Concurrent Systems

Exercise 02 – Processes, Threads, Coroutines

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Agenda

Control Flows

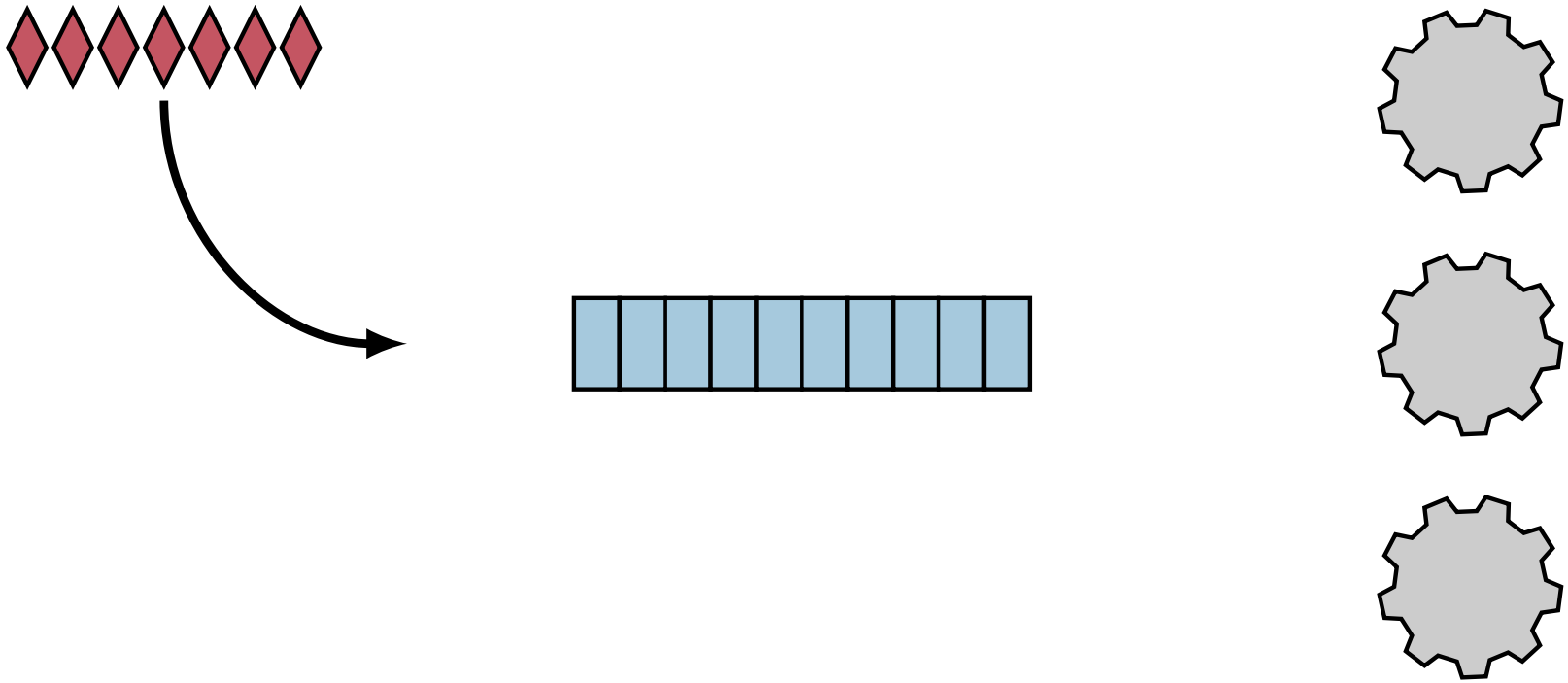
Coroutines

Threads

Assignment 2

Review: Executor Service

- Executor Service ($\Rightarrow$ Assignment 1)
  - Jobs have **run-to-completion** semantics
  - No inter-job coordination
  - No inter-job dependencies
- Example



