

# Concurrent Systems

## Exercise 02 – Processes, Threads, Coroutines

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# Agenda

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Control Flows

Coroutines

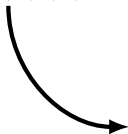
Threads

Assignment 2



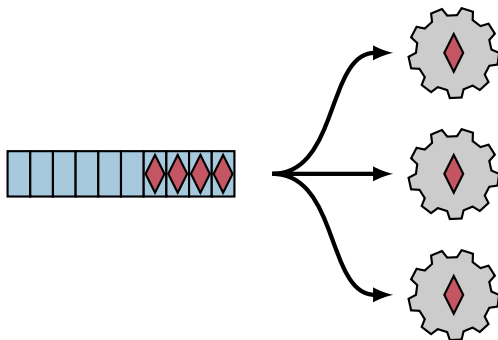
# Review: Executor Service

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



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## ■ Examples

⇒ Instruction sequence, function call, interrupts, coroutines, threads, ...

## ■ Overlapping patterns

⇒ Sequential, stack-like, pseudo-parallel, arbitrary, ...

## ■ Associated resources

⇒ Stack space, address space, file descriptors, ...

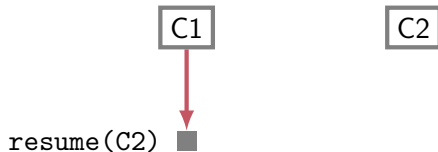
## ■ Synchronization

- Manage concurrent control flows
- Consider application dependencies and overlapping patterns



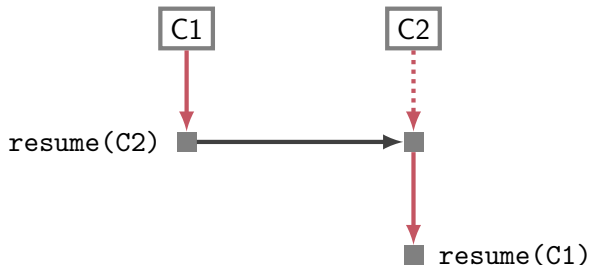
# Coroutines

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



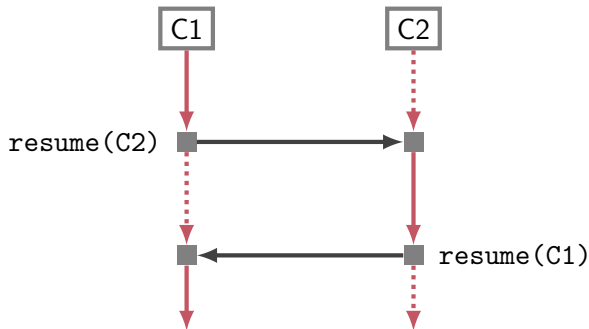
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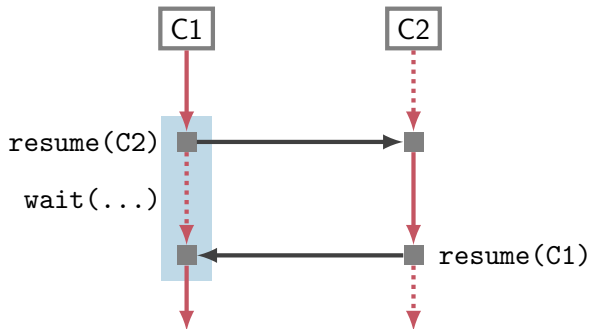
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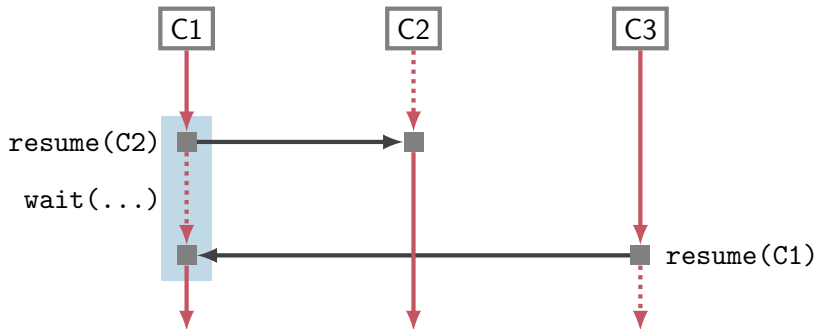
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- How can a processor switch between coroutines?
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## ■ Language Considerations

- 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 a code address
- Typically associated to an individual stack



## ■ Problems with Coroutines

- Unstructured `resume()` calls
- How to choose a successor?

