Towards an Automatically Distributed Evaluation of Event Data

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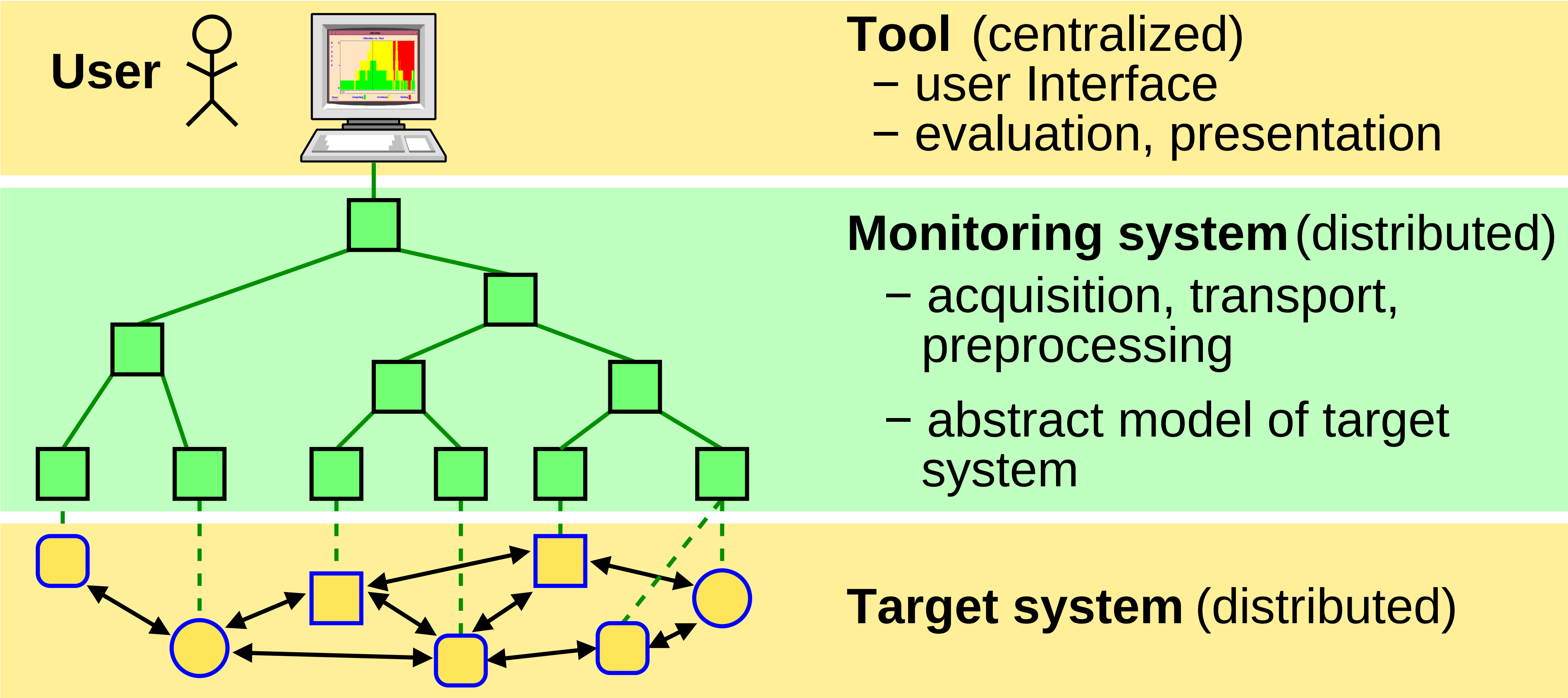
Background

- Online monitoring of parallel and distributed software
- Generic (distributed) monitoring system, supporting different tools
  - goals: ease of use, scalability



Lessons Learned

- Provide a well defined interface for the tools
- Provide an object-oriented model of the target system
- Provide for extensibility of the interface
- Use the event / action paradigm
  - i.e. allow the tool to specify arbitrary actions to be executed when an event is detected in the target system
- Support requests on sets of objects

- Make the implementation as asynchronous as possible
- Push execution of actions towards the event sources

First Approach: OMIS / OCM

- Specification and implementation of an online monitoring interface
- Basis: object based model of target and monitoring system
  - system, nodes, processes, threads; counter, timers
- Request language for event / action relations

```
thread_started_lib_call([p_1,p_2], "MPI_Send") :
    pa_counter_increment(pa_c_1, $par8)
```

```
thread_started_lib_call([p_1,p_2], "MPI_Send") :
    thread_stop([a_]) thread_get_backtrace([$thread])
```

- Location transparency: automatic distribution of requests
- Extensibility via plug-in interface for new events, actions and objects

First Approach: OMIS / OCM ...

