Improving Power Efficiency with App Nap

Session 209

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Software Engineer, Cocoa Frameworks

What is App Nap?

How App Nap Works

App Nap API

What is App Nap?

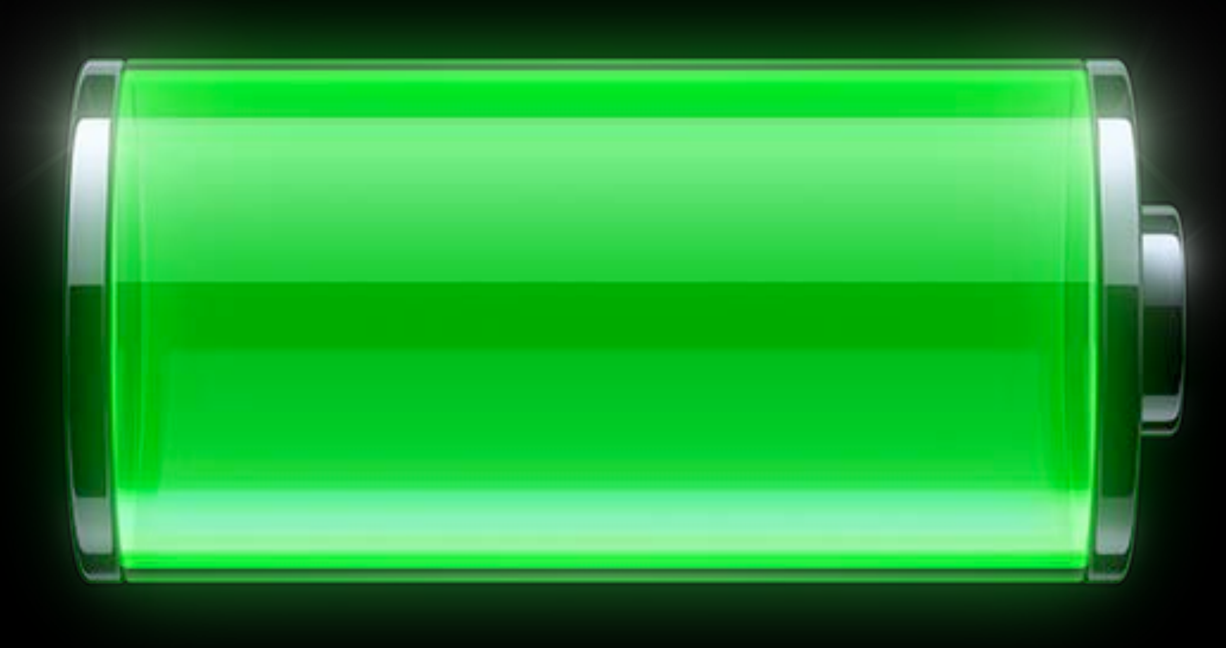
In a World Where…

- Users expect long battery life and high-performance apps

In a World Where…

- Users expect long battery life and high-performance apps
- All apps have about equal access to limited resources
    - CPU time
    - Disk I/O
    - Energy

App Nap focuses system resources on the most important user work.



60
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Battery Life

Responsiveness

App Nap Heuristics

Understanding what’s important

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- Foreground vs. background application

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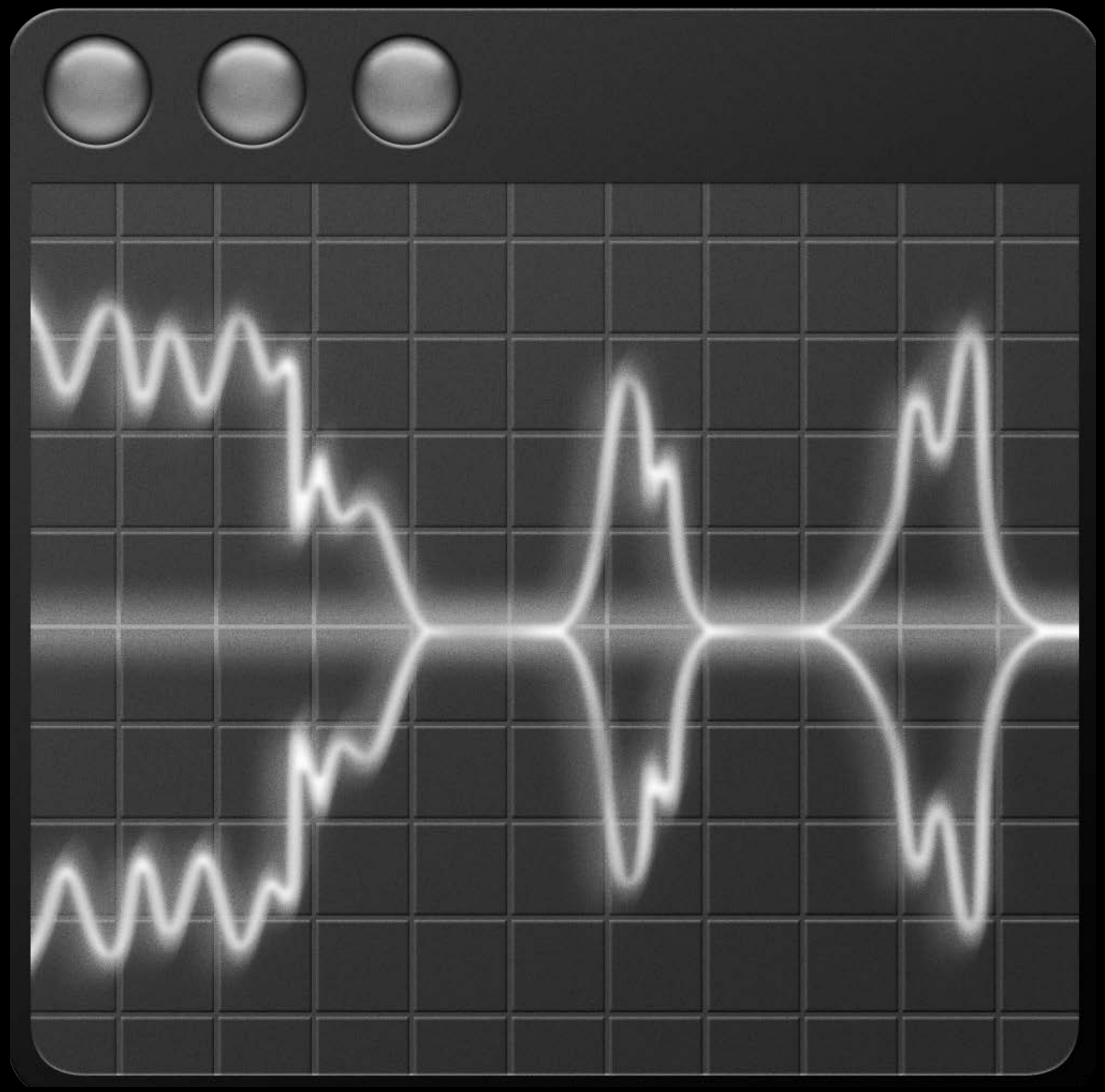

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- Use of existing IOKit power assertion API

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- Foreground vs. background application
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- Audio playback
- Event processing
- Use of existing IOKit power assertion API
- Use of new App Nap API

Demo

App Nap

How App Nap Works

What’s a Watt?

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- Power
  - Rate at which energy is consumed
  - Measured in watts (W)

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  - Rate at which energy is consumed
  - Measured in watts (W)
- Energy
  - Stored potential to do work
  - Measured in watt-hours (Wh)

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- 50 watt-hour battery
- 7 hour battery life

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- GPU
- Network
- Storage
- Memory
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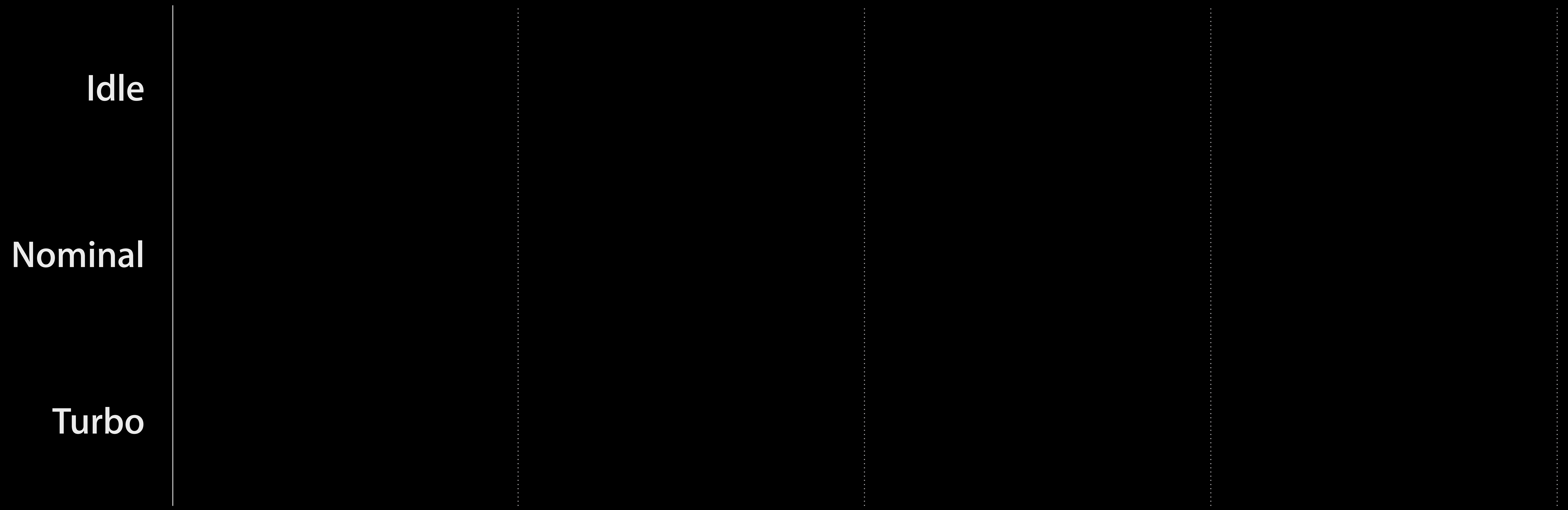

CPU Power Usage

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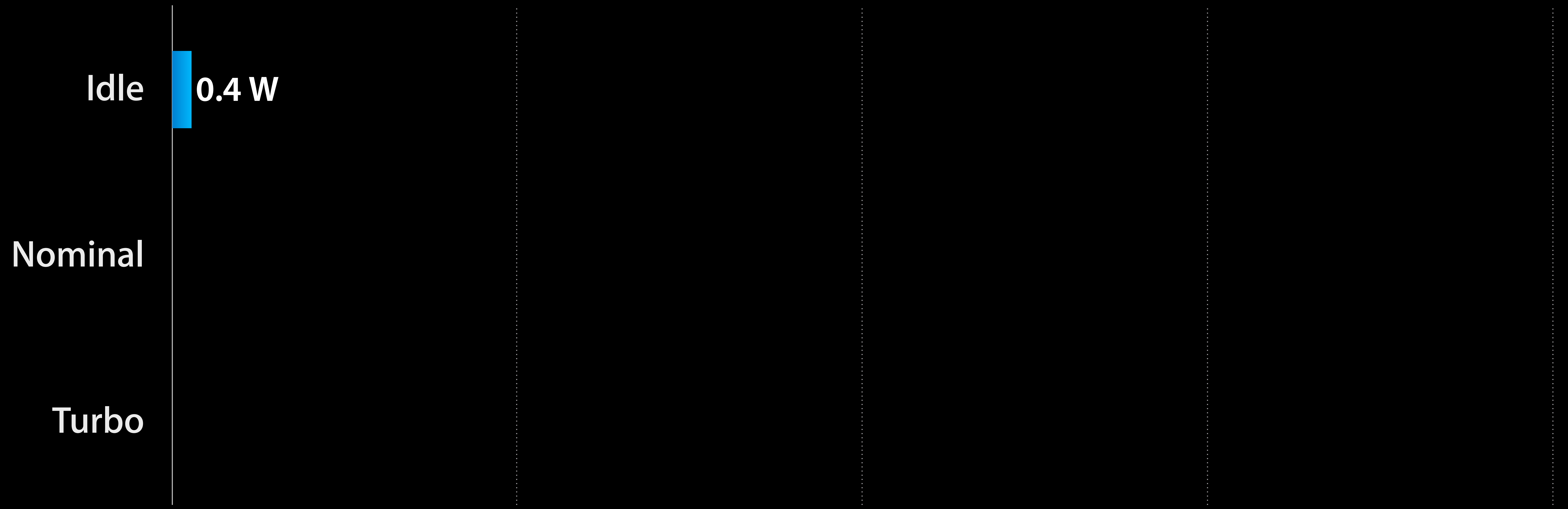

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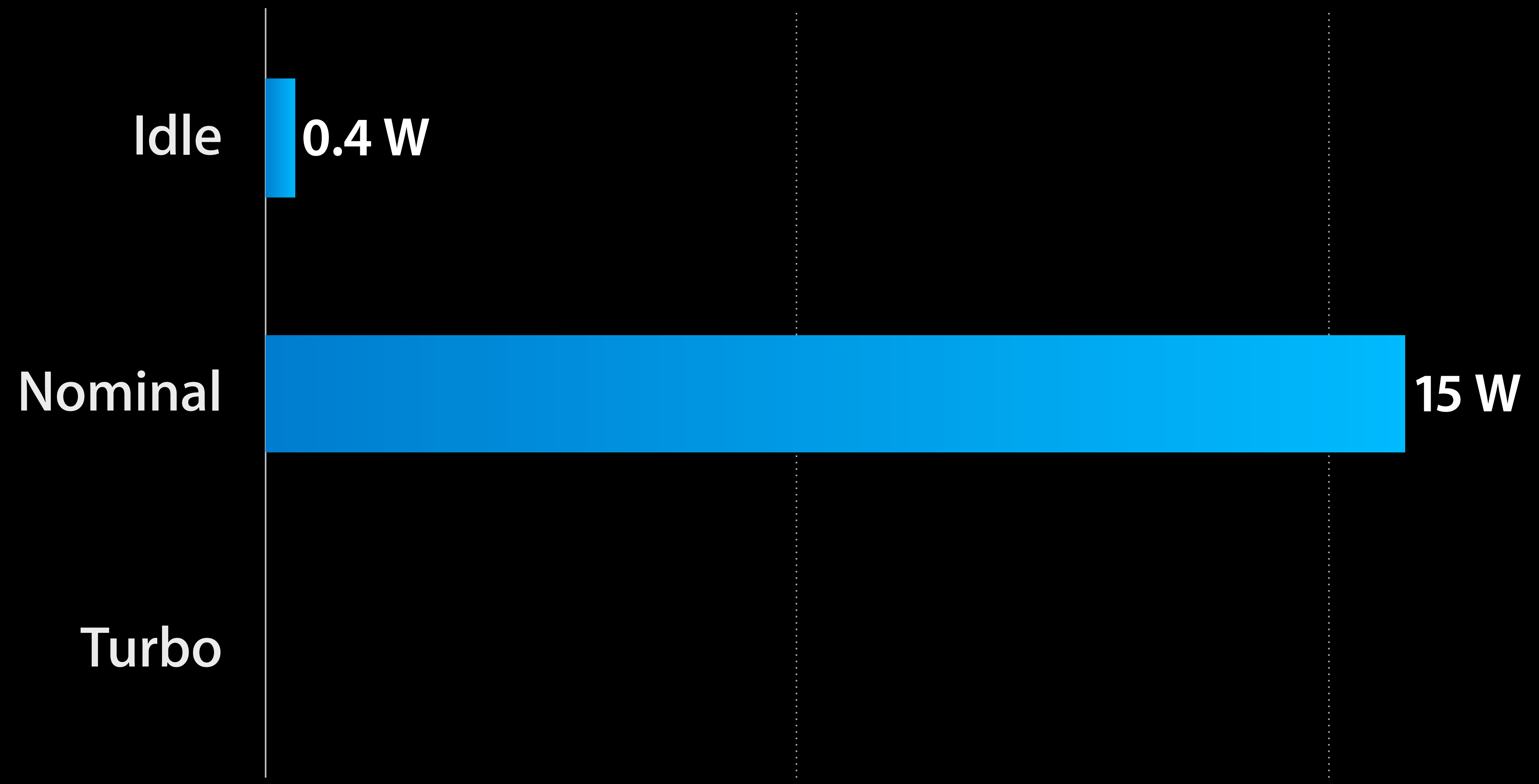

CPU Power Usage

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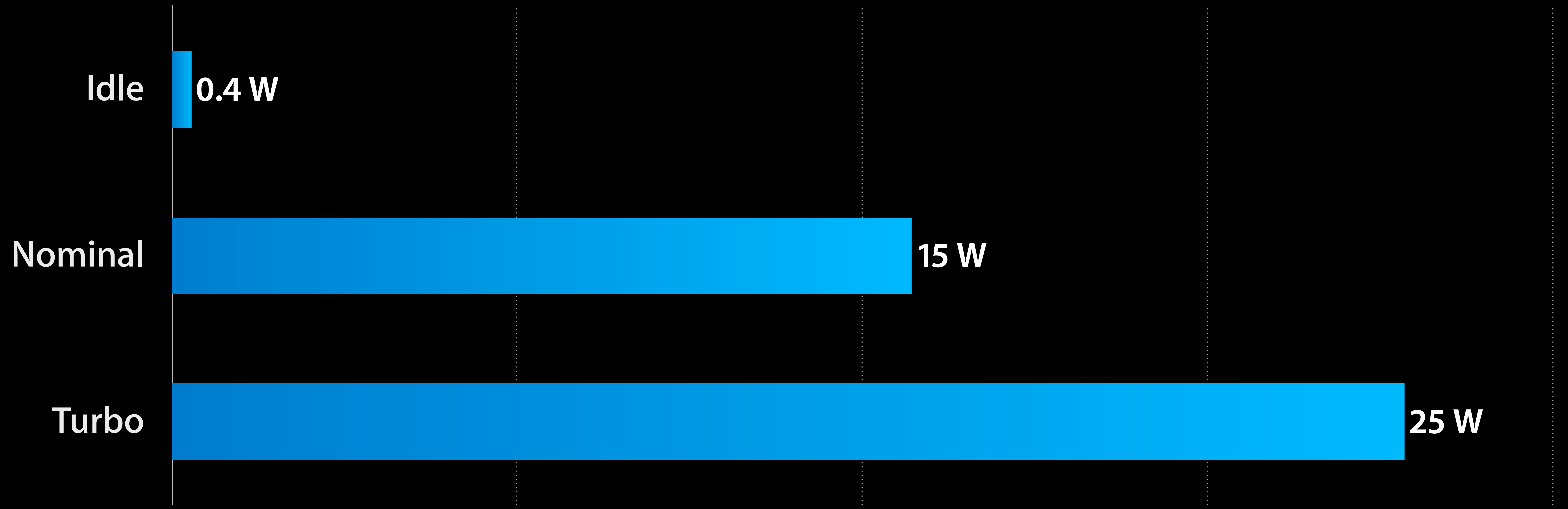

Extending Battery Life

Three key rules

- Stay idle as long as possible
- Avoid unnecessary work
- Return to idle as quickly as possible

