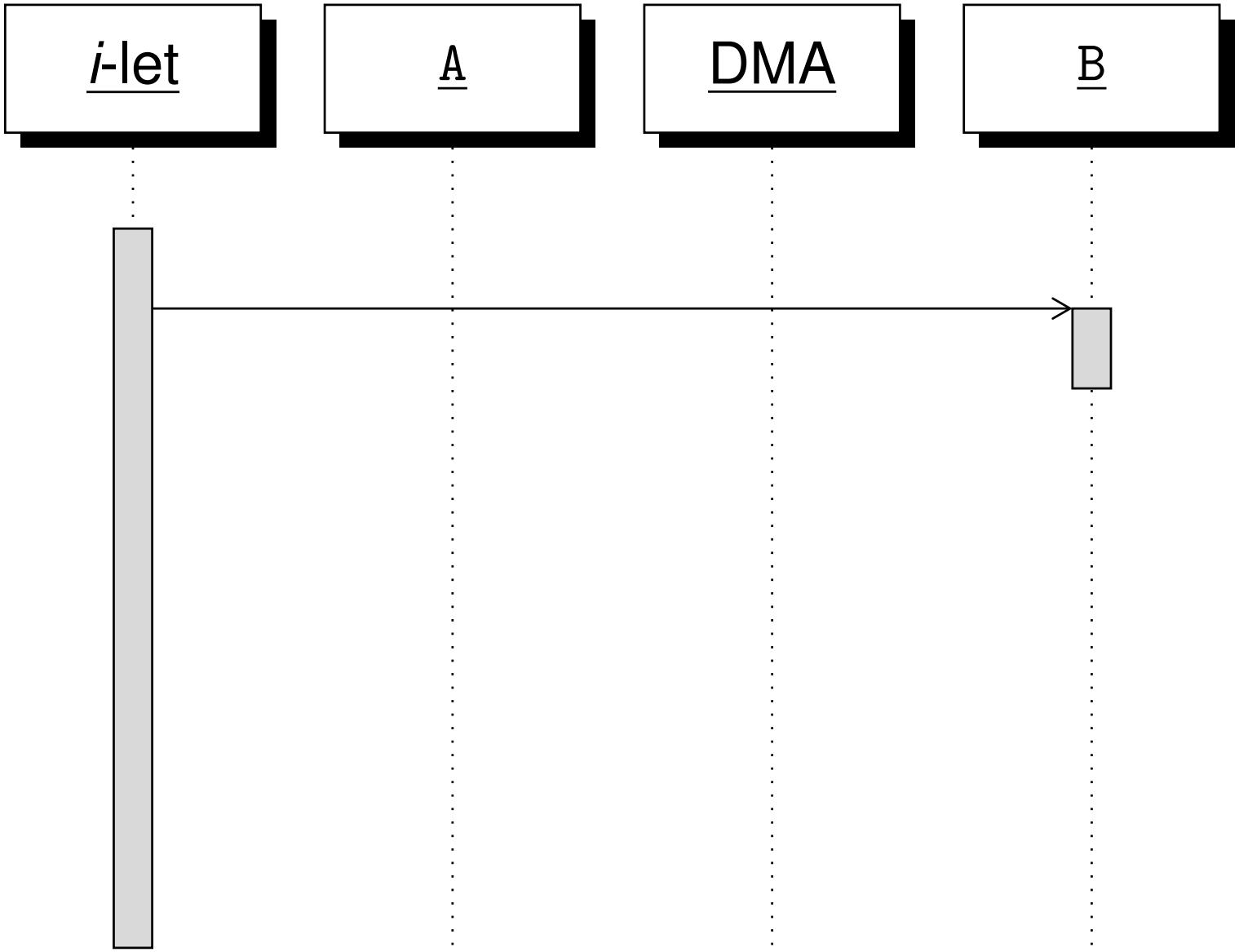

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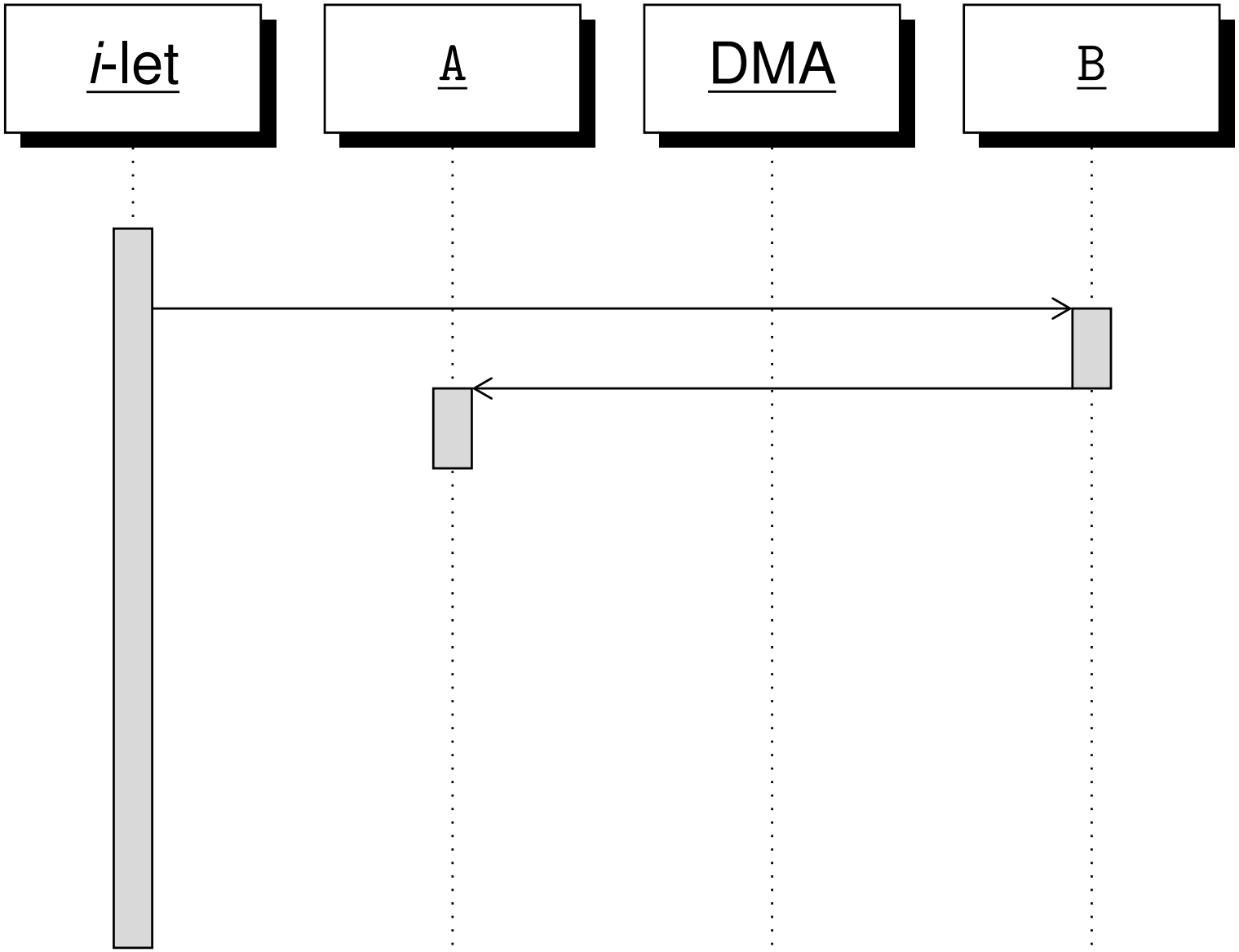