- Problems:
  - “unlovely” programming in the tools
    - tool is programmed in C++/Java
    - monitoring system is “programmed” in OMIS language
  - OMIS language is not really object-oriented
    - c.f. `thread_started_lib_call([p_1,p_2], ...)`
  - extensions are difficult to program
    - complex interface to OCM core
    - distribution must be handled explicitly

The Tool Developer's Wish

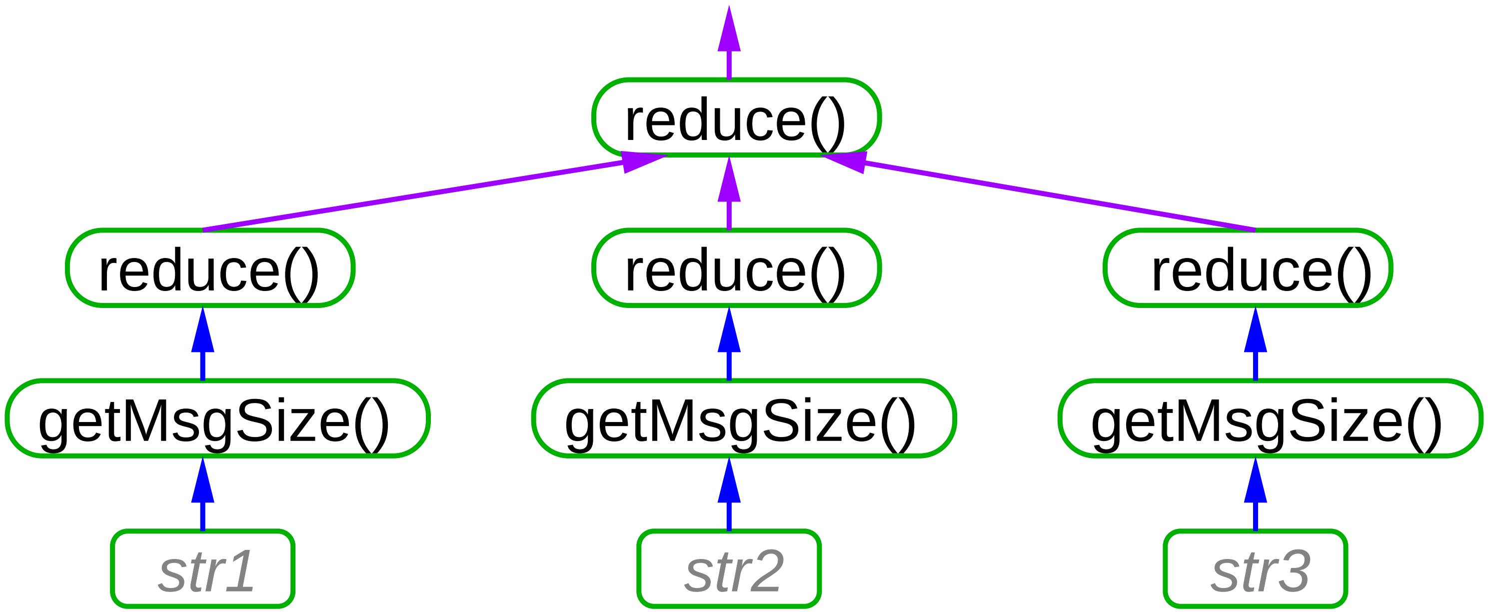
- Object oriented model of target system
  - local (proxy) objects for nodes, processes, ...
- Abstractions for sets and event streams
- Fully integrated into Java / C++:

```
Set<Node> nodes = System.getNodes(...);
Set<Processes> procs = nodes.getProcesses(...);
Set<Stream<SendEvent>> ev = procs.getSendEvents(...);
IntVal tot = Set.reduce(Stream.reduce(ev.getMsgSize(),
                                    SUM),SUM);
...
print(tot.getValue());
```

- Combined with distributed evaluation!

Towards an Implementation (1)

- **Q**: how to map this program to the distributed monitoring system?
- **A**: use data flow graphs as intermediate representation!
  - purely functional model, only explicit (stream) communication
  - easy to (autmatically) distribute them for execution
- Data flow graph for the example (3 processes)



