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Concurrency and Parallelism
(Concorrência e Paralelismo – CP 11158)

Lecture 3

— Blocking and Non-blocking Synchronization,
and Consistency Semantics —

Slides based in material from:
Gadi Taubenfeld (http://www.faculty.idc.ac.il/gadi/book.htm)

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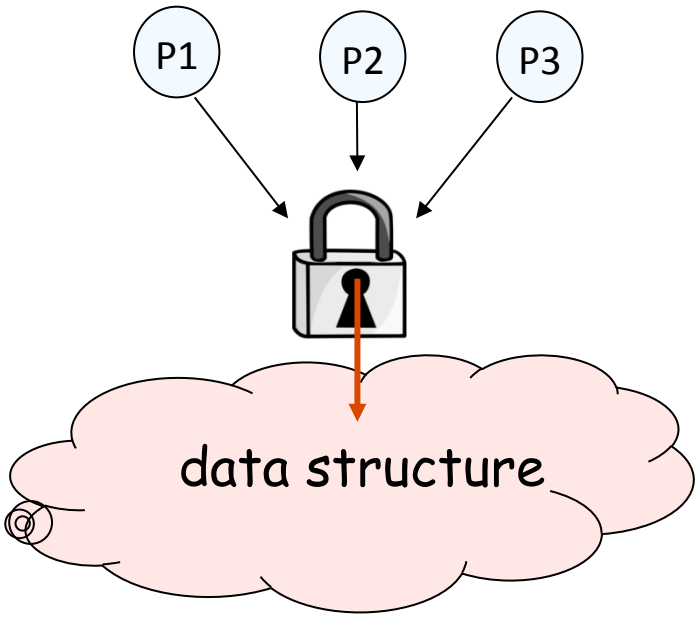
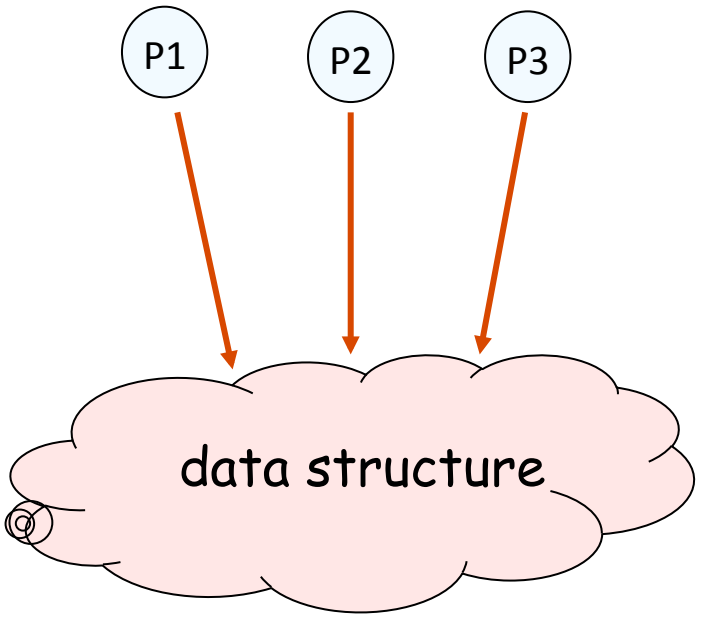
Concurrent Data Structures

Using locks



Without locks



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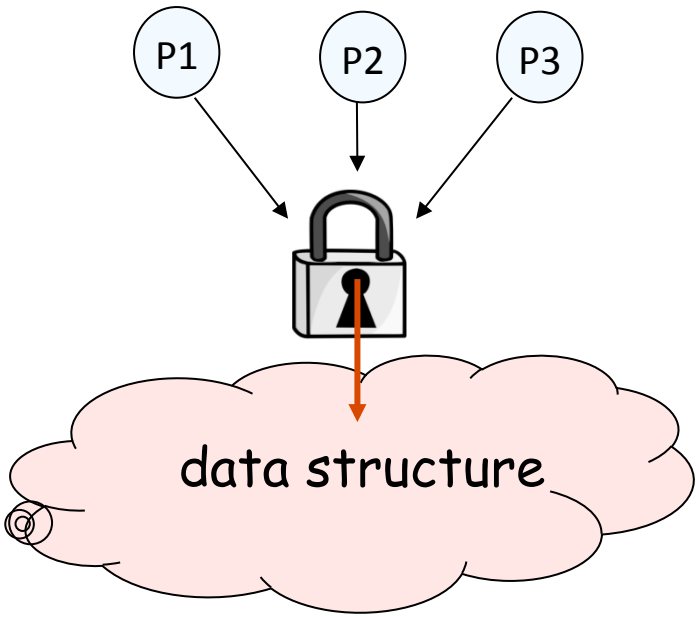
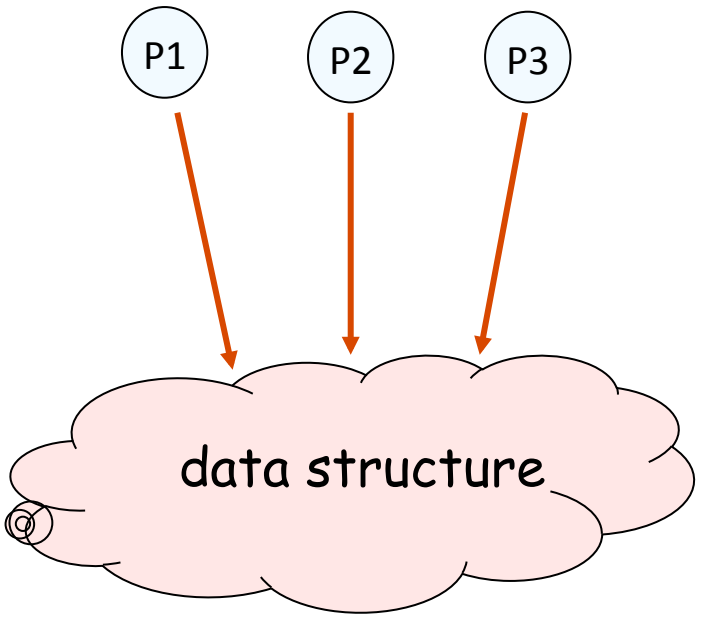


- simple programming model
- false conflicts
- fault-free solutions only
- sequential bottleneck

Without locks



- resilient to failures, etc.
- often complex
- memory consuming
- sometime -- weak progress cond.

