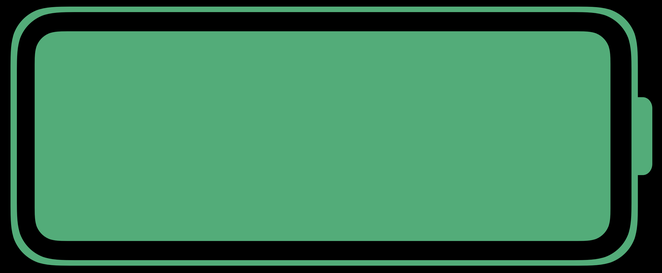
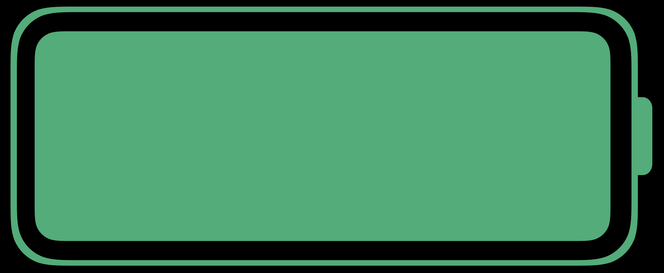
#WWDC18

What's New in Energy Debugging

Phillip Azar, Apple/Battery Life
David Choi, Apple/Battery Life





Review general battery life concepts

Review tools for energy debugging

New features for energy debugging

Review general battery life concepts

Review tools for energy debugging

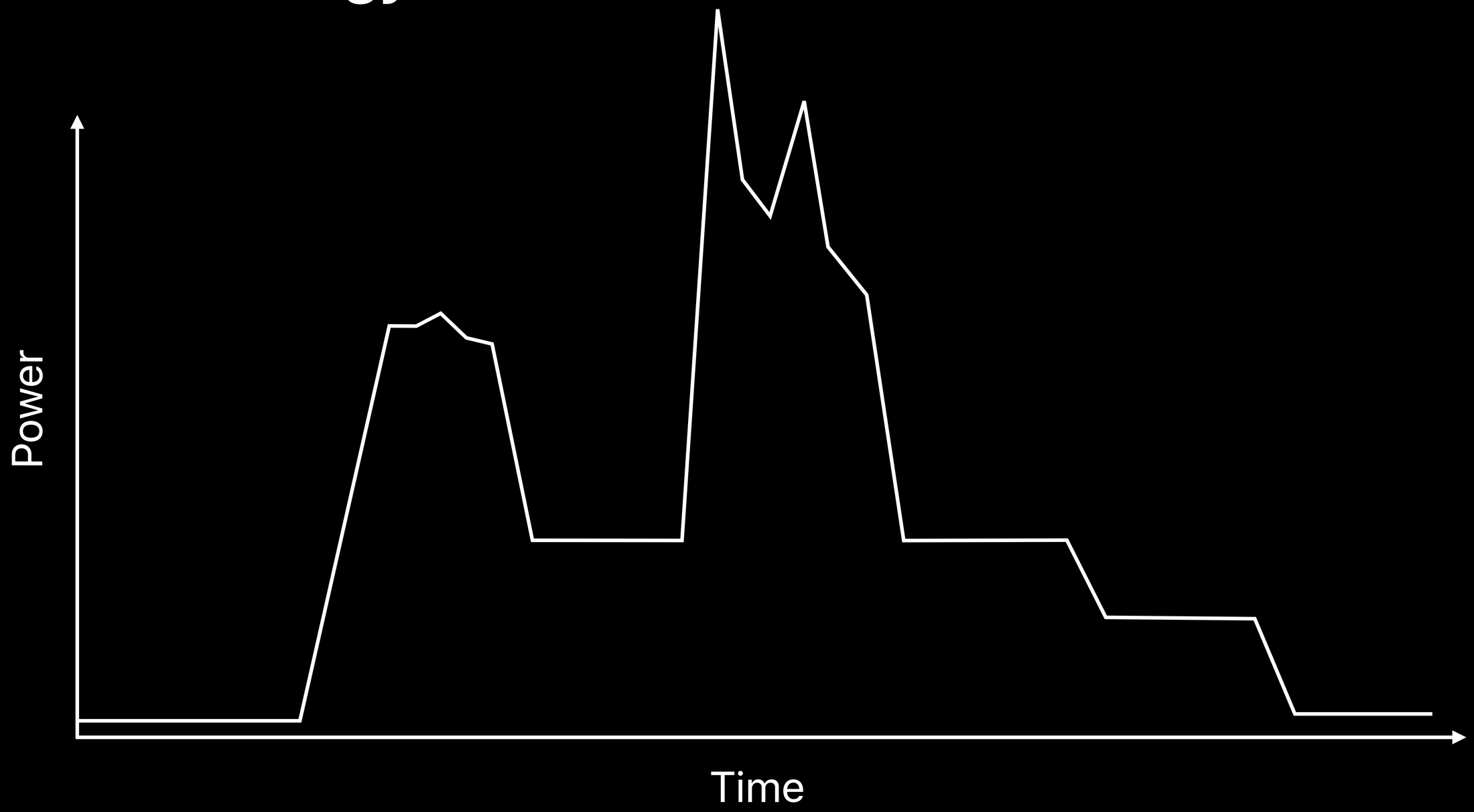
New features for energy debugging

What Is Energy?

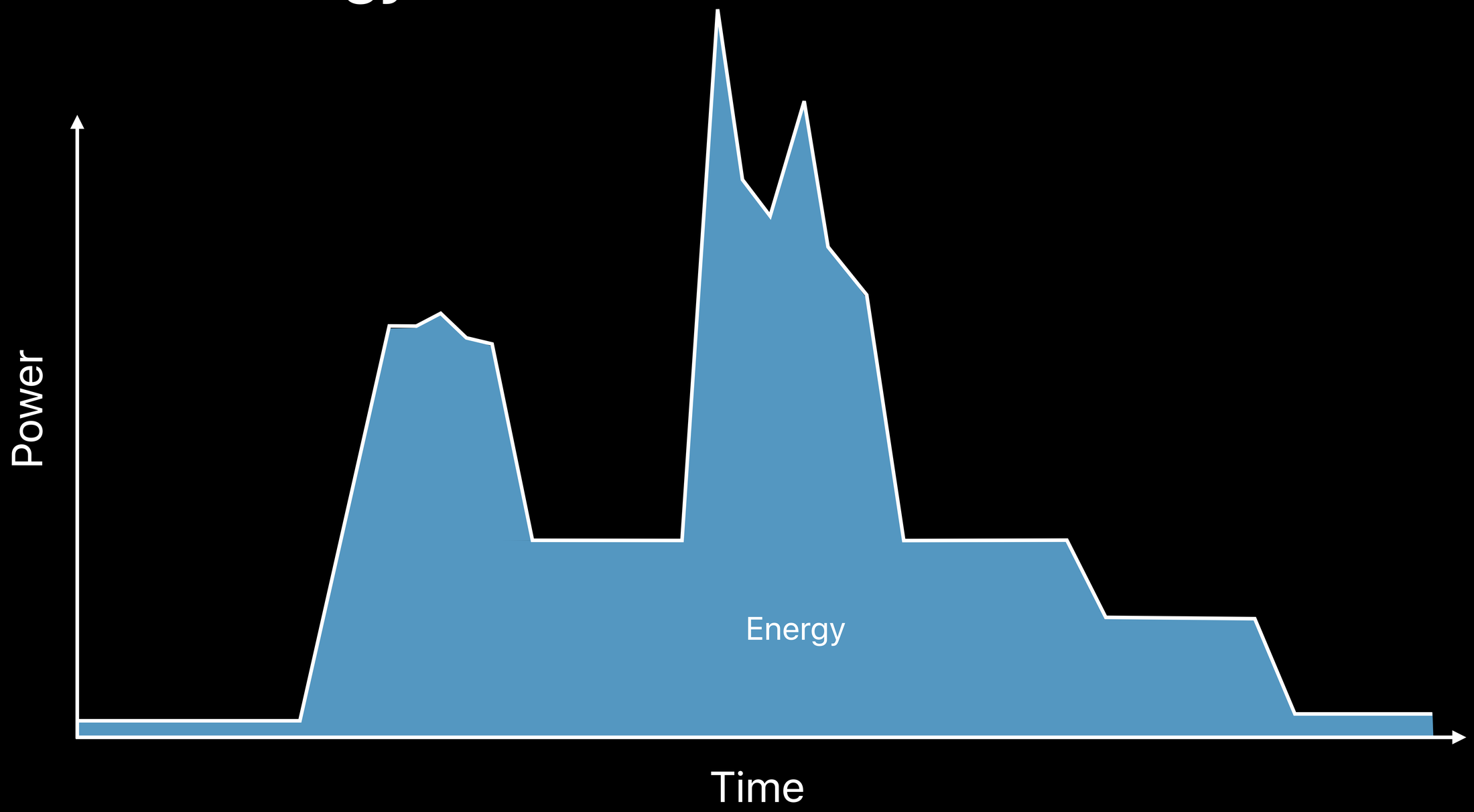
What Is Energy?

Power X Time

What Is Energy?



What Is Energy?



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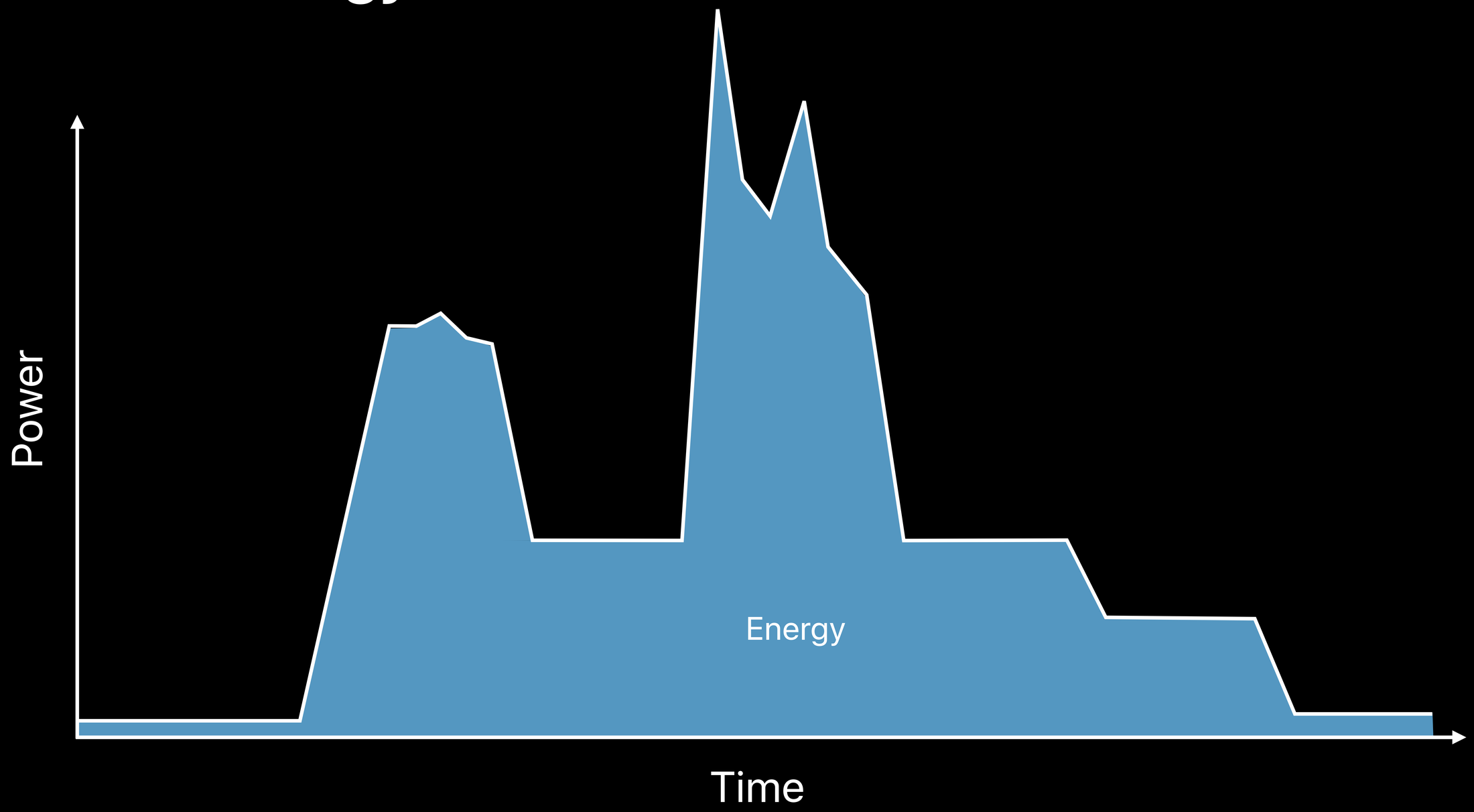

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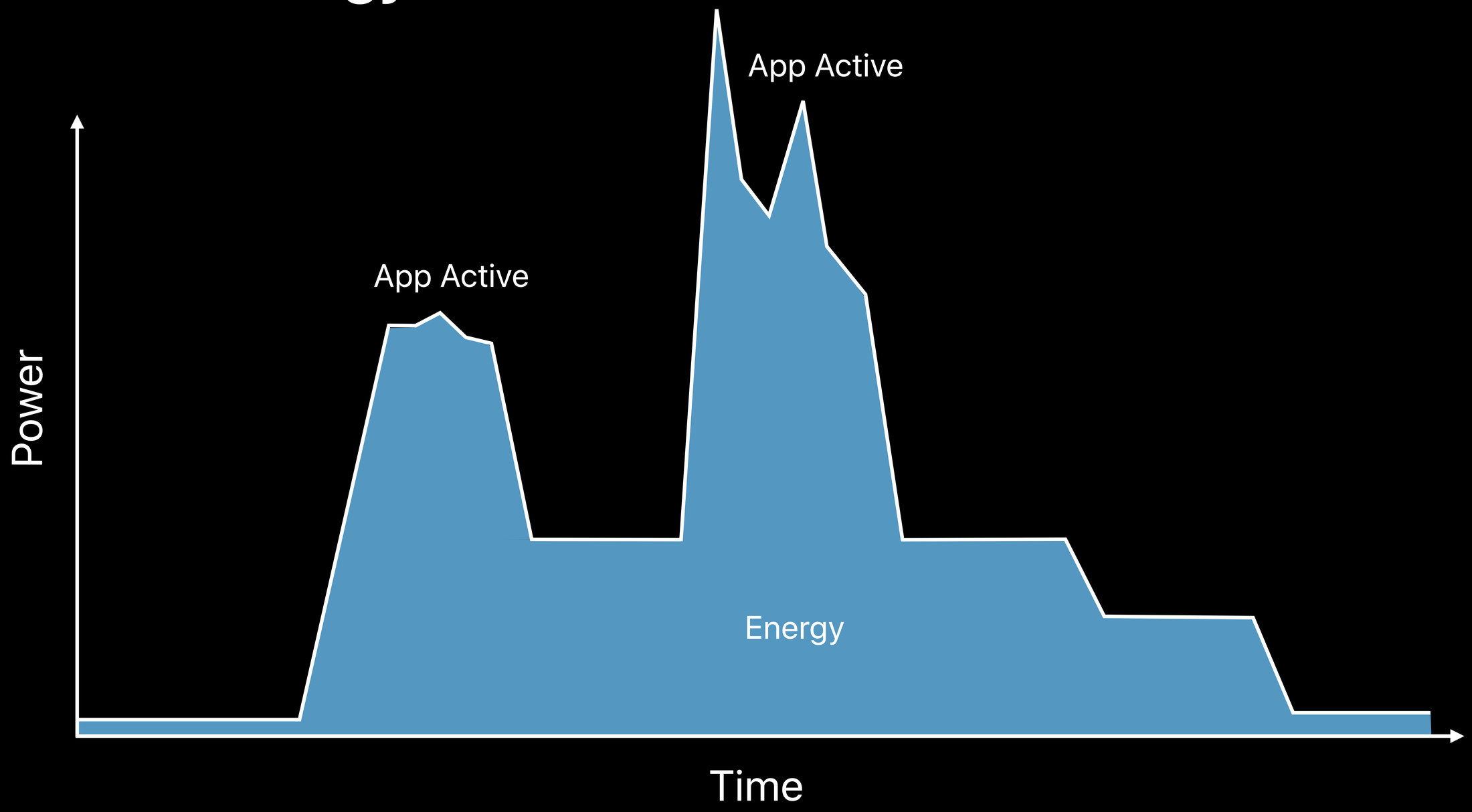

