Light-Weight Contexts

An OS Abstraction for Safety and Performance

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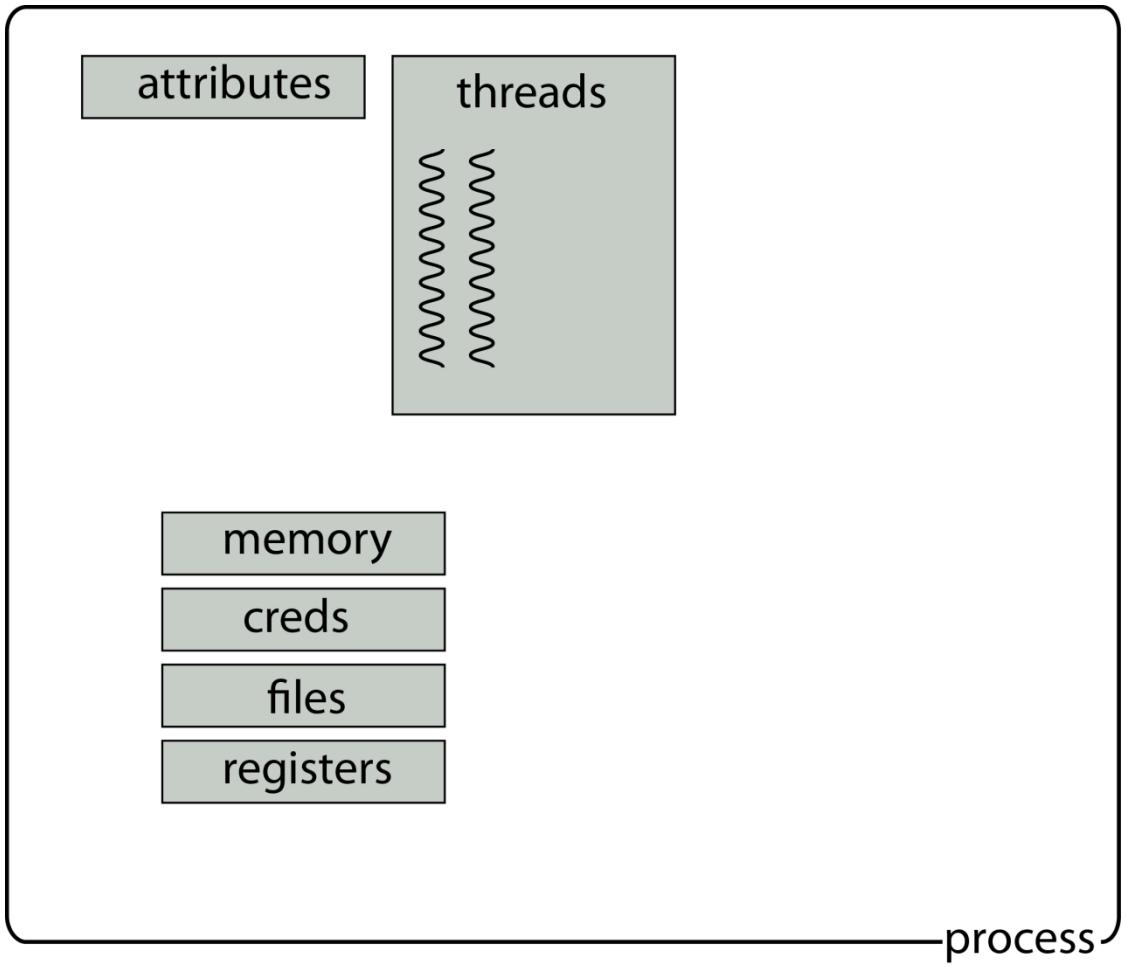
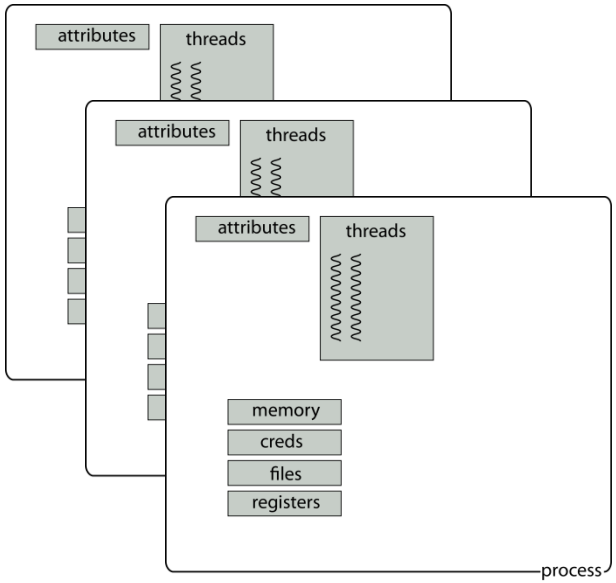
Process



Unit of isolation, privilege separation, and program state

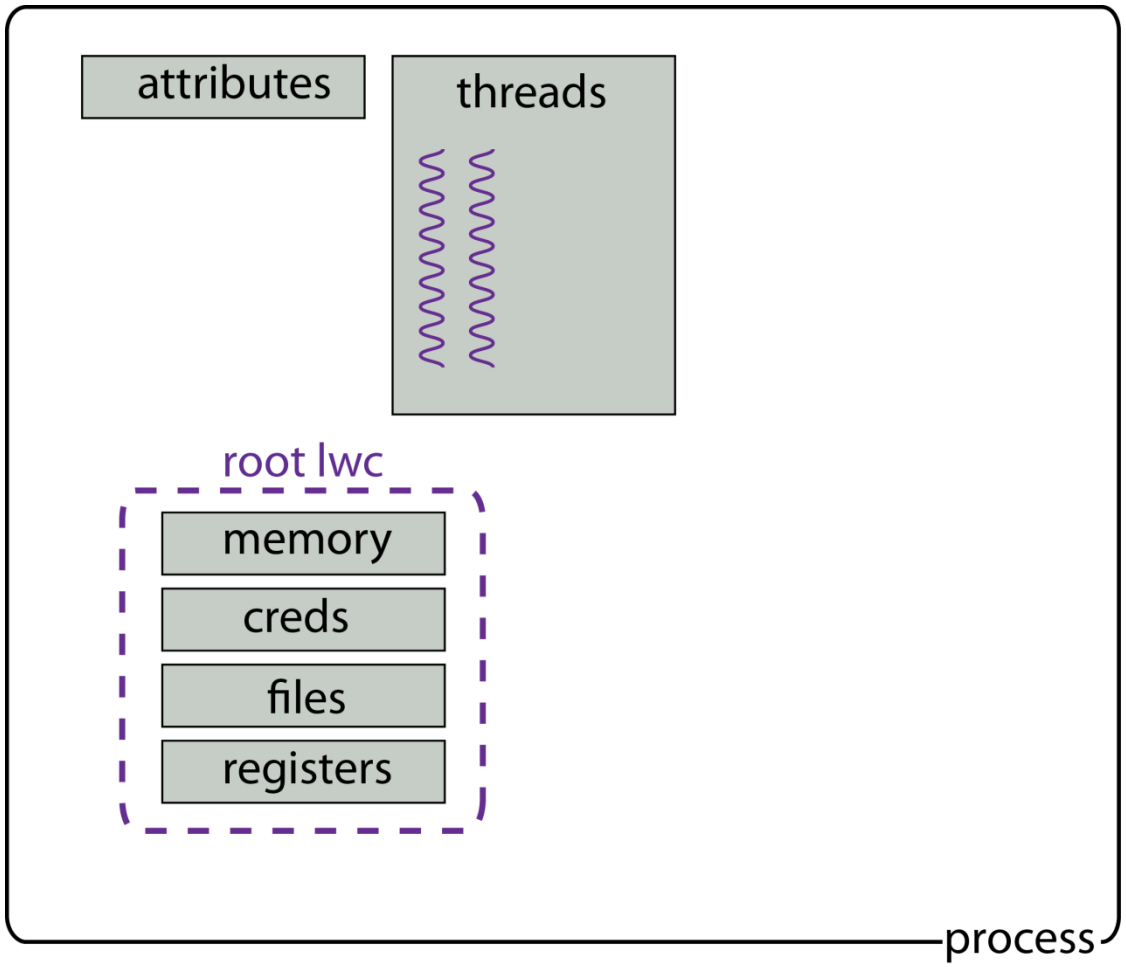
Fork



Used to achieve distinct isolation, privilege separation, and program state

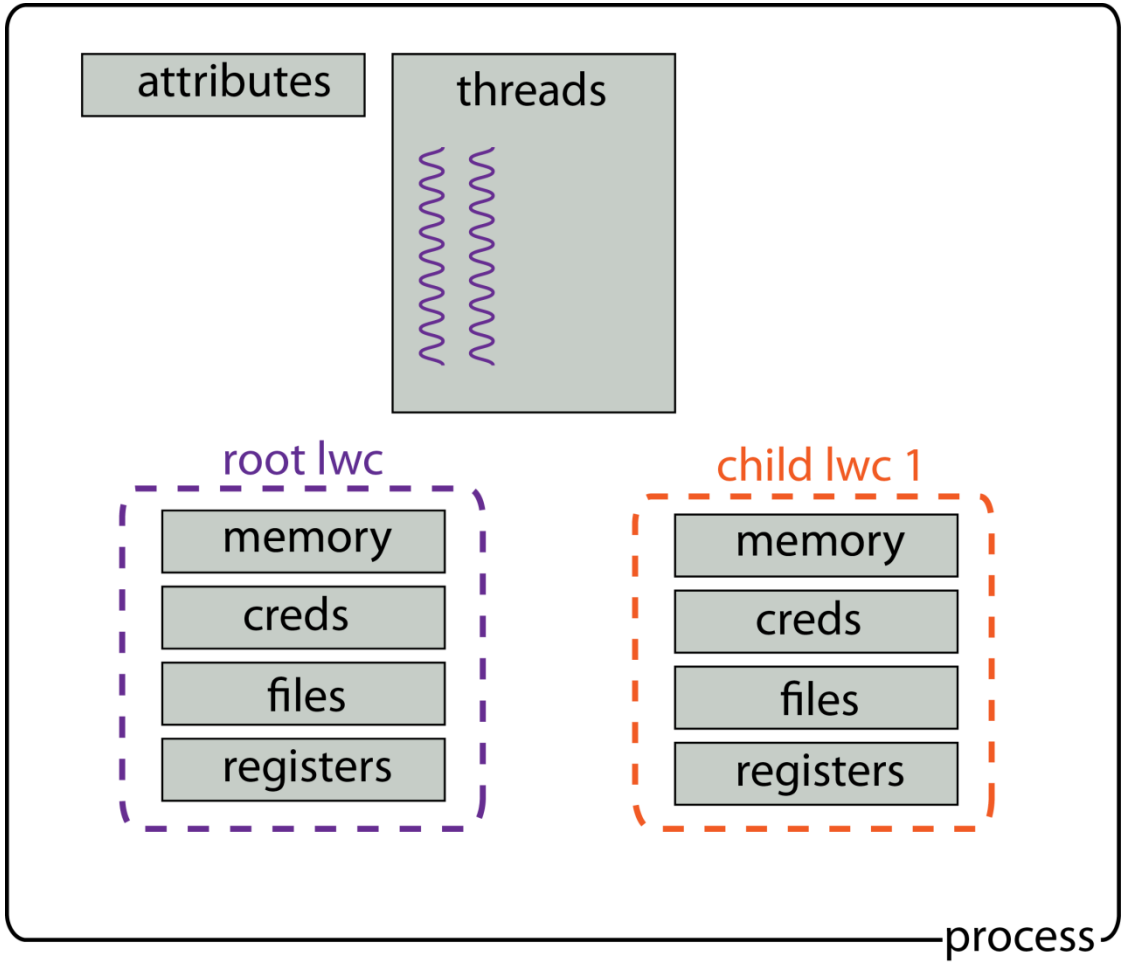
Imposes scheduling and coordination overhead

Light-Weight Context

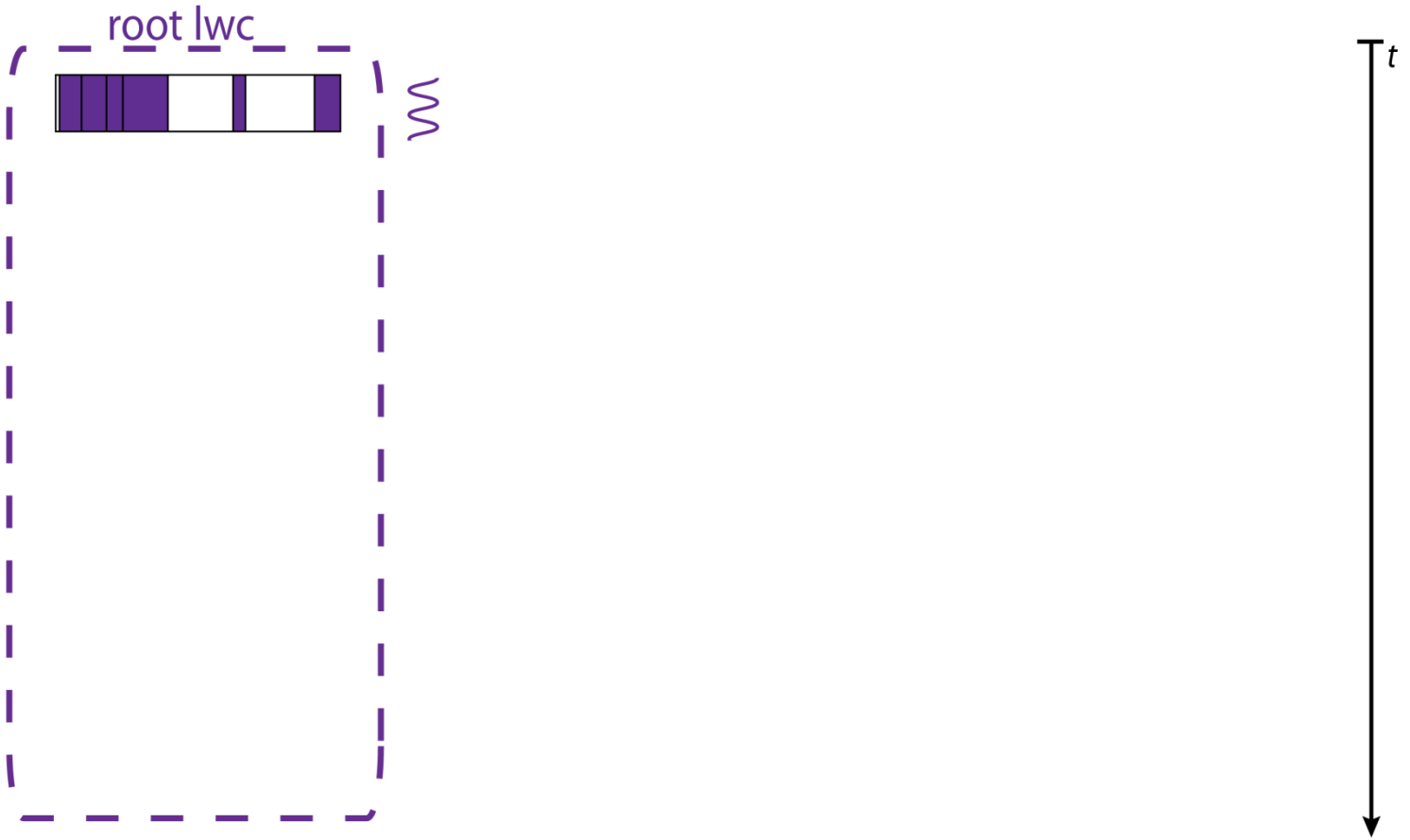


Intra-process isolation of system resources

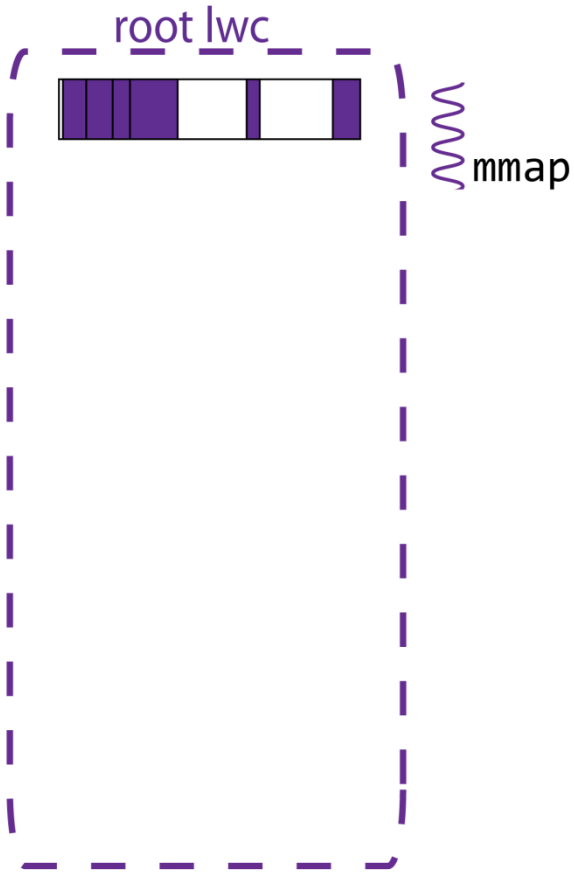
Light-Weight Context

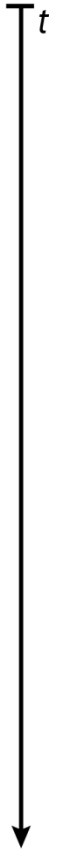


Creating lwCs



lwCreate





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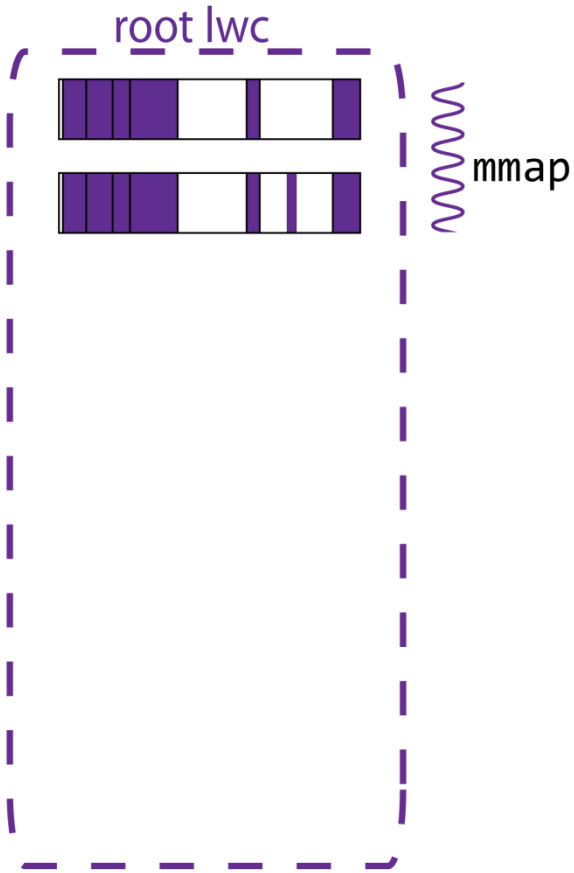
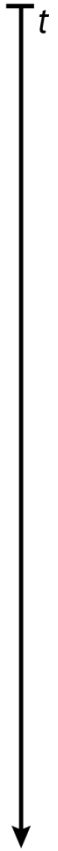
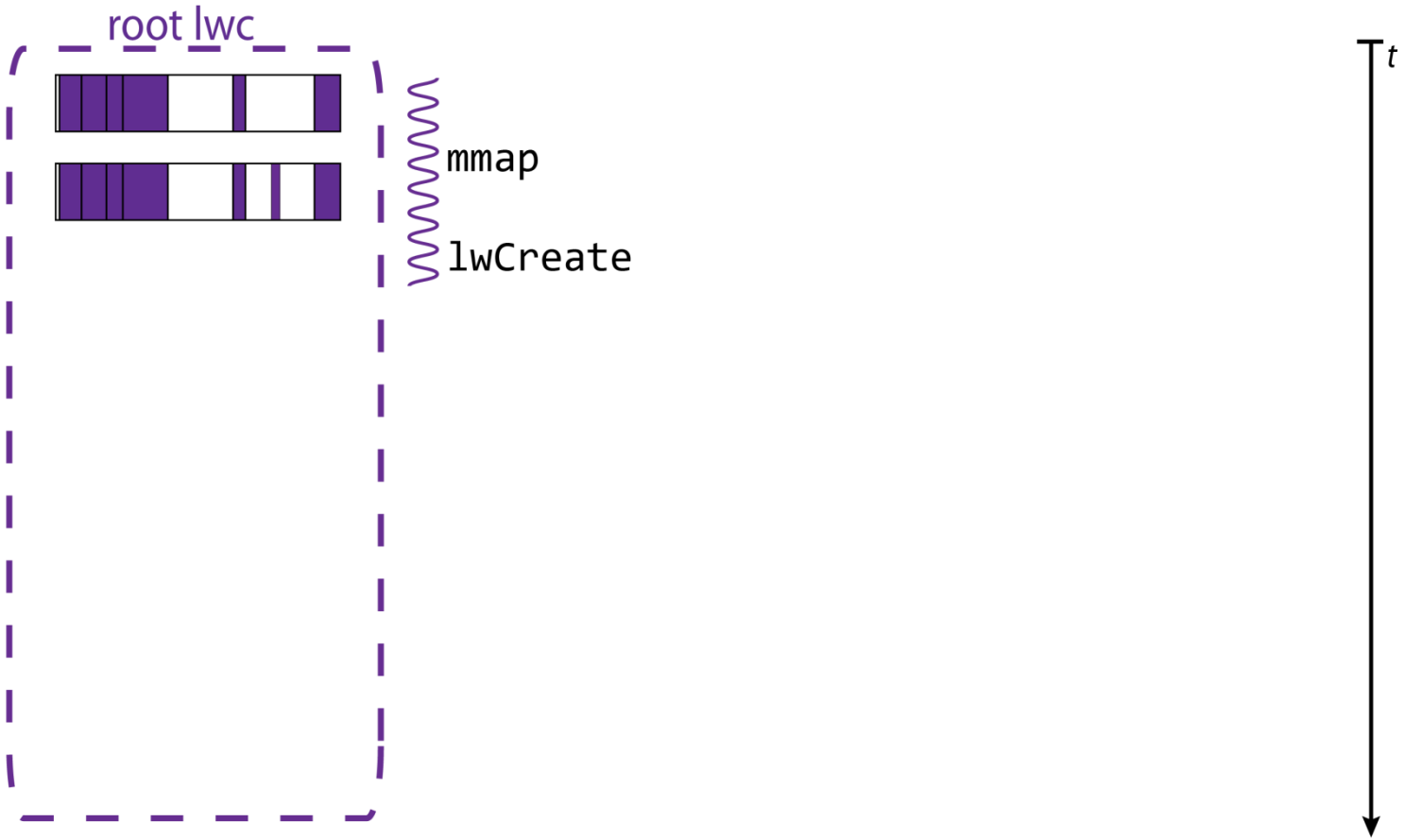