Staying Idle: a Case Study

Visiting apple.com in Safari

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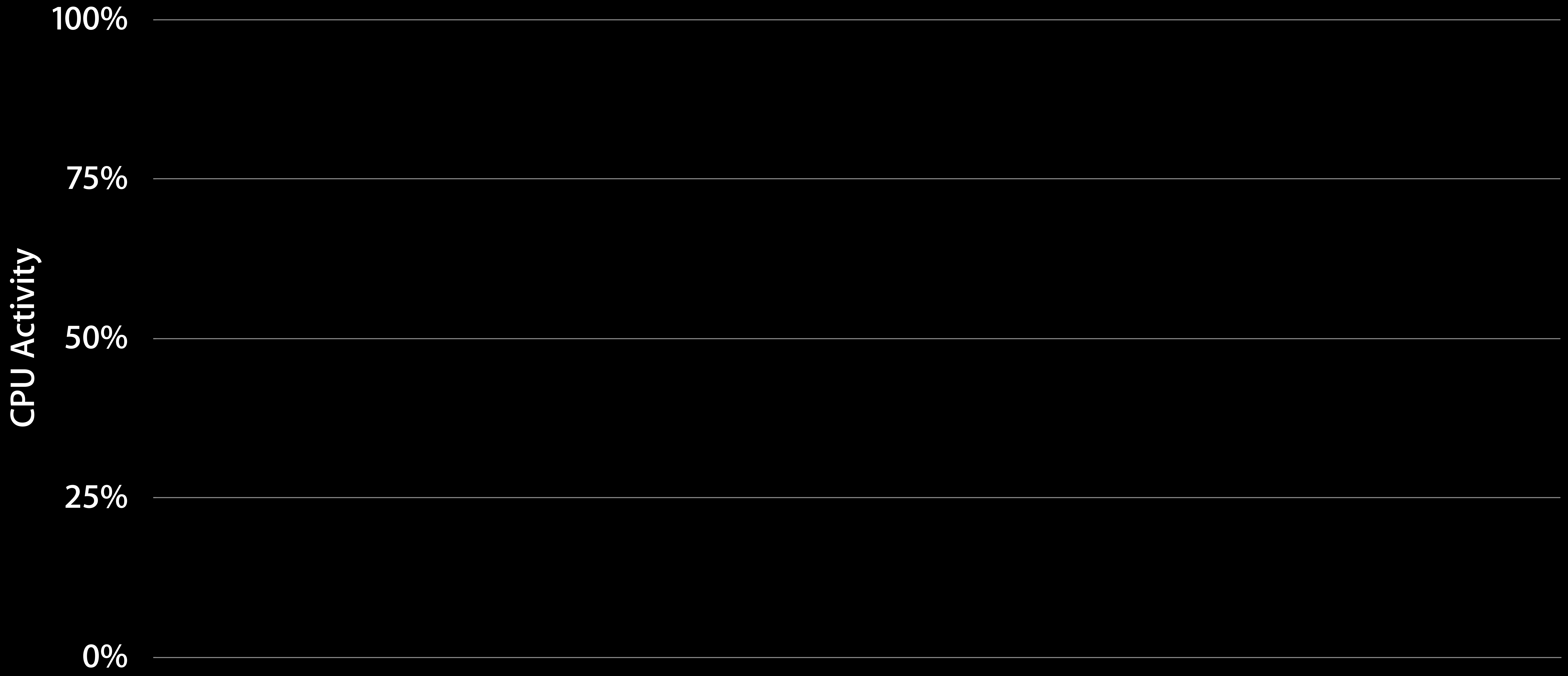

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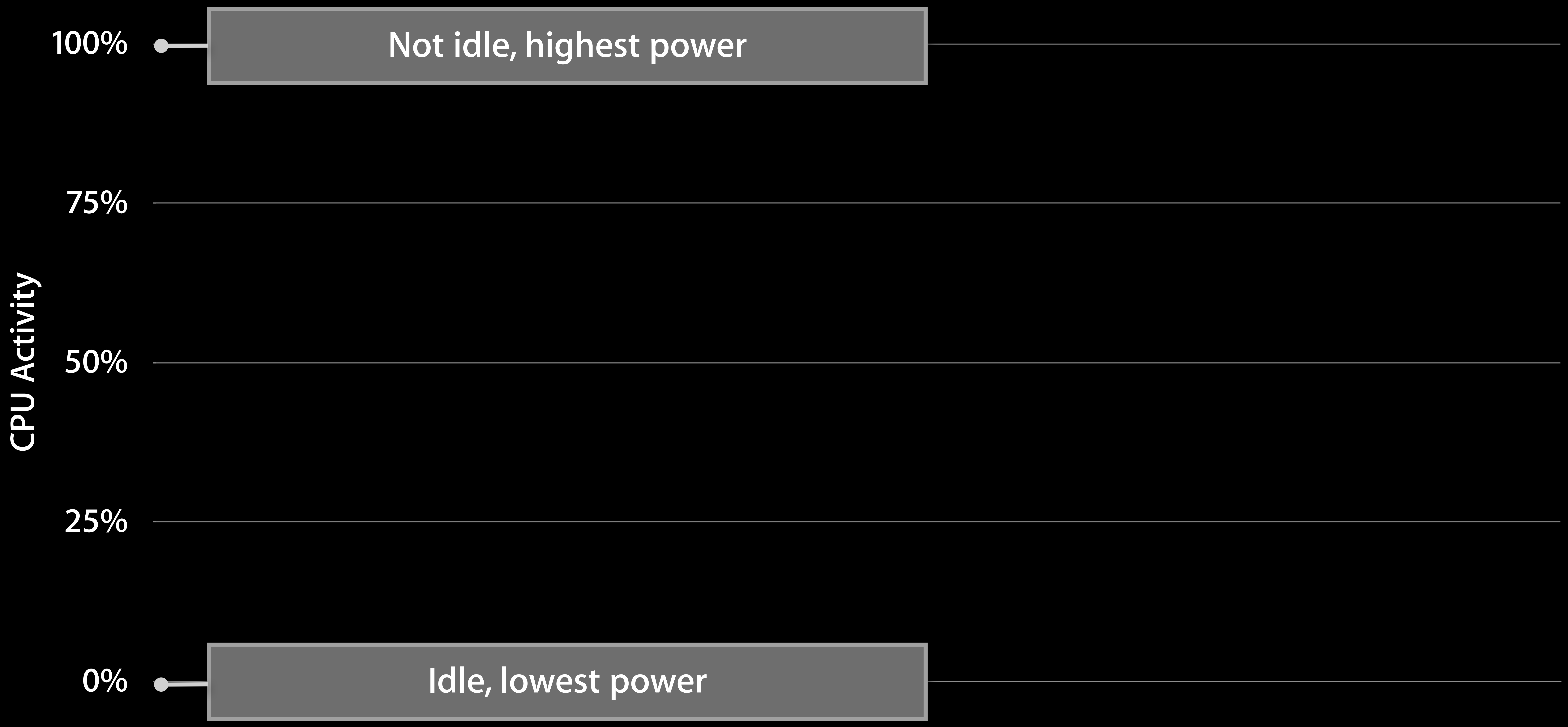

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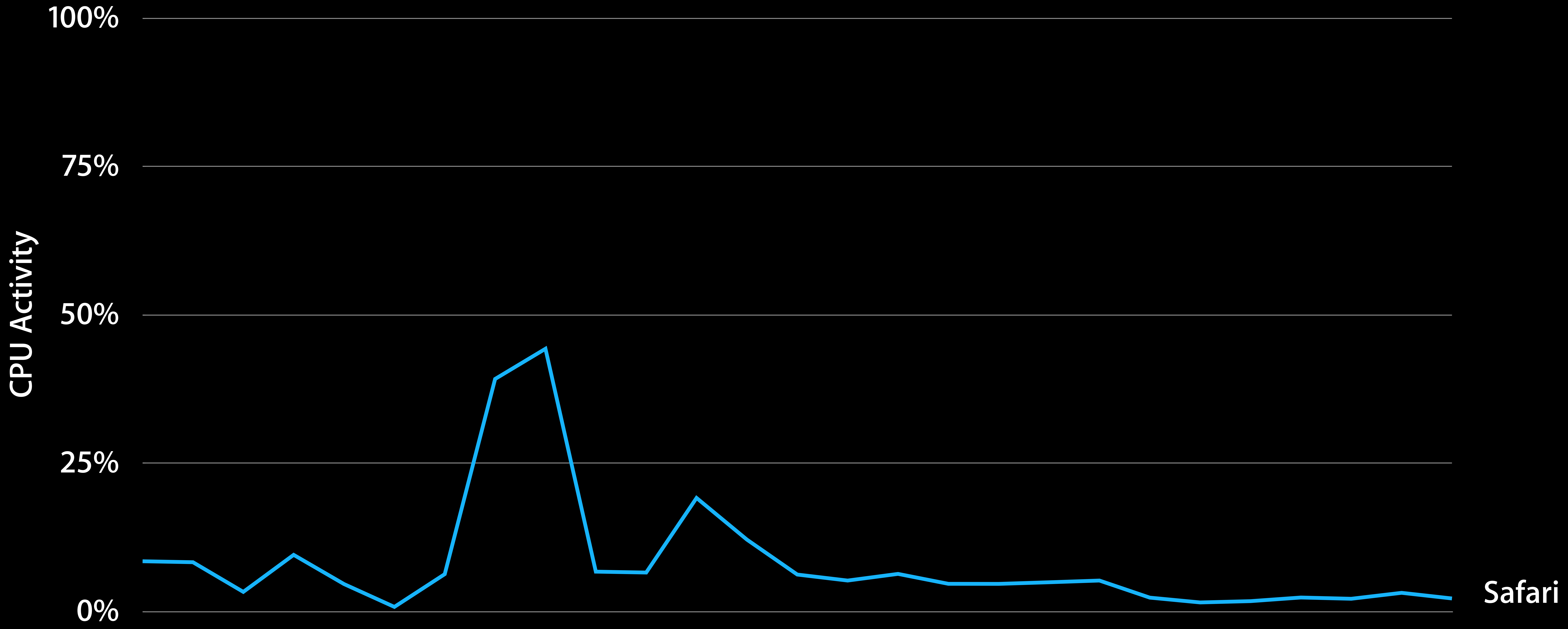

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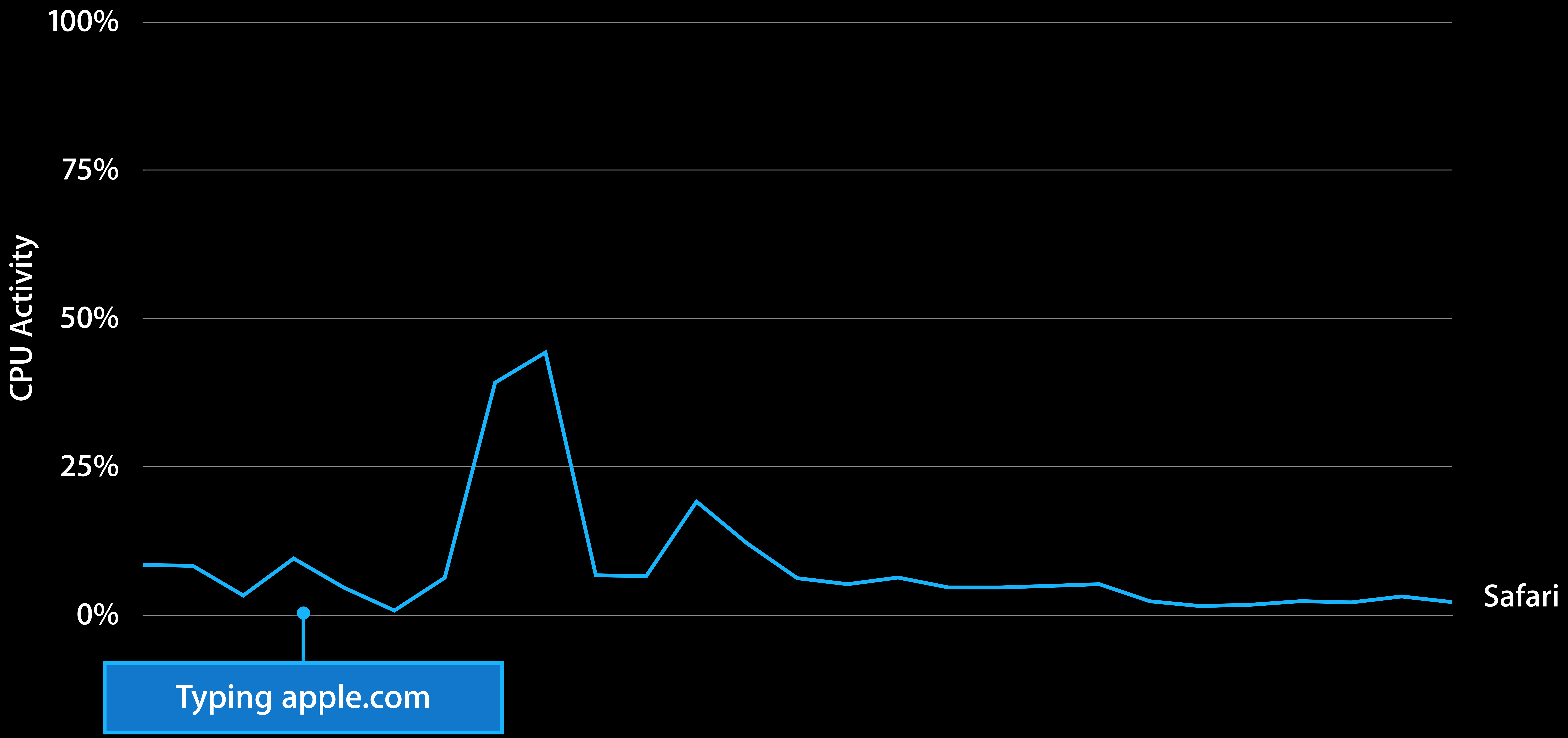

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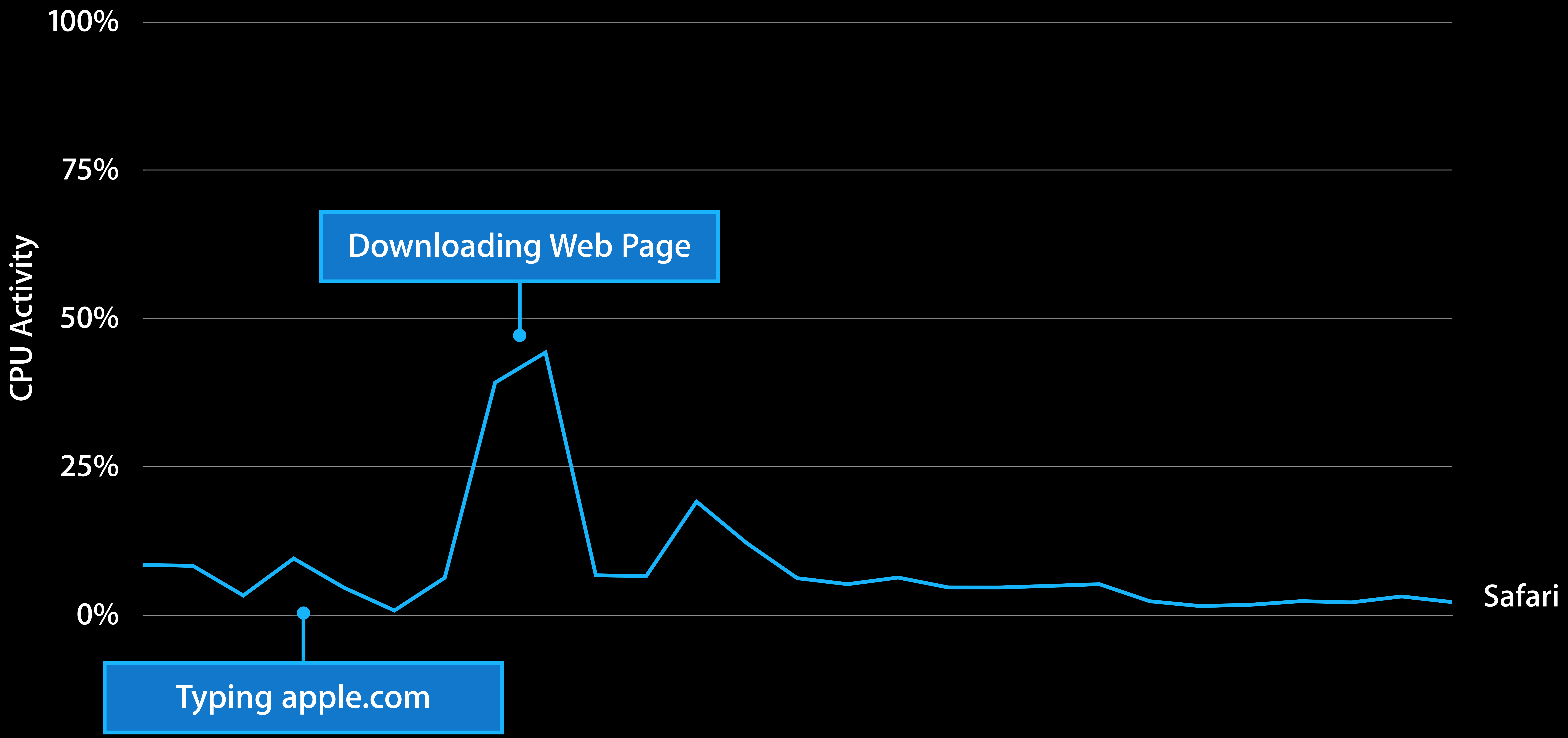

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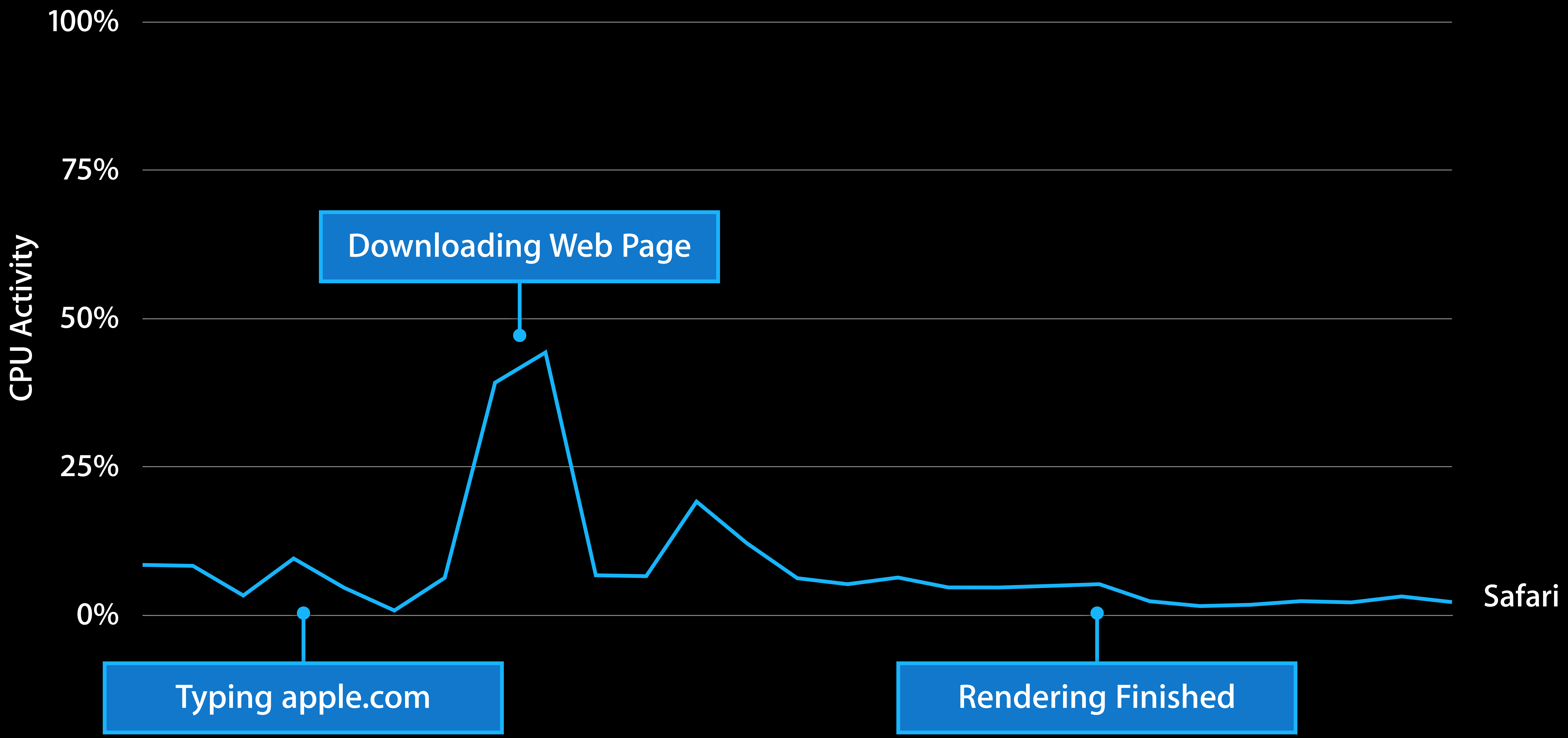