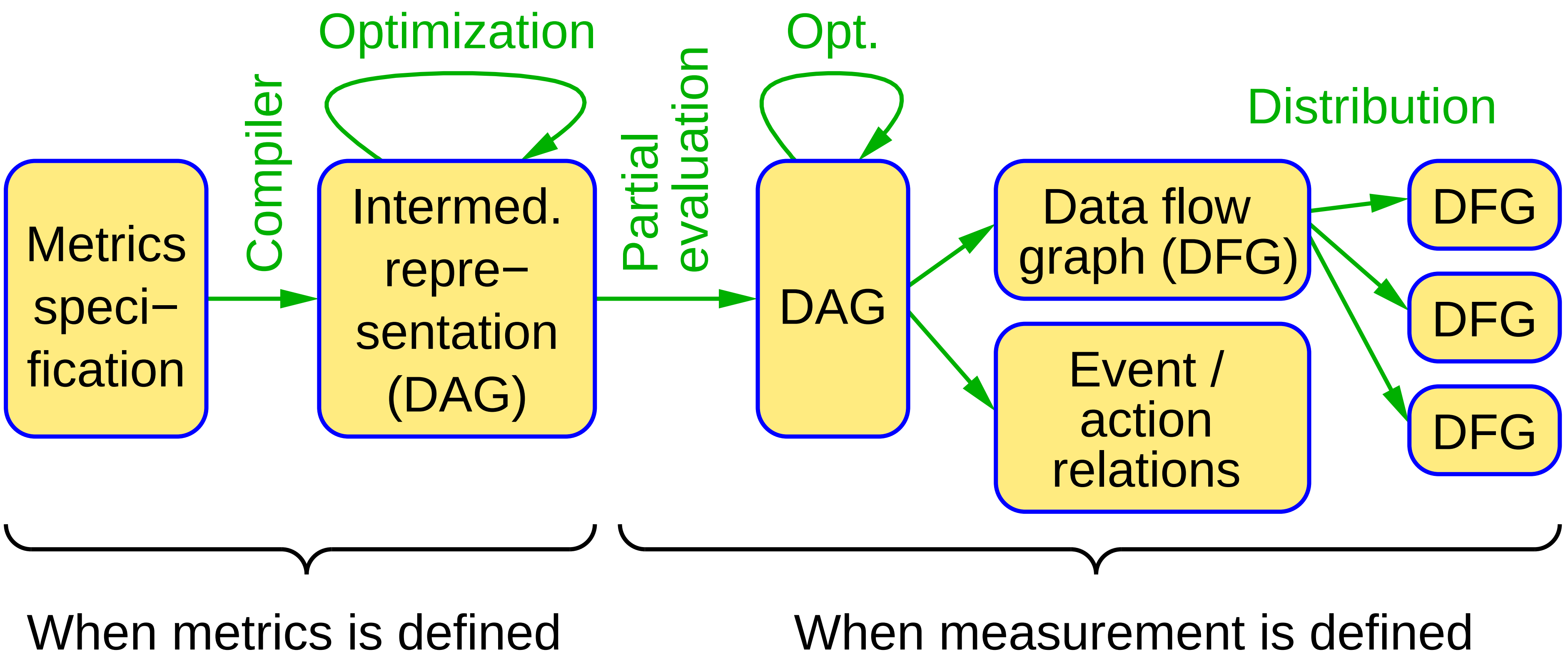
Previous Experience

- EU project CrossGrid: online performance analysis tool G-PM
- Performance metric specification language PMSL
  - allows users to specify new metrics at runtime
  - metrics are evaluated by distributed monitoring system
- Example of PMSL mectrics:

```
Comm_Volume(Process[] procs, TimeInterval ti) {
  PROBE send(Process, VirtualTime, int);
  Value[][] sz; Value[] tmp;
  int size; Process p; VirtualTime vt;
  sz[p][vt] = size AT send(p, vt, size);
  tmp[p] = SUM(sz[p][vt] WHERE sz[p][vt].time IN ti);
  return SUM(tmp[p] WHERE p IN procs);
}
```

Previous Experience ...

Implementation using distributed evaluation



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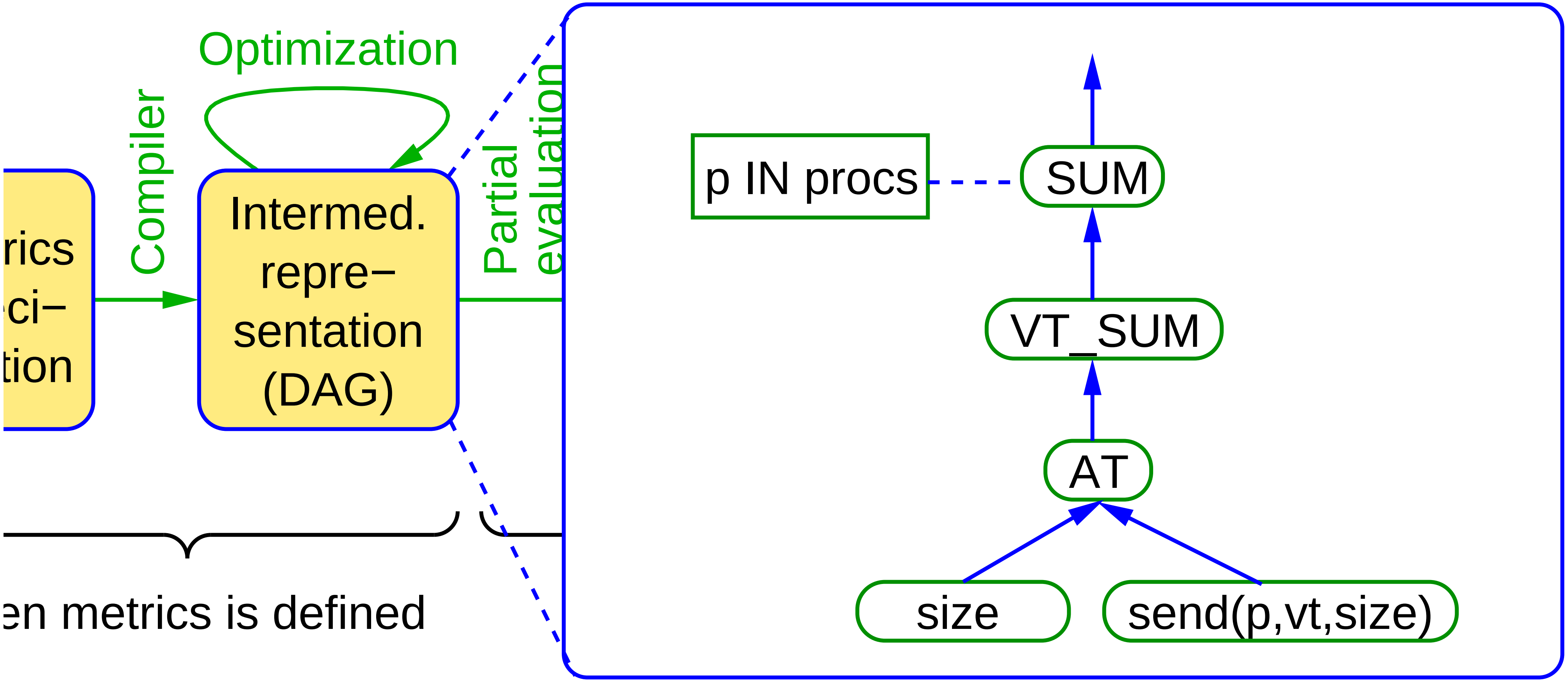

