A Semantics For Distributed Erlang

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“Common knowledge”

“Distribution is Transparent” *[1]*

“Message passing between a pair of processes is assumed to be ordered” *[2]*

[1] J. Armstrong, B. Dacker, T. Lindgren, H. Millroth. *Open Source Erlang – White Paper*. Ericsson Computer Science Laboratory, Stockholm, Sweden 1998.

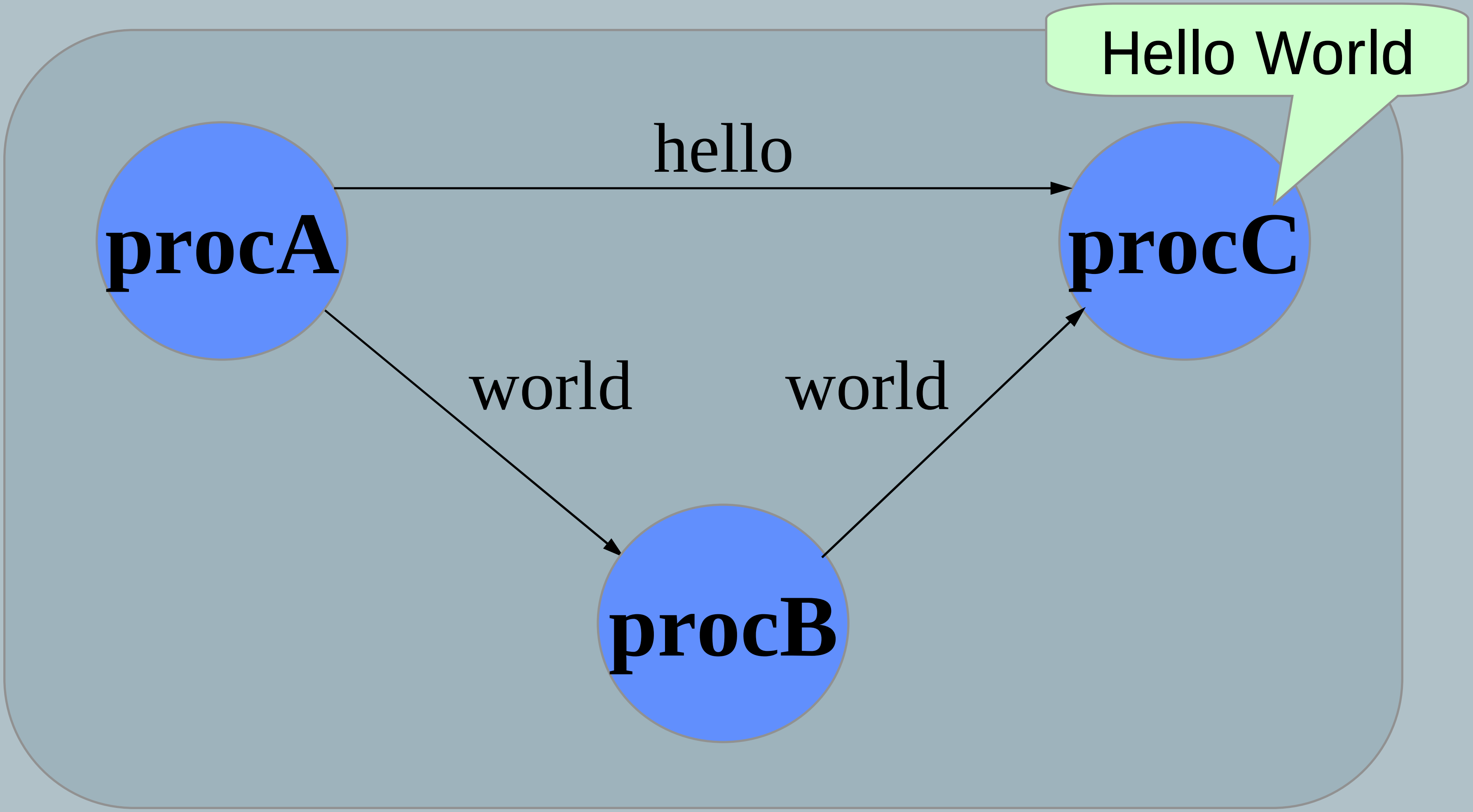
[2] J. Armstrong. *Making reliable distributed systems in the presence of software errors*. Ph.D. Thesis, Royal Institute of Technology, Stockholm, Sweden 2003.