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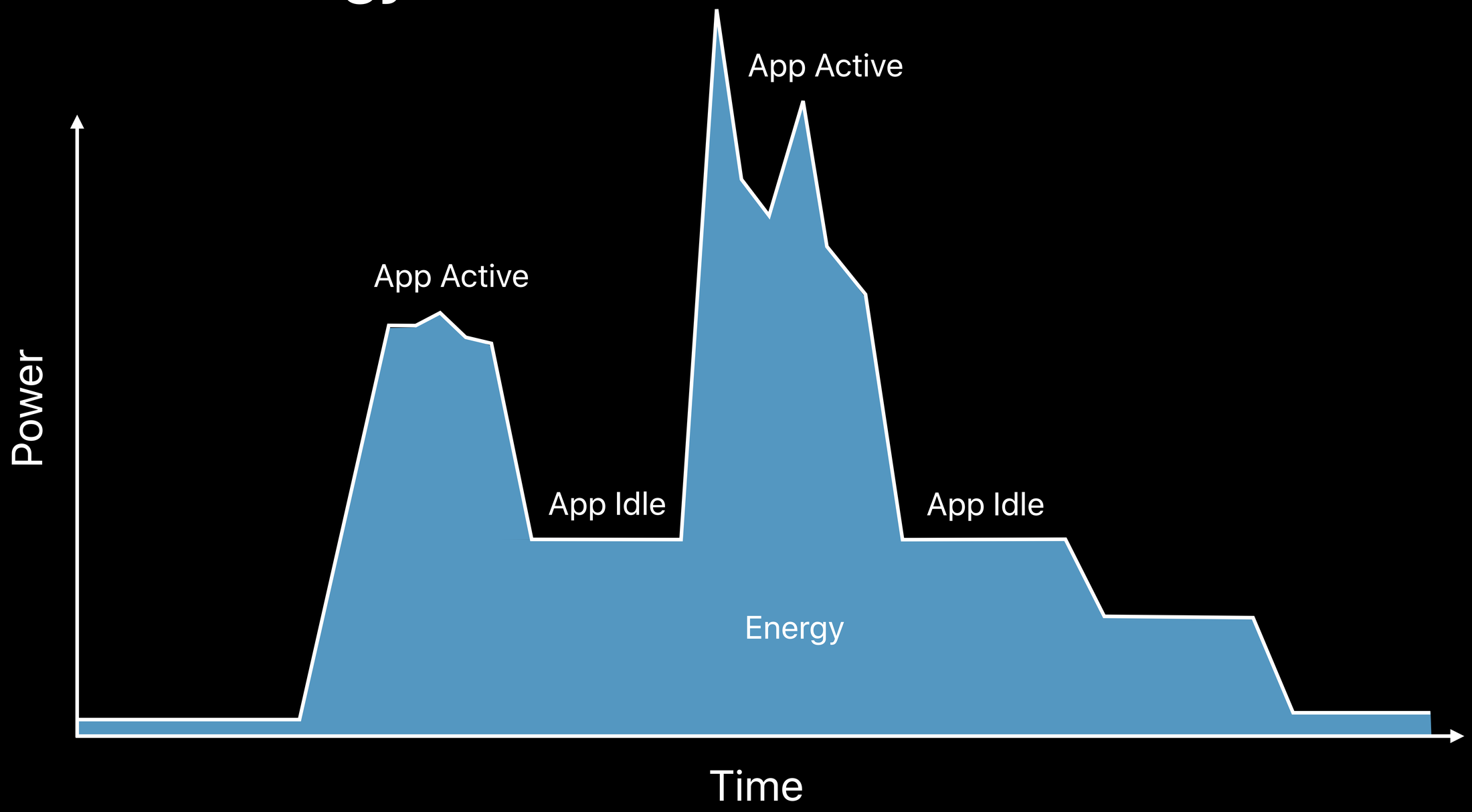

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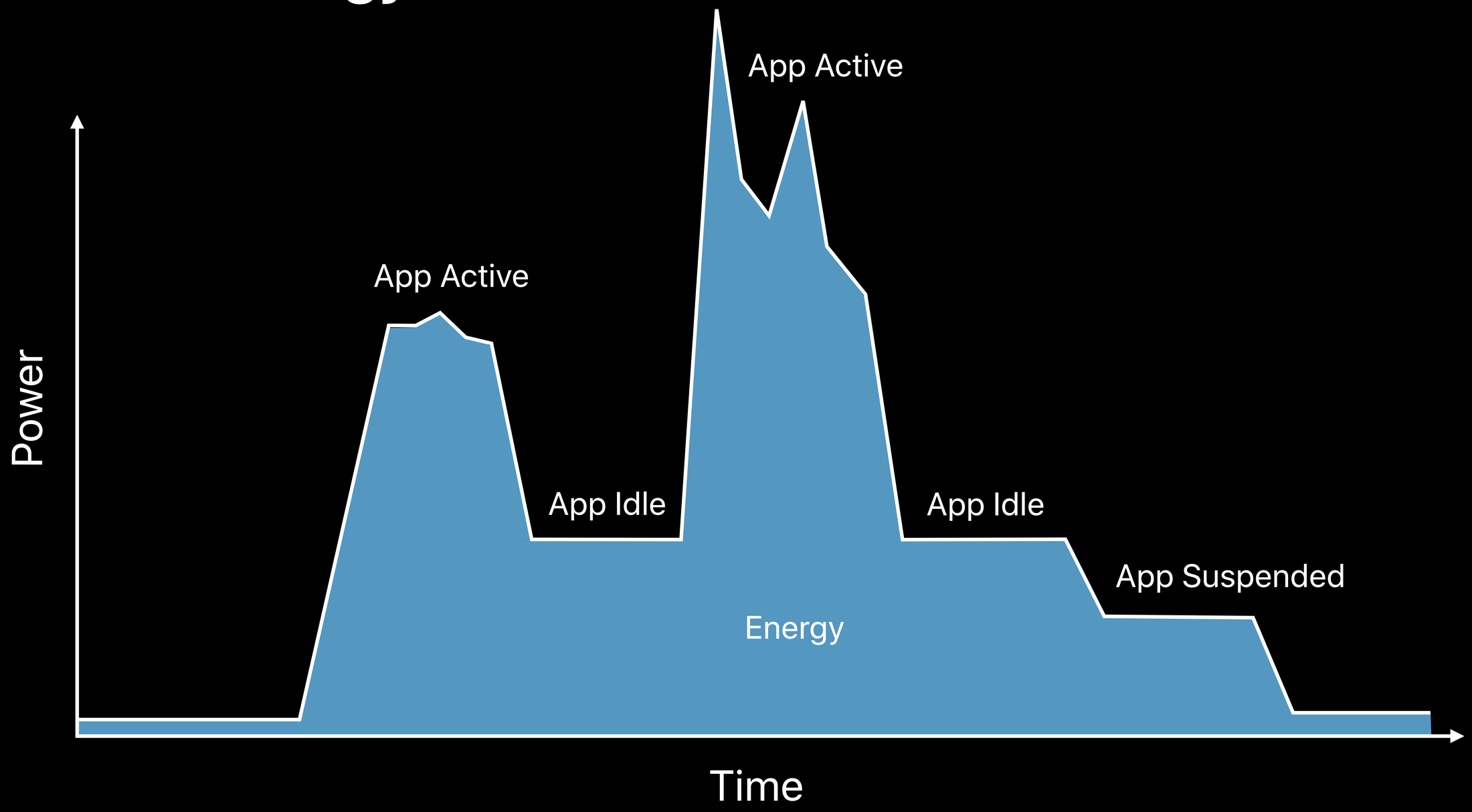

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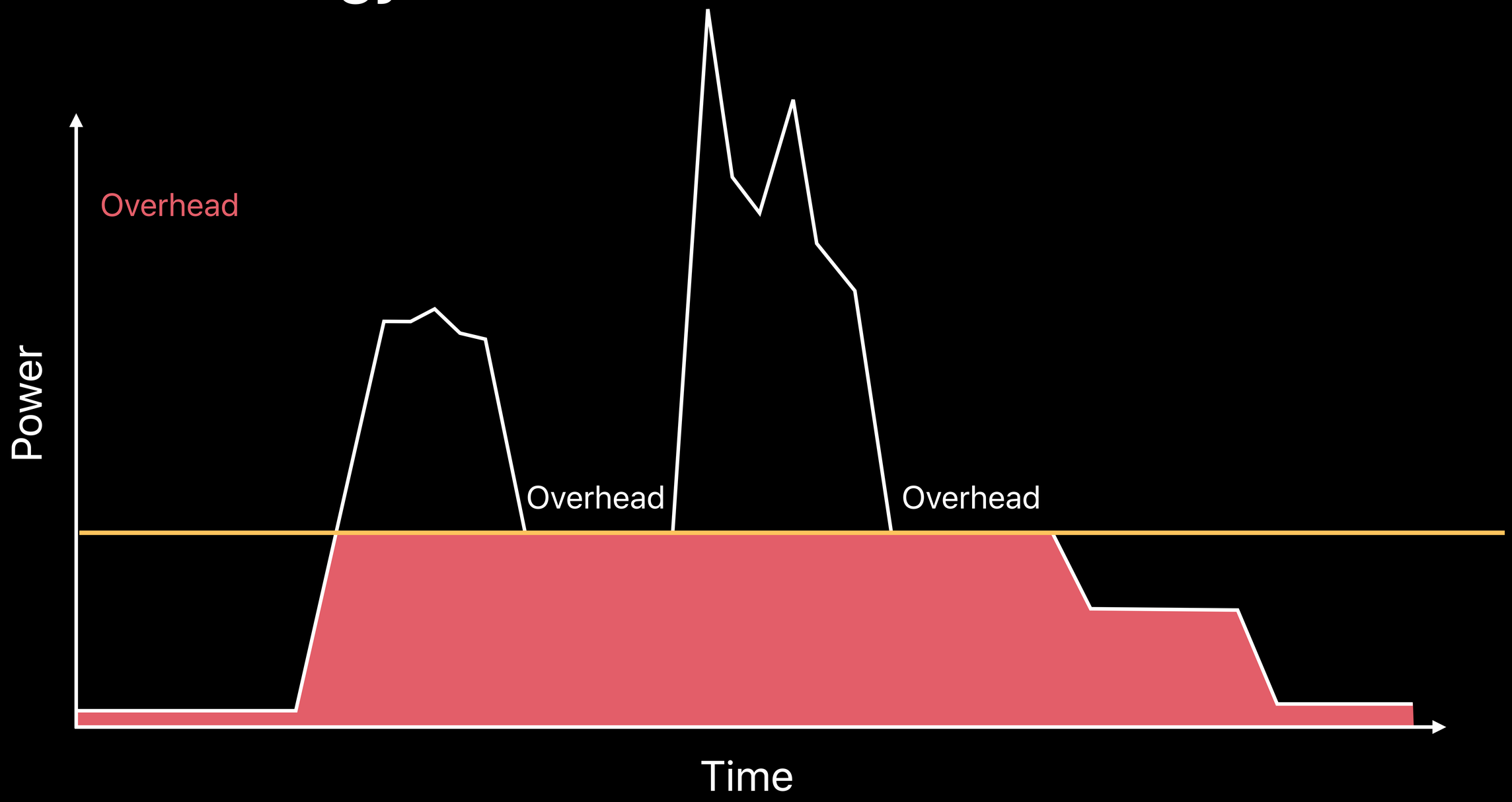

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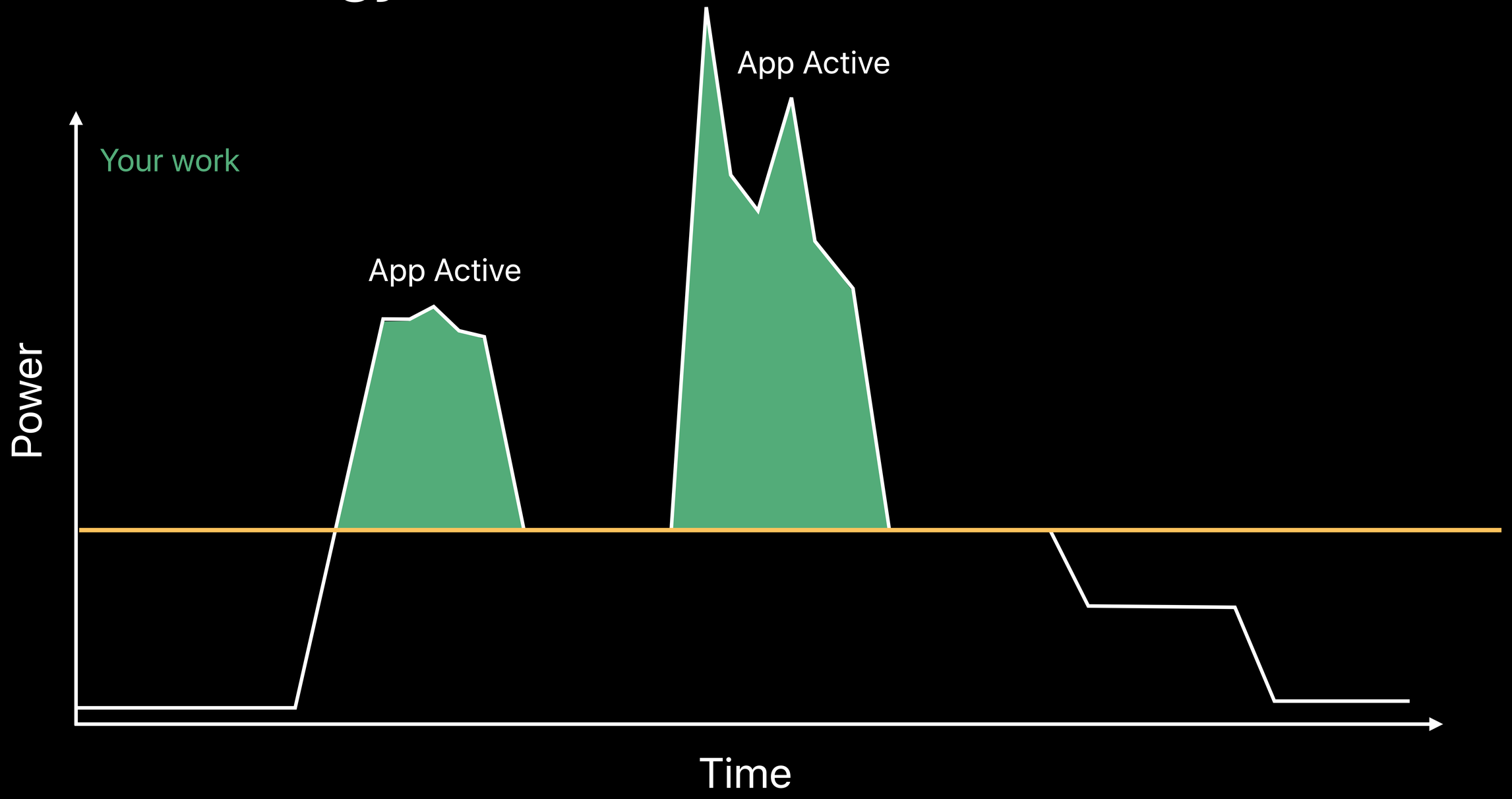

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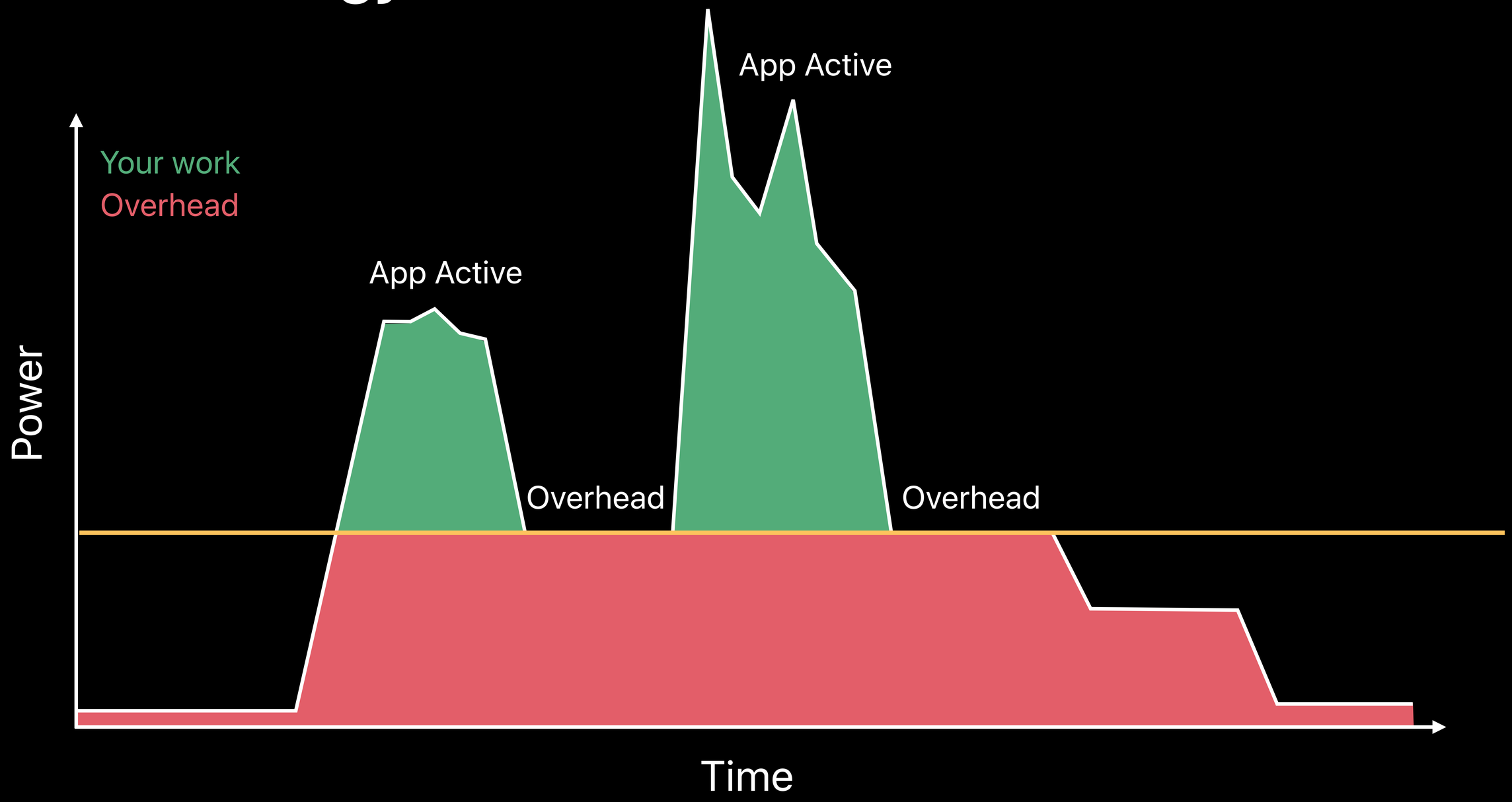


What Consumes Energy?