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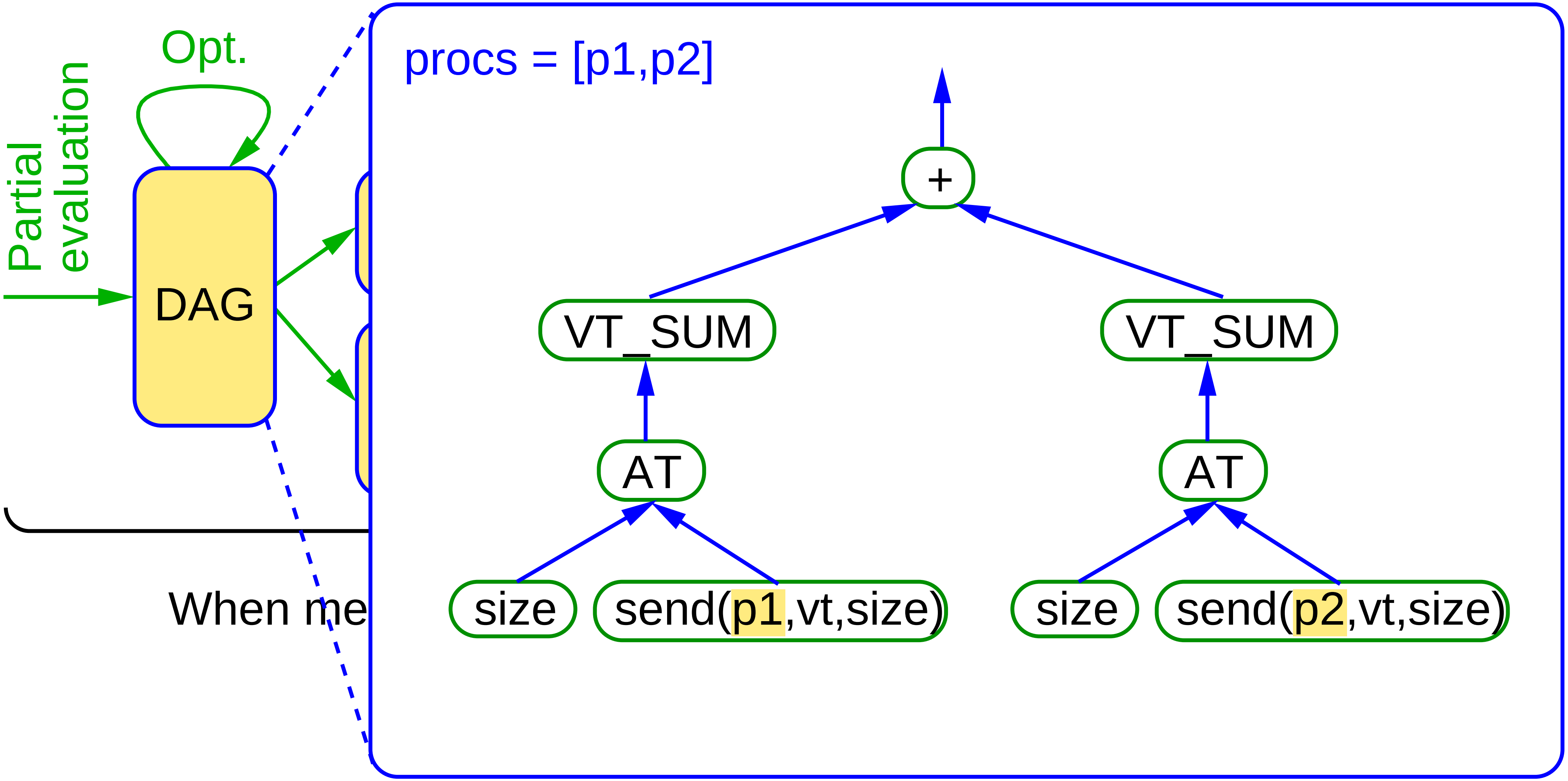

