Process Cooperativity as a Feedback Metric in Concurrent Message-Passing Languages

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- Thank Fluet, Heliotis, and Raj.
- Dedicate to parents, who are unable to be present.

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1 Background
- Message Passing
- Cooperativity
- Runtime Scheduling

2 ErLam
- The Language
- Channel Implementations
- Simulation & Visualization

3 Scheduler Implementations
- Example Schedulers
- Feedback Schedulers

4 Results
- Simulator Evaluation
- Cooperativity Mechanics

5 Conclusions & Future Work
- ErLam Toolkit
- Cooperativity as a Metric

- Break apart title = Background.
- Then simulator and test primitives (process behaviours).
- Schedulers and how comparisons are made.
- Results, Conclusions (of both simulator and cooperativity).

Current Section:

1 Background

- Message Passing
- Cooperativity
- Runtime Scheduling

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Background: Message Passing

A Taxonomy of Message-Passing:

- Message Passing
  - Async
    - Direct
    - Indirect
  - Sync
    - Asymmetric
    - Symmetric

Background: Message Passing
A Taxonomy of Message-Passing:
Message Passing
Async Sync
Direct Indirect Asymmetric Symmetric

- Async: while user code doesn't block, there is blocking in terms of the channel implementation. This is not indicated (in most cases) to the scheduler.
- Direct = Mailboxes
- Indirect = Sockets
- Sync: The issue of process cooperation has been elevated to the process level for the scheduler to directly involve itself.

Background: Message Passing

swap

Our Symmetric Synchronous Message Passing Primitive

- Purely captures cooperation of processes by synchronizing on the shared channel.
- Ultimately can be extended to take into account:
  - Directionality
  - Asynchrony

Background: Message Passing

swap

Our Symmetric Synchronous Message Passing Primitive

- Purely captures cooperation of processes by synchronizing on the shared channel.
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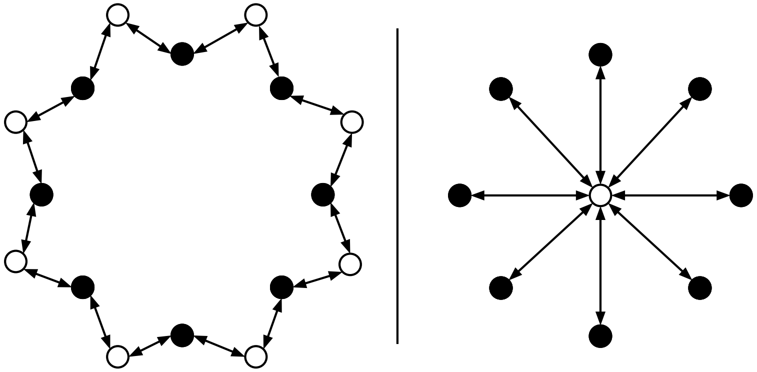
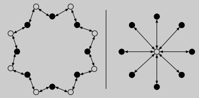
Ultimately there is nothing stopping us from choosing the other types of message passing, but it would conflate the issue of process cooperativity if all we are after is whether two processes are cooperating on some task.

Background: Cooperativity





Whats the difference in cooperativity in the left and right set of processes? Where white represents a channel and black represents a process.

- Left: A Ring, the level of parallelism is nearly nil. Each process is cooperating yes, but the granularity of the application is very fine.
- Right: A Star, the level of parallelism is nearly full. Each process is cooperating, and is not reliant on more than one other.

Overall, what can be gained by looking at cooperativity in terms of understanding the applications behaviour? Knowing the granularity of parallelism.

Background: Runtime Scheduling

Background: Runtime Scheduling

- How much of basic runtime scheduling do I need to talk about here? I may want to save it until Schedulers section and just discuss it all there.

Current Section:

2 ErLam

- The Language
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- Simulation & Visualization

Current Section:
2 ErLam
The Language
Channel Implementations
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ErLam: The Language

```
<Expression> ::= <Variable>
              |  <Integer>
              |  'newchan'
              |  '(' <Expression> ')'
              |  <Expression> <Expression>
              |  'if' <Expression> <Expression> <Expression>
              |  'swap' <Expression> <Expression>
              |  'spawn' <Expression>
              |  'fun' <Variable> '.' <Expression>
```


ErLam: The Language

- Extremely simple on purpose (5 keywords).
- Issue now began to be how to build up test primitives
- Made a library which allowed for built ins.

ErLam: The Language

```
elib
    // ...
    omega = (fun x.(x x));
    // ...
    add = _erl[2]{ fun(X) when is_integer(X) ->
                        fun(Y) when is_integer(Y) ->
                            X+Y
                        end
                    end
                };
    // ...
bile
```


ErLam: The Language

elib
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    // ...
bile

- Theres options for built-ins as well as macros.