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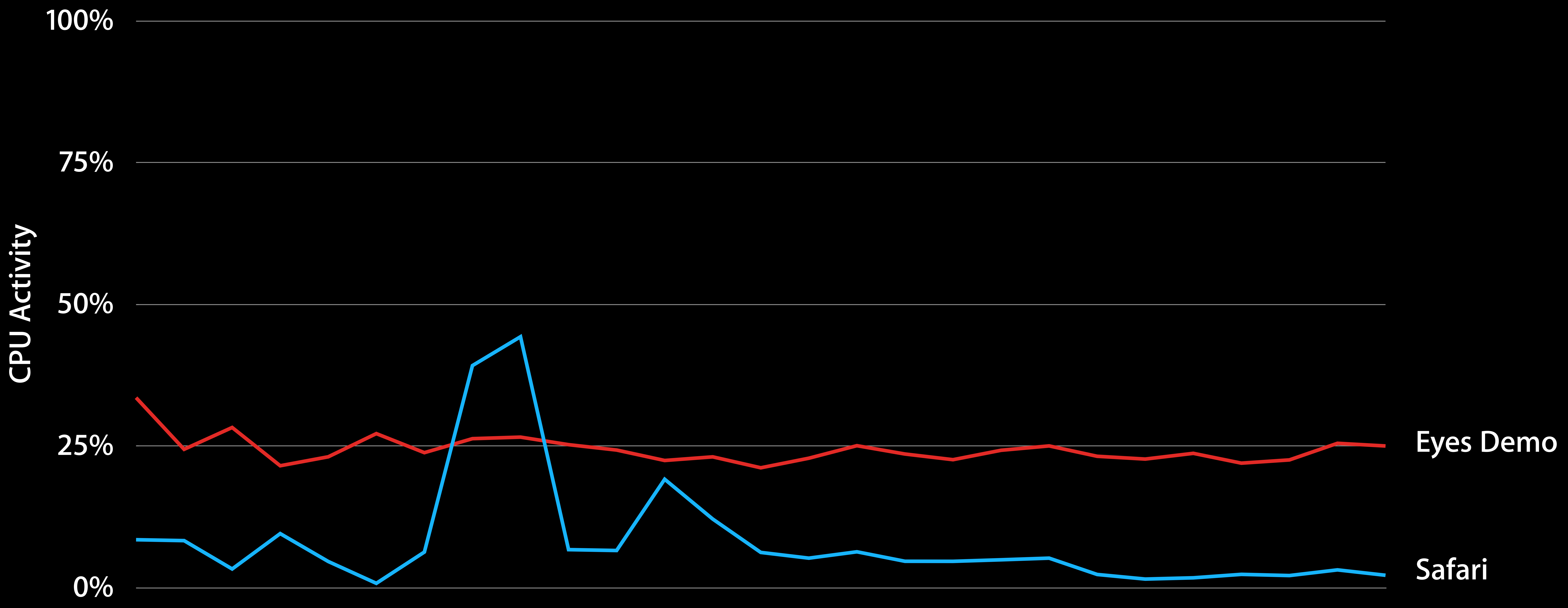

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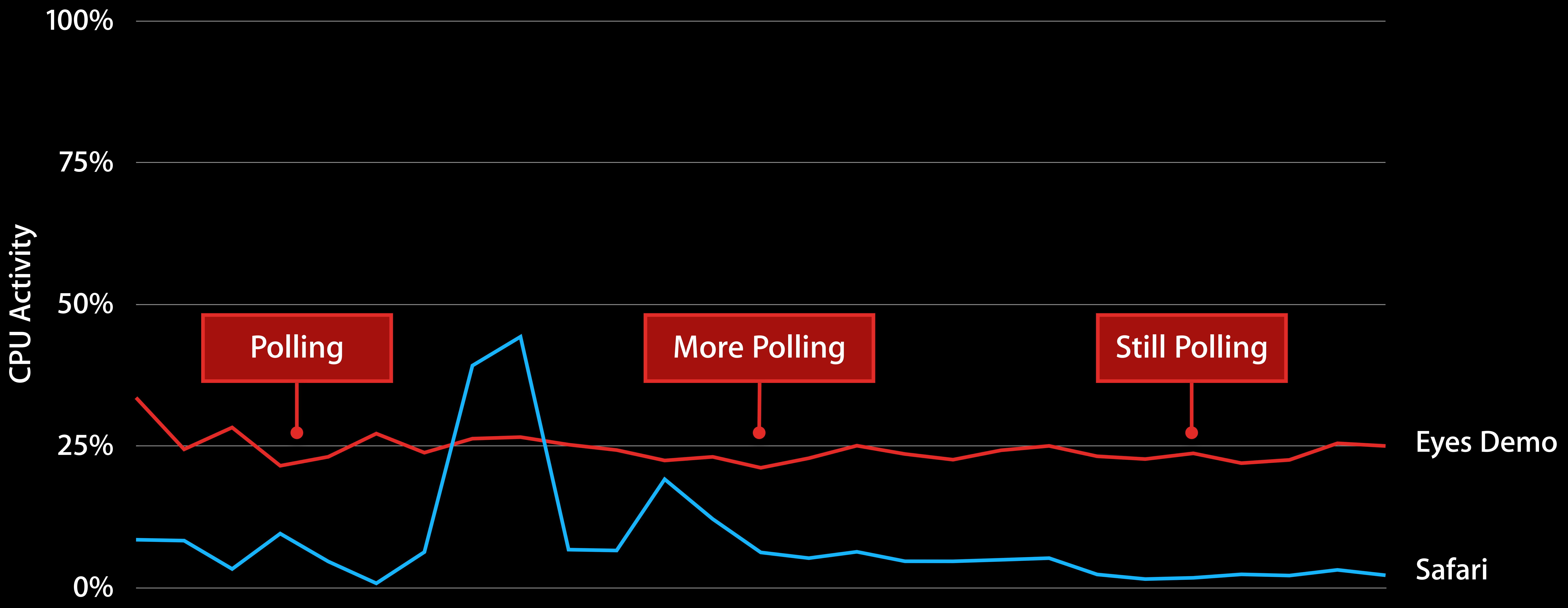

Exiting Idle

When there is work to do

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- Network activity

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API with Timers

Everything with a relative or absolute deadline

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NSTimer, CFRunLoopTimerRef, DISPATCH_SOURCE_TYPE_TIMER
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NSTimer, CFRunLoopTimerRef, DISPATCH_SOURCE_TYPE_TIMER

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-[performSelector:withObject:afterDelay:], -[NSRunLoop runUntilDate:]
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API with Timers

Everything with a relative or absolute deadline

`NSTimer, CFRunLoopTimerRef, DISPATCH_SOURCE_TYPE_TIMER`

`sleep()`

`pthread_cond_timedwait(), semaphore_timedwait()`

`-[performSelector:withObject:afterDelay:], -[NSRunLoop runUntilDate:]`

… and many more

Extending Battery Life

Reducing the impact of timers

Extending Battery Life

Reducing the impact of timers

- Timer Coalescing
- Timer Rate Limiting

Timer Coalescing

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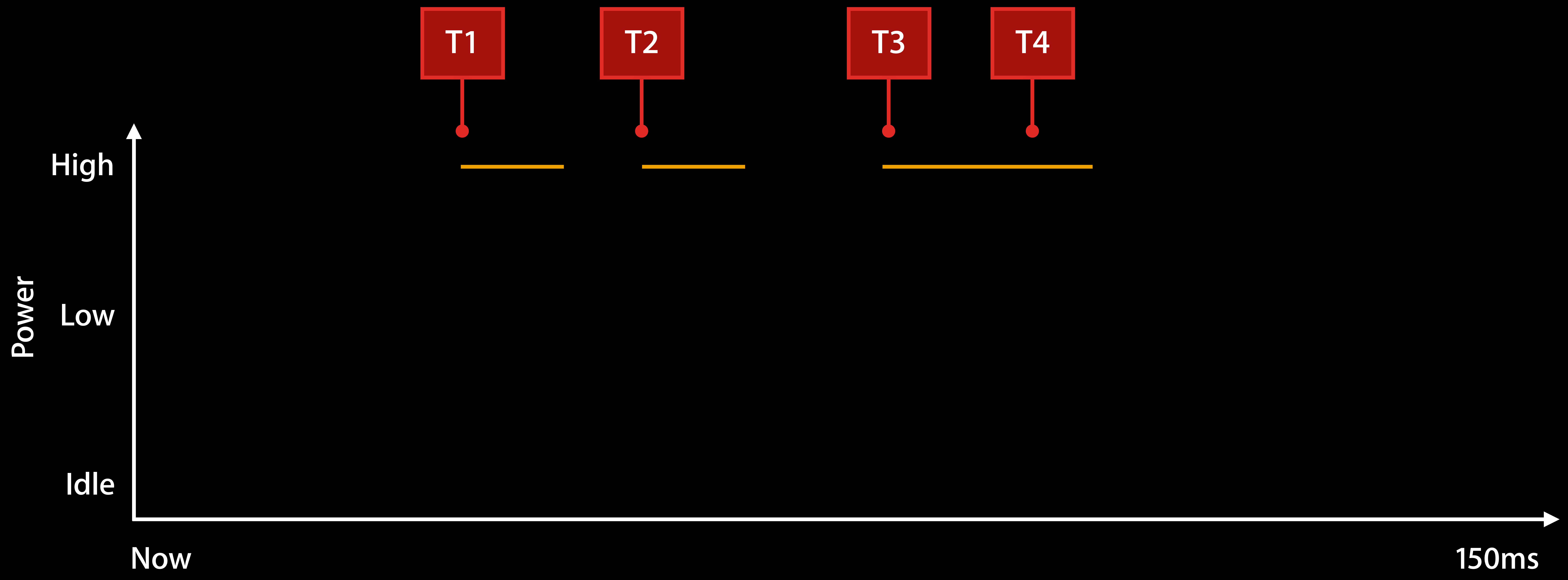
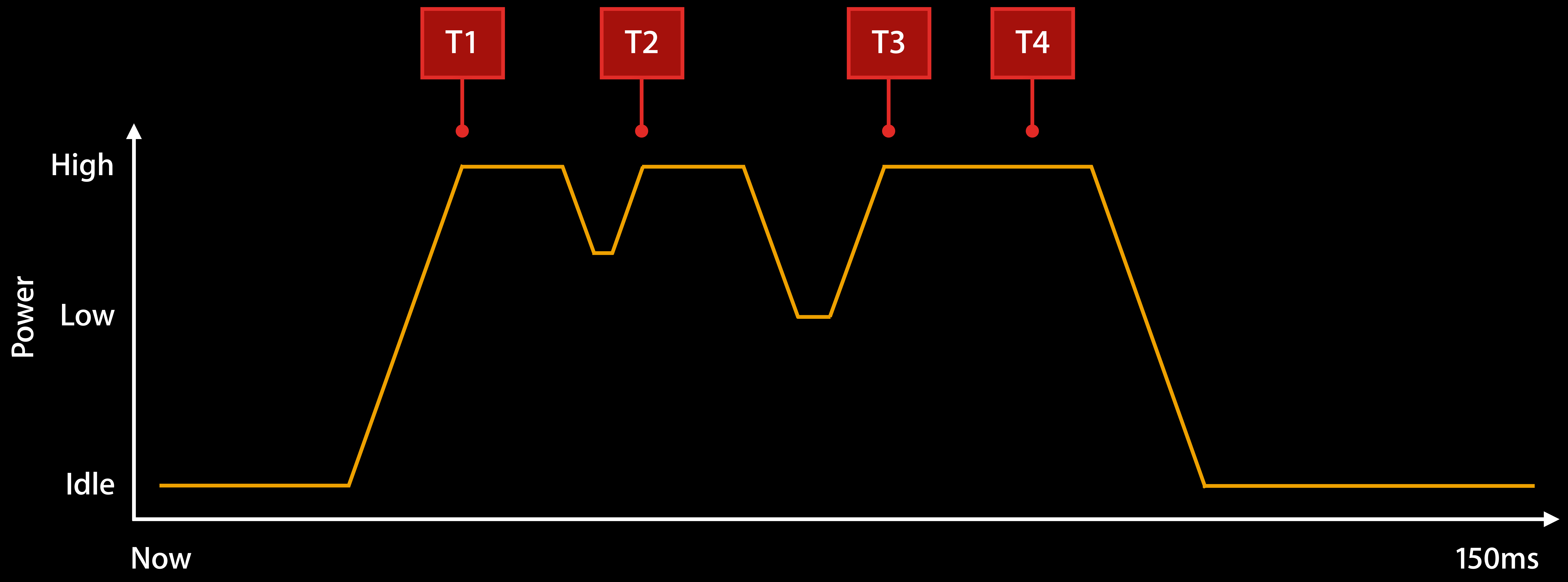


Timer Coalescing



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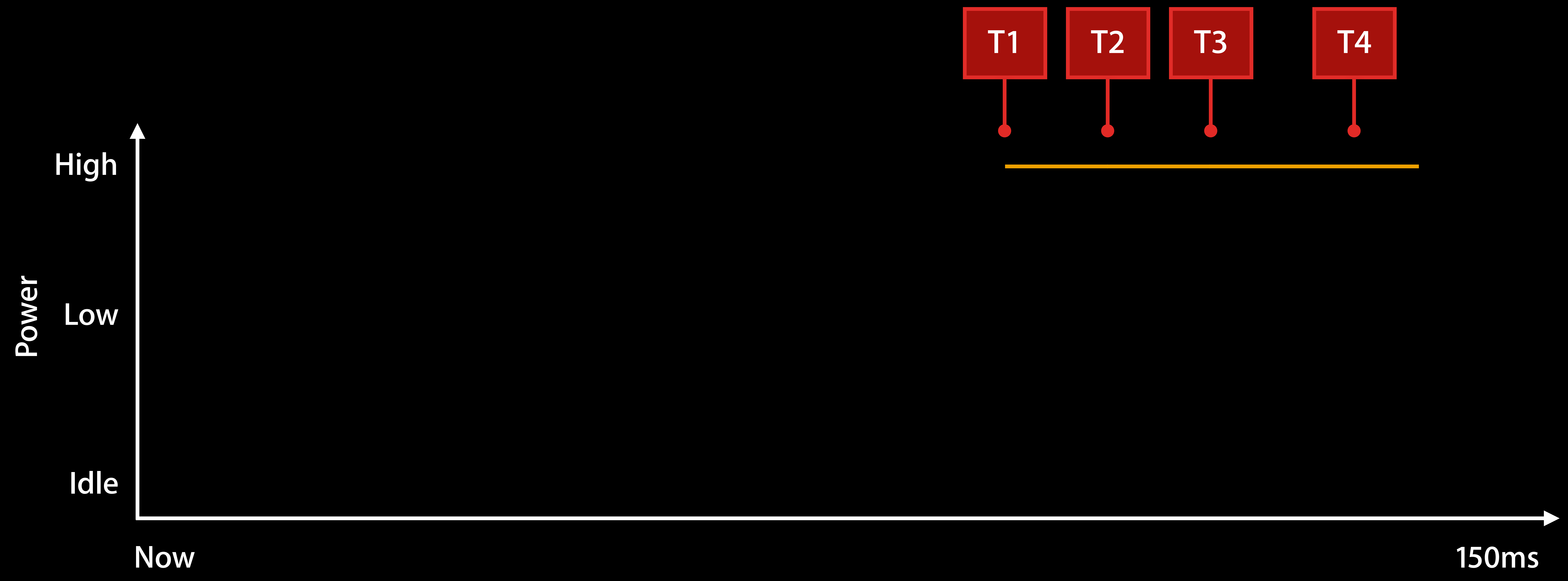

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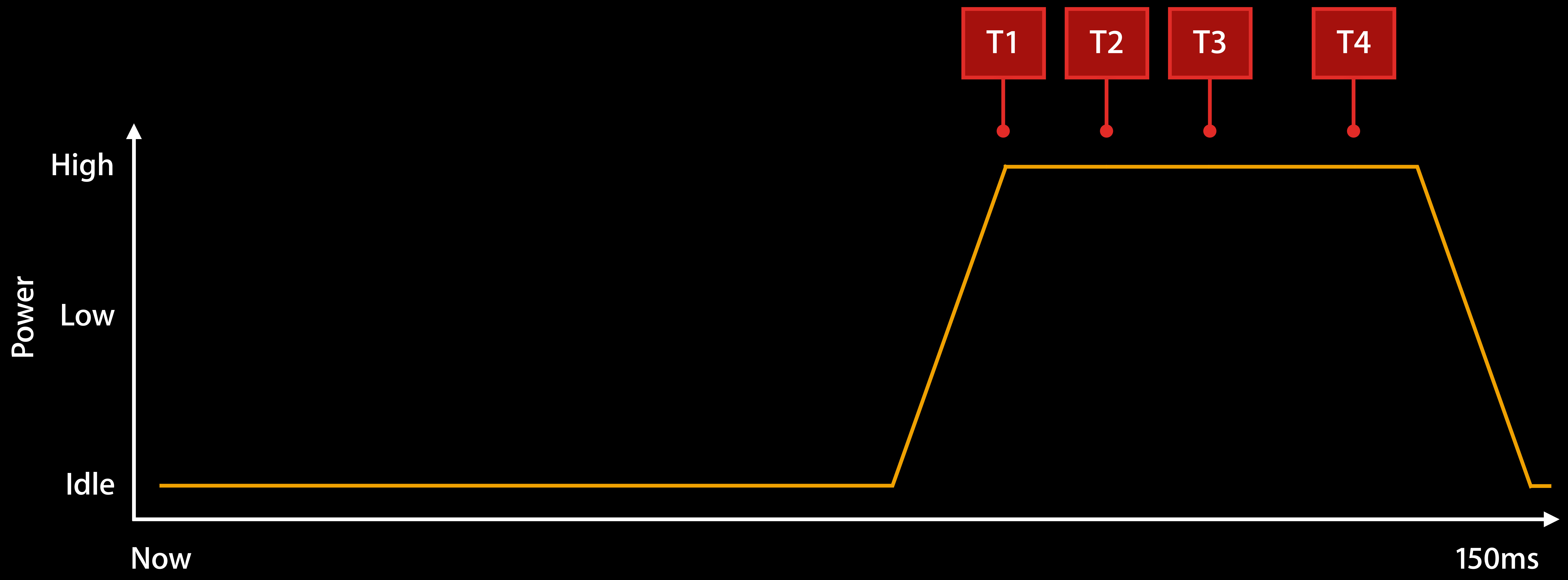