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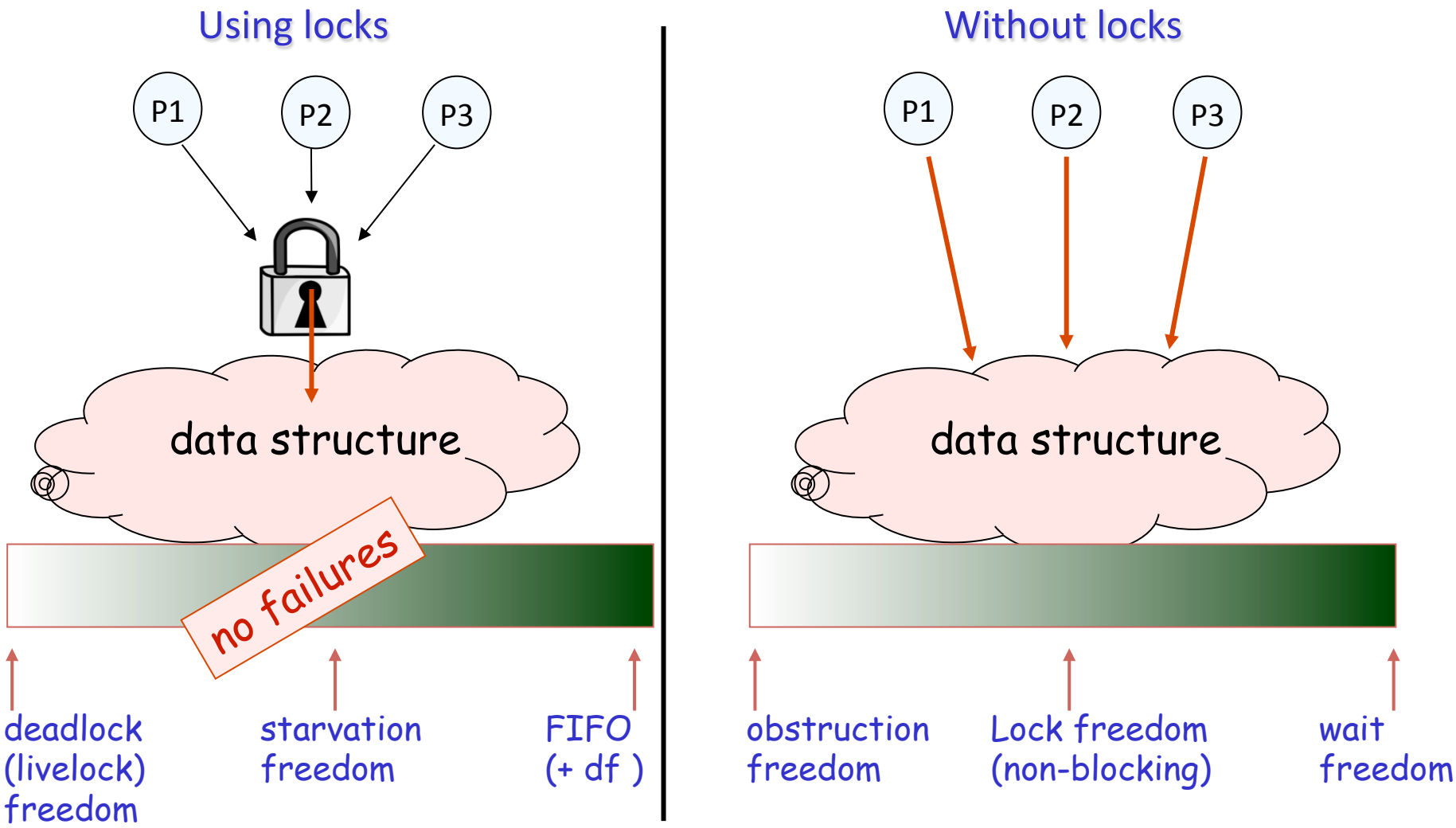
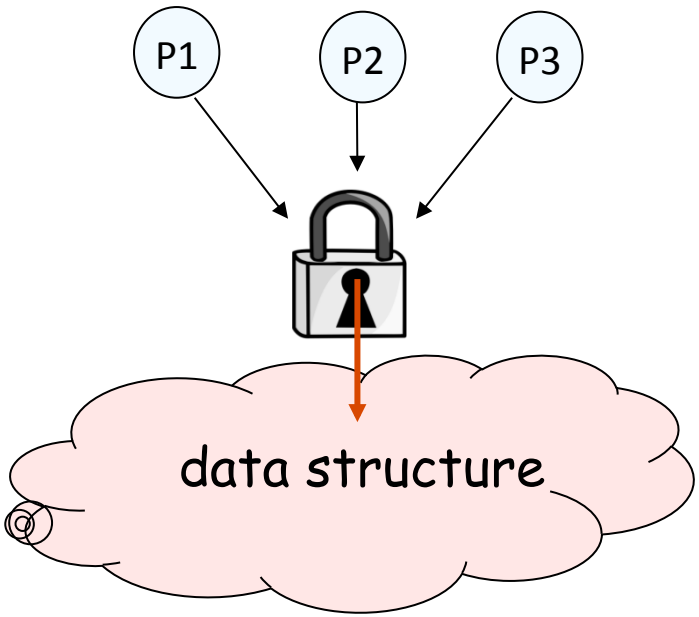
Concurrent Data Structures

