Non-deterministic parallelism considered useful

Derek G. Murray Steven Hand

University of Cambridge

1. **Parallelization**
2. **Synchronization**
3. **Scheduling**
4. **Load balancing**
5. **Communication**
6. **Fault tolerance**
7. **Guaranteed termination**

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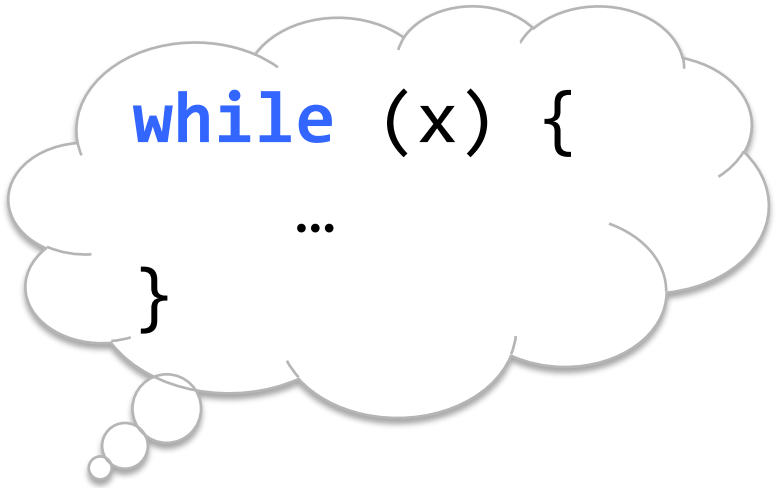

1. Parallelization
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5. Communication
6. Fault tolerance ⇔ Deterministic
7. ~~Guaranteed termination~~

