Concurrent Programming

Example

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int y = 0, z = 0;
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int y = 0, z = 0;

P1::  x = y + z;
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int y = 0, z = 0;

P1::  x = y + z;        P2::  y = 1;
                              z = 2;
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  - Execution order
  - What is atomic

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- History: a trace of ONE execution; an interleaving of atomic actions
- Property: an attribute of ALL histories of a program, e.g., correctness

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- Atomicity may be required when fine-grained atomicity is insufficient
  - Need mechanism for constructing coarse-grained atomic actions
    - Sequence of fine-grained atomic actions
    - Appearance of indivisibility

Specifying Atomic Actions

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- < S; >
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- < await(B); >
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- < await(B) S; >
  - wait for B to be true, then execute S ALL AS A SINGLE ATOMIC ACTION

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if n = 2 and m = 4, this is 70 histories!

Proving Properties

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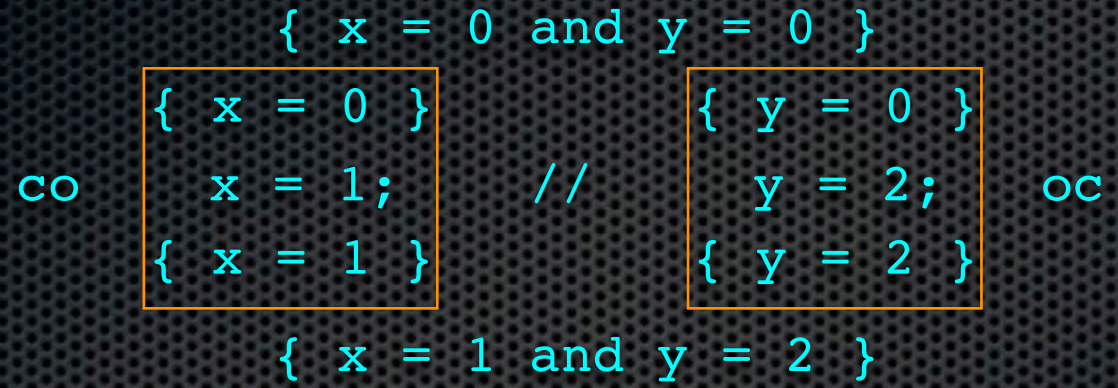
```
co    x = 1;    //     y = 2;   oc
```

Proving Properties

```
co  { x = 0 }      //   { y = 0 }   oc
      x = 1;             y = 2;
    { x = 1 }          { y = 2 }
```

Proving Properties



- The precondition of the concurrent program is the conjunction (and) of the preconditions of the processes.

Proving Properties

```
                { x = 0 and y = 0 }
          { x = 0 }          { y = 0 }
     co     x = 1;     //      y = 2;     oc
          { x = 1 }          { y = 2 }
                { x = 1 and y = 2 }
```

- The precondition of the concurrent program is the conjunction (and) of the preconditions of the processes.
- If the processes are disjoint -- as here -- then the "proofs" don't interfere, so the postcondition is the conjunction (and) of the postconditions of the processes.

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  - Statements in one process invalidating assertions in another
  - Caused by shared variables

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1) disjoint variables -- independent processes
2) weakened assertions -- say less than you could in isolation
3) synchronization -- hide states and/or delay execution
4) global invariants -- predicates that are true in ALL visible states

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  - Combining fine-grained atomic actions into coarse-grained atomic actions
    - *Mutual exclusion*
  - Delaying process execution until some predicate is satisfied
    - *Condition Synchronization*