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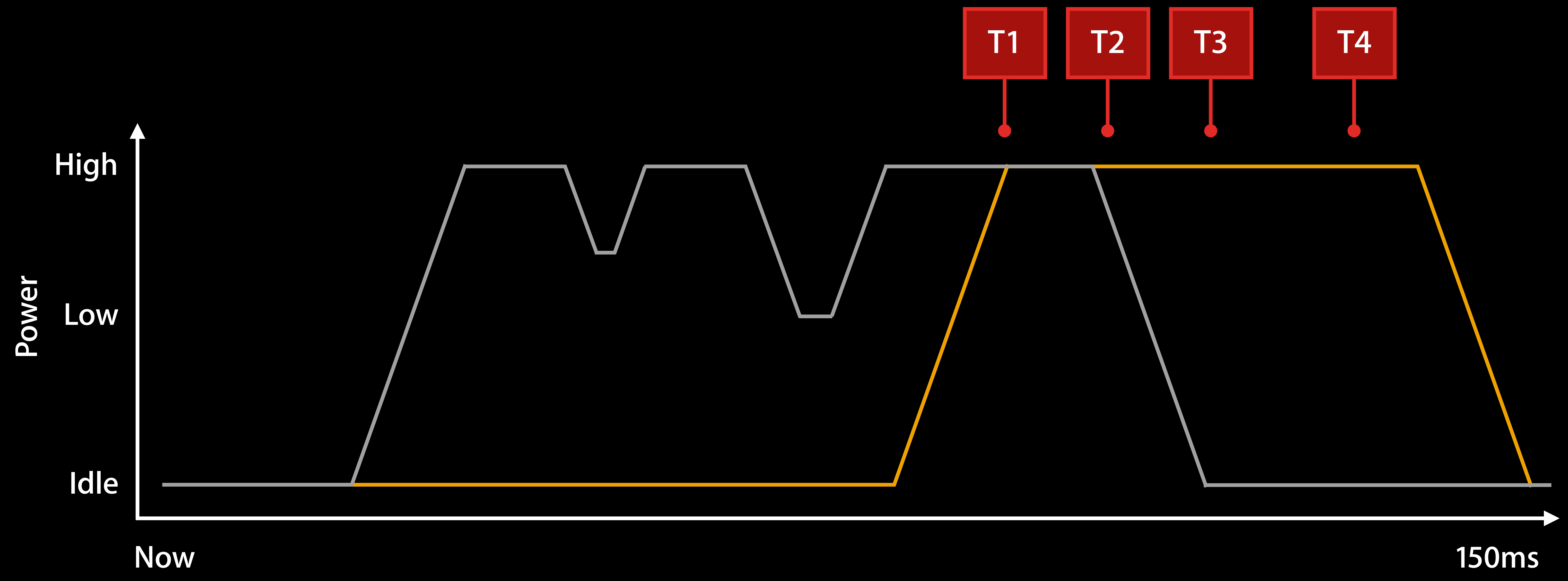

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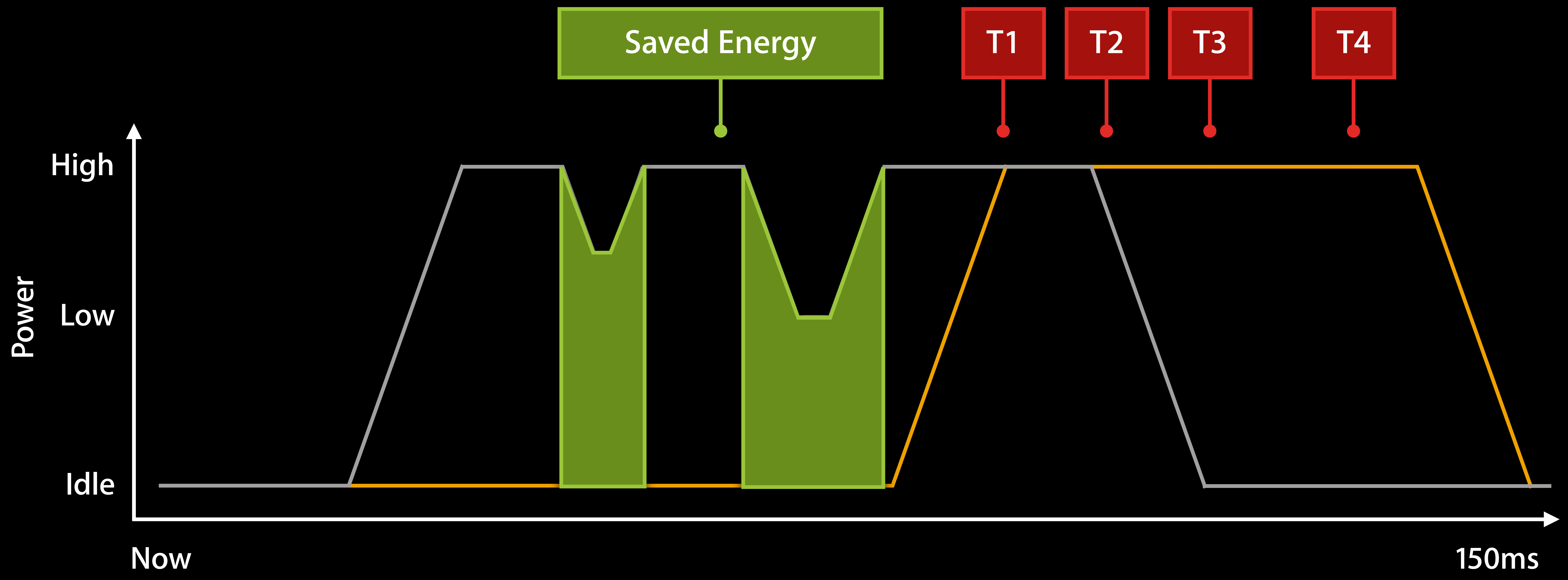

Second Order Effects

After the timer fires

- CPU usage

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- CPU usage
- Screen

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- GPU usage

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Second Order Effects

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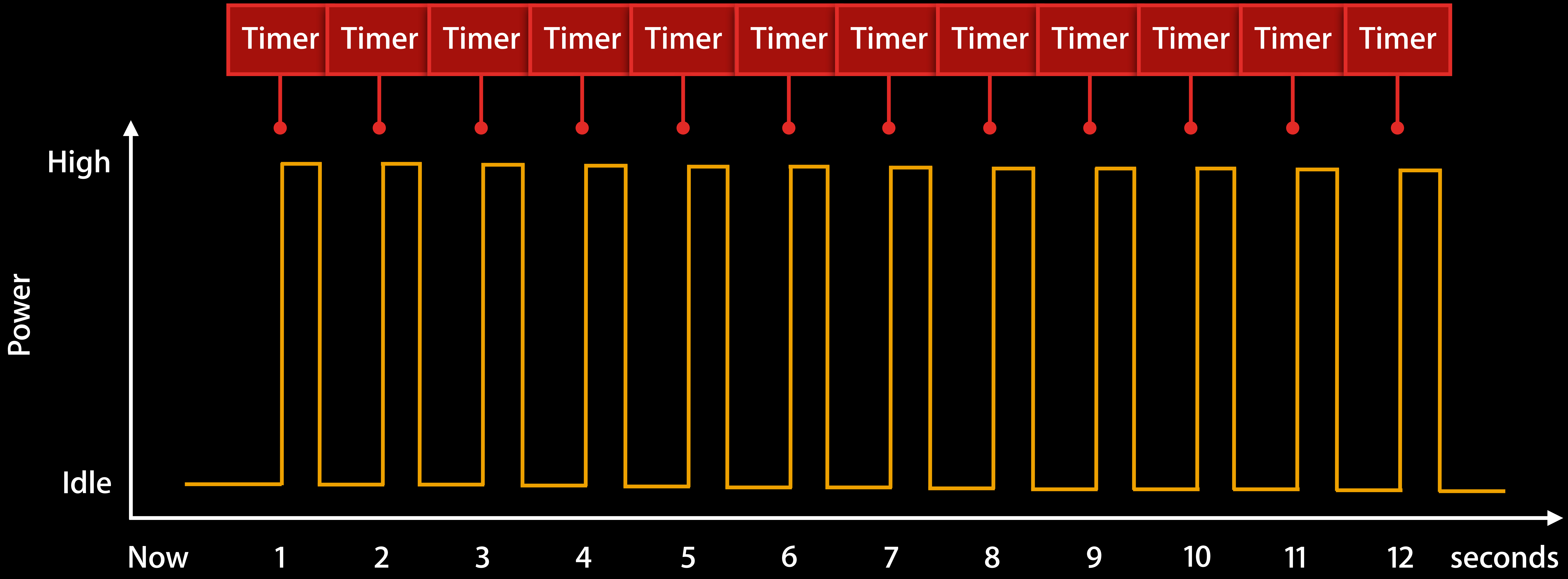
Timer Rate Limiting



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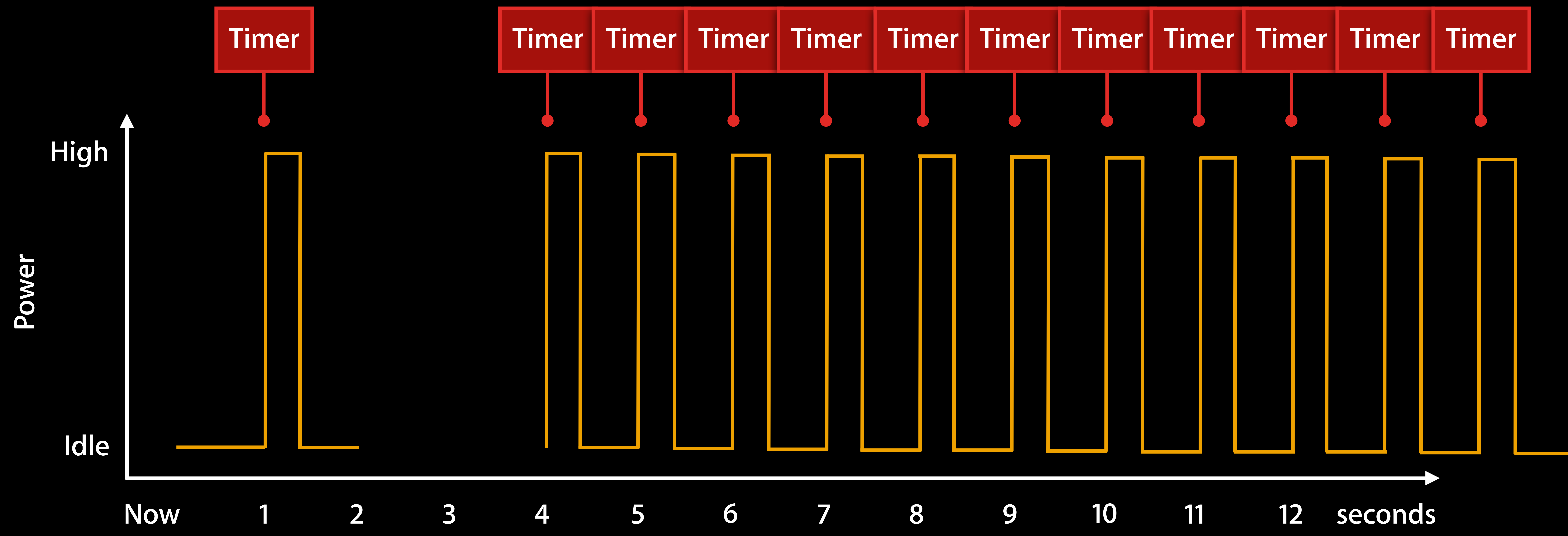

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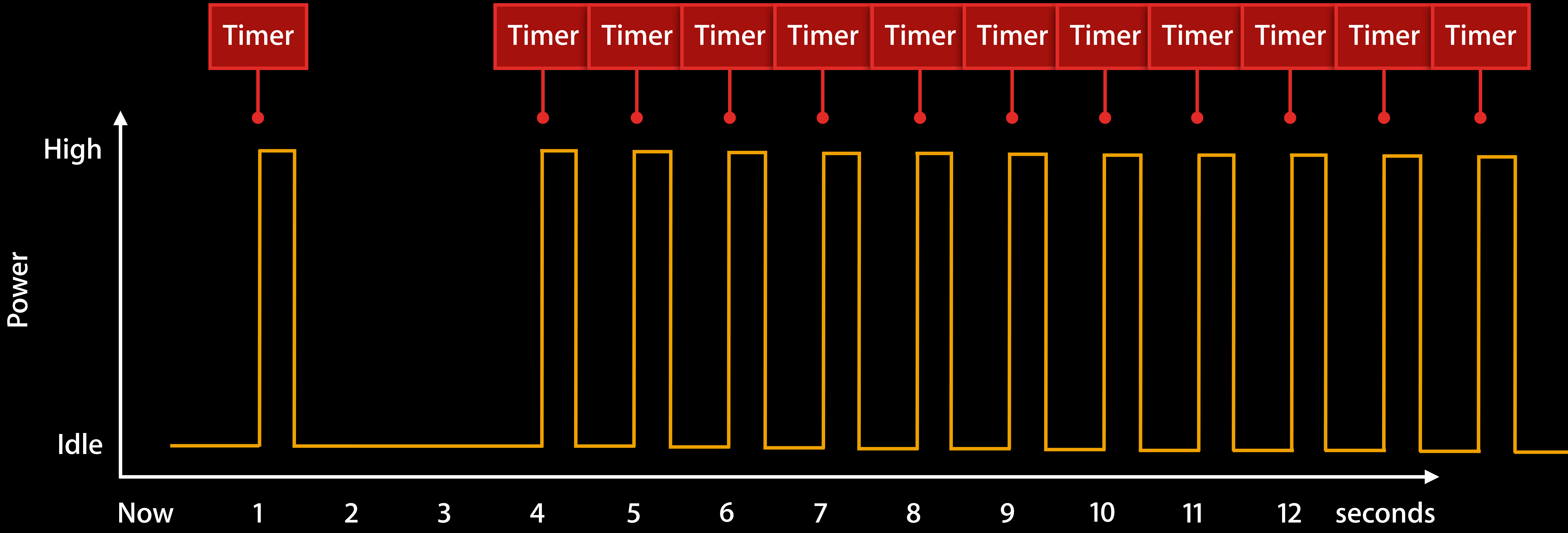

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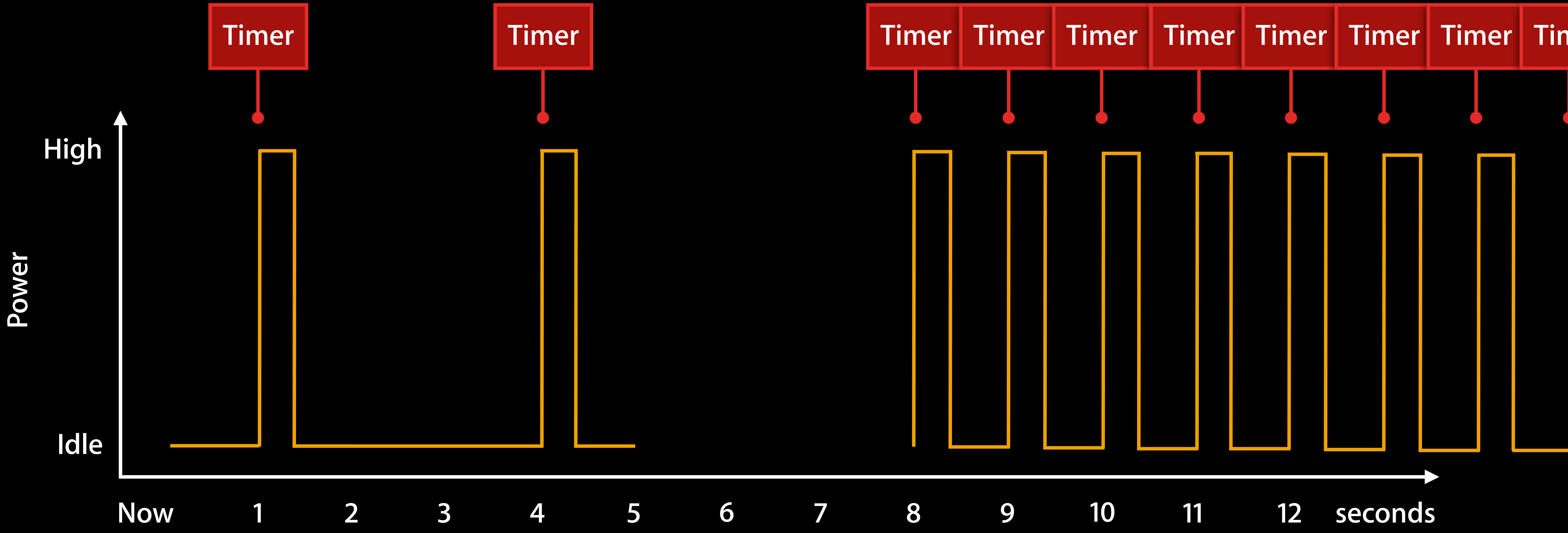

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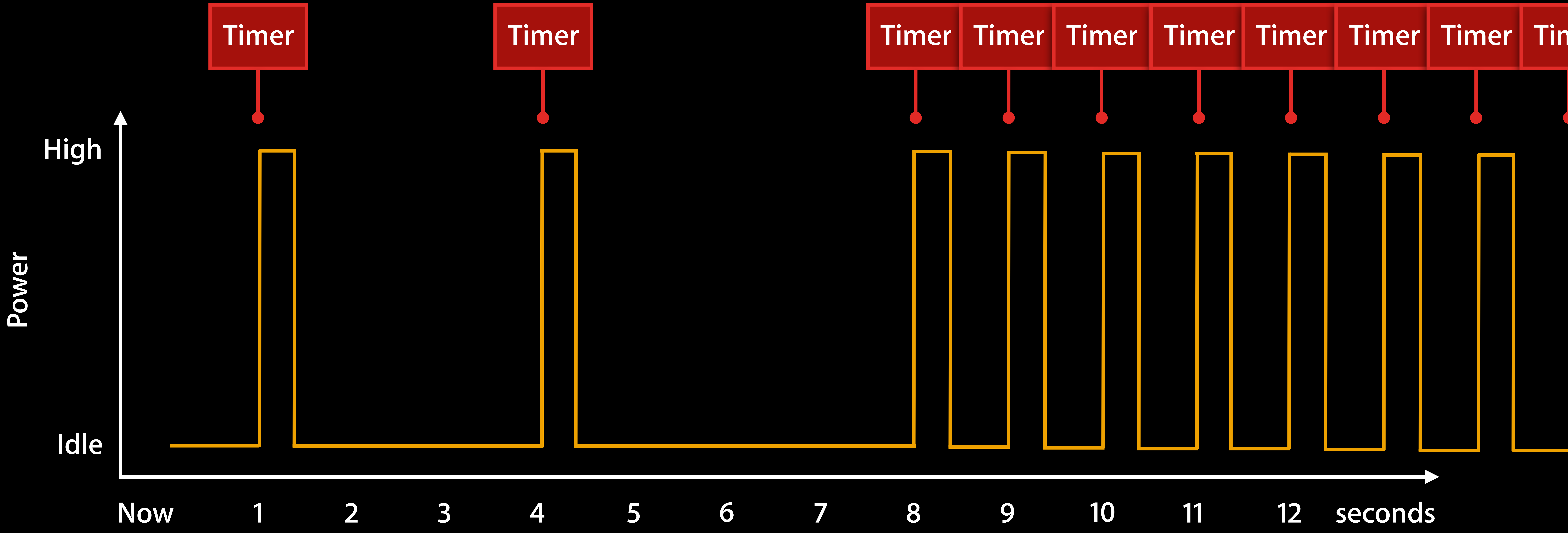

