UPC-THRILLE Demo

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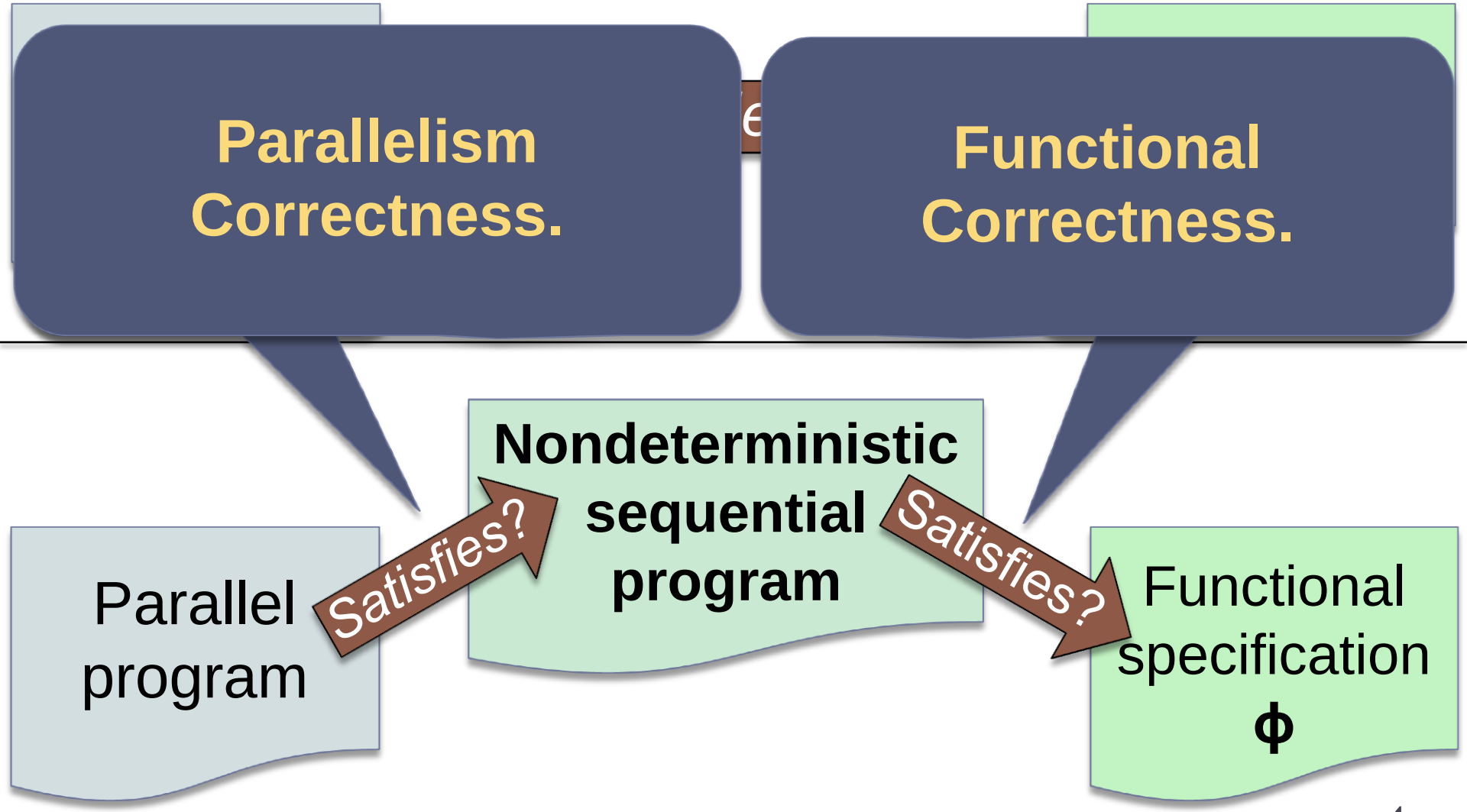
Correctness Group Highlights

- Active Testing for Java, C, and UPC
  - Practical, easy-to-use tools for finding bugs, with sophisticated program analysis internally
- **Lightweight Specs for Parallelism**
  - By focusing just on parallelism, can we develop simple specifications that greatly improve or ability to find real parallelism bugs?
- Concurrit DSL for testing parallel code