ErLam: The Language

Example Application: Parallel Fibonacci

```
// pfib.els -
fun N.
    (omega fun f,m.(
        if (leq m 1)
           m
           (merge fun _.(f f (sub m 1))
                  fun _.(f f (sub m 2))
                  add)) N)
```

```
$ els pfib.els       (Compile the script)
$ ./pfib.ex -r 10    (Finds the 10th Fibonacci number)
```


ErLam: The Language
Example Application: Parallel Fibonacci
// pfib.els -
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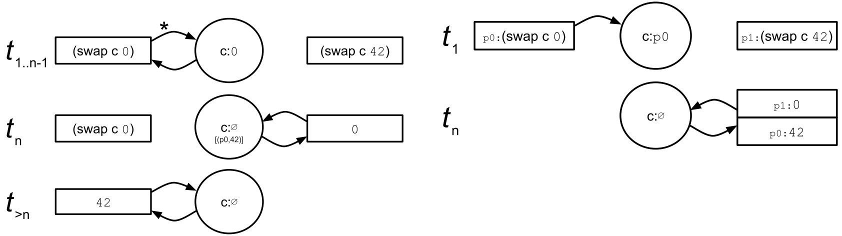
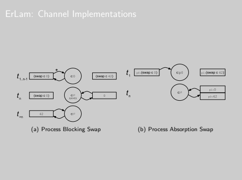
$ els pfib.els (Compile the script)
$ ./pfib.ex -r 10 (Finds the 10th Fibonacci number)

- R option is to run program applied to 10.
- To add more to this presentation than just reading paper I want to also give more detail as to system usage.
- Explain this Common Usage Pattern.

ErLam: Channel Implementations



(a) Process Blocking Swap (b) Process Absorption Swap



- Blocking: Maintains state of current and previous swap value until swap is completed.
- Absorption: Stores process which initializes the swap and returns it along with completion.
- Mention expected effects on scheduler.
- Blocking is default, passing '-a' to els

ErLam: Simulation & Visualization

- Need to talk about Chart types and chart generation.

Current Section:

3 Scheduler Implementations

- Example Schedulers
- Feedback Schedulers

2014-08-07

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└─Scheduler Implementations
  └─Current Section:

Current Section:

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Current Section:

Current Section:

4 Results

- Simulator Evaluation
- Cooperativity Mechanics

Results: Simulator Evaluation

Results: Simulator Evaluation

- TODO: Talk about the overhead

Results: Cooperativity Mechanics

Longevity-Based Batching Scheduler:

- Spawn Mechanism

  (Where does a new process go if batch is too big?)

Channel Pinning Scheduler:

- Channel Spread

  (How to spread the channels across processors?)

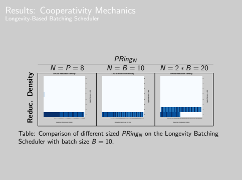
Bipartite-Graph Aided Sorting Scheduler:

- Channel Implementation

  (Does blocking help to take advantage of sorting?)

Results: Cooperativity Mechanics
Longevity-Based Batching Scheduler:
Spawn Mechanism
(Where does a new process go if batch is too big?)
Channel Pinning Scheduler:
Channel Spread
(How to spread the channels across processors?)
Bipartite-Graph Aided Sorting Scheduler:
Channel Implementation
(Does blocking help to take advantage of sorting?)

- LBB: Can also look at how the batch size effects different types of behaviours.
- SS: Could also look at a stealing mechanism.



Results: Cooperativity Mechanics

Longevity-Based Batching Scheduler

$PRing_N$

	$N = P = 8$	$N = B = 10$	$N = 2 * B = 20$

Reduc. Density

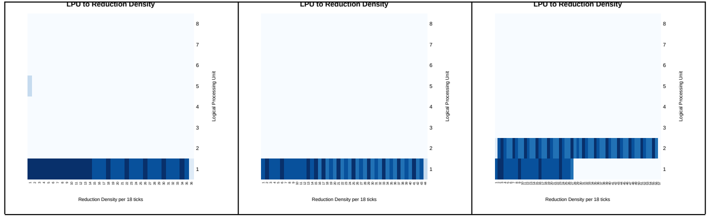


Table: Comparison of different sized $PRing_N$ on the Longevity Batching Scheduler with batch size $B = 10$.