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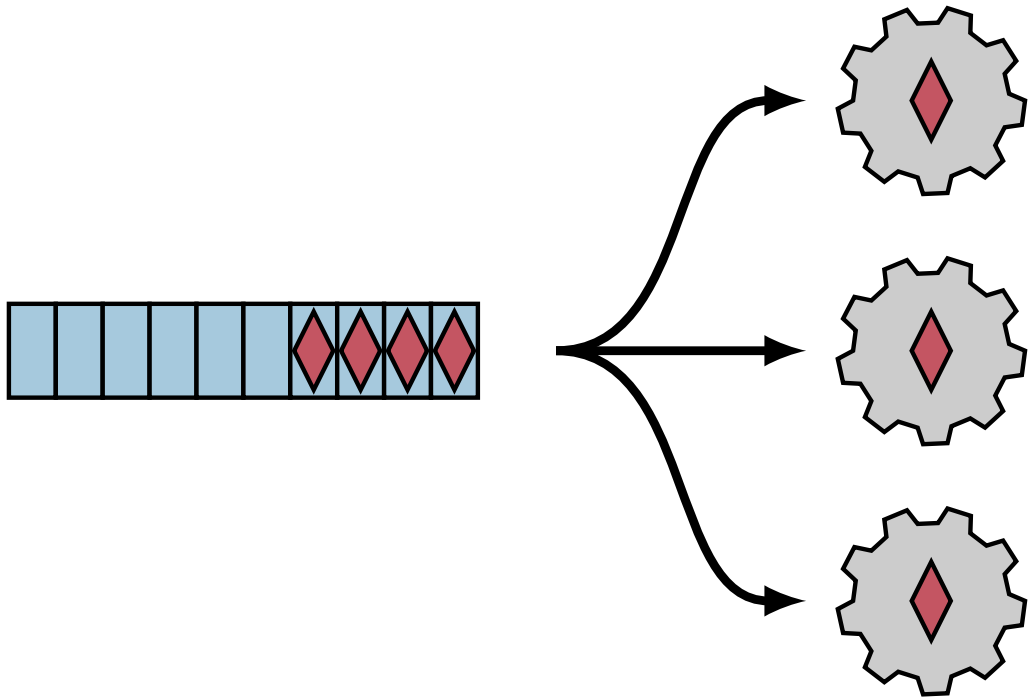
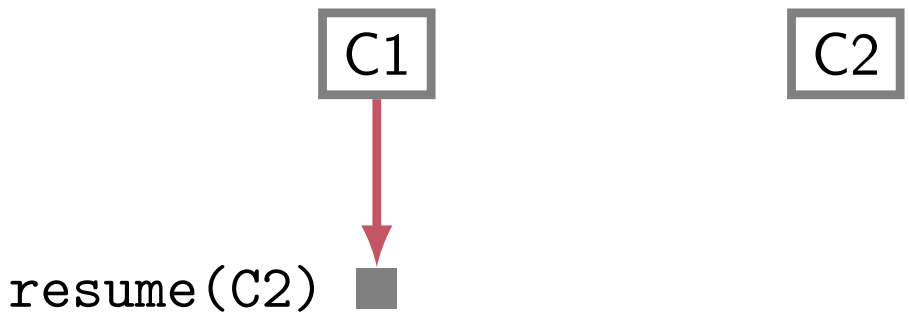


Control Flows

- Examples
  - ⇒ Instruction sequence, function call, interrupts, coroutines, threads, ...
- Overlapping patterns
  - ⇒ Sequential, stack-like, pseudo-parallel, arbitrary, ...
- Interaction patterns
  - ⇒ Independence, shared variables, producer/consumer, ...
- Associated resources
  - ⇒ Stack space, address space, file descriptors, ...
- Synchronization
  - Manage concurrent control flows
  - Consider application dependencies and overlapping patterns

Coroutines

- Voluntarily release the processor
  - `create()`, `resume()`, `destroy()`
  - Switch to another coroutine explicitly
- Symmetric relation
- Example