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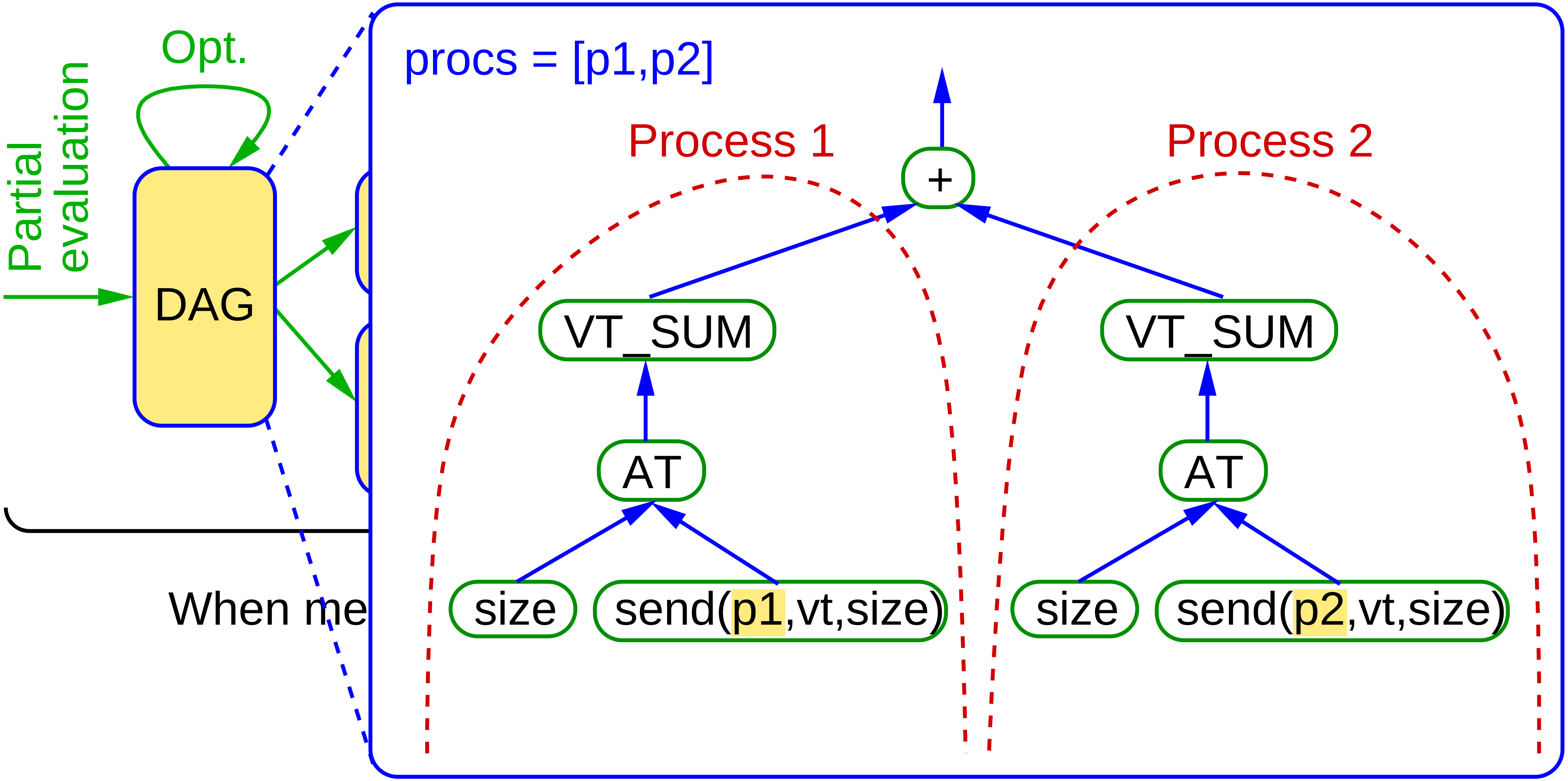

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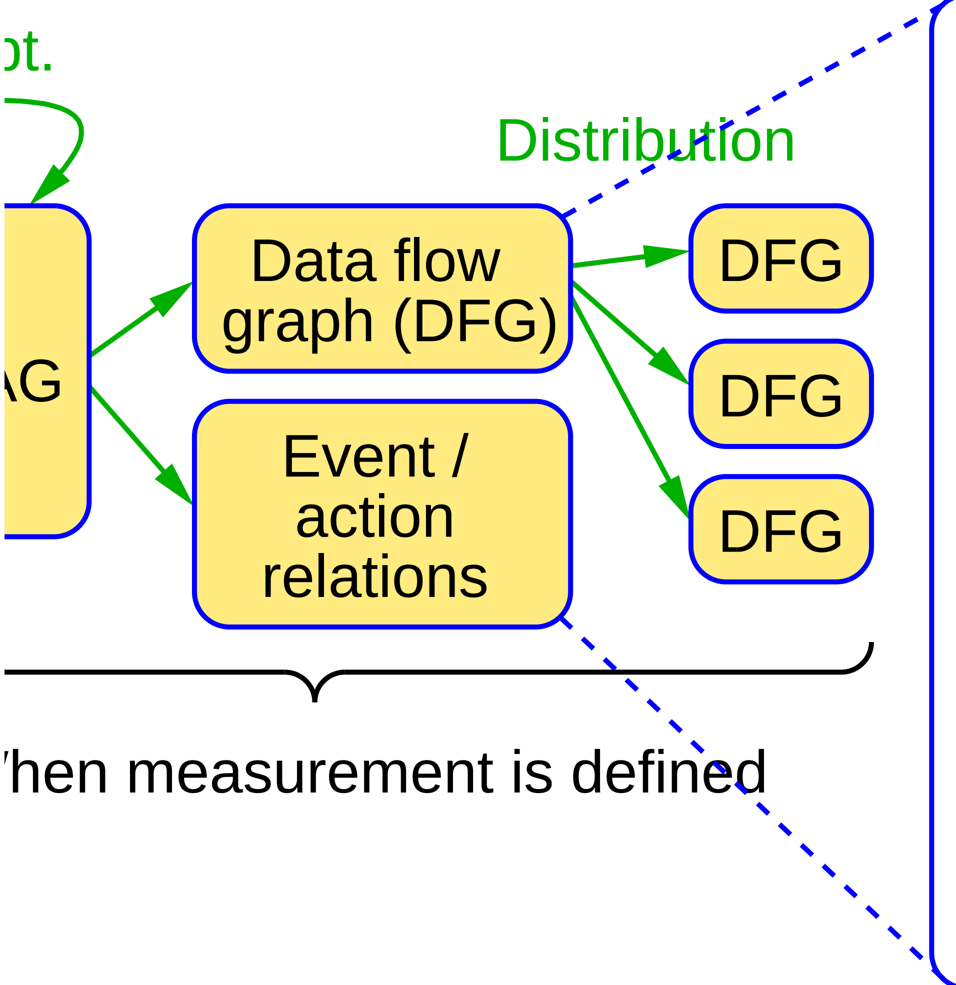