Real programmers don't use

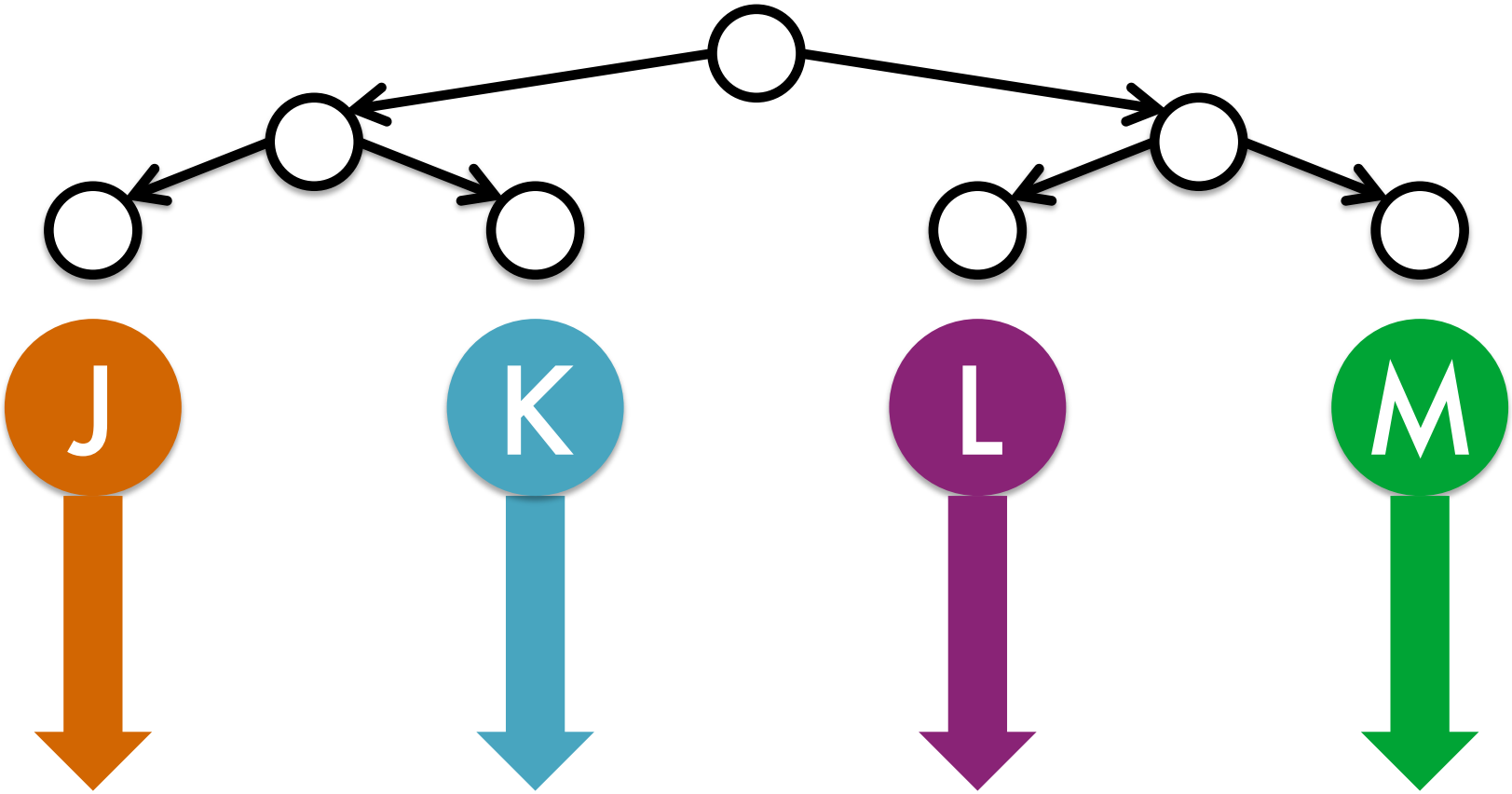
deterministic parallelism

Real programmers use

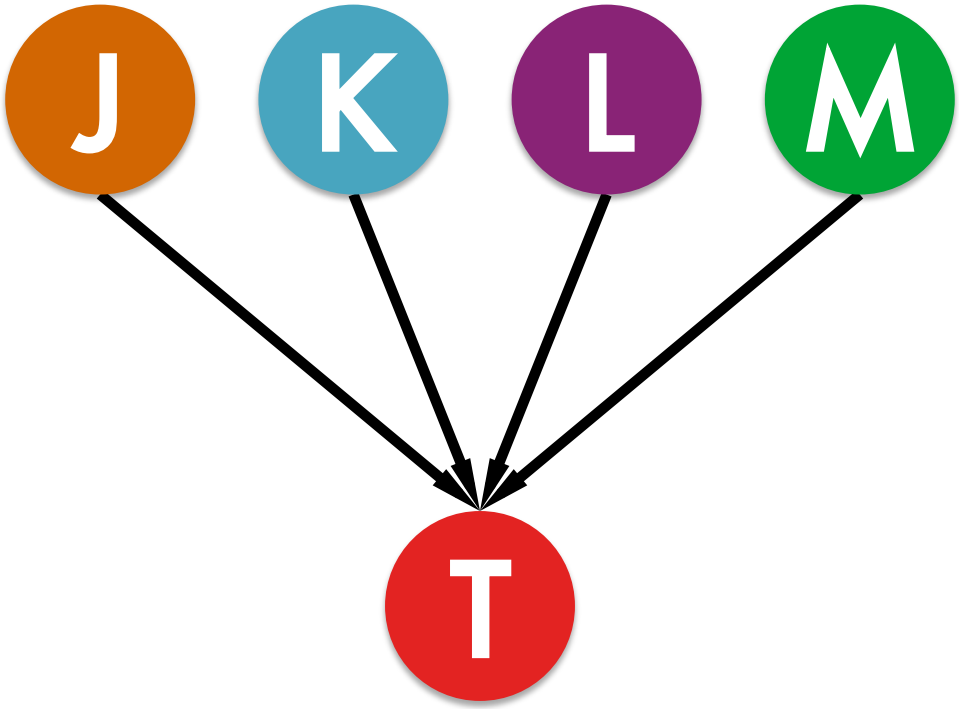
- Async. Networks
- Real hardware
- Performance interference
- User input
- Timeouts
- Signals
- `select()` loops
- Condition variables
- Mutable state

All of these cause non-determinism!