lwCreate

```
new,caller,args ← lwCreate(spec, options)
```



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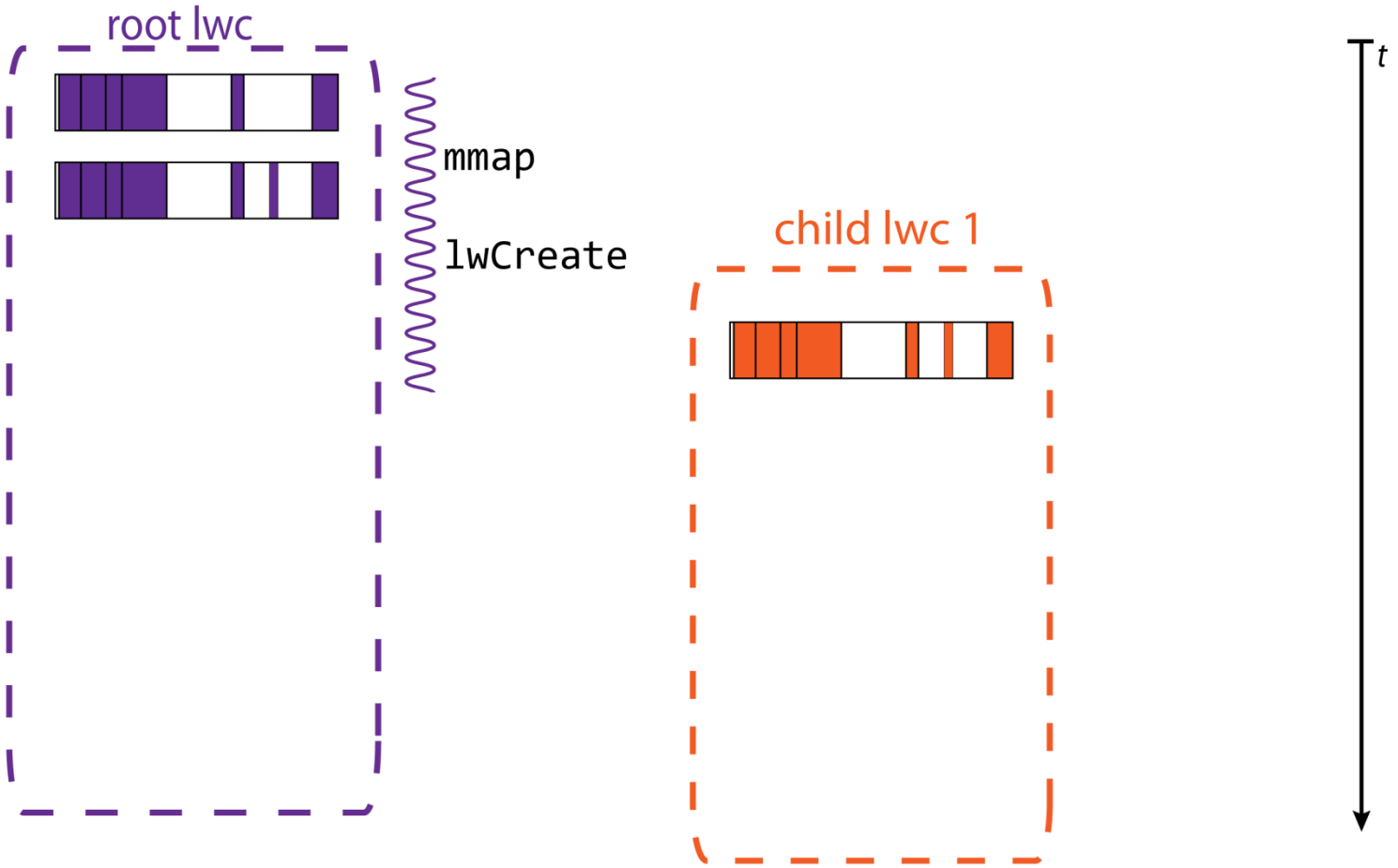

The child is a copy (via COW) of the parent by default

lwCreate

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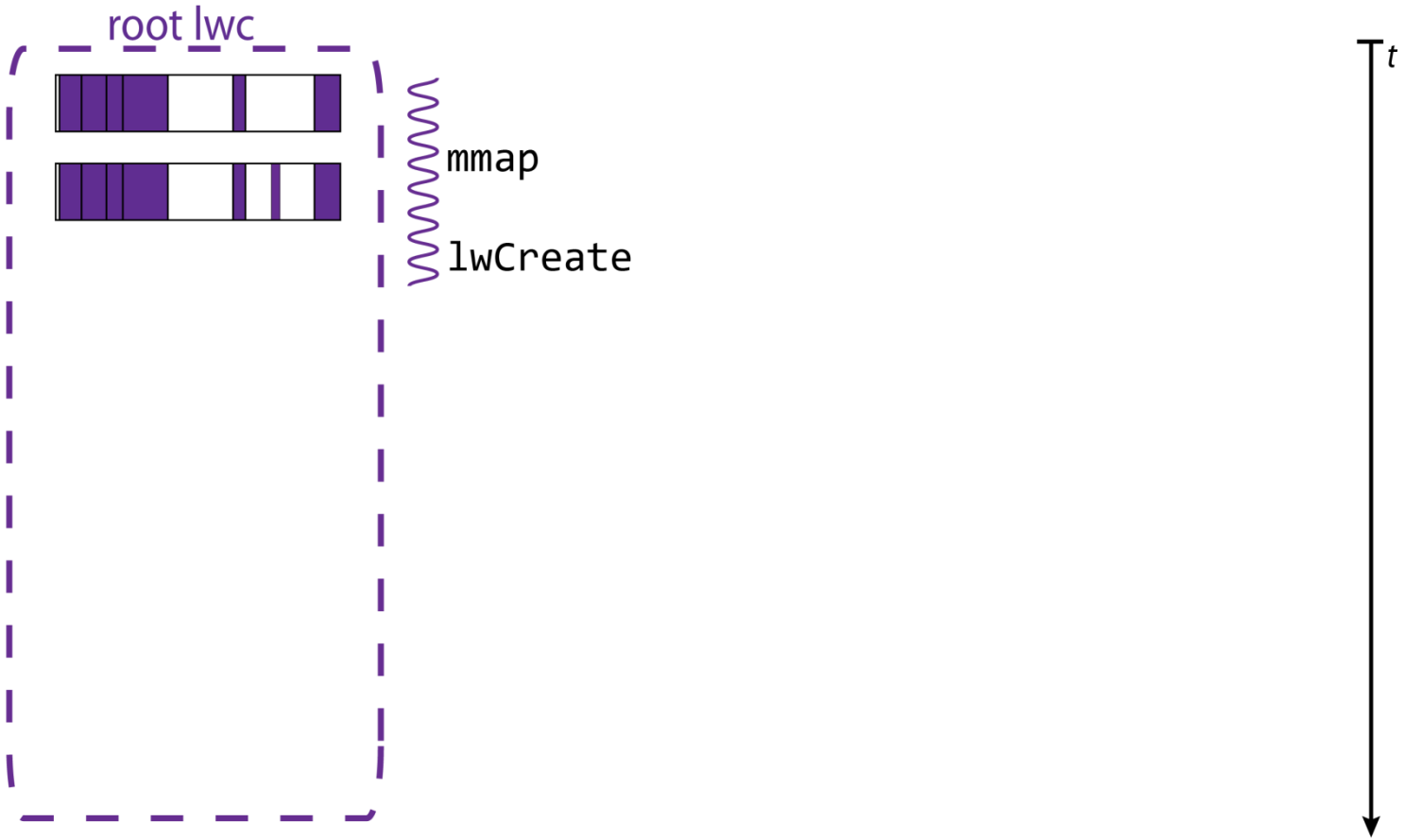

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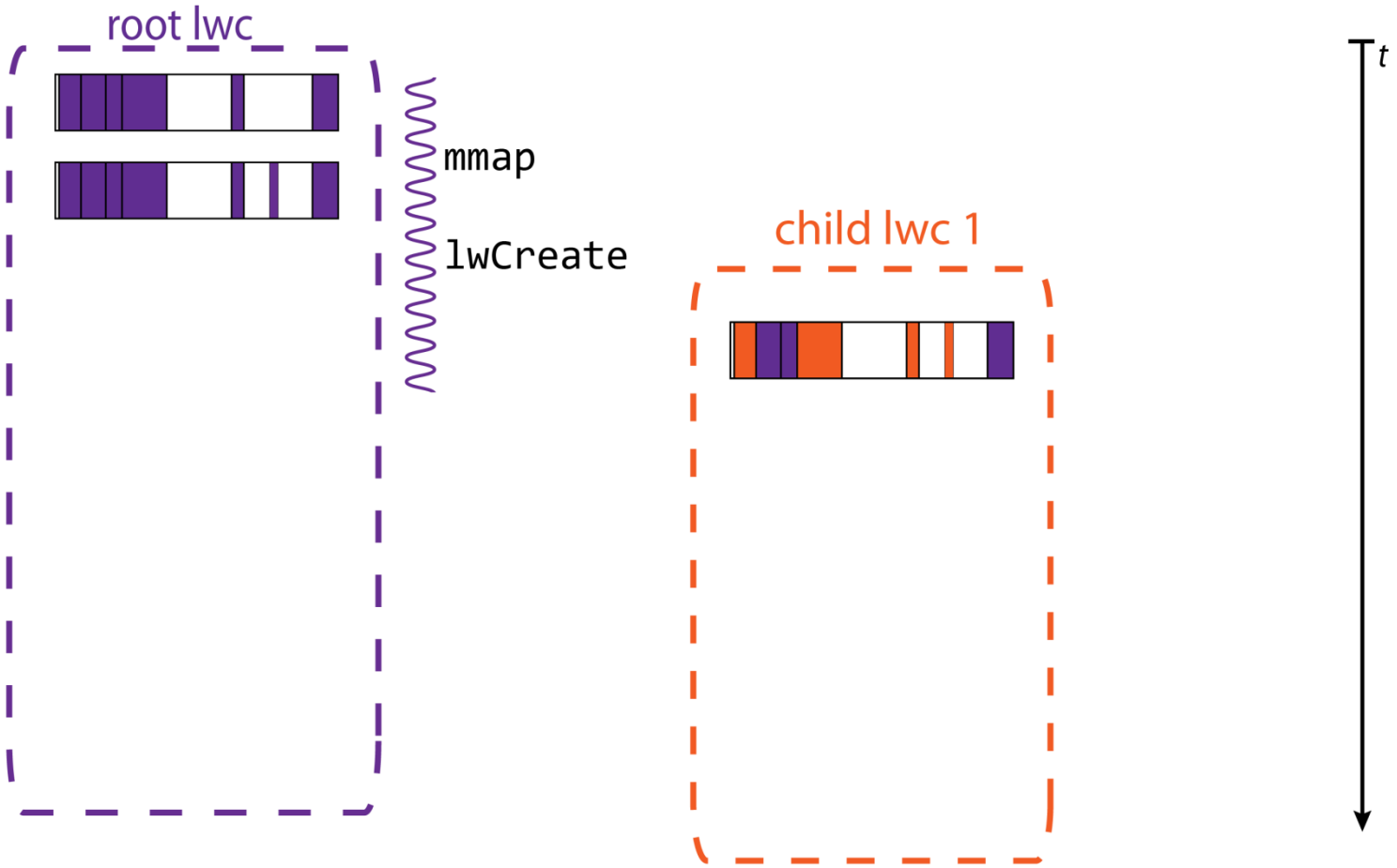
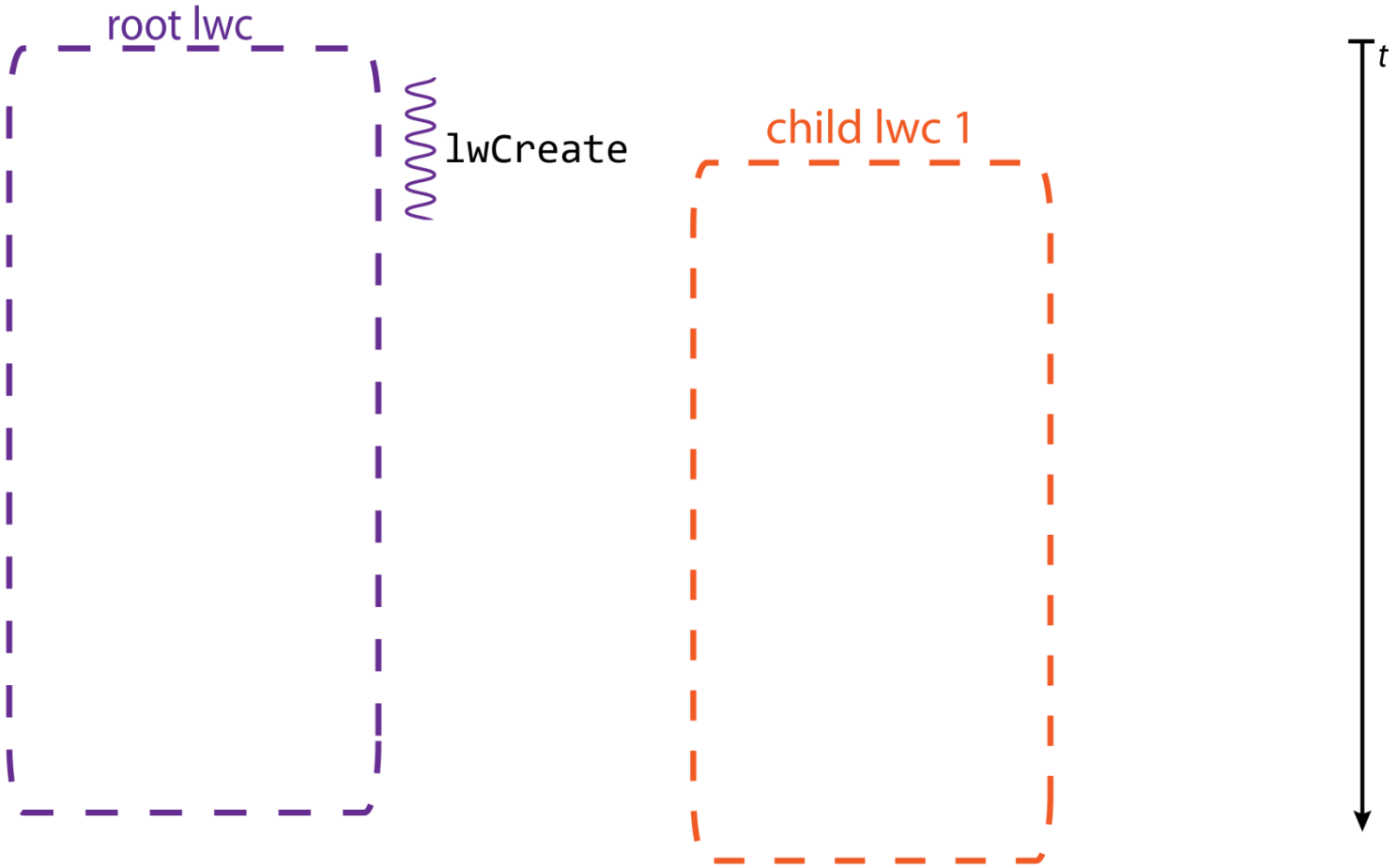


The child may share or omit parent resources

lwSwitch

```
caller,args ← lwSwitch(target, args)
```



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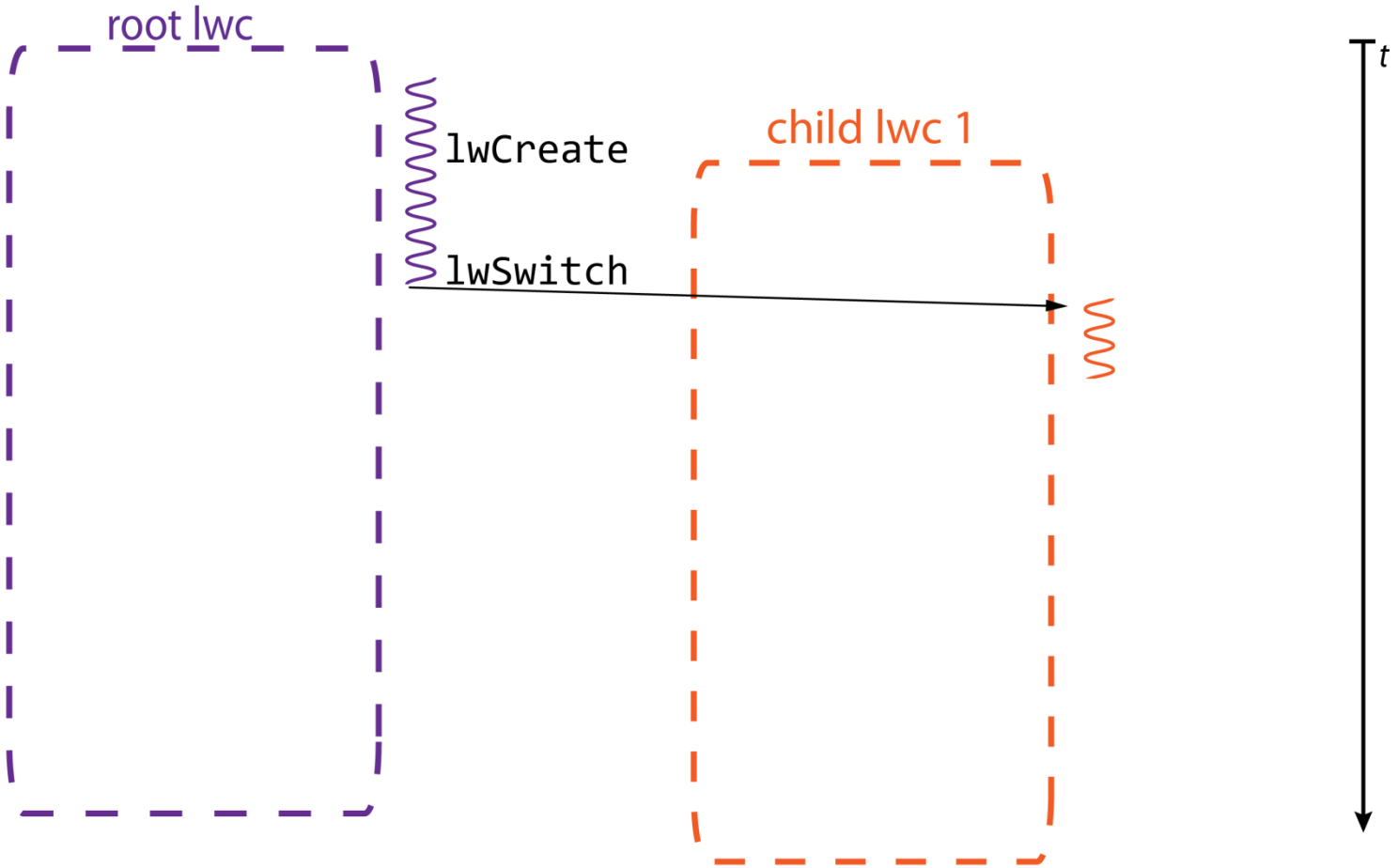