Hello World

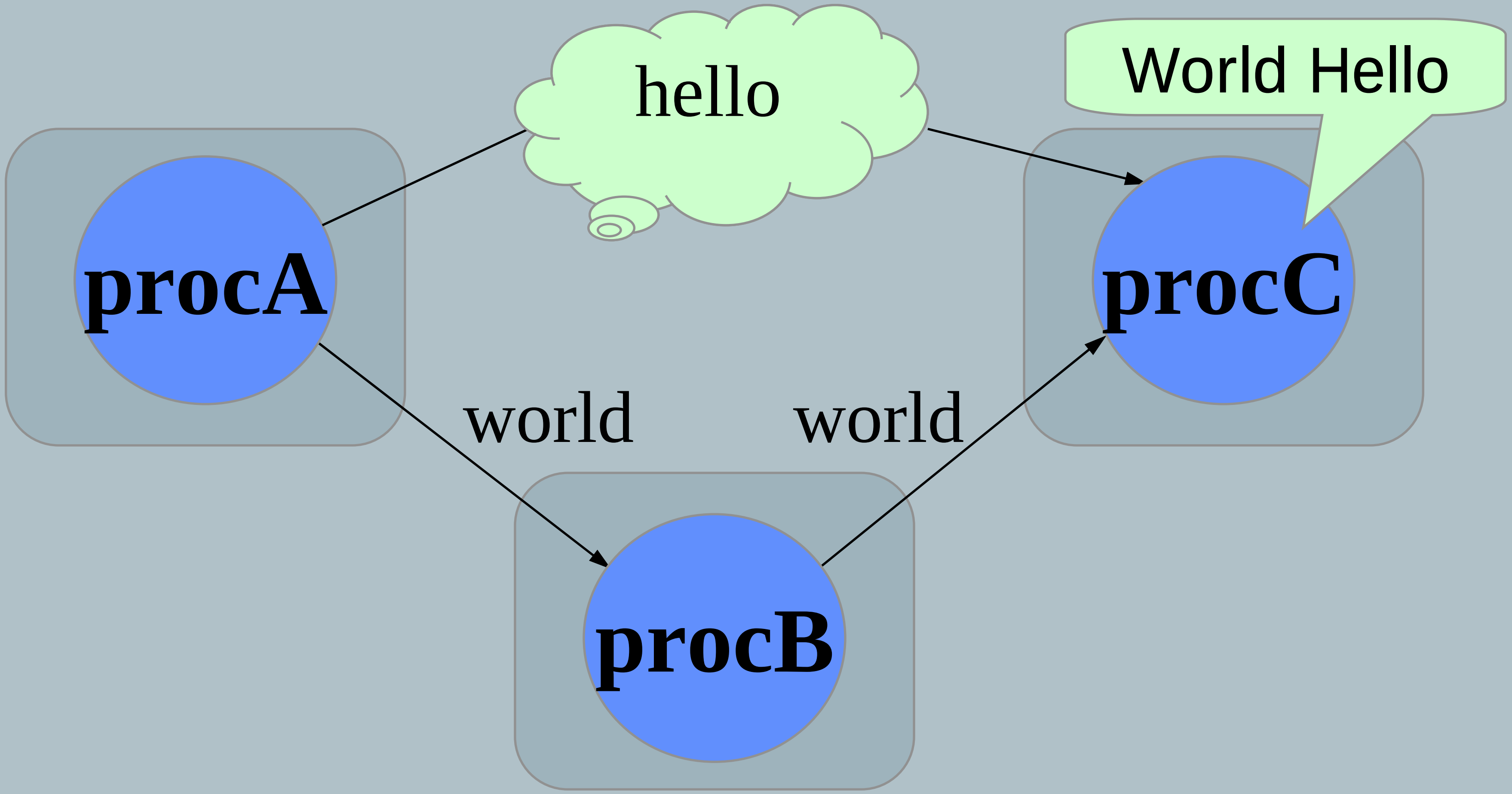
```
procA() ->
    PidC =
         spawn(?N1,?MODULE,procC,[]),
    PidB =
         spawn(?N2, ?MODULE, procB,[PidC]),
    PidC ! hello,
    PidB ! world.

procB(PidC) ->
    receive X ->
         PidC ! X
    end.
```

```
procC() ->
    receive X ->
         ok
    end,
    receive Y ->
         ok
    end,
    io:format(“~p ~p”, [X,Y]).
```