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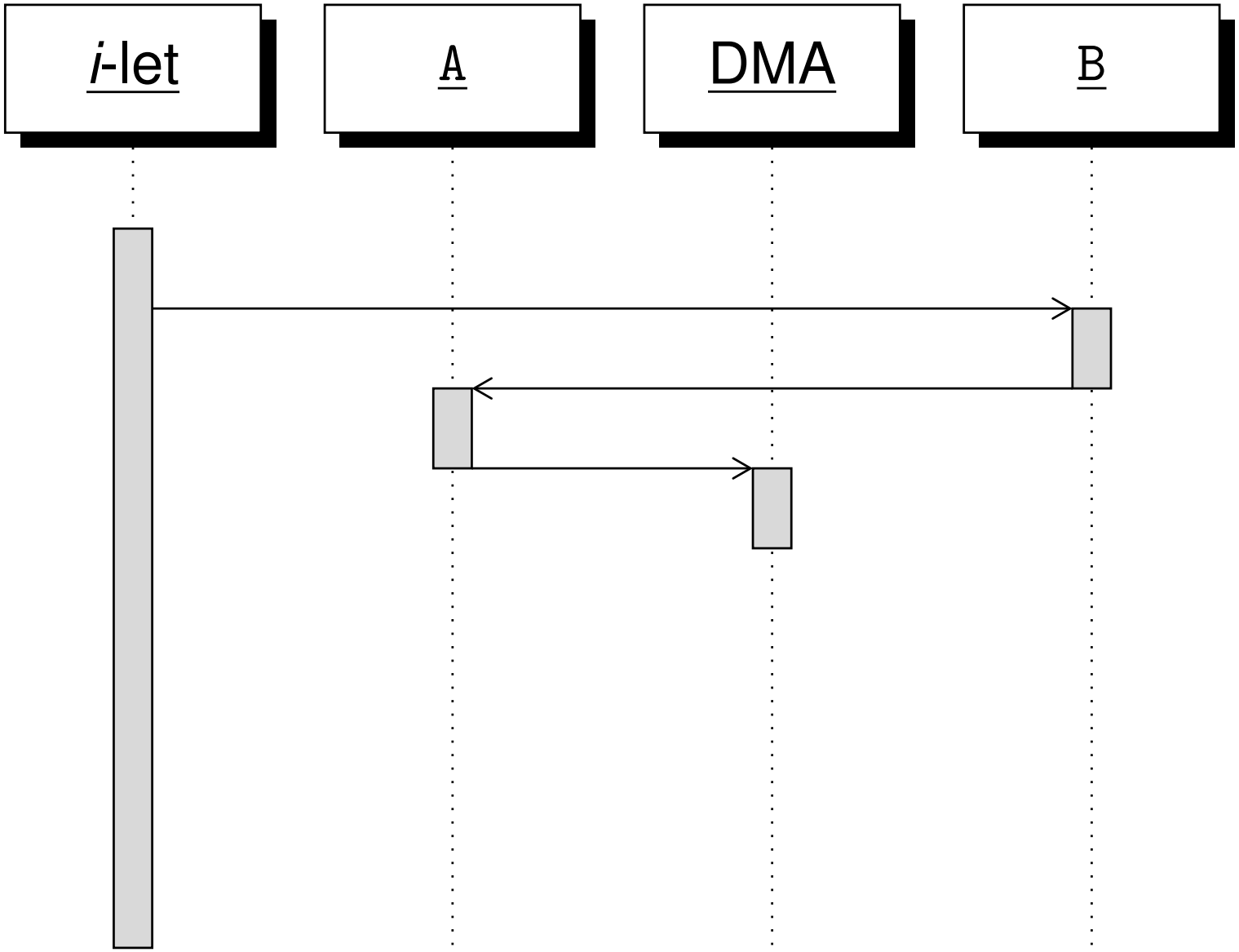

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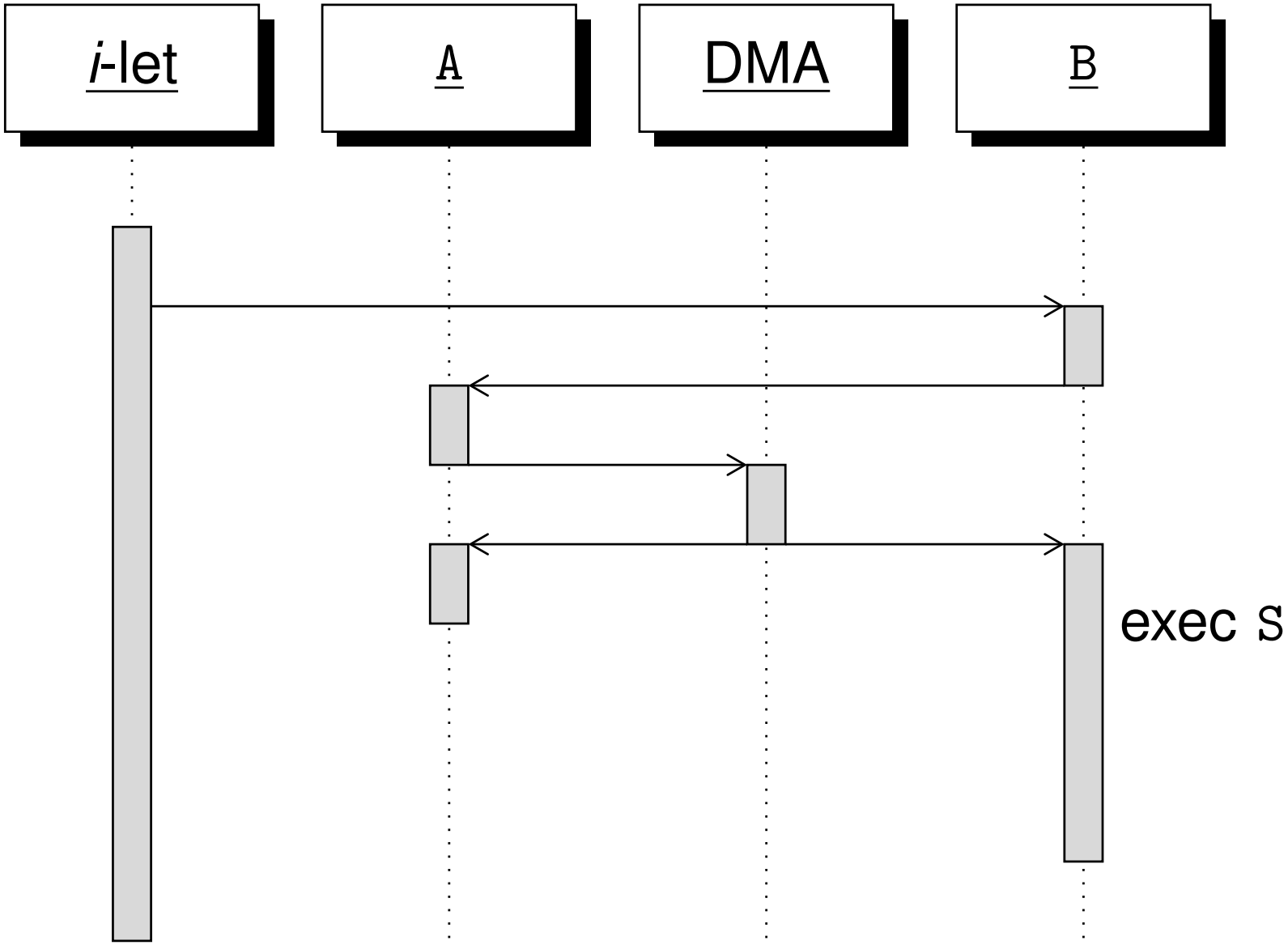