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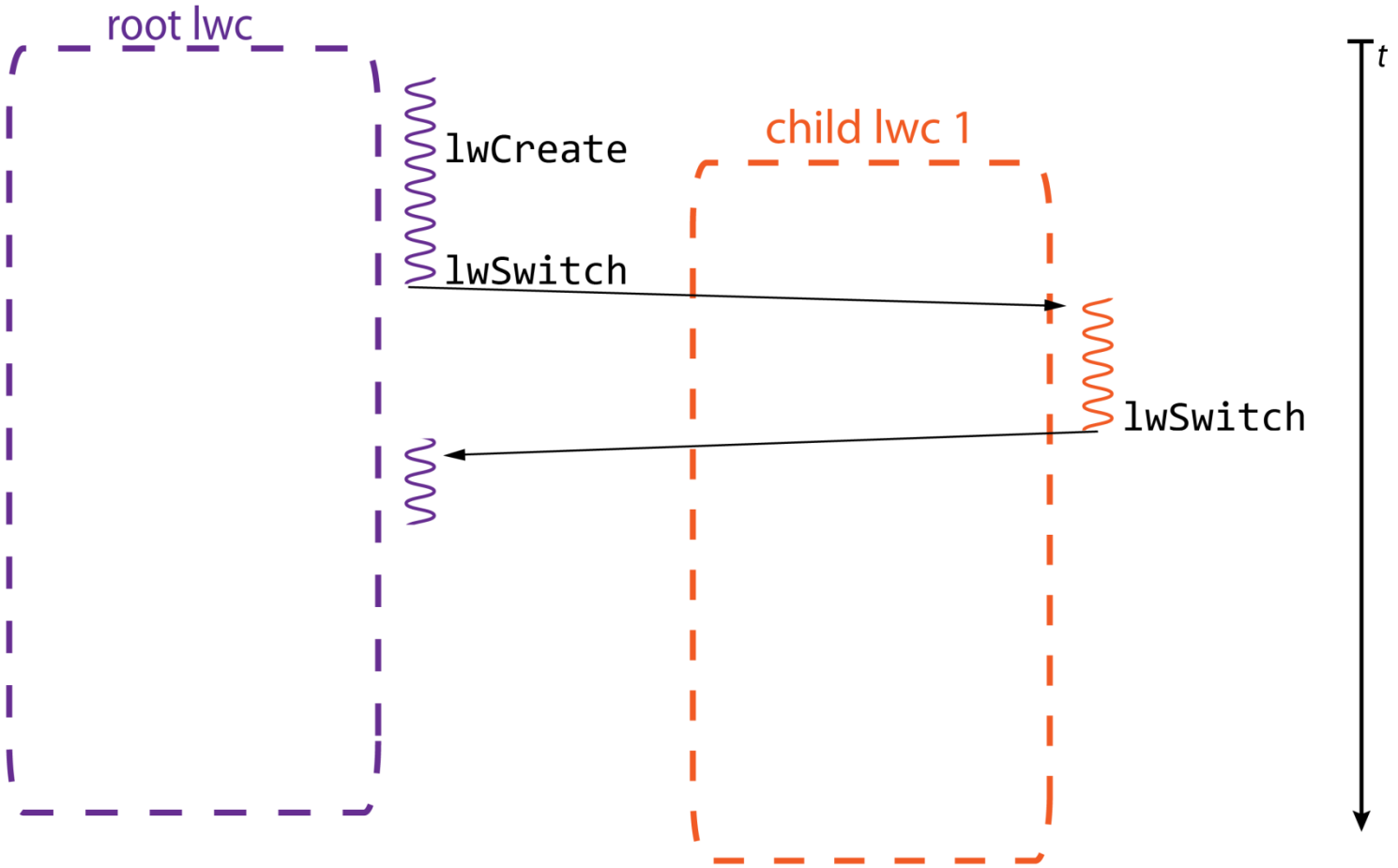

lwSwitch provides coroutine semantics

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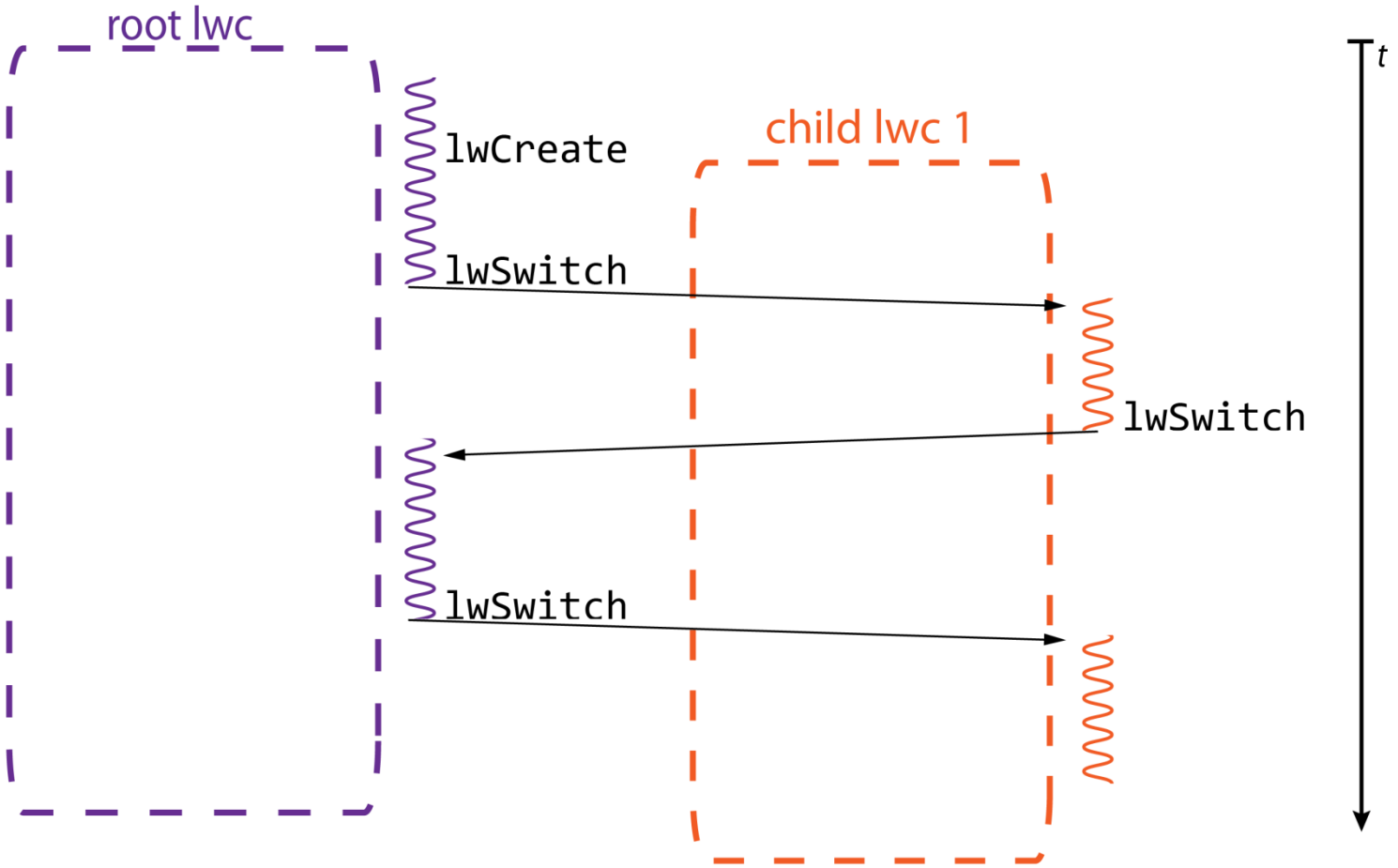

lwSwitch provides coroutine semantics

API Summary

Create lwC		
new,caller,args	←	lwCreate(spec, options)
Switch to lwC		
caller,args	←	lwSwitch(target, args)
Resource Access		
status	←	lwRestrict(lwc, spec)
status	←	lwOverlay(lwc, spec)
status	←	lwSyscall(target, mask, syscall, args)

Common uses

- Session isolation

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- Sensitive data isolation

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- Snapshot and rollback

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- Session isolation
- Sensitive data isolation
- Snapshot and rollback
- Reference monitoring

Snapshots

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3:      if caller = -1 then
4:          return new
5:      else
6:          close(caller)
7:          return snapshot()
8:  function ROLLBACK(snap)
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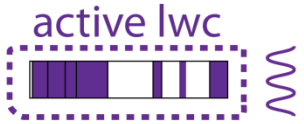

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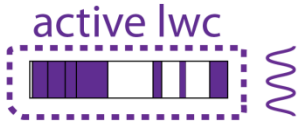

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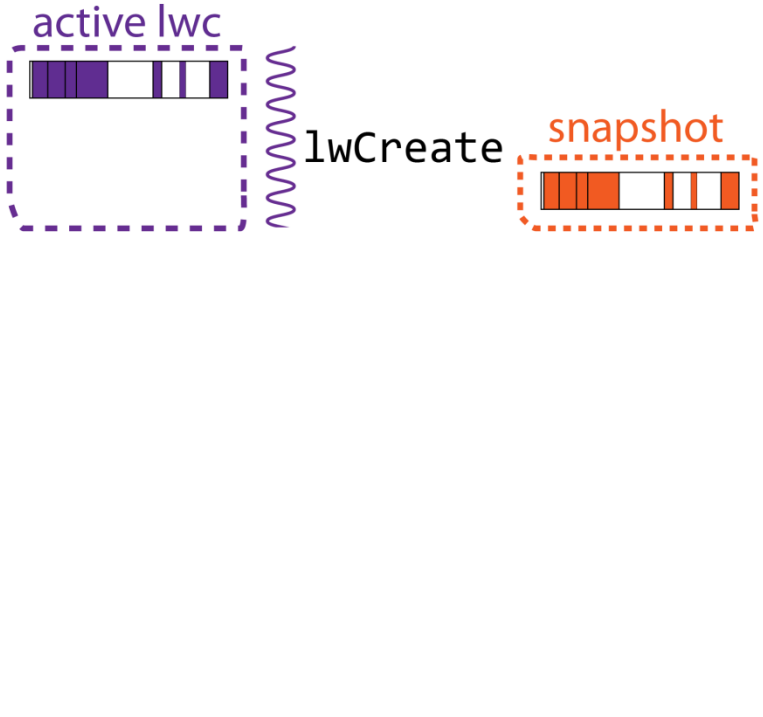

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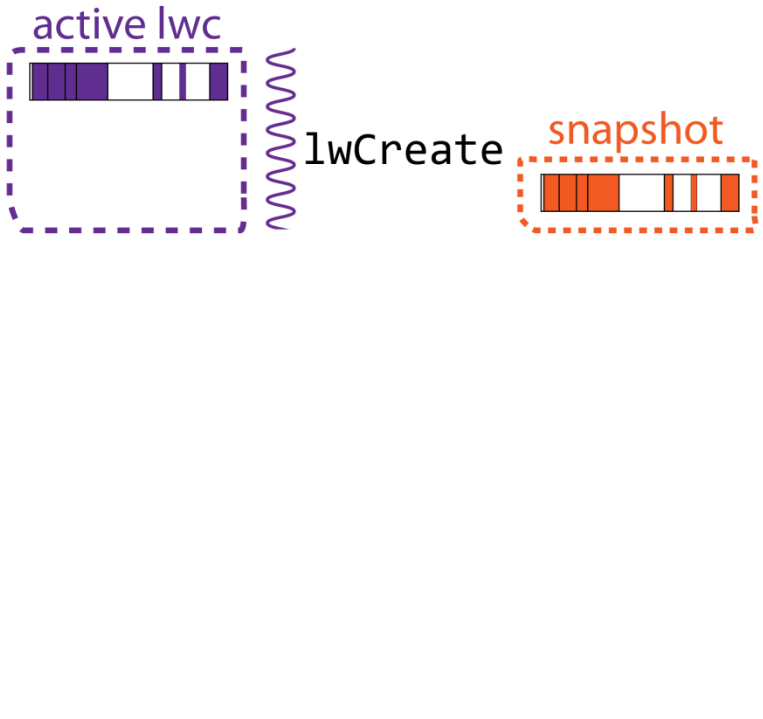

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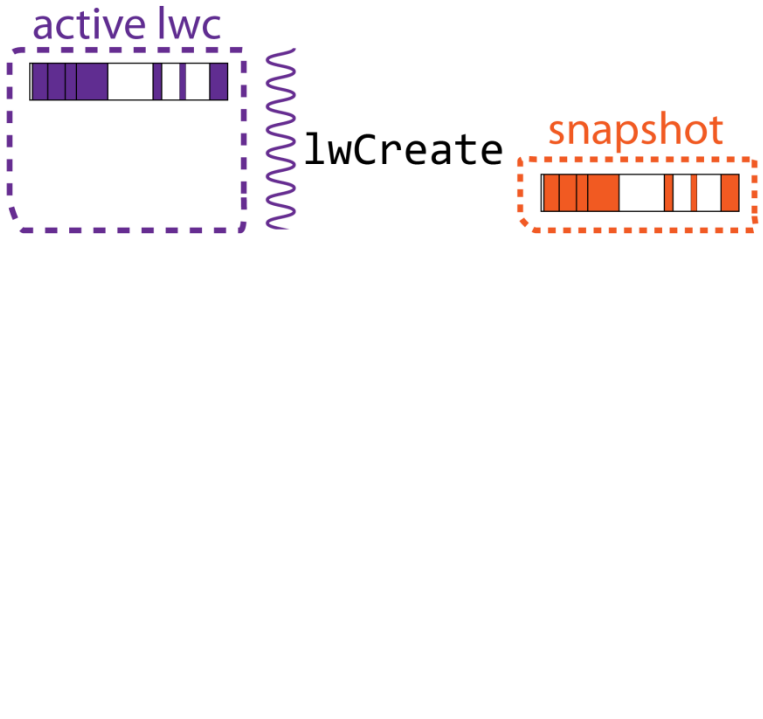

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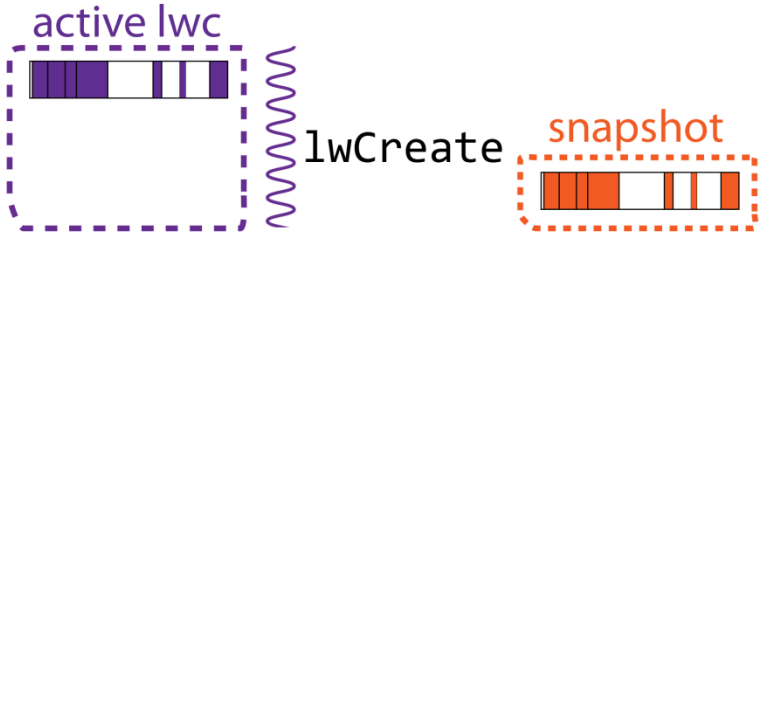

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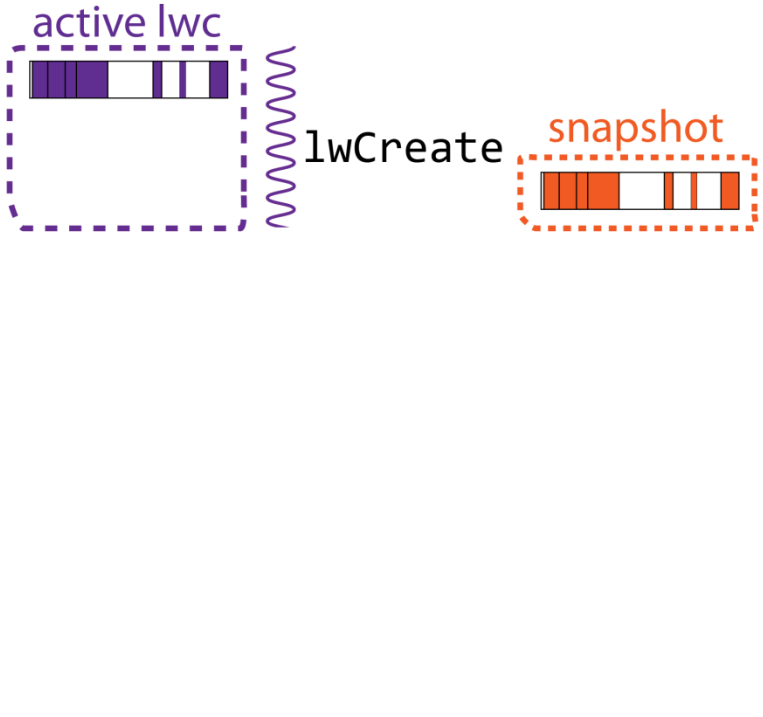

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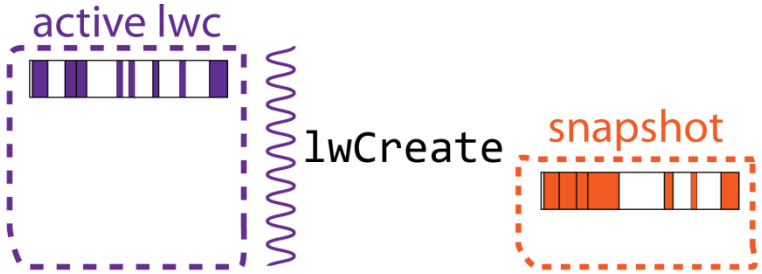

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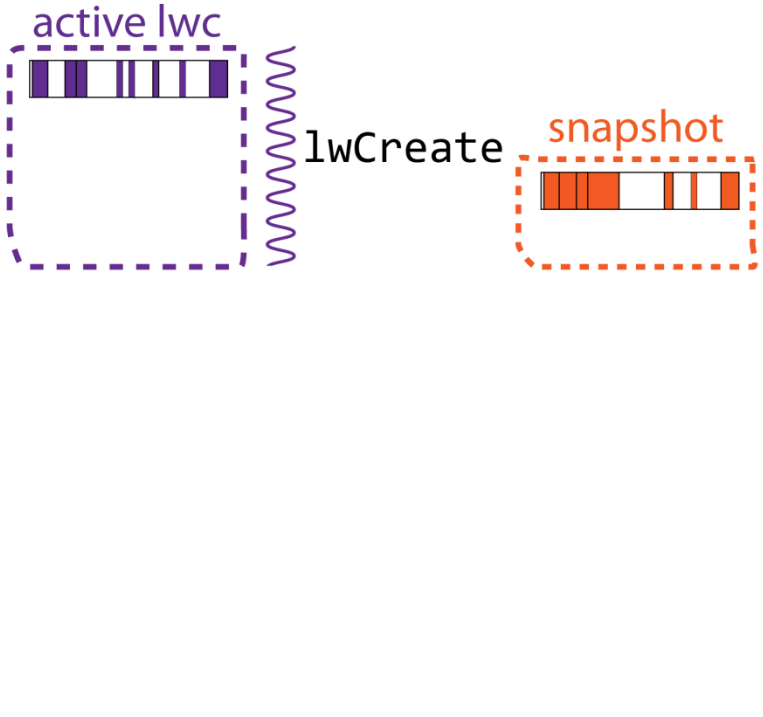