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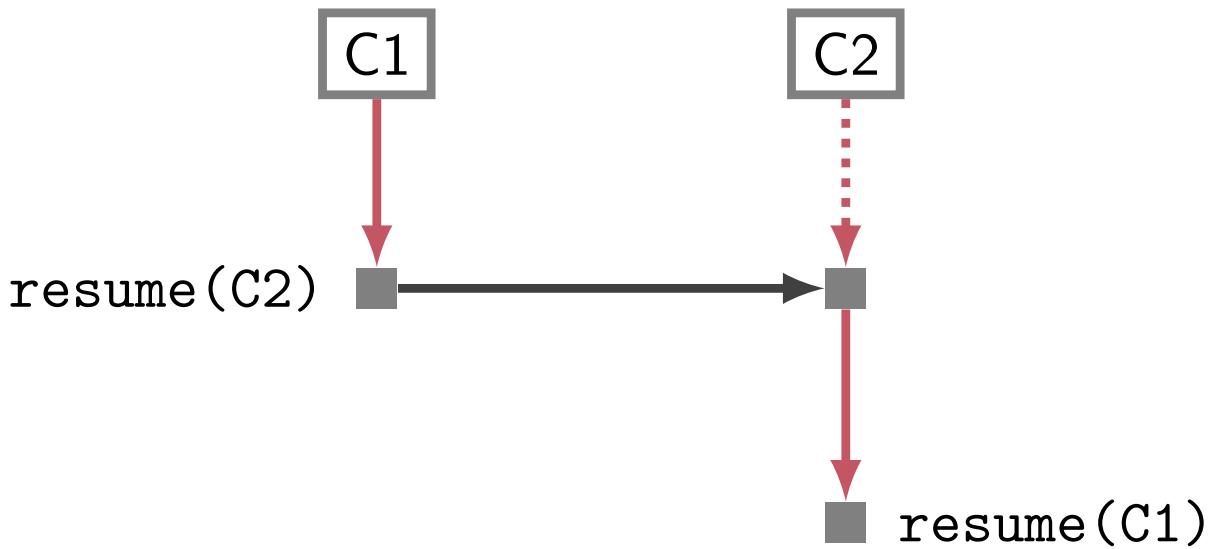

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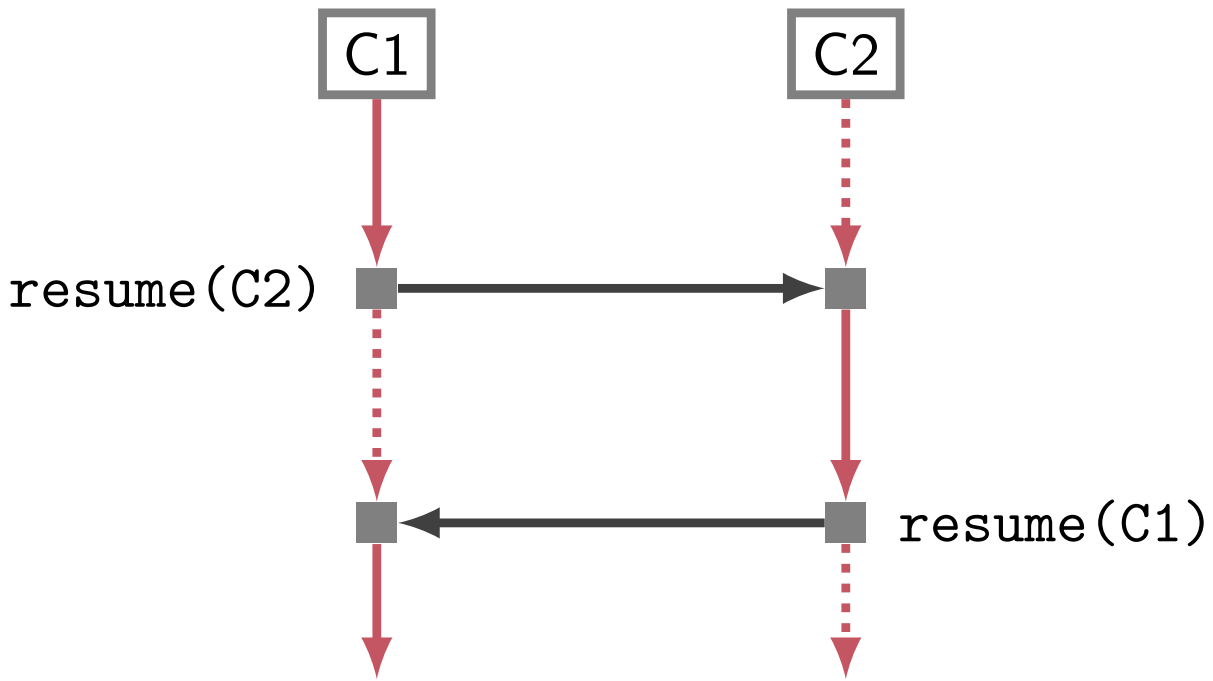

