Macro Data Flow execution model

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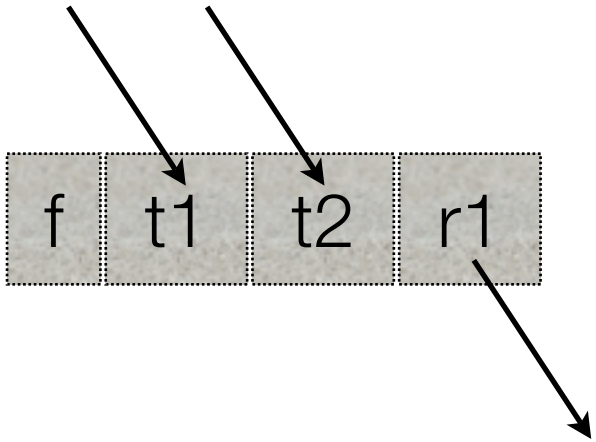
Summary

- Macro Data flow
- Skeletons to macro data flow
- Workflows
- Distributed macro data flow interpreter
- MDF for grids
- Conclusions

Macro Data flow

- Data flow
  - graphs of data flow instructions
  - tokens
  - fireable instructions
  - handling state
  - handling stream computations



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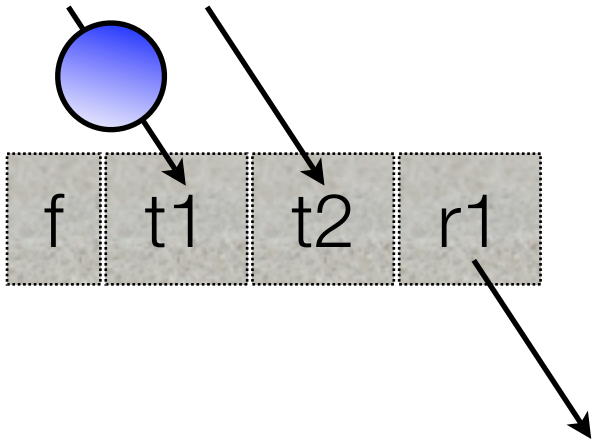

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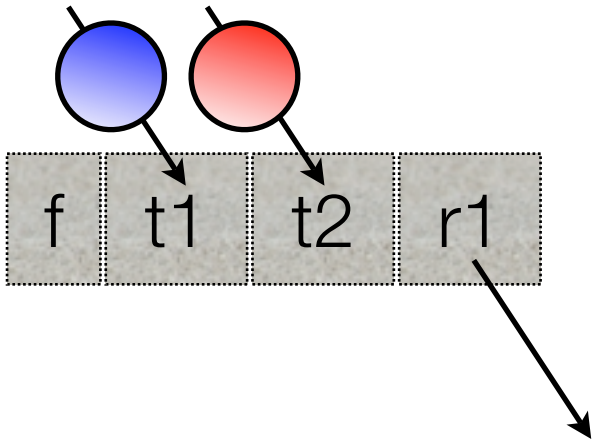

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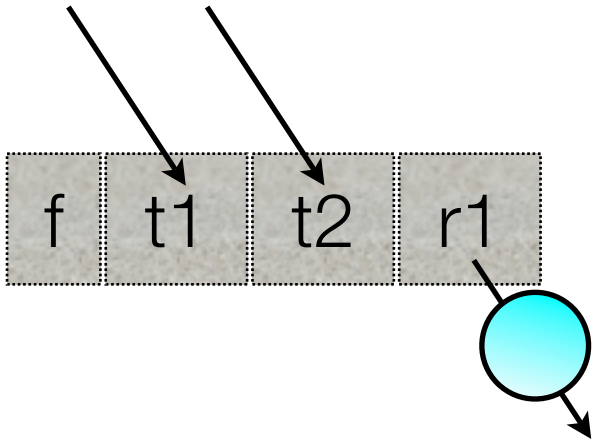

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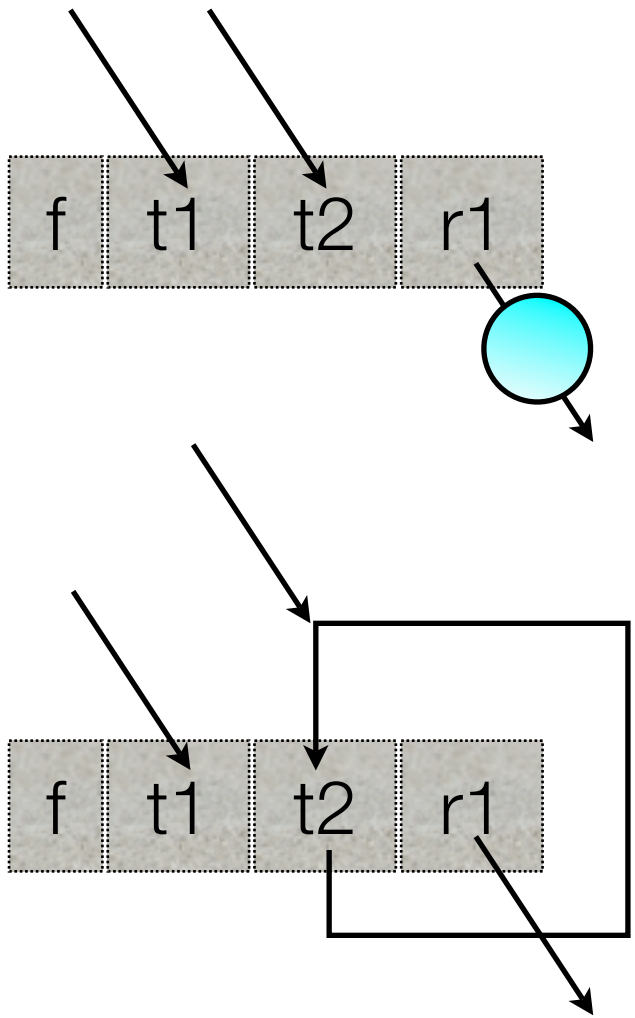

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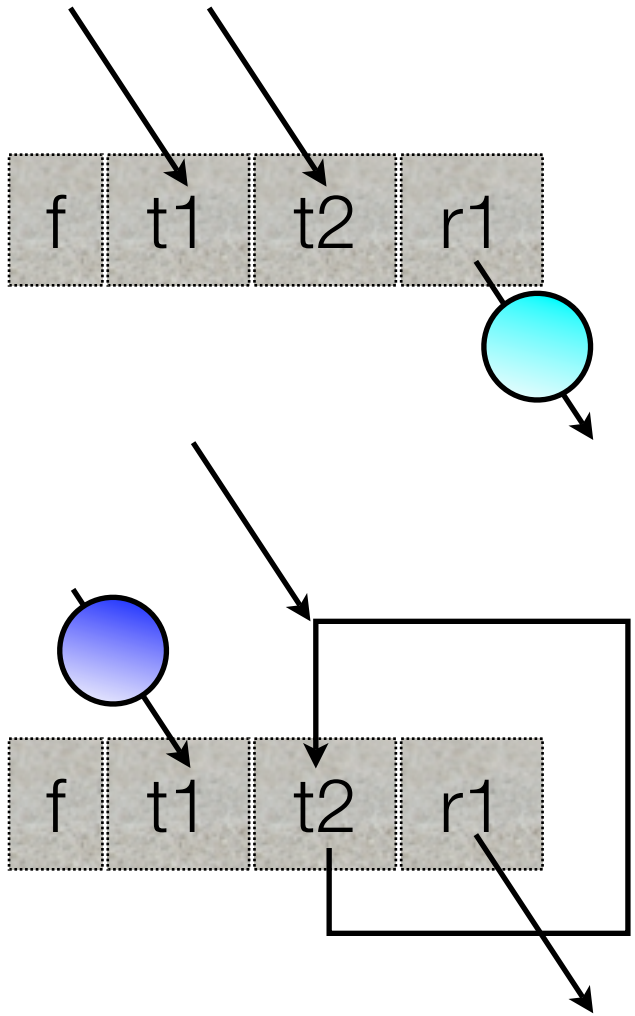

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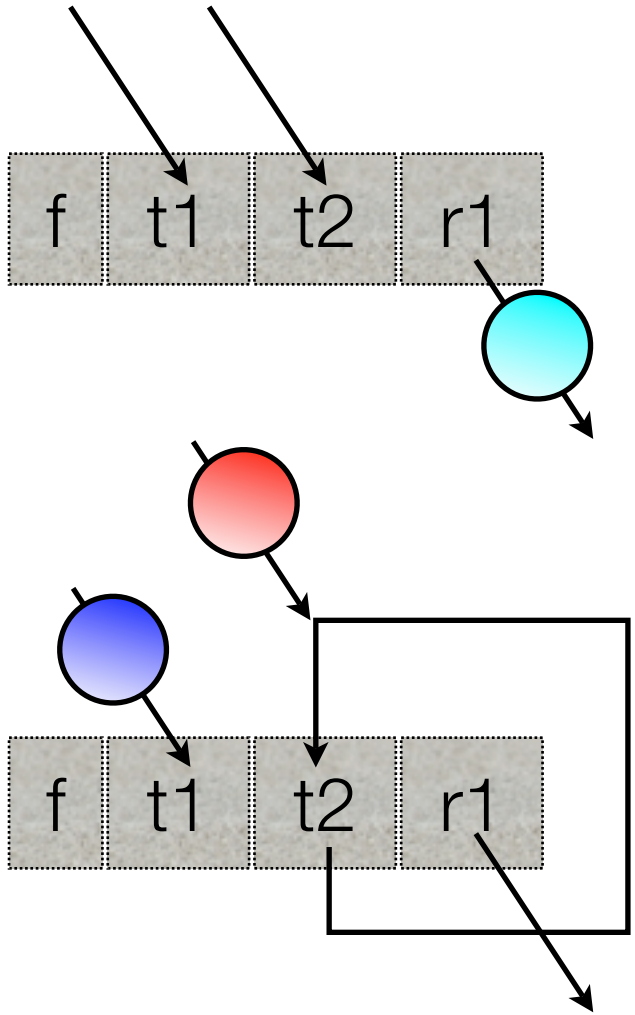

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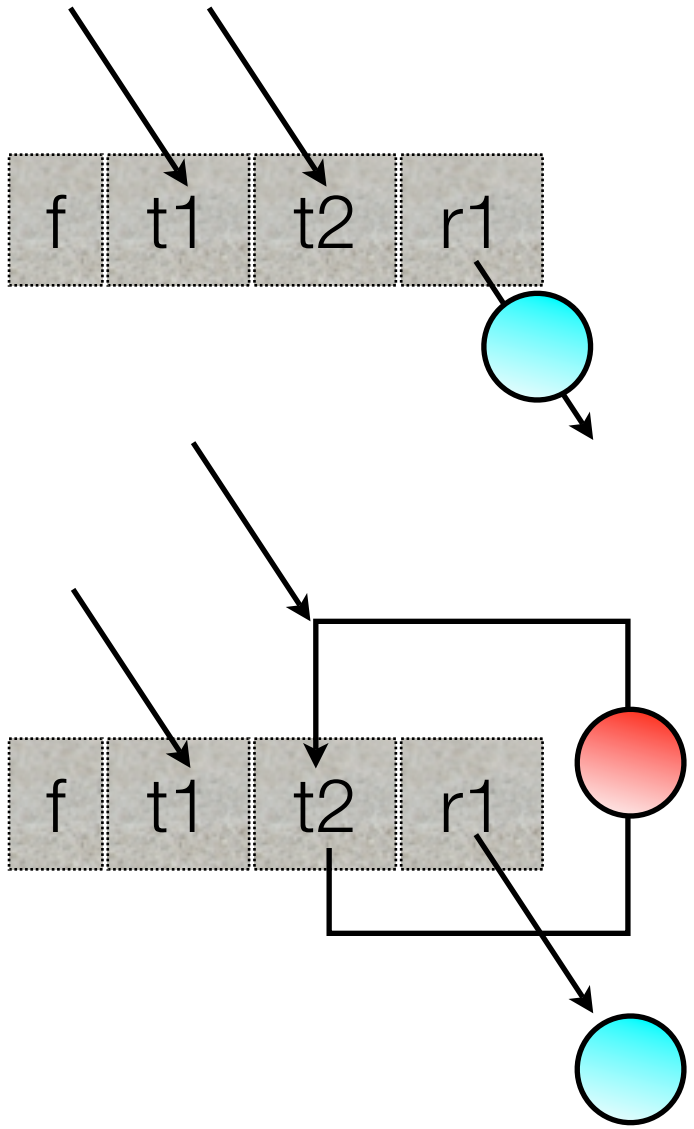