Lightweight Parallel Specs

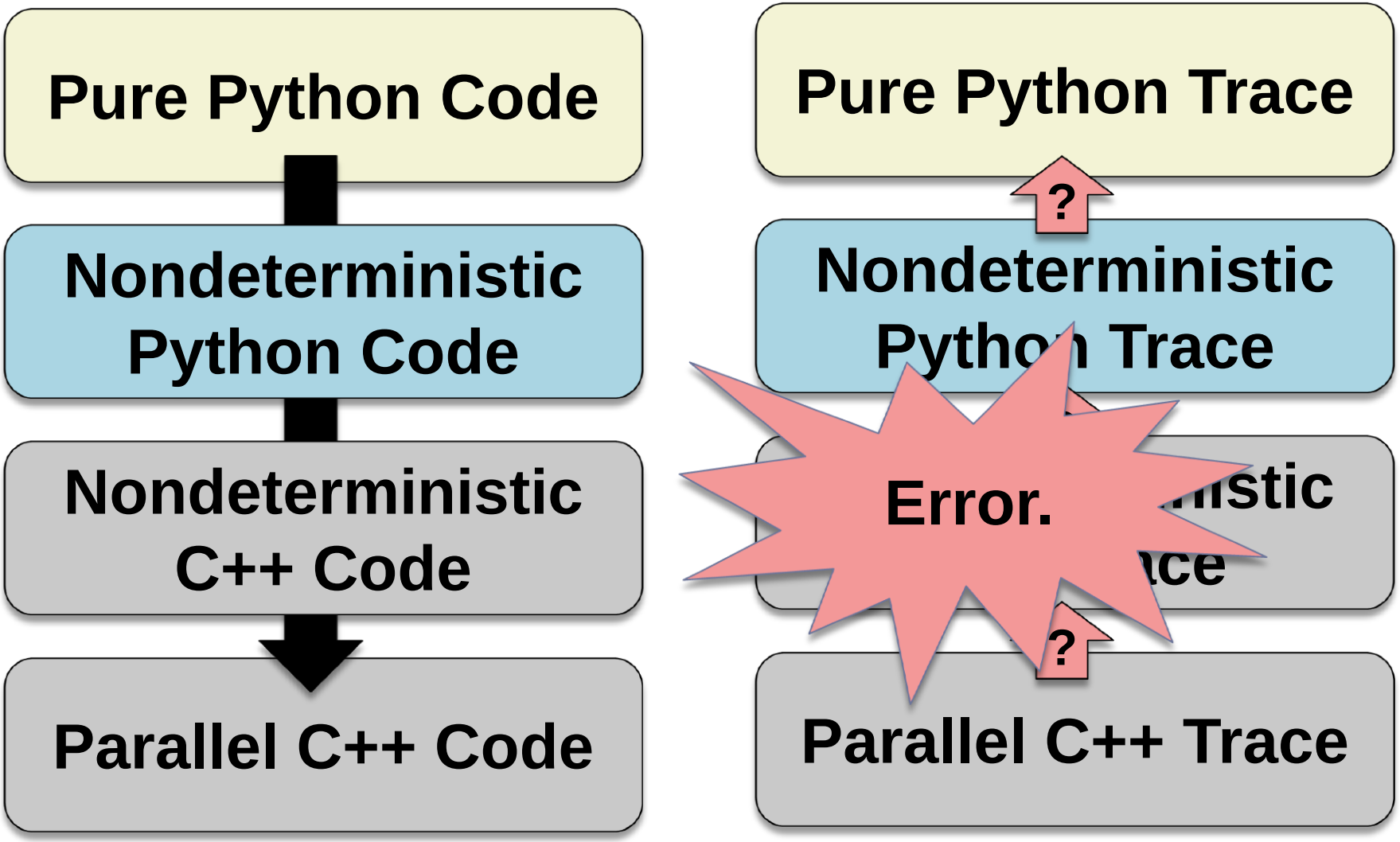
- **Goal: Lightweight** specifications for **parallelism correctness**.
  - Easy for programmers to write
  - Greatly increase effectiveness in testing, debugging, and verifying parallel programs
- Semantic determinism
  [FSE'09 (**best paper**), CACM'10, ICSE'10 (**IFIP TC2 Manfred Paul**)]**.**
- Semantic atomicity [ASPLOS'11]**.**
- **Nondeterministic sequential specs for parallel correctness** [HotPar'10, PLDI'11, PPoPP'12]**.**

Key: Decompose effort in addressing parallelism and functional correctness



NDSeq for SEJITS Debugging

- **Goal:** Localize bug in a SEJITS execution.