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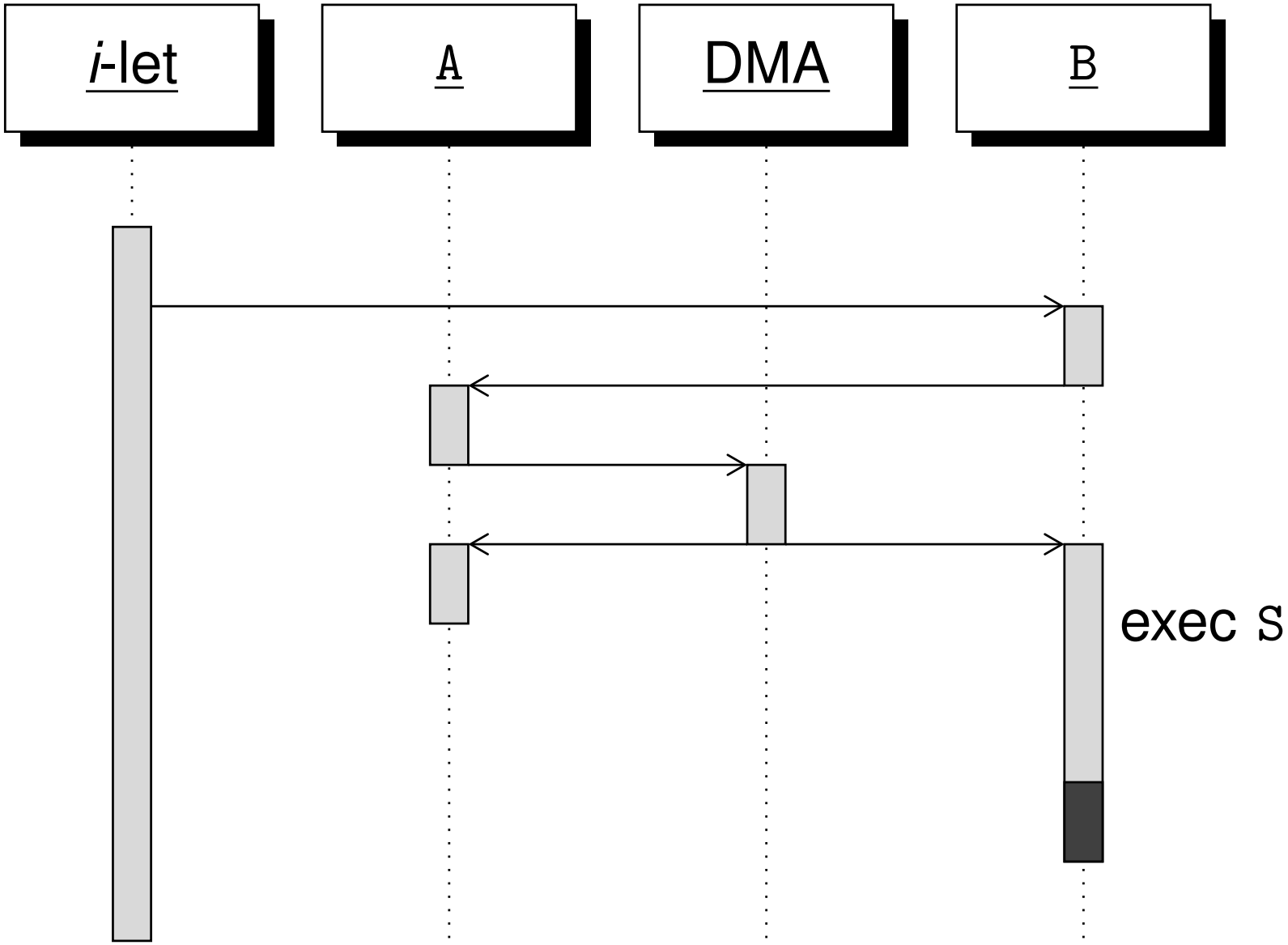

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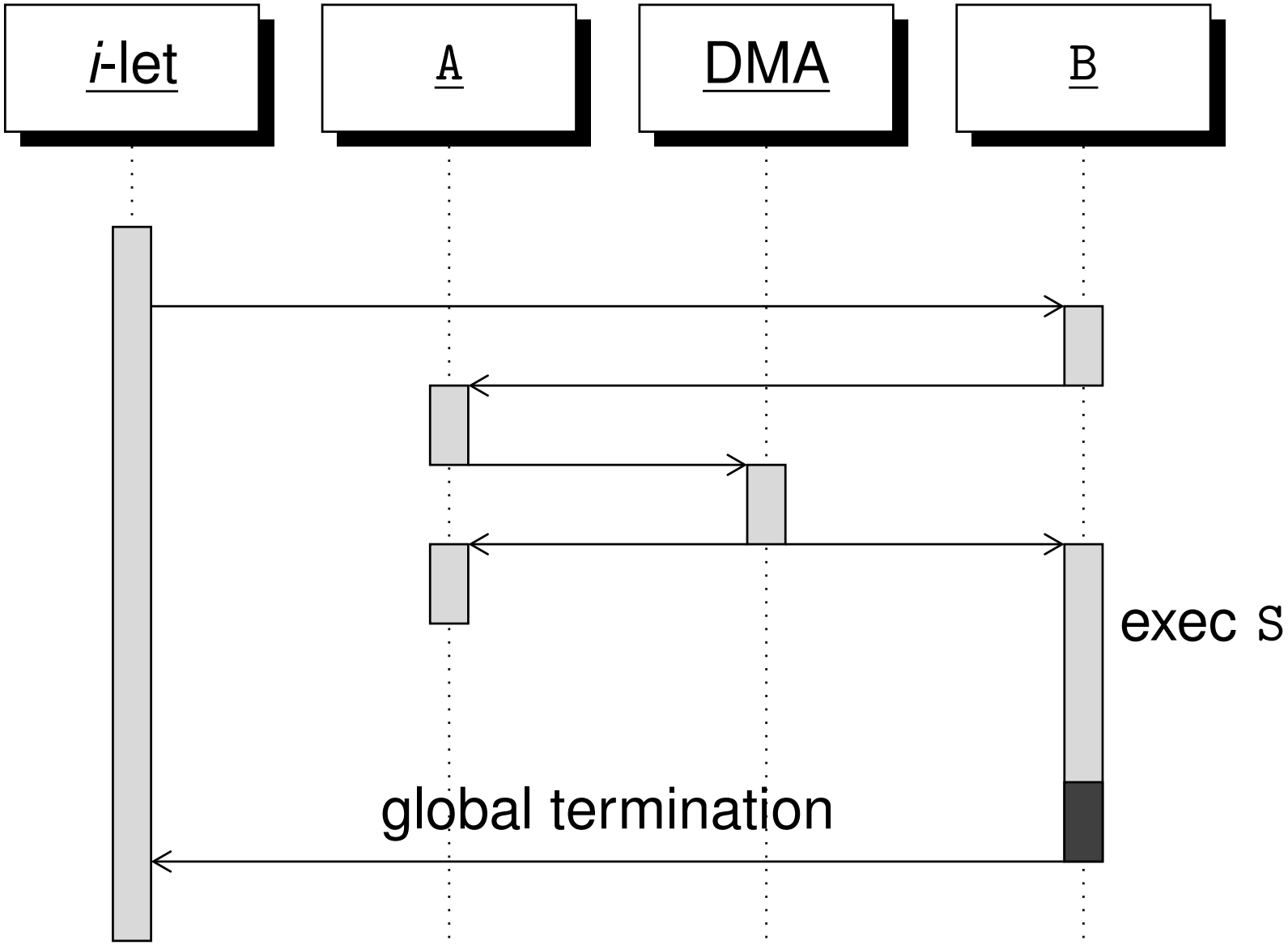

Evaluation

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- Operations are cheap (in absolute numbers)

Conclusion & Future Work

We have:

- Implemented X10 activity management without a user-level scheduler
  - Possible by exclusively allocating cores and using cooperative scheduling
  - Essentially puts user-level-like scheduler into kernel
- Adapted the X10 runtime
- Evaluated the efficiency on a prototype many-core architecture

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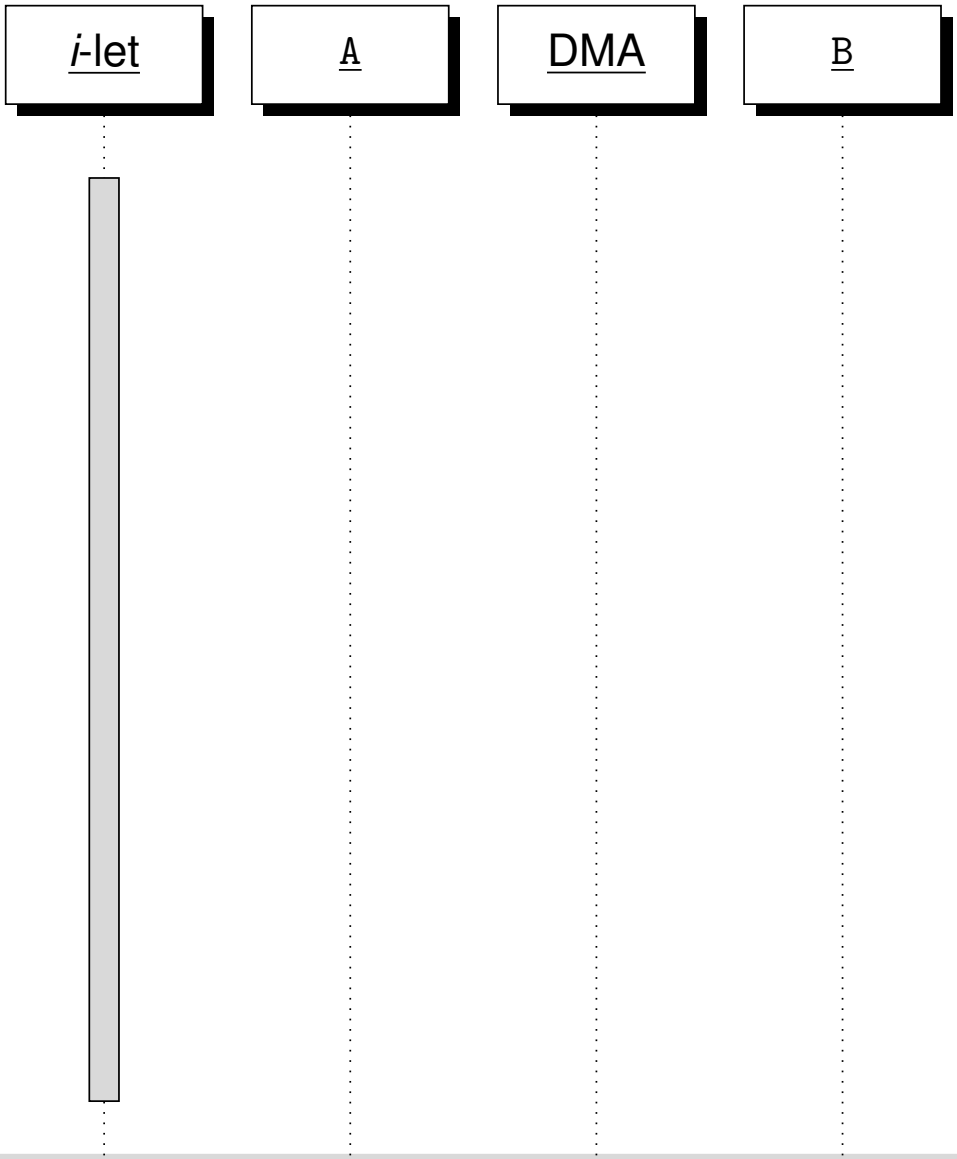
We plan to:

