ParaFuzz: Fuzzing Multicore OCaml programs

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joint work with
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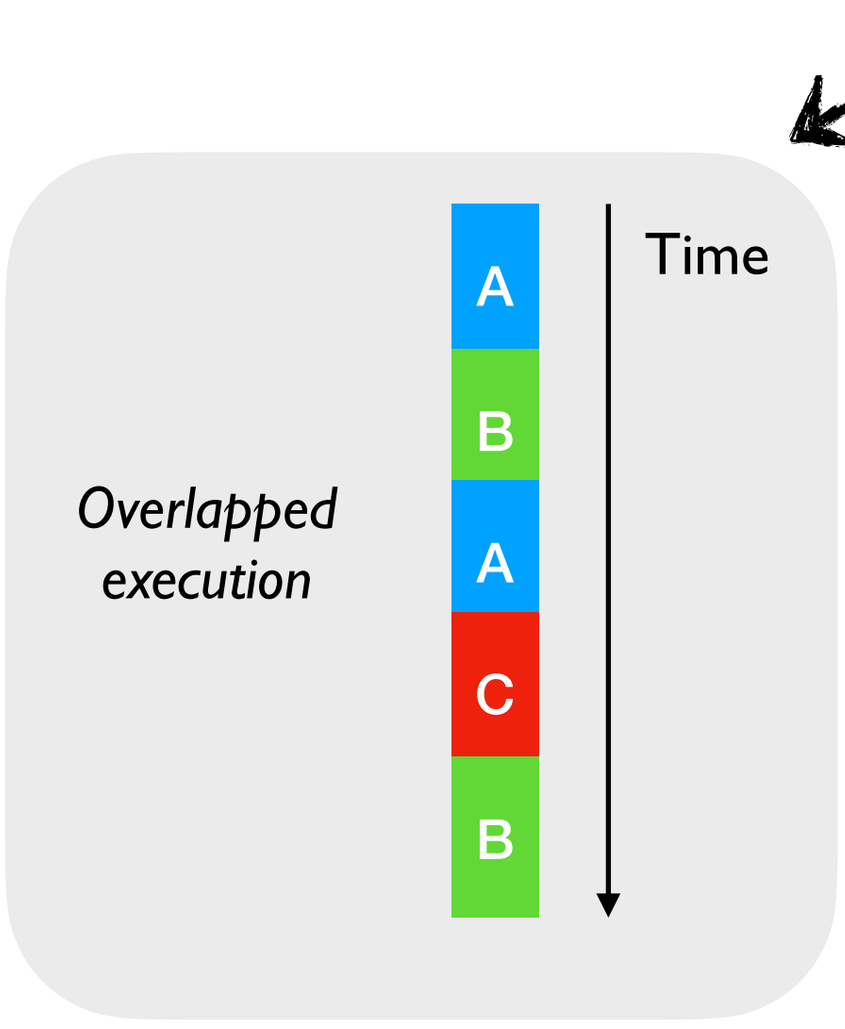

