GeMS:
A Generator for Modulo Scheduling Problems

built GeMS

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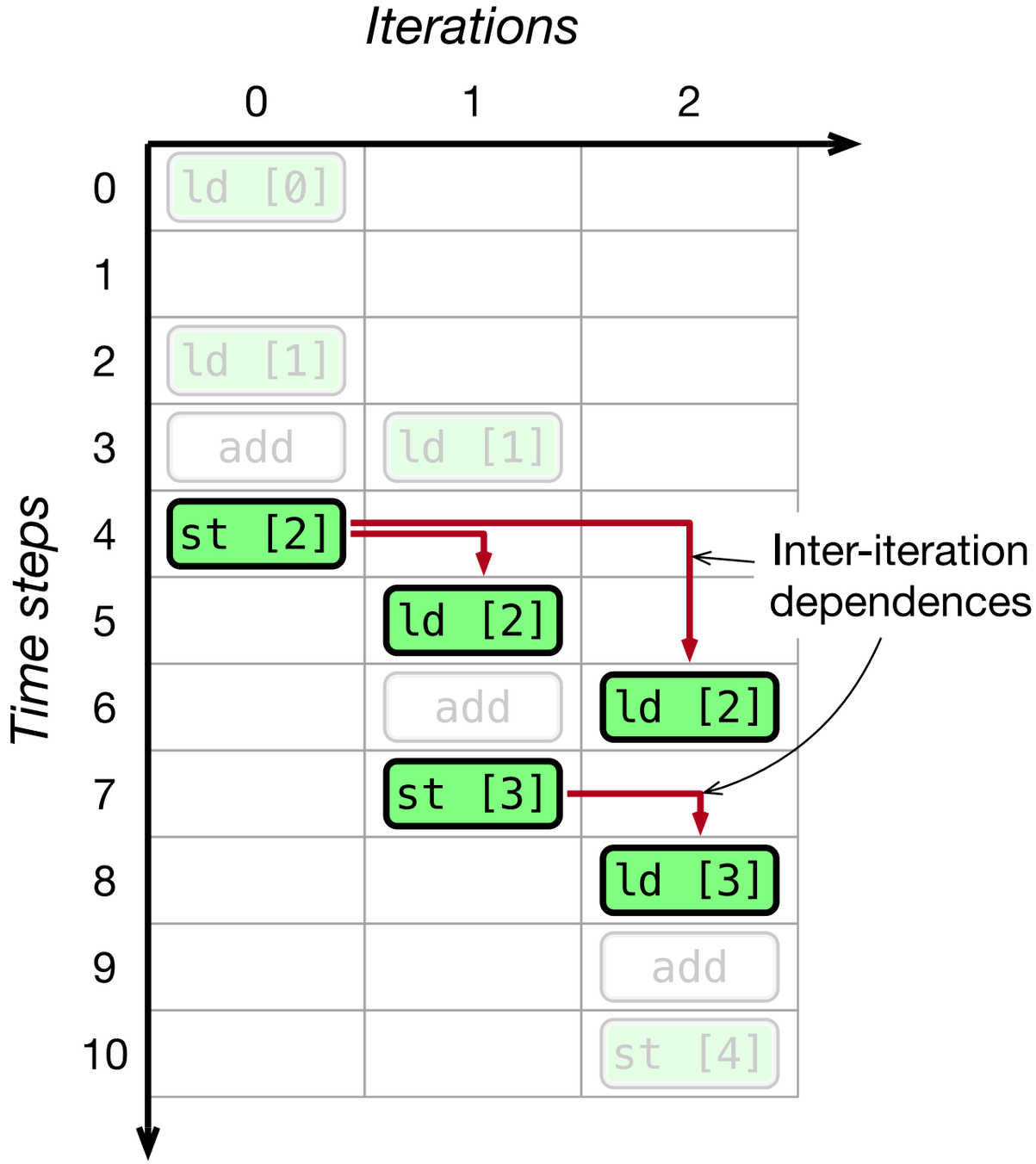
Modulo Scheduling

- **Loop/software pipelining**
  = increase throughput by overlapping iterations

- **Modulo schedulers**
  compute
  - initiation interval (II)
  - start times (= „schedule“)