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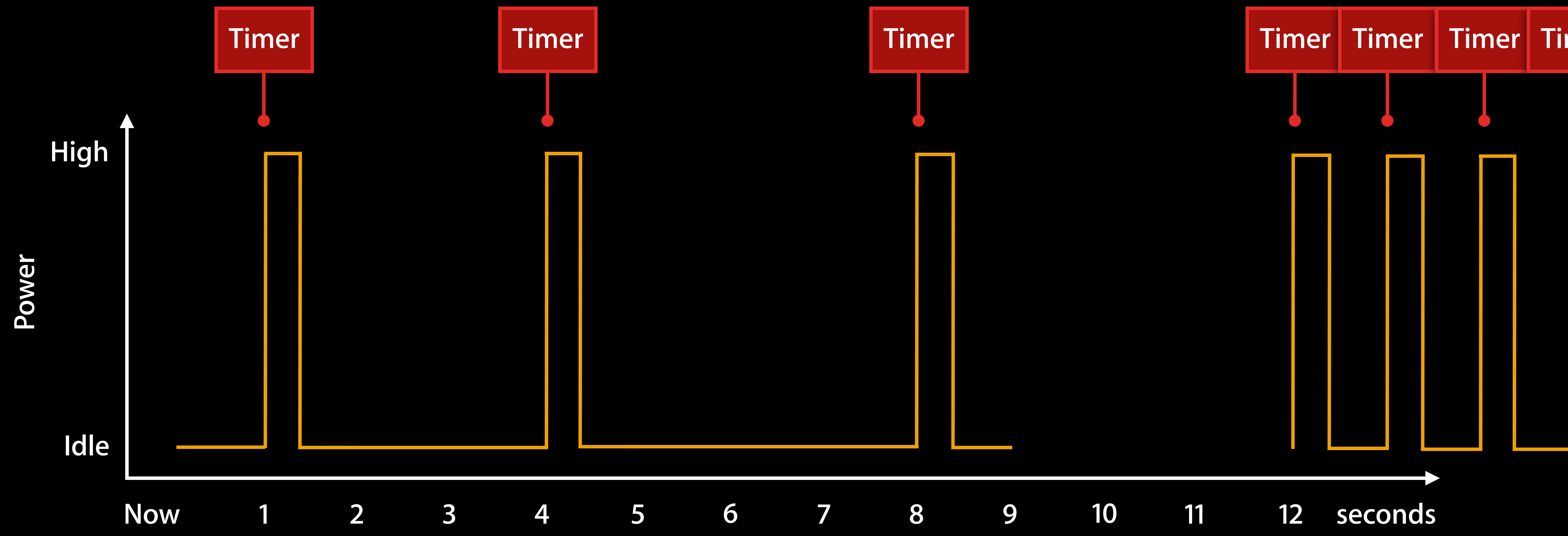

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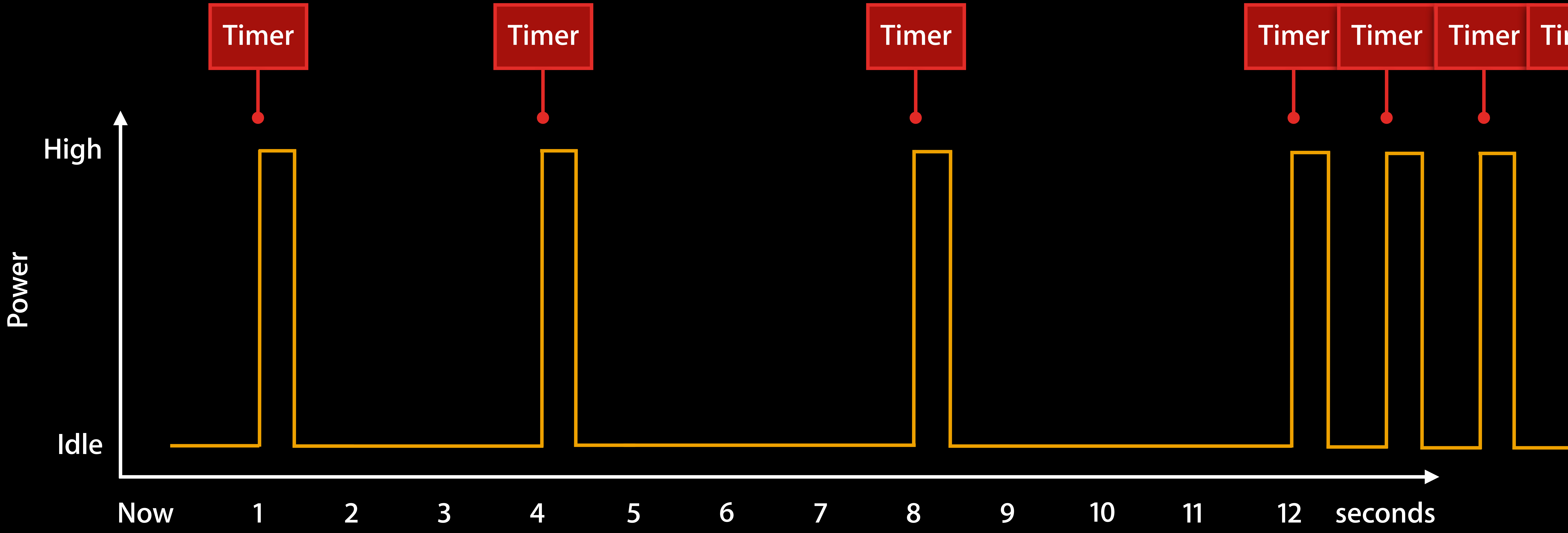

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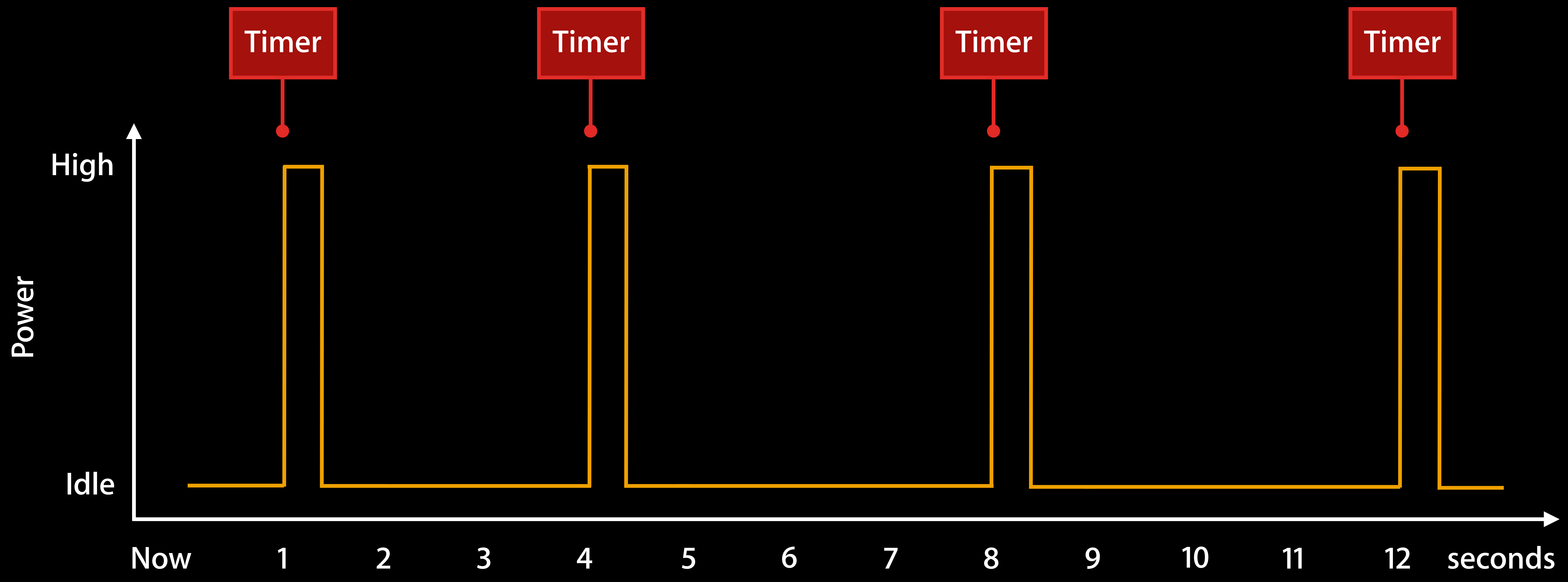

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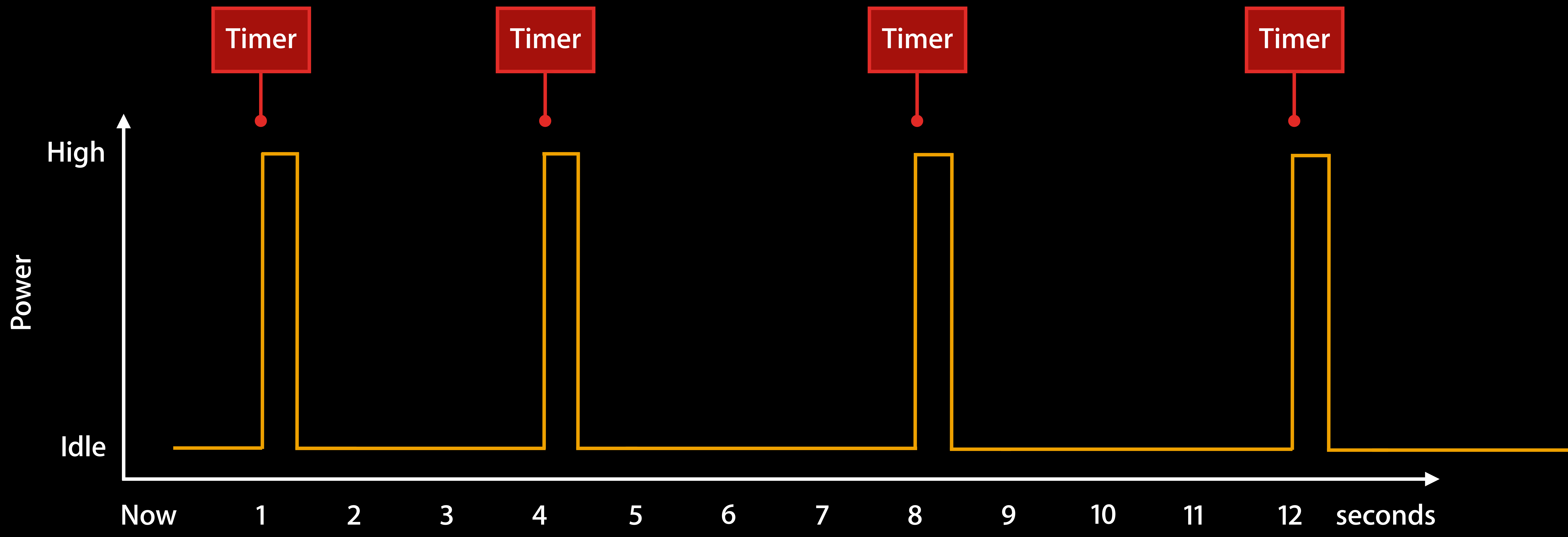

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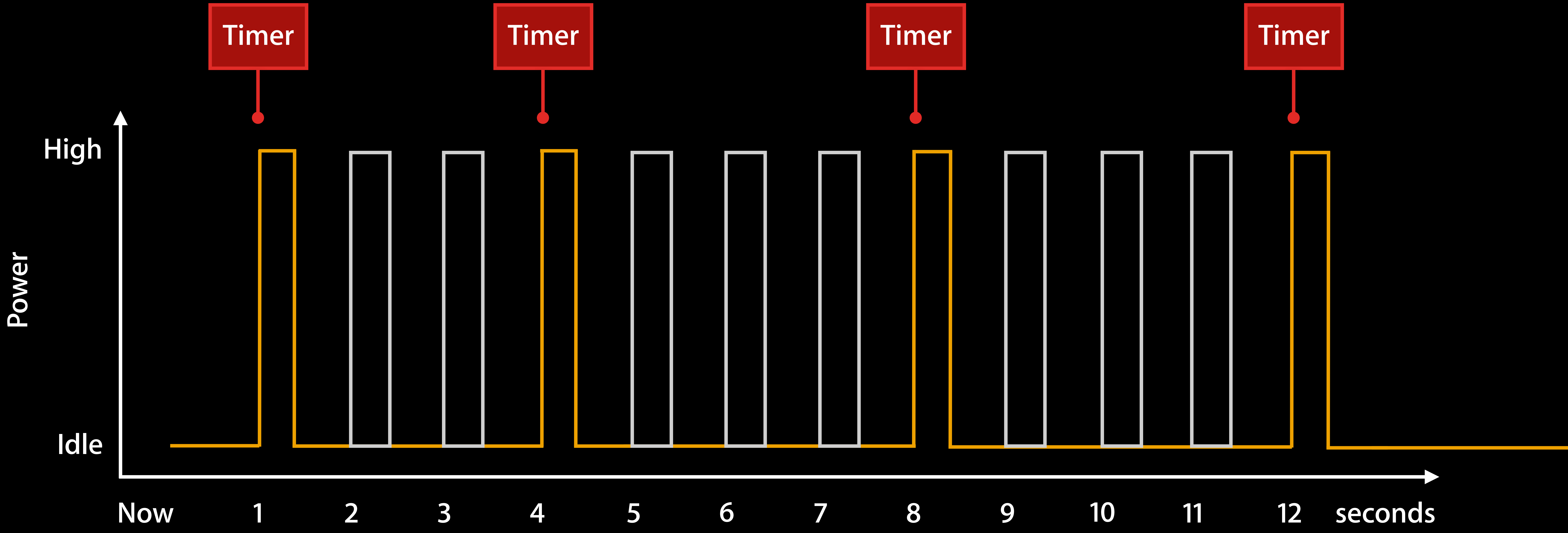

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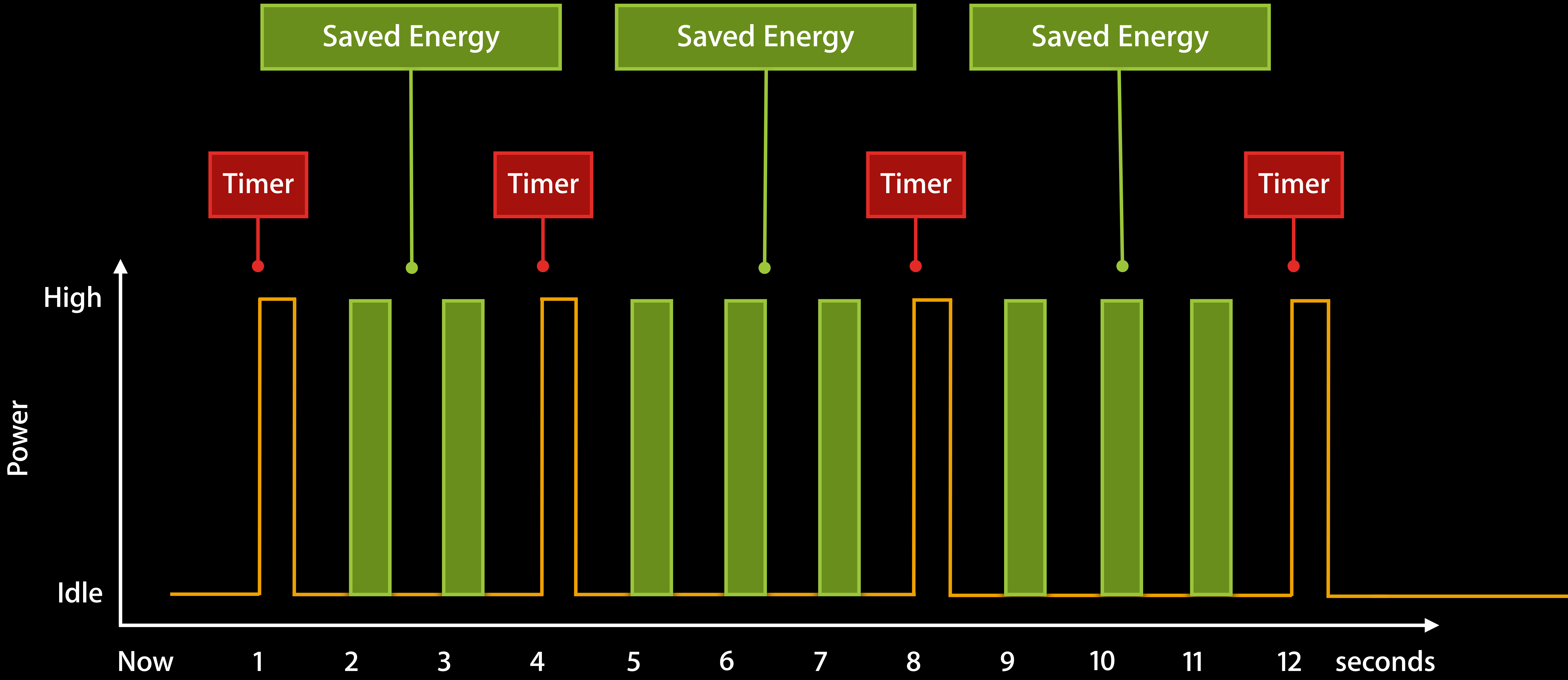

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- Configurable

The Result

Eyes demo

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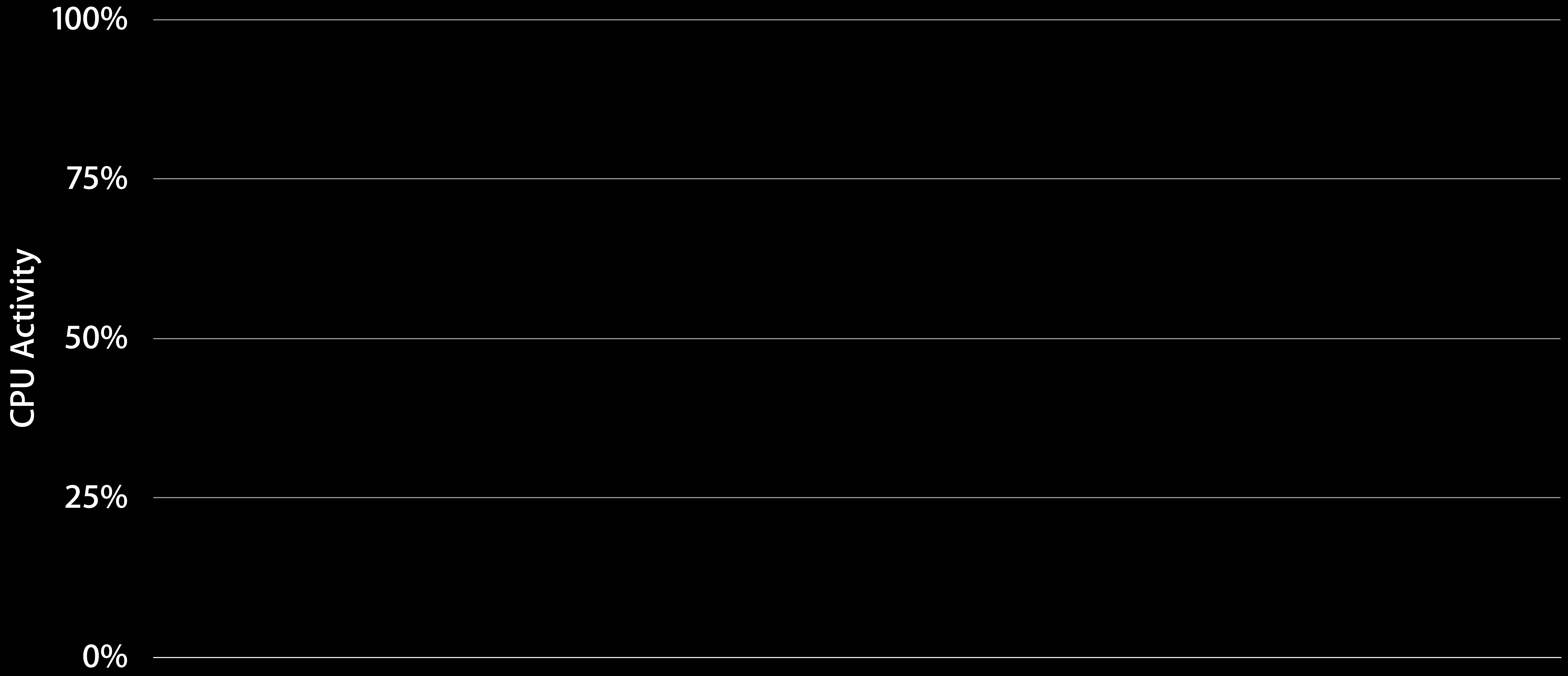
Eyes demo