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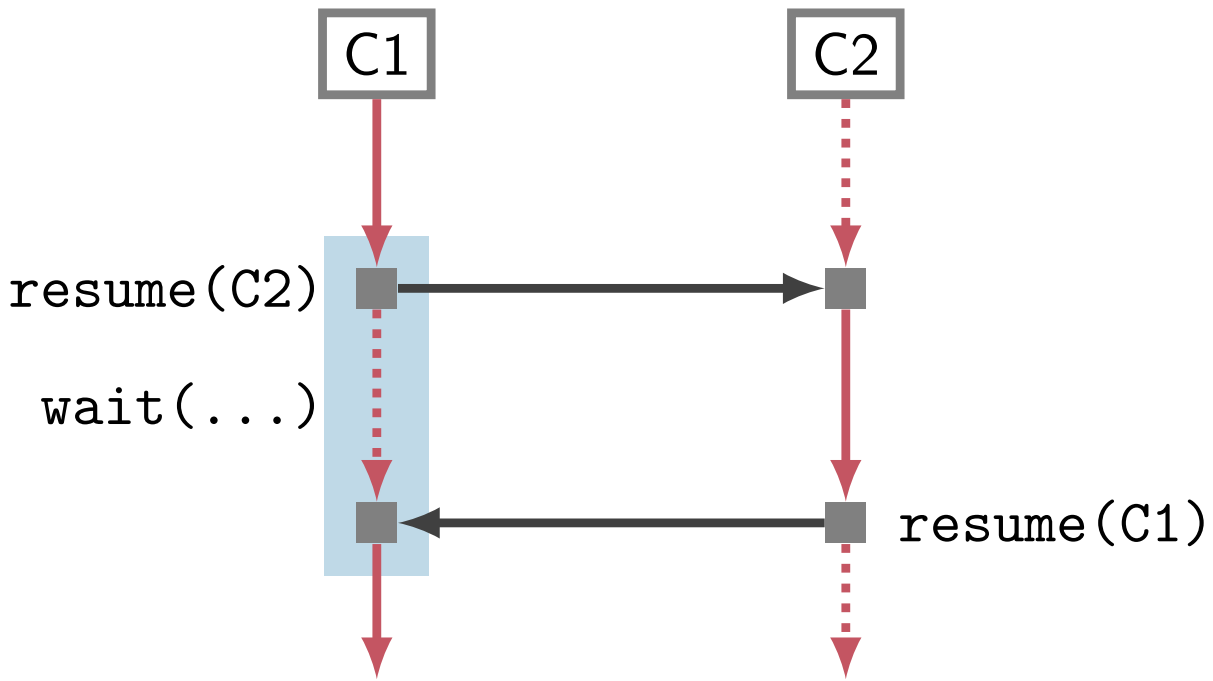