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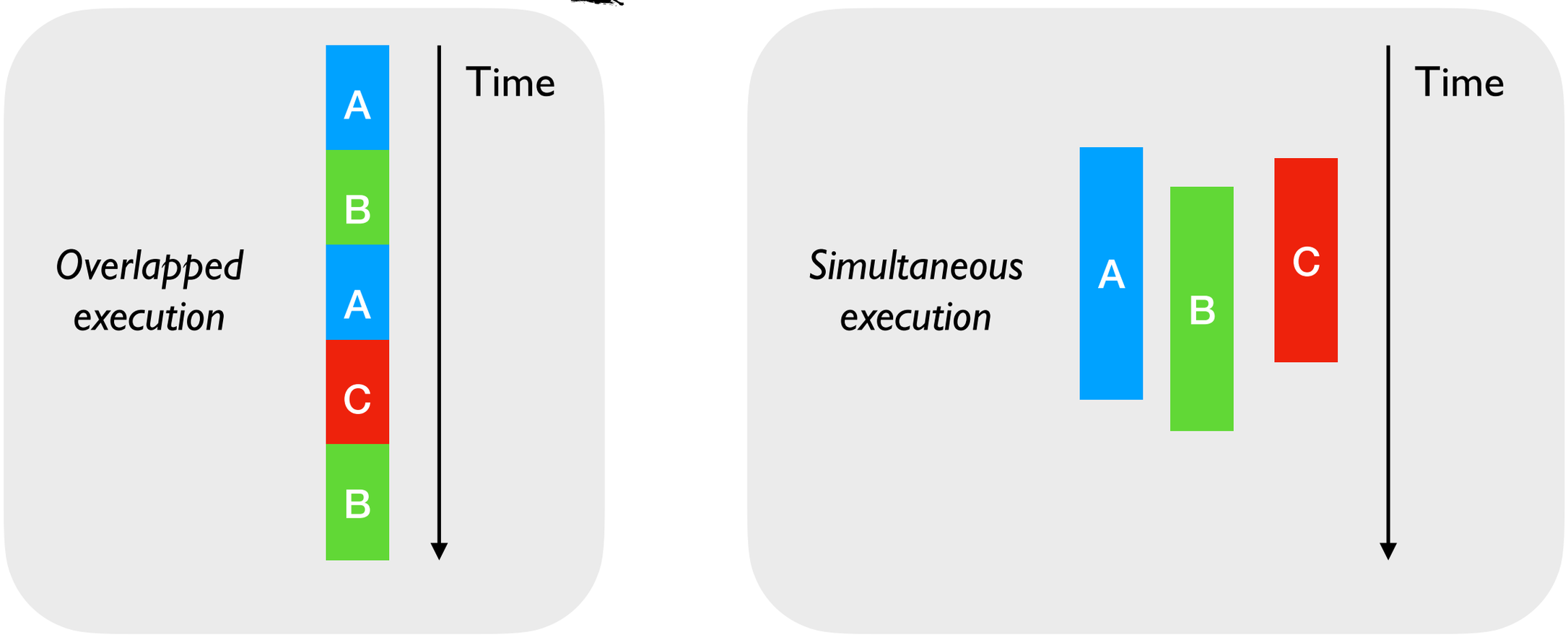

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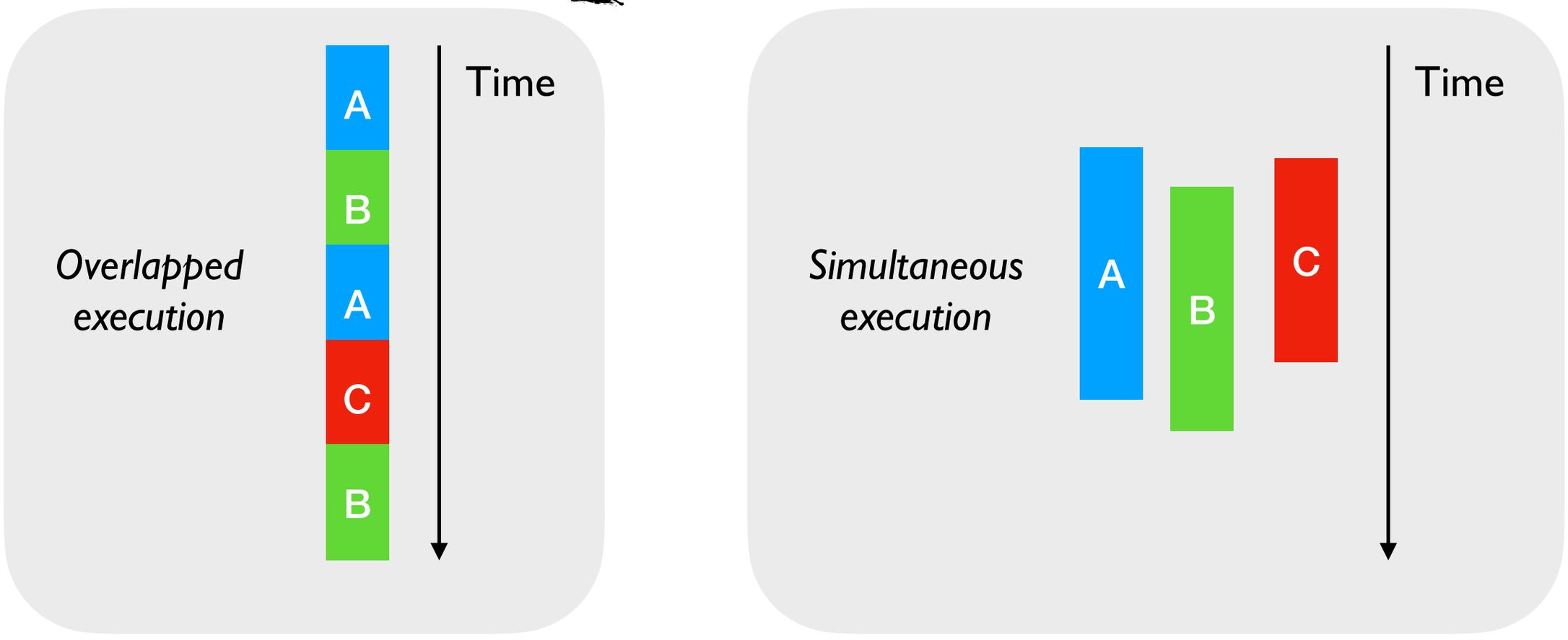