- Port OctoPOS to AMD64 NUMA systems (in progress)
- Evaluate against common Linux-MPI implementations

Backup Slides

At Expression: `at (B) E`



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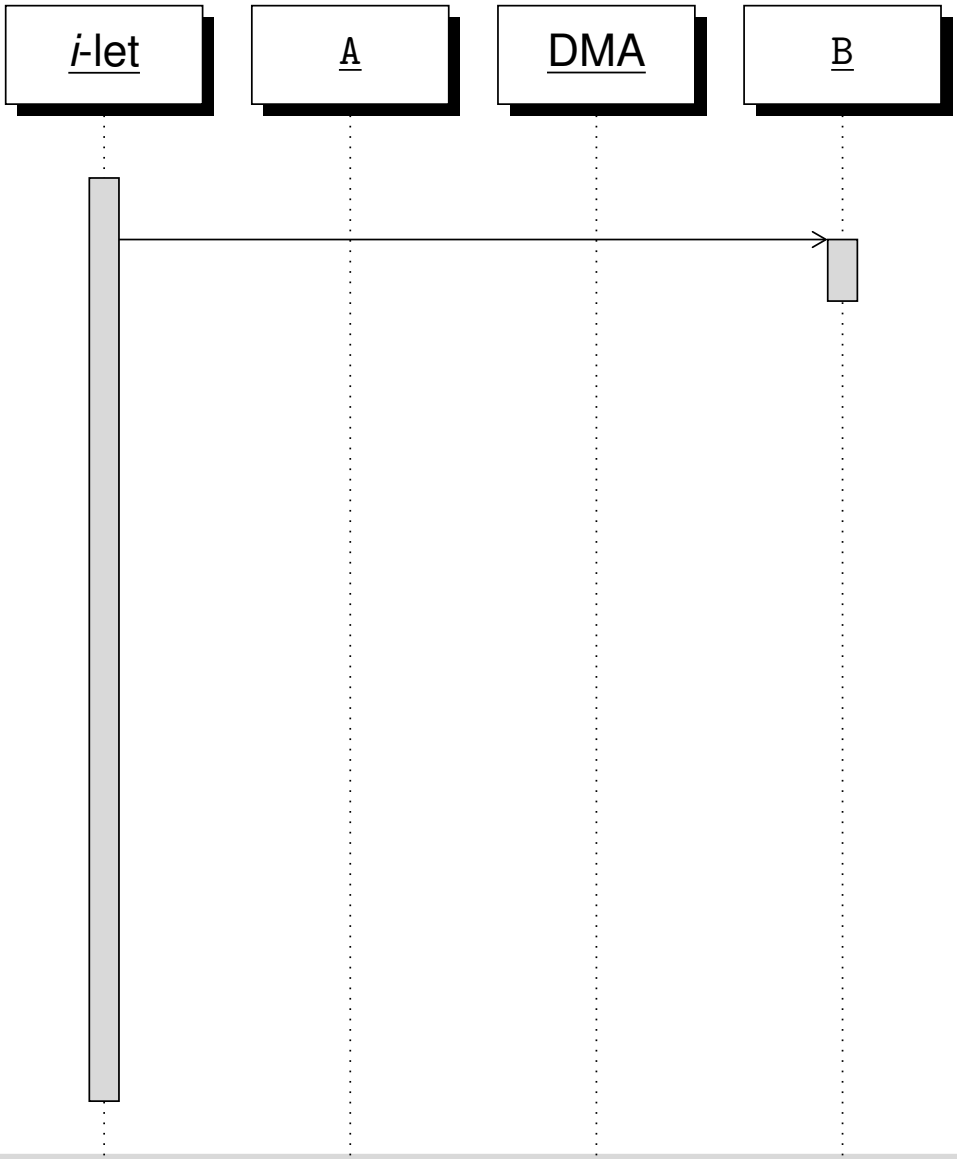

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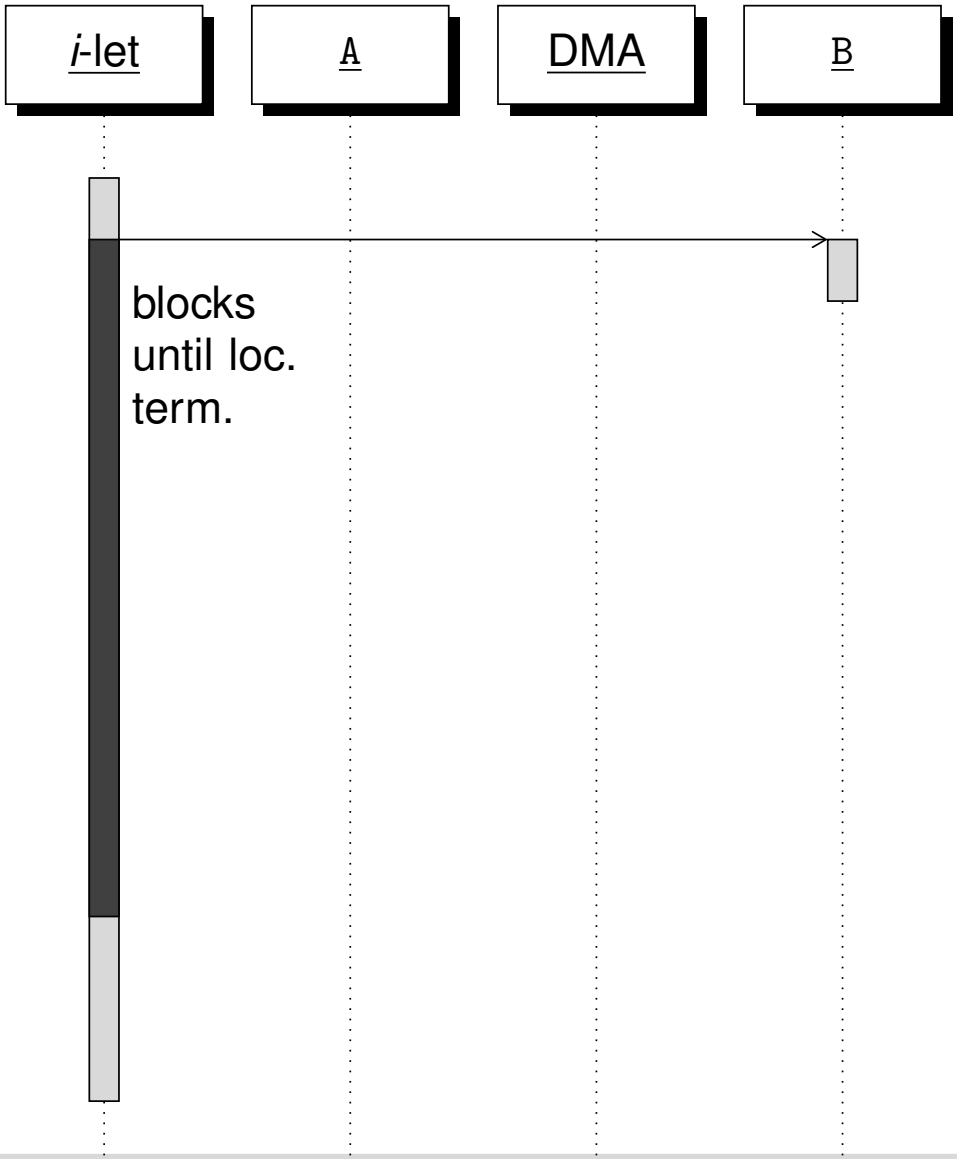