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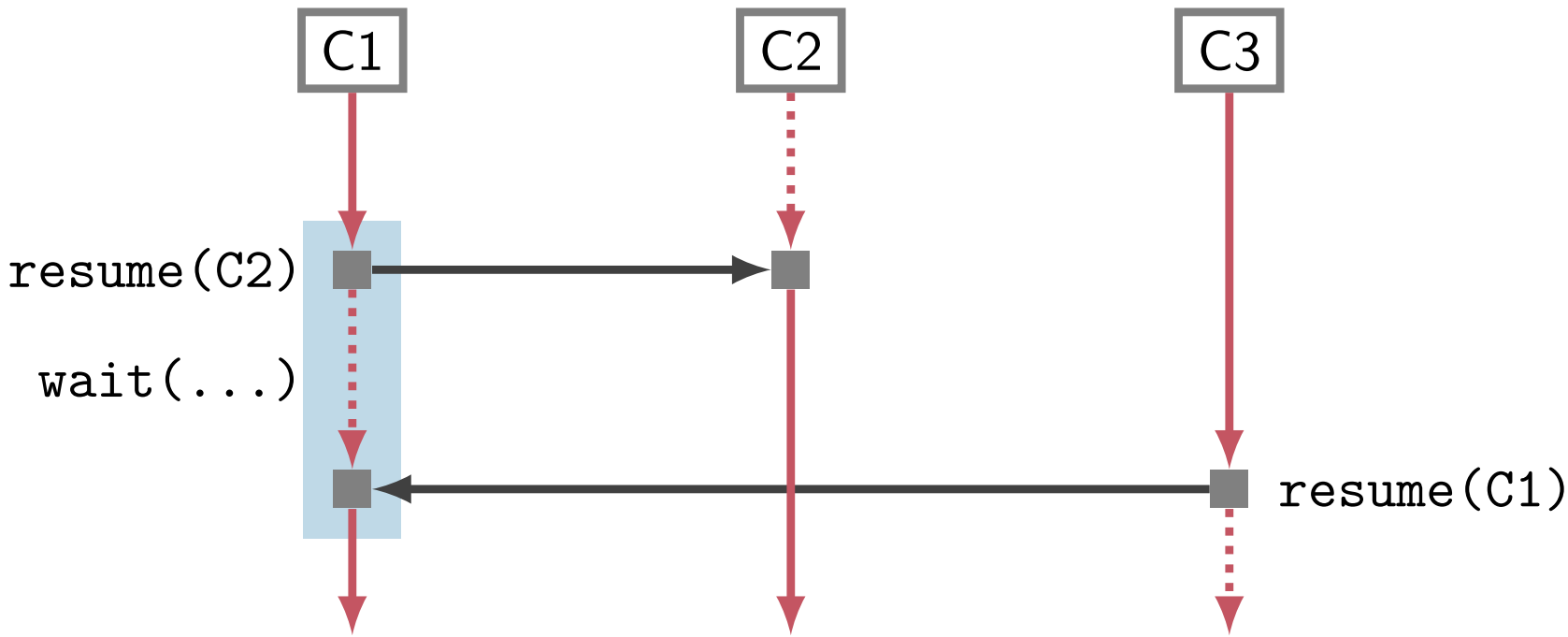

Continuations

Context Switches

- How can a processor switch between coroutines?
- How can a coroutine be continued?

Continuations

- ## Context Switches
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  - How can a coroutine be continued?

- ## Language Considerations
  - Typical high-level programming languages cannot implement `resume`
  - Some languages offer "coroutines" to programmers

    → e.g. Python `yield`
  - Context switches need assembler language support

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Continuation

- Data structure for the **Context** of a coroutine
- Stopped control flow can proceed later
- Stores at least an address of the next instruction
- Typically associated with an individual stack

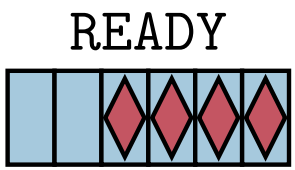
Threads

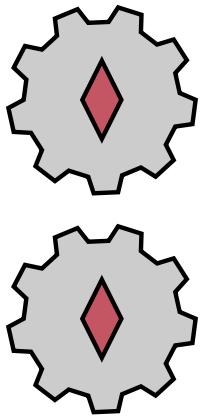
- Problems with Coroutines
  - Unstructured `resume()` calls
  - How to choose a successor?
- Threads extend Coroutines
  - Structured synchronization primitives
    → Mutex, Condition Variable, Semaphor, Monitor, Signal, ...
  - Thread states
    → `READY`, `RUNNING`, `BLOCKED`, `TERMINATED`, ...
  - Scheduling
    → Manage control flows explicitly
    → Implement a strategy for idle processors

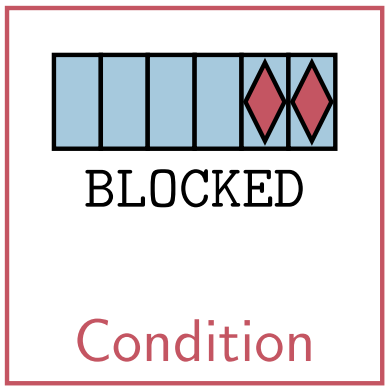
Assignment 2

- Implement a Light-weight Threading Library (LWT)
  - Extend jobs to coroutines/threads
  - Implement synchronization primitives
- Scheduling
  - Cooperative, non-preemptive
  - One shared ready list
- Use a thread library as back-end
  - Pthreads represent "logical processor cores"
  - Pthread synchronization mechanisms are available
- Simplifications
  - No graceful termination
  - No dynamic adaption of parallelism
  - Simple scheduler