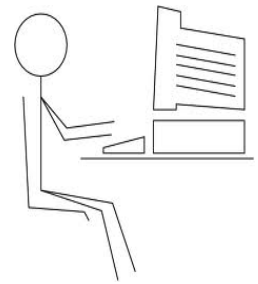


Correctness Group Highlights

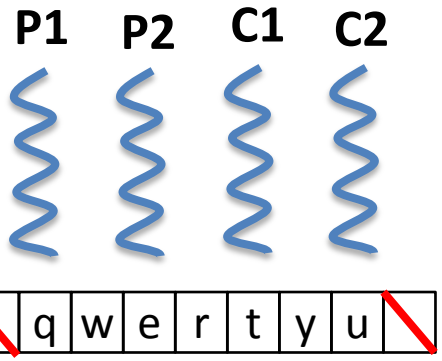
- Active Testing for Java, C, and UPC
  - Practical, easy-to-use tools for finding bugs, with sophisticated program analysis internally
- Lightweight Specs for Parallelism
  - Easy to write and, with testing, effective in finding real parallelism bugs
  - Determinism, atomicity, and NDSeq
- **Concurrit DSL for Testing Parallel Code**
  - Can we combine programmer intuition with testing techniques to find, reproduce bugs?

Concurrit: Domain Specific Language for Writing Concurrent Tests

Insights/ideas about thread schedules



Software Under Test



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Test in Concurrit DSL

Systematically explore **all-and-only** thread schedules specified by DSL

Specify a set of schedules in **formal**, **concise**, and **convenient** way

Concurrit Demo

Tayfun Elmas

Simple Test for an Apache bug

1 Now suppose there are 3 threads, A, B, C running `testfunc`.
2 Threads A and B call js_DestroyContext and thread˜C calls js_NewContext.
3 First thread˜A removes its context from the runtime list. That context is not
4 the last one so thread does not touch rt−> state and eventually calls js_GC.
5 The latter skips the above check and tries to to take the GC lock.
6 Before this moment the thread˜B takes the lock, removes its context from the
7 runtime list, discovers that it is the last, sets rt−> state to LANDING, runs
8 the-last-context-cleanup, runs the GC and then sets rt−> state to DOWN.
9 At this stage the thread˜A gets the GC lock, setup itself as the thread that
10 runs the GC and releases the GC lock to proceed with the GC
11 when rt−> state is DOWN.
12 Now the thread˜C enters the picture. It discovers under the GC lock in
13 js_NewContext that the newly allocated context is the first one. Since
14 rt−> state is DOWN, it releases the GC lock and starts the first context
15 initialization procedure. That procedure includes the allocation of the initial
16 atoms and it will happen when the thread˜A runs the GC.
17 This may lead precisely to the first stack trace from the comment 4.

Figure 2. Bug scenario, taken from Comment #5 of the bug report, describing an interleaving of threads for the program in Figure 1.