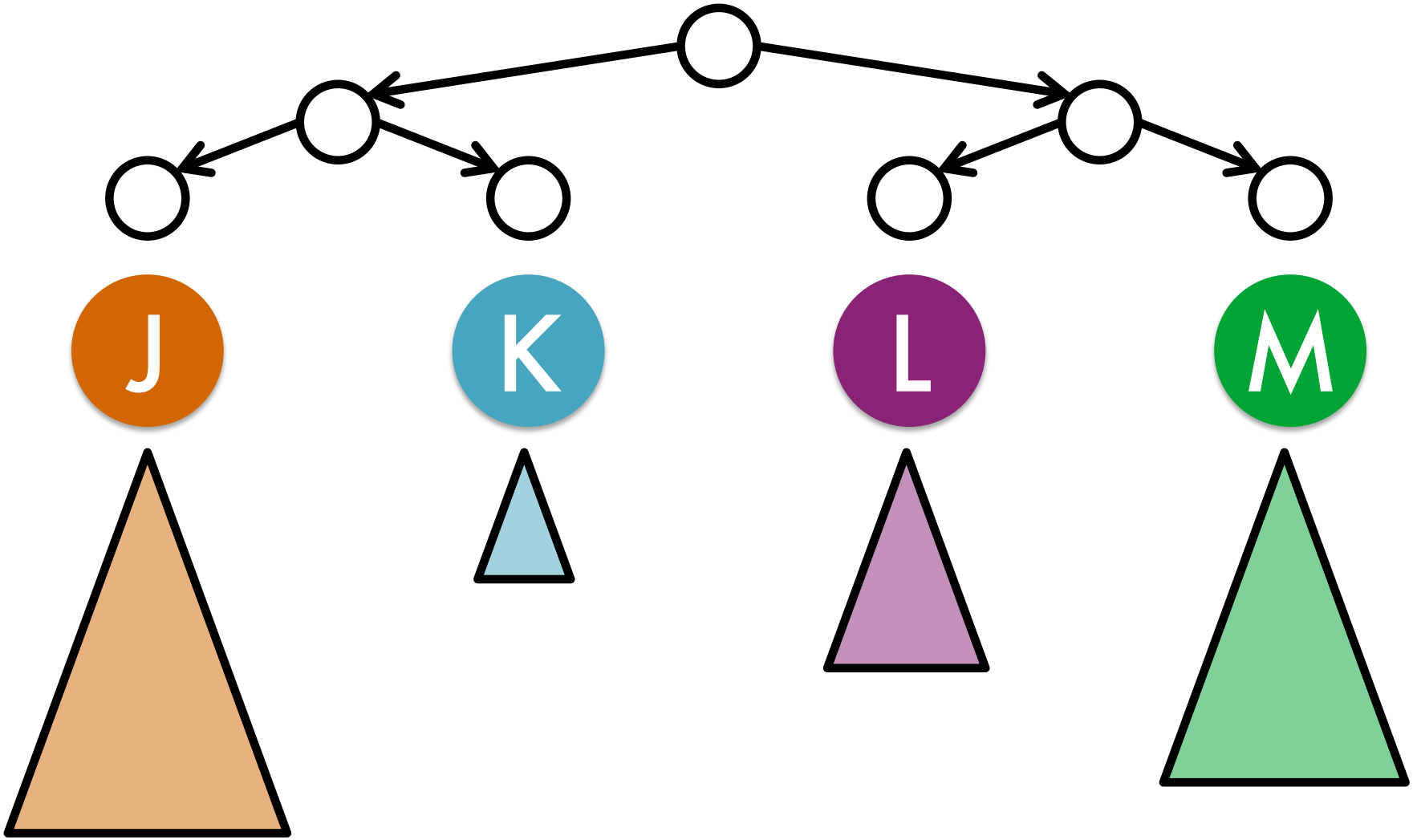
Example: branch-and-bound



Deterministic data flow



Irregular parallelism