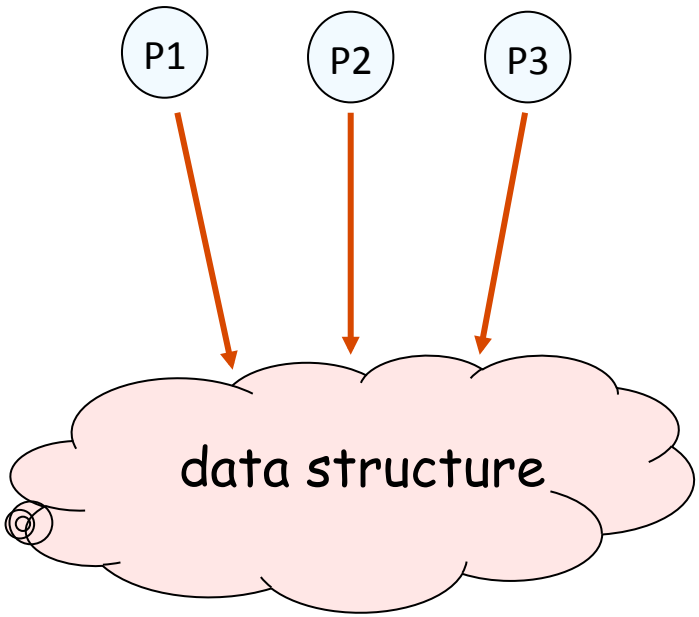


Progress Conditions

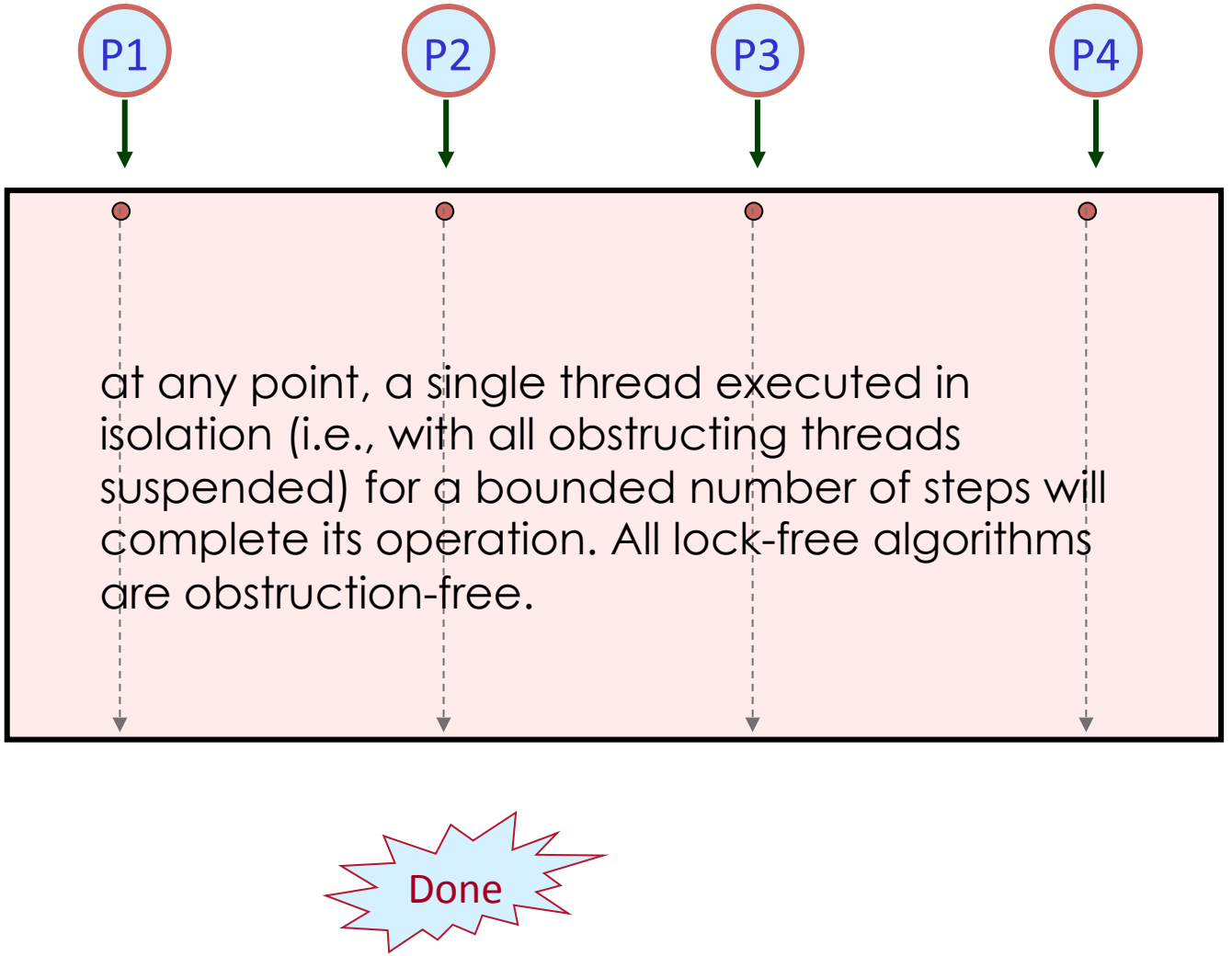
Using locks



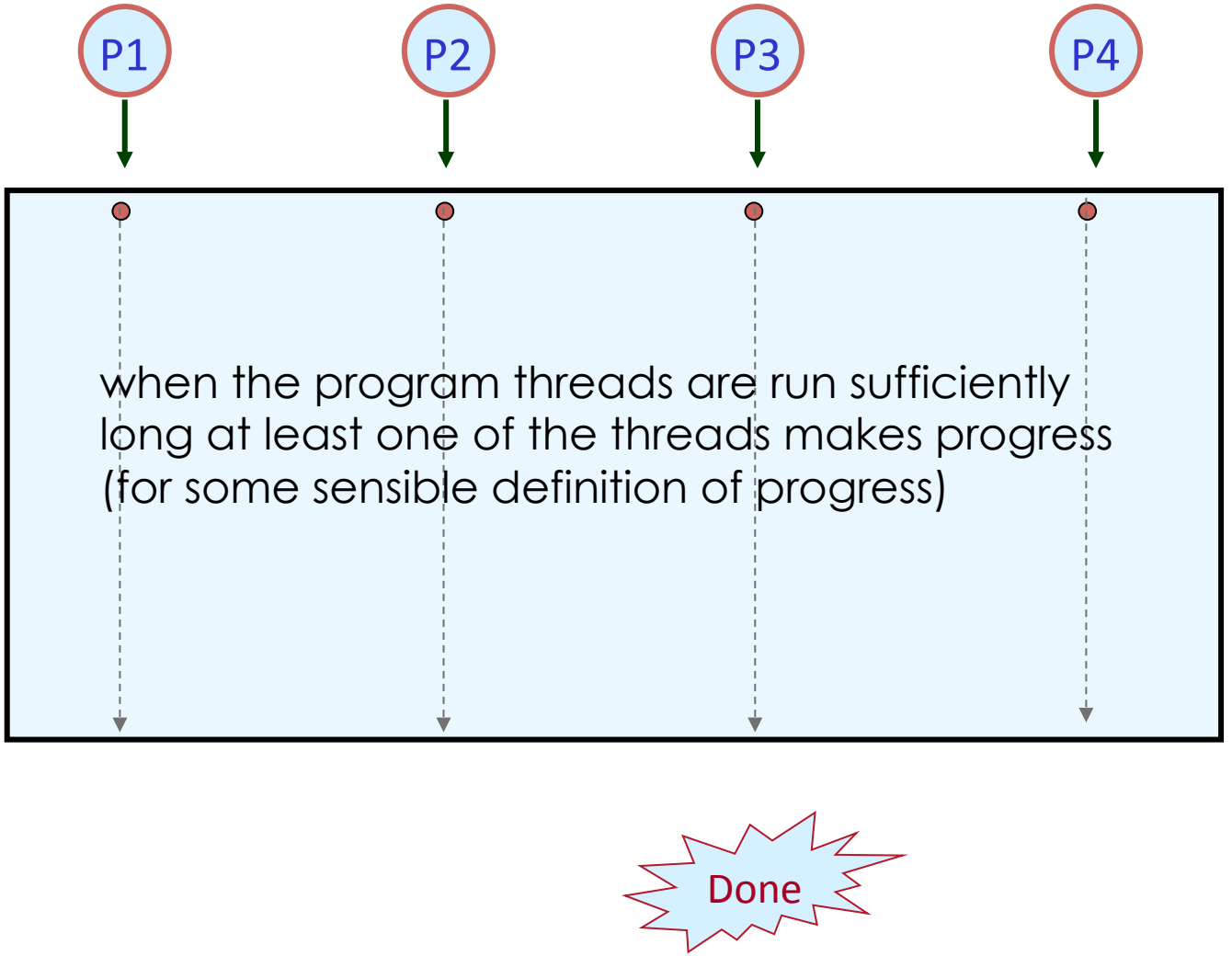
Without locks



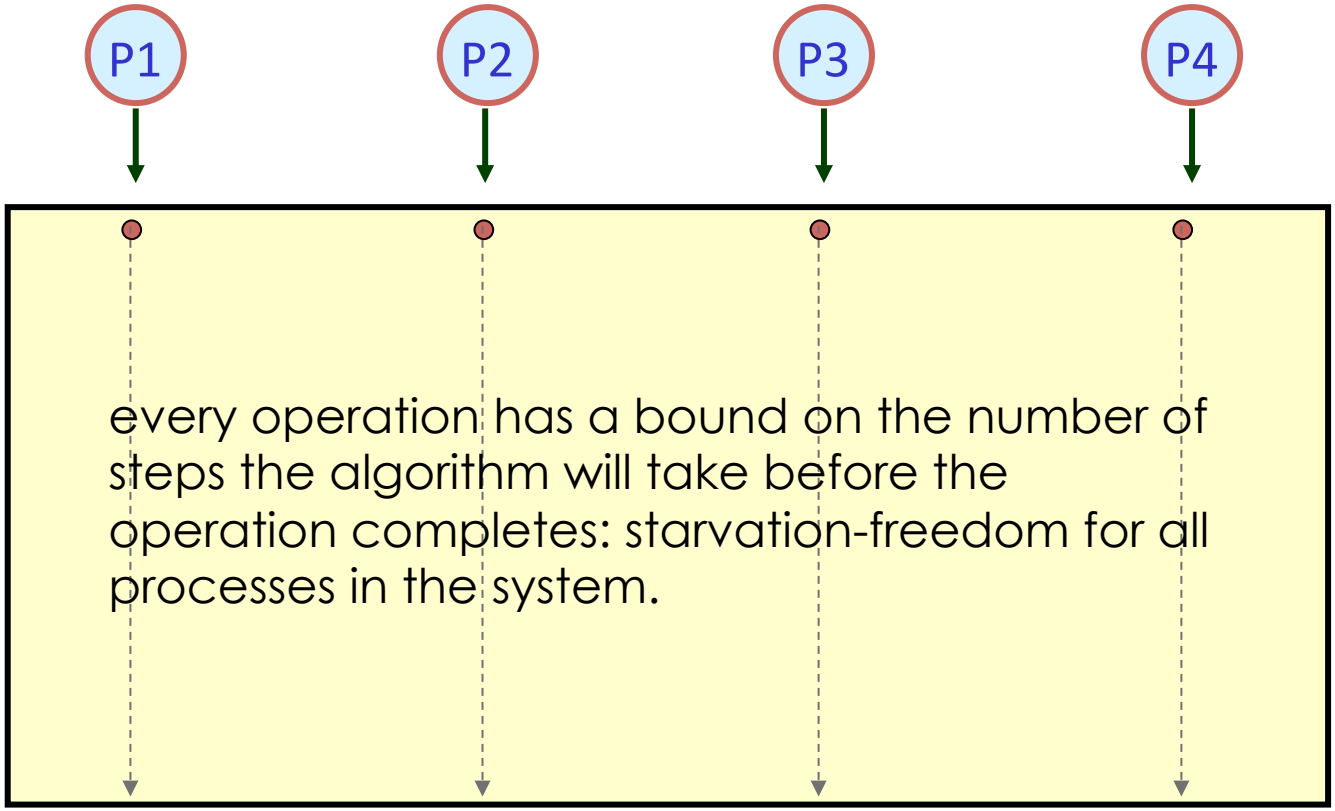
Obstruction-freedom