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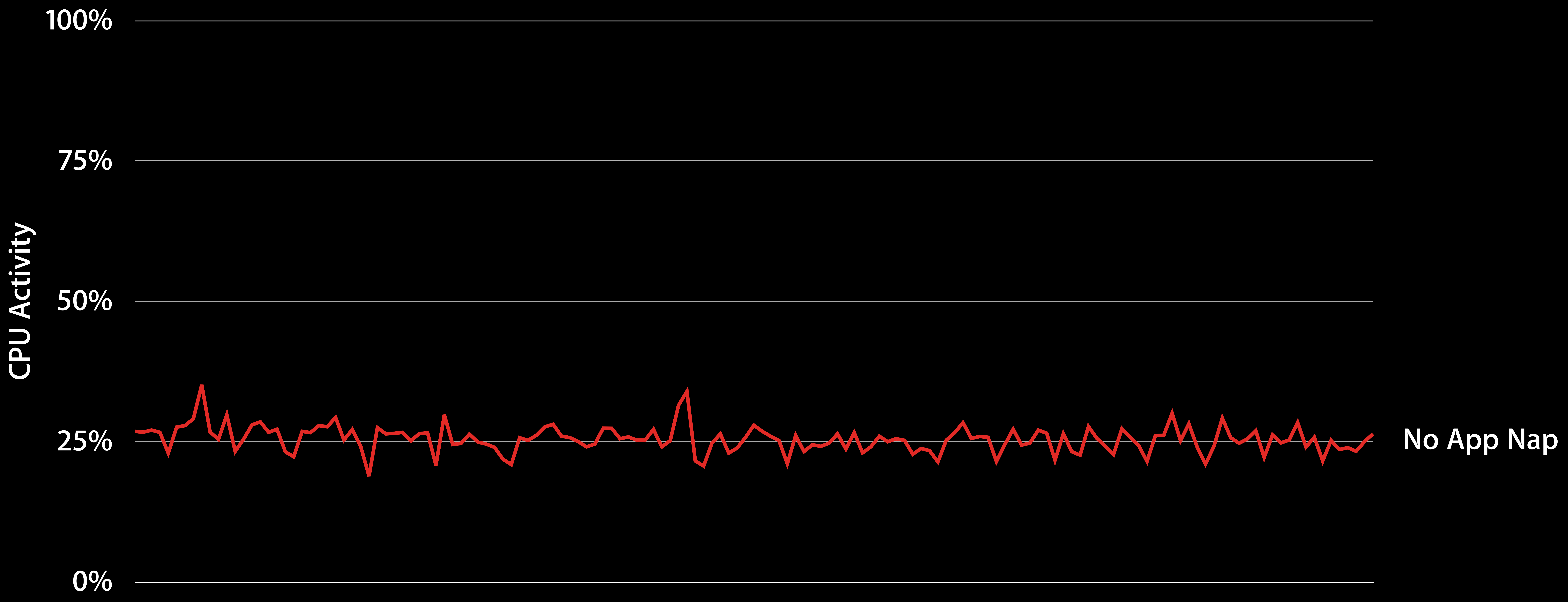

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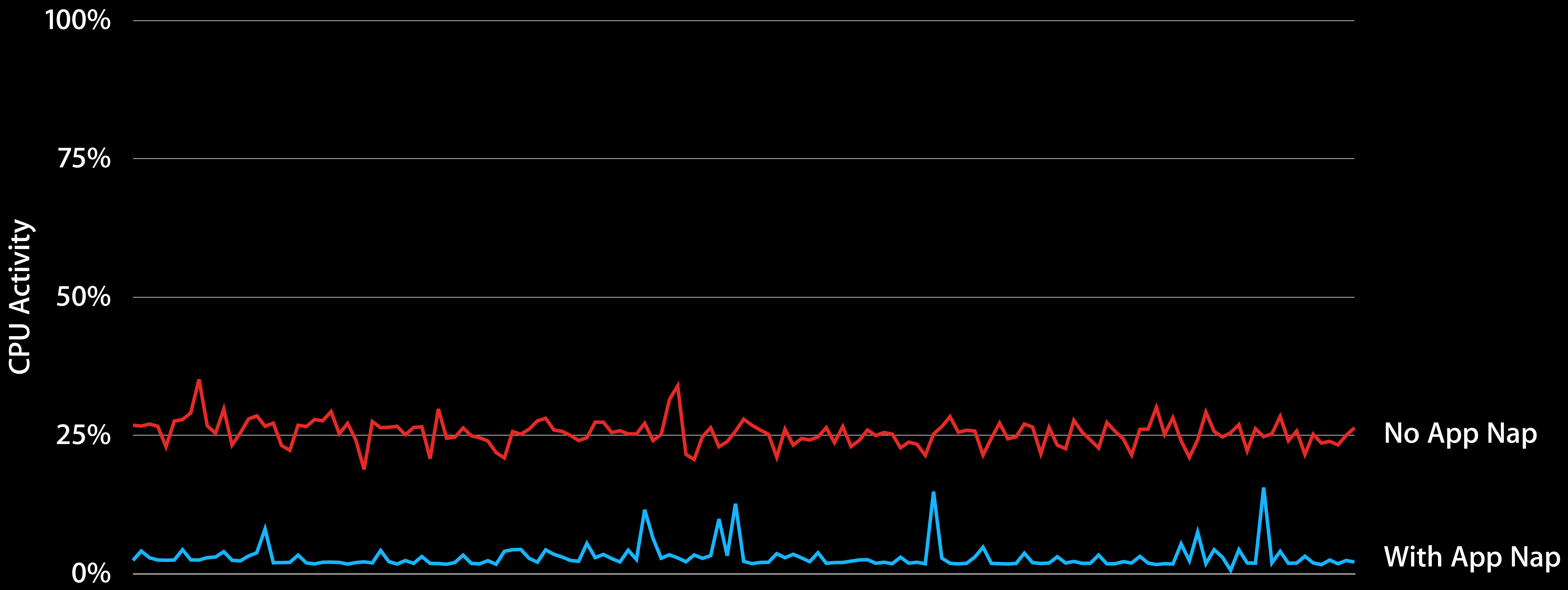

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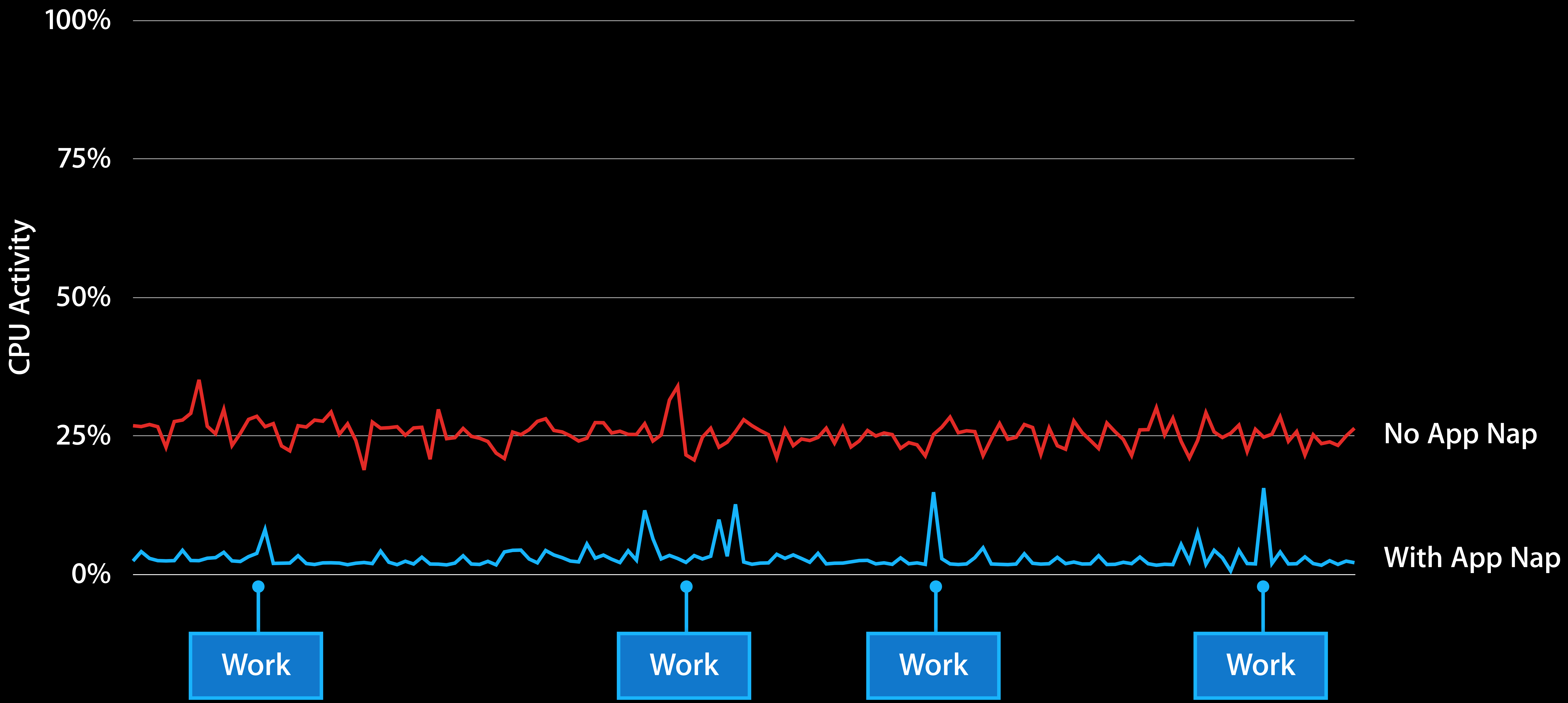

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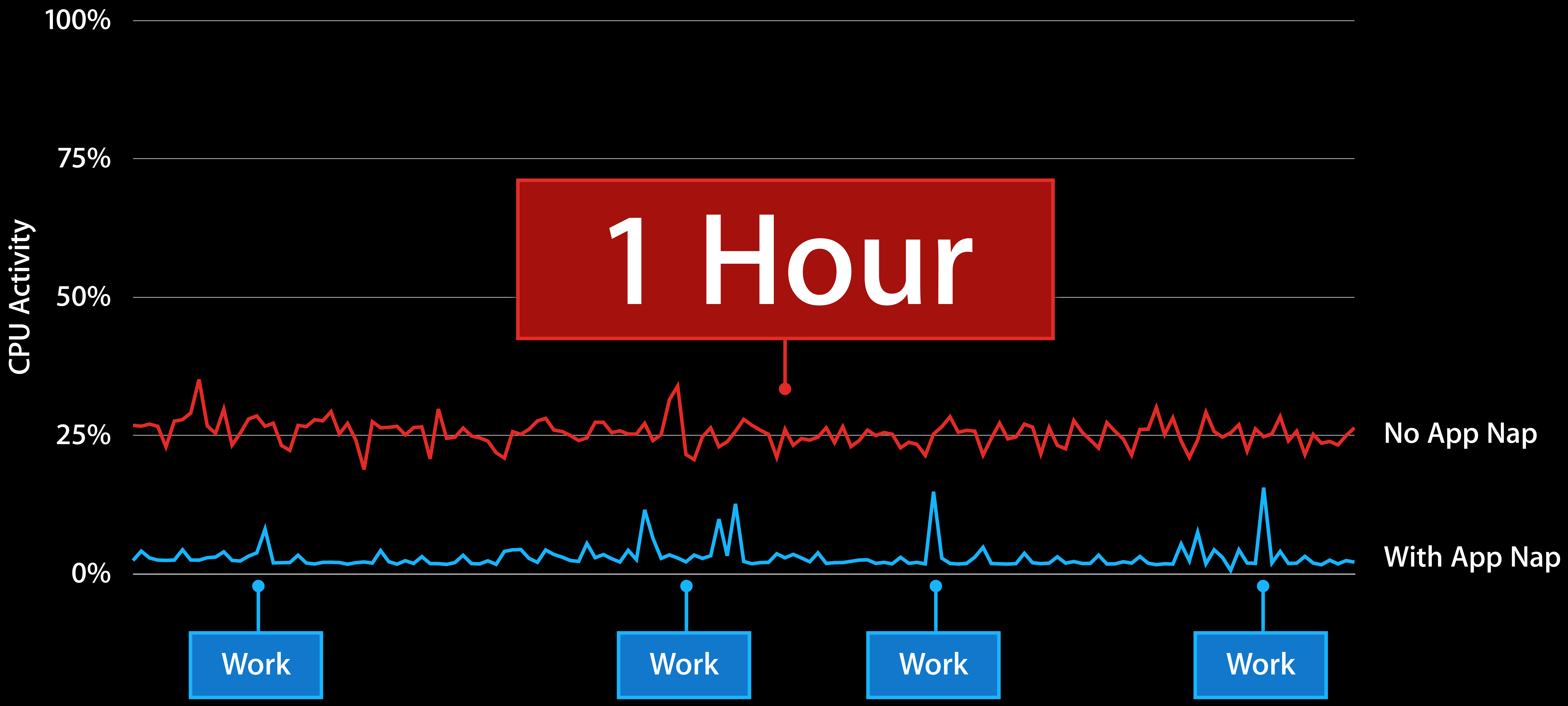

2012 15" MacBook Pro with Retina Display, 2.6 GHz Intel Core i7, OS X 10.9 Developer Preview

Improving the Result

Switch from timer API to event API

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Improving the Eyes application

Responsiveness

- Important work should have higher priority

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- Apps in App Nap have lower priority
    - I/O
    - CPU

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App Nap API

App Nap API

- Find out when your app is visible
- Add tolerance to timers
- Tell system about user activities

Visibility

- Find out when a window or application is occluded
    - On another space
    - Another app is in front
    - Screen saver is on

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- Halt expensive work when occluded

Visibility

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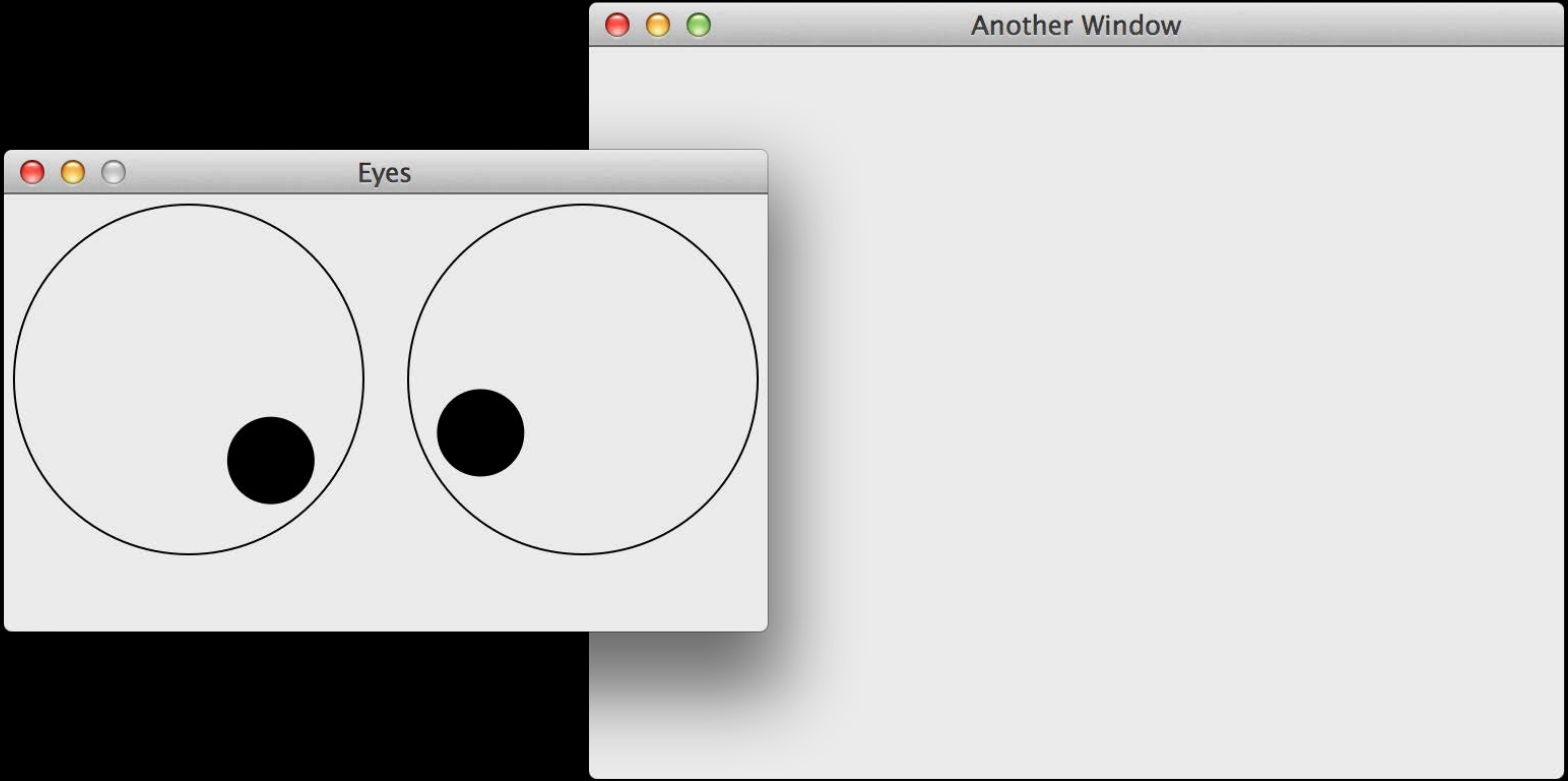
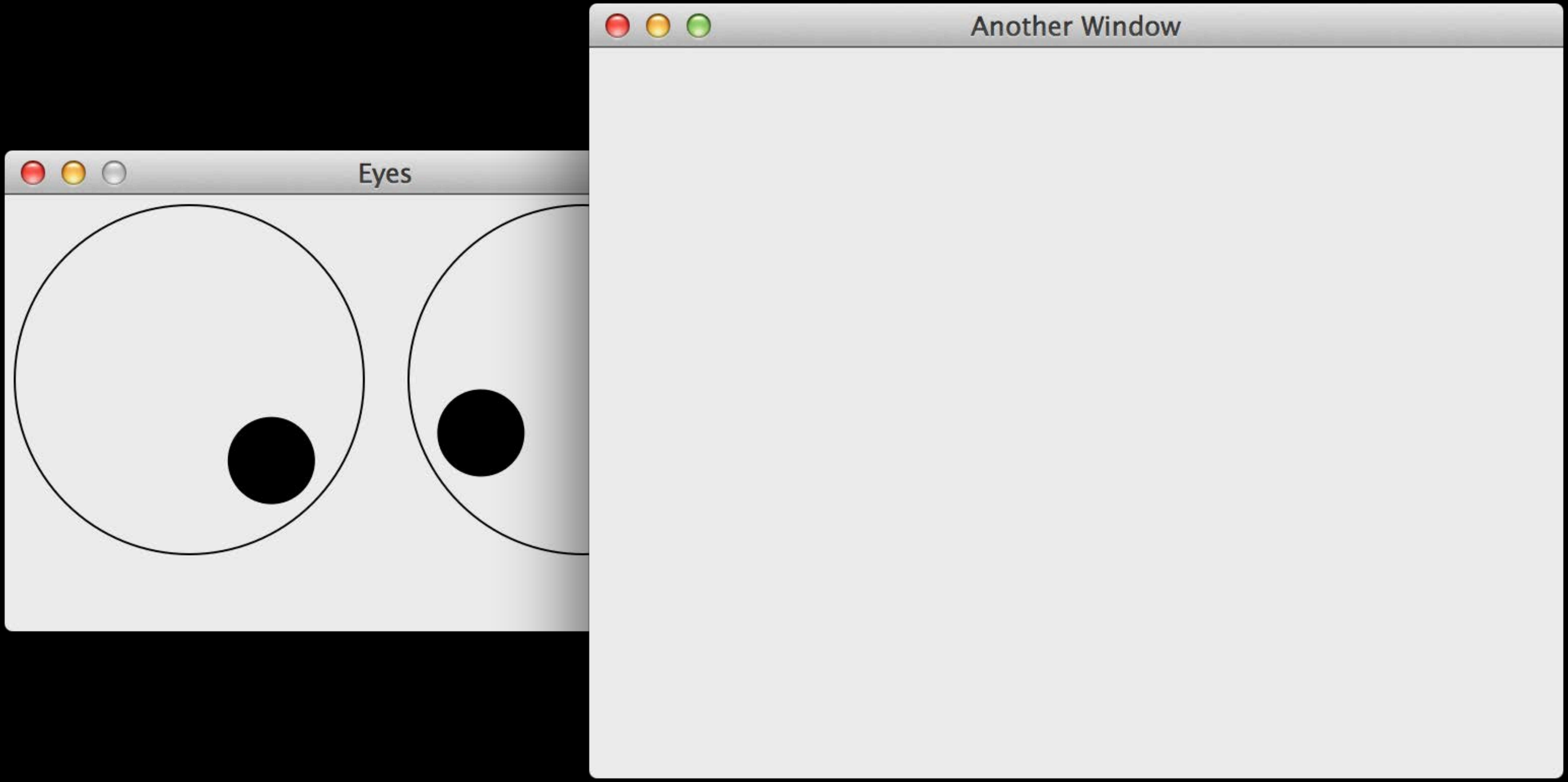
    - Another app is in front
    - Screen saver is on
- Halt expensive work when occluded
- Refresh content when becoming visible