- Subject to
  - inter-iteration dependences
  - resource constraints

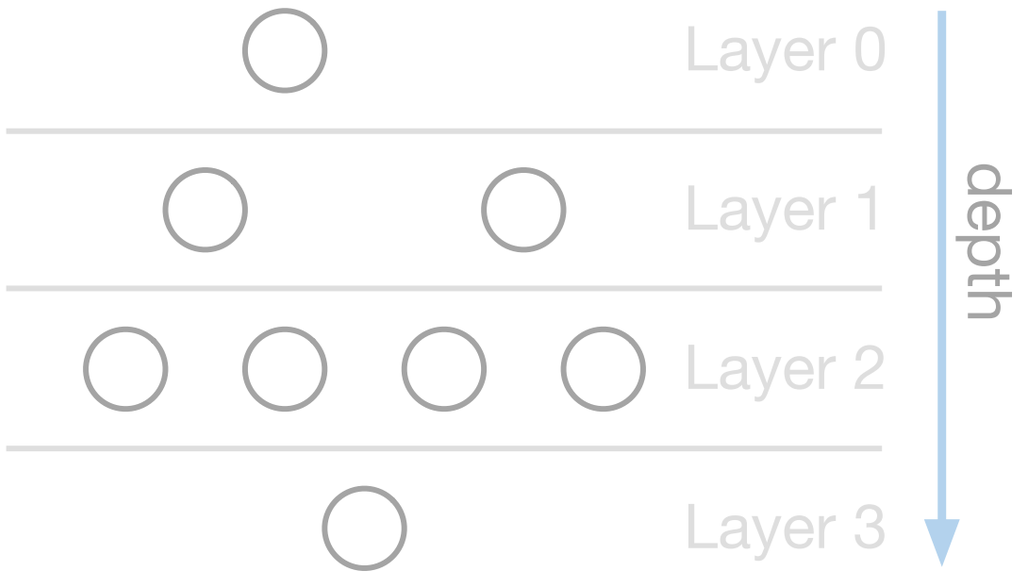


Why Generate Problems?

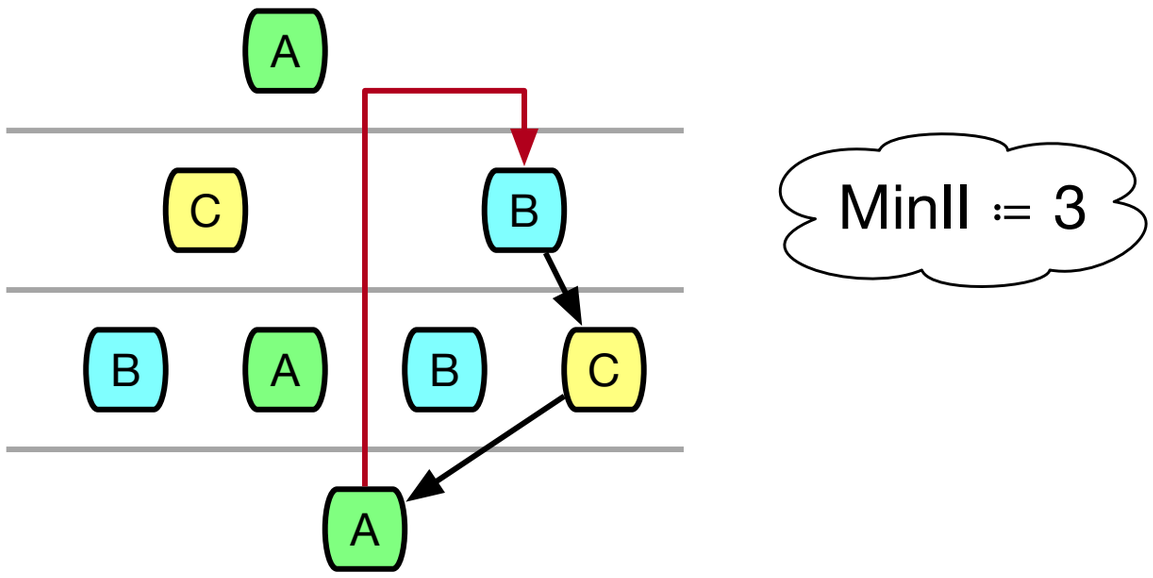
- Finding an optimal II and schedule is NP-hard, 
  - only a few problem instances are slow/intractable 
  - what's a **„hard" instance** for a particular scheduler?
- **GeMS**-generated instances „fill the gaps"
  - small/large, sparse/dense, …
- Long-term: build an **oracle**

[CASES'16] Oppermann et al.: ILP-based Modulo Scheduling for High-level Synthesis
[FPL'18] Oppermann et al.: Dependence Graph Preprocessing for Faster Exact Modulo Scheduling in HLS