Macro Data Flow

- Code computed in instructions
  - sensibly bigger that a single instruction, possibly entire chucks of code
- Conceivable as plain sequential code
  - clearly identified input and output parameters
  - any kind of code, provided there is some common primitive data representation

Translating to MDF : skeletons

- Danelutto 1999, PARCO paper
  - Skipper (J. Serót 2002)
  - Lithium (Teti, Danelutto, Aldinucci 2002) and **muskel** (Danelutto, 2004)
- compile(seq(S)) => mdfi(S)
- compile(pipe(A,B)) => Ga = compile(A), Gb = compile(B), concat(Ga,Gb)
- compile(farm(A)) => compile(A)
- ∀input task Ti instantiate G(Ti) and run it on the (distributed) interpreter

Translating to MDF: workflows

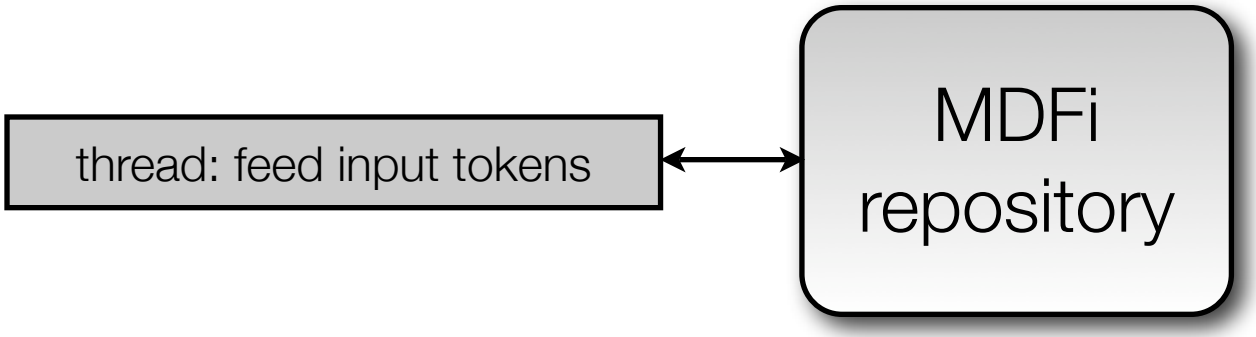
- Naive translation
  - each node in the graph corresponds to a single MDFi
- Works under two assumptions
  - serializability of the code
  - stream parallel computations (if #stream=1 then limited advantages)

Distributed MDF interpreter

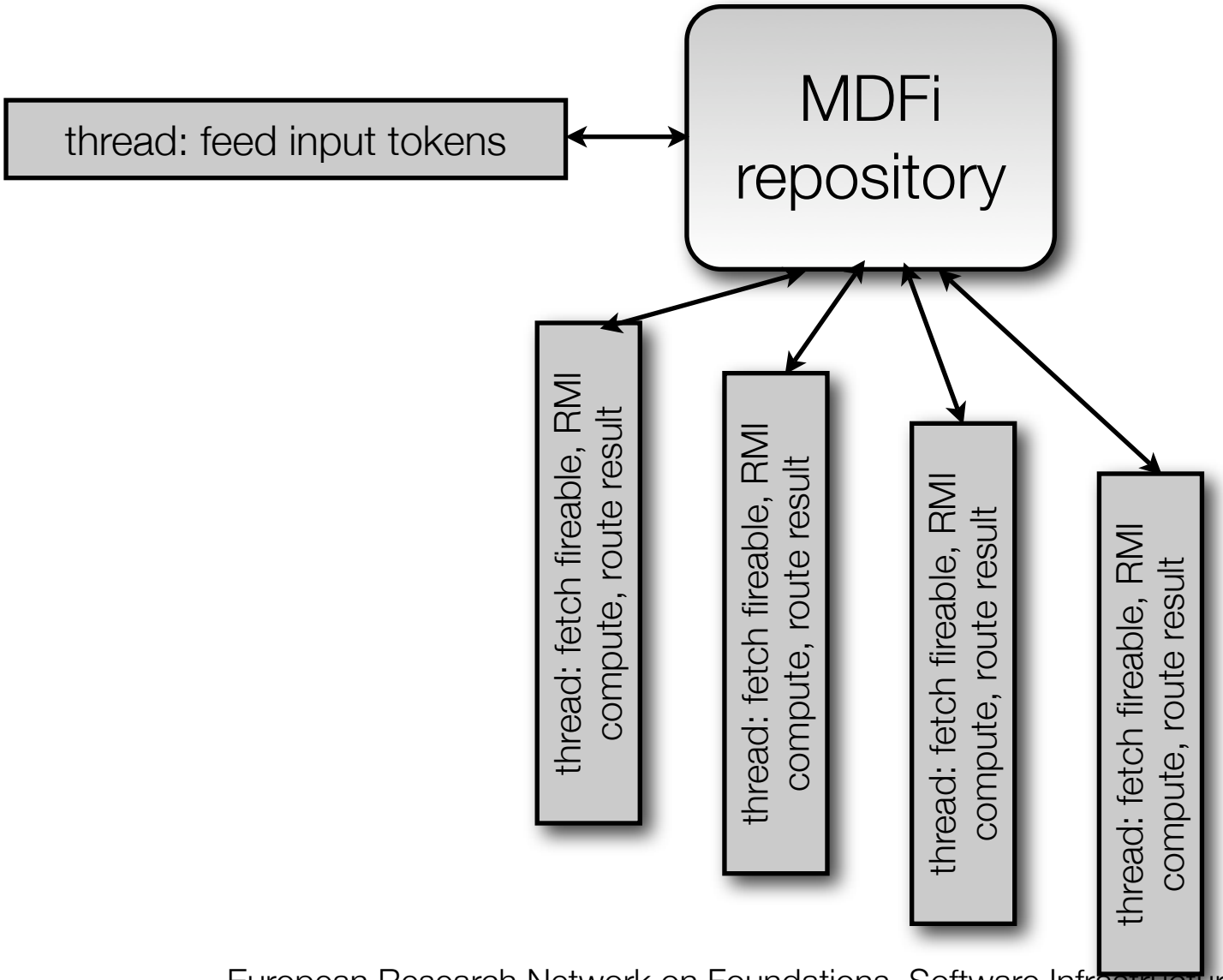
- Centralized instruction pool
  - thread instantiating graphs with input tokens (tasks)
  - n threads feeding remote PEs (1 per PE)
    - fetch fireable, dispatch, get results, route results, loop
  - code to be executed in the MDFis is serialized first, once and for all
- Remote interpreter instance
  - provides a **Object compute(Object)** method + stats and discovery

Distributed MDF interpreter

Distributed MDF interpreter



Distributed MDF interpreter



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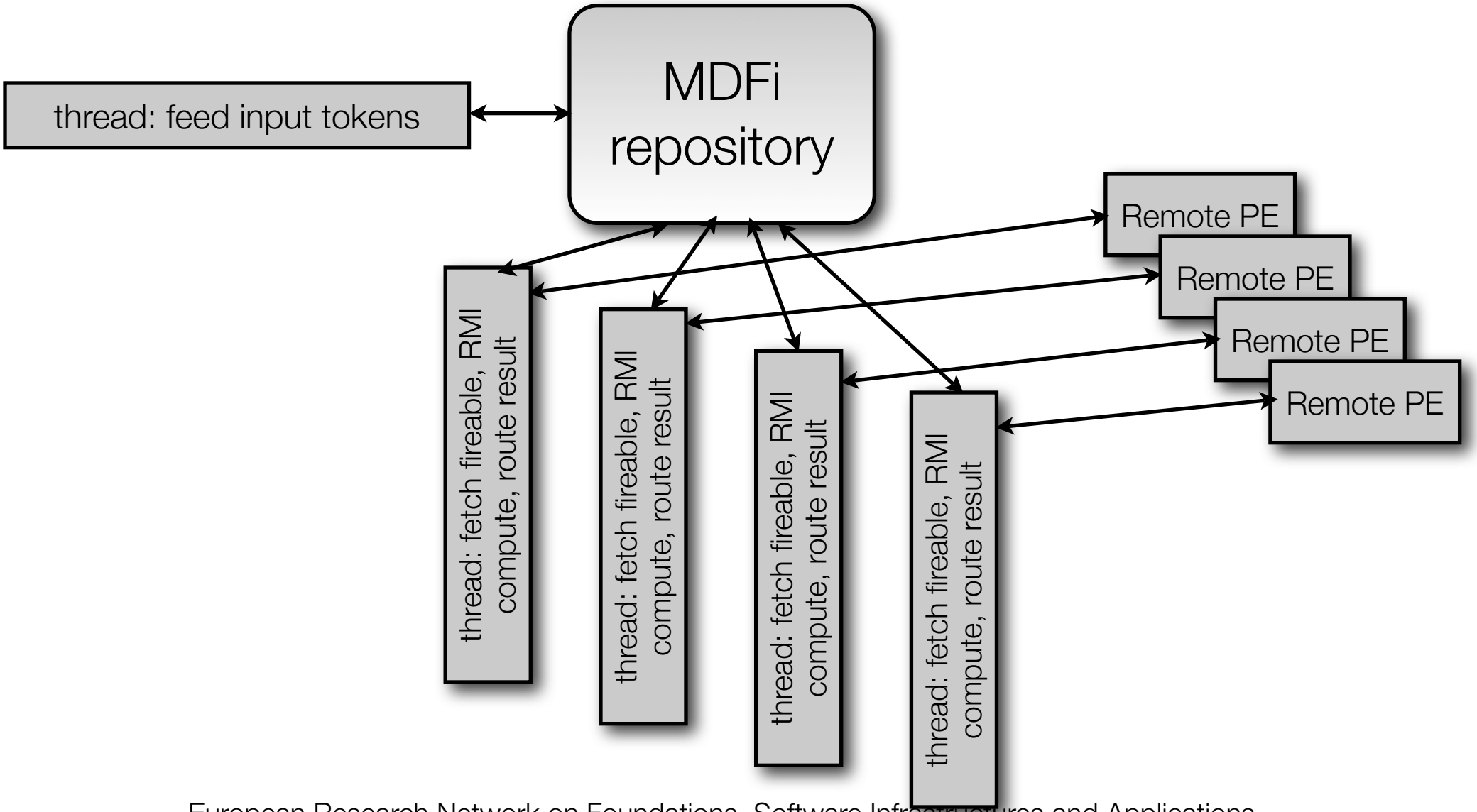
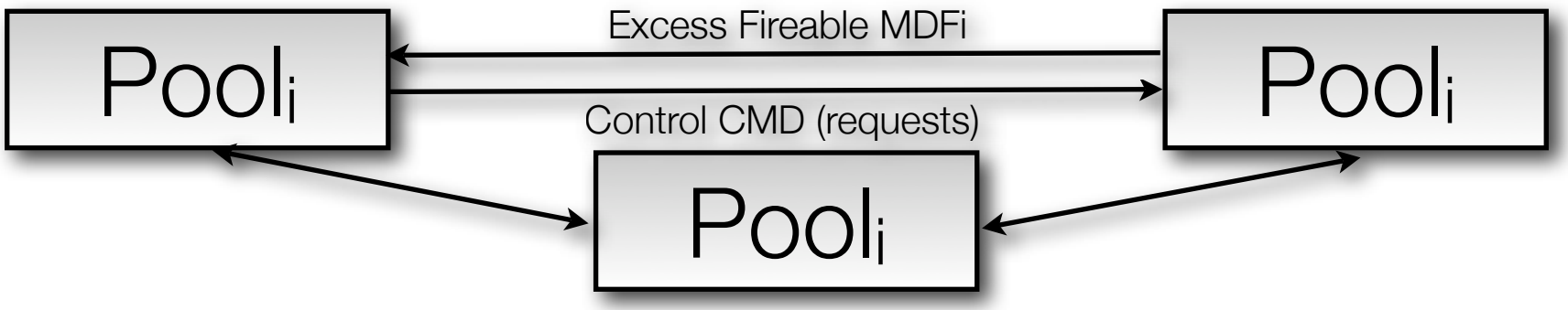