Converting the DAG into data structures for execution in OCM

- Data flow graphs
  - distribution to OCM components
  - interpretation by OCM plug−in
- Event/action relations
  - monitoring the events
  - data transport between data flow graphs

Towards an Implementation (2)

- **Q**: how to create the data flow graphs?
- **A**: use transparent proxies!

- Inspiration: ProActive (INRIA)
  - transparent asynchronous RMI (remote method invocation)
    - RMI immediately returns a *future* (proxy object)
    - once the result arrived, method calls are forwarded to it
    - method call blocks, if result is not yet available
  - groups (sets)
    - method called on group is executed for each member
    - method result again is a group
    - also implemented via proxy object
  - proxy classes are generated at run time (using Java reflection)

Towards an Implementation (2) ...

- Observation: invoking a method on a future doesn't have to block
  - we can immediately return another future as the result
  - but we have to remember to method to be executed
    $\Rightarrow$ we end up with a data flow graph

```
b = a.m1();
...
c = b.m2(x);
...
d = c.m3(y,b);
...
e = d.m4();
```

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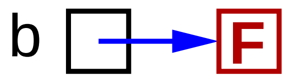

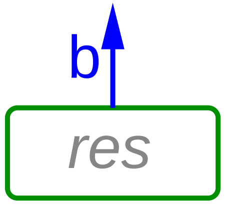

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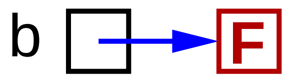

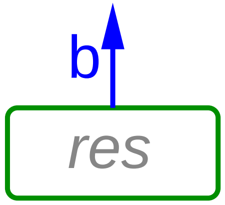

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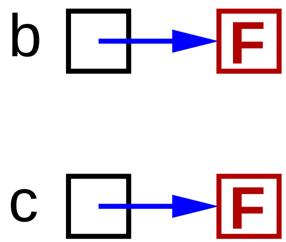

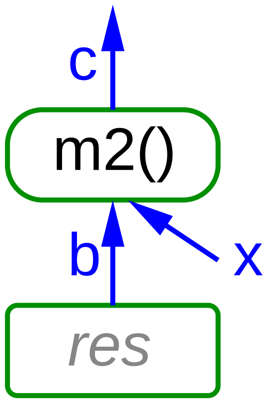

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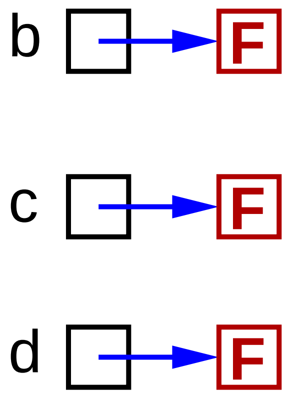