Effect Handlers

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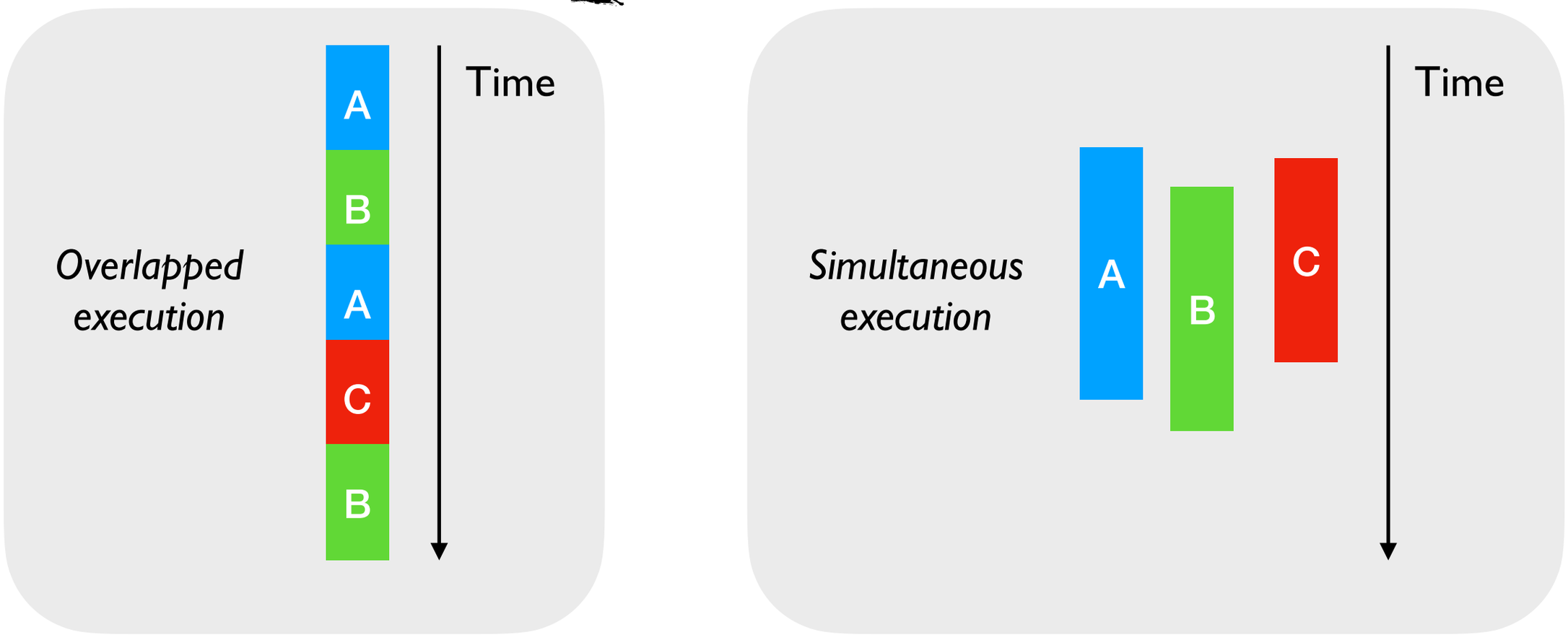