Distributed^2 MDF interpreter

- Decentralized MDFi repository
  - tree, ring
  - processes in the distributed MDFi repository nodes
    - distribute excess instructions to other instances if over a high water mark and ask for fireable instructions if under a low water mark
    - other strategies of work stealing can be implemented
- remote interpreters directly associated to MDFi repositories
  - hopefully most communication are local

Distributed^2 MDF interpreter



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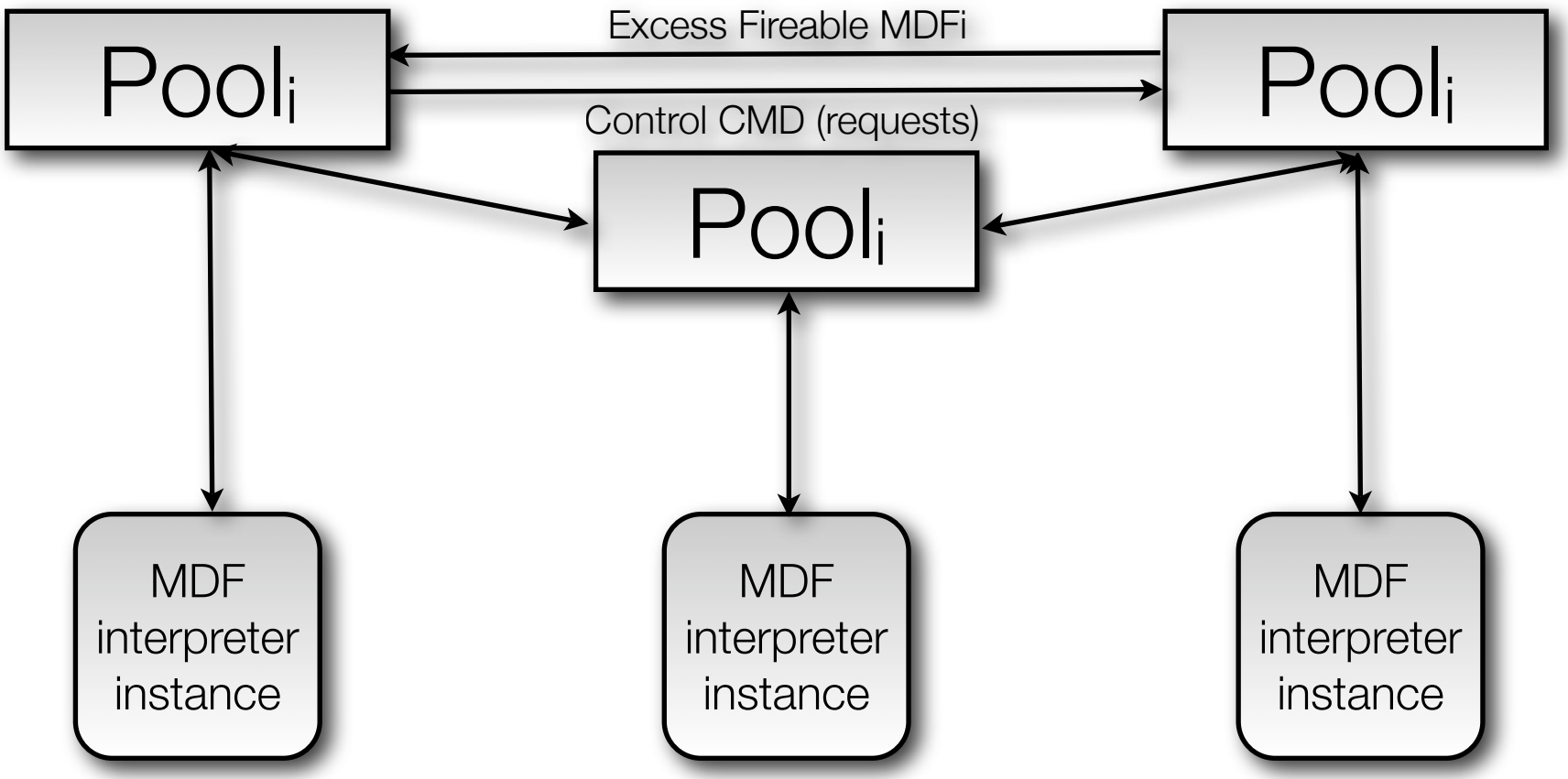

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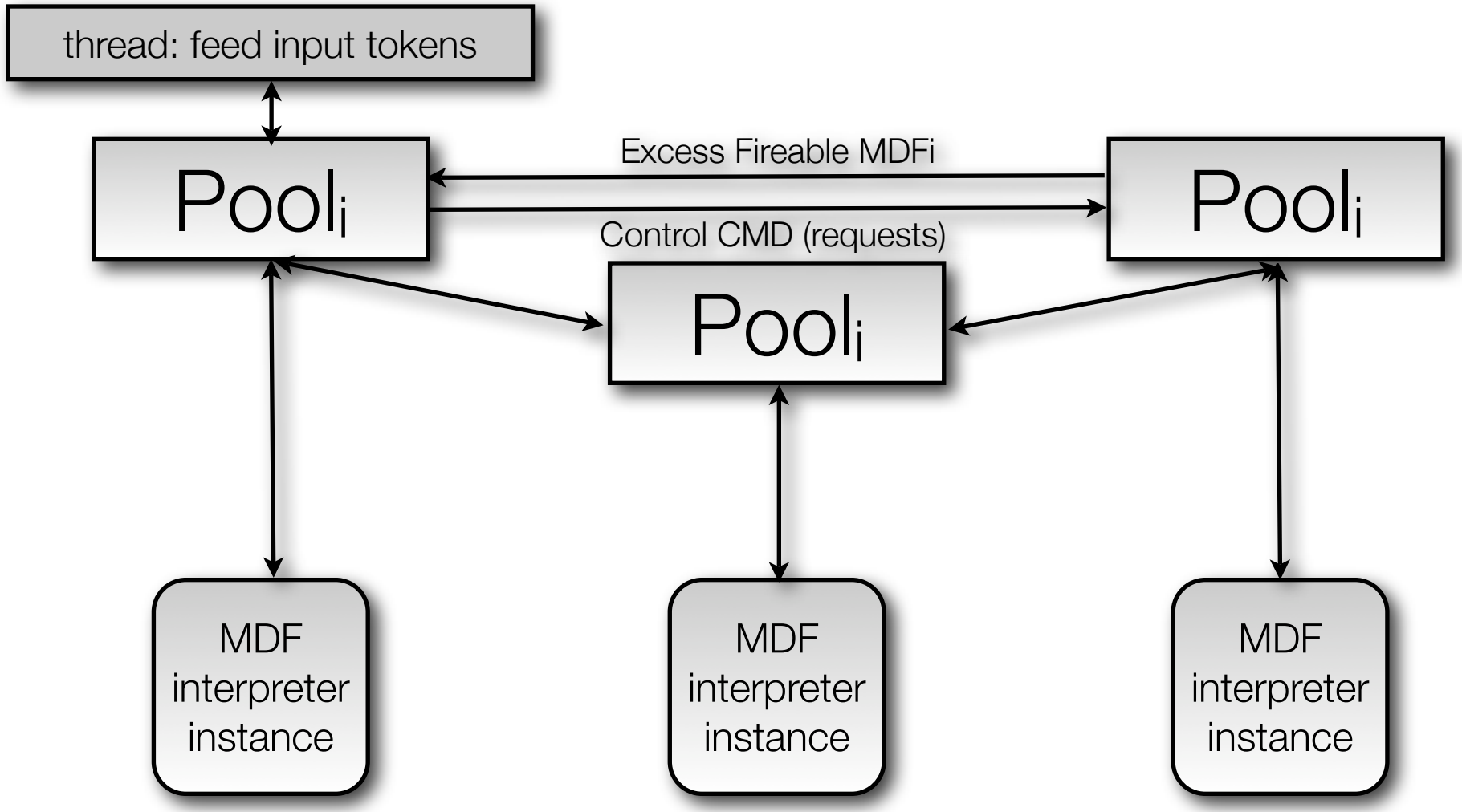
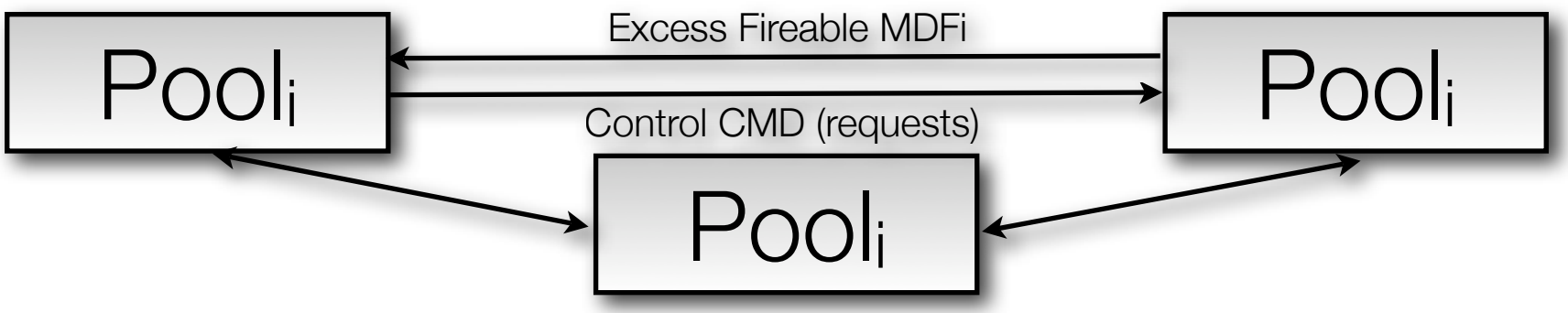
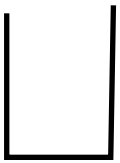


Distributed^2 MDF interpreter (2)