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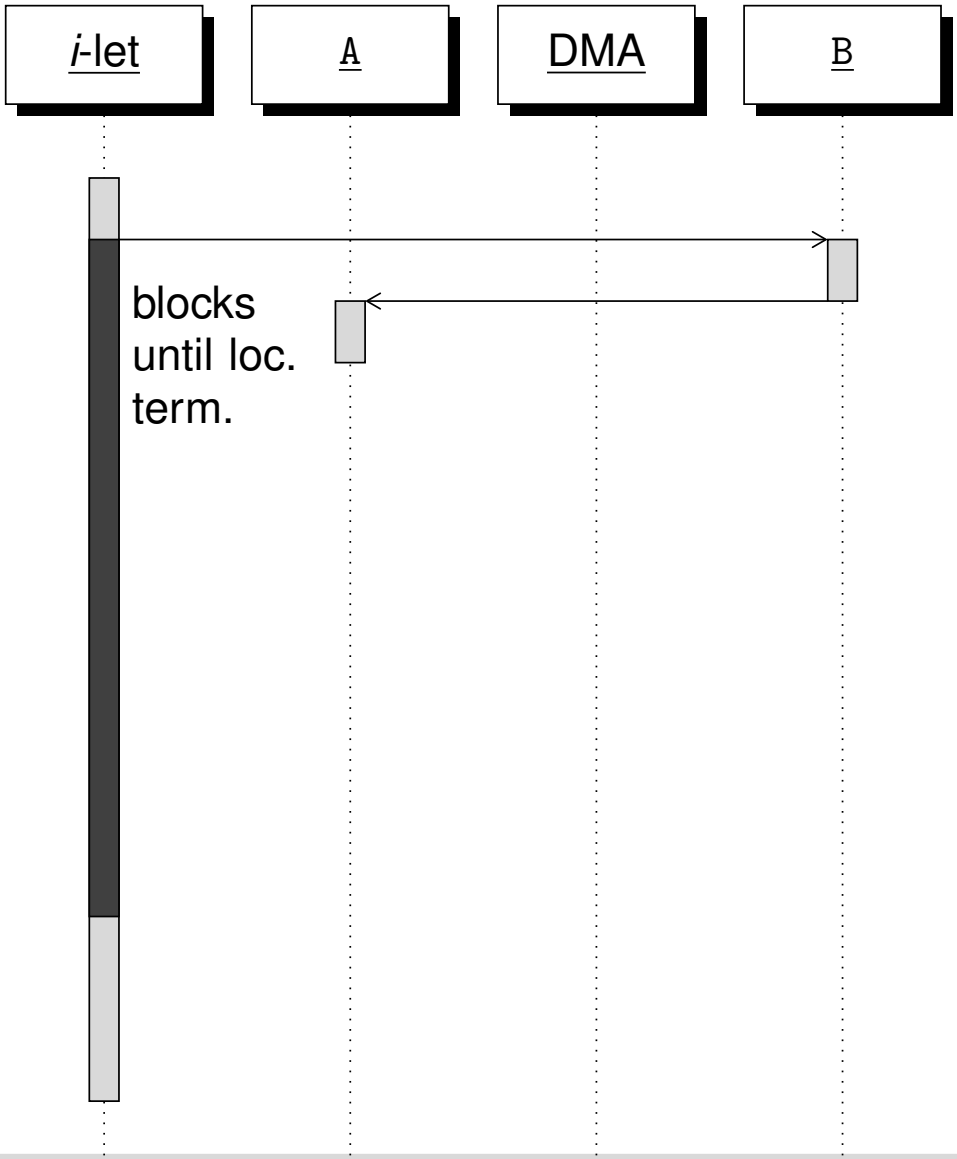

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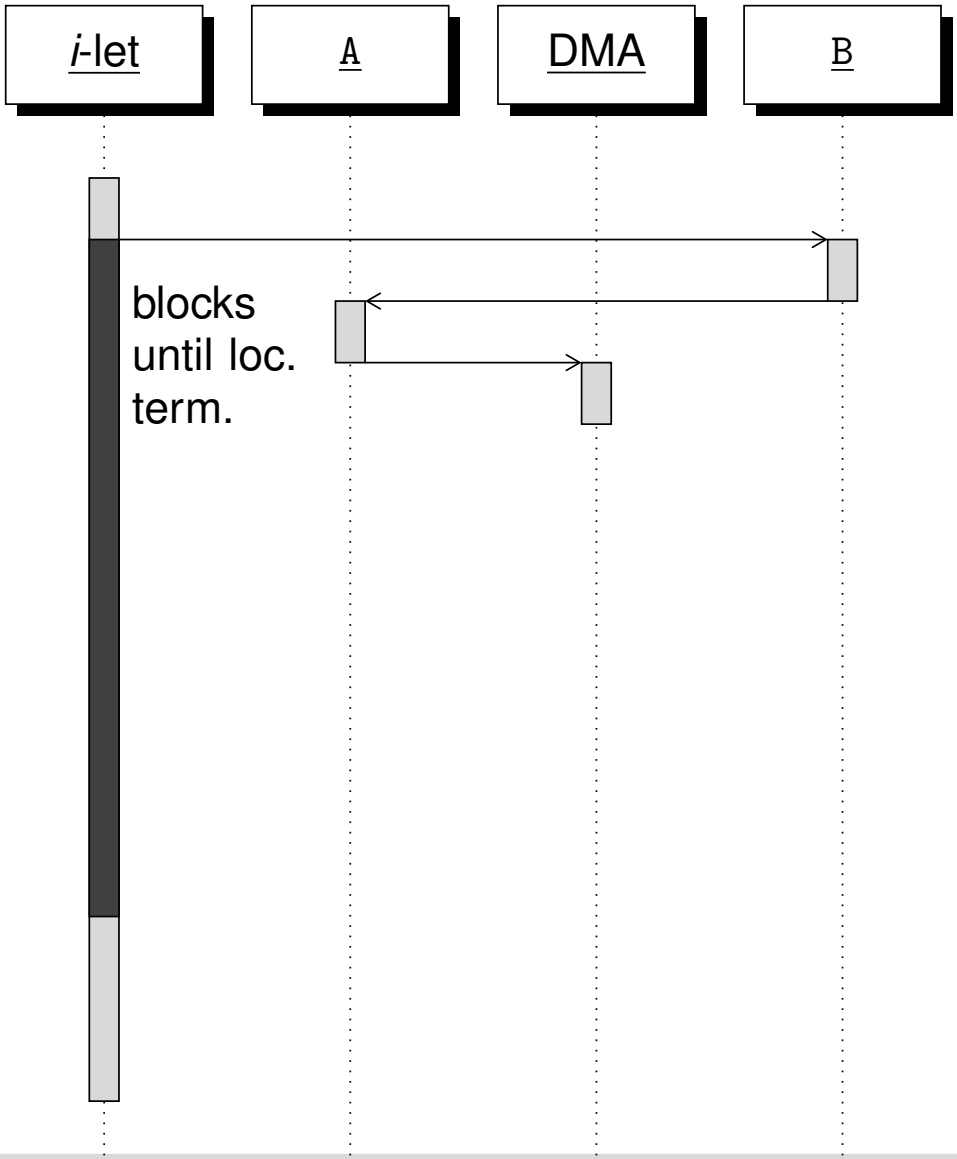