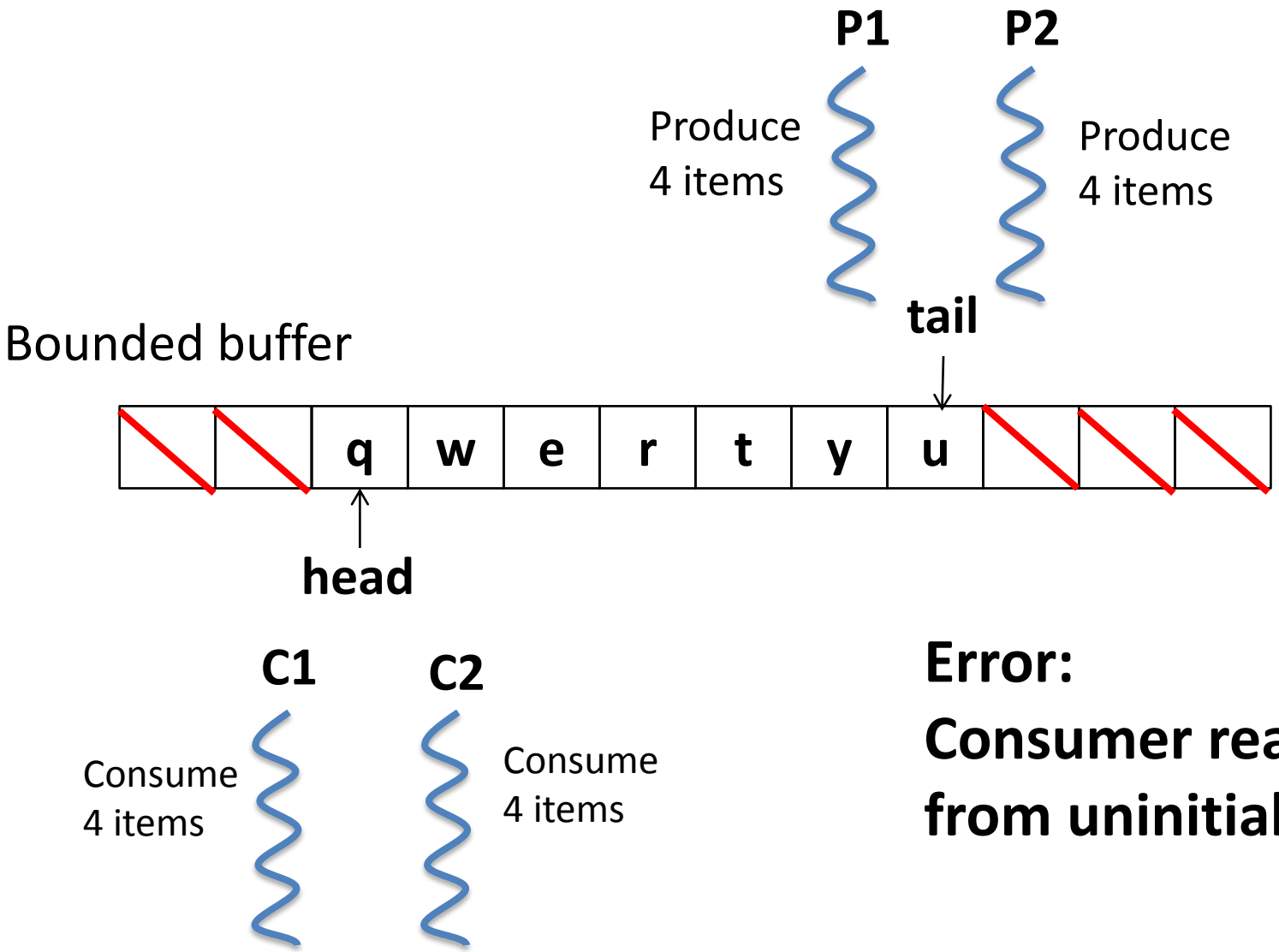
```
ExactScheduleTest :
1 Tid tA, tB, tC = WaitForDistinctThreads(3, EntersFunc(JS_NewContext));
2 RunThreadsUntil(tA, tB, EntersFunc(JS_DestroyContext));
3 RunThreadUntil(tA, InFunc(js_GC) && ReadsMem(&rt−> state));
4 RunThreadUntil(tB, ThreadEnds);
5 RunThreadUntil(tA, InFunc(js_GC) && WritesMem(&rt−> gcNumber));
6 RunThreadUntil(tC, EntersFunc(js_AddRoot));
7 RunThreadUntil(tA, ReturnsFunc(js_GC)); // violates assertion!
```

Concurrit

- **To appear in PLDI 2013.**
- **Implementation**: DSL embedded in C++
  - Available at *http://code.google.com/p/concurrit/*

– Can write tests for
  - **Unit testing:**
    – Both manual and automated (Pin) instrumentation
  - **System testing:**
    – Manual instrumentation (lightweight and portable)
    – Test servers, e.g. Memcached, MySQL, Apache Httpd.