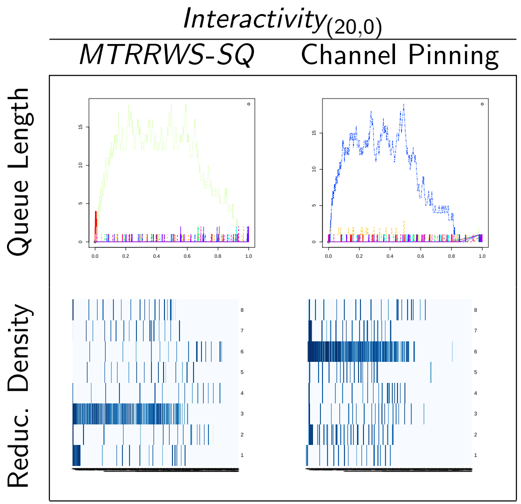
- Before talking about spawn mechanism, pointing out the primary goal and effect of batching to catch the granularity of the application.

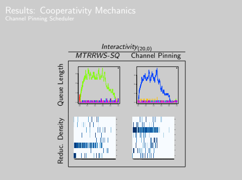
Results: Cooperativity Mechanics
Longevity-Based Batching Scheduler

Results: Cooperativity Mechanics
Longevity-Based Batching Scheduler

- TODO: Get simple $\mathit{ClusterComm}_{(N,1)}$ or the PTree results to contrast with PRING
- This brings it back to an issue of behaviour recognition.

Results: Cooperativity Mechanics
Channel Pinning Scheduler



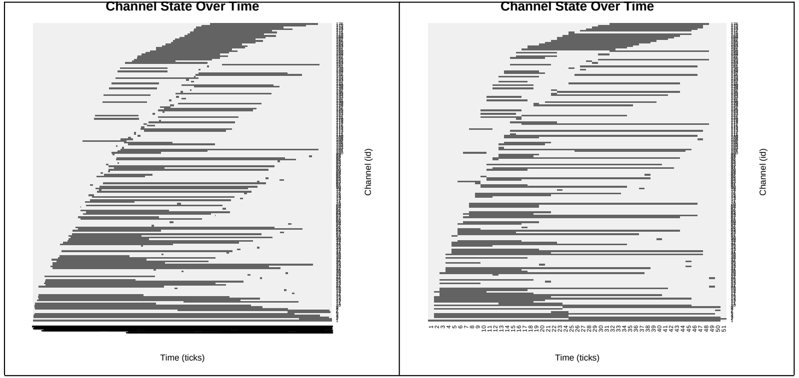


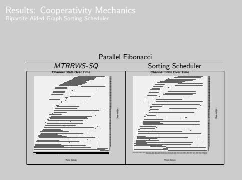
- Comparison of Uniform synchronization for *MTRRWS-SQ* and the Channel Pinning Scheduler on Absorption Channels.
- This used the *even* spread type.
- Note the speed at which it saturates all cores.
- Despite Naive WS, we still have decent spread.

Results: Cooperativity Mechanics
Bipartite-Aided Graph Sorting Scheduler

Parallel Fibonacci

MTRRWS-SQ	Sorting Scheduler





- Channel State comparison of Parallel Fibonacci executed on *MTRRWS-SQ* and the Bipartite-Graph Aided Sorting Scheduler.
- Note the large reduction in number of ticks.

Current Section:

5 Conclusions & Future Work

- ErLam Toolkit
- Cooperativity as a Metric

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5 Conclusions & Future Work
ErLam Toolkit
Cooperativity as a Metric

Conclusions & Future Work: ErLam Toolkit

- Test Primitives proved to be a good abstraction for Process behaviours.
- Log generation, lots of overhead, but good observations.

Conclusions & Future Work: ErLam Toolkit

- Test Primitives proved to be a good abstraction for Process behaviours.
- Log generation, lots of overhead, but good observations.

- Overall pleased with simulator and achieved its goal.
- Future Work:
  - Generate more test primitives.
  - Clean up log generation (reduce overhead).
  - Process evaluation uses alpha-reduction (can be sped up substantially).
  - Make schedulers more adjustable (different spawn/yields/etc).
  - More Channel implementations

Conclusions & Future Work: Cooperativity as a Metric

- **Longevity Batching:** -
- **Channel Pinning:** -
- **Queue Sorting:** Would benefit from merging with Channel Pinning scheduler to increase likelihood that sorting puts channel partners close.

Conclusions & Future Work: Cooperativity as a Metric
- Longevity Batching: -
- Channel Pinning: -
- Queue Sorting: Would benefit from merging with Channel Pinning scheduler to increase likelihood that sorting puts channel partners close.

- Alternate message-passing types (asymmetric).
- Merging Schedulers

Questions/Comments?

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Thank You!

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Links:

- https://github.com/dstar4138/erlam
- https://github.com/dstar4138/thesis_cooperativity
- http://dstar4138.com

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