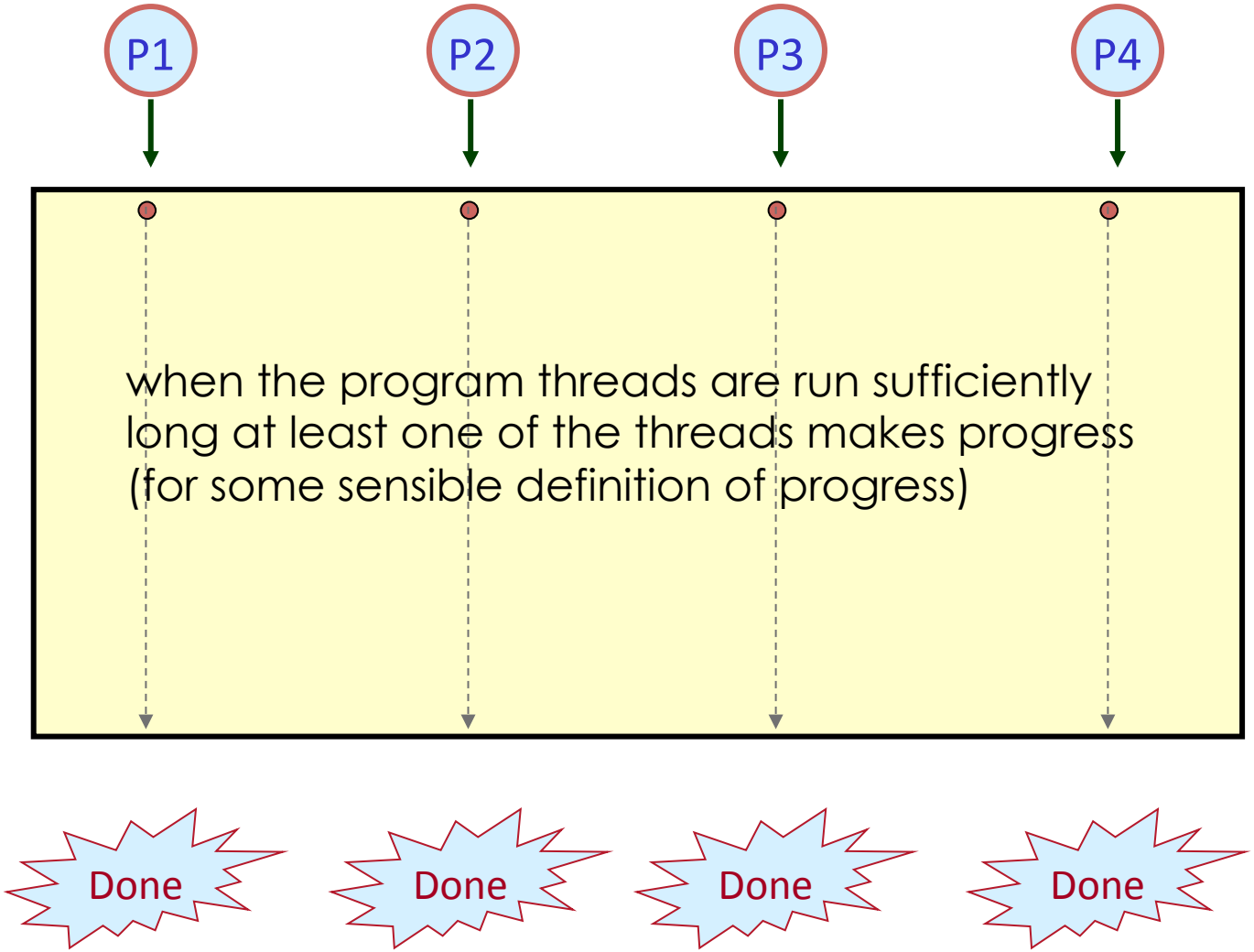
Lock-freedom



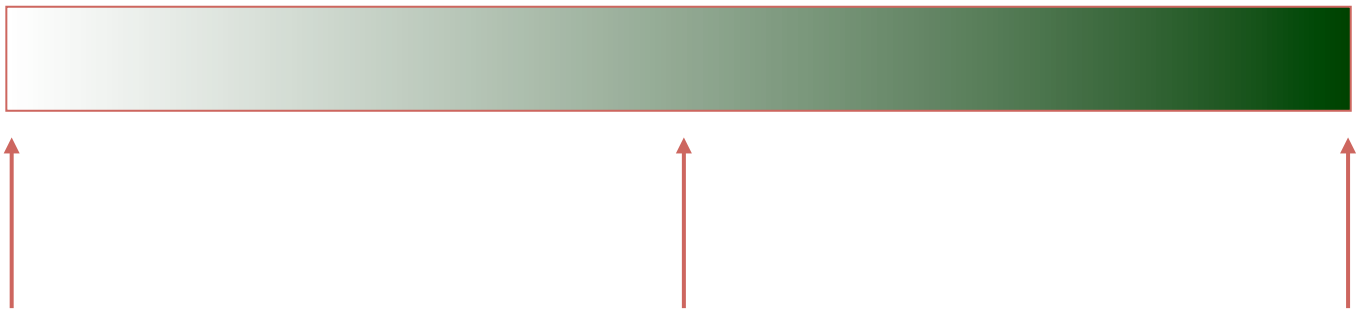
Wait-freedom



Wait-freedom



Lock-free Data Structures



Obstruction-freedom

- too weak progress condition
- not complex