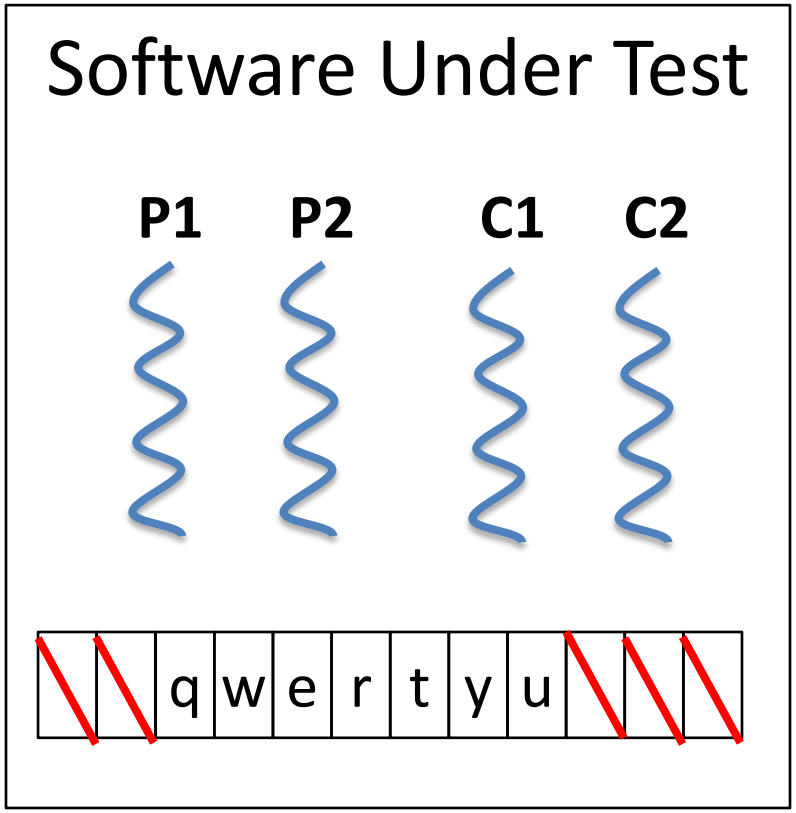
Example: Producer/consumer



Error:
Consumer reads from uninitialized cell.

How to reproduce a concurrency error?

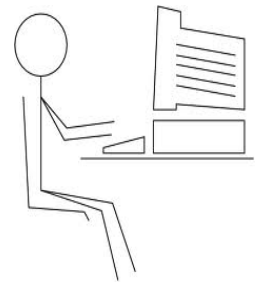
(Consumer reads from uninitialized cell.)



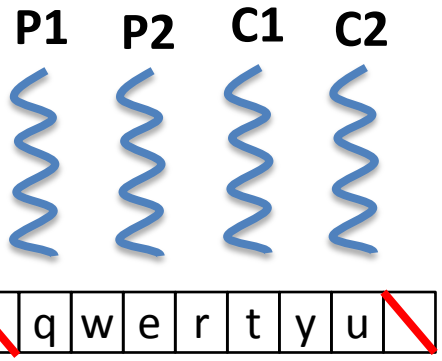
- **Run 1000 times:**
  - No guarantee
- **Insert sleeps:**
  - Useful but ad hoc, informal
- **Concurrit approach**
  - Write test to search for buggy schedules

Concurrit: Domain Specific Language for Writing Concurrent Tests

Insights/ideas about thread schedules



Software Under Test



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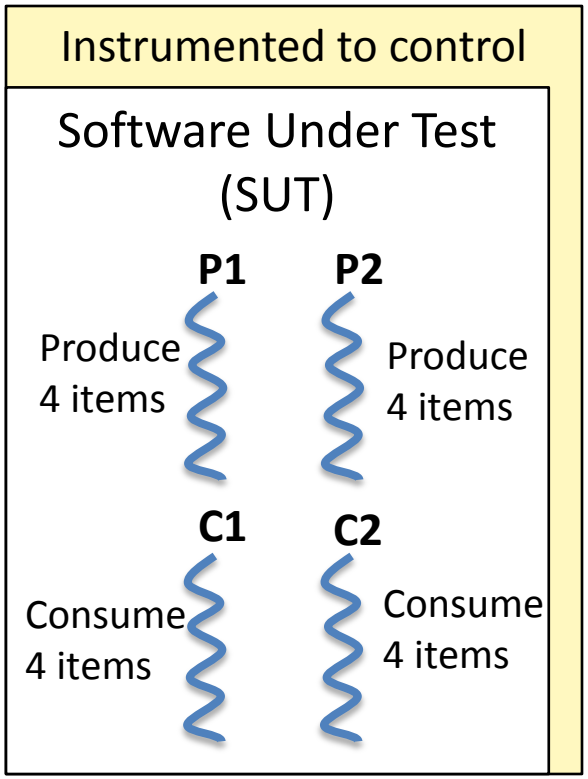
Test in Concurrit DSL