Hello World



World Hello?!?



Only when processes are on separate nodes

~~“Distribution is Transparent”~~

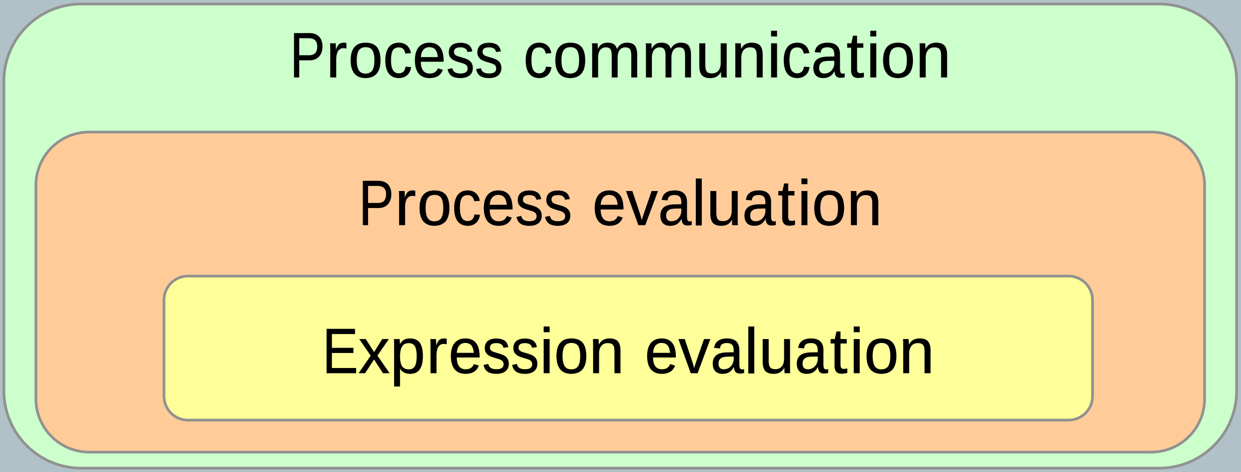
- Local system (one ERTS)
  - – Messages are delivered instantly
  - – The result is always “Hello World”

Even on the same machine

- Distributed system (many ERTSs)
  - – Messages are really ‘sent’ between processes
  - – Only message order between pair of processes
  - – The result can be “World Hello”

Erlang Semantics

- Fredlund: Single-node semantics
  - Faithfully describes a single-node system
  - Used in model checking of Erlang software