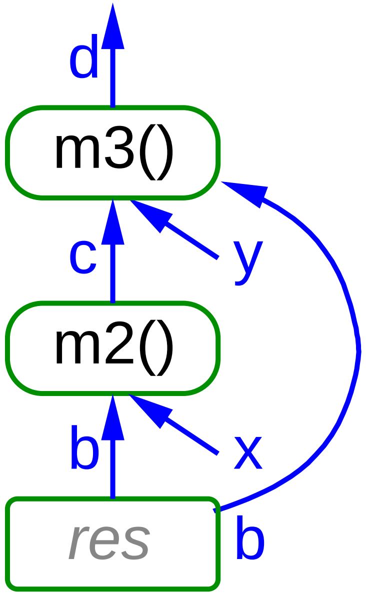

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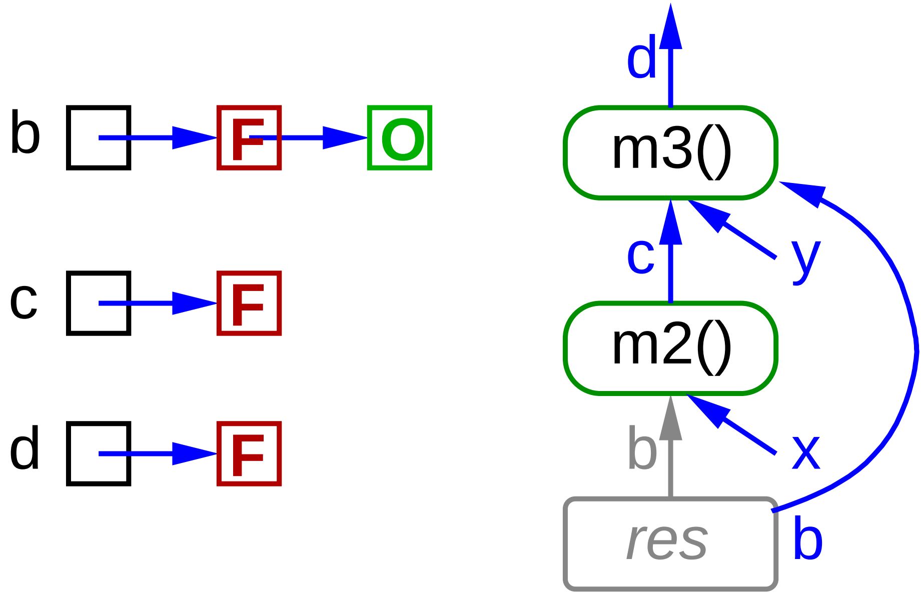

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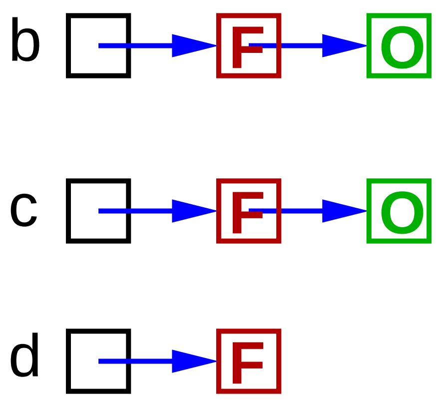

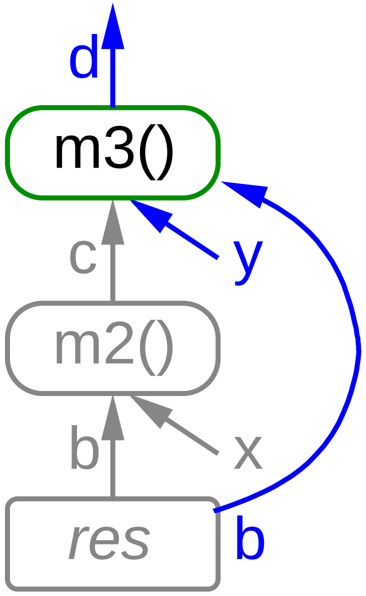

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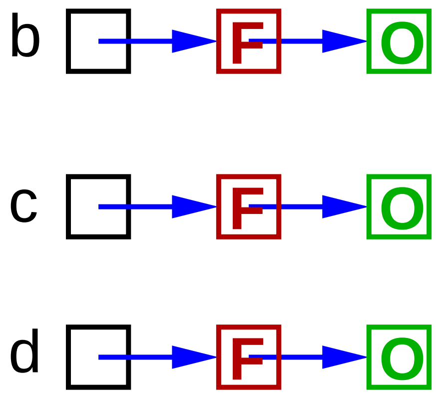