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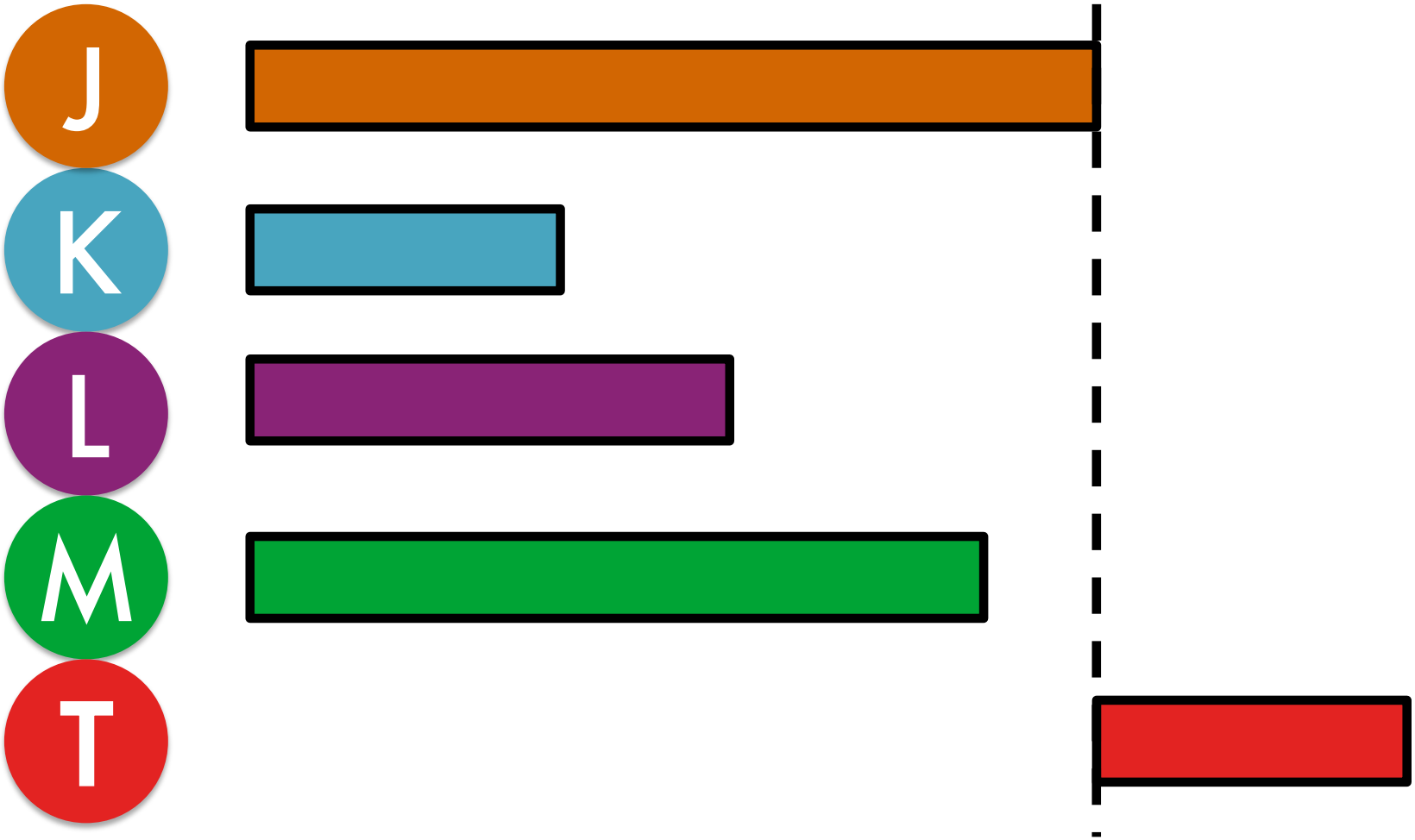
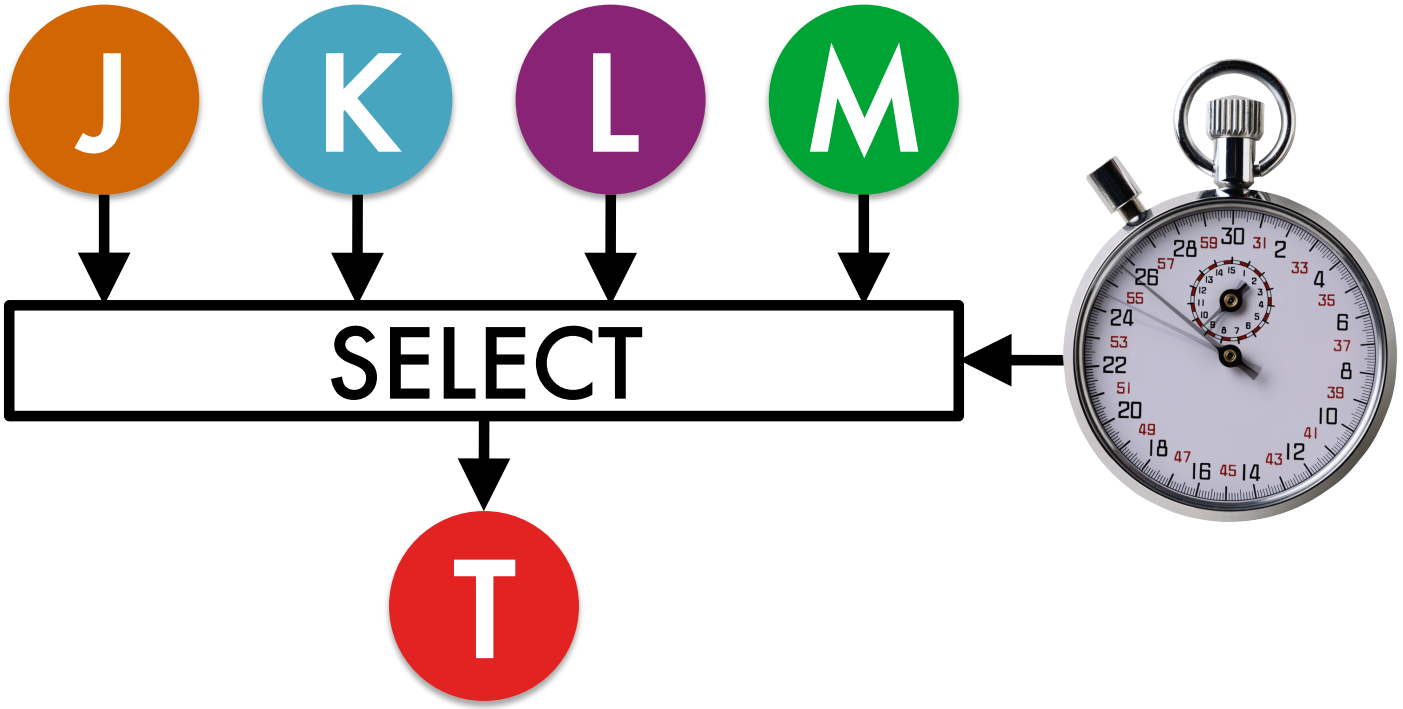