Systematically explore **all-and-only** thread schedules specified by DSL

Specify a set of schedules in **formal**, **concise**, and **convenient** way

SearchAll: Search all schedules

Capture threads from SUT




```
TESTCASE() {

  TVAR(P1);  TVAR(P2);
  TVAR(C1);  TVAR(C2);

  WAIT_FOR_DISTINCT_THREADS(
      (P1, P2), ENTERS(producer_routine));

  WAIT_FOR_DISTINCT_THREADS(
      (C1, C2), ENTERS(consumer_routine));

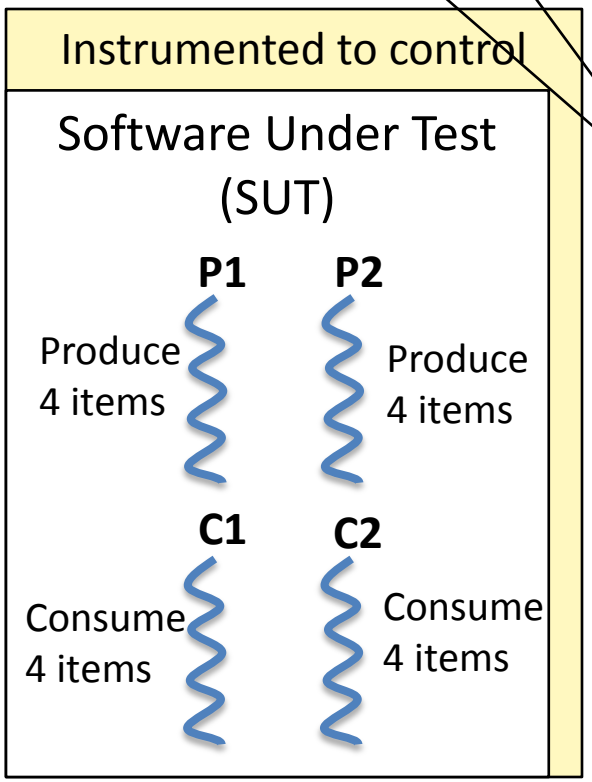
  WHILE (!ALL_ENDED(P1, P2, C1, C2)) {
    TVAR(t);

    CHOOSE_THREAD_BACKTRACK(
        t, (P1, P2, C1, C2));

    RUN_THREAD_THROUGH(
        t, READS() || WRITES() || CALLS()
           || ENTERS() || RETURNS());
  }
}
```

SearchAll: Search all schedules

Run captured threads

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TESTCASE() {

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  TVAR(C1);  TVAR(C2);

  WAIT_FOR_DISTINCT_THREADS(
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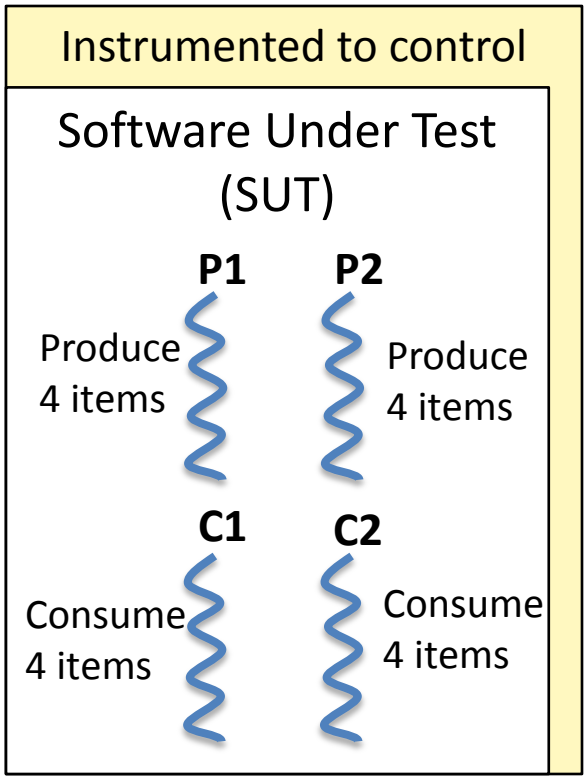
  WAIT_FOR_DISTINCT_THREADS(
      (C1, C2), ENTERS(consumer_routine));