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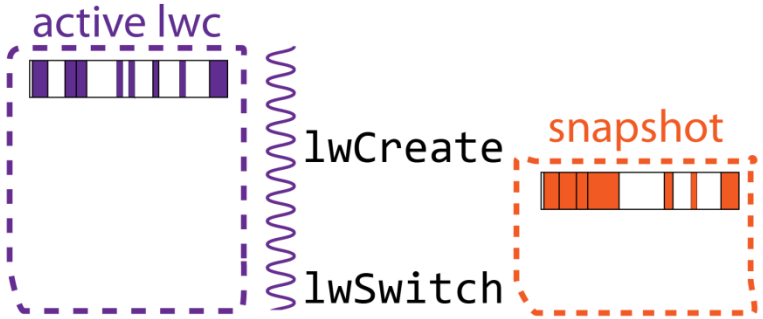

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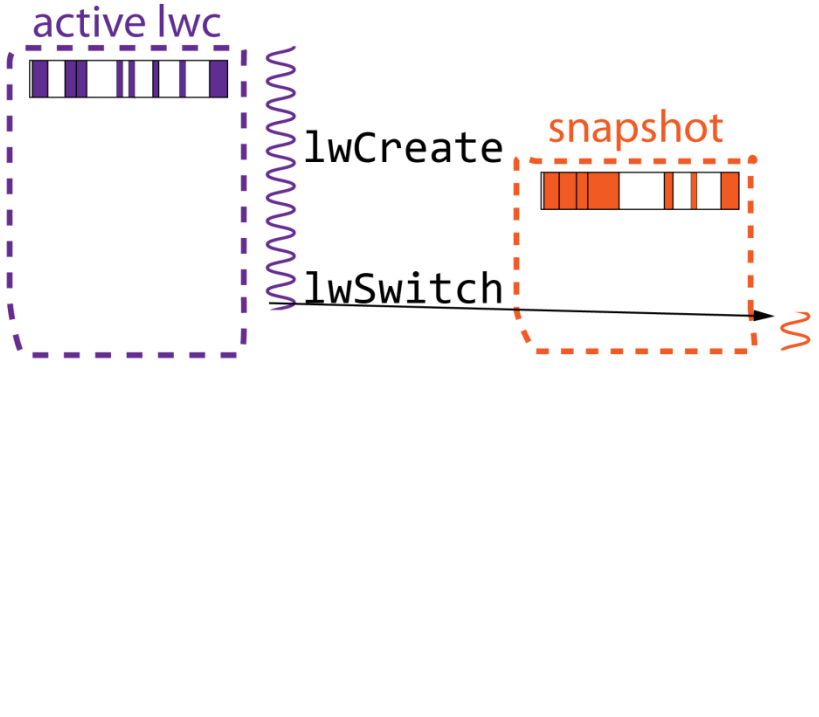

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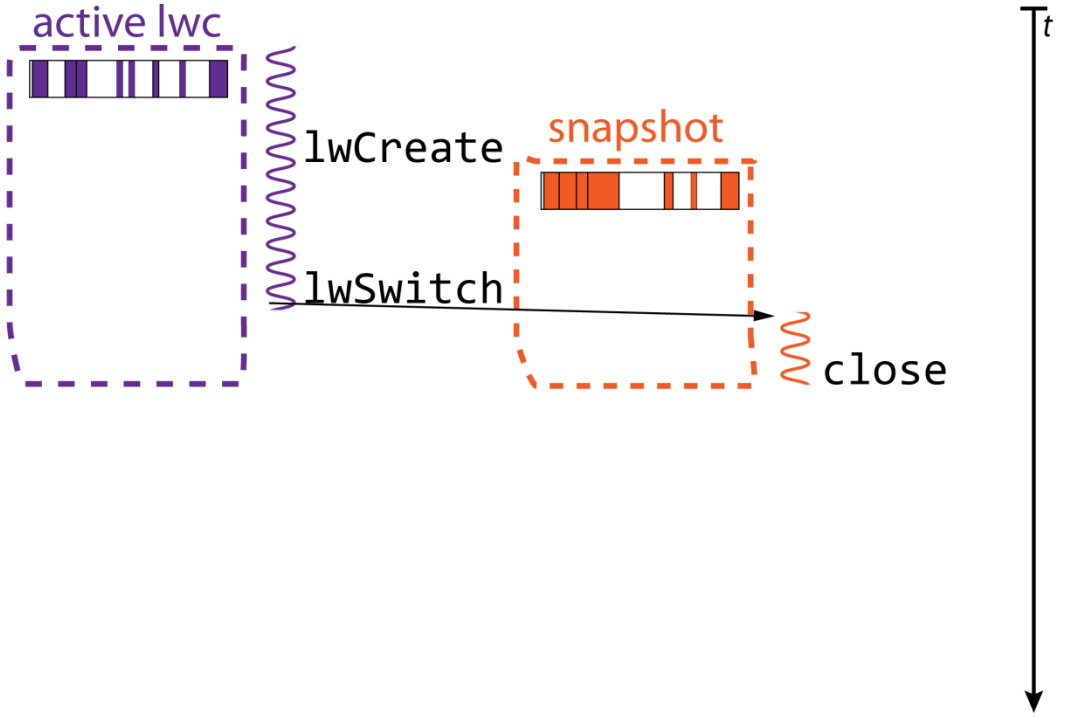

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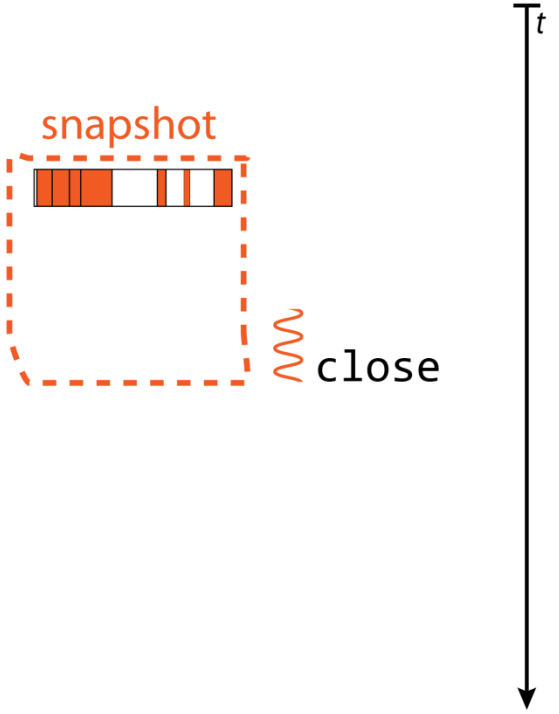

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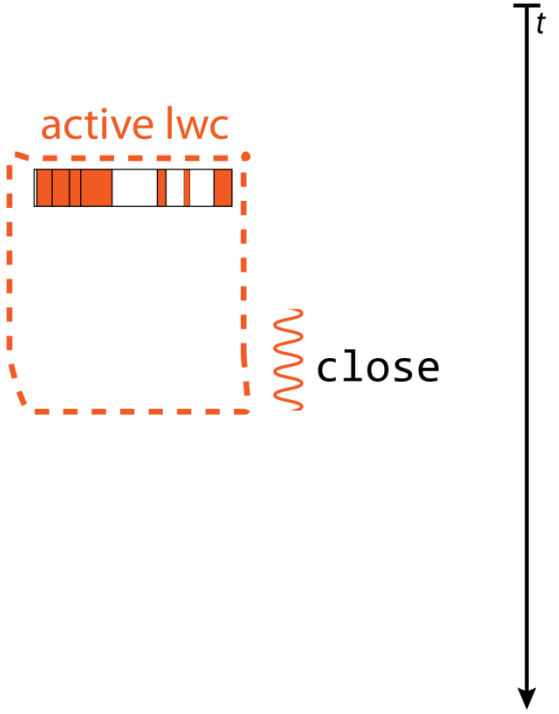

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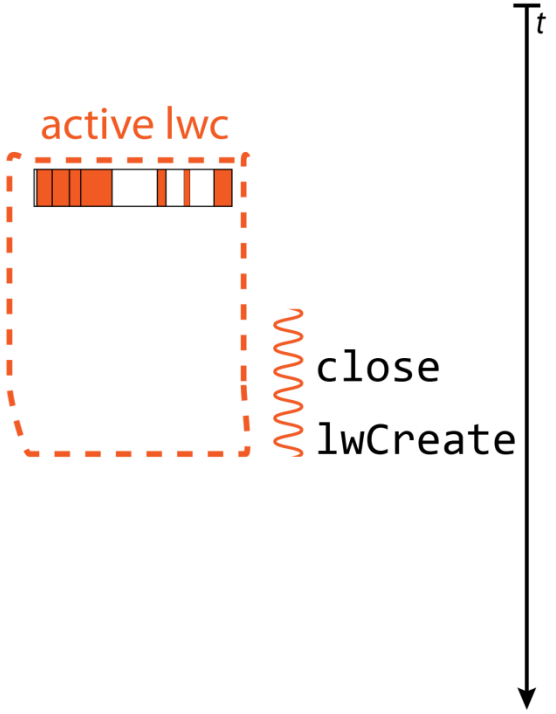

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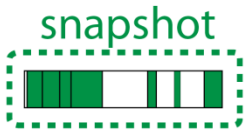