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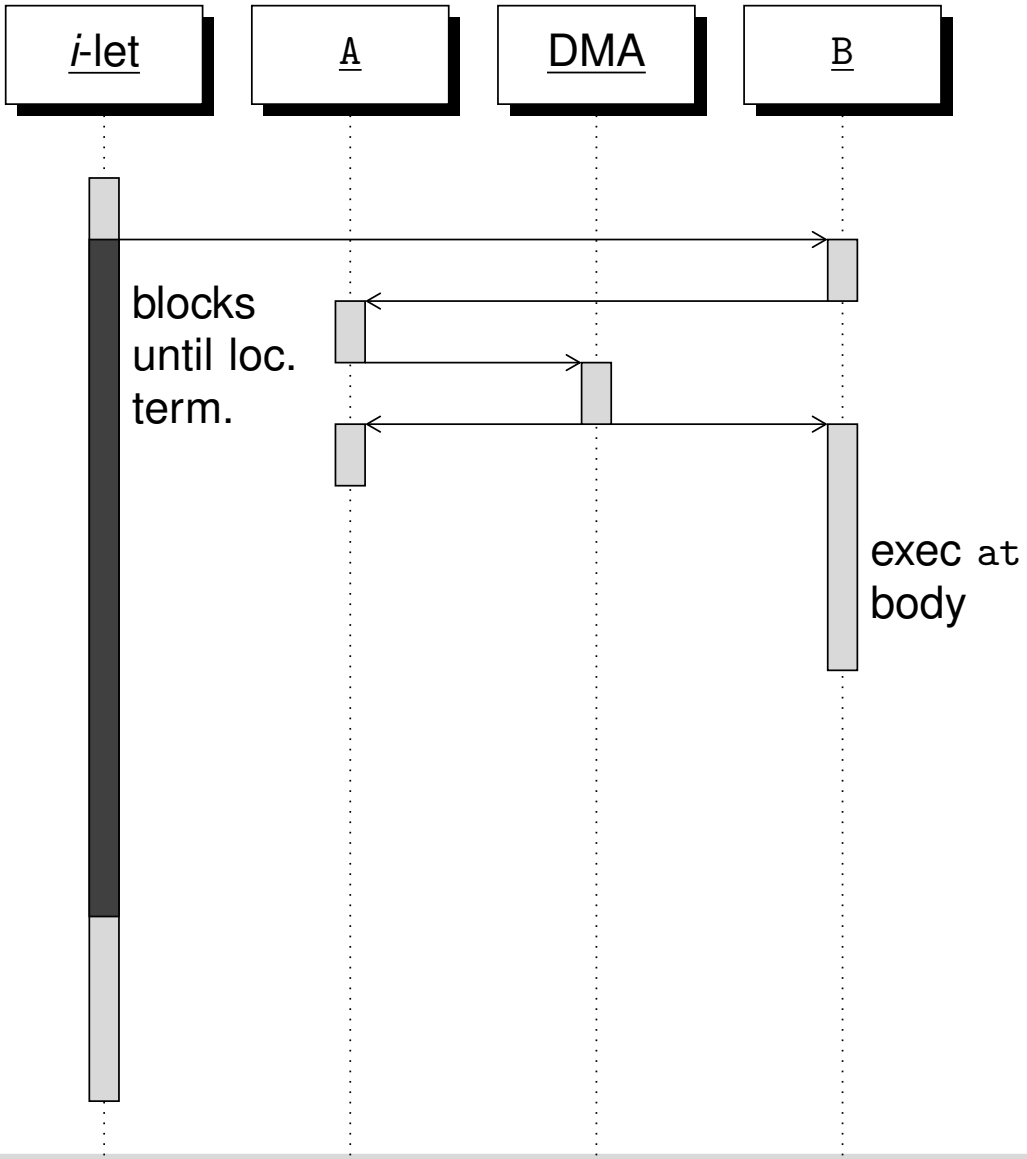

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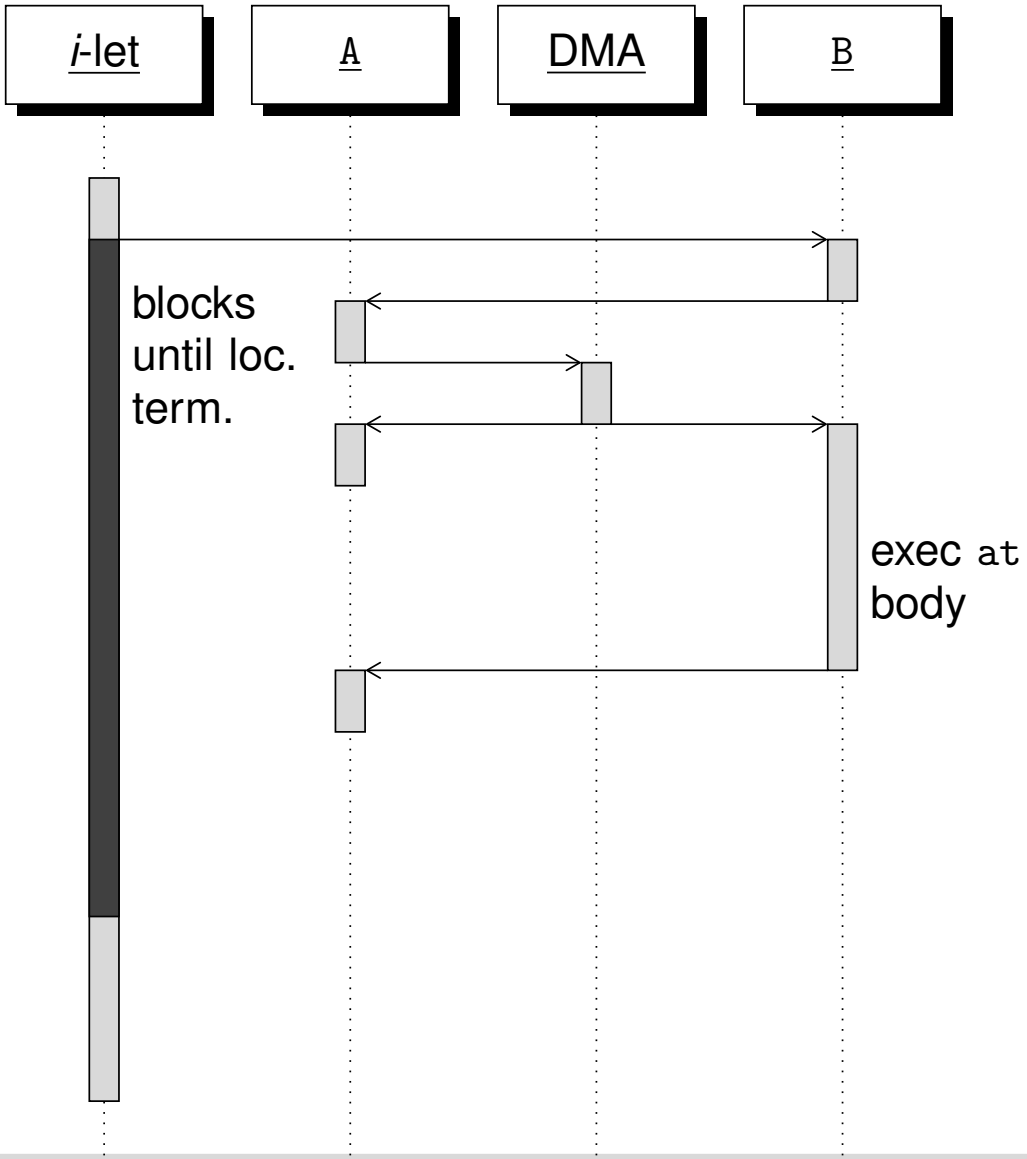

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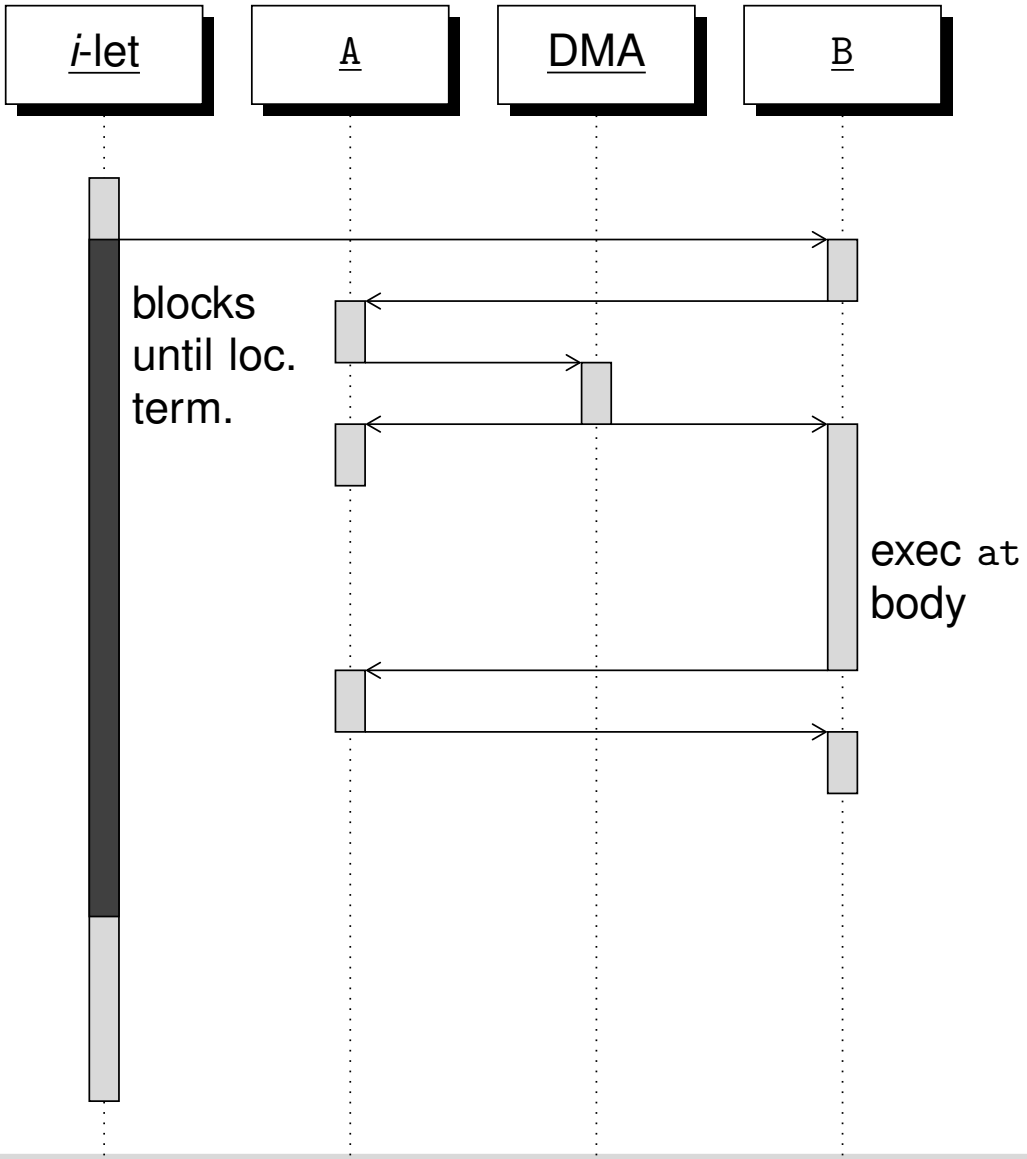