- Blocking synchronization
  - Set thread state to `BLOCKED`
  - Add thread to condition-specific waiting queue
- Thread notification
  - Set thread state to `READY`
  - Add thread to ready list







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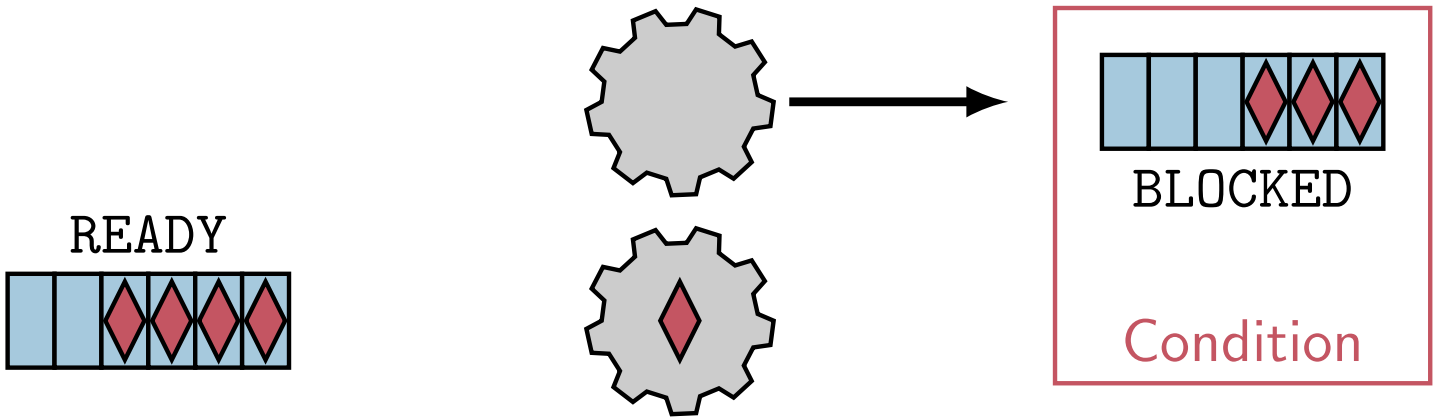

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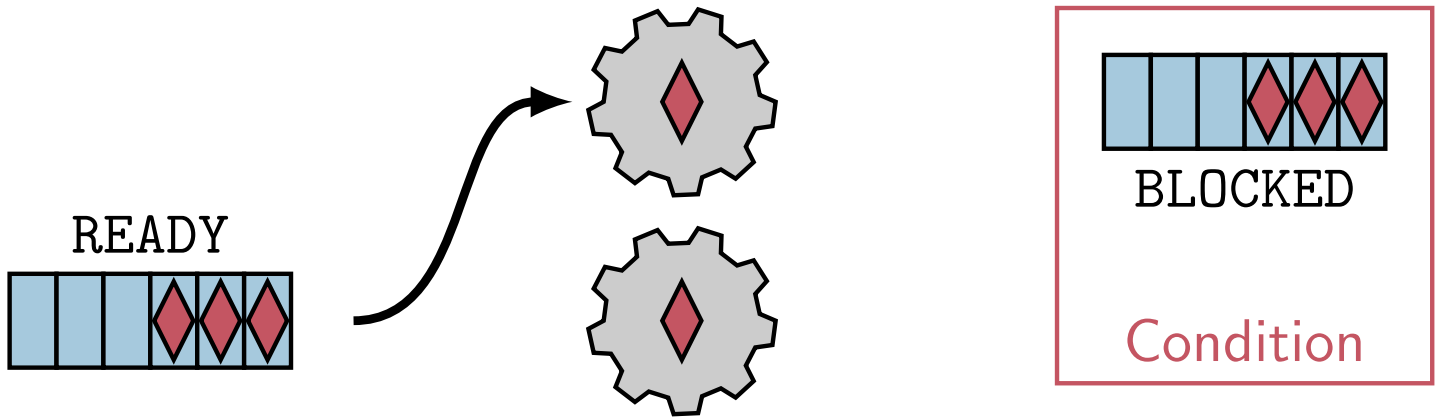