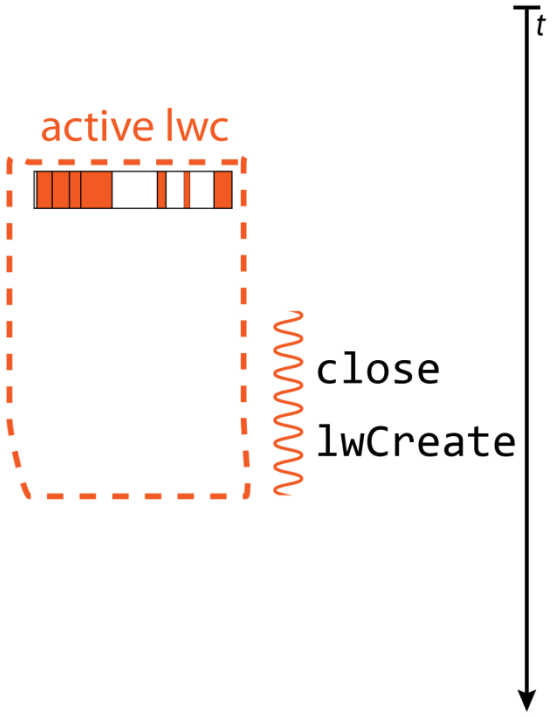

Reference Monitor

```
1:  function MONITOR(child)
2:      _,call = lwSwitch(child, NULL)
3:      loop
4:          if is_allowed(call) then
5:              specs = { ... }
6:              rv = lwSyscall(child, specs,
                                call.num, call.params)
7:              out.err,out.rv = errno, rv
8:          else
9:              out.err,out.rv = EPERM, -1
10:         _,call = lwSwitch(child, out)
11: function MAIN
12:     specs = { ... }
13:     child,c,_ = lwCreate(specs, LWC_SYSTRAP)
14:     if c = -1 then
15:         monitor(child)
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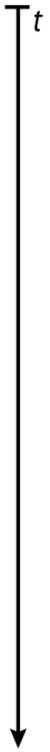

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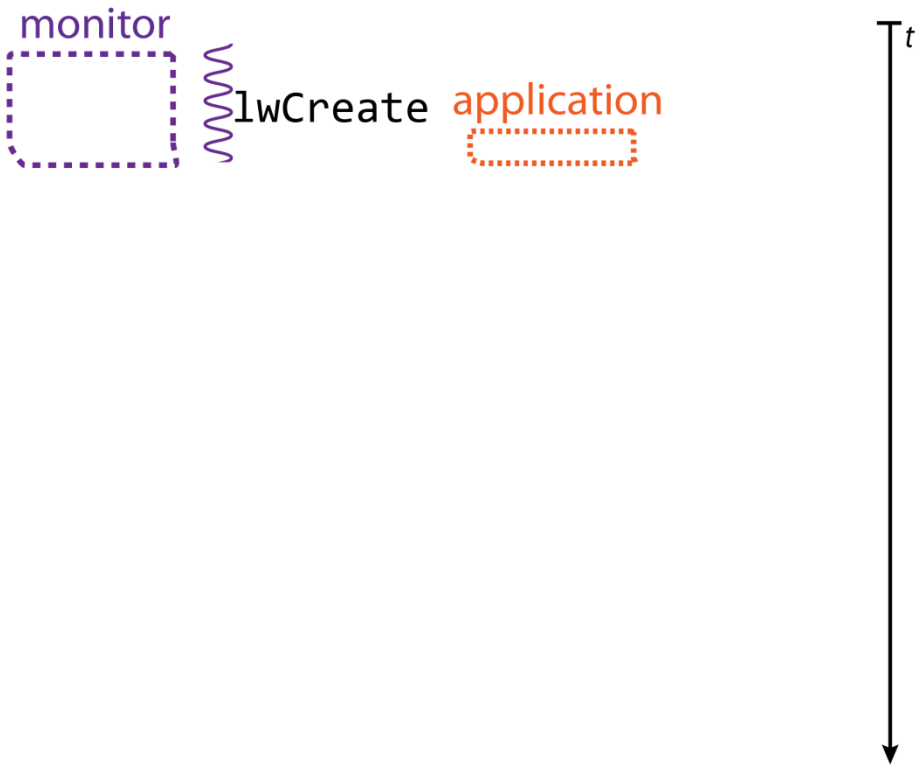

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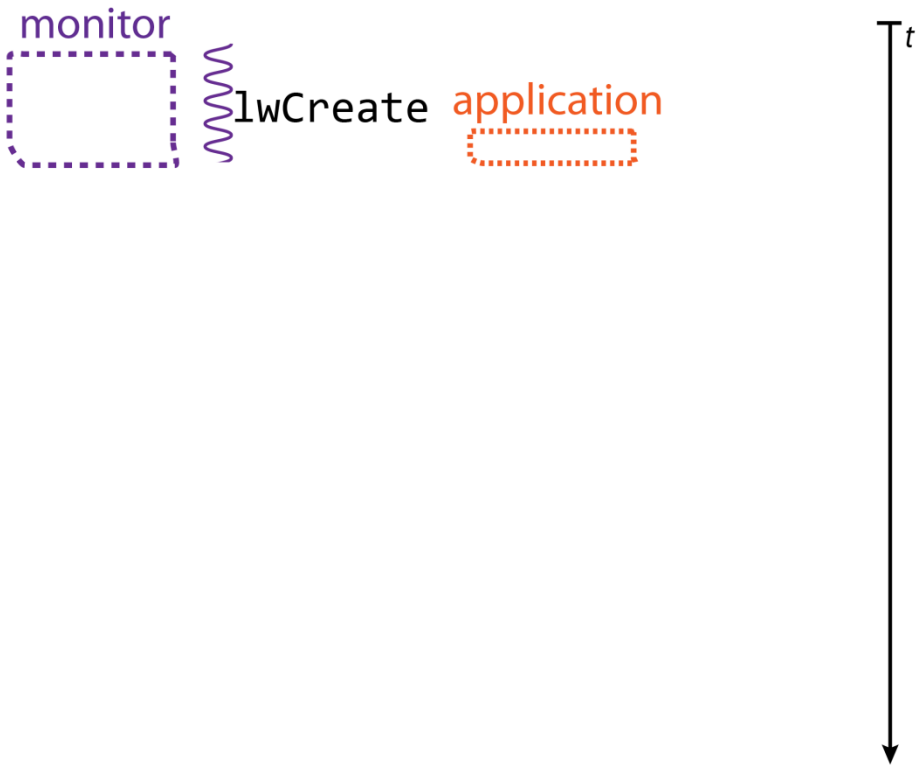

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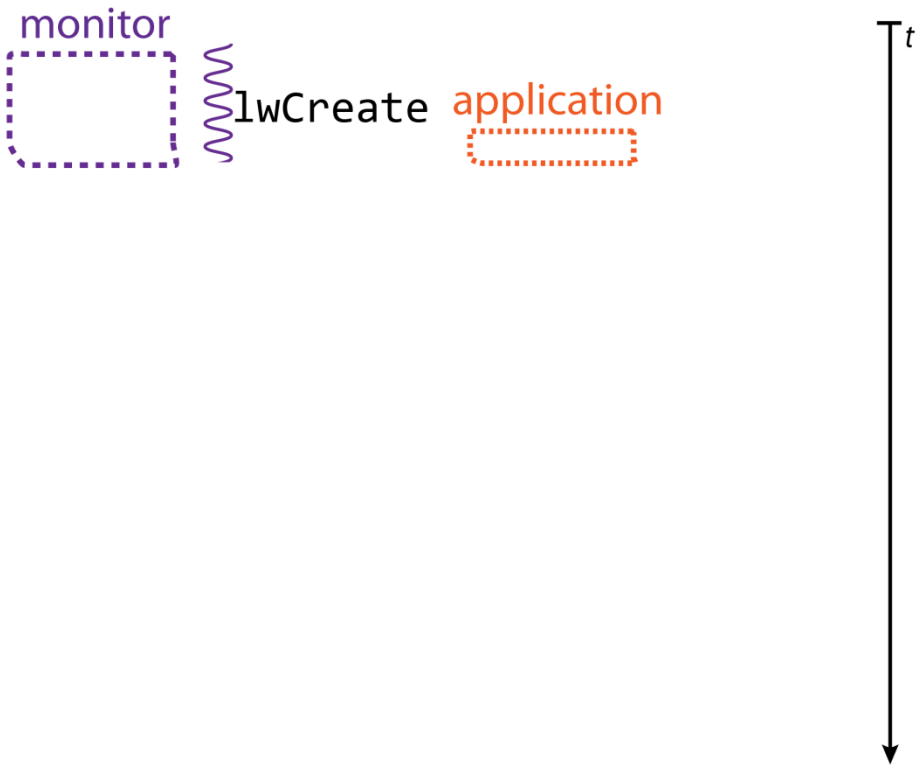

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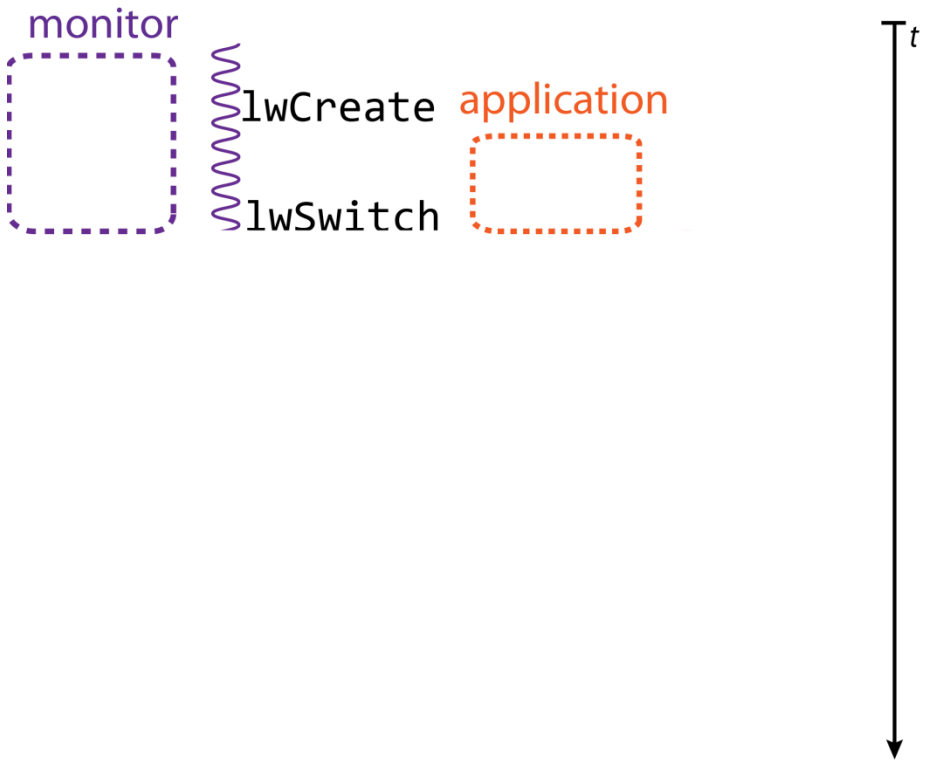