Non-deterministic select



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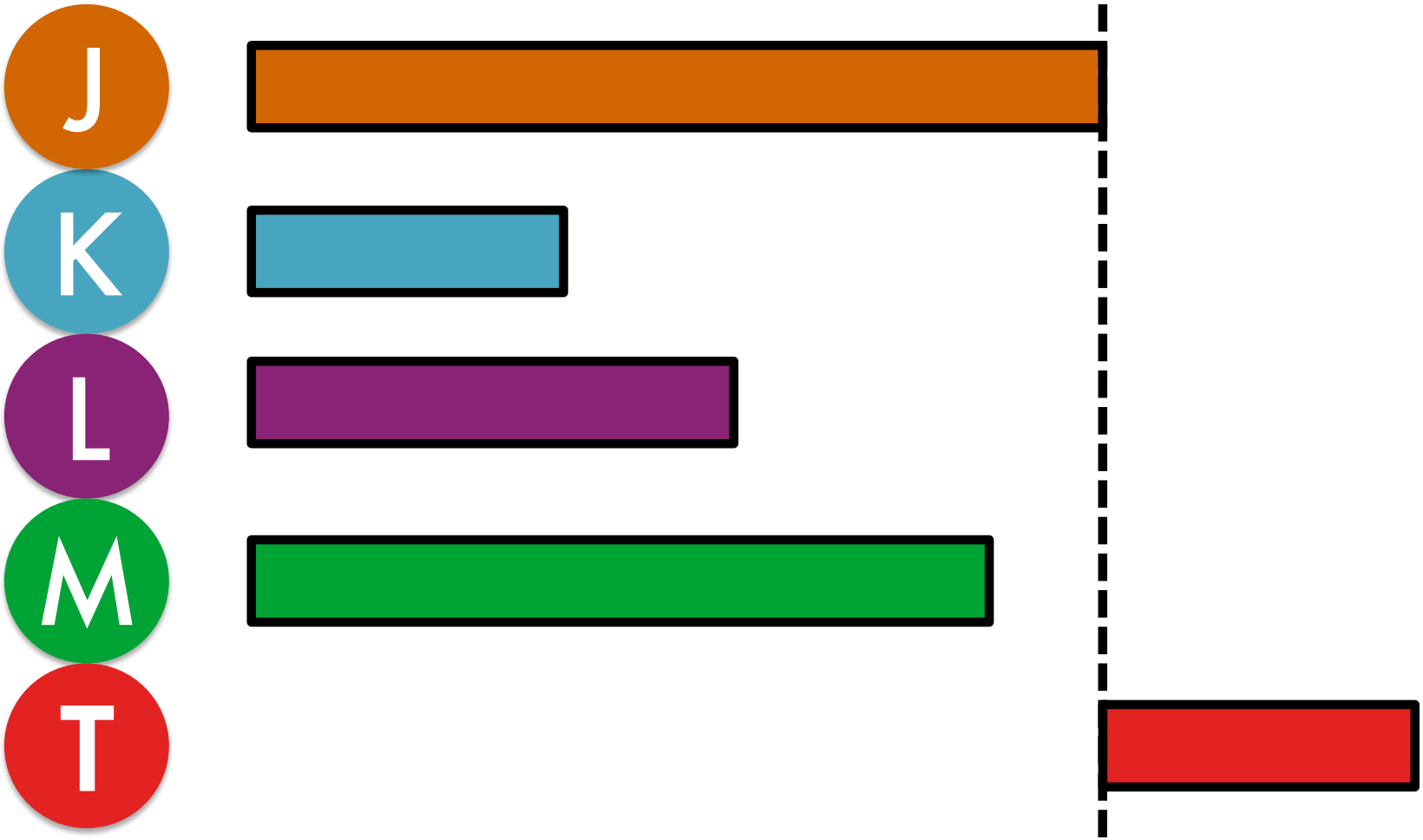