What Consumes Energy?

Processing

Networking

Location

Graphics


CPU

Processing

Processing

The “work horse”

Processing

The “work horse”

Workload-dependent

Processing

The “work horse”

Workload-dependent

More operations by your app = more energy

Networking

Networking

Cellular, Wi-Fi, Bluetooth

Networking

Cellular, Wi-Fi, Bluetooth

Traffic-dependent

Networking

Cellular, Wi-Fi, Bluetooth

Traffic-dependent

More network requests = more energy

Location

Location

GPS, WiFi, Cellular

Location

GPS, WiFi, Cellular

Accuracy, frequency-dependent

Location

GPS, WiFi, Cellular

Accuracy, frequency-dependent

More time spent tracking location = more energy

Graphics

Graphics

Animations and UI

Graphics

Animations and UI

Complexity-dependent

Graphics

Animations and UI

Complexity-dependent

More rendering = more energy

Processing

Networking

Location

Graphics

Processing

Networking

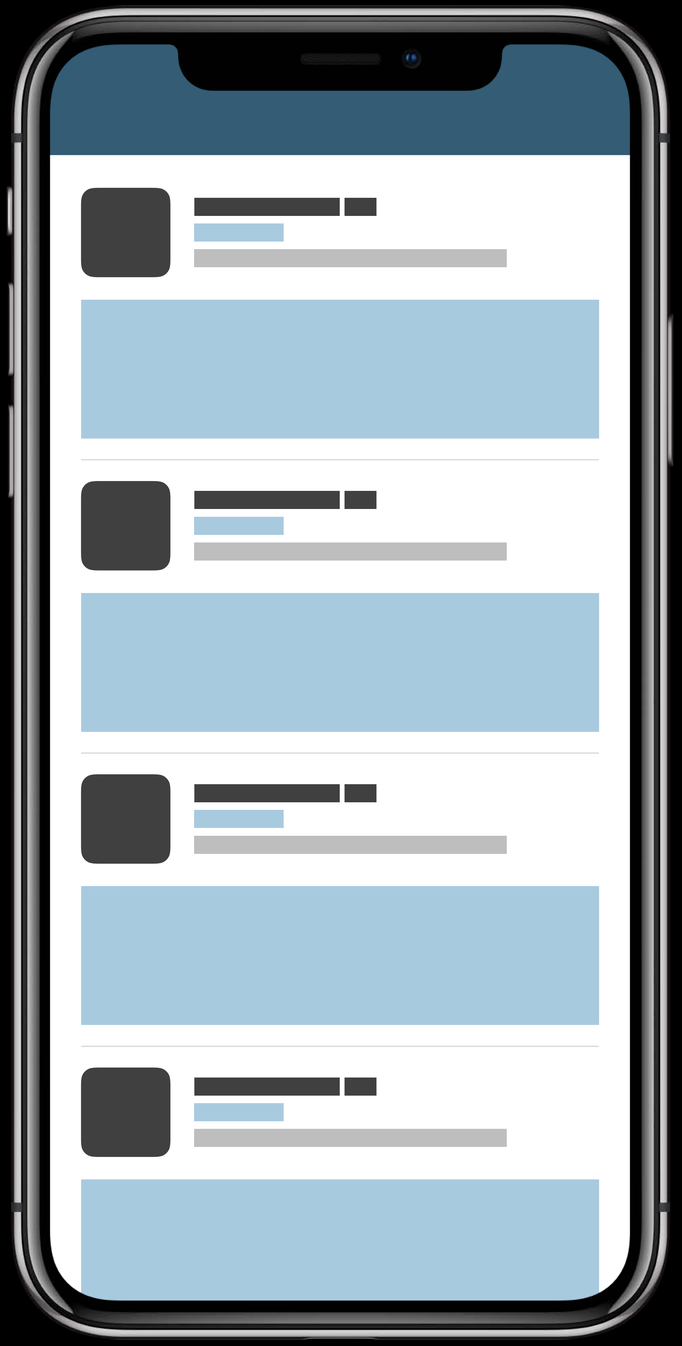
Location

Graphics

More work = More energy

How Do We Optimize Energy Consumption?

Foreground



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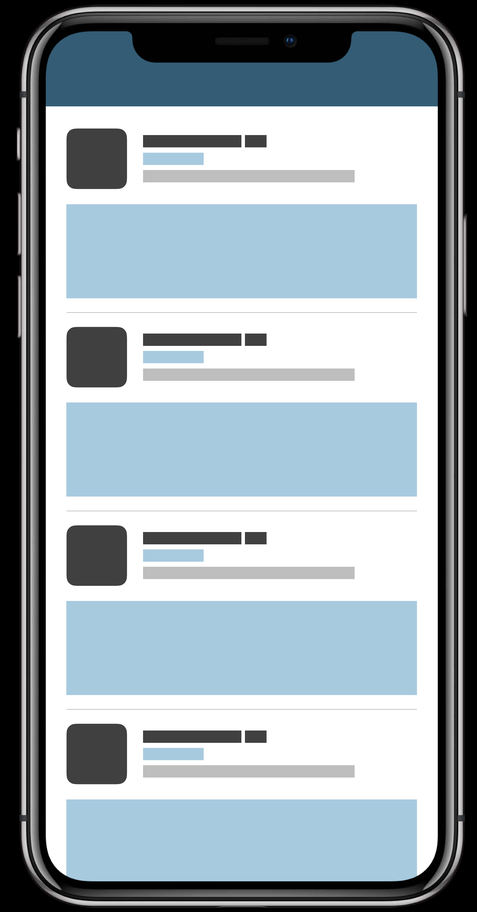
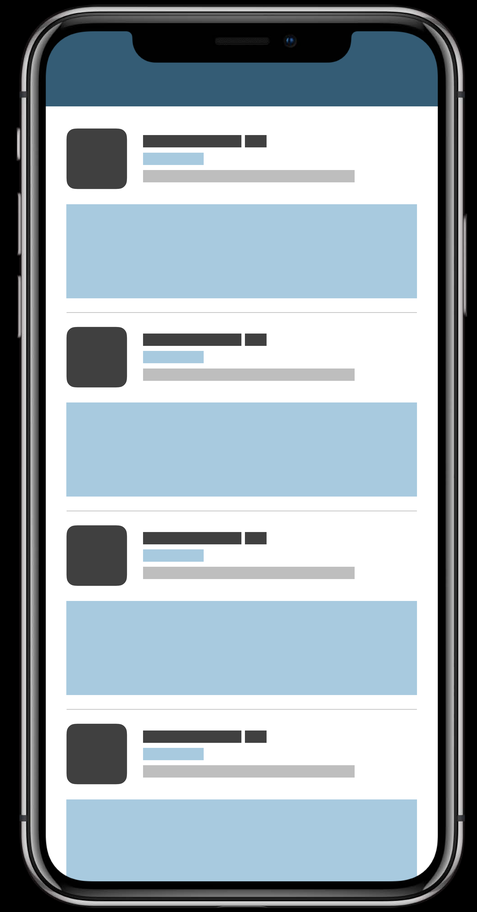