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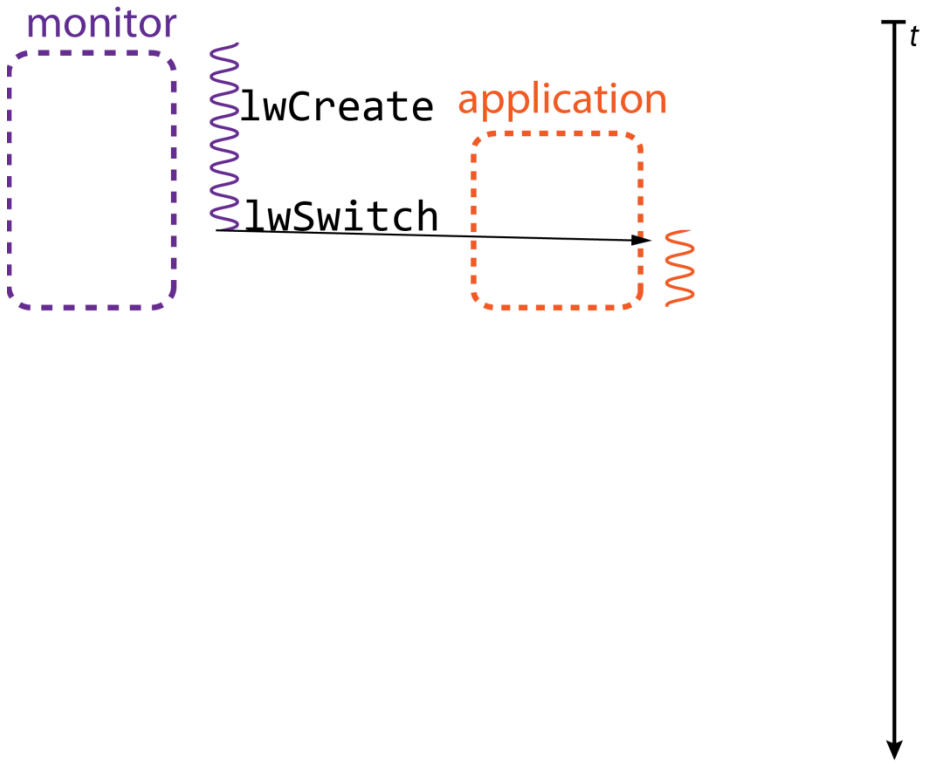

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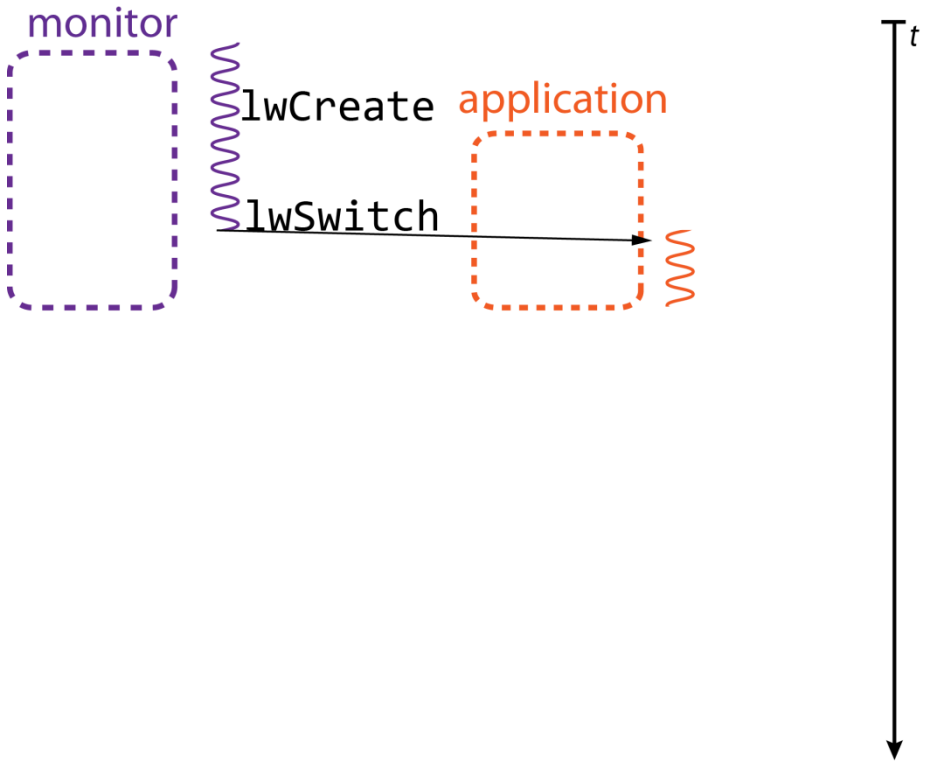

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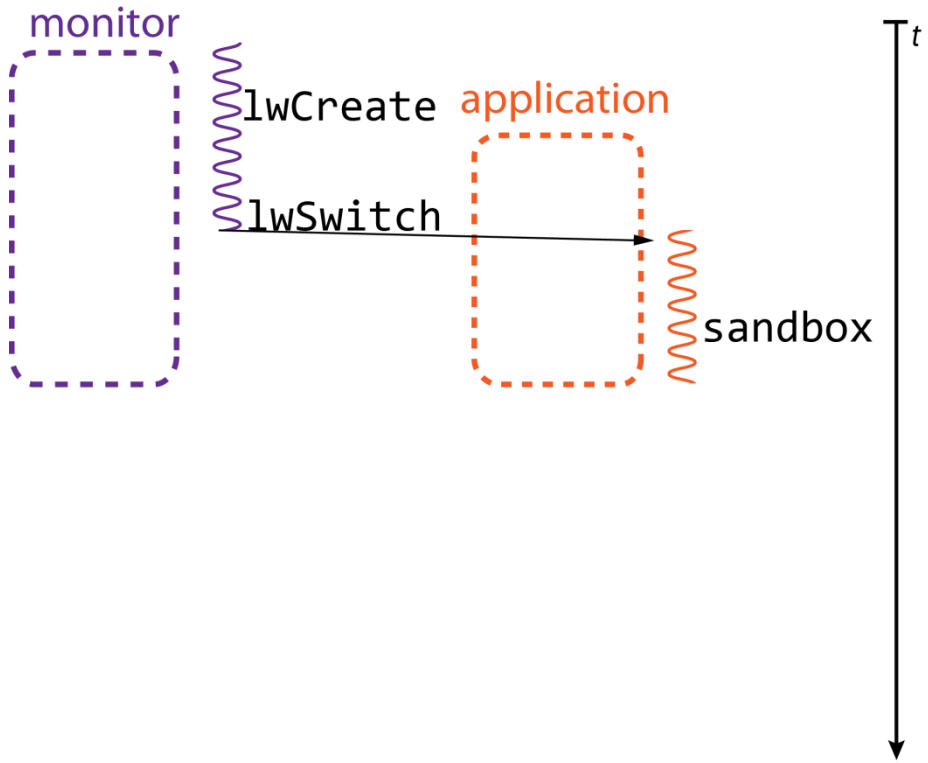

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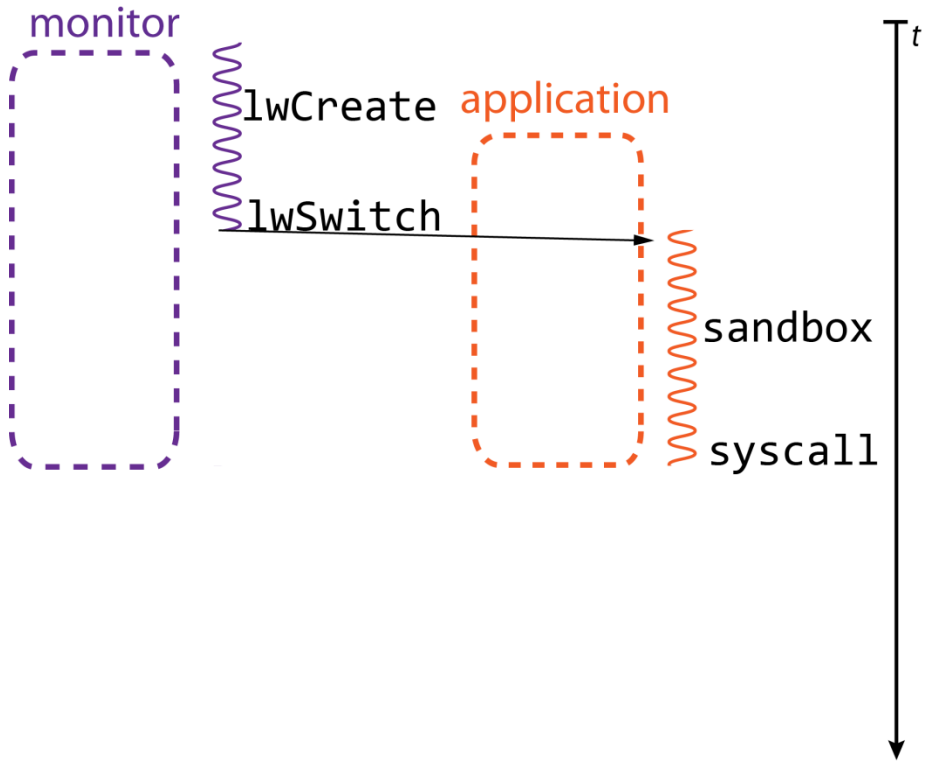

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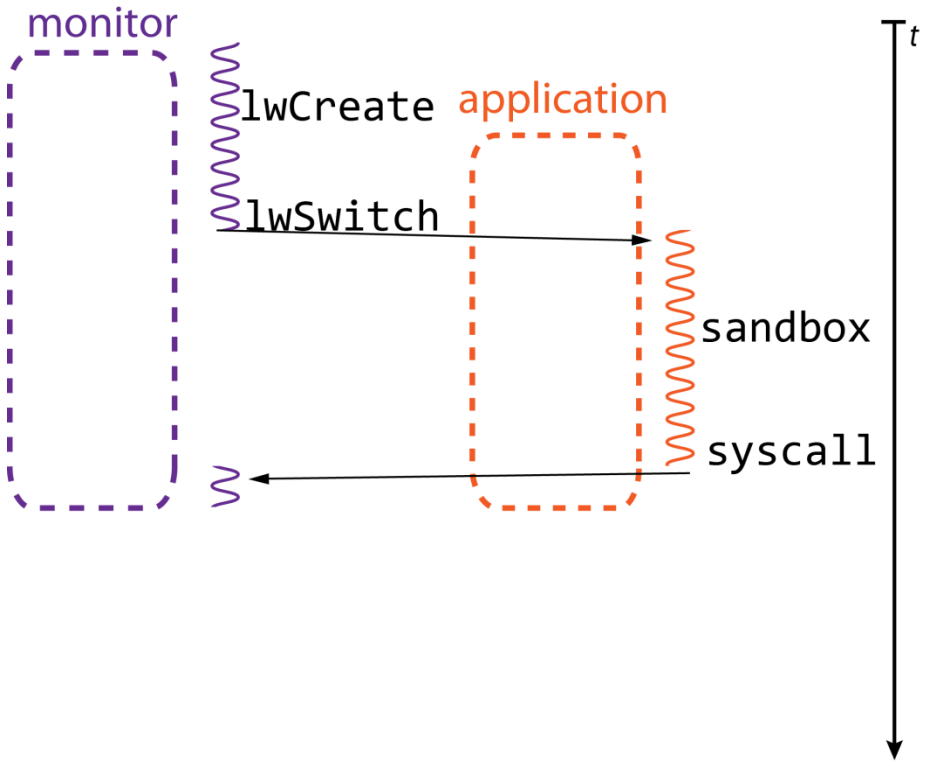

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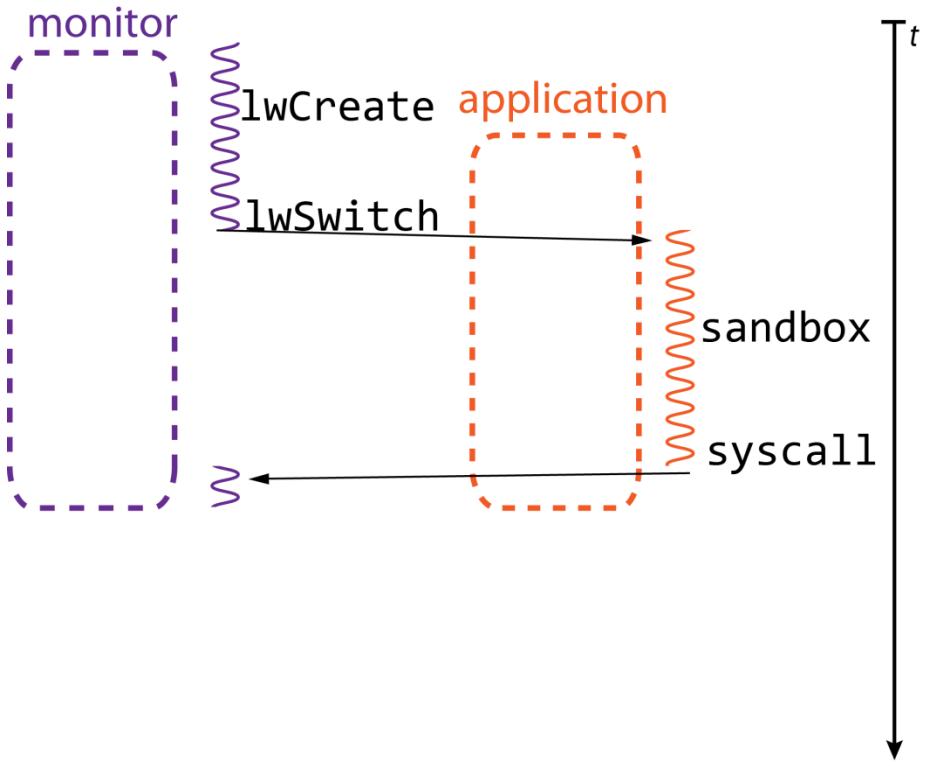

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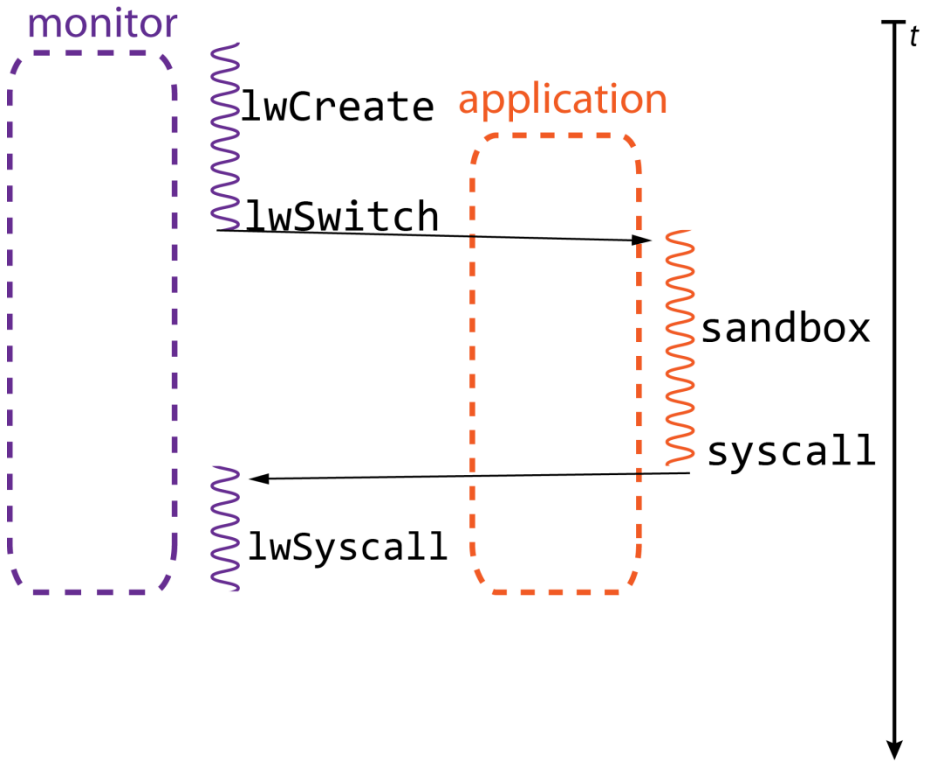

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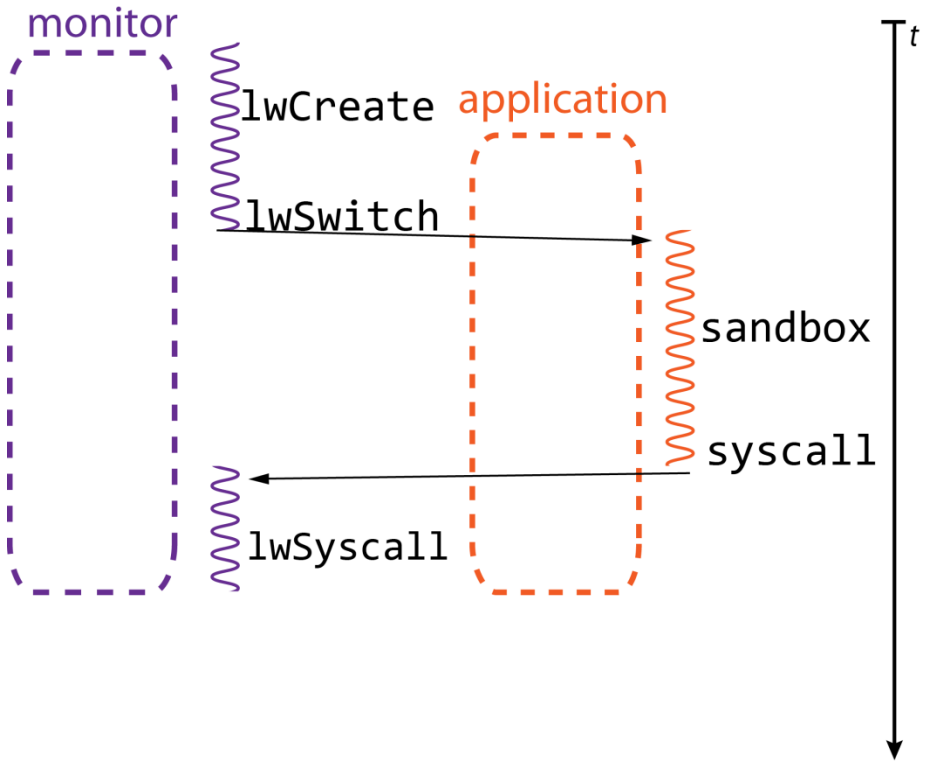

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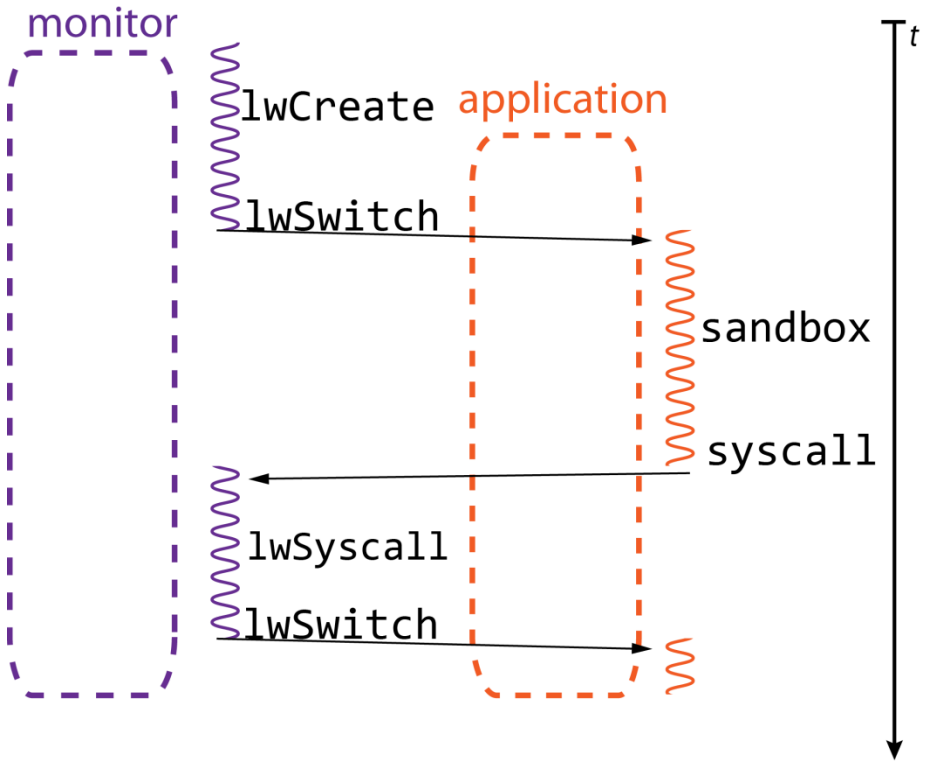


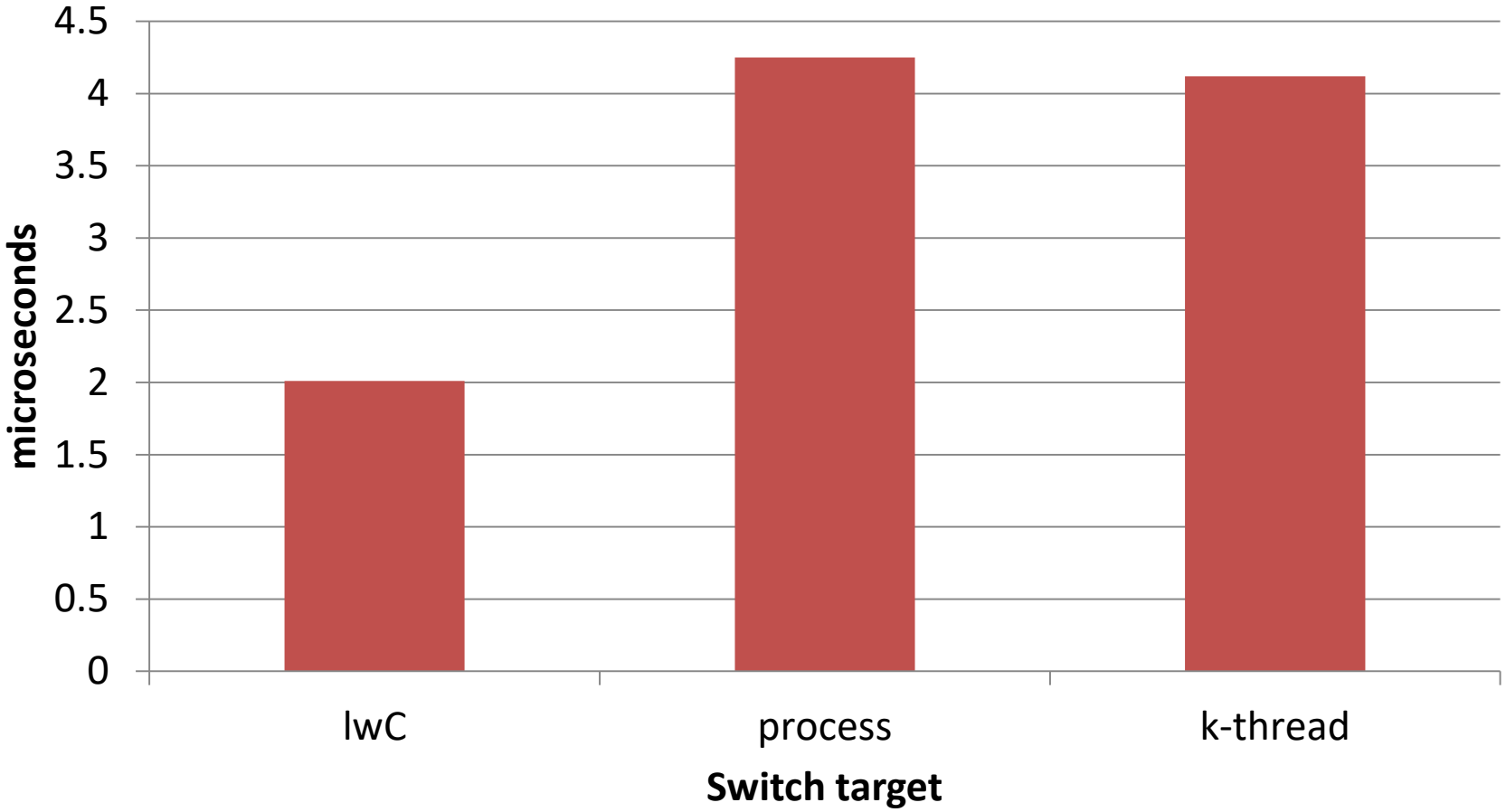
Evaluation

- Microbenchmarks
  - lwCreate
  - lwSwitch
  - Reference monitoring (systrap)
- Apache (v. 2.4.18)
  - Session isolation
  - Reference monitoring
- Nginx (v. 1.9.15)
  - Session isolation