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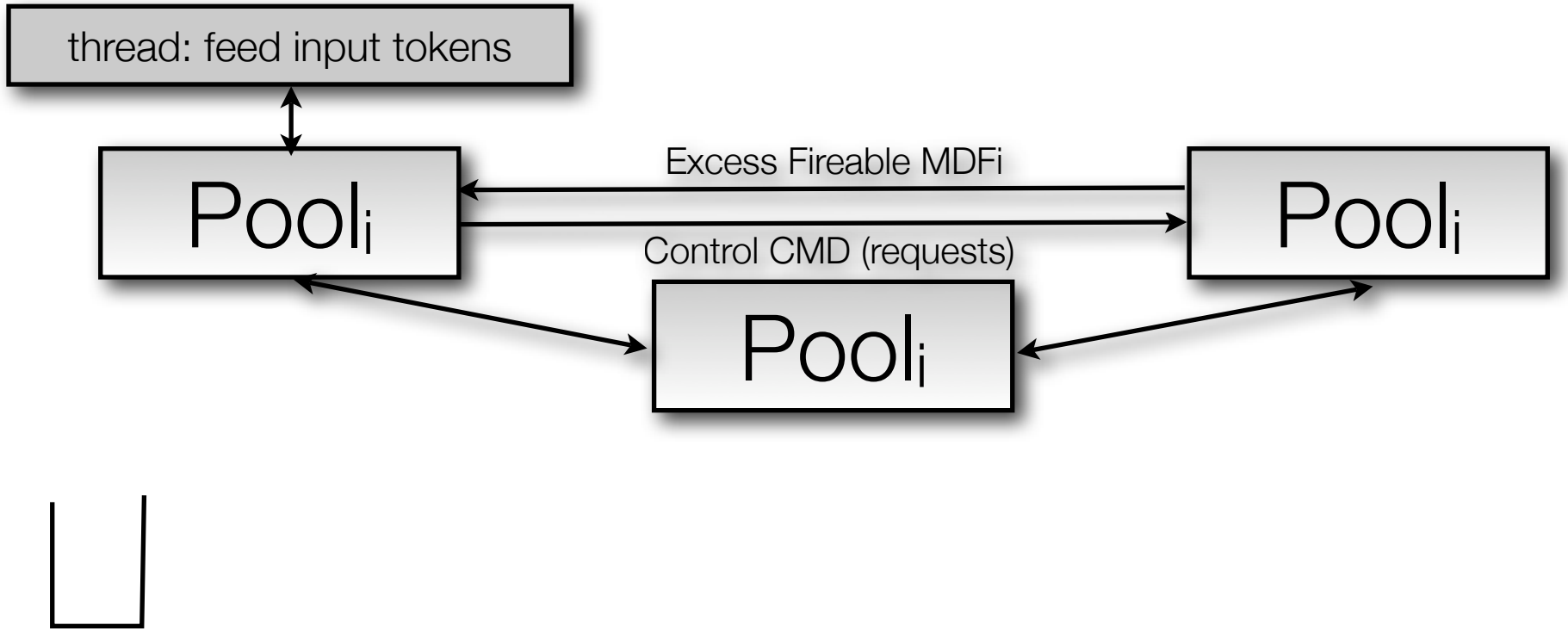

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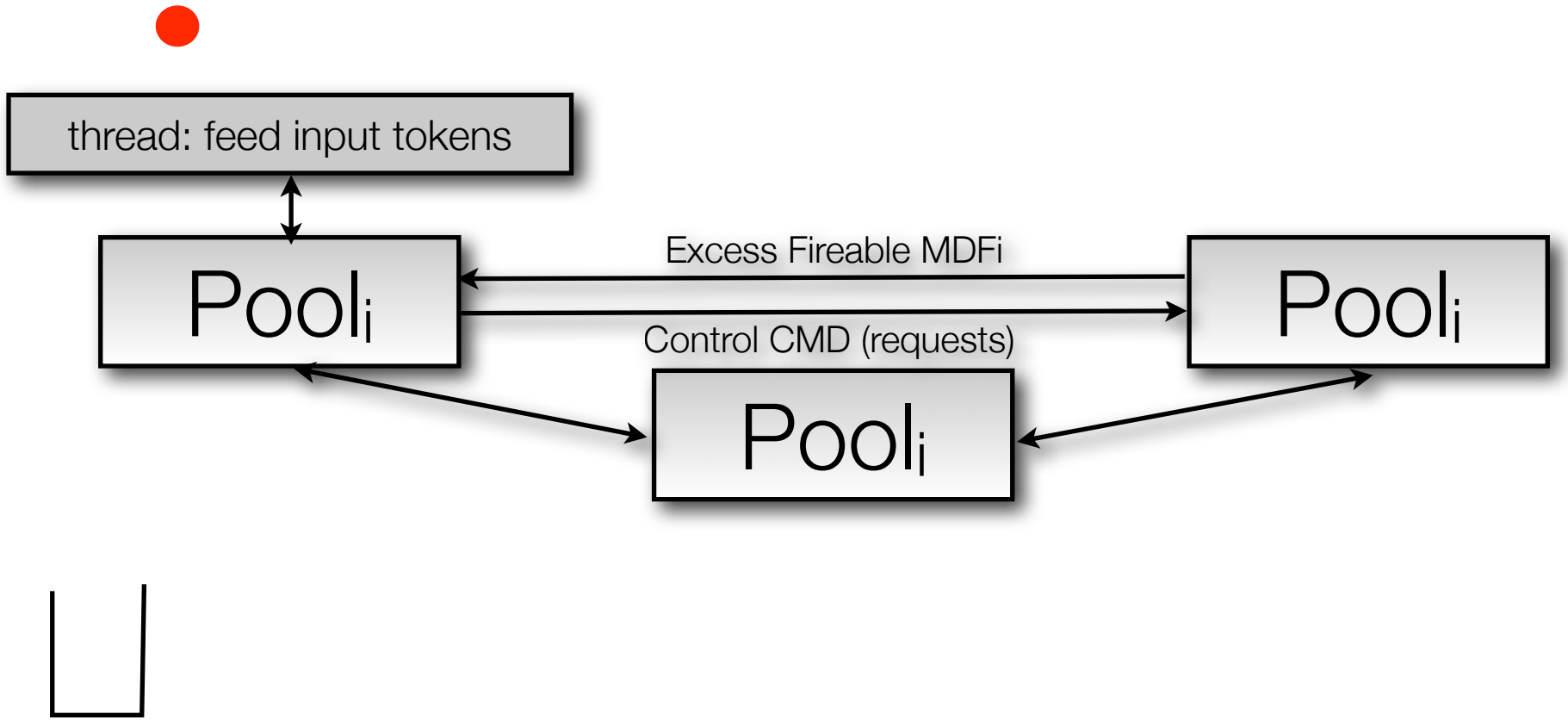

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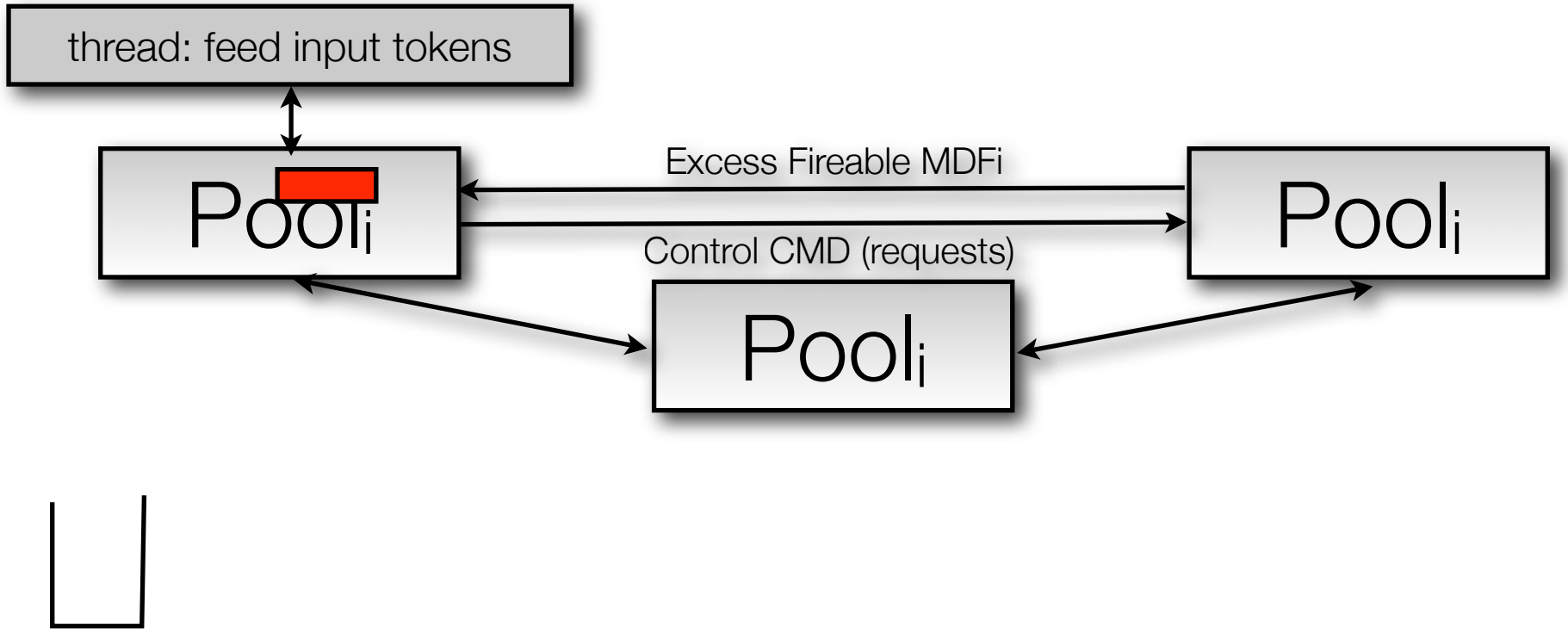

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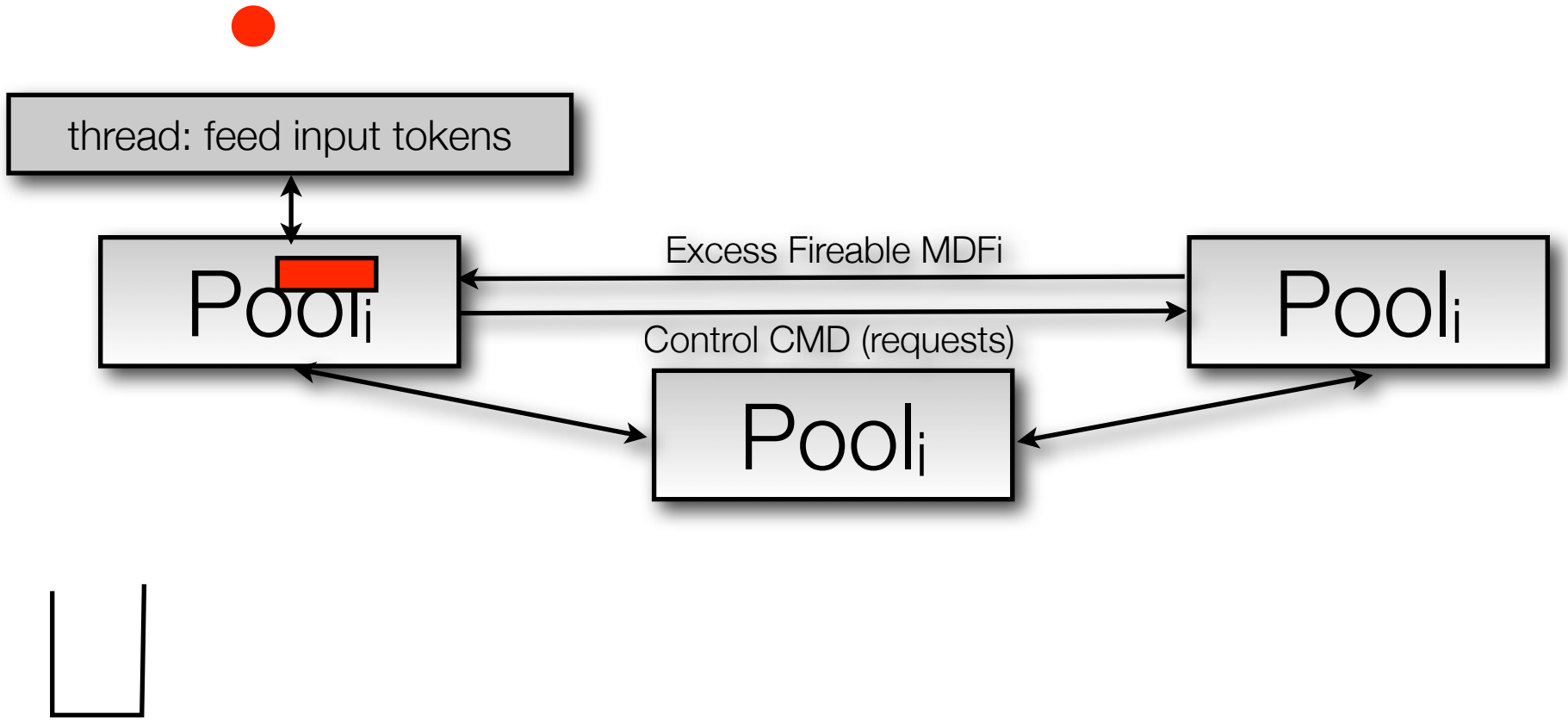