Foreground

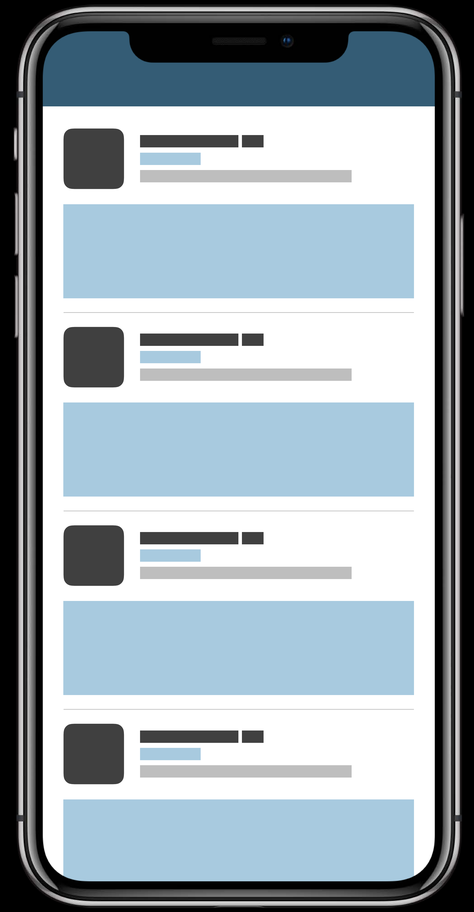
Focus on providing value to the user



Foreground

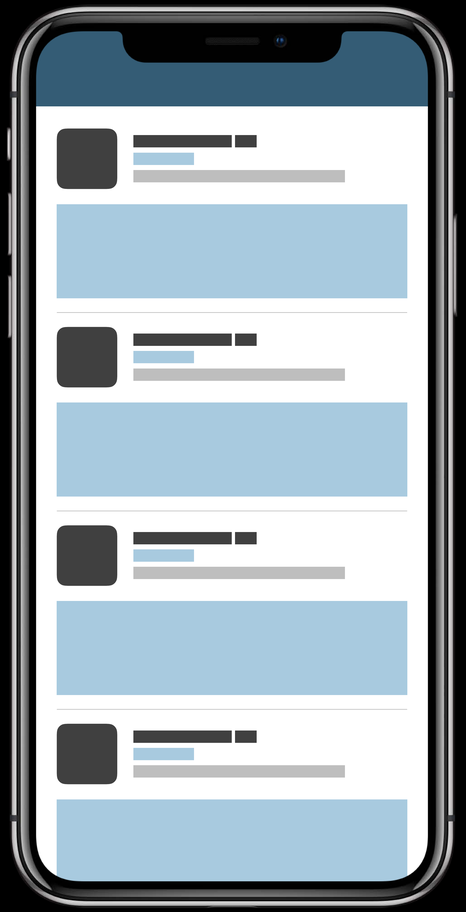
Focus on providing value to the user

- Do required work only



Example

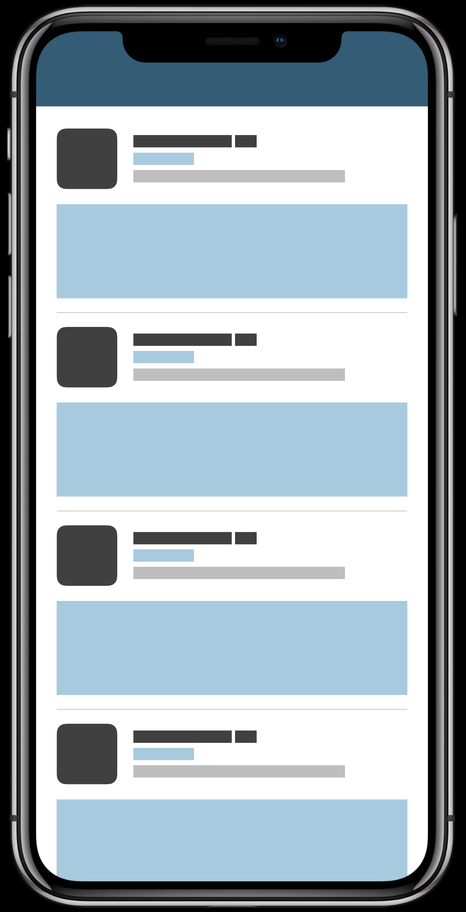
Media app feed



Example

Media app feed

Timer based feed refresh



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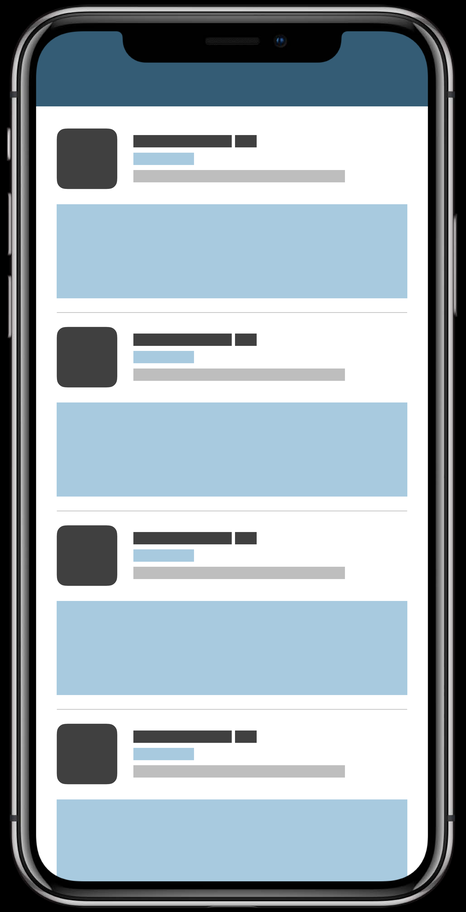
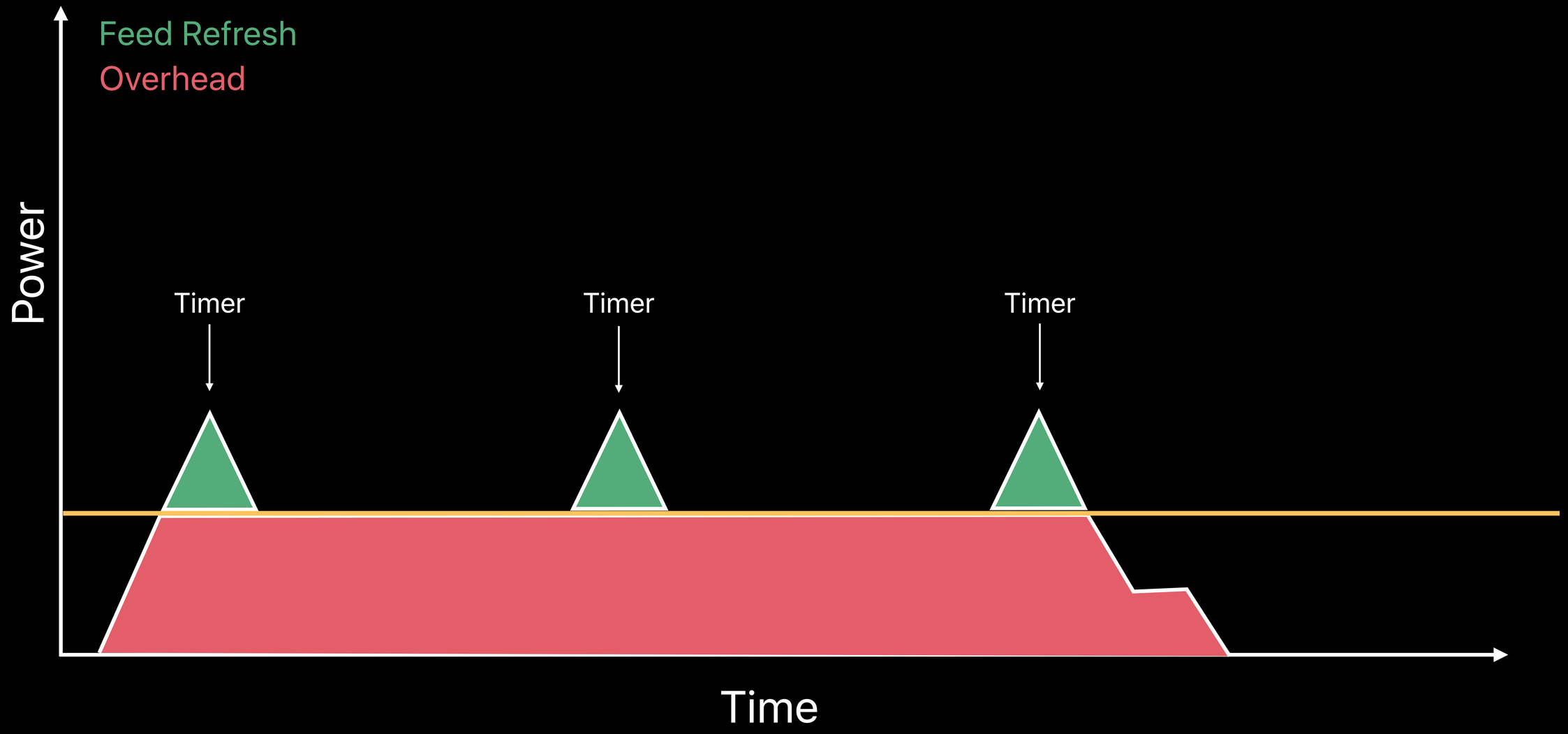
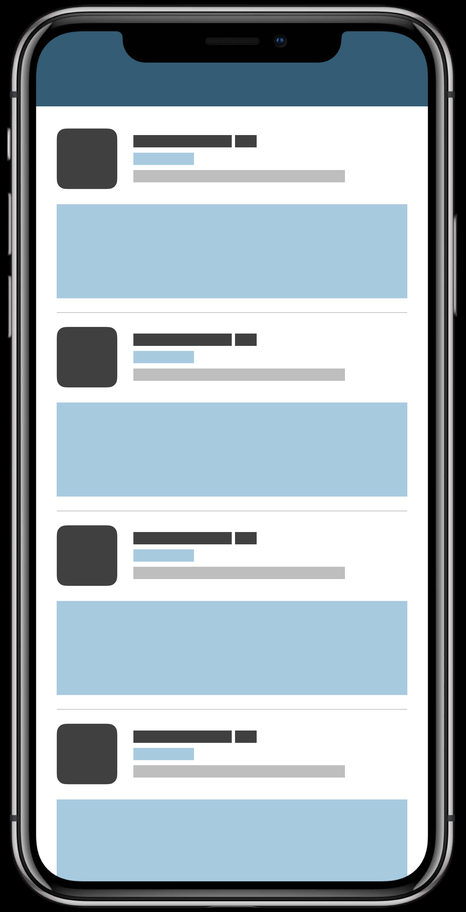



Feed Refresh
Overhead
Power
Timer
Timer
Timer
Time

Example

Media app feed

Timer based feed refresh



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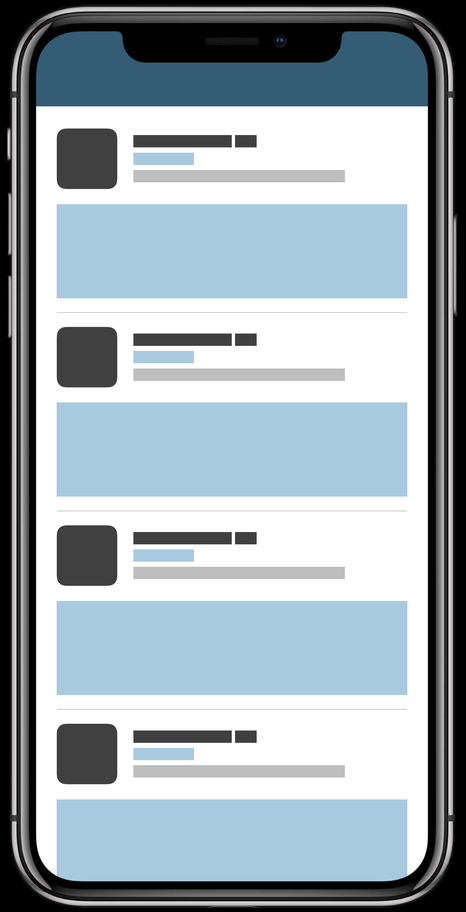


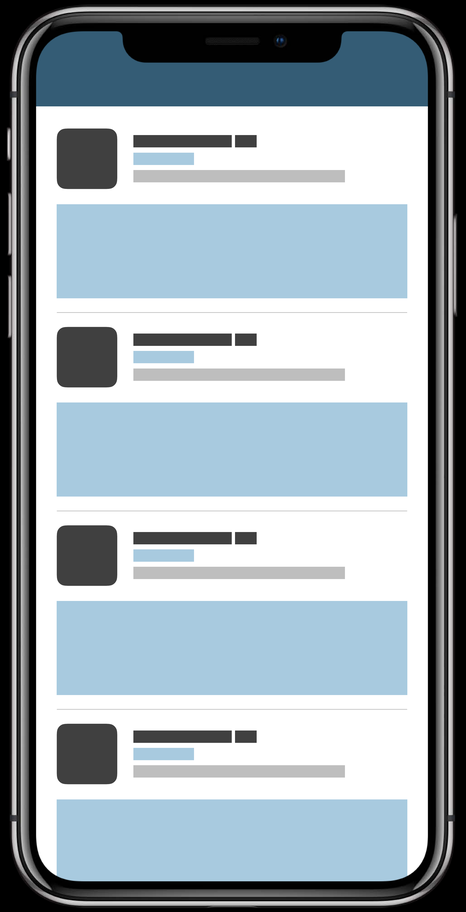
Feed refresh on demand

- Notification
- User interaction

Example

Media app feed

Timer based feed refresh



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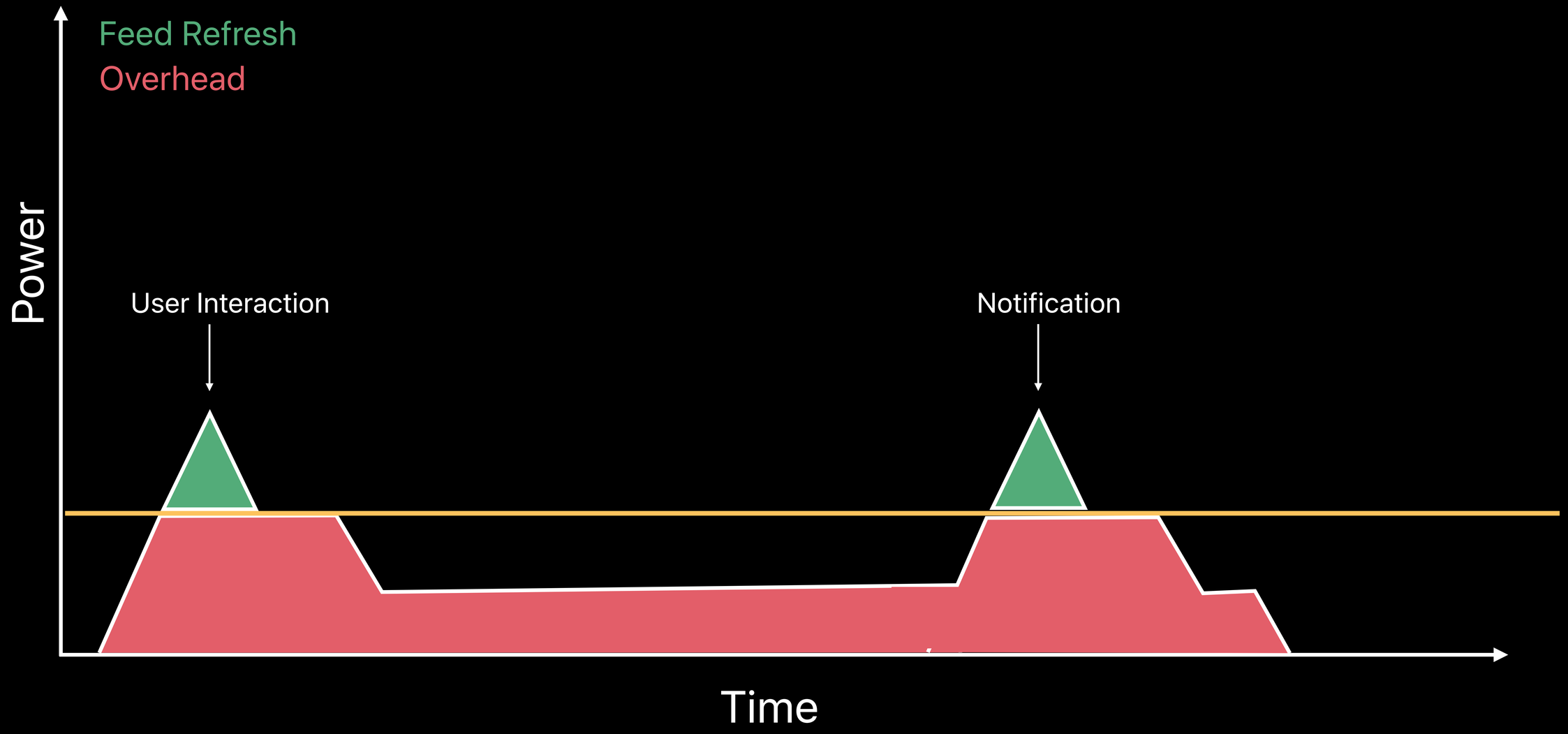
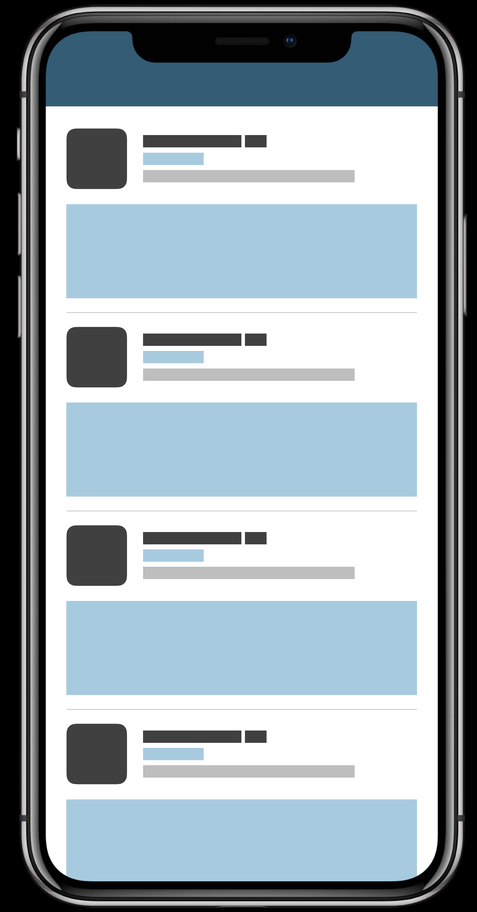

Feed Refresh
Overhead
Power
User Interaction
Notification
Time

Foreground

Focus on providing value to the user

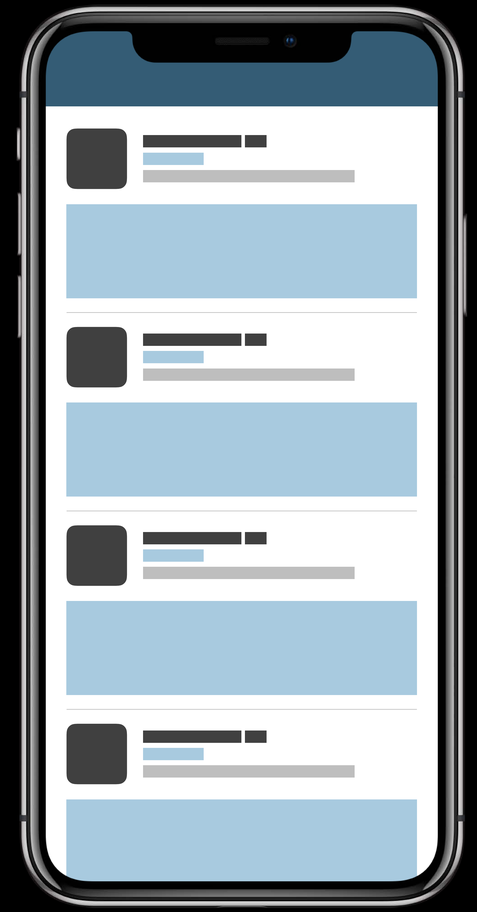
- Do work when requested



Foreground

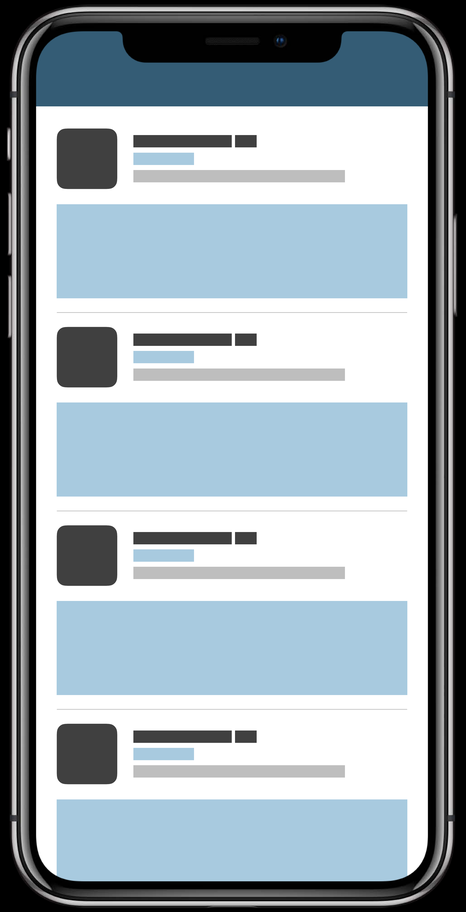
Focus on providing value to the user

- Do work when requested
- Minimize complex UI



Example

Video player app



Example

Video player app

Example

Video player app

Persistent UI controls

Example

Video player app

Persistent UI controls

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Video player app

Persistent UI controls

Example

Video player app

Persistent UI controls

Auto dismissed UI controls

- No user interaction
- Timeout based

Example

Video player app

Persistent UI controls

Auto dismissed UI controls

- No user interaction
- Timeout based

Background


9:41
Mail
Monday
4
Calendar
Photos
Camera
Maps
Clock
Weather
News
Home
Notes
Stocks
Reminders
TV
App Store
iTunes Store
iBooks
Health
Wallet
Settings

Background


9:41
Mail
Monday
4
Calendar
Photos
Camera
Maps
Clock
Weather
News
Home
Notes
Stocks
Reminders
TV
App Store
iTunes Store
iBooks
Health
Wallet
Settings