Window Occlusion



Visible

Window Occlusion



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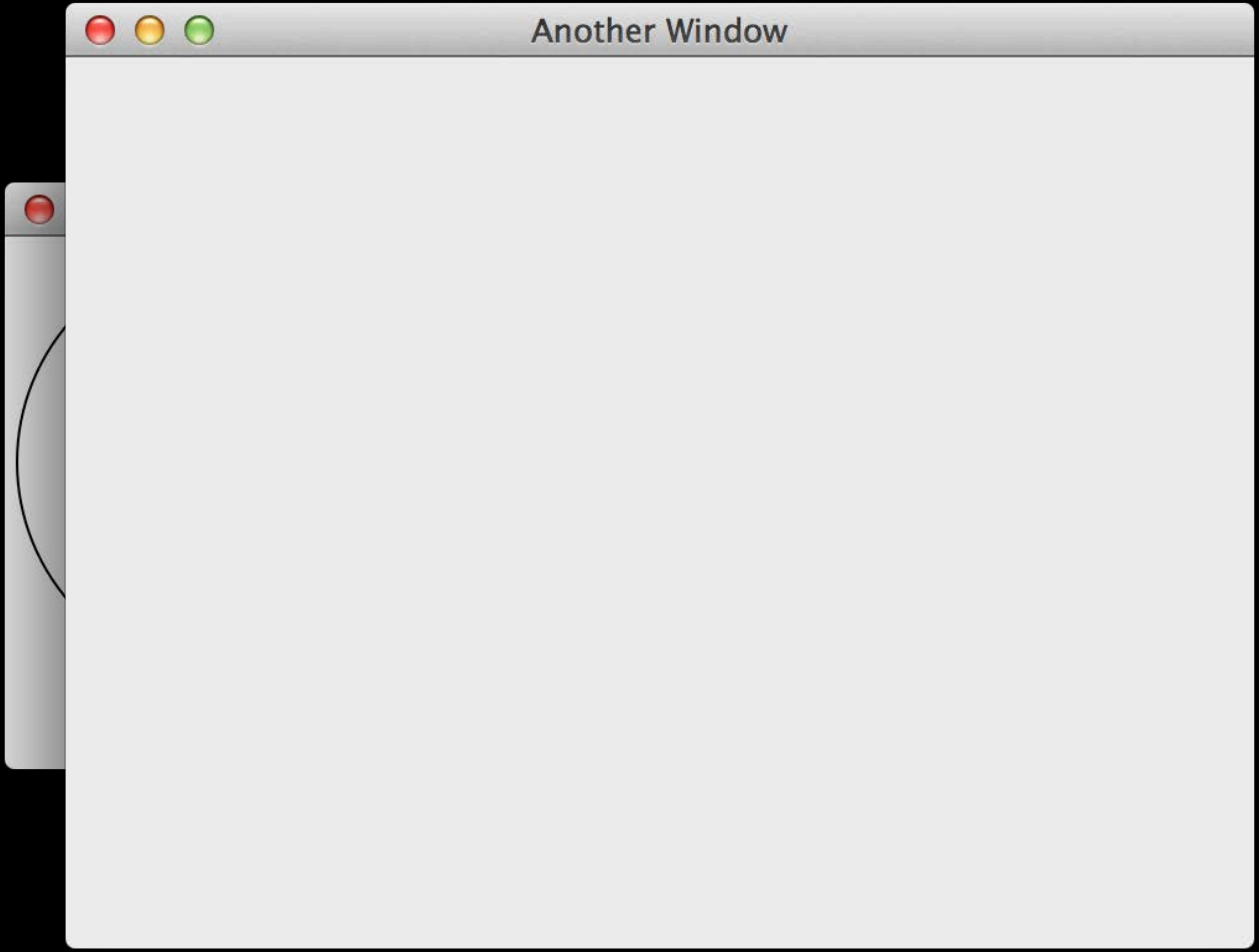

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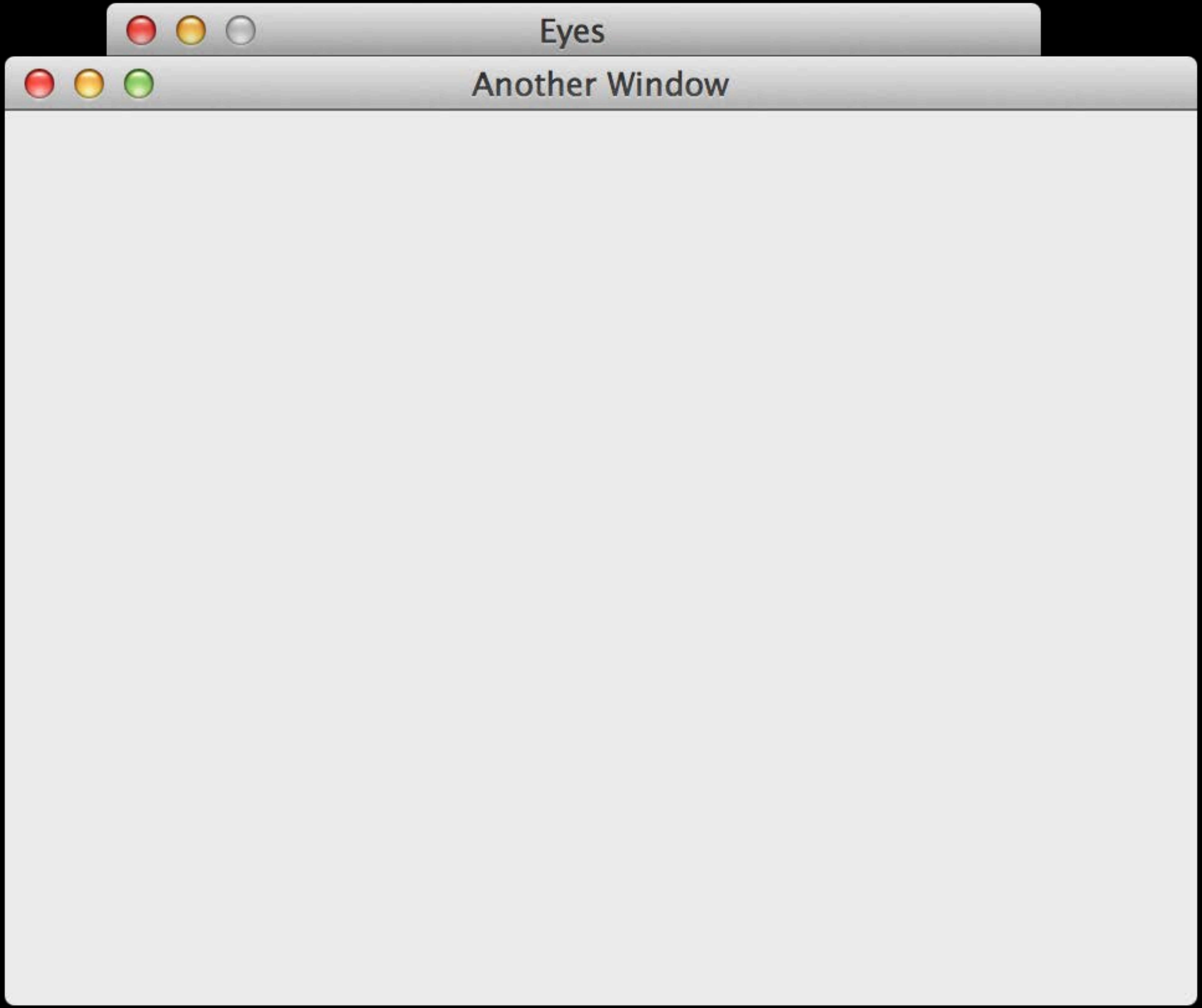

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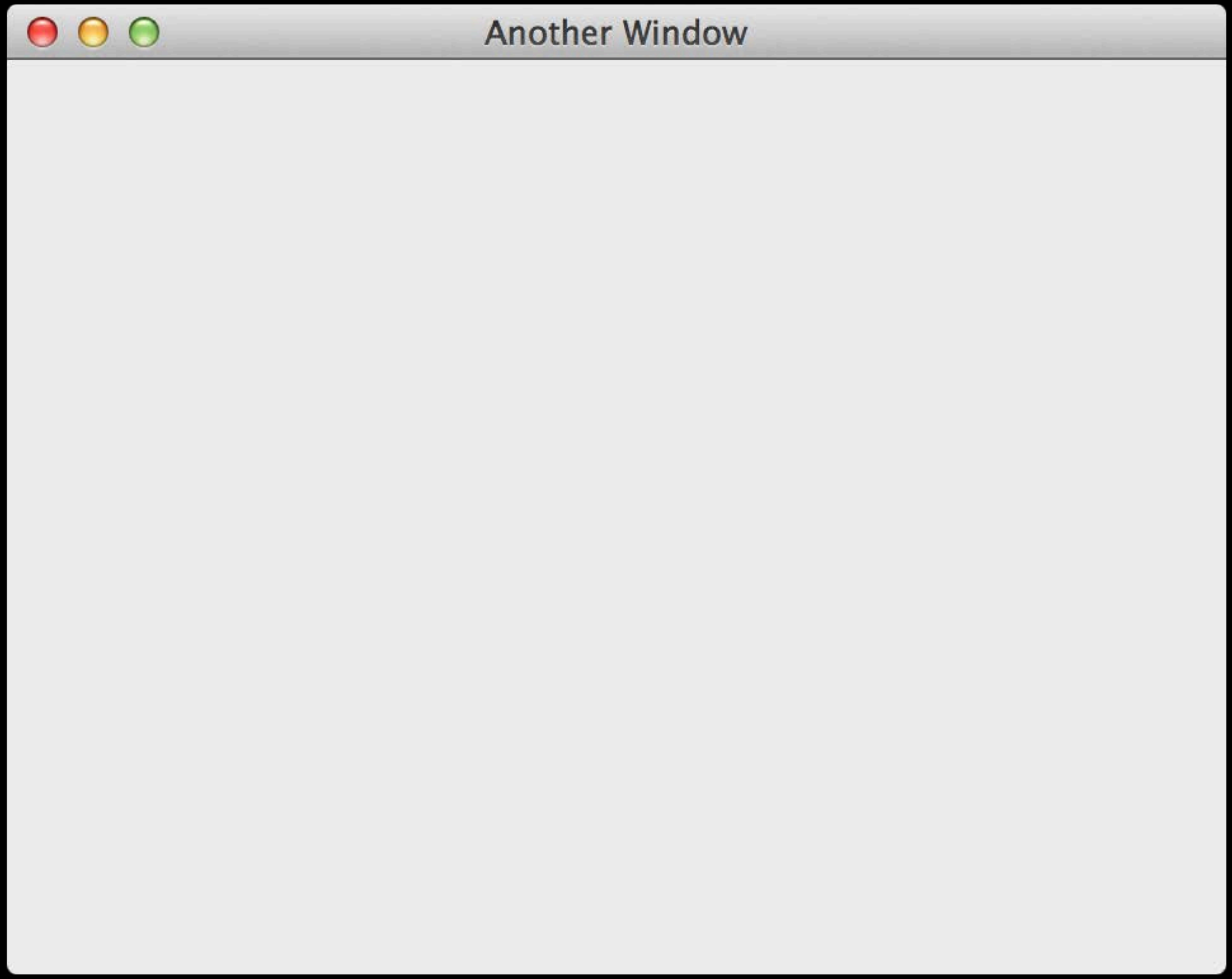
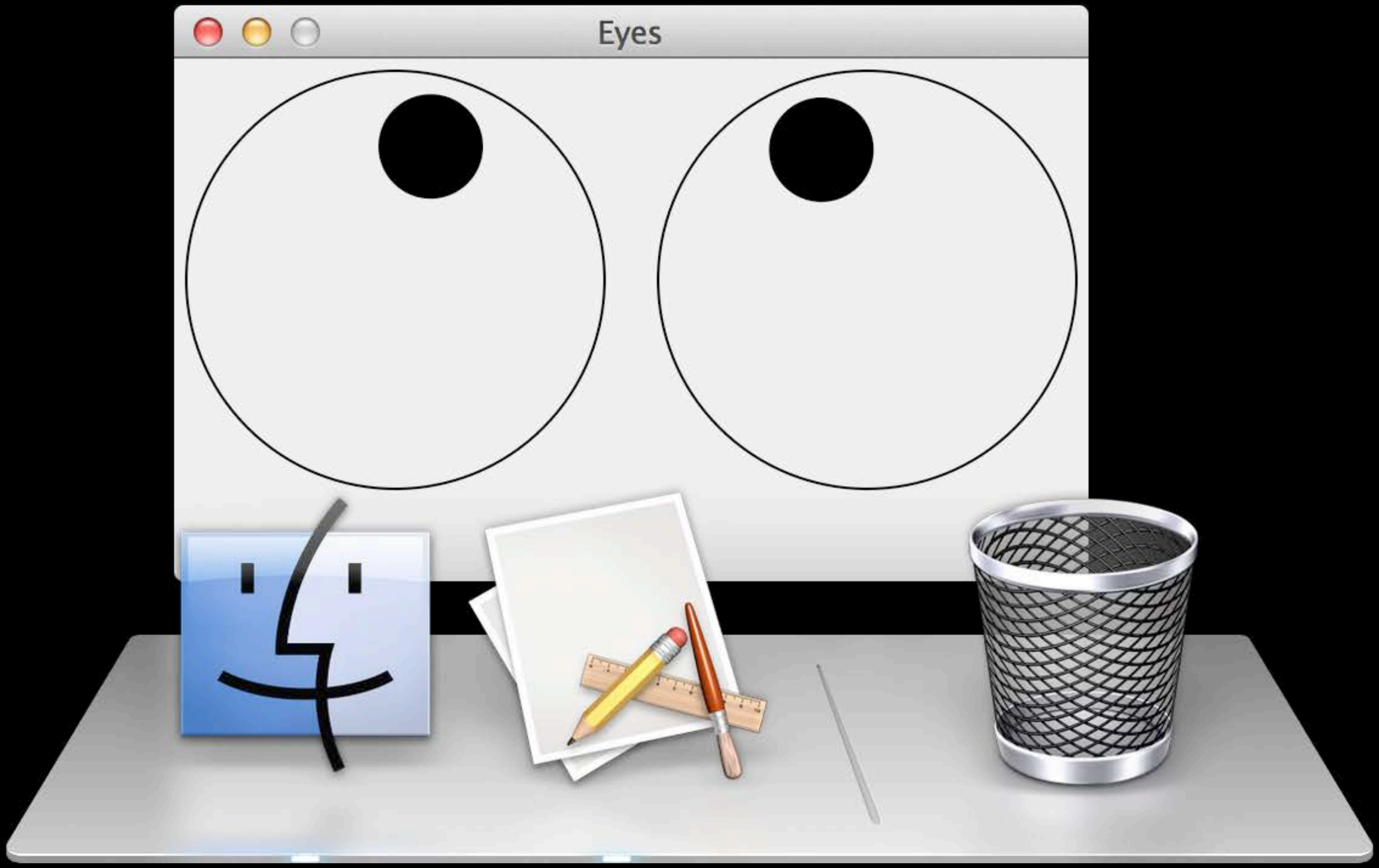


Occluded

Minimized Windows

Visible

Minimized Windows



Occluded

Application Occlusion

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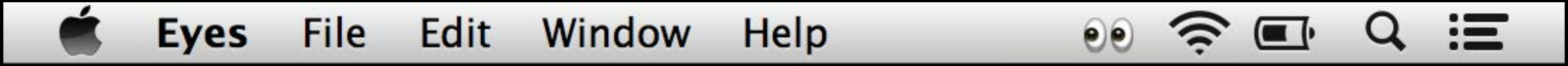

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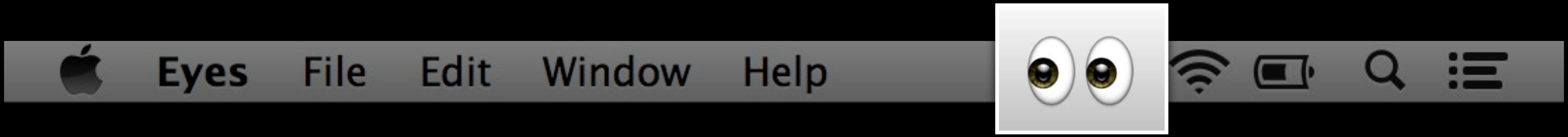

Application Occlusion

```
@protocol NSApplicationDelegate
- (void)applicationDidChangeOcclusionState:(NSNotification *)notification;
@end

@interface NSApplication
- (NSApplicationOcclusionState)occlusionState;
@end

typedef NS_OPTIONS(NSUInteger, NSApplicationOcclusionState) {
    NSApplicationOcclusionStateVisible = 1UL << 1,
}
```

Window Occlusion

```
@protocol NSWindowDelegate
- (void)windowDidChangeOcclusionState:(NSNotification *)notification;
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@interface NSWindow
- (NSWindowOcclusionState)occlusionState;
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typedef NS_OPTIONS(NSUInteger, NSWindowOcclusionState) {
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}
```