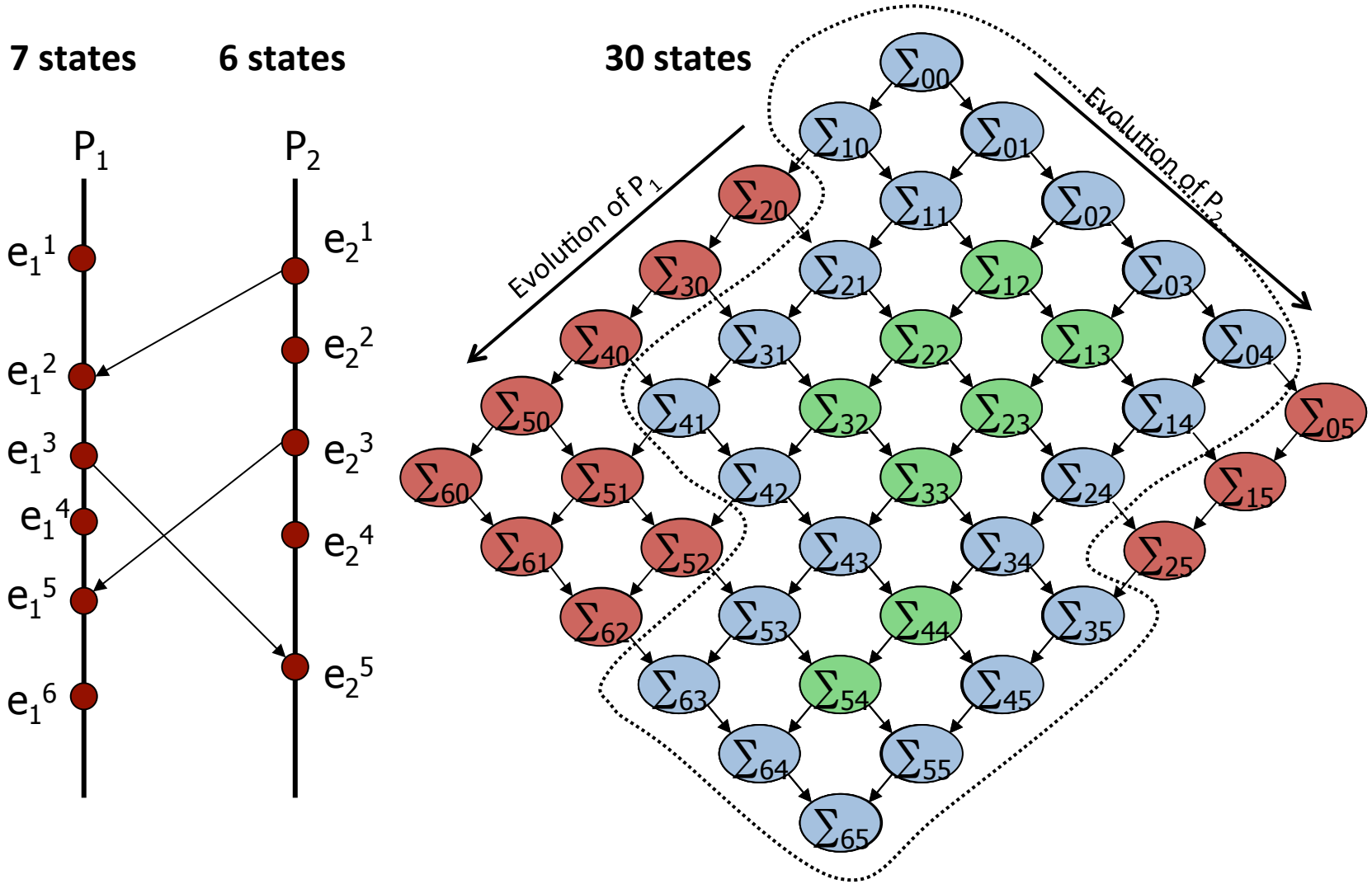
Lock-freedom

- strong enough
- not so complex

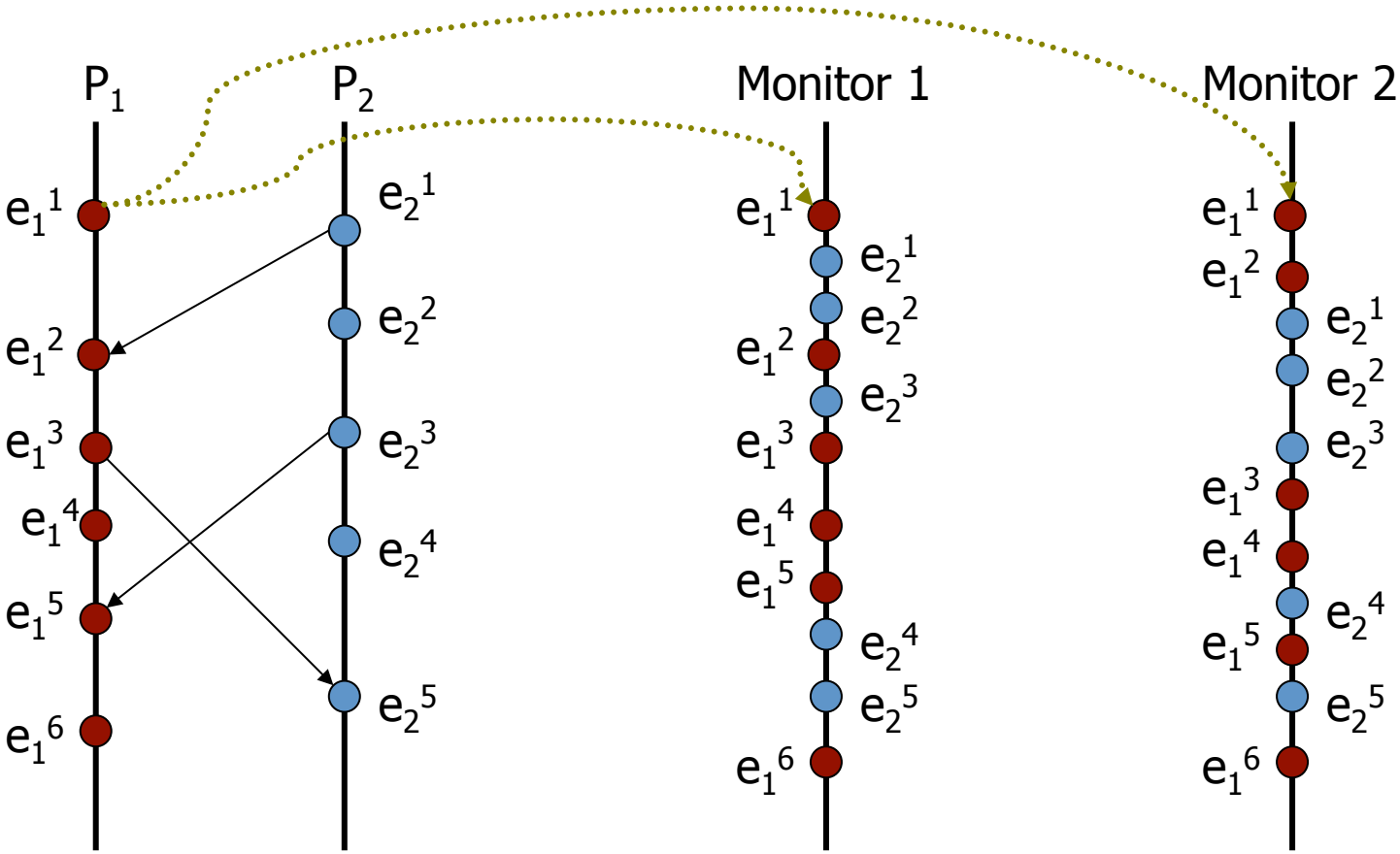
Wait-freedom

- strong/desirable
- complex/less efficient

State explosion in concur. progs.