Background

Focus on minimizing workload

Background

Focus on minimizing workload

- Coalesce tasks

Example

App analytics

Example

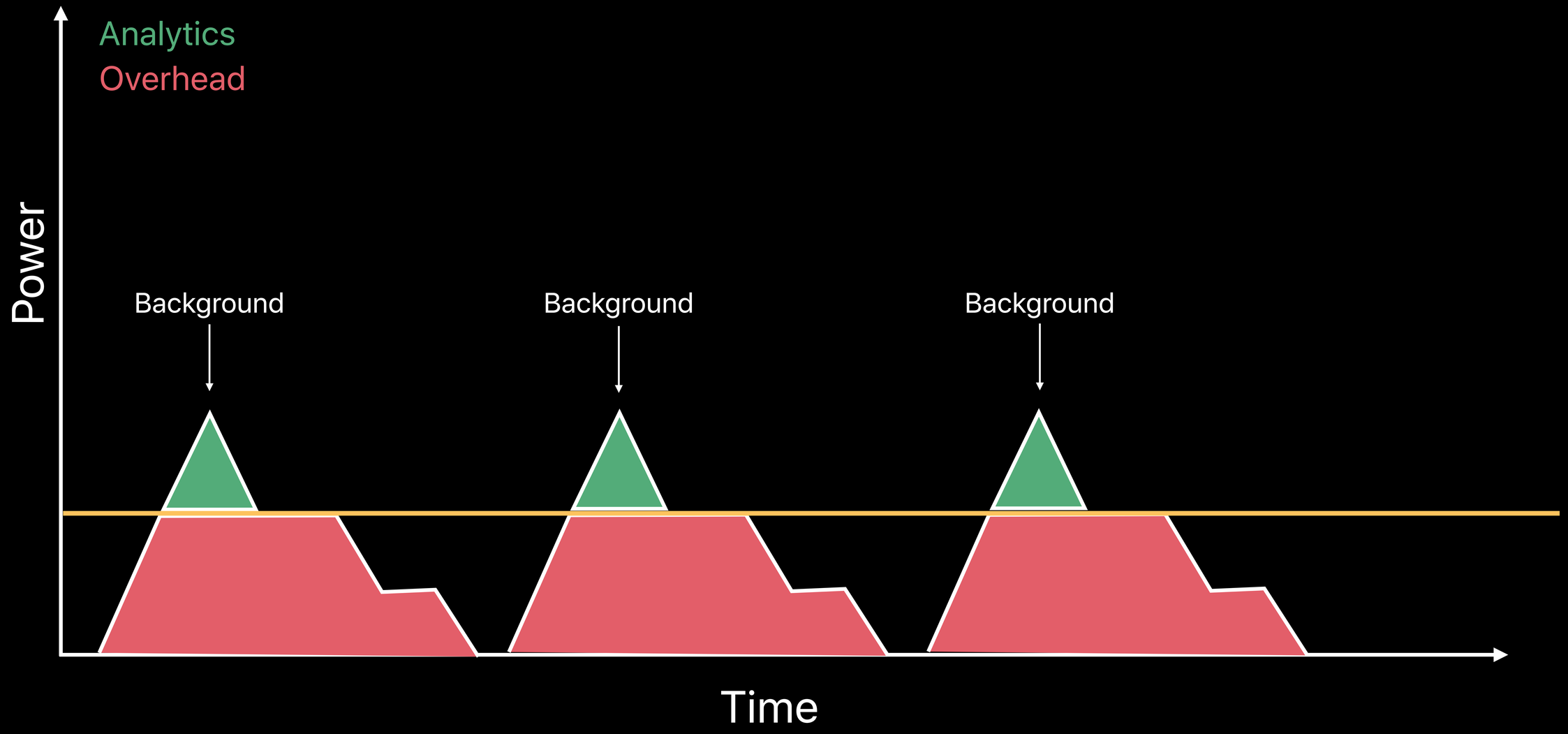
App analytics

Sending immediately

Example

App analytics

Sending immediately


Analytics
Overhead
Power
Background
Background
Background
Time

Example

App analytics

Sending immediately

Example

App analytics

Sending immediately

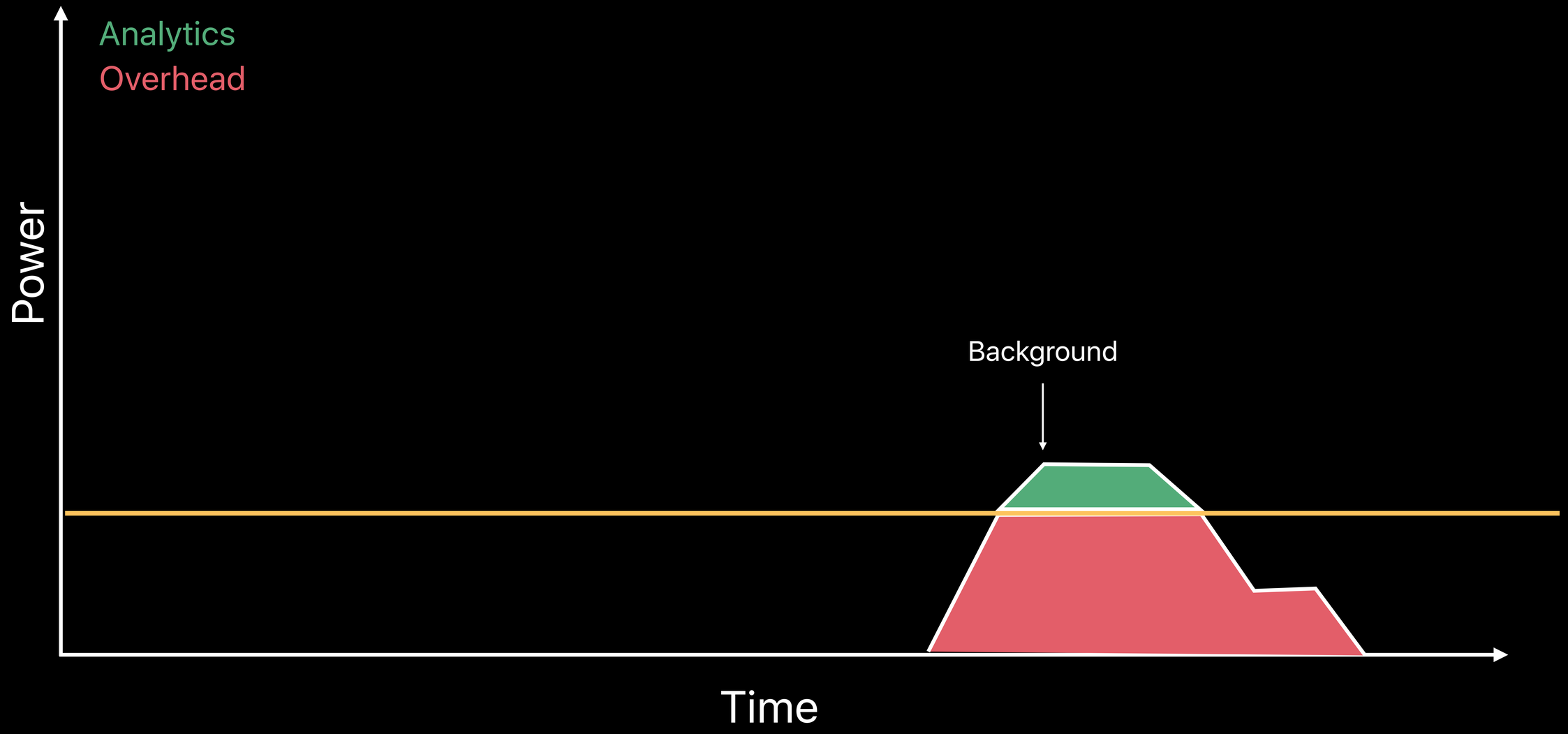
Sending deferred batches

Example

App analytics

Sending immediately

Sending deferred batches


Analytics
Overhead
Power
Background
Time

Background

Focus on minimizing workload

- Coalesce tasks

Background

Focus on minimizing workload

- Coalesce tasks
- End tasks quickly

Example

Background modes

Example

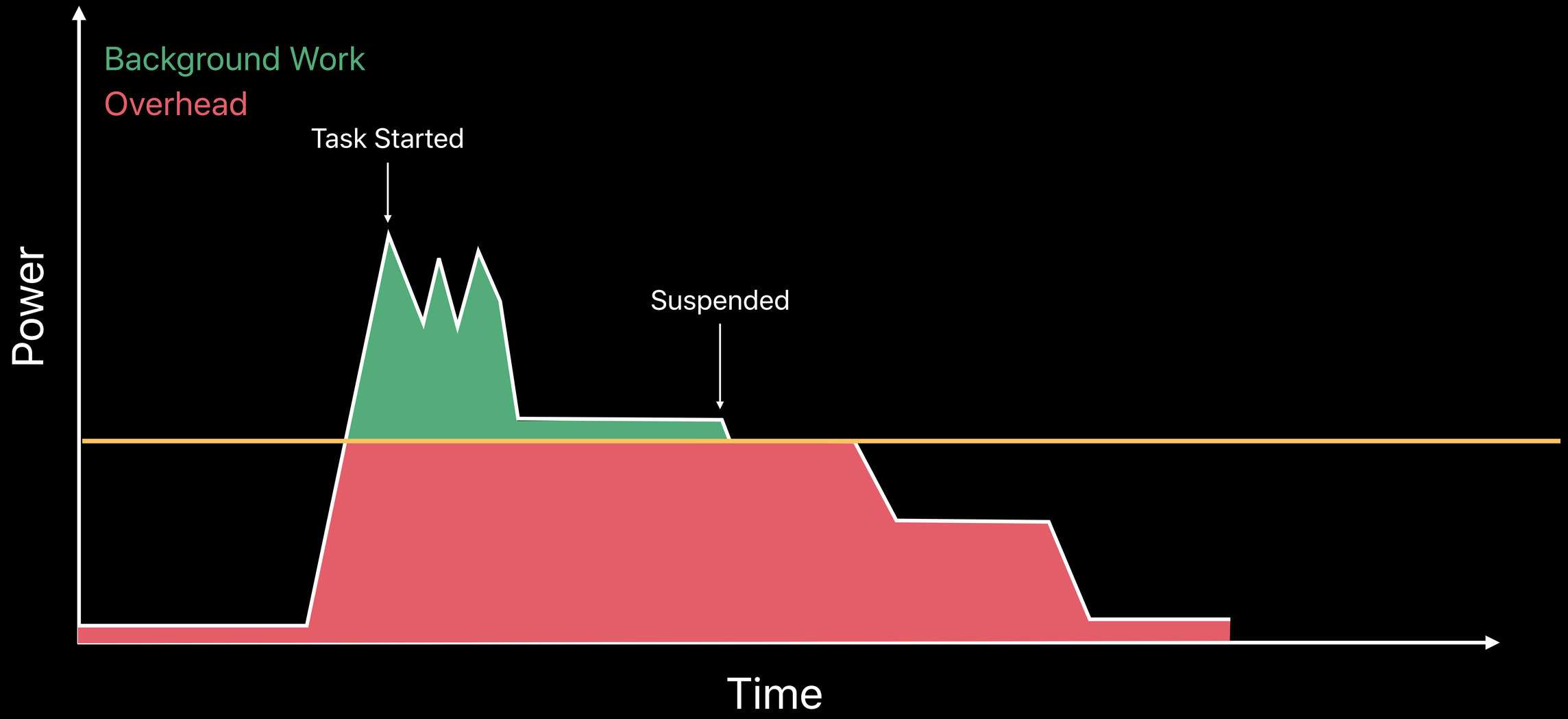
Background modes

Lettings tasks expire

Example

Background modes

Lettings tasks expire


Background Work
Overhead
Task Started
Suspended
Power
Time

Example

Background modes

Lettings tasks expire

Example

Background modes

Lettings tasks expire

Calling completion handlers

- UIBackgroundTask
- VoIP
- Etc

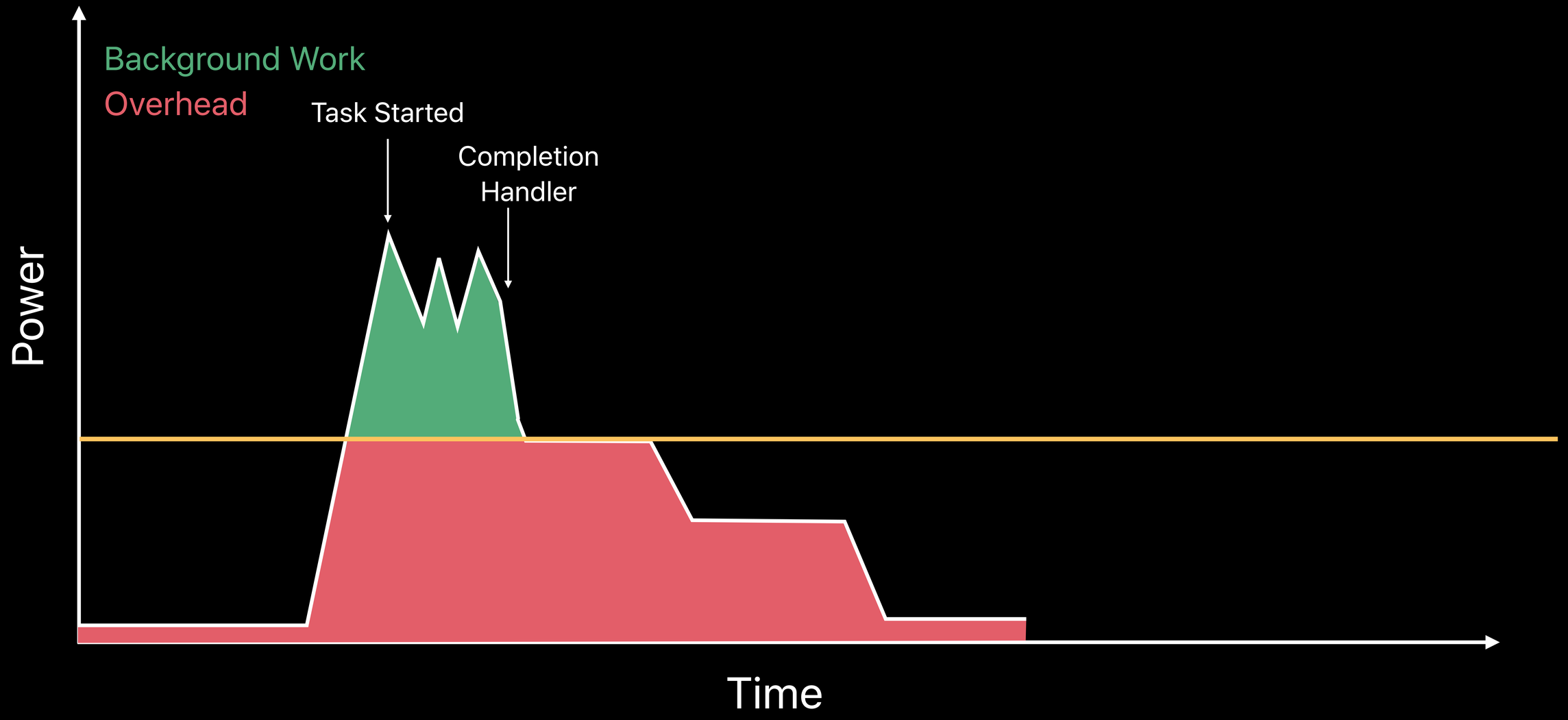
Example

Background modes

Lettings tasks expire

Calling completion handlers

- UIBackgroundTask
- VoIP
- Etc


Background Work
Overhead
Task Started
Completion Handler
Power
Time

Processing

Networking

Location

Graphics

Processing

Networking

Location

Graphics

https://developer.apple.com/videos/play/wwdc2017/238/

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Review tools for energy debugging