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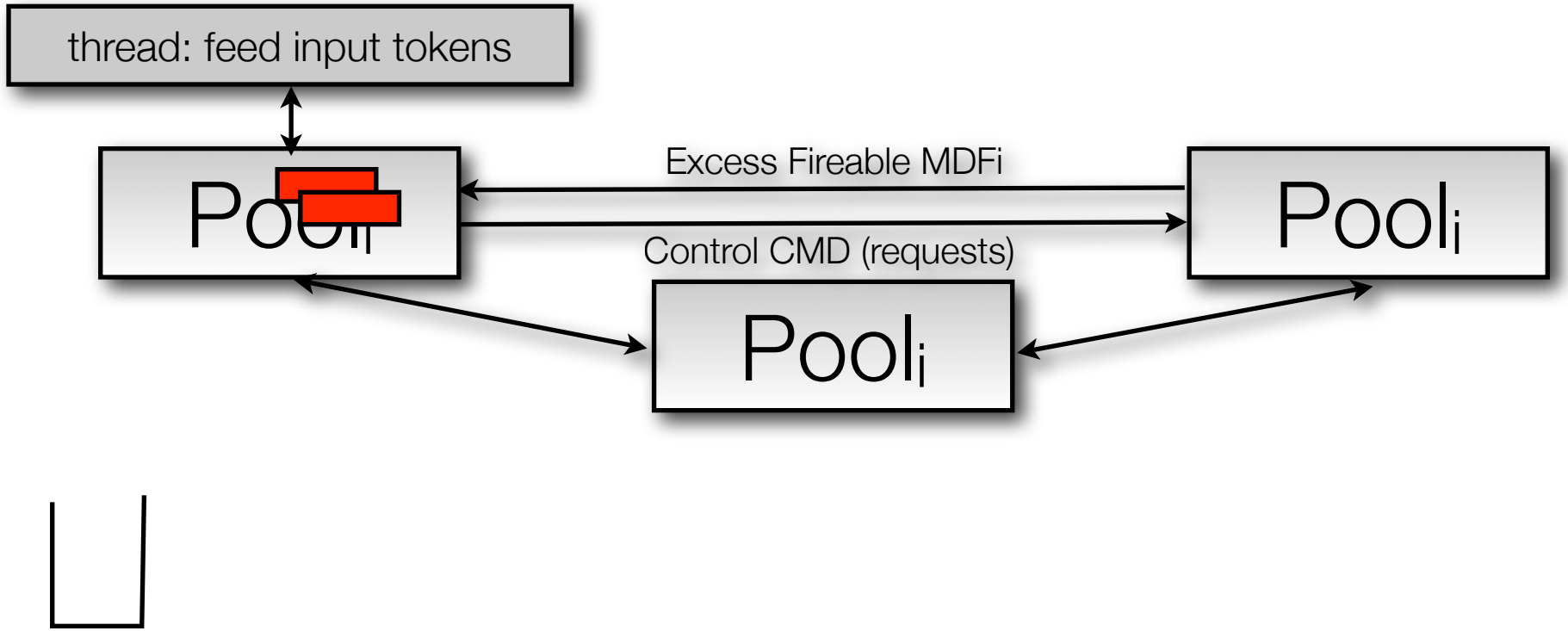

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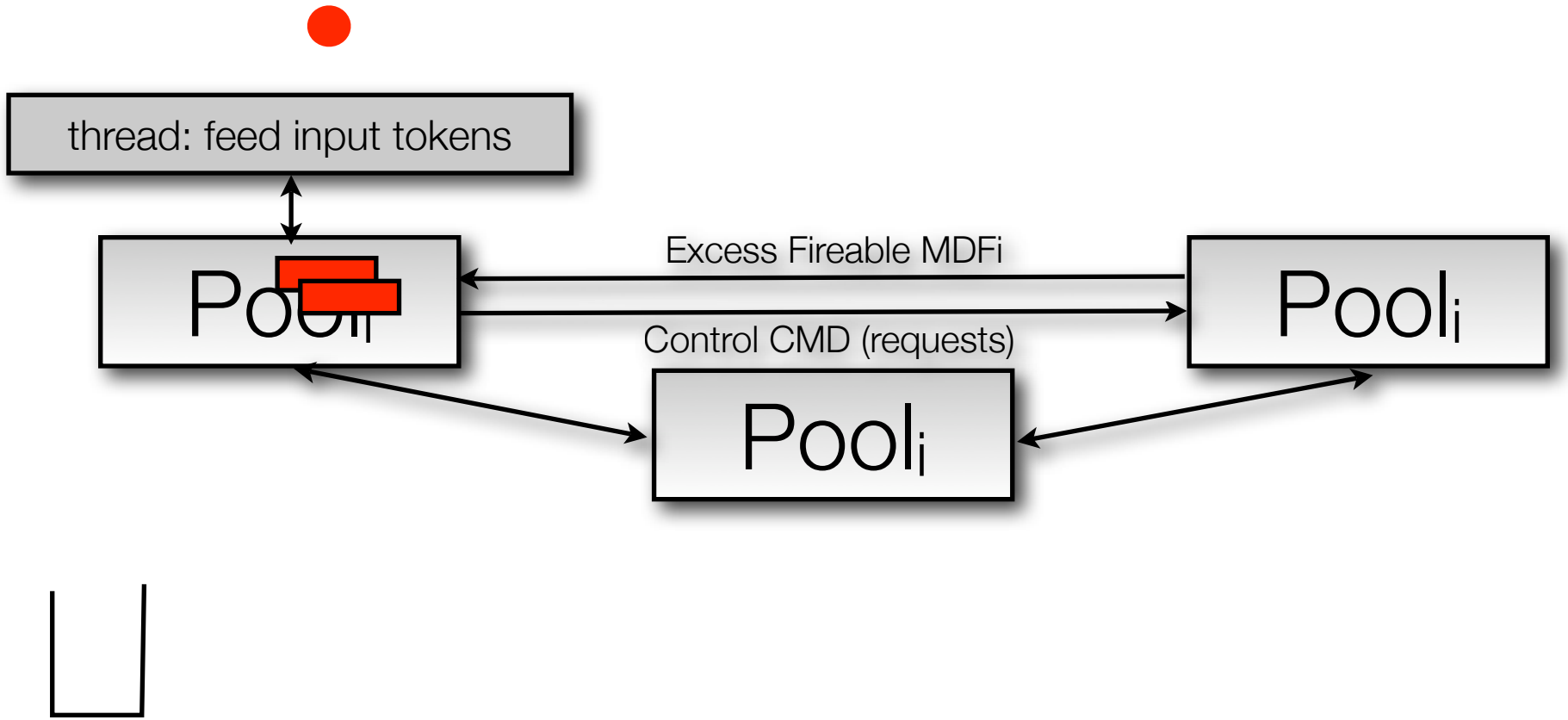

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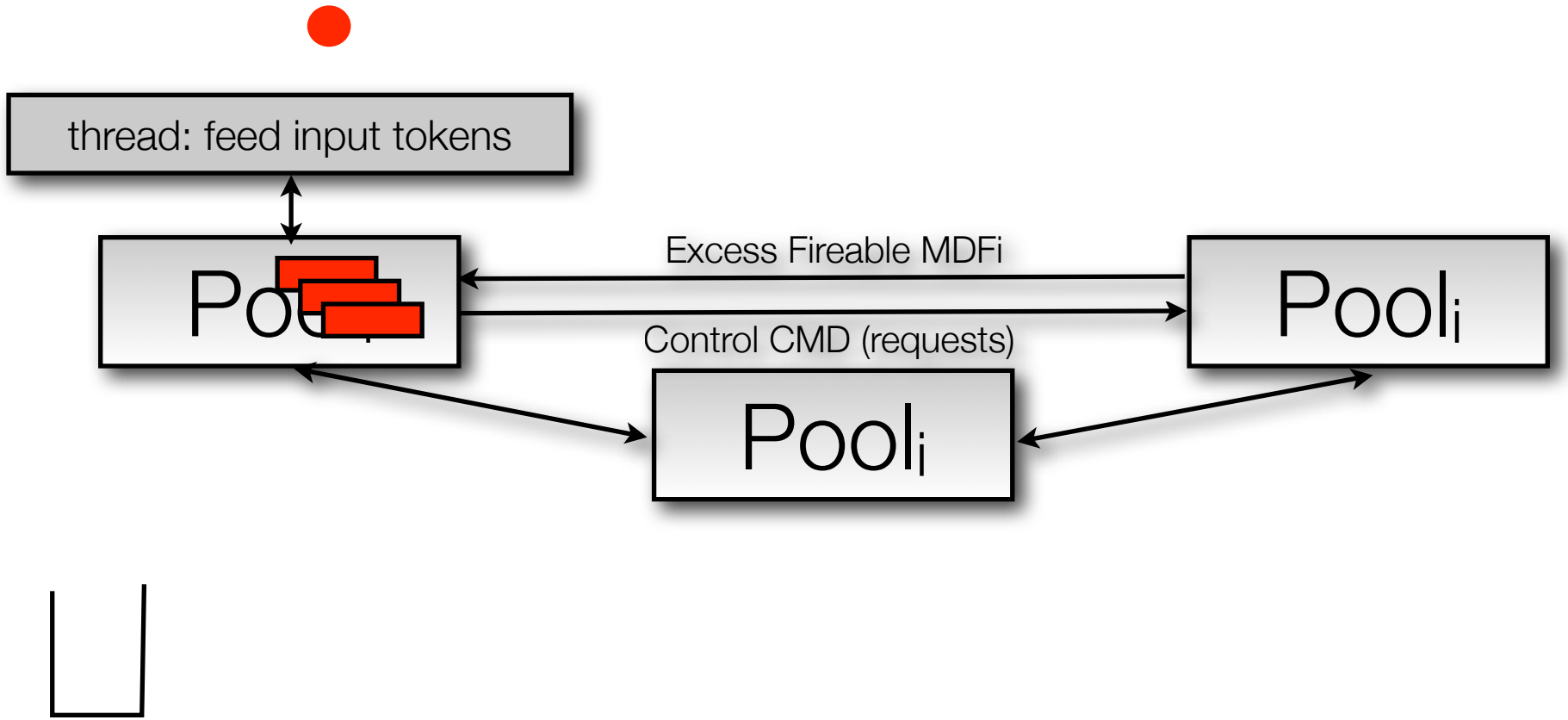