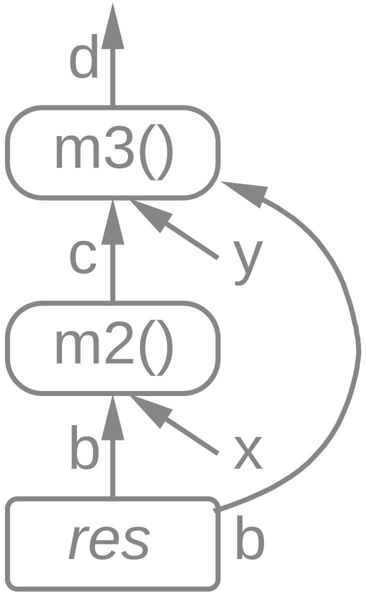

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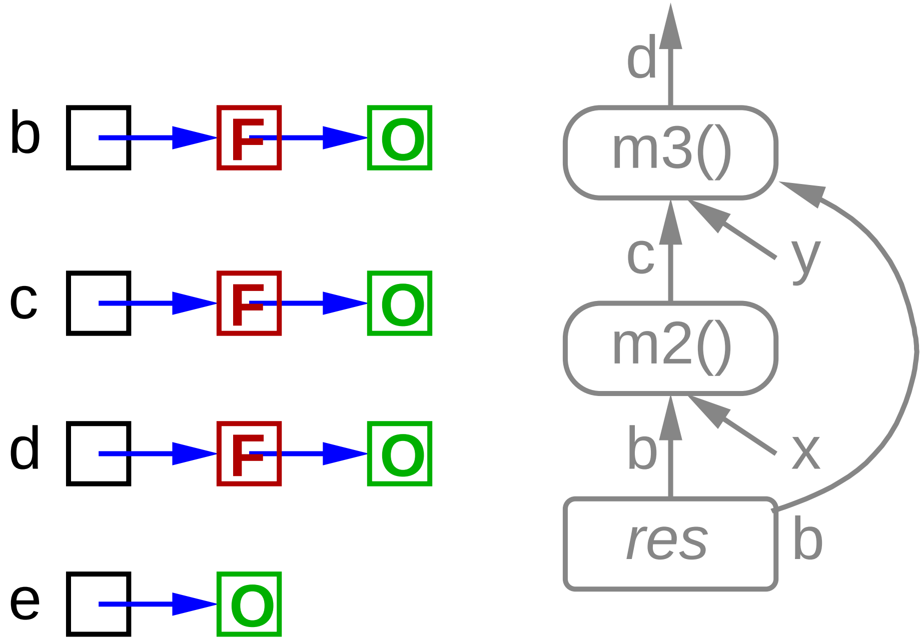

Proof-of-Concept Implementation

- Using ProActive run time code generator for proxy classes
  - can generate a proxy class for every non-final class
- Three kinds of proxies:
  - future proxy for asynchronous RMIs
    - method call results in creation of a data flow node, if object is not yet available
  - group proxy for sets
    - basically identical to ProActive
  - stream proxy
    - invokes method on each object in the stream, as it arrives
    - method result again is a stream
    - implemented using a data flow node, similar to future proxy
- Plus all kinds of combinations (e.g.: future group of streams)

The Example Revisited

```
Set<Node> nodes = System.getNodes(...);
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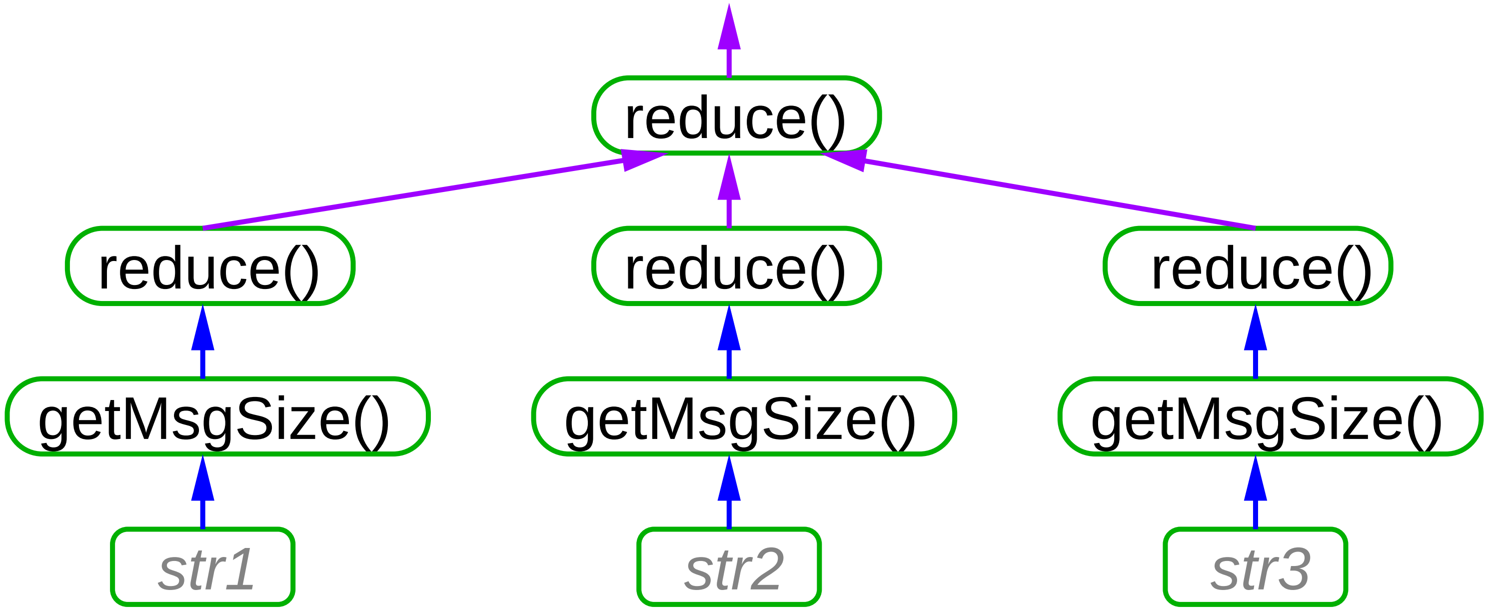

Conclusions / Status

- A “natural” object oriented model for online analysis is feasilbe
  - use transparent proxies to create data flow graphs
  - distribute the data flow graphs (and the code of the required classes) to the target system for execution
- Still many issues open for research:
  - semantics (method parameters, excution order, ...)
  - implementation of special functions
    - reductions, scatter, ...
  - best way to generate proxy classes
    - currently: set / stream of A is subclass of A
  - distribution of data flow graphs
    - esp. distribution of reduction methods