New features for energy debugging

Tools for Energy Debugging

Tools for Energy Debugging

Energy Gauges

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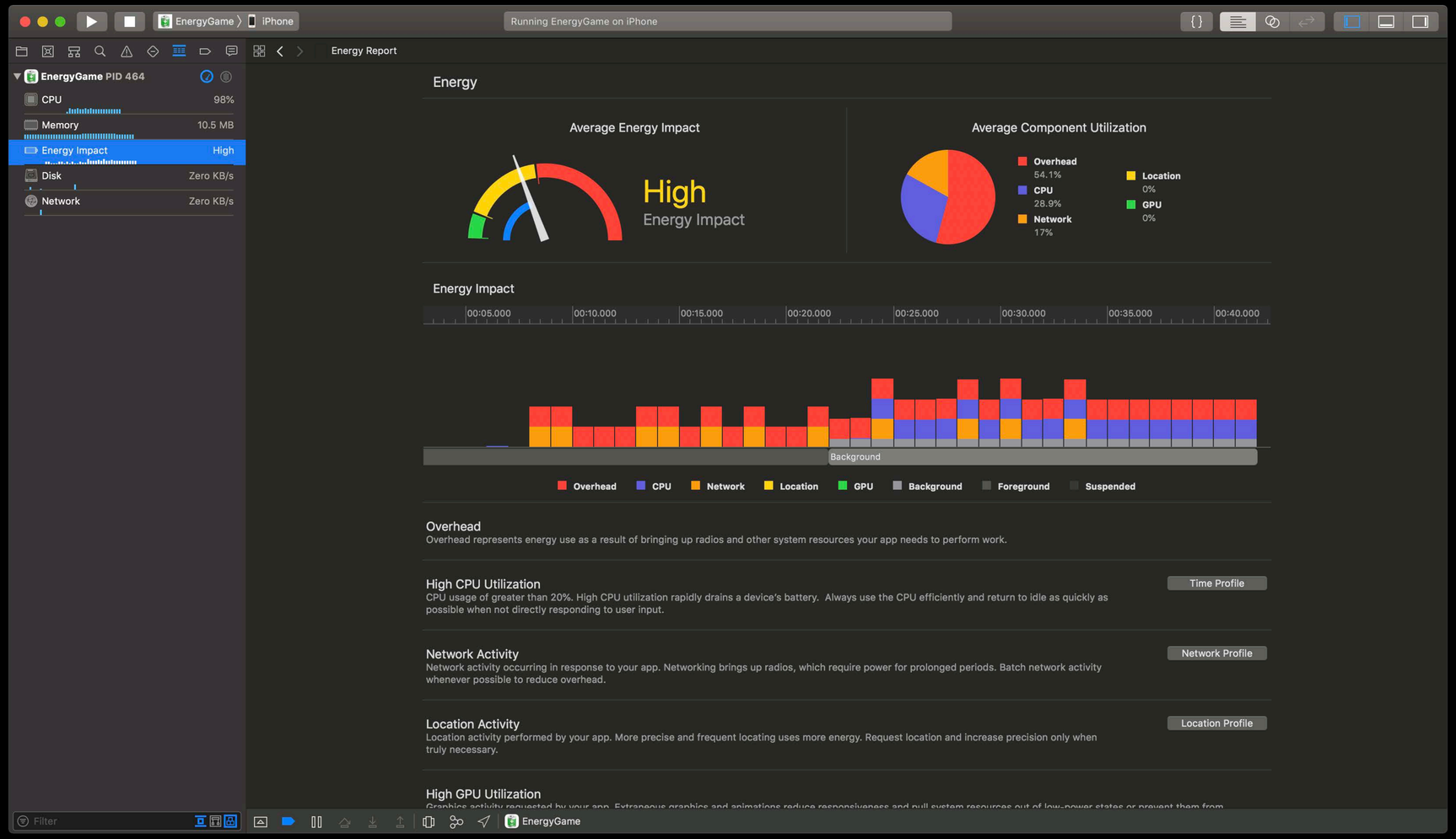
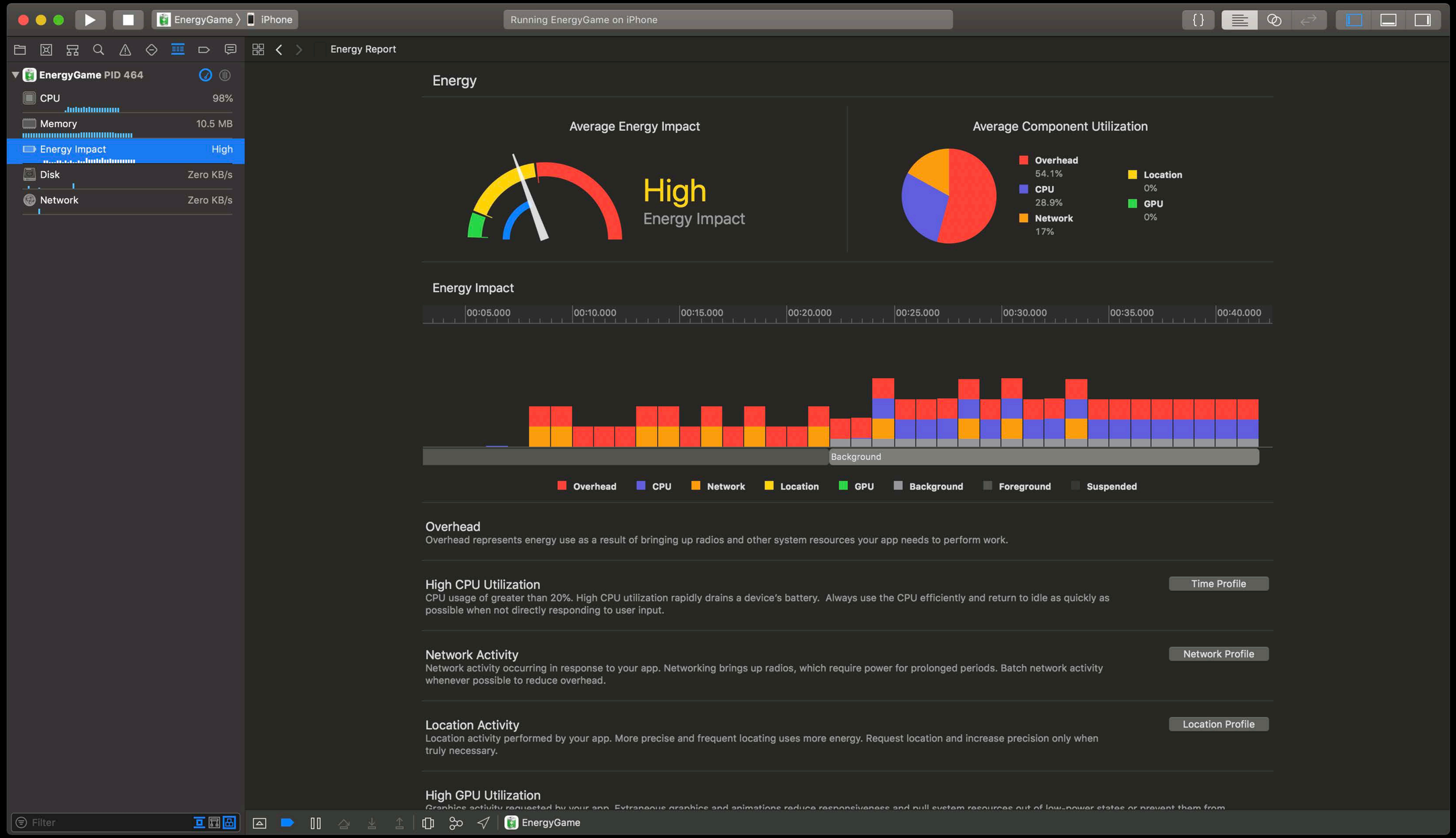
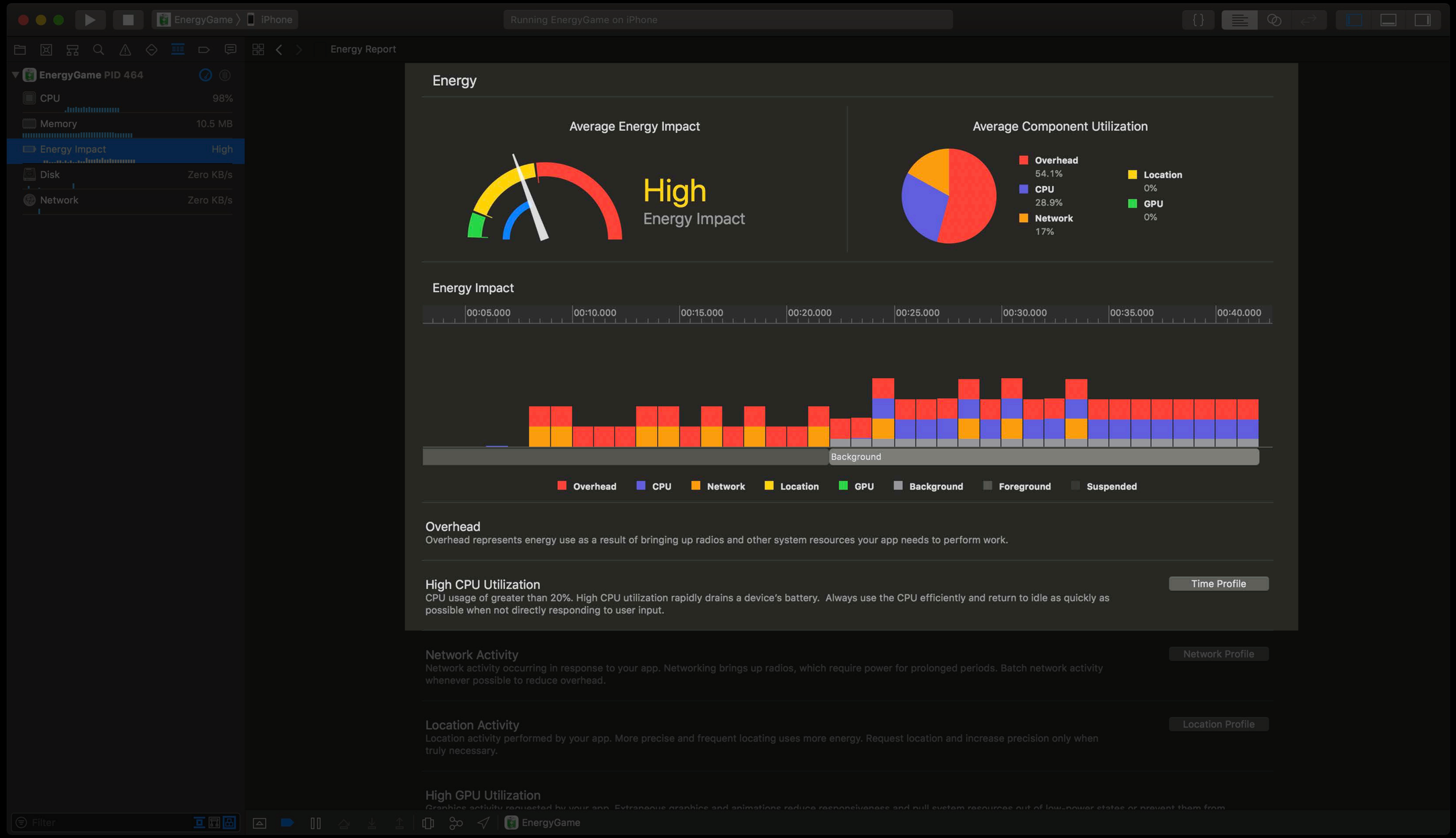