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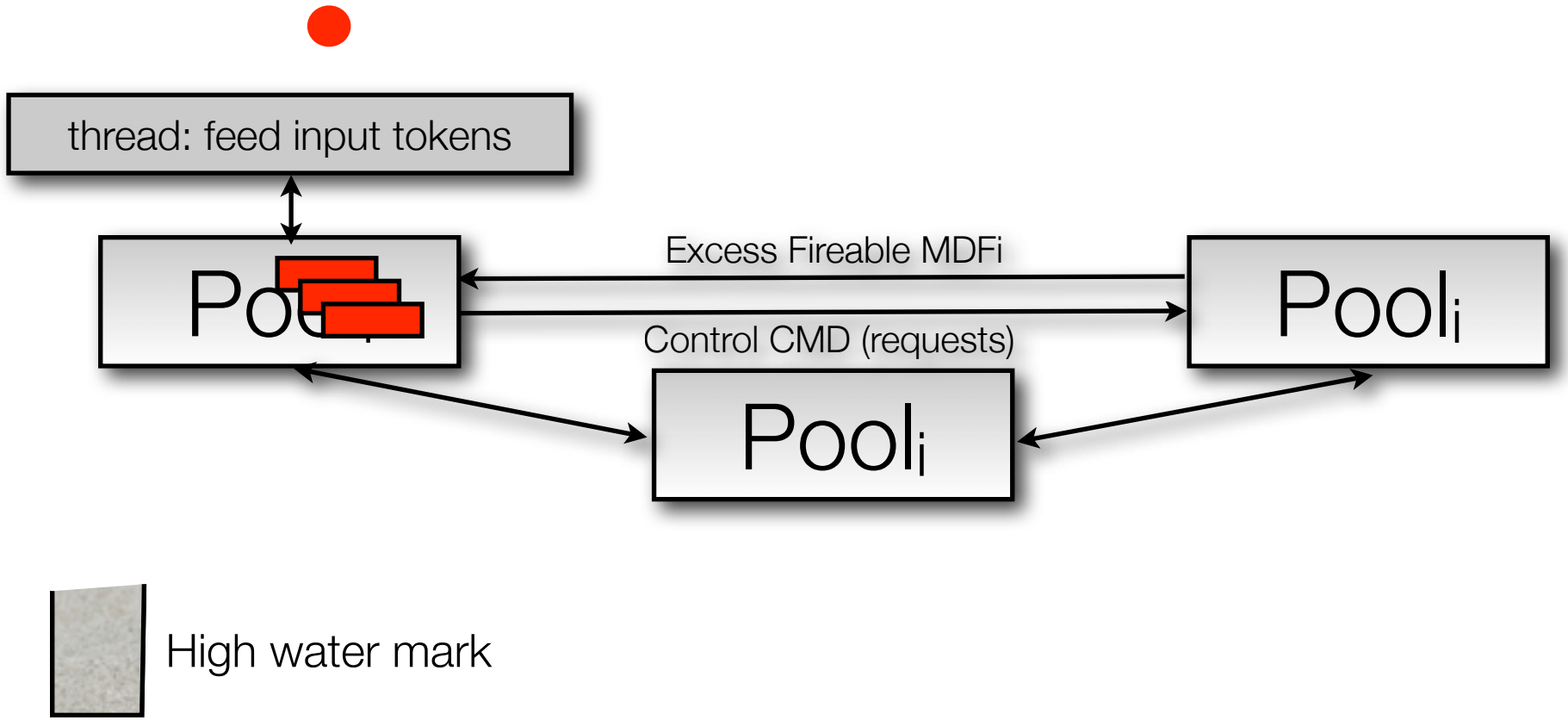

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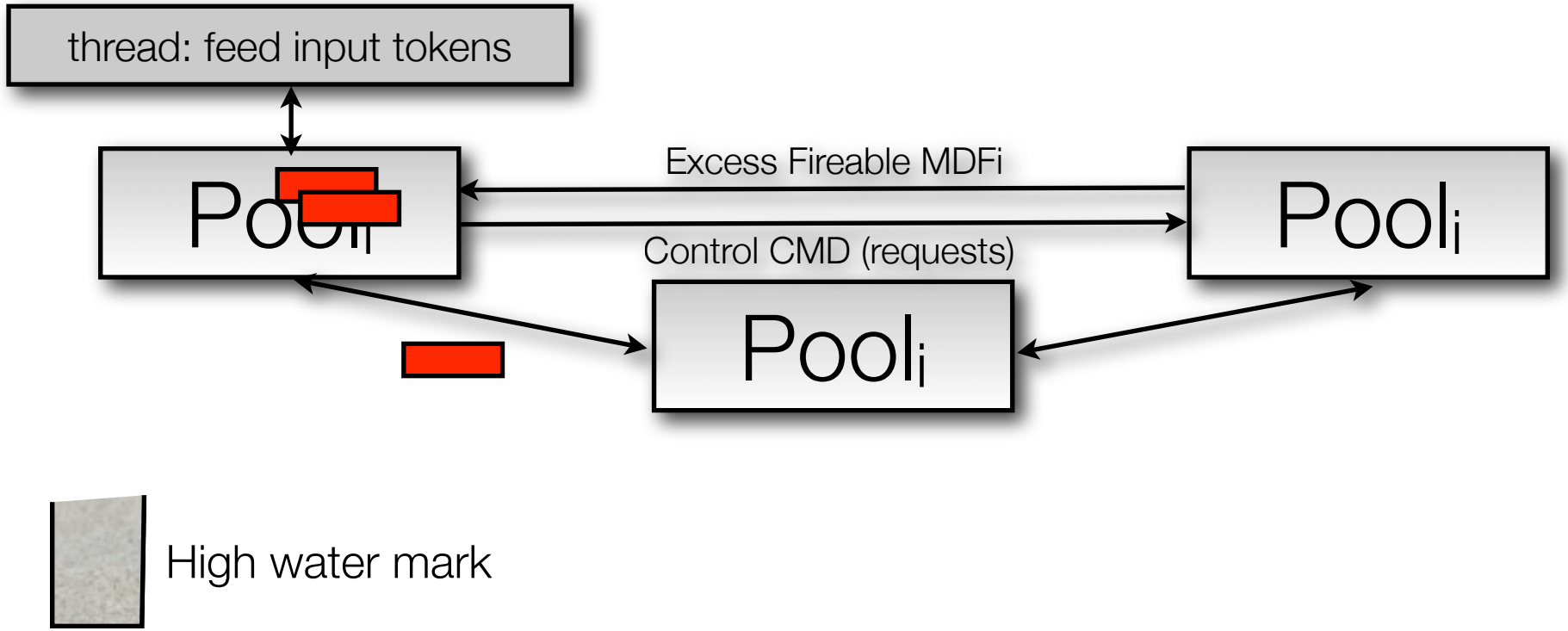

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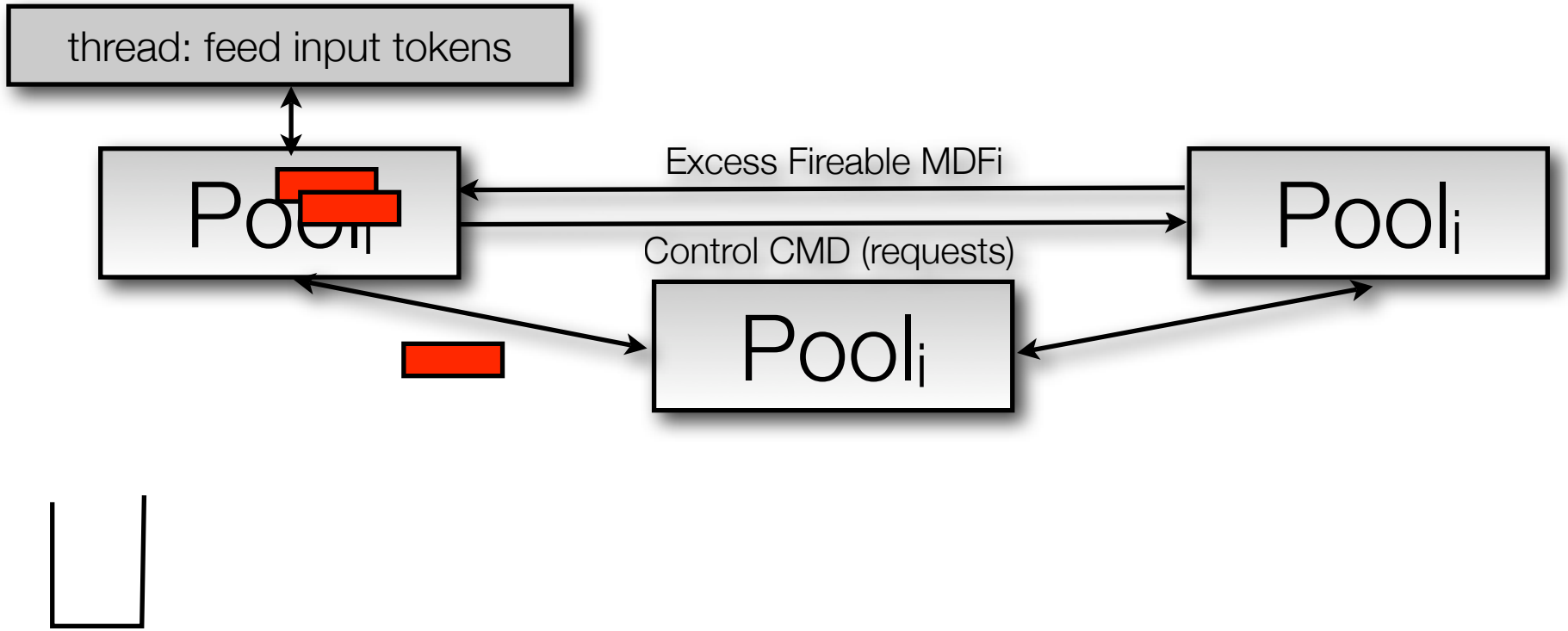

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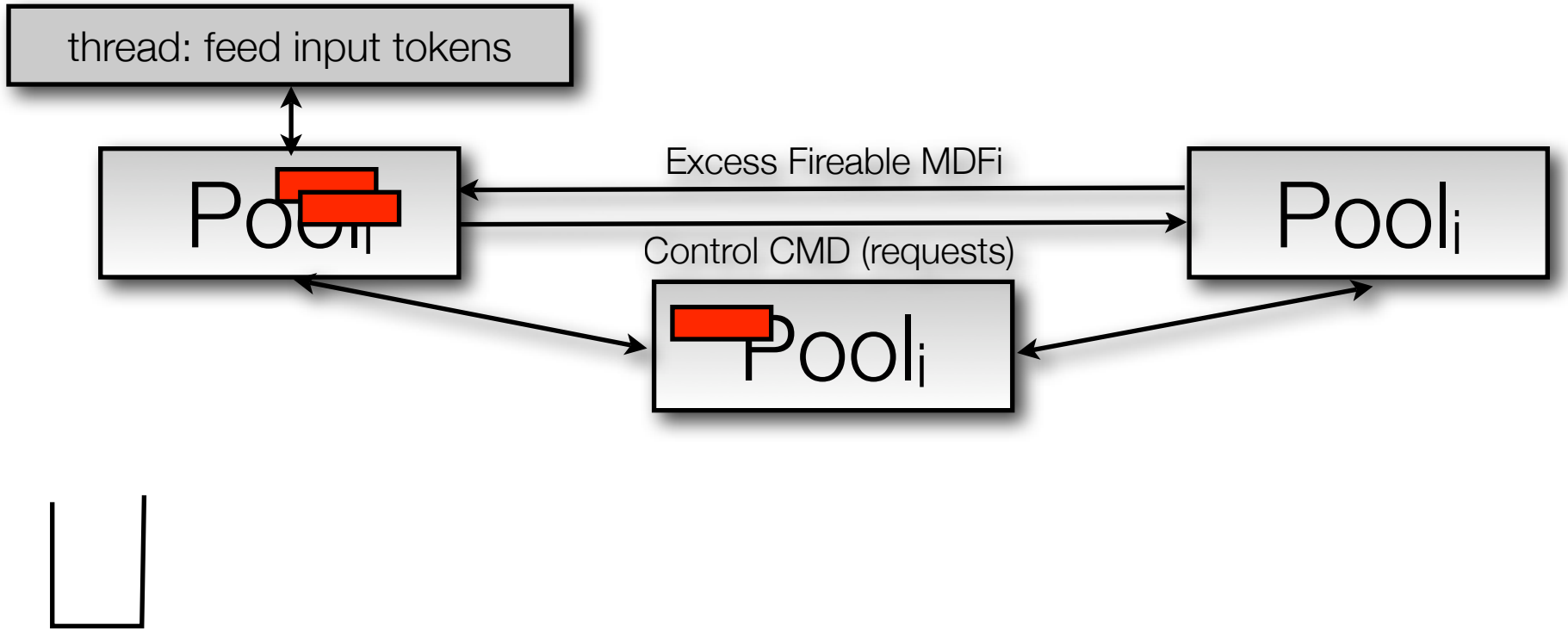
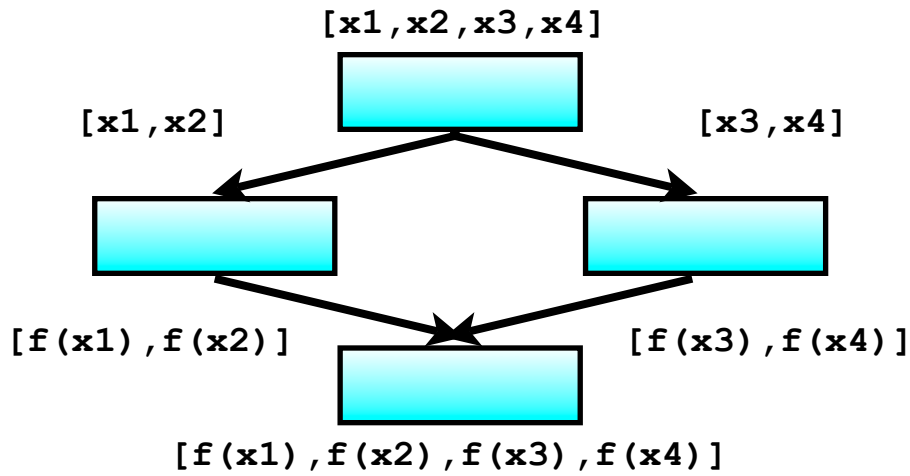