  WHILE (!ALL_ENDED(P1, P2, C1, C2)) {
    TVAR(t);

    CHOOSE_THREAD_BACKTRACK(
        t, (P1, P2, C1, C2));

    RUN_THREAD_THROUGH(
        t, READS() || WRITES() || CALLS()
           || ENTERS() || RETURNS());
  }
}
```

SearchInFunc: Localize search to particular functions and operations




```
TESTCASE() {

  TVAR(P1);  TVAR(P2);
  TVAR(C1);  TVAR(C2);

  WAIT_FOR_DISTINCT_THREADS(
      (P1, P2), ENTERS(bounded_buf_put));

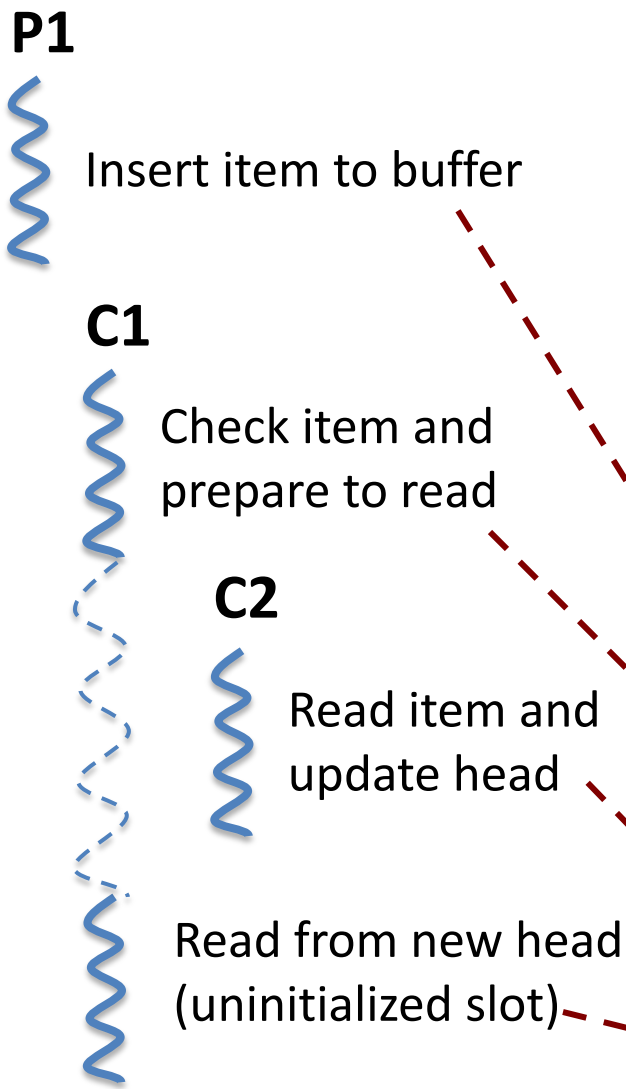
  WAIT_FOR_DISTINCT_THREADS(
      (C1, C2), ENTERS(bounded_buf_get));

  WHILE (!ALL_ENDED(P1, P2, C1, C2)) {
    TVAR(t);

    CHOOSE_THREAD_BACKTRACK(
        t, (P1, P2, C1, C2));

    RUN_THREAD_THROUGH(
        t, ENTERS() || RETURNS()
            || HITS_MANUAL_PC());
  }
}
```

BuggySchedule




```
TESTCASE() {

  TVAR(P1);
  TVAR(C1);  TVAR(C2);

  WAIT_FOR_THREAD(
       P1, ENTERS(bounded_buf_put));

  WAIT_FOR_DISTINCT_THREADS(
       (C1, C2), ENTERS(bounded_buf_get));

  RUN_THREAD_THROUGH(
       P1, RETURNS(bounded_buf_put));

  RUN_THREAD_THROUGH(
       C1, HITS_MANUAL_PC(42));

  RUN_THREAD_THROUGH(
       C2, RETURNS(bounded_buf_get));

  RUN_THREAD_THROUGH(C1, ENDS()); // ERROR!
}
```

Where We Ended Up

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