EnergyGame 〉 iPhone
Running EnergyGame on iPhone
Energy Report
EnergyGame PID 464
CPU 98%
Memory 10.5 MB
Energy Impact High
Disk Zero KB/s
Network Zero KB/s
Energy
Average Energy Impact
High
Energy Impact
Average Component Utilization
Overhead 54.1%
CPU 28.9%
Network 17%
Location 0%
GPU 0%
Energy Impact
00:05.000
00:10.000
00:15.000
00:20.000
00:25.000
00:30.000
00:35.000
00:40.000
Background
Overhead
CPU
Network
Location
GPU
Background
Foreground
Suspended
Overhead
Overhead represents energy use as a result of bringing up radios and other system resources your app needs to perform work.
High CPU Utilization
CPU usage of greater than 20%. High CPU utilization rapidly drains a device's battery. Always use the CPU efficiently and return to idle as quickly as possible when not directly responding to user input.
Time Profile
Network Activity
Network activity occurring in response to your app. Networking brings up radios, which require power for prolonged periods. Batch network activity whenever possible to reduce overhead.
Network Profile
Location Activity
Location activity performed by your app. More precise and frequent locating uses more energy. Request location and increase precision only when truly necessary.
Location Profile
High GPU Utilization
Filter
EnergyGame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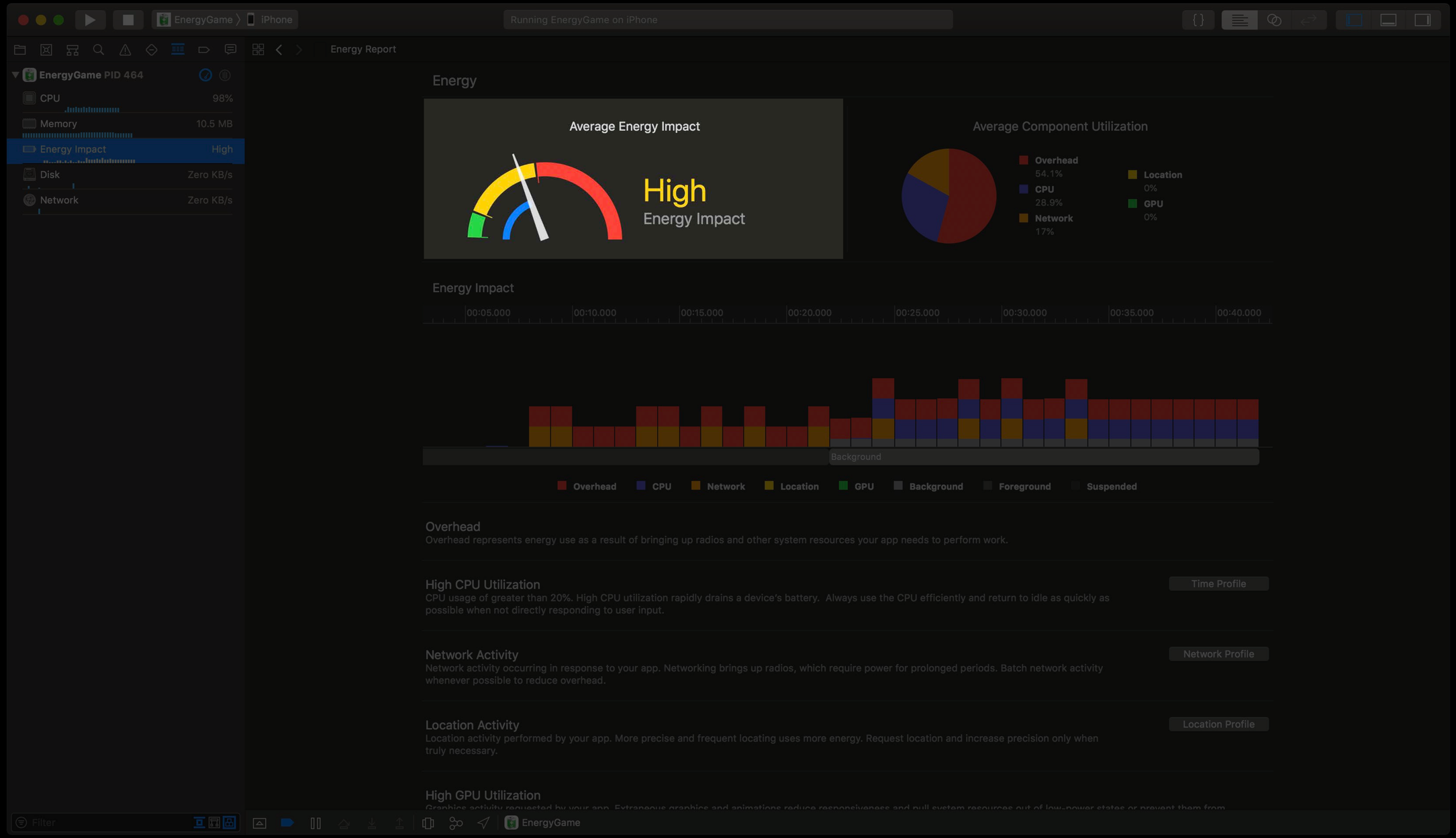
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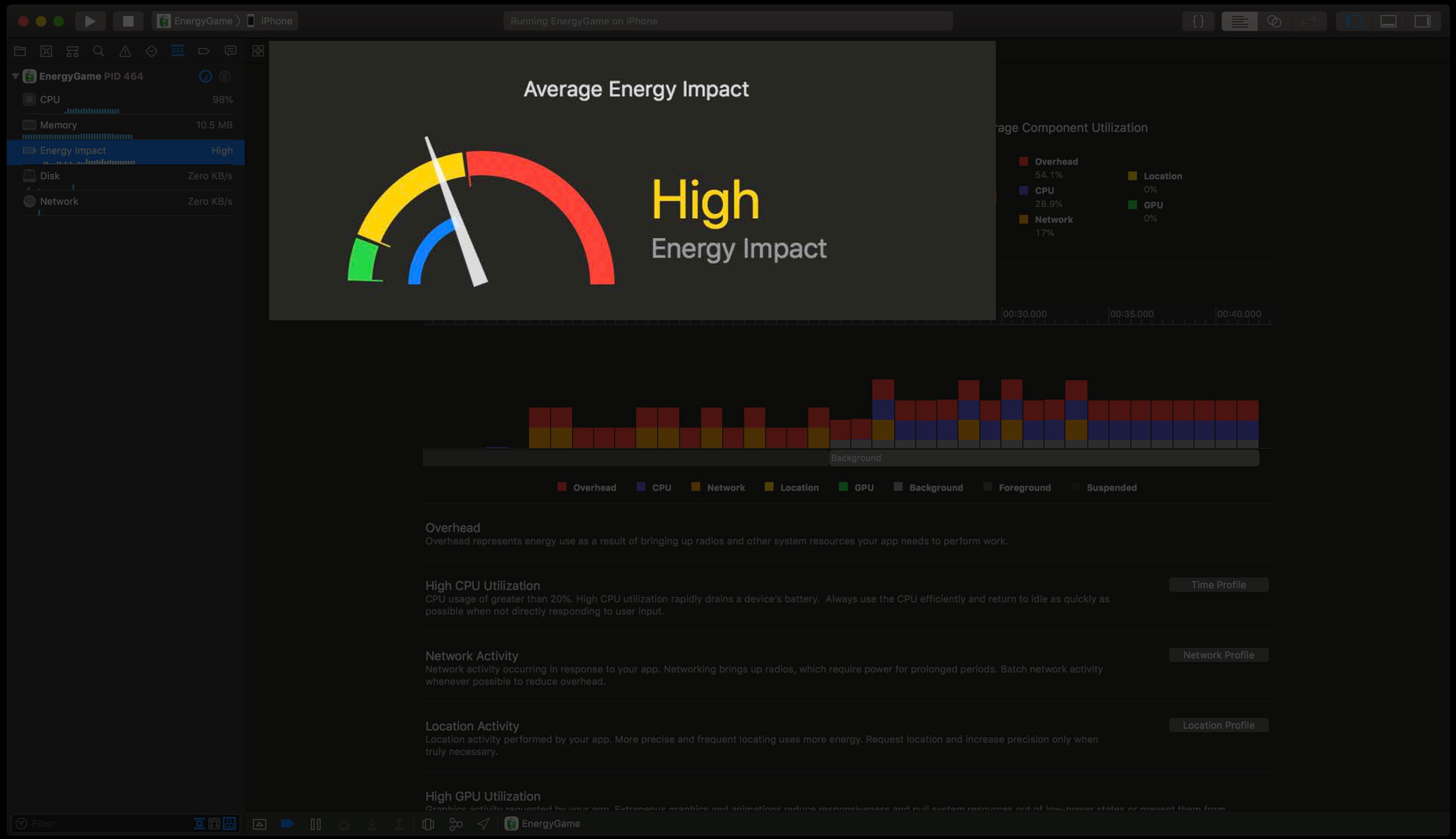
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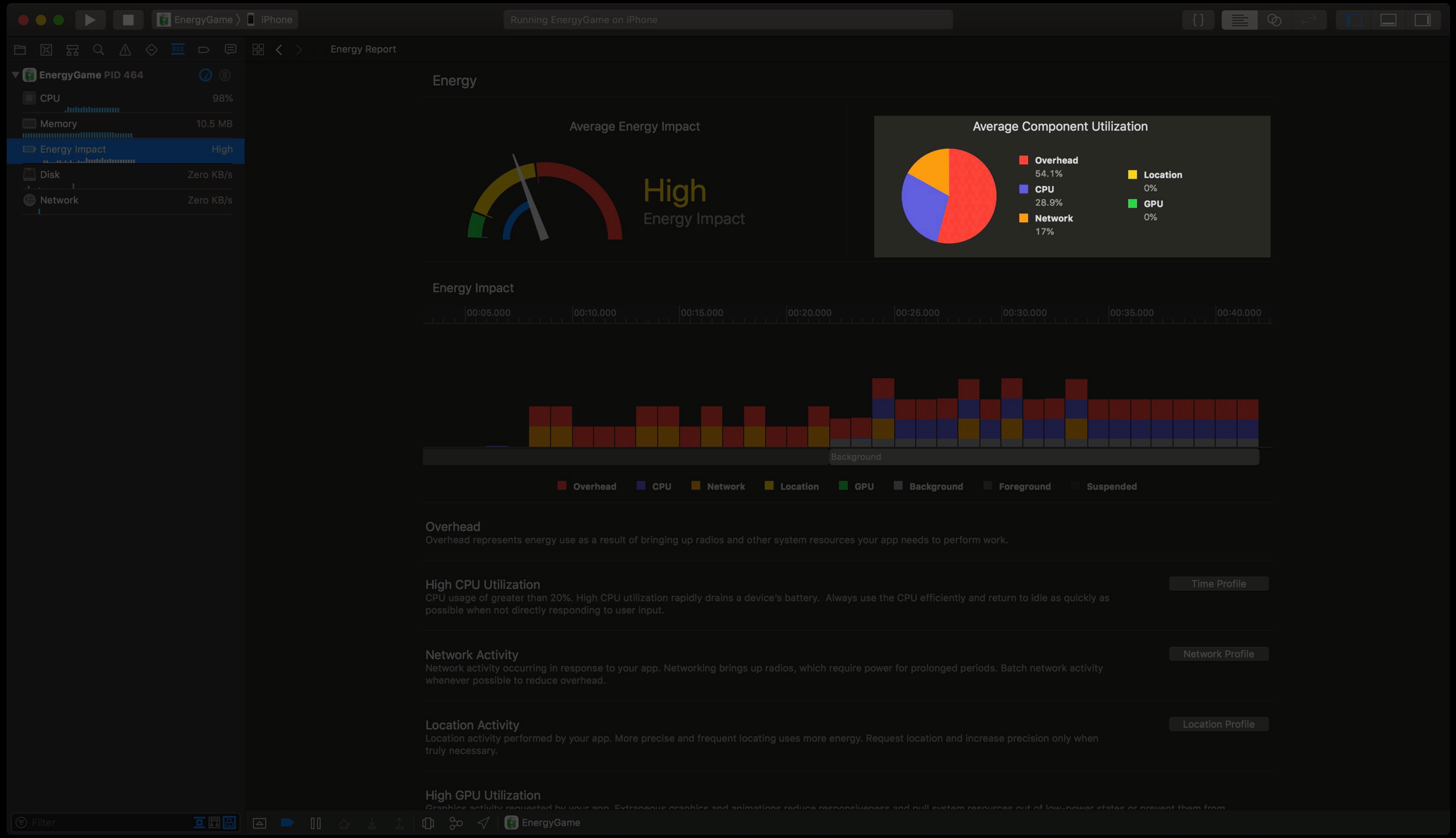
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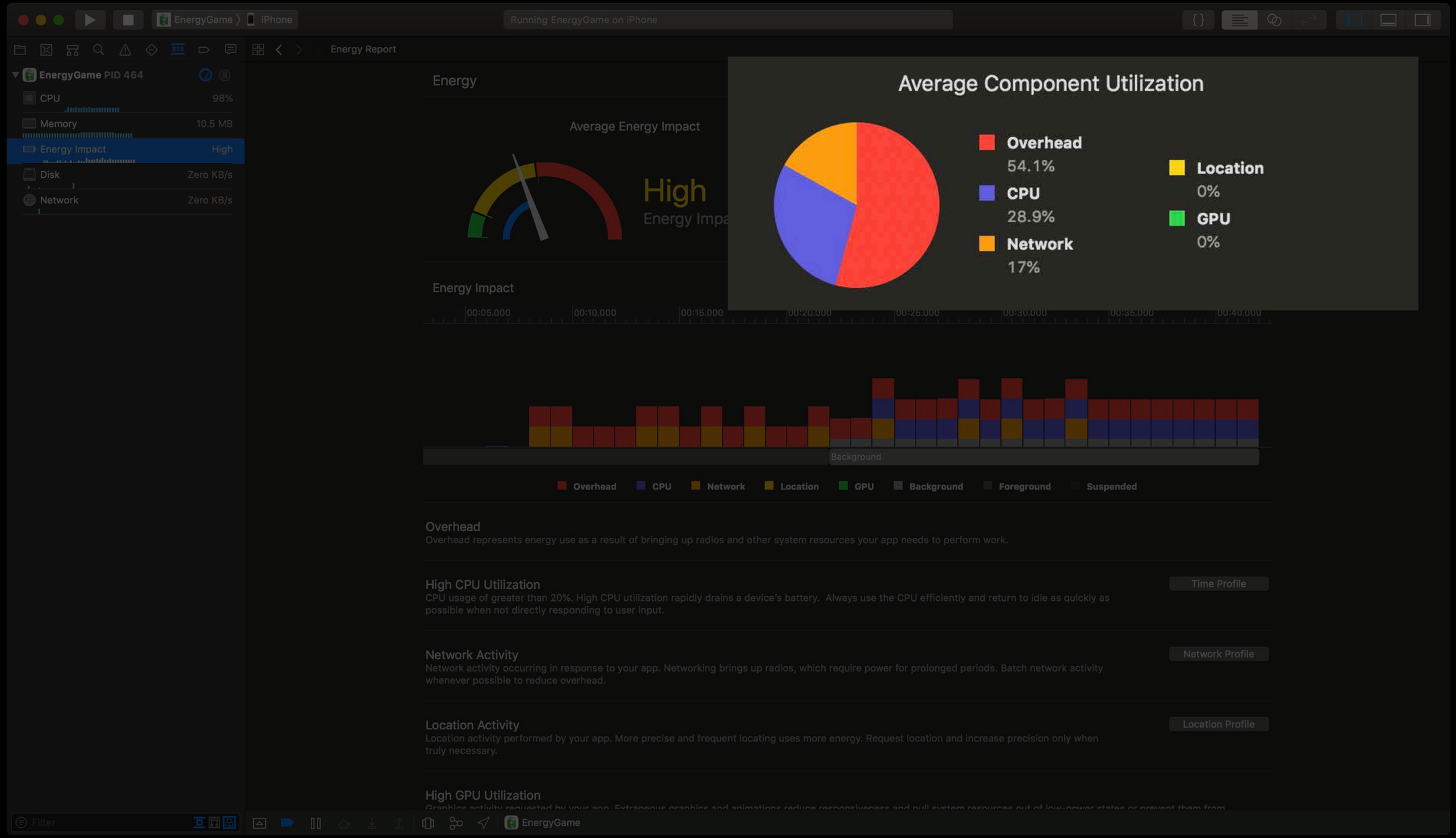
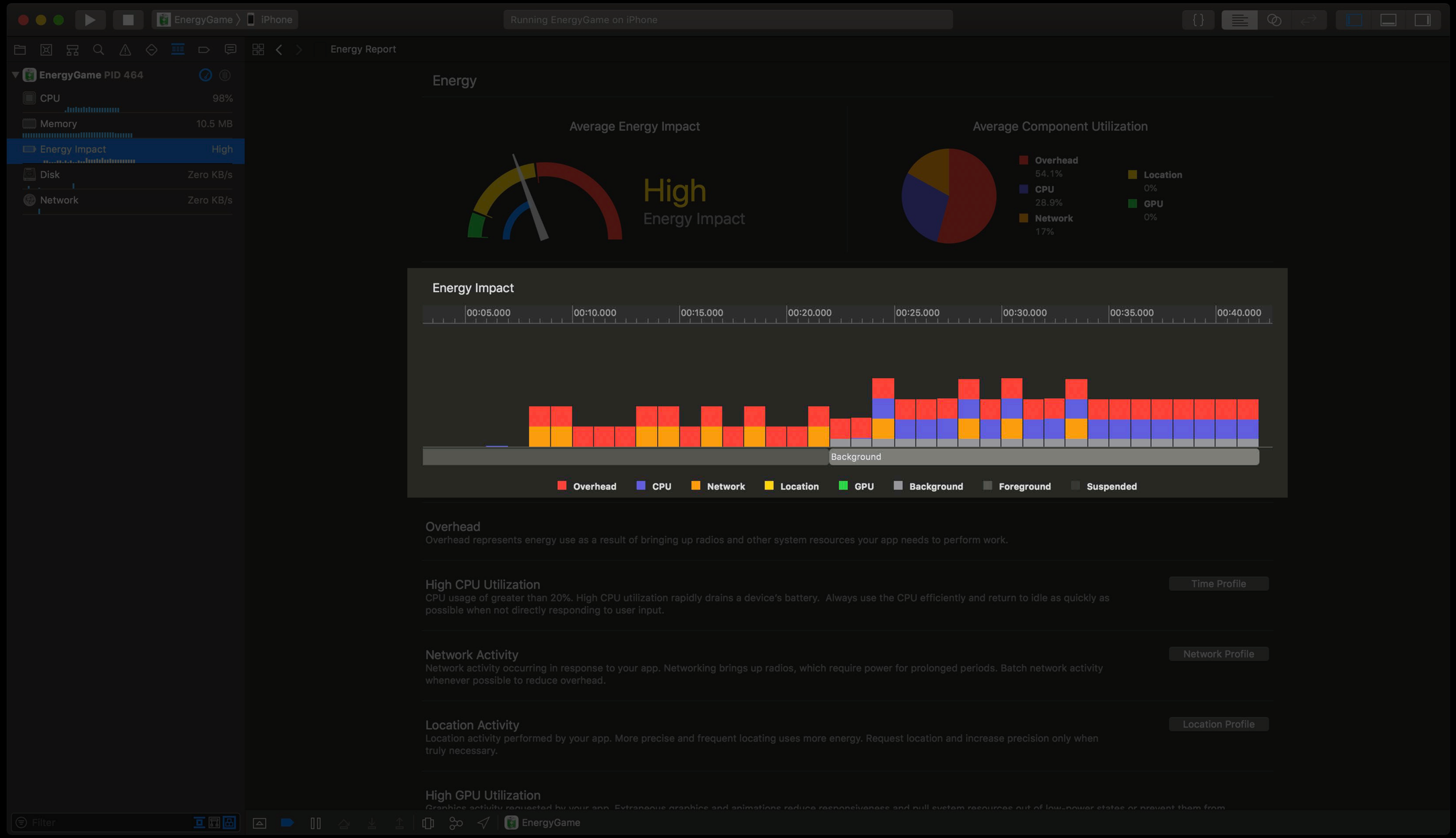
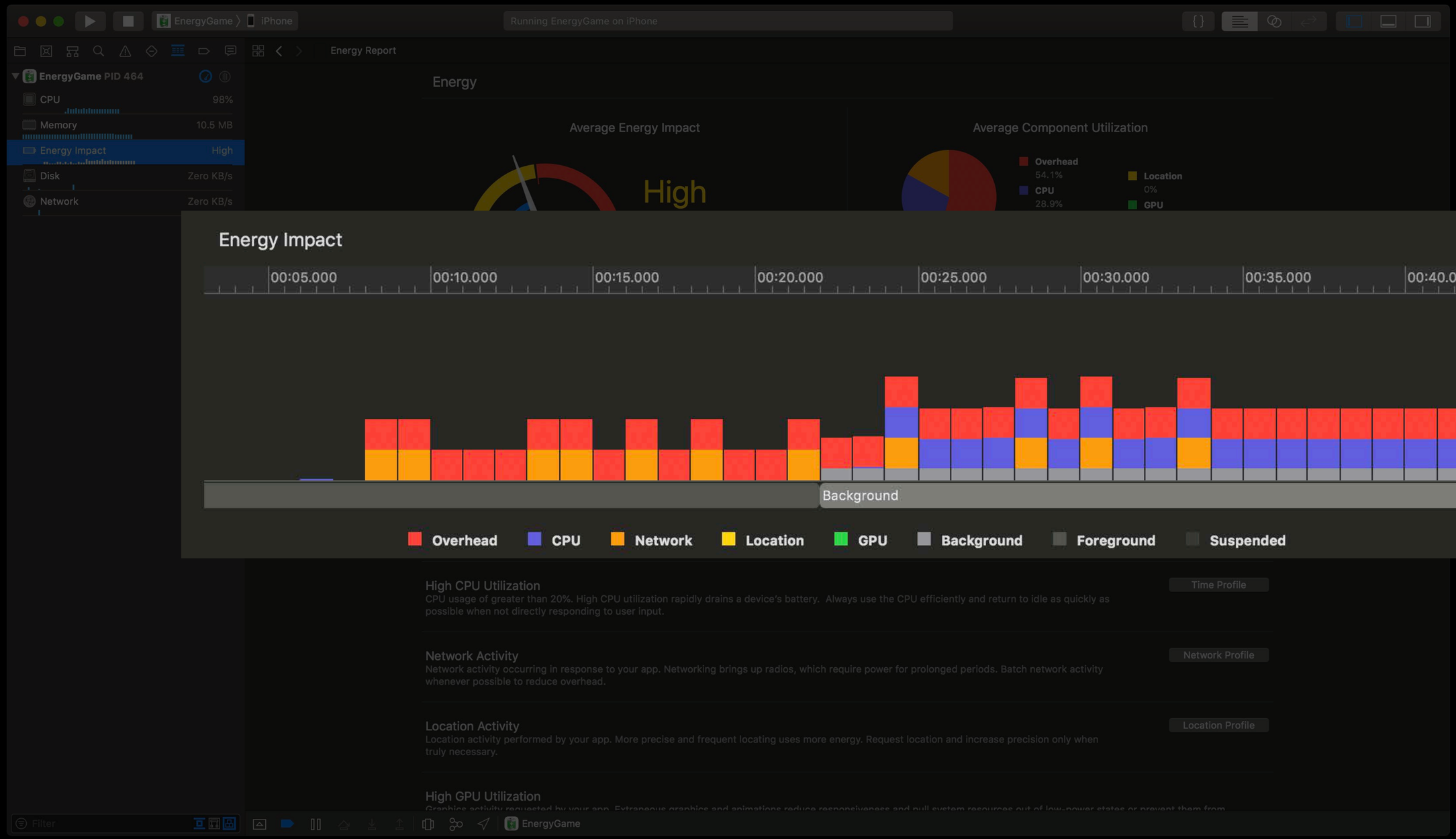


Average Component Utilization

- **Overhead** 54.1%
- **CPU** 28.9%
- **Network** 17%
- **Location** 0%
- **GPU** 0%


EnergyGame 〉 iPhone
Running EnergyGame on iPhone
Energy Report
EnergyGame PID 464
CPU 98%
Memory 10.5 MB
Energy Impact High
Disk Zero KB/s
Network Zero KB/s
Energy
Average Energy Impact
High
Energy Impact
Average Component Utilization
Overhead 54.1%
CPU 28.9%
Network 17%
Location 0%
GPU 0%
Energy Impact
00:05.000
00:10.000
00:15.000
00:20.000
00:25.000
00:30.000
00:35.000
00:40.000
Background
Overhead
CPU
Network
Location
GPU
Background
Foreground
Suspended
Overhead
Overhead represents energy use as a result of bringing up radios and other system resources your app needs to perform work.
High CPU Utilization
CPU usage of greater than 20%. High CPU utilization rapidly drains a device's battery. Always use the CPU efficiently and return to idle as quickly as possible when not directly responding to user input.
Time Profile
Network Activity
Network activity occurring in response to your app. Networking brings up radios, which require power for prolonged periods. Batch network activity whenever possible to reduce overhead.
Network Profile
Location Activity
Location activity performed by your app. More precise and frequent locating uses more energy. Request location and increase precision only when truly necessary.
Location Profile
High GPU Utilization
Filter
EnergyGame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High GPU Utilization
Filter
EnergyGame

Energy Gauges Are Great for...