  - Reference monitoring
  - SSL private key isolation
- PHP (v. 7.0.11)
  - Fast startup via snapshots

Creation/Destruction Cost

- No pages dirtied
  - 87.7 microseconds
- Additional COW cost per page dirtied
  - ~ 3.4 microseconds

Switching Cost

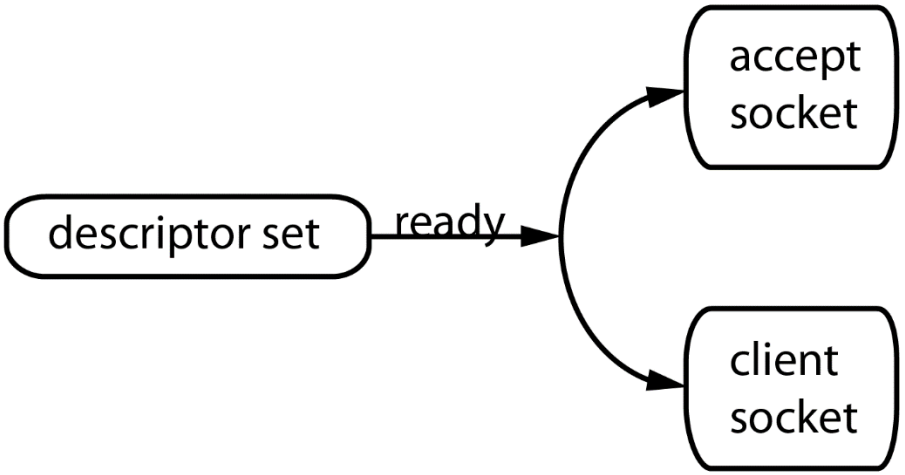


Evaluation – nginx

- High performance web server
  - Asynchronous & event-driven
  - No session isolation

nginx execution

nginx execution



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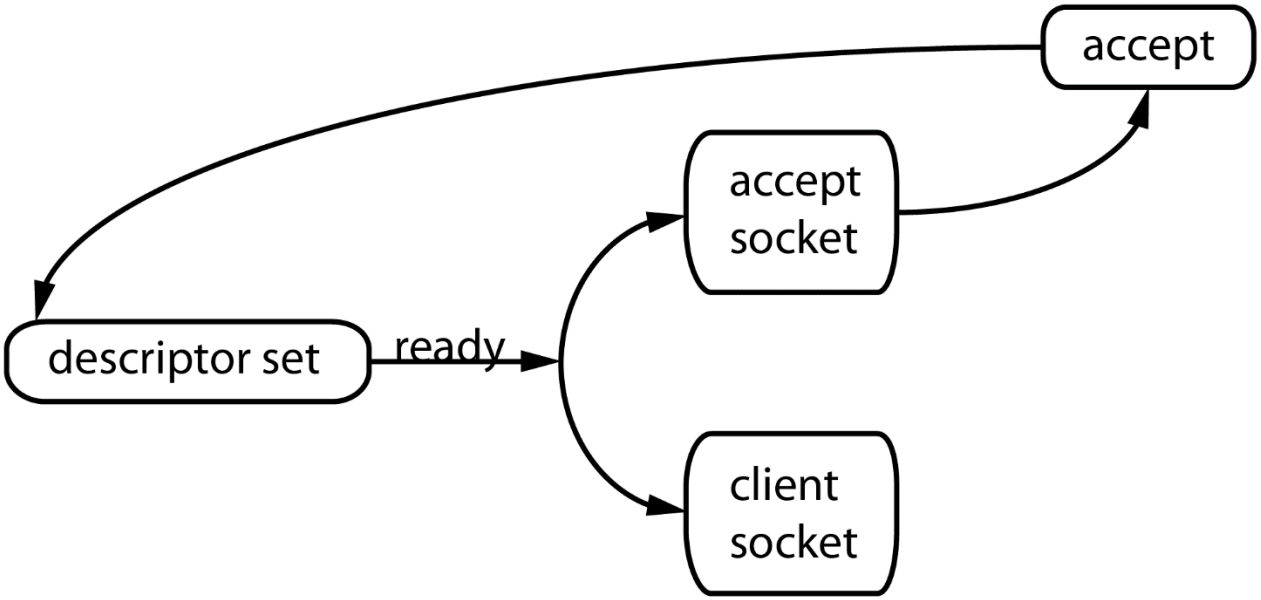

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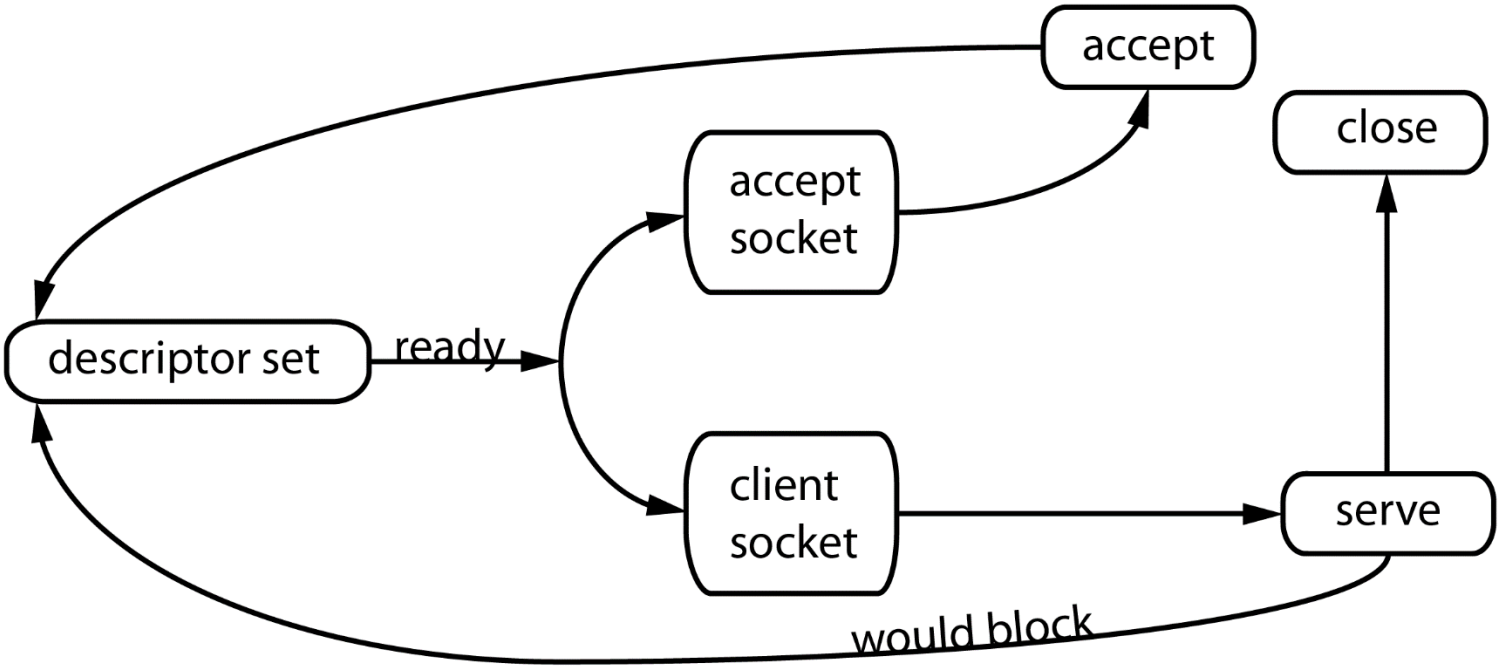

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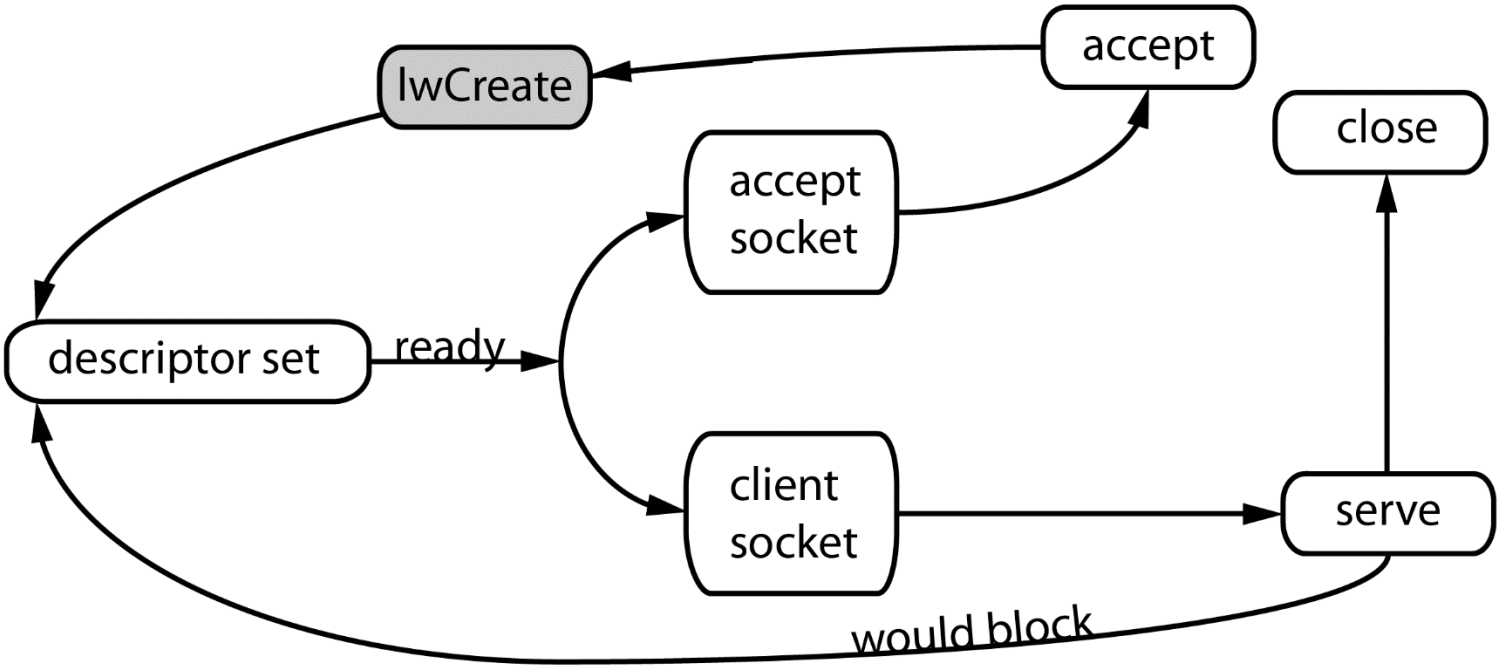

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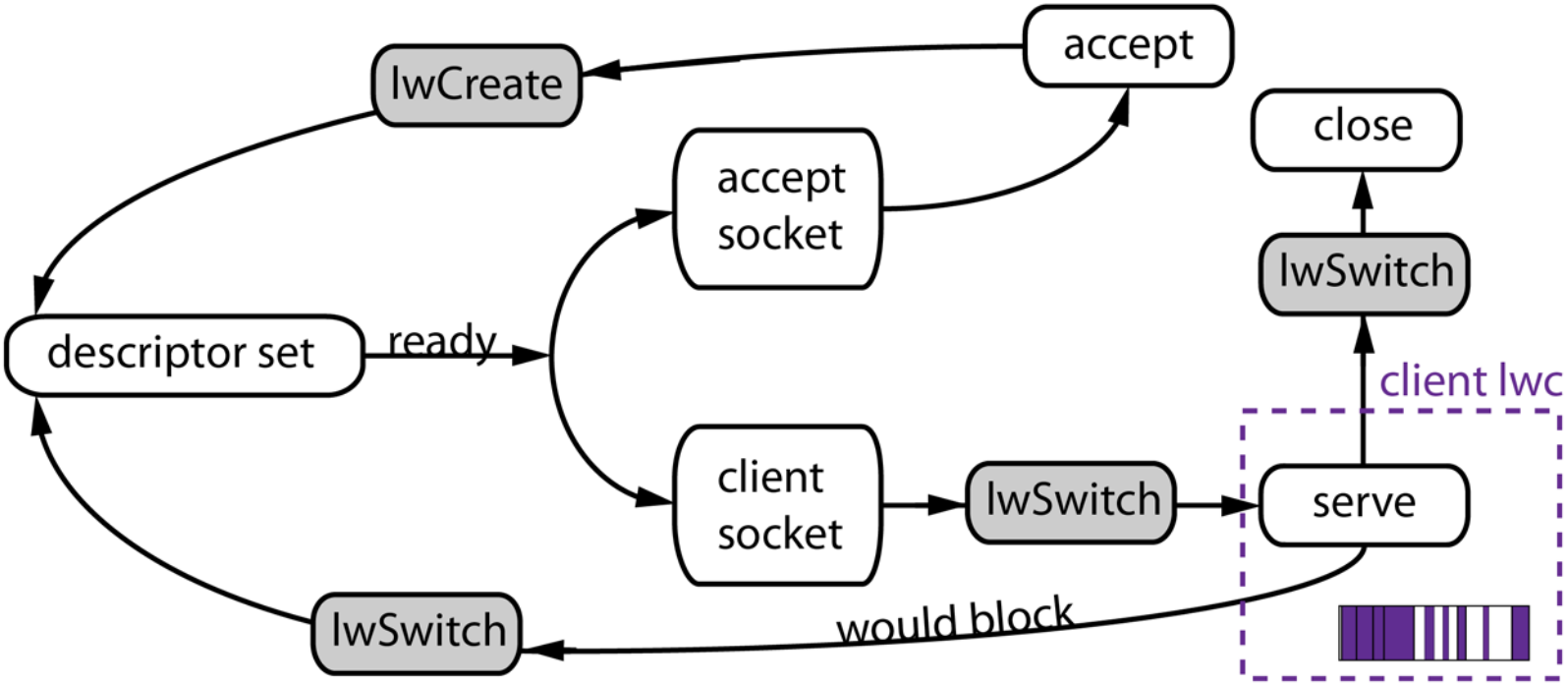

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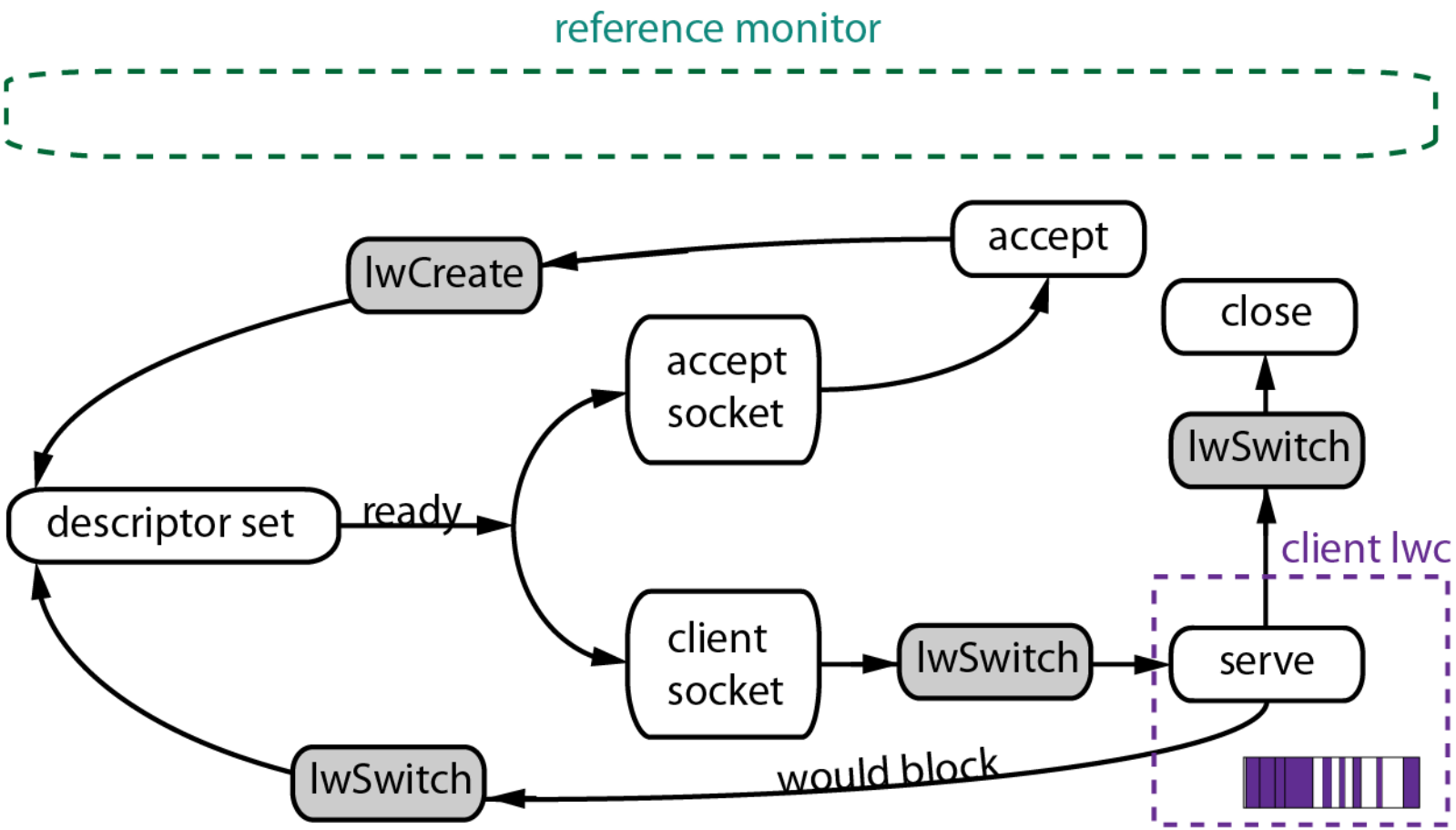
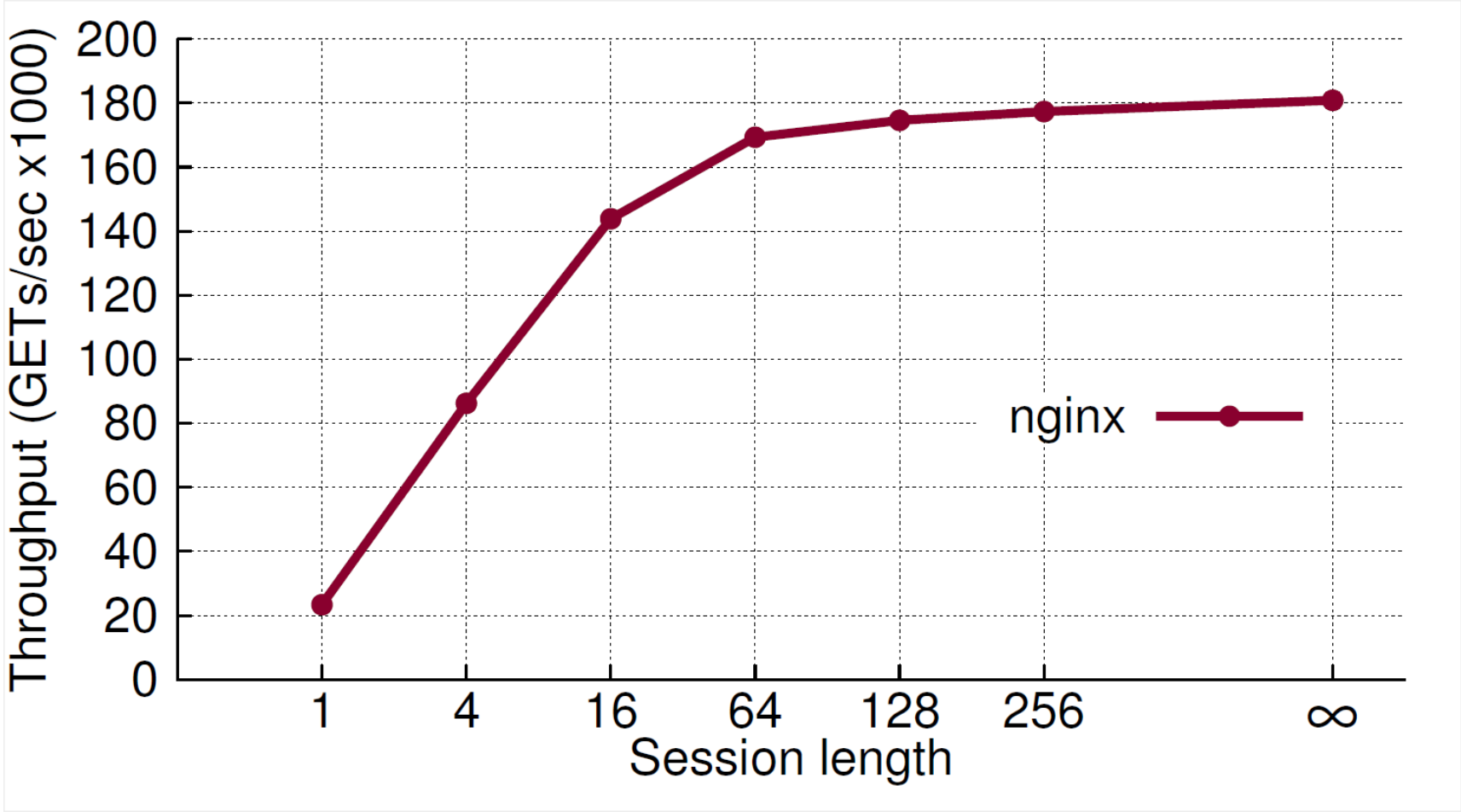


Evaluation - nginx



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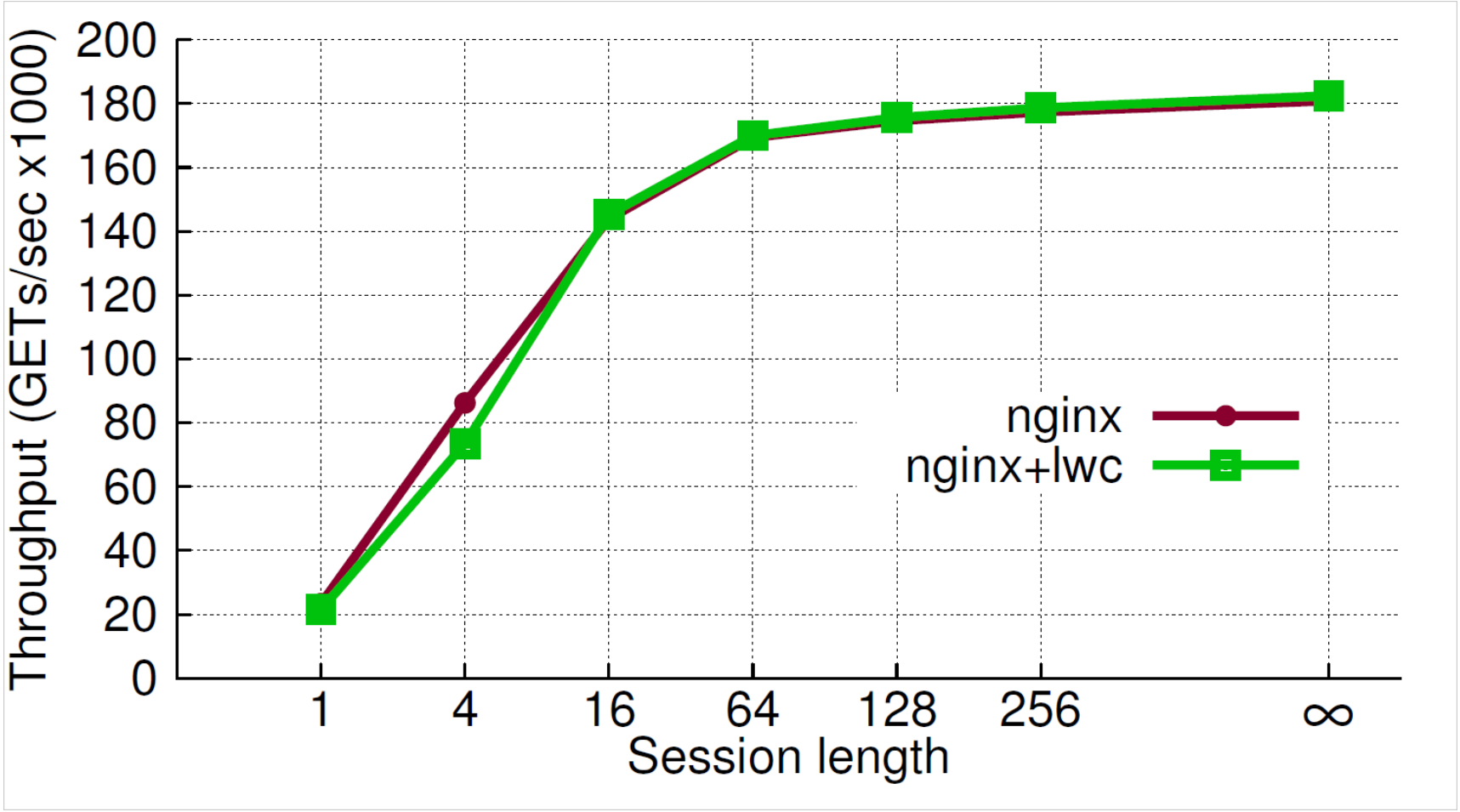