Observations



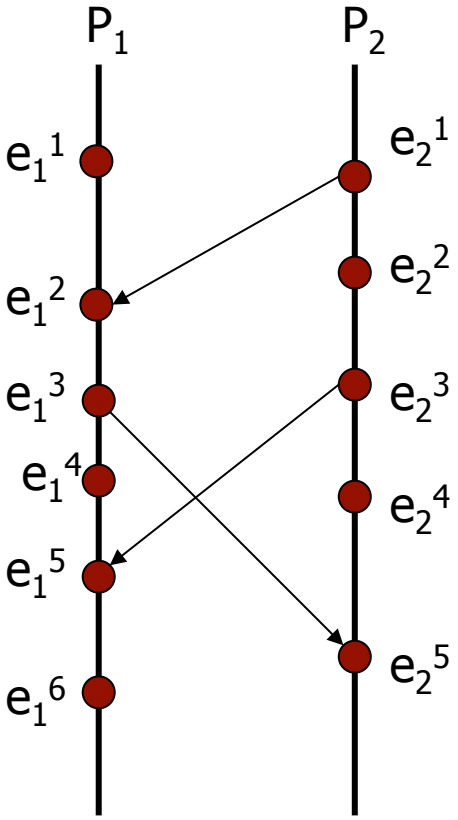
Consistent observations

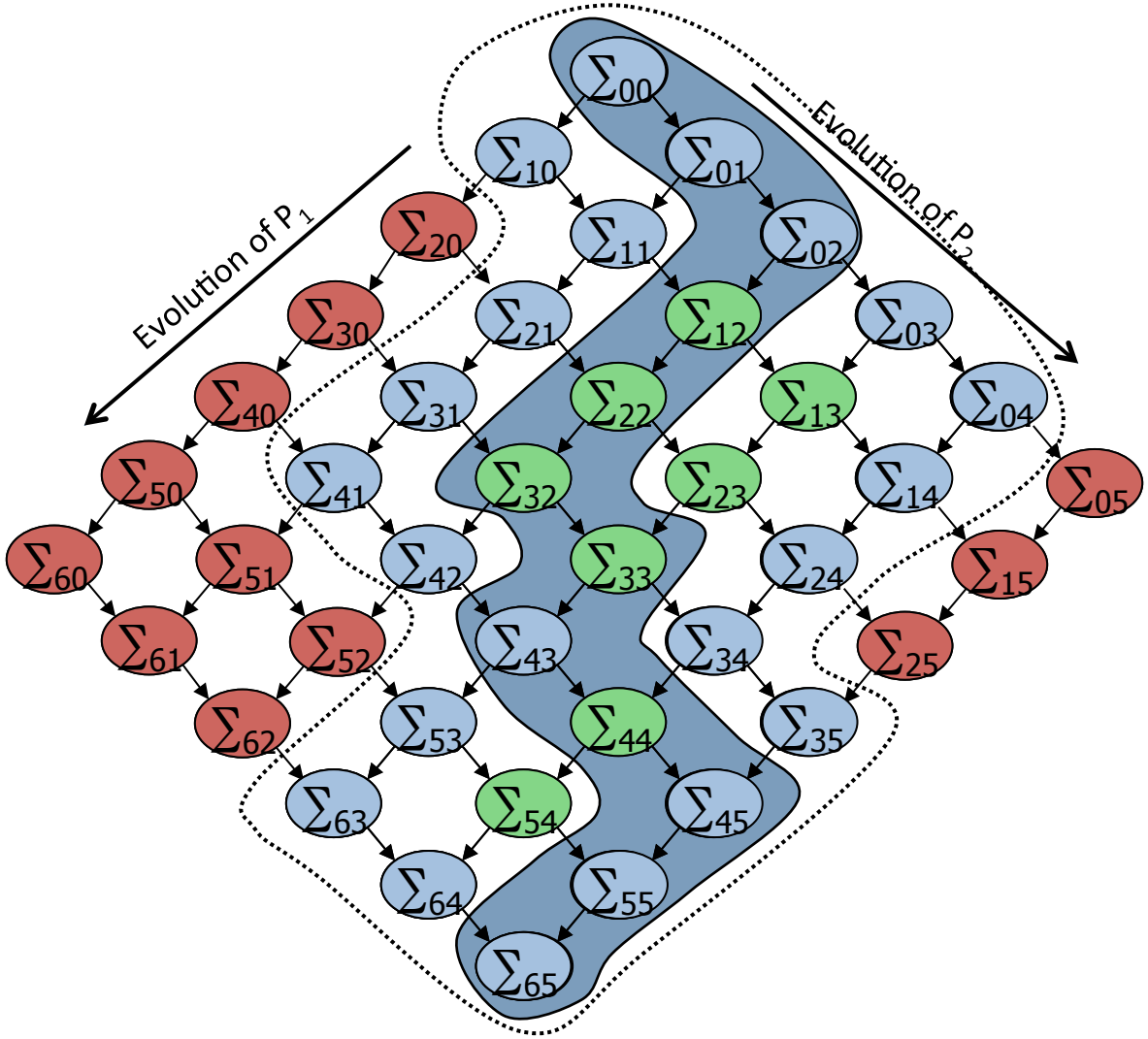
- Any permutation of a run R is a **possible observation** of it
  - The communication channels may not preserve message order
- A ***consistent (inconsistent) observation*** is one that corresponds to a consistent (inconsistent) run

Consistent run

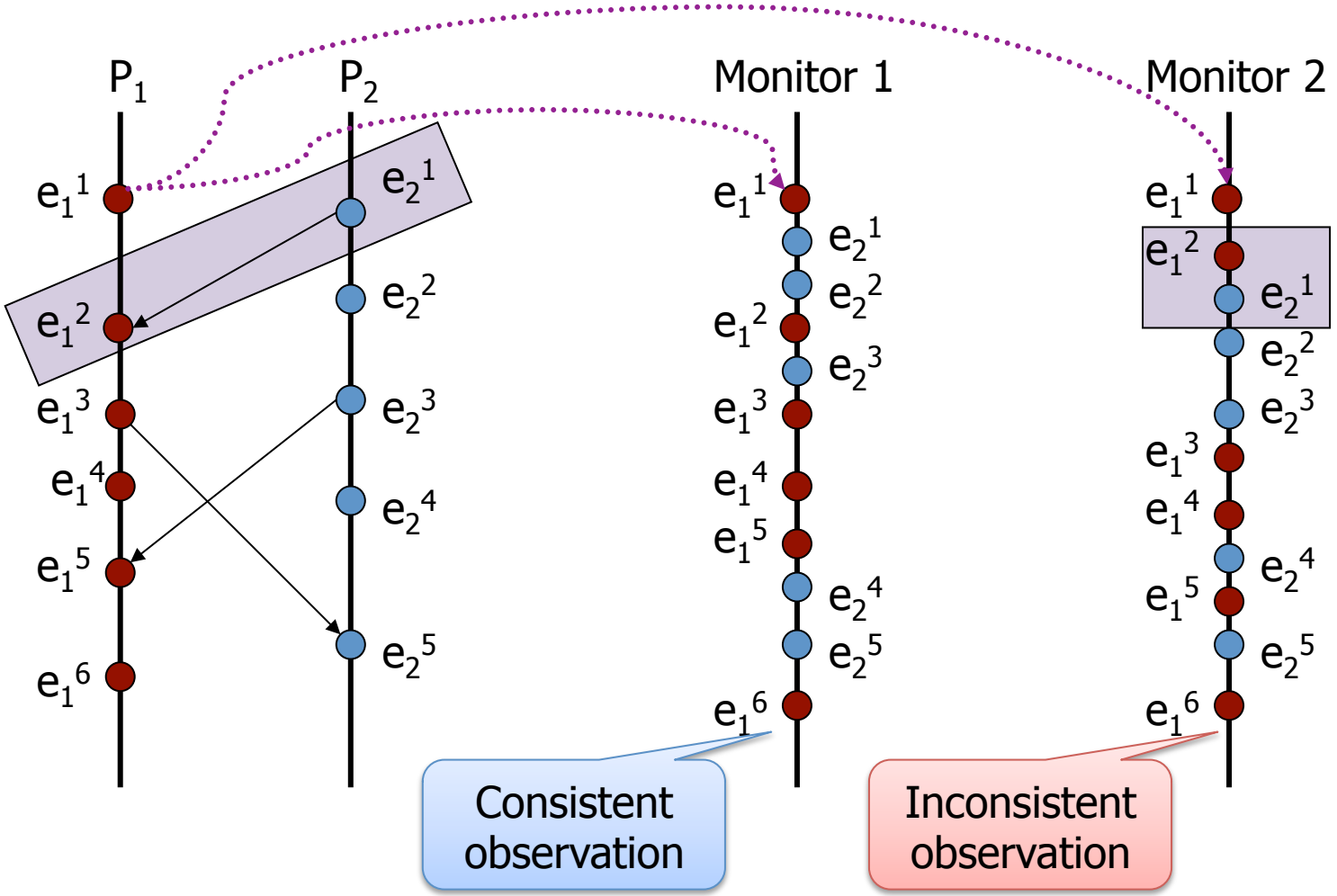
- A ***run is consistent*** if all of its states/events verify the causal precedence relation
  - Any consistent run is a possible execution of a concurrent program