Effect Handlers

Domains

Testing Parallel Programs

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let test i =
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  let y = Atomic.make 0 in
  let dom = Domain.spawn (fun () ->
    if (Atomic.get x = 10) then Atomic.set y 2)
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- *How can we help test Multicore OCaml programmers detect such bugs?*

Existing solutions

- **Testing**
  - ✦ Stress testing — run the program over and over again and hope that the assertion is triggered
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- **Formal verification**
  - ✦ Requires expert knowledge and lots of time and effort

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- *Crowbar* = Fuzzing + QuickCheck
  - ✦ Coverage-guided property-fuzzing
  - ✦ https://github.com/stedolan/crowbar

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- Idea
  - ✦ *Mock parallelism API using an effect handler based scheduler*
  - ✦ *Yield at every synchronisation point*
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- Synchronisation points
  - ✦ Domain (spawn, join)
  - ✦ Atomic (get, put, compare_and_swap)
  - ✦ Mutex (lock, unlock)
  - ✦ Condition variable (wait, notify, broadcast) — also fuzz wake up order

ParaFuzz

- Idea
  - ✦ *Mock parallelism API using an effect handler based scheduler*
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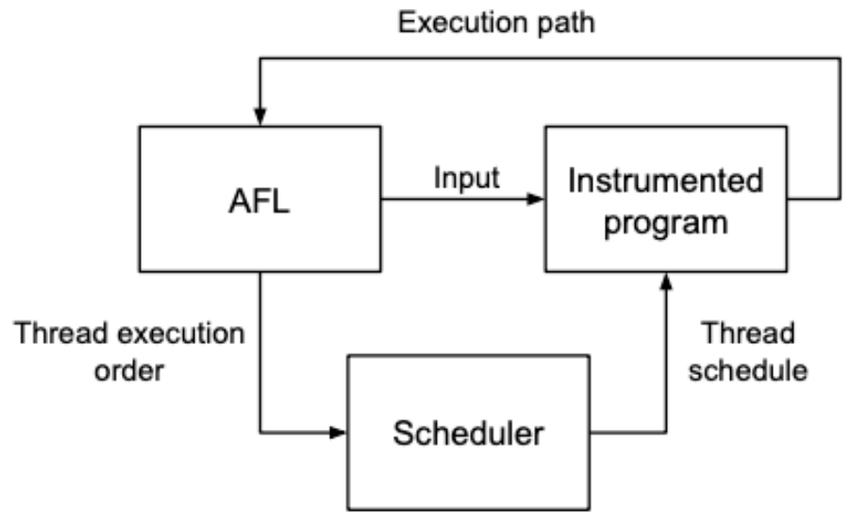

- Advantages
  - ✦ No false positives
  - ✦ Record and replay
  - ✦ Drop-in replacement for parallel Multicore OCaml programs

Evaluation

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Testing Technique	Executions (millions)	Time (minutes)	Bug Found
ParaFuzz	0.55	10.5	**Yes**
Random	108.6	60	**No**
Stress	25.2	60	**No**

Evaluation

Name(abbreviation)	Bug type
mysql-bug(SQL)	race-condition
circular-list(CL)	race-condition
deadlock3(D3)	deadlock
buffer-if(BI)	deadlock
buffer-notify(BN)	deadlock
RAX-jpf(RAX)	deadlock
domainslib(DL)	deadlock
motivating-example(MX)	race-condition
effective-random-testing-example (ERT)	race-condition

	Stress	Random	ParaFuzz
SQL	0.00	0.00	1.00
CL	0.00	0.00	0.96
D3	0.00	0.00	1.00
BI	0.00	0.03	1.00
BN	0.00	0.00	1.00
RAX	0.00	0.00	1.00
DL	0.00	1.00	1.00
MX	0.00	0.00	1.00
ERT	0.00	0.00	1.00
Avg	0.00	0.003	0.99

Effectiveness

fraction of runs that found the bug

	Stress	Random	ParaFuzz
SQL	-	-	734.26
CL	-	-	971.16
D3	-	-	469.63
BI	-	100.76	20.36
BN	-	-	875.4
RAX	-	-	111
DL	-	0	0
MX	-	-	625.36
ERT	-	-	88.83

Efficiency

Mean-time to failure

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- *Can we make it fast?*