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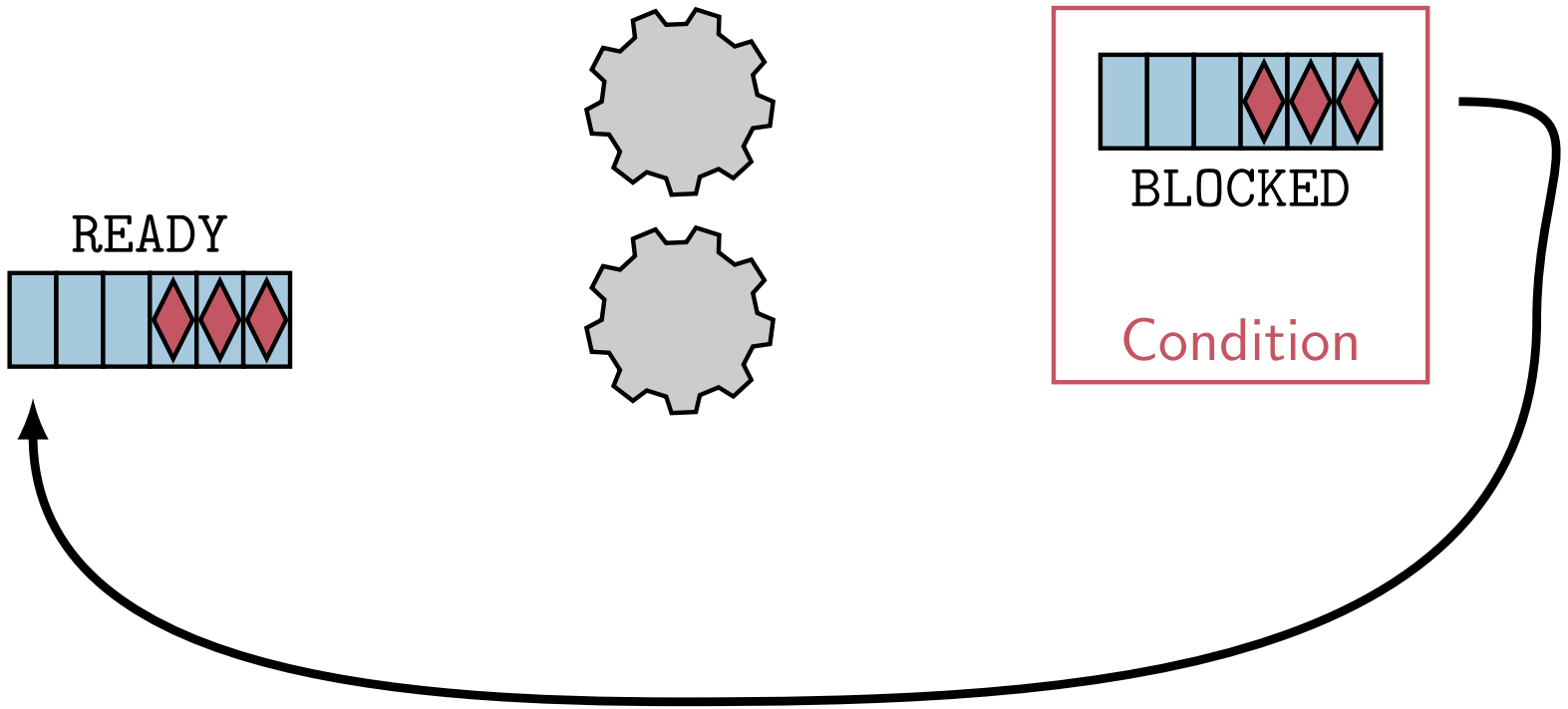