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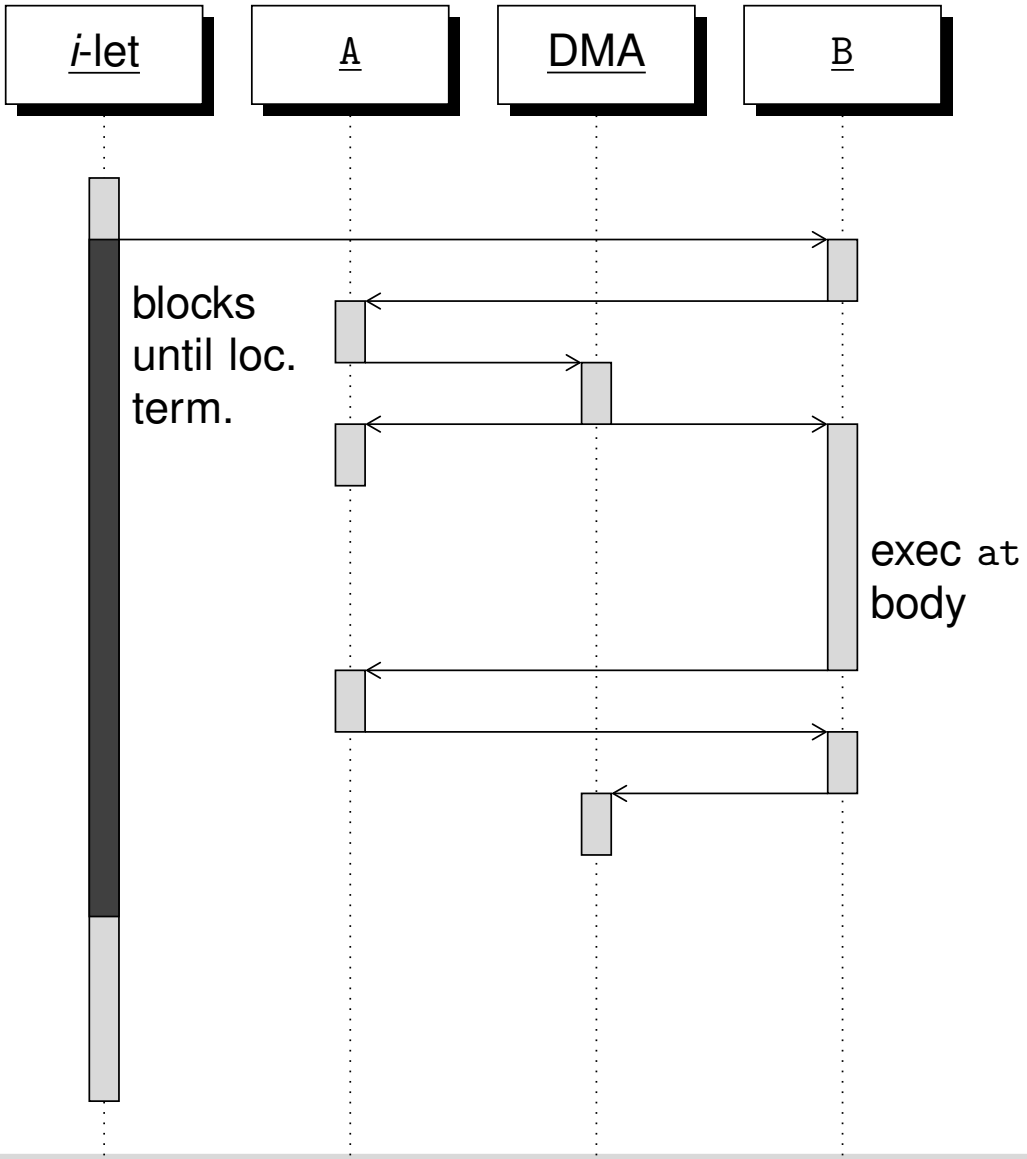

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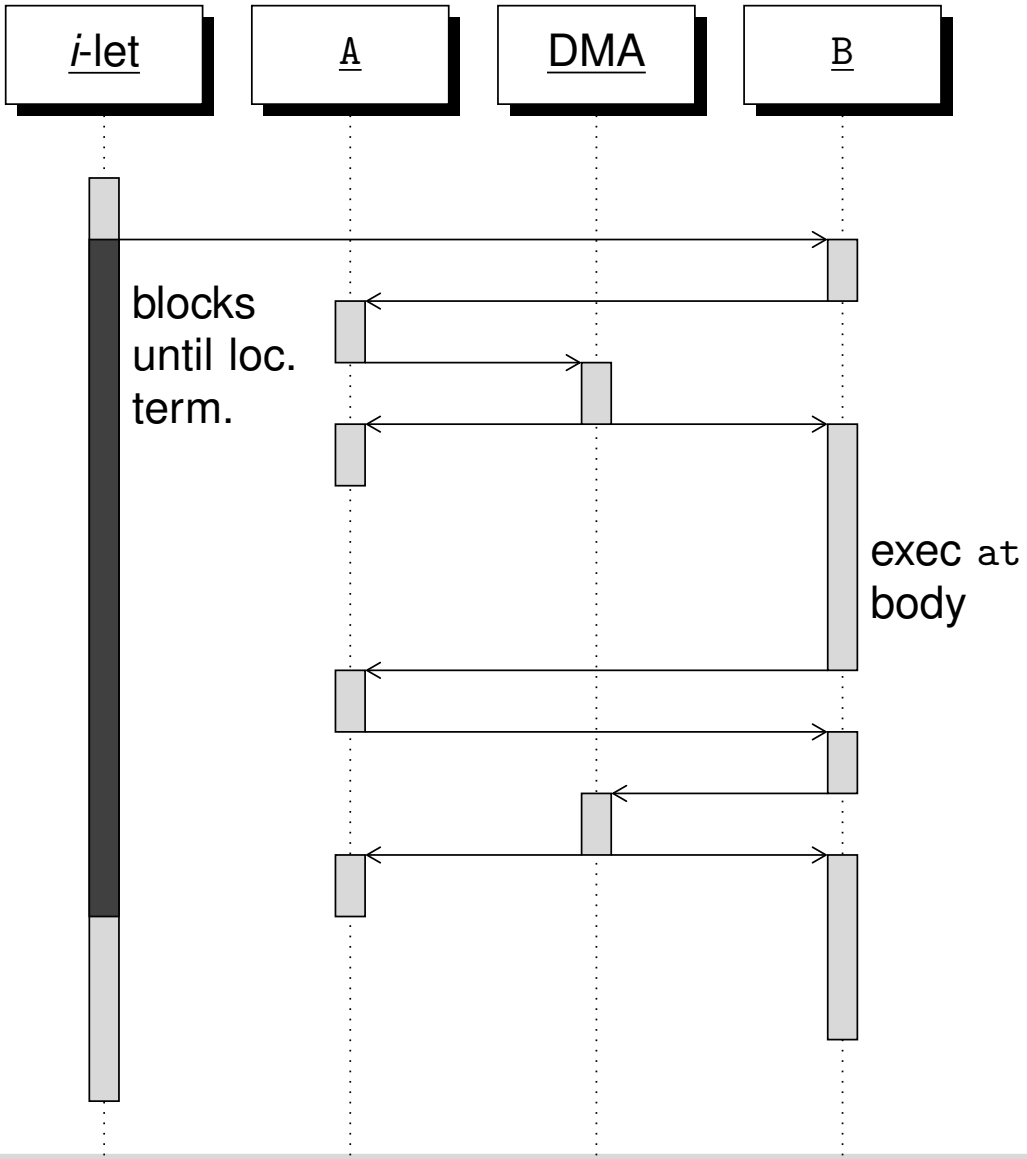