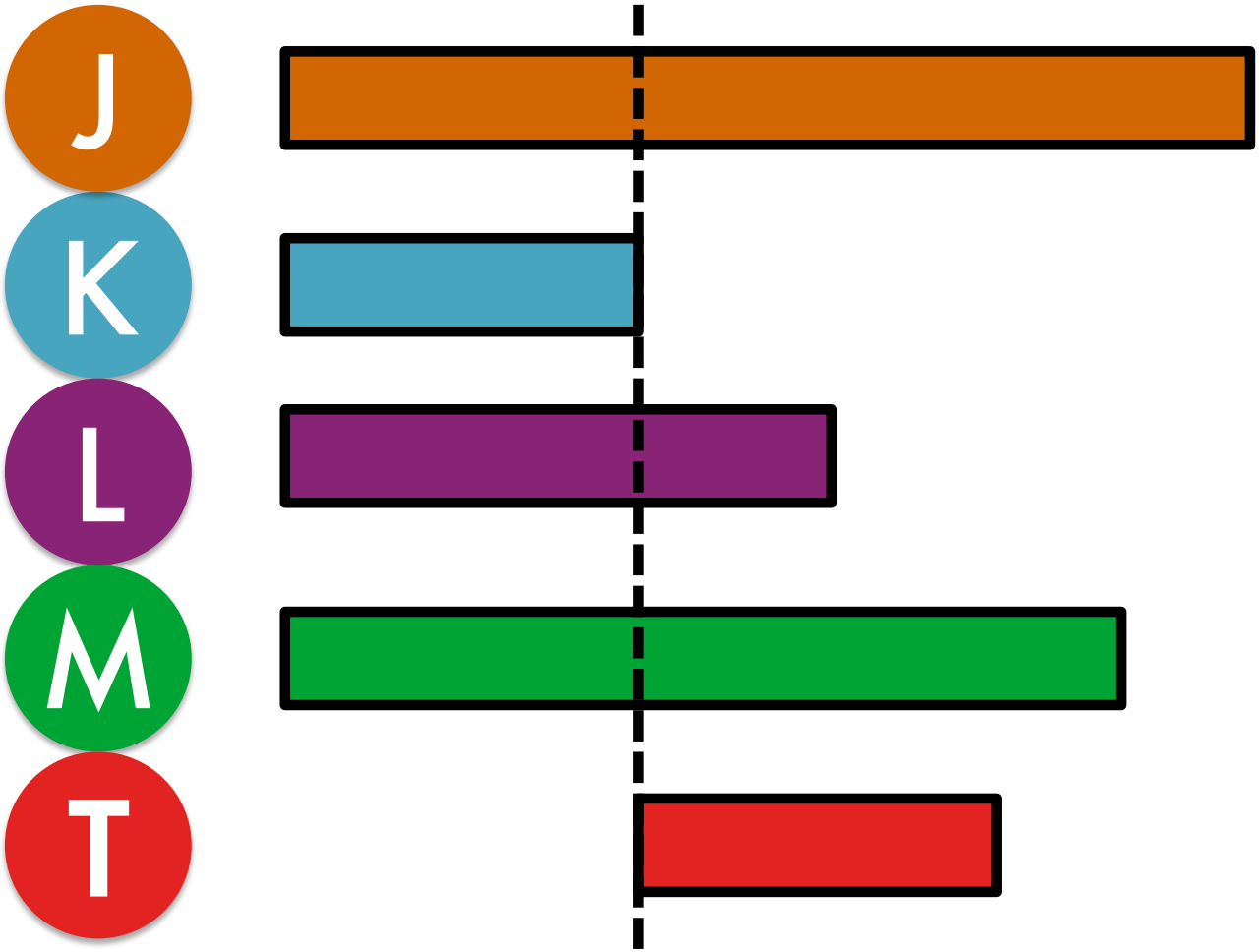
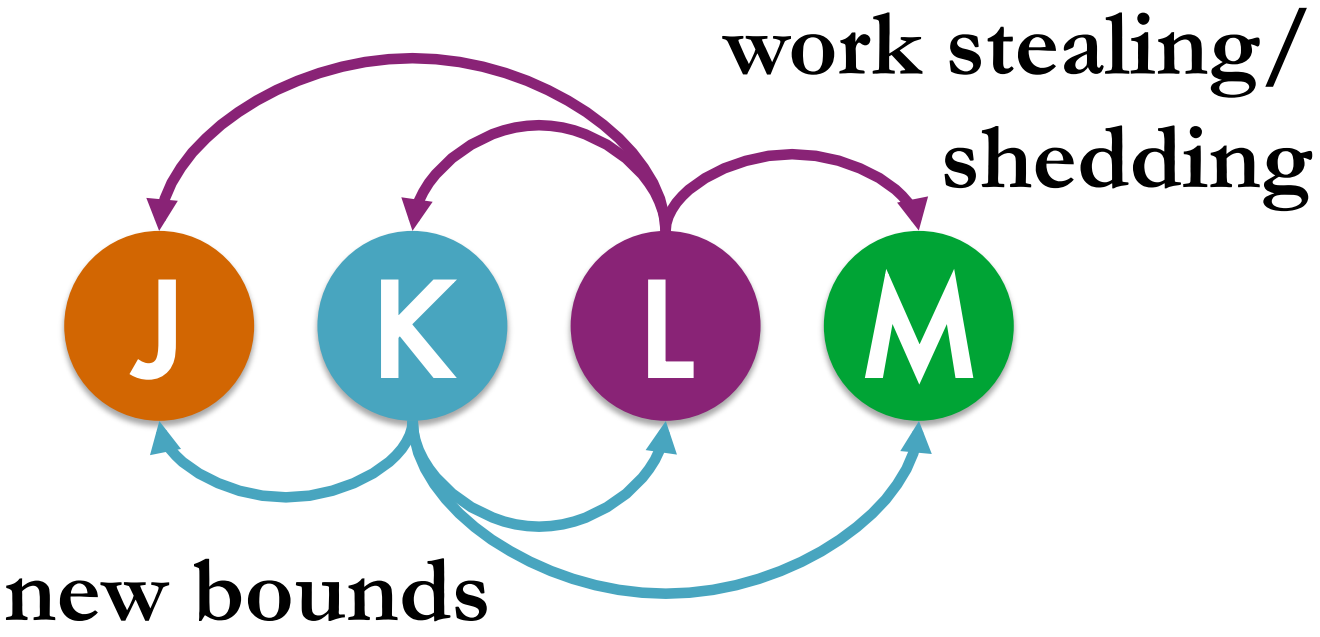