## ■ Threads extend Coroutines

- Structured synchronization primitives
  - Mutex, Condition Variable, Semaphore, Monitor, Signal, ...
- Thread states
  - READY, RUNNING, BLOCKED, TERMINATED, ...
- Scheduling
  - Manage control flows explicitly
  - Implement a strategy for idle processors



# Assignment 2

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## ■ Implement a Light-weight Threading Library (LWT)

- Extend jobs to coroutines/threads
- Implement synchronization primitives

## ■ Scheduling

- Cooperative, non-preemptive
- One shared ready list

## ■ Use kernel-level threads as back-end

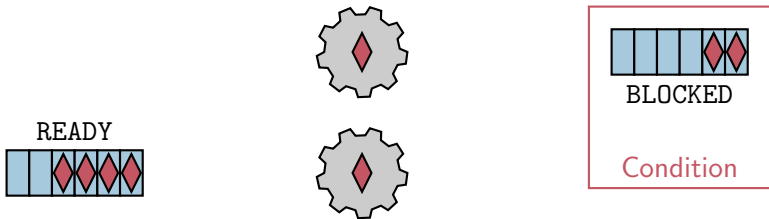
- Pthreads logically represent processor cores
- Pthread synchronization mechanisms are available

## ■ Simplifications

- No graceful termination
- No dynamic adaption of parallelism
- Simple scheduler

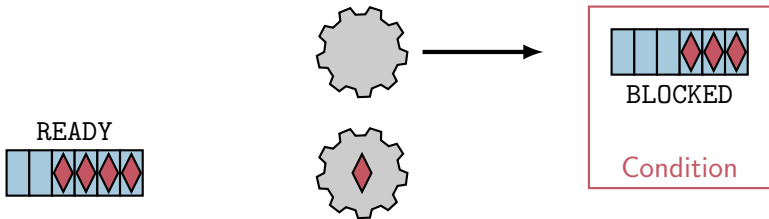


- Blocking synchronization
  - Set thread state to BLOCKED
  - Add thread to condition-specific waiting queue
- Thread notification
  - Set thread state to READY
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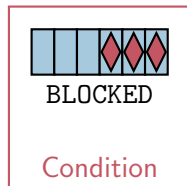
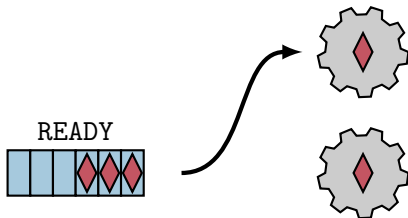




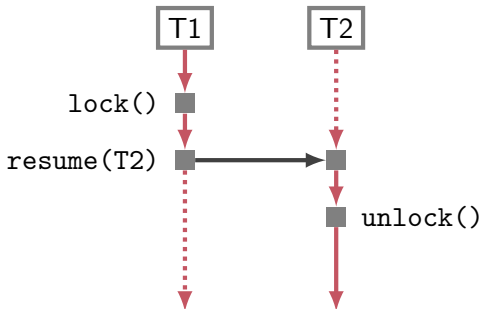
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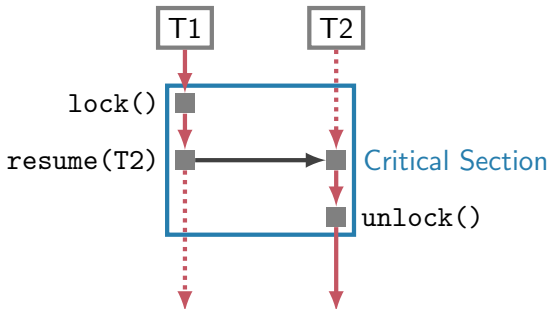
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  - We can use a pthread mutex
  - We will use non-blocking synchronization later
- What to do in idle state?
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