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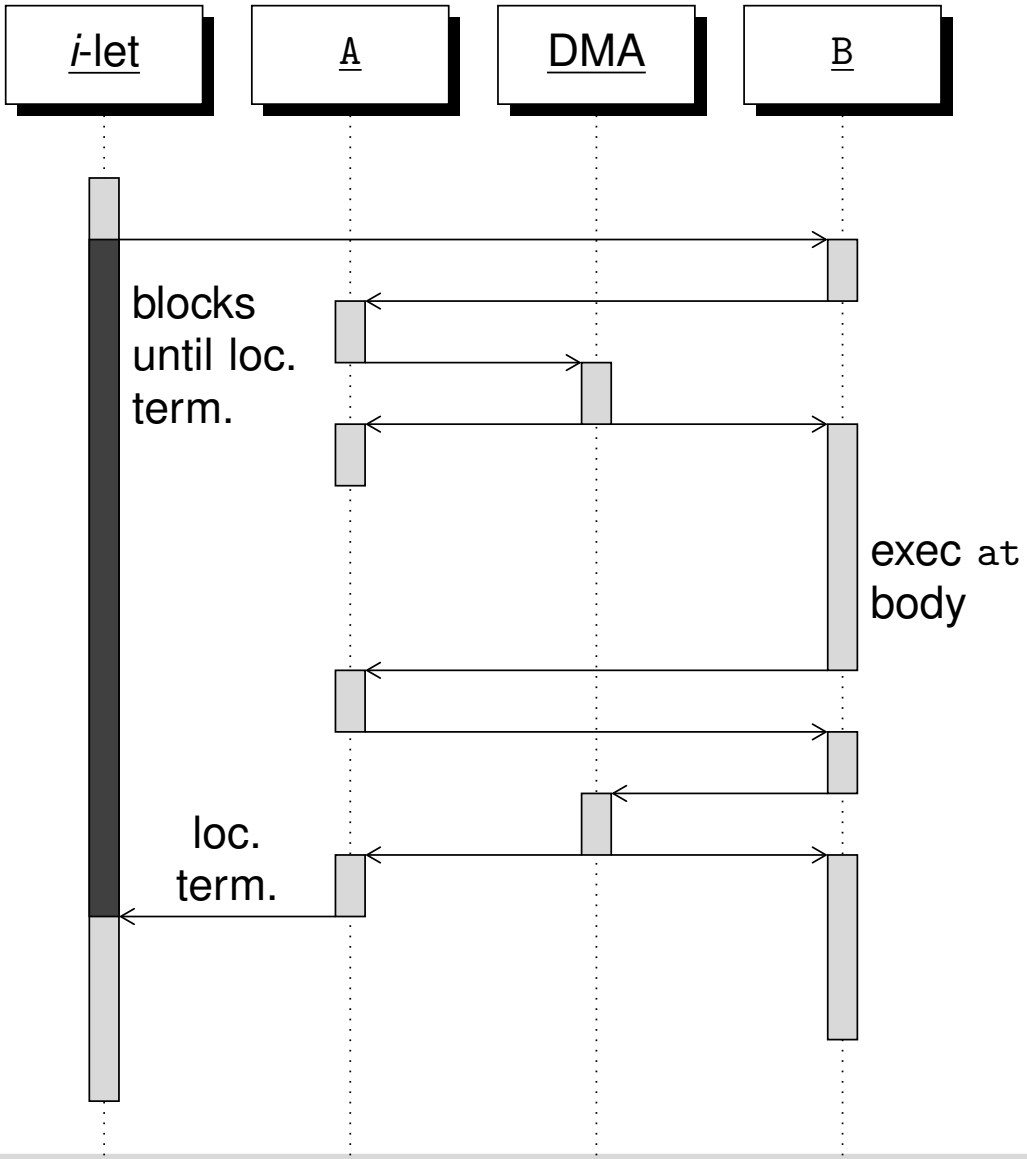

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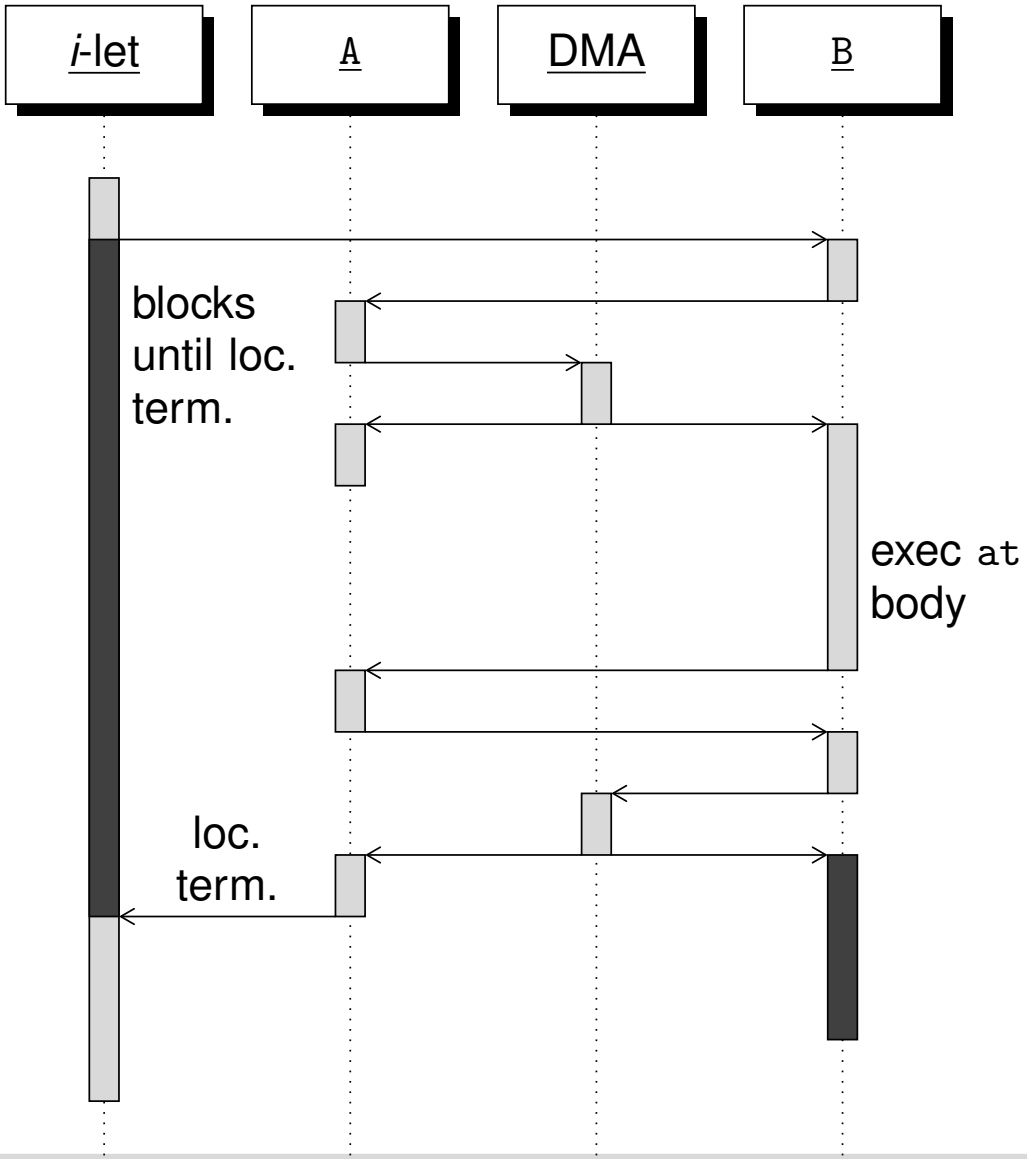

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