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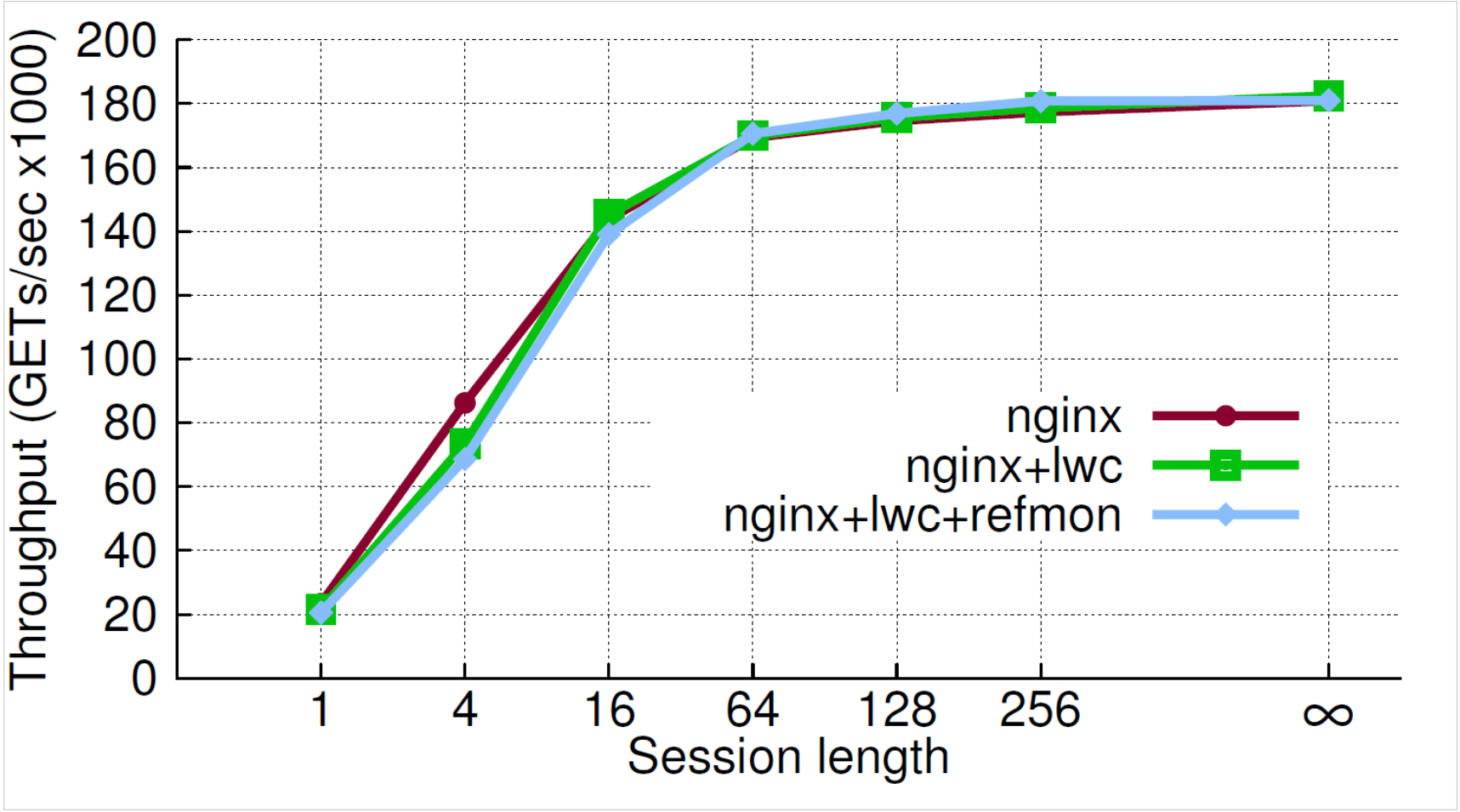
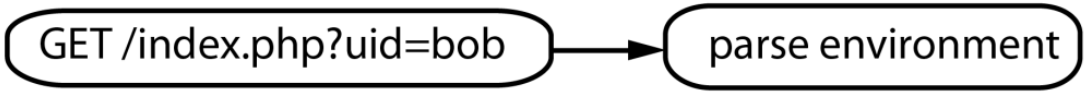


Evaluation - PHP-FCGI

- Use lwC snapshots to speed up PHP
- Evaluated using Zend MVC Framework

PHP Execution



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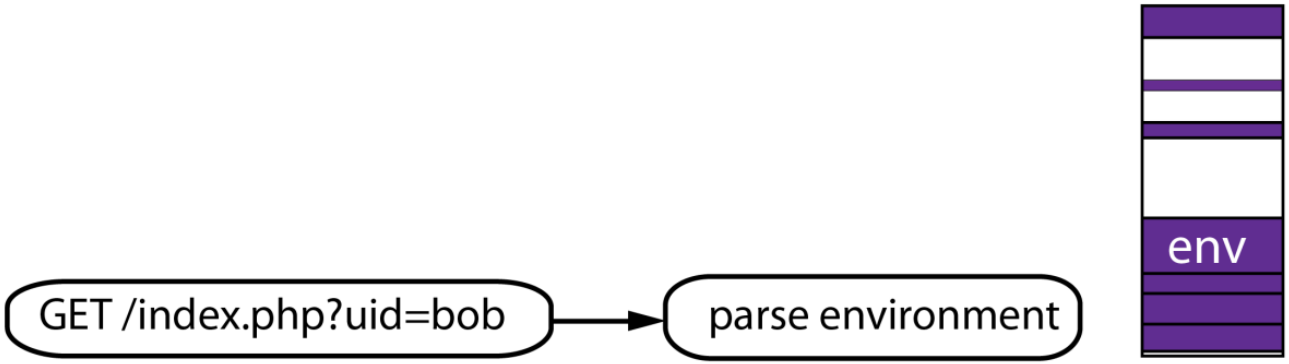

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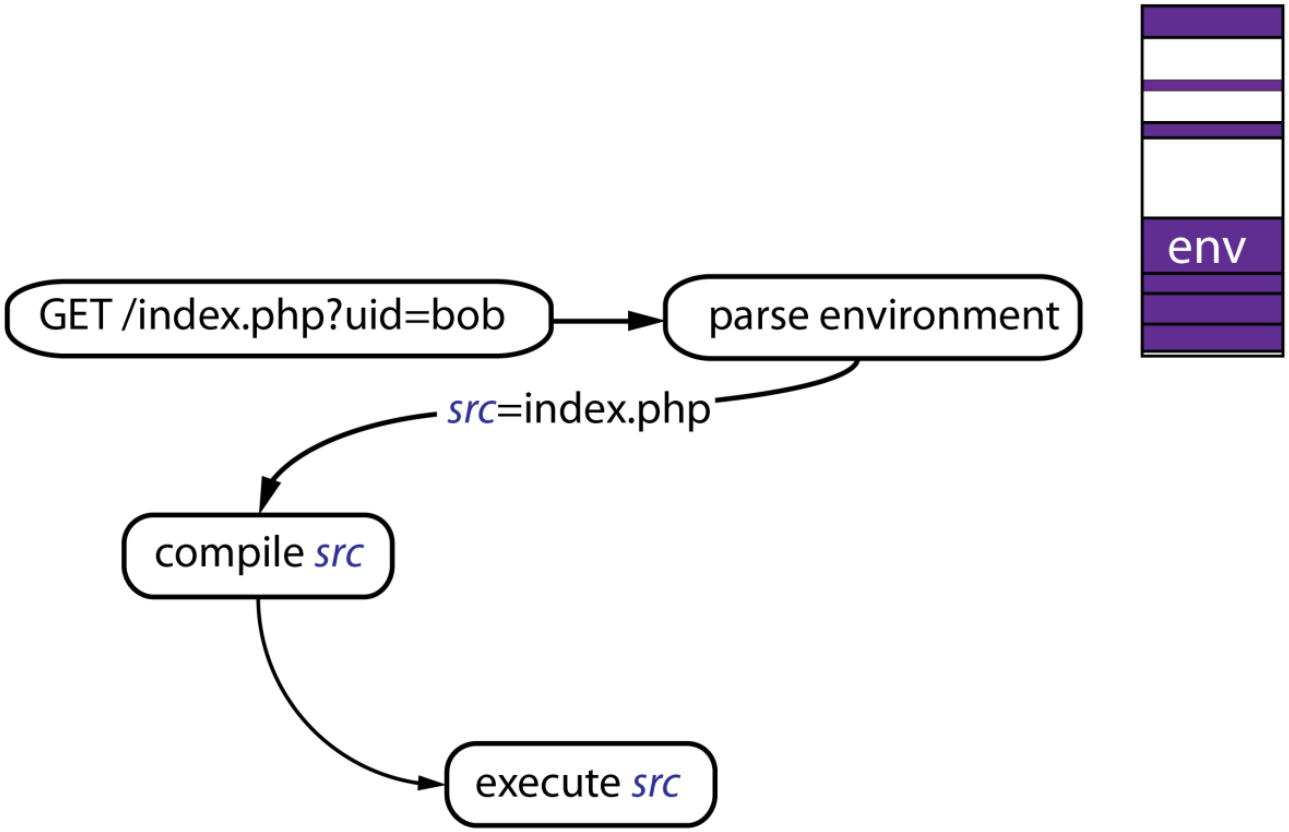

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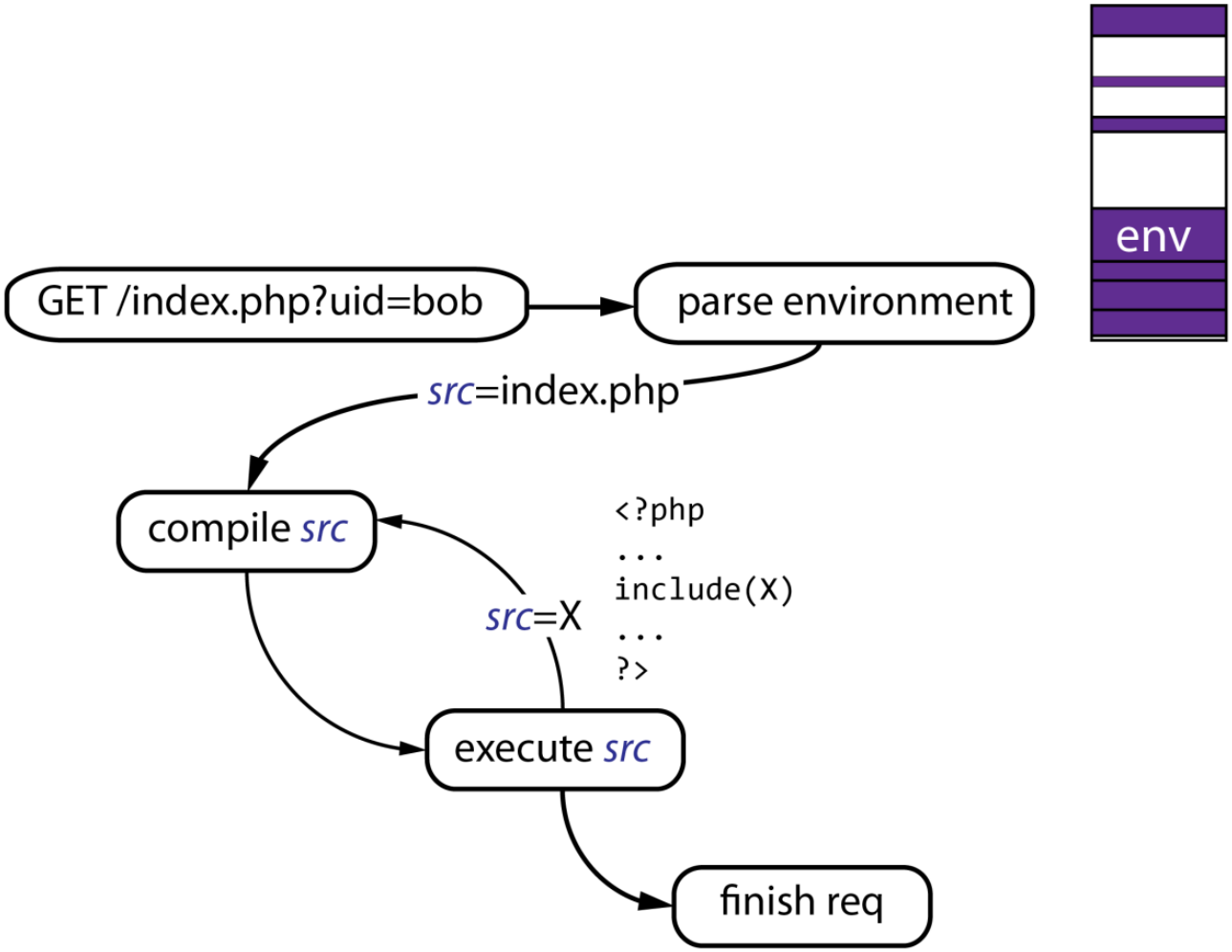

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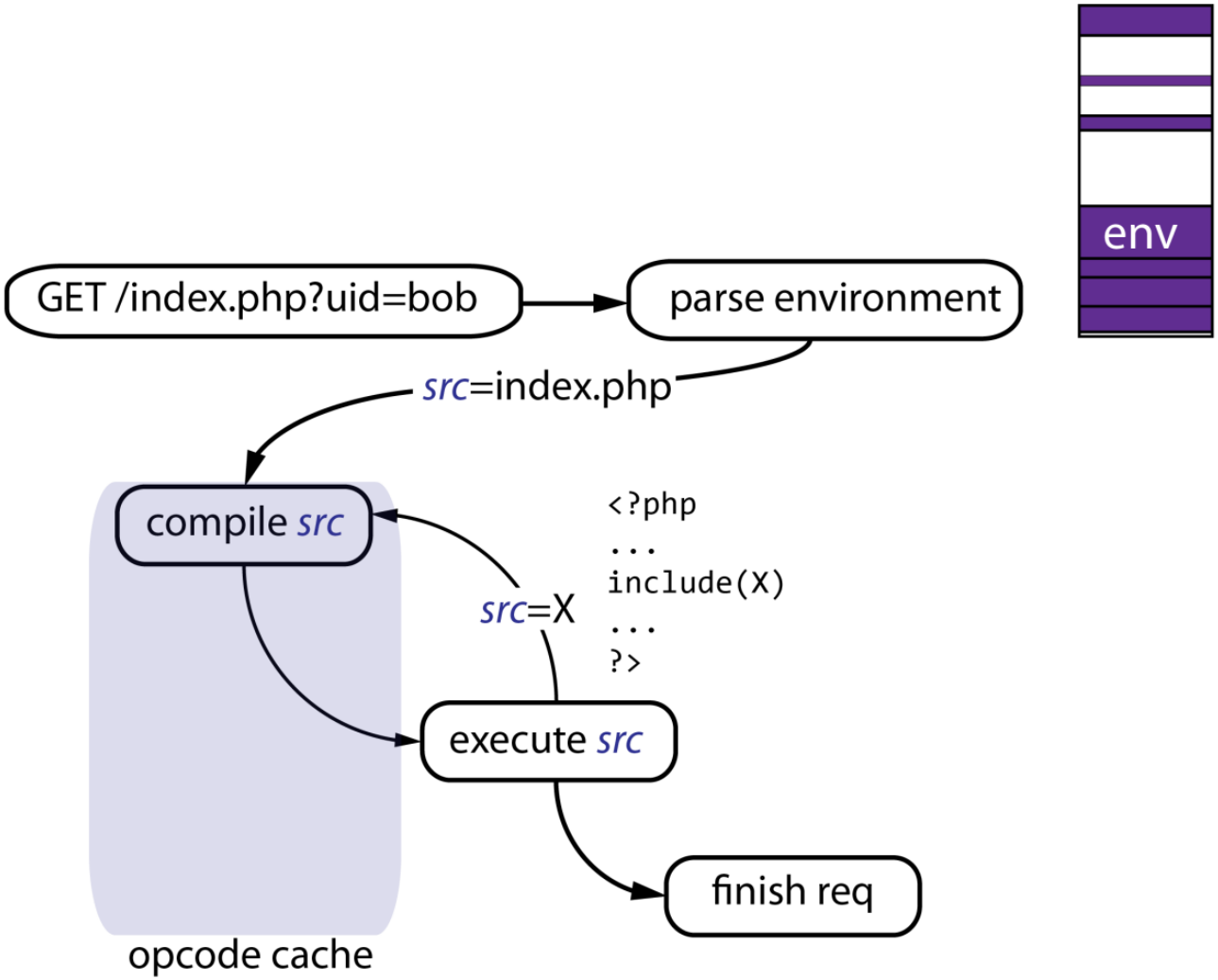
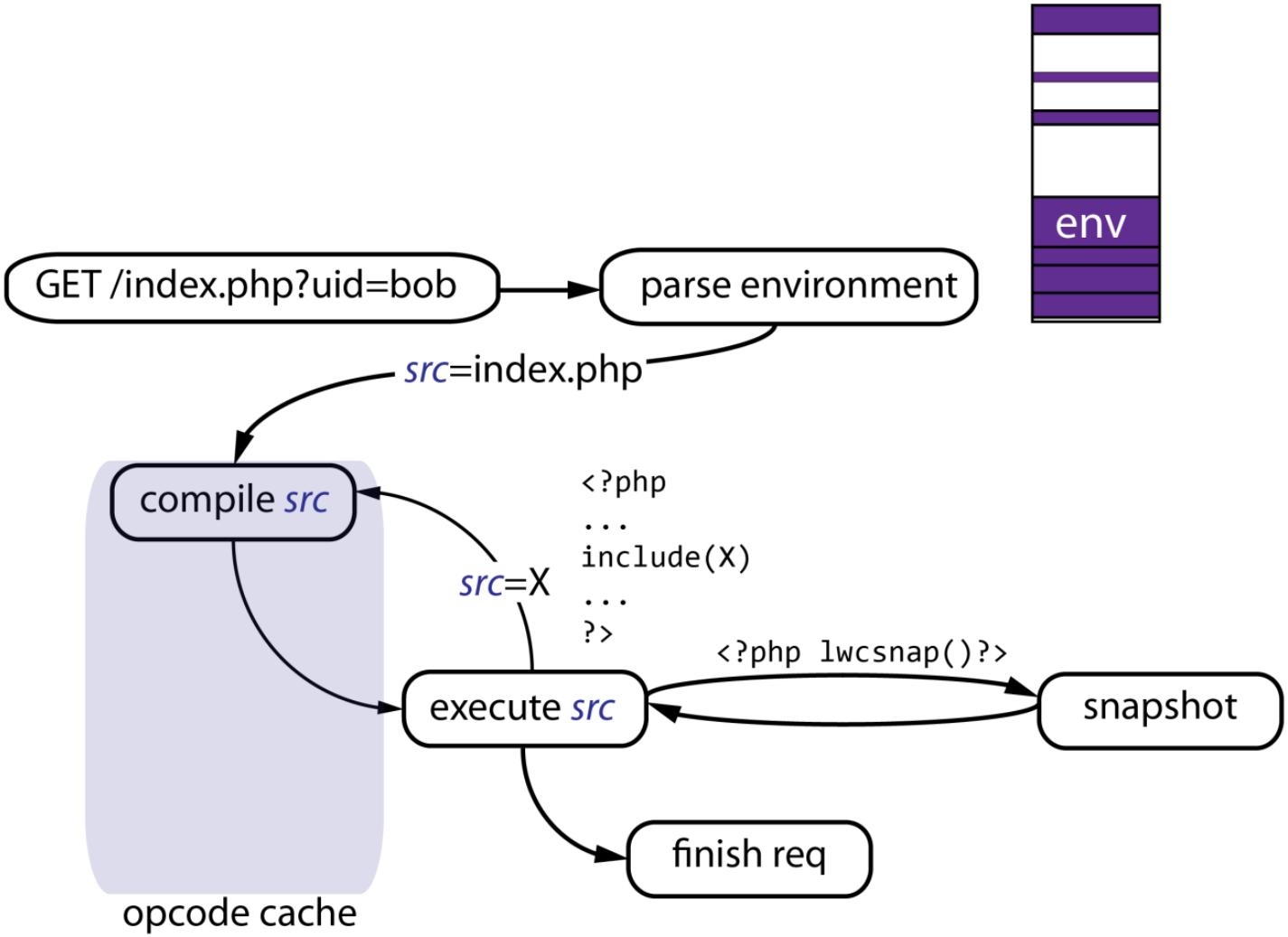


PHP Fast Startup



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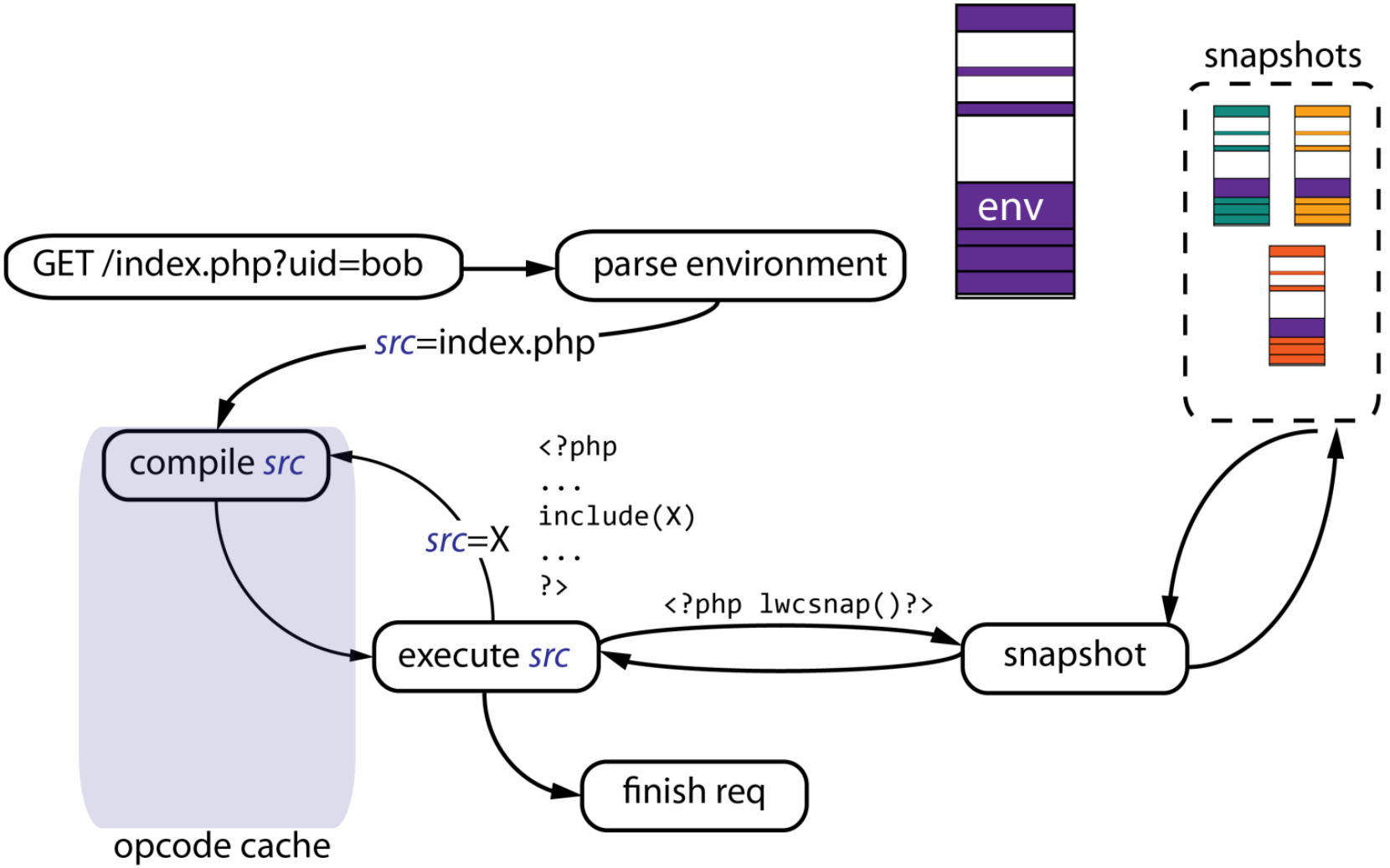

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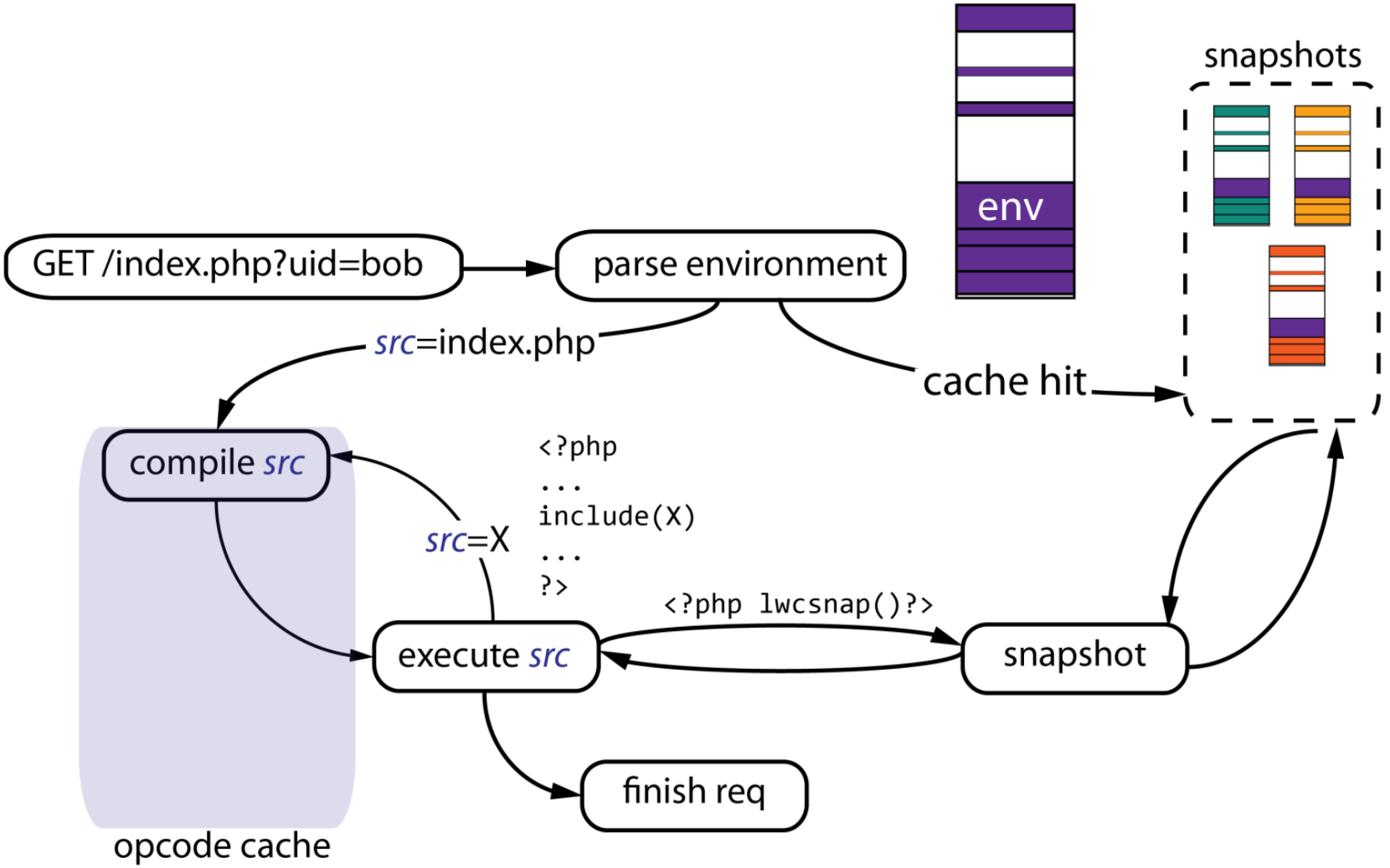

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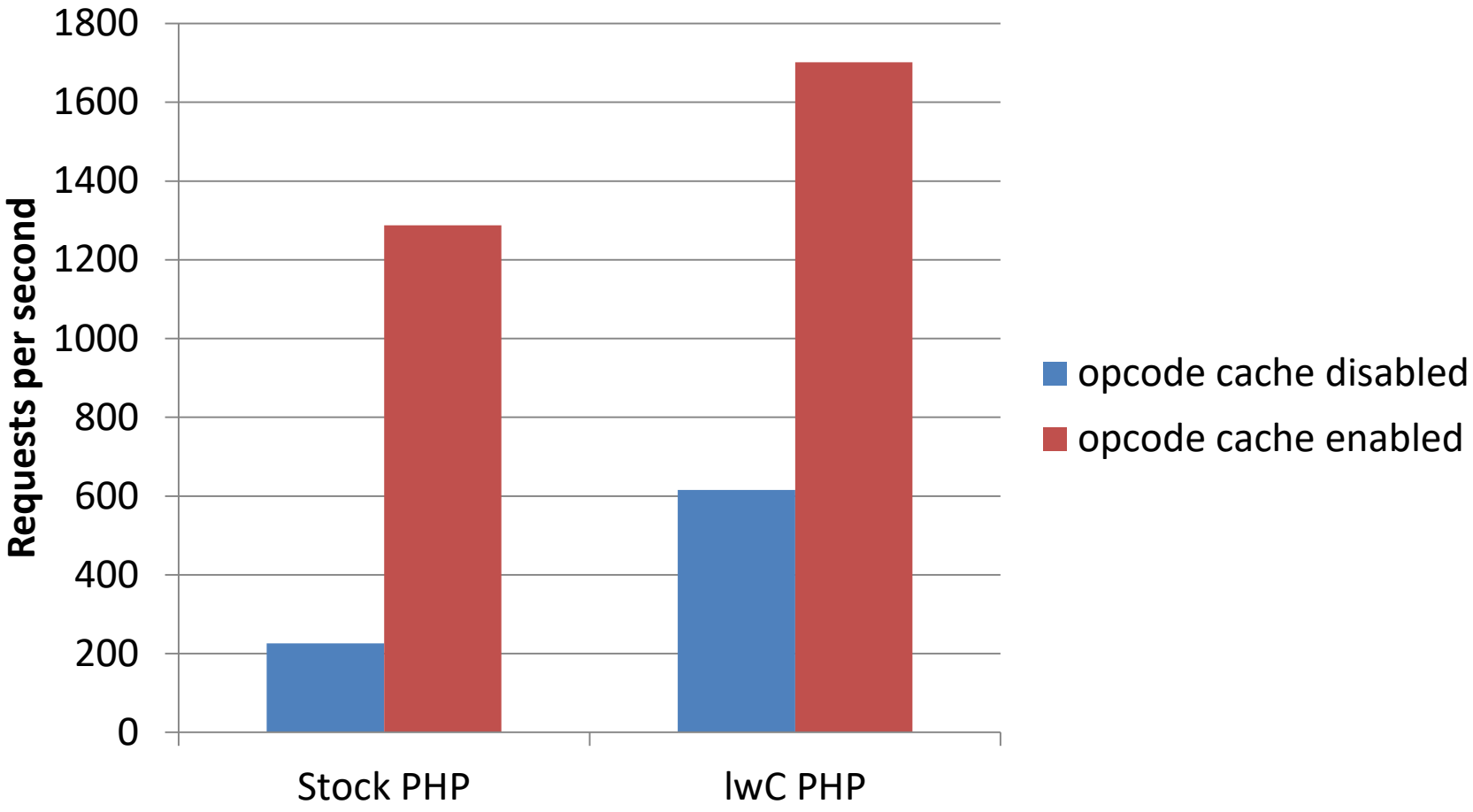

Light-Weight Contexts

Source code will be available at
http://www.cs.umd.edu/projects/lwc/

Max
Planck
Institute
for
Software Systems