Consistent run





Inconsistent observation



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Consistency Conditions for Concurrent Objects

- How do we define the correctness of a concurrent object ?
  - Linearizability
  - Sequential Consistency
  - …

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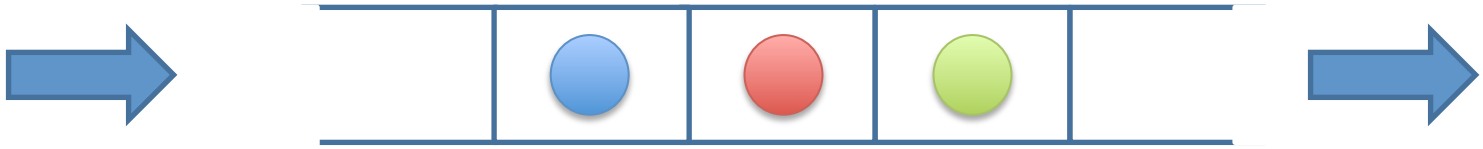
Why are consistency conditions important

- Help to understand possible behaviors of an implementation of a concurrent object and to reason about correctness
- Clarifies what optimizations are acceptable
- Allows the formal specification of concurrent objects

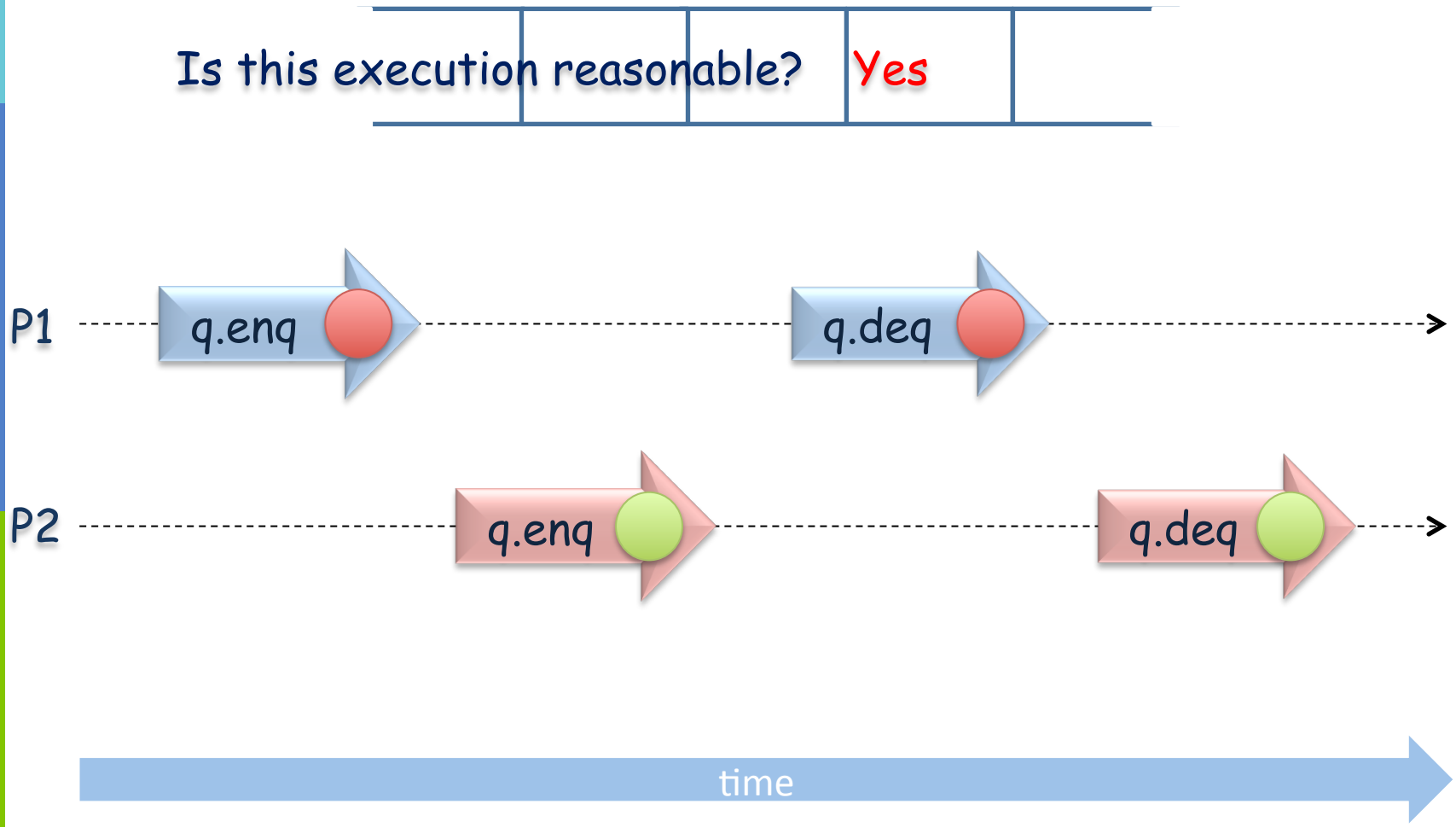
Example: Concurrent Queue



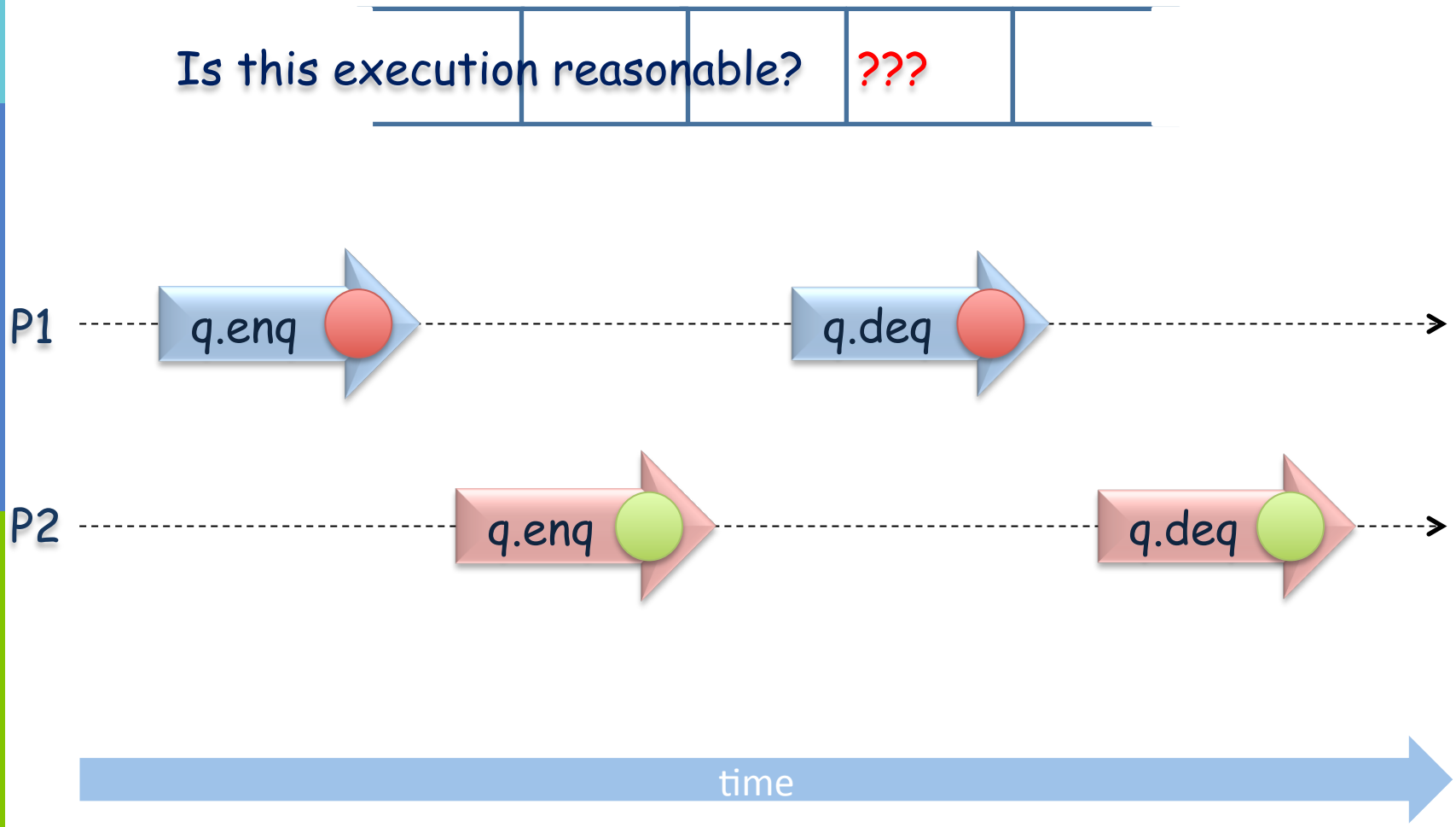
q.enq( )