Generation Approach



1) Generate layer structure



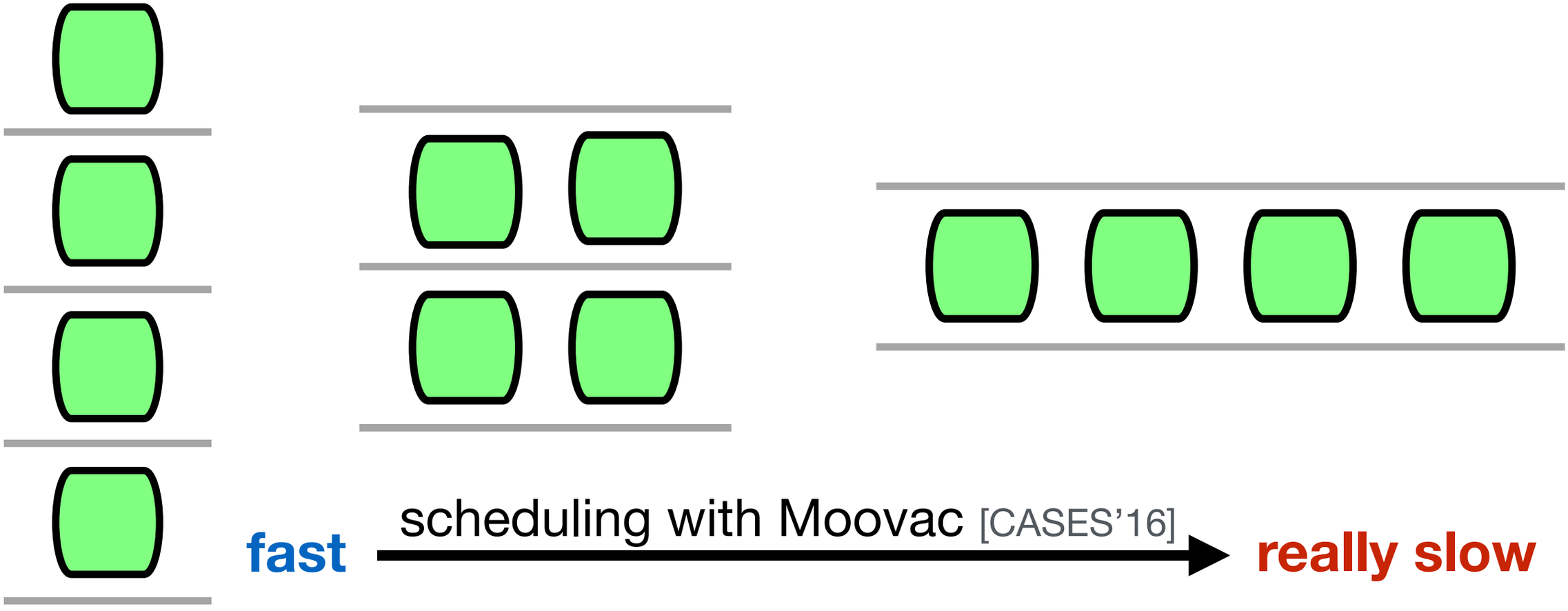
3) Establish user-specified MinII (optional)

- **MinII** = lower bound for the optimal II
  - schedulers typically try several **candidate IIs**
- GeMS picks operations to form a special cycle if needed
  - can be **feasible** or **infeasible** at that II

Case Study

[CASES'16] Oppermann et al.: ILP-based Modulo Scheduling for High-level Synthesis

- 48 operations compete for resource type with 2 units
- Using layer structures with **increasing parallelism** among the operations



Code Example

- GeMS is a **toolkit** written in Java → no CLI
  - source available under Apache License

```
Resource resA = new Resource("A", 2, 2);
Resource resB = new Resource("B", 1, 4);
Resource resC = new Resource("C", 0);

GraphGenerator gen = new GraphGenerator(
  new FixedShapeLayerCreator(/* nodes in layer */ 1, 2, 4, 1),
  new DistributionNodeCreator(new ProbabilityDistribution<>(resA, resB, resC)),
  new EdgeCreator(
    /* edge delay         */ new ConstantValueComputer(0),
    /* backedge delay     */ new ConstantValueComputer(0),
    /* backedge distance */ new ConstantValueComputer(1)),
  /* forward edges */ new ProbabilityEdgeIncluder(0.0075),
  /* backedges     */ new ProbabilityEdgeIncluder(0.0030)
);
GraphFileUtils.graphToHatScheTFiles(gen.createGraph(/* seed */ 42), "graph");
```

- Export generated graphs directly to **HatScheT** scheduler library
  - great for scheduler research!

Thanks, see you at the poster!

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Get **GeMS**

Try **HatScheT**,
a toolkit for schedulers

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