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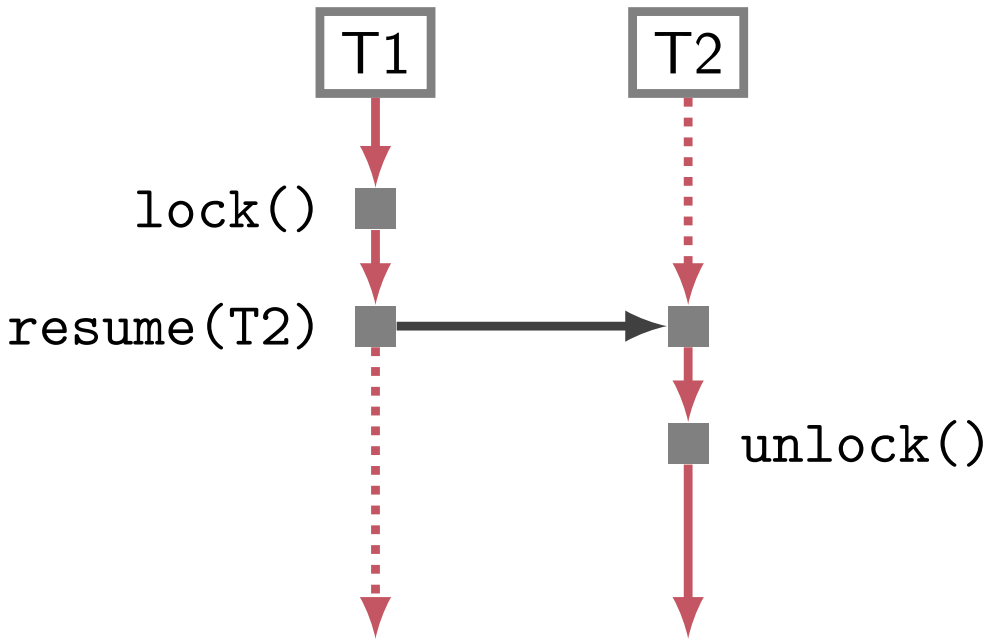
- What to do in idle state?
  - We can use pthread condition variables to wait passively



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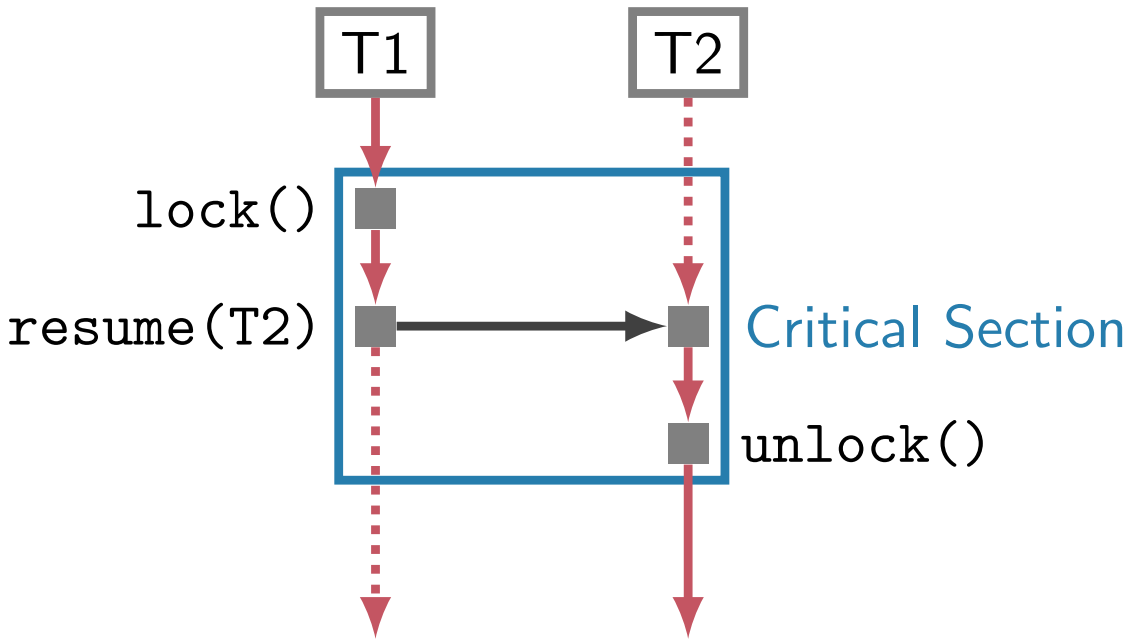

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