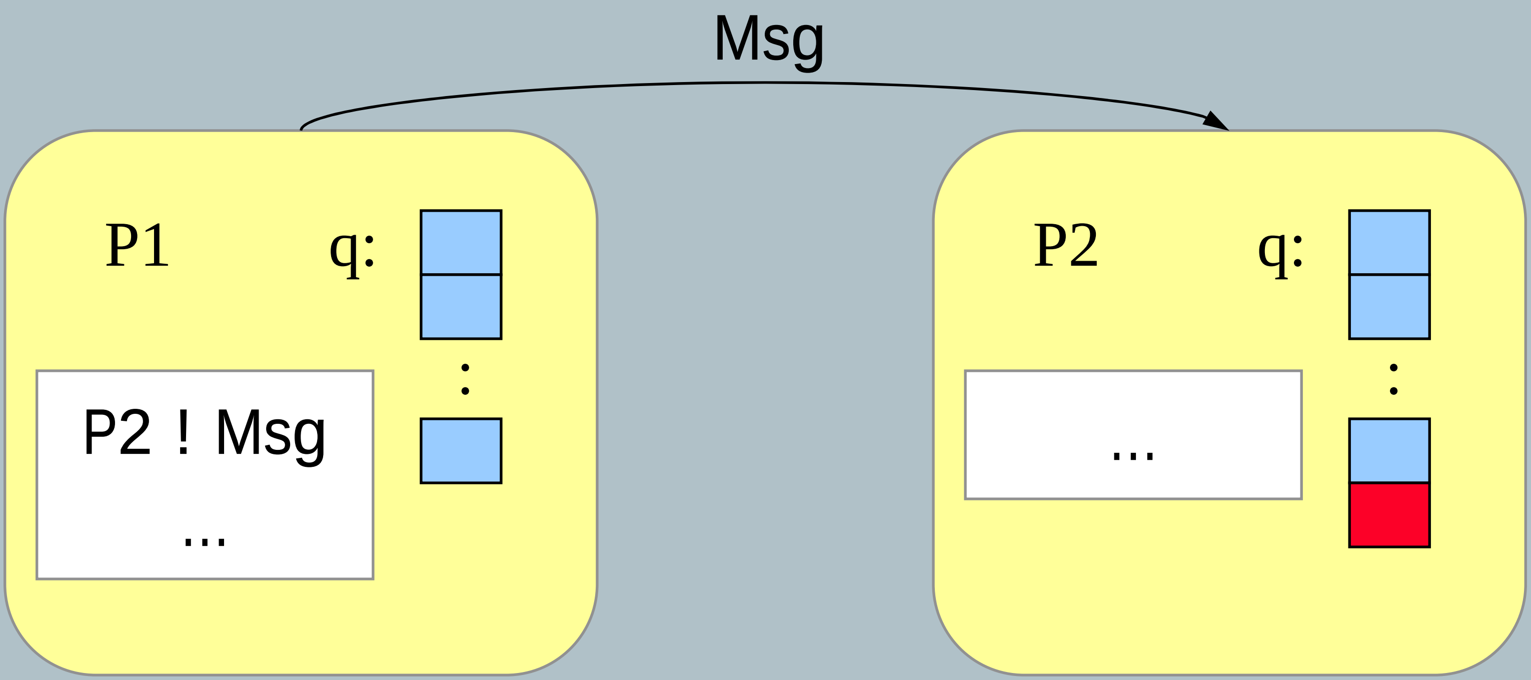


Process communication

Process evaluation

Expression evaluation

Single-node process communication



Message is added directly in the receivers queue

Distributed Semantics

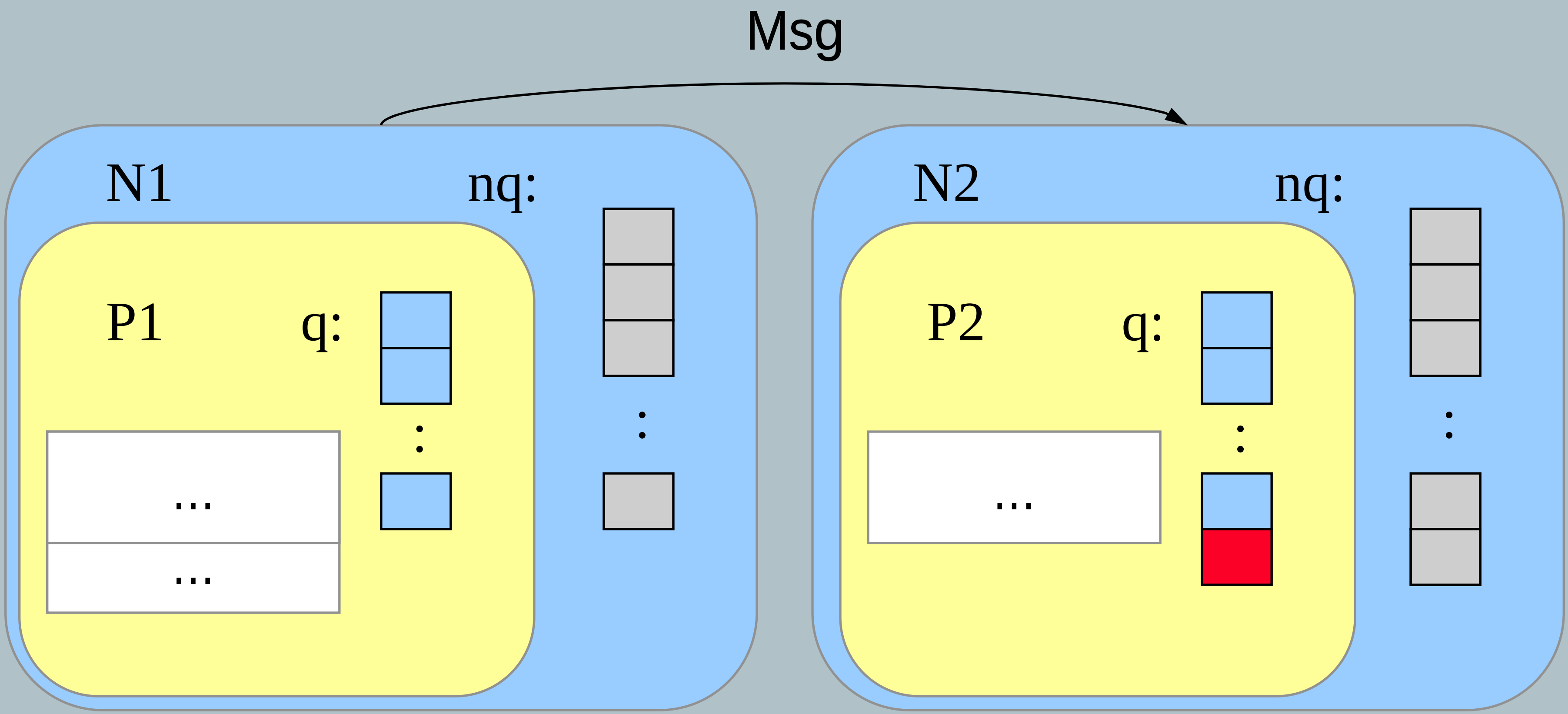
- Changes to existing semantics
  - Introduce the concept of nodes
  - Alter *spawn*-function
  - Restrict communication to one node
- Additions
  - Start and failure of nodes
  - Node-to-node communication
  - One intermediate mailbox per node
  - Fairness

Distributed Semantics

$$\text{input}\ \frac{s \xrightarrow{pid\,?\,sig} s' \qquad \mathrm{nmatch}(nq,\ from,\ pid) = sig}{\langle s, node, nq \rangle \xrightarrow{pid\,?_{from}\,sig} \langle s', node, nq \setminus (\,from,\ pid\,, sig) \rangle}$$

Node communication

Distributed process communication



Messages are later delivered to processes, not necessarily in order of delivery, but without breaking the order for each process-pair.

Conclusions

- Distribution is only almost Transparent
- There exist problems where a single-node semantics isn’t descriptive enough
  - Leader election implementation
- Model checking: future work
  - More accurate => Harder problem
  - Larger state space