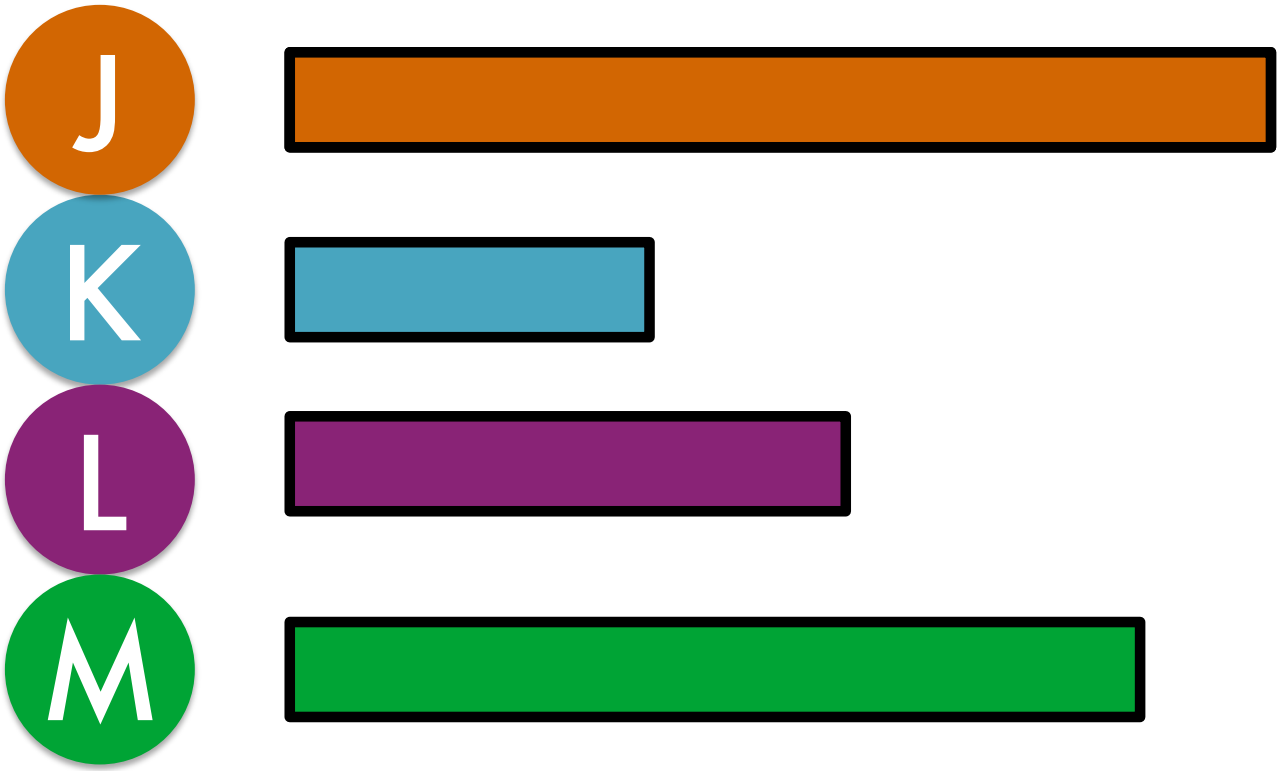
Non-deterministic select



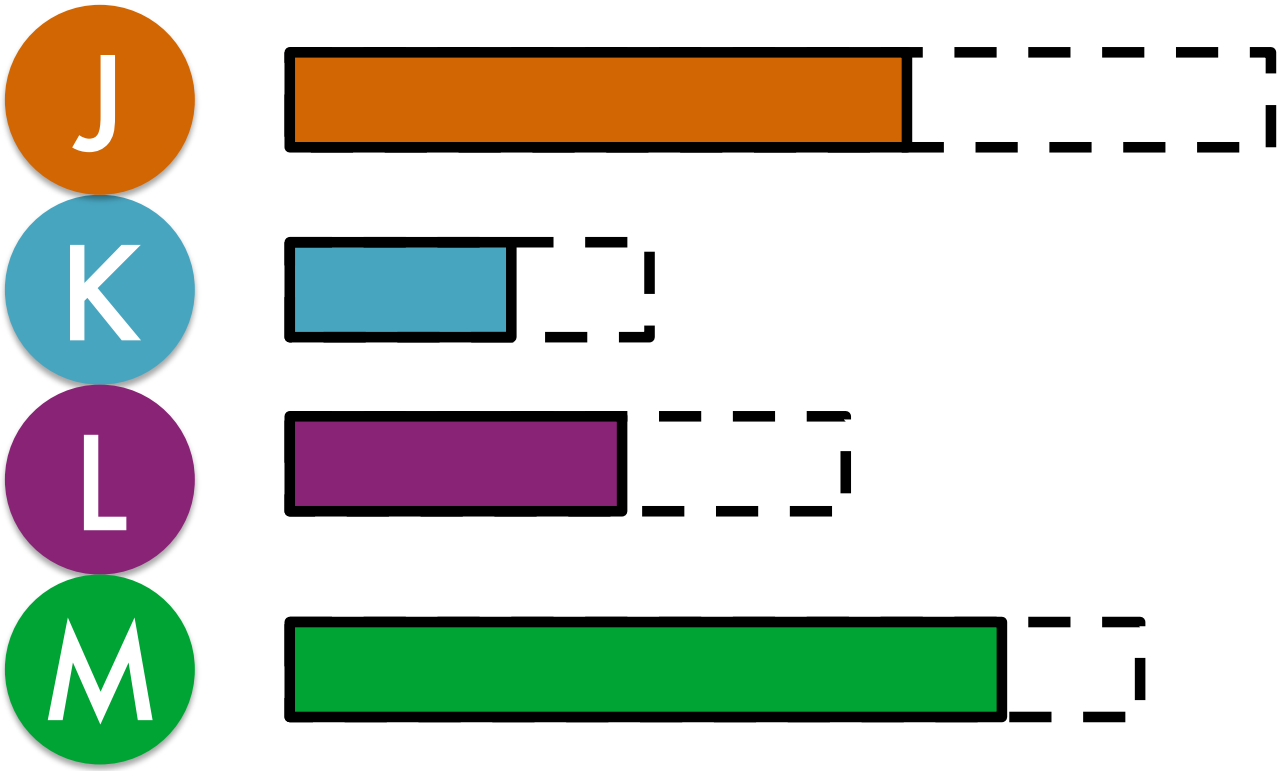
Asynchronous signals



Asynchronous signals



Asynchronous signals



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Challenge: dealing with faults

- Fail everything
  - Error codes/exceptions
  - Bounded non-determinism
  - Checkpoints
- Record and replay

Conclusions

- Many benefits of non-determinism
  - Performance, adaptability, interactivity
- System must allow non-determinism
- Determinism at language-level
  - For programmers who need training wheels