Current prototype **muskel**

- Java library
  - RMI based remote interpreters
  - UDP multicast for discovery
  - MDFi storage serialized at the very beginning
- Classical stream parallel skeletons: farm & pipelines
- **Compute** wrapper for sequential code & **ParCompute** special wrapper for arbitrary macro data flow code
  - possibility to implement any kind of skeleton

muskel

muskel



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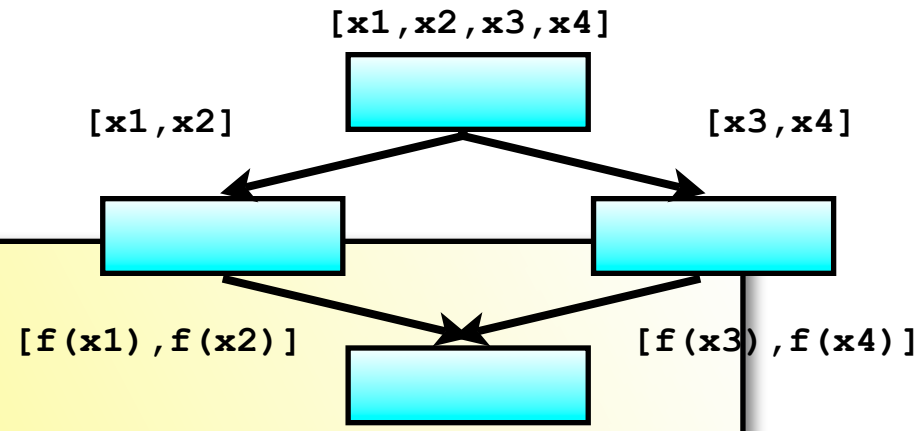
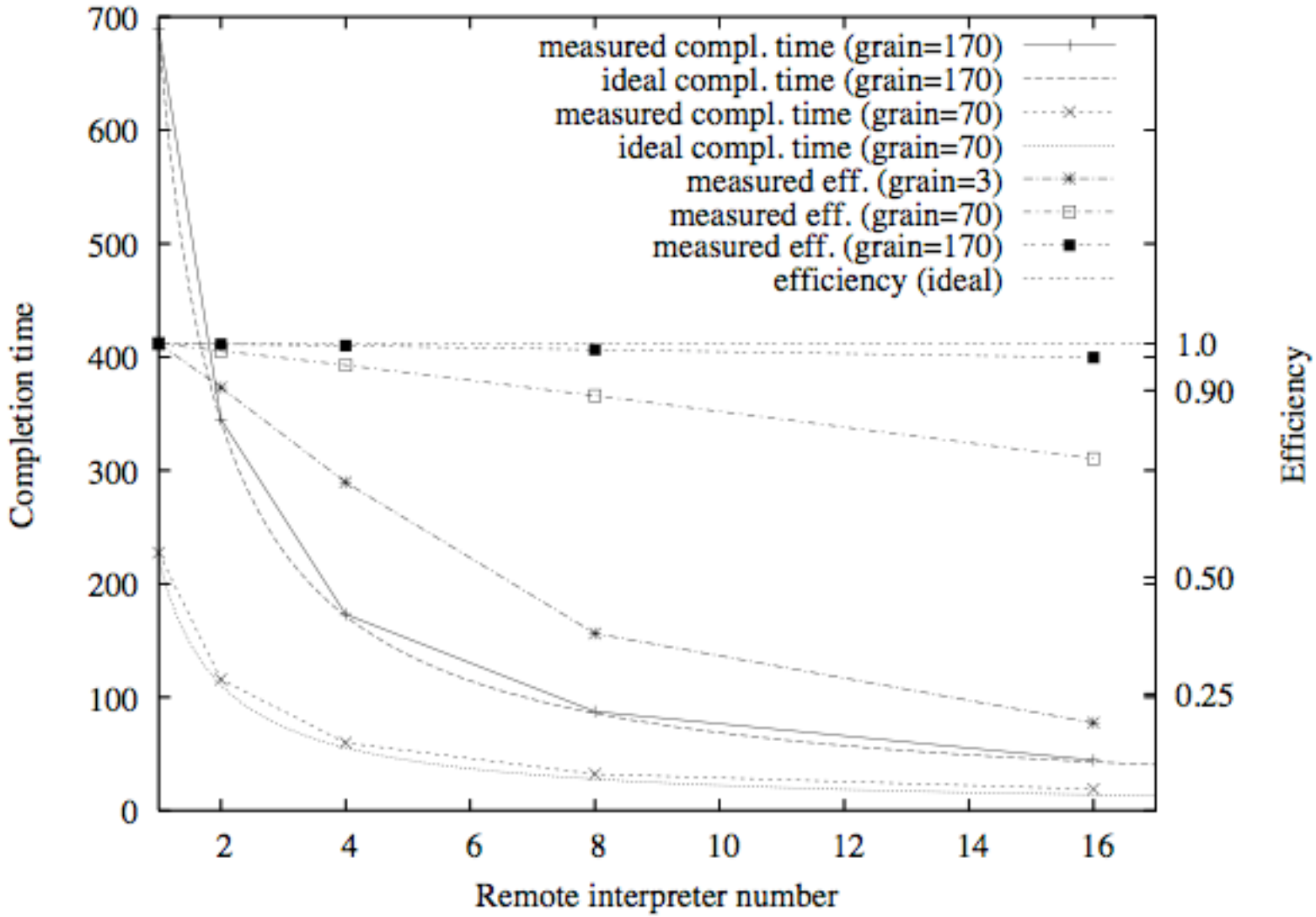


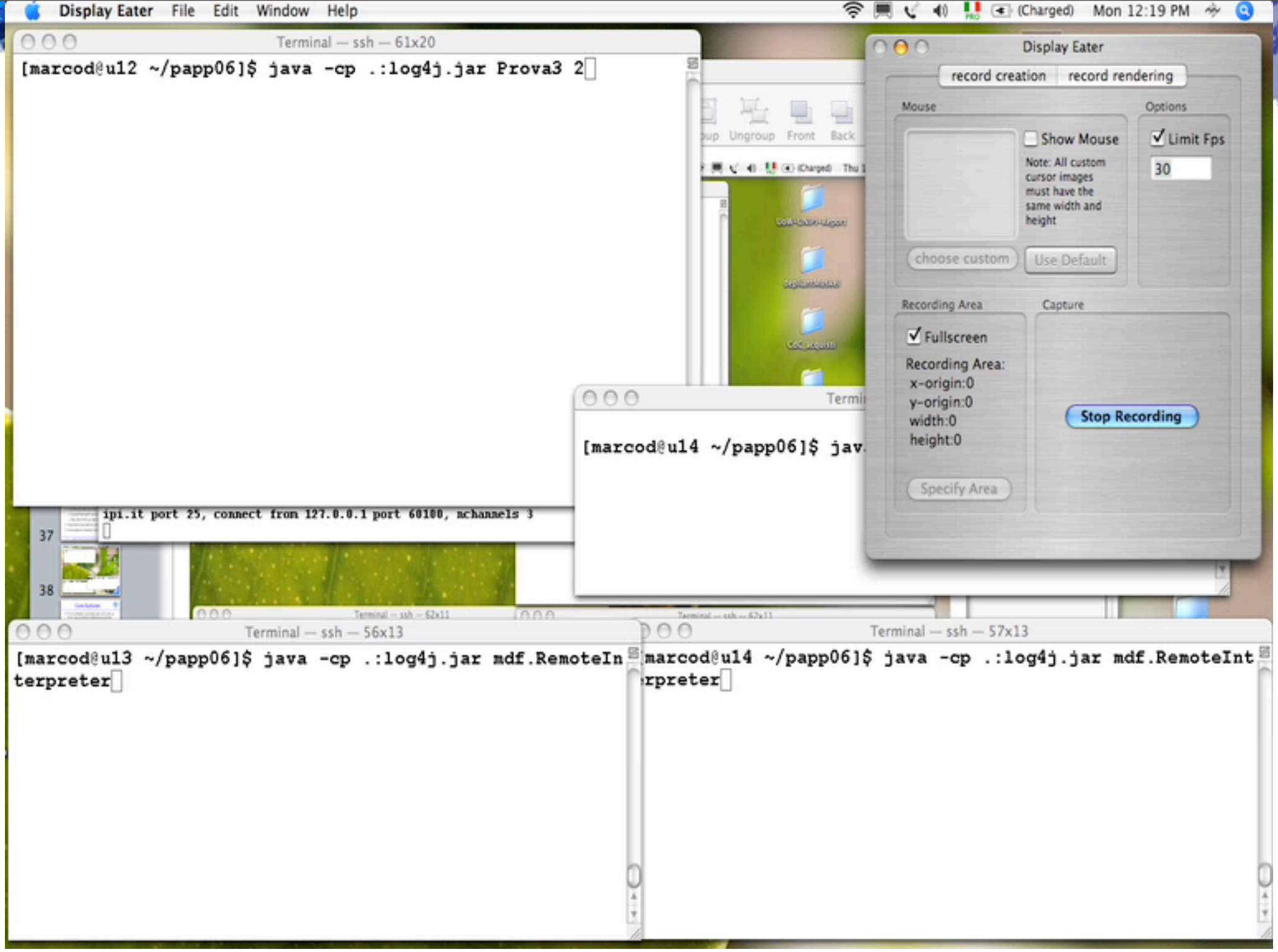

```
public class Map2 extends ParCompute {
    public Map2(Compute f, Manager manager) {
                program = new MdfGraph();
        Dest [] dds1 = new Dest[2];
        dds1[0]=new Dest(0,2);
        dds1[1]=new Dest(0,3);
        Mdfi emitter = new Mdfi(manager,1,new MapEmitter(2),1,2,dds1);
        program.addInstruction(emitter);
        Dest [] dds2 = new Dest[1];
        dds2[0] = new Dest(0,4);
        Mdfi if1 = new Mdfi(manager,2, f, 1, 1, dds2);
        program.addInstruction(if1);
        Dest []dds3 = new Dest[1];
        dds3[0] = new Dest(1,4);
        Mdfi if2 = new Mdfi(manager,3, f, 1, 1, dds3);
        program.addInstruction(if2);
        Dest[] ddslast = new Dest[1];
        ddslast[0] = new Dest(0,Mdfi.NoInstrId);
        Mdfi coll = new Mdfi(manager,4,new MapCollector(),2,1,ddslast);
        program.addInstruction(collector);
        return;
    }
```

muskel

```
public static void main(String[] args) {
    Manager manager = new Manager();

    Compute seqStage = new IncDoubleVector();
    Compute worker   = new Fdouble();
    Compute mapStage = new Map2(worker,manager);
    Pipeline main = new Pipeline(mapStage,seqStage);

    InputManager inManager = new DoubleVectIM(5,4); // 5 tasks (#=4)
    OutputManager outManager = new DoubleVectOM();
    ParDegree contract = new ParDegree(Integer.parseInt(args[0]);
    manager.setInputManager(inManager);
    manager.setOutputManager(outManager);
    manager.setContract(contract);
    manager.setProgram(main);

    manager.compute();
}
```

muskel


measured compl. time (grain=170)
ideal compl. time (grain=170)
measured compl. time (grain=70)
ideal compl. time (grain=70)
measured eff. (grain=3)
measured eff. (grain=70)
measured eff. (grain=170)
efficiency (ideal)
Completion time
Efficiency
Remote interpreter number
700
600
500
400
300
200
100
0
1.0
0.90
0.50
0.25
2
4
6
8
10
12
14
16