q.deq( )

Sequential Execution

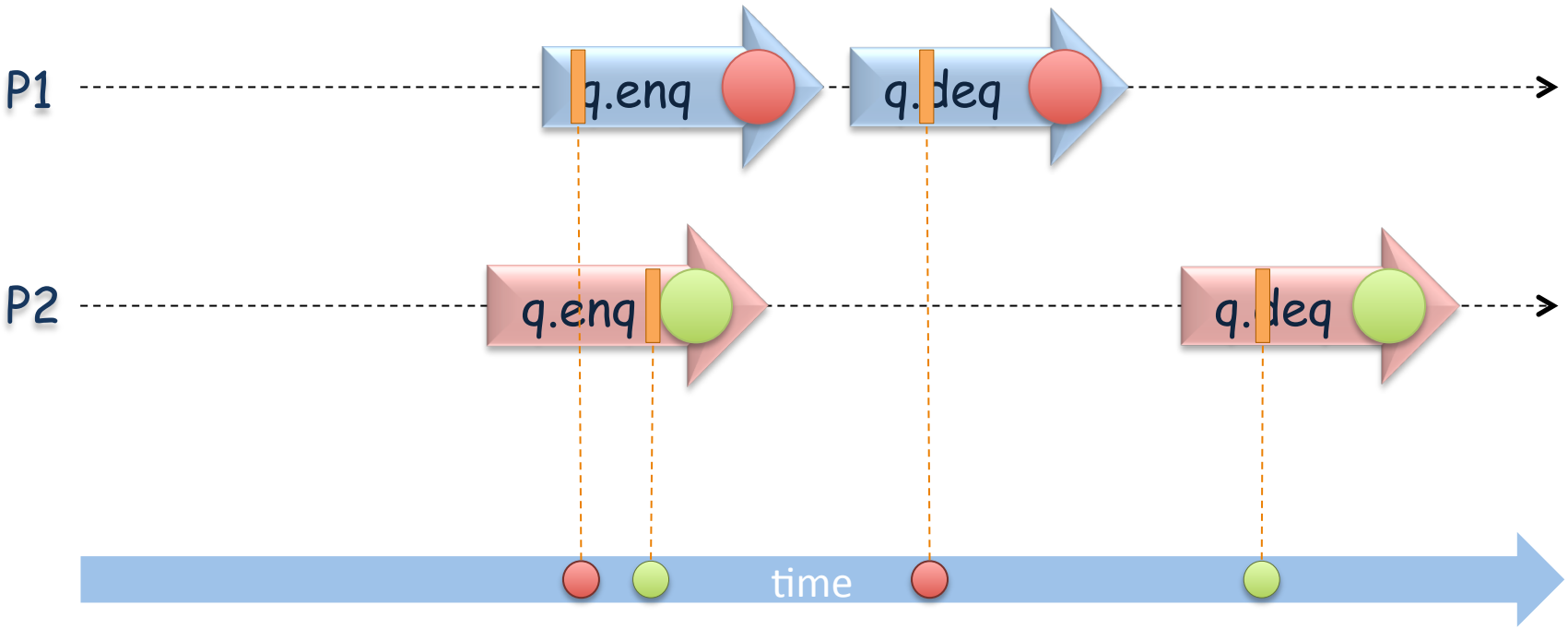


Concurrent Execution



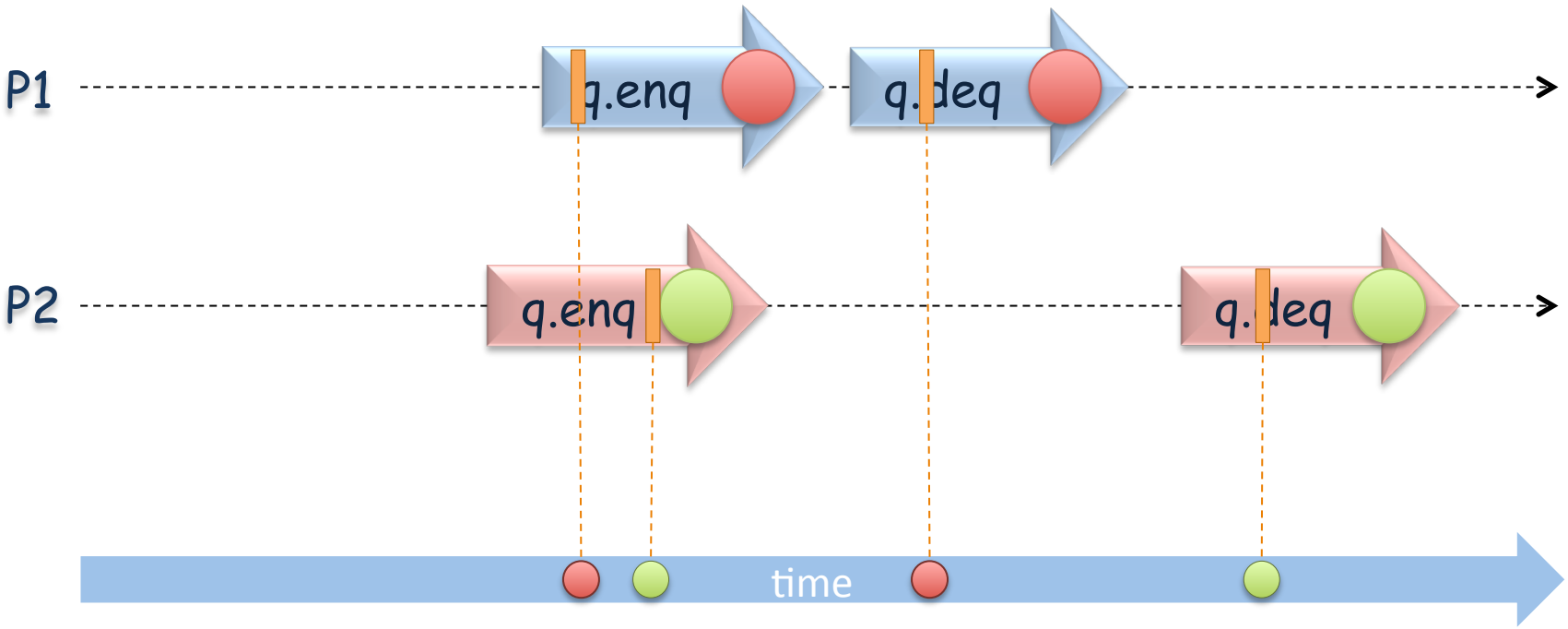
Concurrent Execution

Is this execution reasonable? Yes



Concurrent Execution

Is this execution reasonable? Yes



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