Occlusion Example

```
@implementation EYEAppDelegate

- (void)applicationDidChangeOcclusionState:(NSNotification *)n
{
    if ([NSApp occlusionState] & NSApplicationOcclusionStateVisible) {
        // Visible
    } else {
        // Occluded
    }
}

@end
```

Timer Tolerance

- Most timers do not need to be hyper-accurate
    - Default tolerance is applied to all timers

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- New API allows for increasing default tolerance

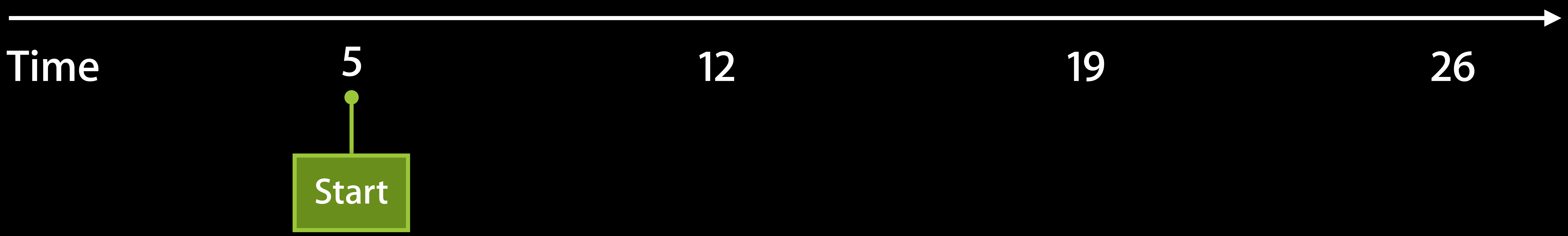
Timer Tolerance

- Most timers do not need to be hyper-accurate
    - Default tolerance is applied to all timers
- New API allows for increasing default tolerance
- System fires timer at best time in tolerance window

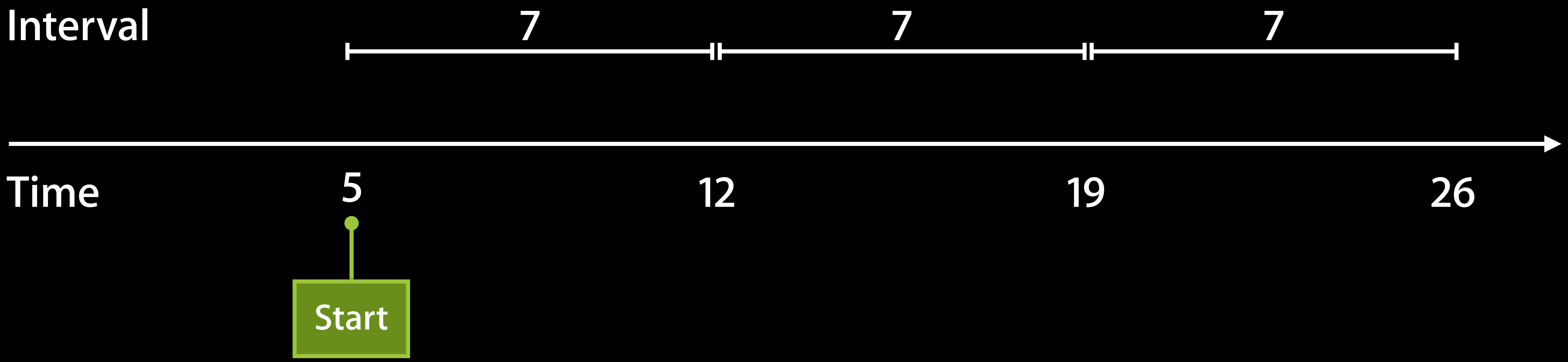
Timer Tolerance

Time
5
12
19
26

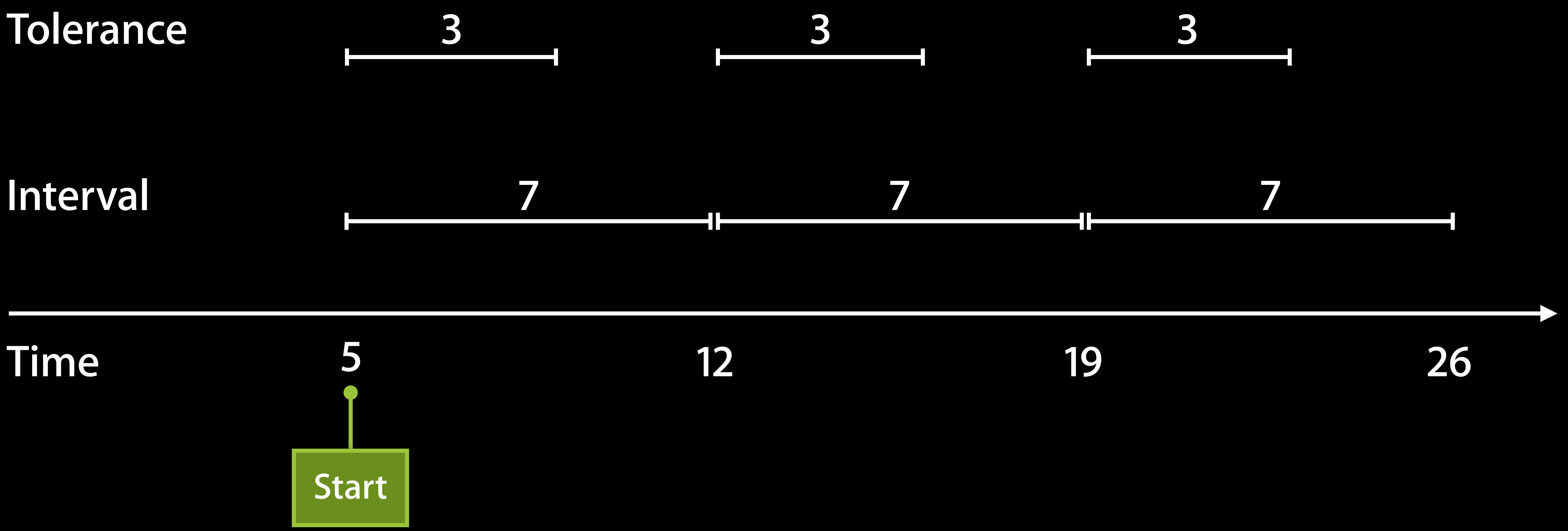
Timer Tolerance



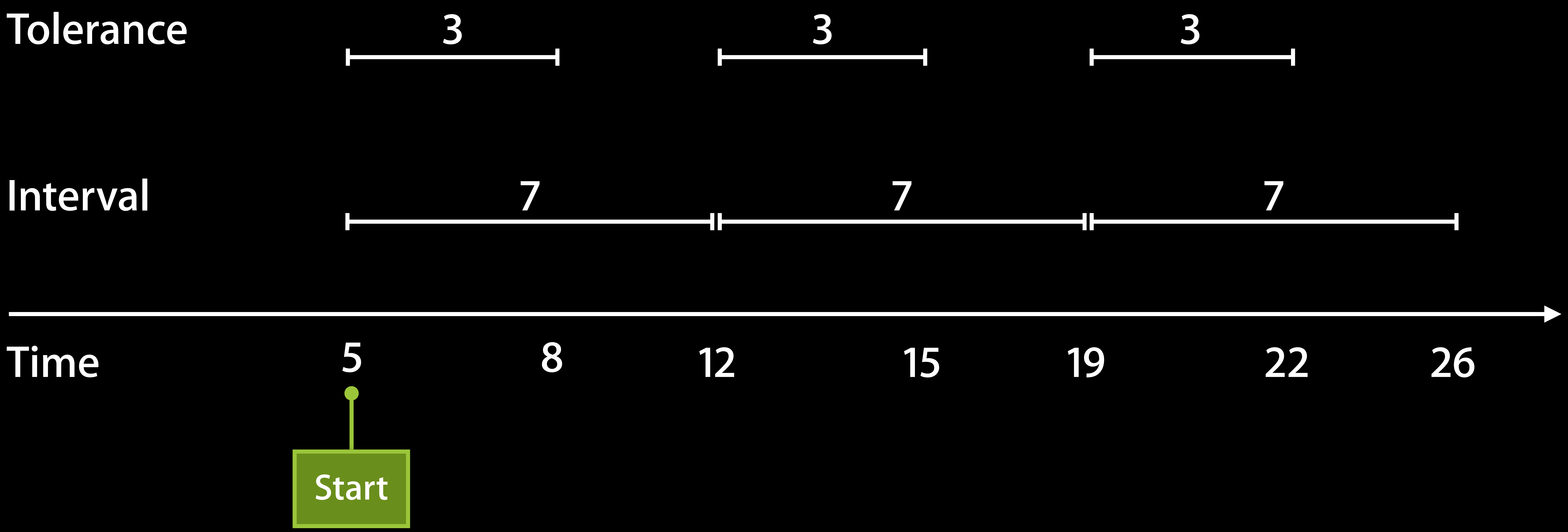
Timer Tolerance



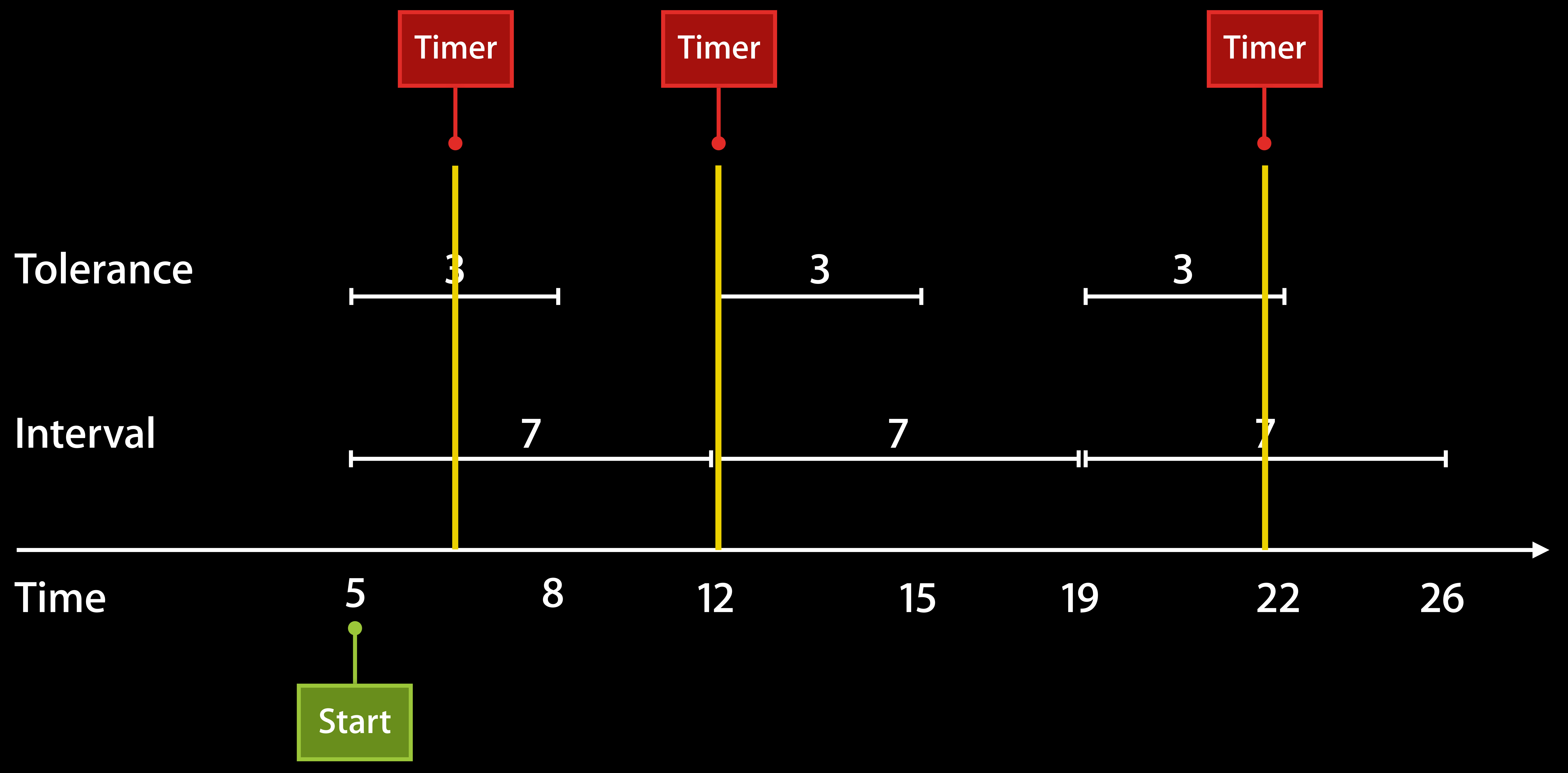
Timer Tolerance



Timer Tolerance



Timer Tolerance



NSTimer Tolerance

```
@interface NSTimer
- (void)setTolerance:(NSTimeInterval)tolerance;
- (NSTimeInterval)tolerance;
@end
```

NSTimer Tolerance

```
// Create repeating timer
NSTimer *timer = [NSTimer timerWithTimeInterval:7.0
                                          target:self
                                        selector:@selector(timerFired:)
                                        userInfo:nil
                                         repeats:YES];

// Set fire date
[timer setFireDate:[NSDate dateWithTimeIntervalSinceNow:5.0]];

// Set tolerance
[timer setTolerance:3.0];

[[NSRunLoop currentRunLoop] addTimer:timer forMode:NSRunLoopCommonModes];
```

Dispatch Timer Tolerance

```
dispatch_source_t timer;
timer = dispatch_source_create(DISPATCH_SOURCE_TYPE_TIMER,
                               0,
                               0,
                               queue);

dispatch_source_set_event_handler(timer, ^{ /* Work goes here */ });

dispatch_source_set_timer(timer,
                    dispatch_time(DISPATCH_TIME_NOW, 5 * NSEC_PER_SEC),
                    7 * NSEC_PER_SEC,
                    3 * NSEC_PER_SEC);

dispatch_resume(timer);
```

Dispatch Strict Timers

```
dispatch_source_t timer;
timer = dispatch_source_create(DISPATCH_SOURCE_TYPE_TIMER,
                               0,
                               DISPATCH_TIMER_STRICT,
                               queue);

dispatch_source_set_event_handler(timer, ^{ /* Work goes here */ });

dispatch_source_set_timer(timer,
                    dispatch_time(DISPATCH_TIME_NOW, 5 * NSEC_PER_SEC),
                    7 * NSEC_PER_SEC,
                    700 * NSEC_PER_MSEC);

dispatch_resume(timer);
```

Timer Tolerance

- Suggested tolerance is at least 10% of interval
  - Exact value will be application specific

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    - Disables timer rate limiting
    - You should still specify a tolerance

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- Suggested tolerance is at least 10% of interval
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- Strict timers are rare
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- Critical mass effect

User Activities

- Improves accuracy of App Nap heuristics

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- Use for long-running or asynchronous work

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- Cocoa API to prevent idle system sleep

User Activities

- Improves accuracy of App Nap heuristics
- Use for long-running or asynchronous work
- Cocoa API to prevent idle system sleep
- Includes automatic and sudden termination

User Activities

```
@interface NSProcessInfo

- (void)performActivityWithOptions:(NSActivityOptions)options
                            reason:(NSString *)reason
                             block:(void (^)())block;




@end
```

User Activities

```
@interface NSProcessInfo

- (void)performActivityWithOptions:(NSActivityOptions)options
                            reason:(NSString *)reason
                             block:(void (^)())block;

- (id)beginActivityWithOptions:(NSActivityOptions)options
                        reason:(NSString *)reason;

- (void)endActivity:(id)activity;

@end
```

User Activities

NSActivityOptions

- Exporting, recording, processing

```
NSActivityUserInitiated
NSActivityUserInitiatedAllowingIdleSystemSleep
```

User Activities

NSActivityOptions

- Exporting, recording, processing

```
NSActivityUserInitiated
NSActivityUserInitiatedAllowingIdleSystemSleep
```

- Maintenance

```
NSActivityBackground
```

User Activities

NSActivityOptions

- Exporting, recording, processing

```
NSActivityUserInitiated
NSActivityUserInitiatedAllowingIdleSystemSleep
```

- Maintenance

```
NSActivityBackground
```

- Latency sensitive

```
NSActivityUserInitiated | NSActivityLatencyCritical
```

User Activities

NSActivityOptions

- Idle system sleep

```
NSActivityIdleDisplaySleepDisabled
NSActivityIdleSystemSleepDisabled
```

User Activities

NSActivityOptions

- Idle system sleep

```
NSActivityIdleDisplaySleepDisabled
NSActivityIdleSystemSleepDisabled
```

- Sudden termination

```
NSActivitySuddenTerminationDisabled
```

User Activities

NSActivityOptions

- Idle system sleep

```
NSActivityIdleDisplaySleepDisabled
NSActivityIdleSystemSleepDisabled
```

- Sudden termination

```
NSActivitySuddenTerminationDisabled
```

- Automatic termination

```
NSActivityAutomaticTerminationDisabled
```

User Activities

```
NSOperationQueue *queue = ...;

id token = [[NSProcessInfo processInfo]
              beginActivityWithOptions:NSActivityUserInitiated
                                reason:@"Batch processing files"];

[queue addOperationWithBlock:^{
    // Do work here

    [[NSProcessInfo processInfo] endActivity:token];
}];
```

Choosing the Right Activity

- Applications can have multiple concurrent activities
    - NSActivityBackground for maintenance work
    - NSActivityUserInitiated when user takes action

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- Avoid rapidly starting and ending activities

Choosing the Right Activity

- Applications can have multiple concurrent activities
    - NSActivityBackground for maintenance work
    - NSActivityUserInitiated when user takes action
- Avoid rapidly starting and ending activities
- Idle system sleep assertions should be used with care
    - Don’t prevent idle sleep forever
    - Verify power assertions are dropped

Choosing the Right Activity

Verify power assertions

Choosing the Right Activity

Verify power assertions

```
$ pmset -g assertions
```

Choosing the Right Activity

Verify power assertions

```
$ pmset -g assertions
Assertion status system-wide:
   BackgroundTask                0
   PreventUserIdleDisplaySleep   0
   PreventSystemSleep            0
   PreventDiskIdle               0
   PreventUserIdleSystemSleep    1
   ExternalMedia                 0
   UserIsActive                  0
   ApplePushServiceTask          0
Listed by owning process:
   pid 1963(Eyes): [0x0000000100000196] 00:03:36 PreventUserIdleSystemSleep
named: "Keeping the computer awake"
```

Demo

Adopting App Nap API

Summary

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- Software has a huge impact on energy efficiency

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    - Stay idle as long as possible
    - Avoid unnecessary work
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  - Instead, use event based API
  - If you must use timers, add tolerance

Summary

- Software has a huge impact on energy efficiency
- To extend battery life
  - Stay idle as long as possible
  - Avoid unnecessary work
  - Race back to idle
- Avoiding timers allows a longer idle time
  - Instead, use event based API
  - If you must use timers, add tolerance
- Use activity API to inform system of important user work

Related Sessions

Maximizing Battery Life on OS X	Mission Tuesday 11:30AM	🟩
Building Efficient OS X Apps	Nob Hill Tuesday 4:30PM	🟩
Power and Performance: Optimizing Your Website for Great Battery Life and Responsive Scrolling	Russian Hill Wednesday 9:00AM	🟪
Energy Best Practices	Marina Thursday 10:15AM	🟩

Labs

Cocoa Lab	Frameworks Lab A Wednesday 11:30AM
Cocoa Lab	Frameworks Lab A Thursday 9:00AM
Cocoa Lab	Frameworks Lab A Friday 9:00AM

More Information

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WWDC2013