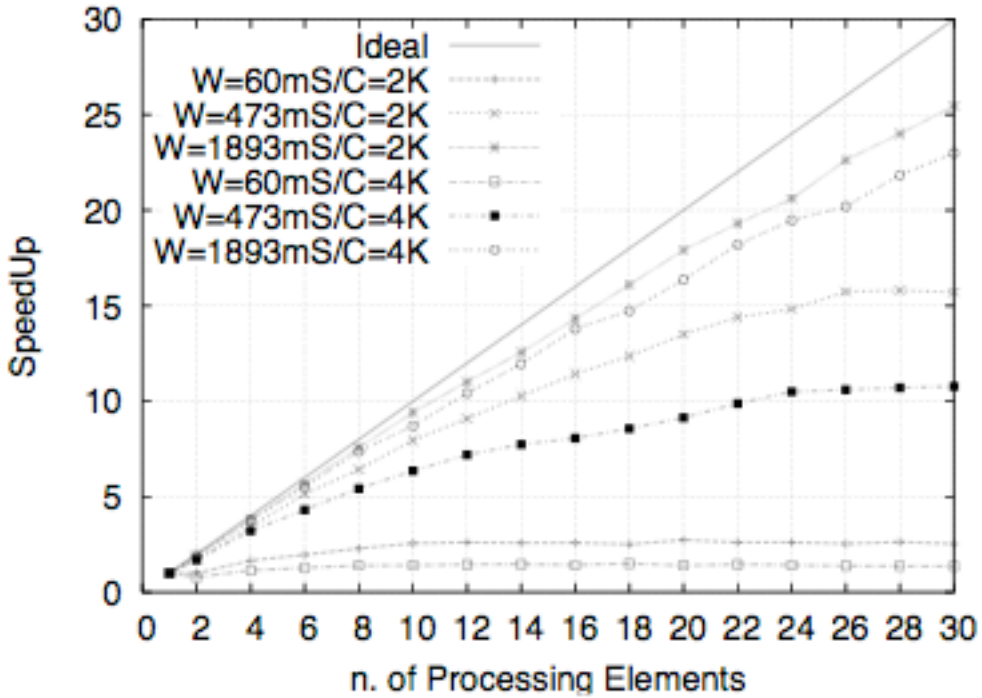
for large scale distributed, GRID and Peer-to-Peer Technologies

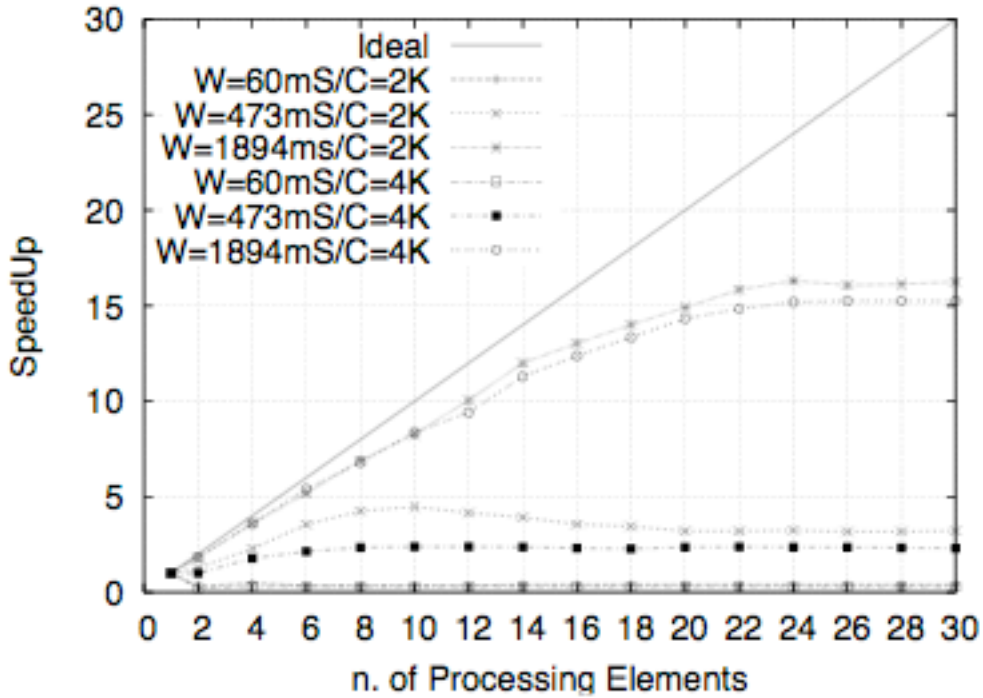
muskel on grids

- Current port of **muskel** on top of ProActive
  - without firewalls: remote interpreters migrateTo remote nodes discovered through multicast or XML config files
  - with firewalls: remote interpreters launched via descriptors exploiting ssh tunneling
- Interpreter unchanged
  - advantages retained
  - small additional overhead, mainly for launching and ssh tunneling

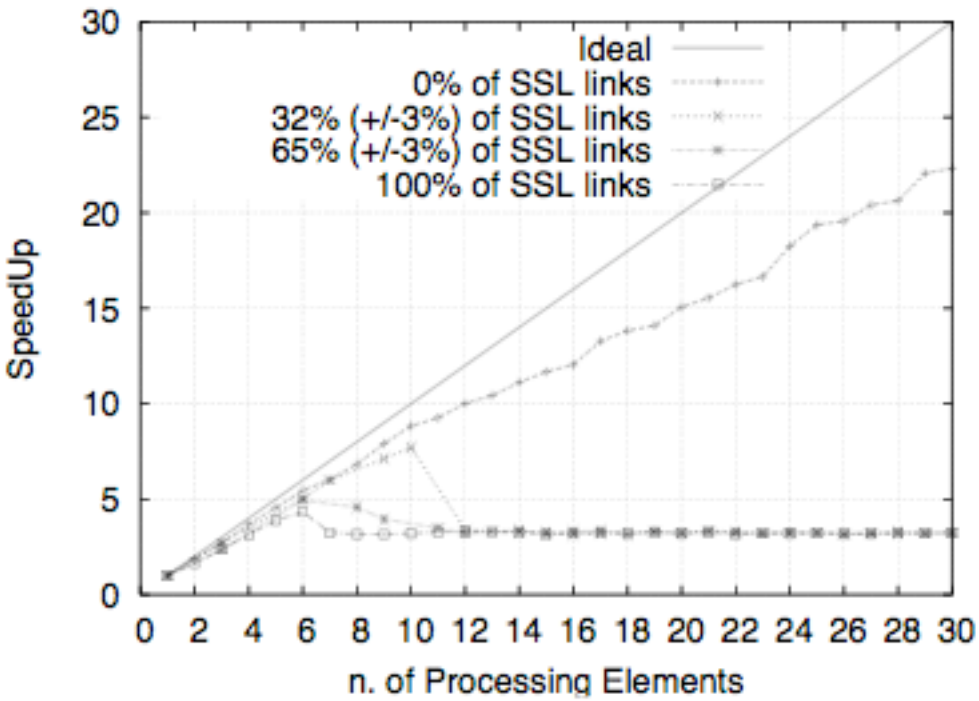
muskel on grids (security)

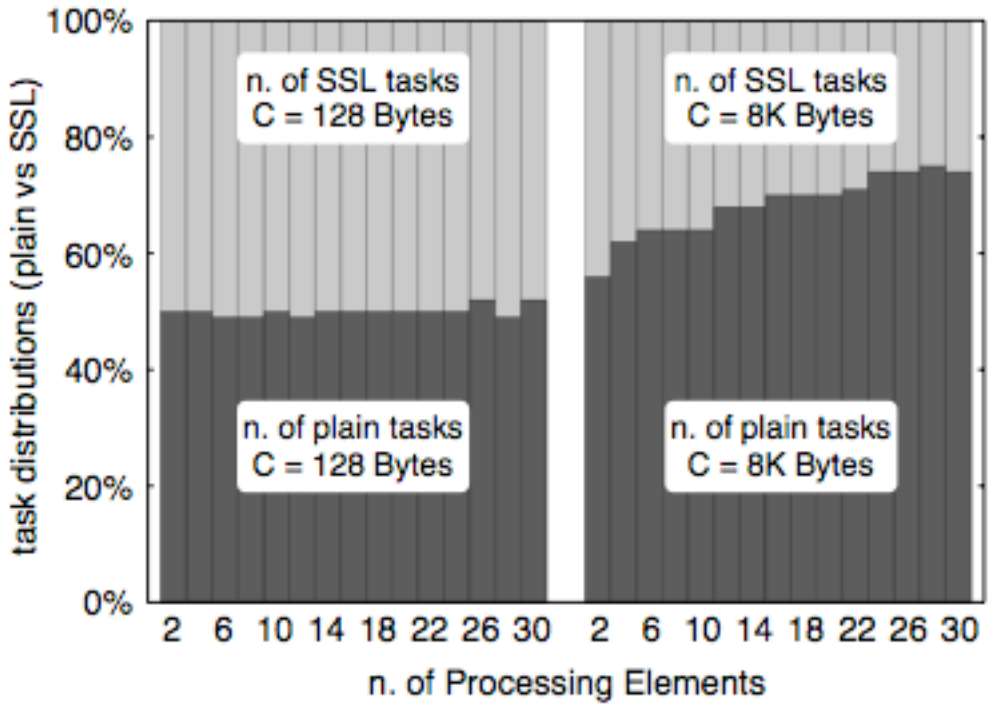
- Aldinucci, Marco; Danelutto, Marco. The cost of security in skeletal systems , February 07, 2006 TR-06-03 Technical Report Dept. Computer Science Univ. Pisa (Submitted)





muskel on grids (security 2)





Task 3.3 connection

- Worth to investigate new models on top of the component model
  - remote interpreter component + custom front end parser/compiler components
- Worth to compare with other skeleton approaches
  - HOC ?
- Suitable to host several different high level programming models on top of
- Open problems : affinity scheduling, token caching, D^2 implementation

Conclusions

- Fairly simple execution model
- Works with serializable code
- Suitable to implement several higher level models
- Call for cooperation !

Credits

- MDF model
  - UNIPI (M. Danelutto, M. Aldinucci)
- expandability
  - UNIPI (M. Danelutto) + ISTI/CNR (P. Dazzi)
- Security
  - UNIPI (M. Aldinucci)