Energy Gauges Are Great for...

High level energy characterization

Rapid profiling

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High CPU Utilization
Time Profile

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Location Activity
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High GPU Utilization
Graphics activity requested by your app. Extraneous graphics and animations reduce responsiveness and pull system resources out of low-power states or prevent them from powering down all together, resulting in significant energy use. Make updates to visible content only, reduce the use of opacity, and prefer lower, consistent frame rates when performing animations.

Background State
Your app is in a background state, keeping the system awake. Even an idle background app uses energy. If your app requires background operations, use deferral APIs that let the system schedule the work efficiently and wake to run your app only when necessary. Otherwise, reduce activity immediately when placed in the background and notify the system once the activity is complete.

Foreground State
Your app is in the foreground. Use recommended APIs, batch and reduce network operations, and avoid unnecessary updates to the user interface. Strive to make your app absolutely idle when it's not responding to user input.

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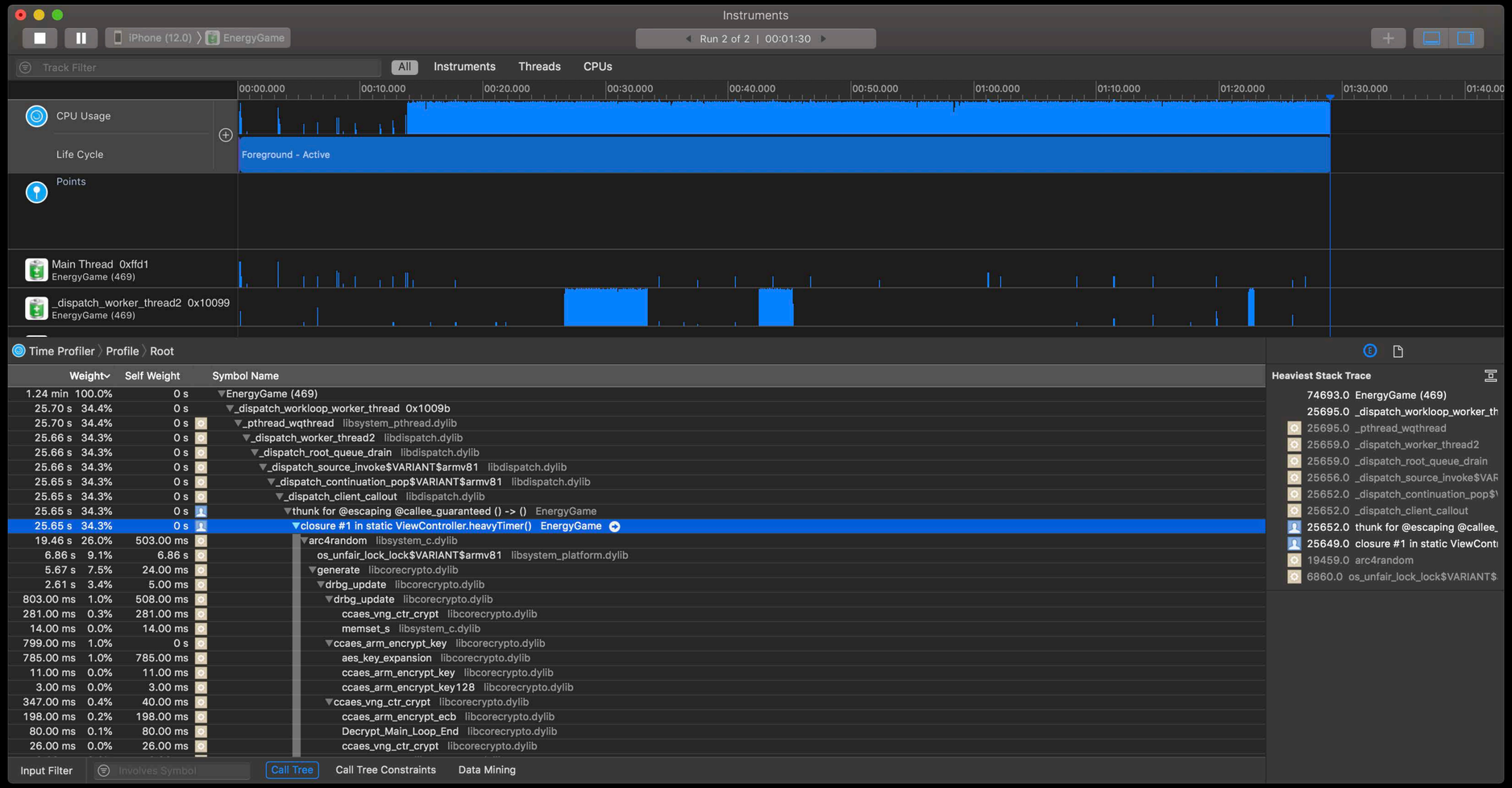
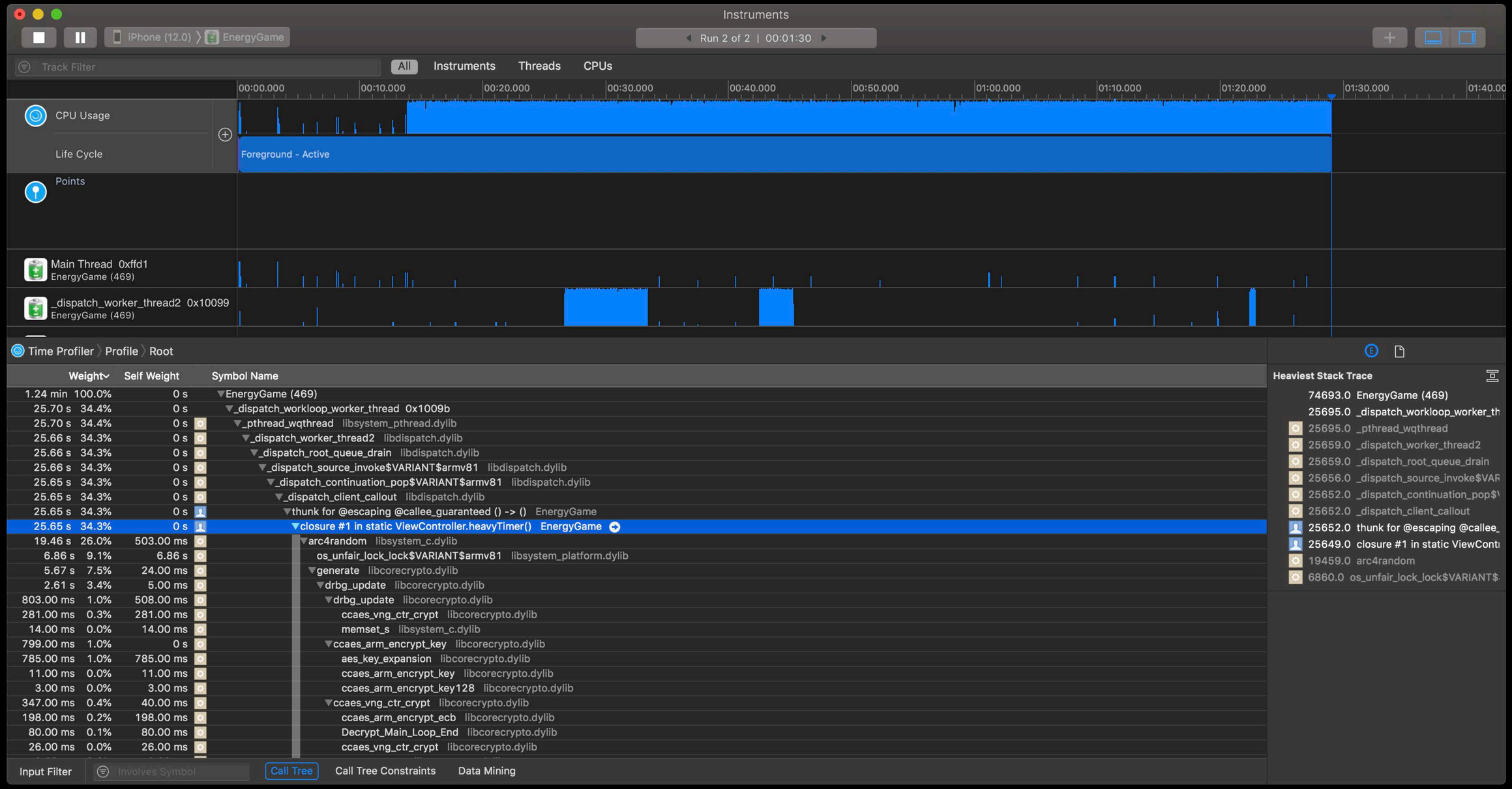
Time Profiler




Instruments
iPhone (12.0) 〉 EnergyGame
Run 2 of 2 | 00:01:30
Track Filter
All
Instruments
Threads
CPUs
00:00.000
00:10.000
00:20.000
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CPU Usage
Life Cycle
Foreground - Active
Points
Main Thread 0xffd1
EnergyGame (469)
_dispatch_worker_thread2 0x10099
EnergyGame (469)
Time Profiler 〉 Profile 〉 Root
Weight
Self Weight
Symbol Name
1.24 min 100.0% 0 s EnergyGame (469)
25.70 s 34.4% 0 s _dispatch_workloop_worker_thread 0x1009b
25.70 s 34.4% 0 s _pthread_wqthread libsystem_pthread.dylib
25.66 s 34.3% 0 s _dispatch_worker_thread2 libdispatch.dylib
25.66 s 34.3% 0 s _dispatch_root_queue_drain libdispatch.dylib
25.66 s 34.3% 0 s _dispatch_source_invoke$VARIANT$armv81 libdispatch.dylib
25.65 s 34.3% 0 s _dispatch_continuation_pop$VARIANT$armv81 libdispatch.dylib
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25.65 s 34.3% 0 s thunk for @escaping @callee_guaranteed () -> () EnergyGame
25.65 s 34.3% 0 s closure #1 in static ViewController.heavyTimer() EnergyGame
19.46 s 26.0% 503.00 ms arc4random libsystem_c.dylib
6.86 s 9.1% 6.86 s os_unfair_lock_lock$VARIANT$armv81 libsystem_platform.dylib
5.67 s 7.5% 24.00 ms generate libcorecrypto.dylib
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803.00 ms 1.0% 508.00 ms drbg_update libcorecrypto.dylib
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785.00 ms 1.0% 785.00 ms aes_key_expansion libcorecrypto.dylib
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26.00 ms 0.0% 26.00 ms ccaes_vng_ctr_crypt libcorecrypto.dylib
Heaviest Stack Trace
74693.0 EnergyGame (469)
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Input Filter
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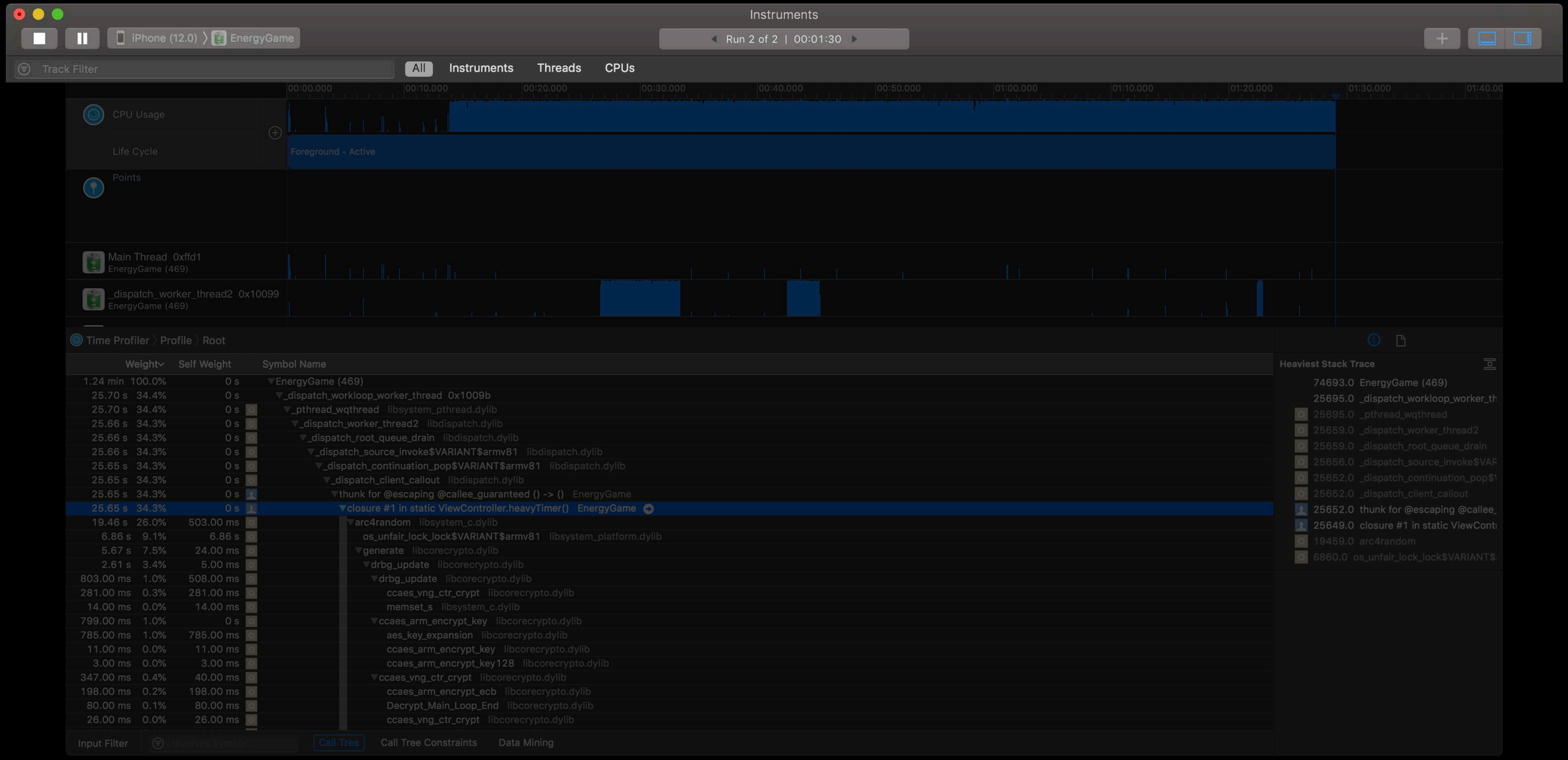
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iPhone (12.0) 〉 EnergyGame
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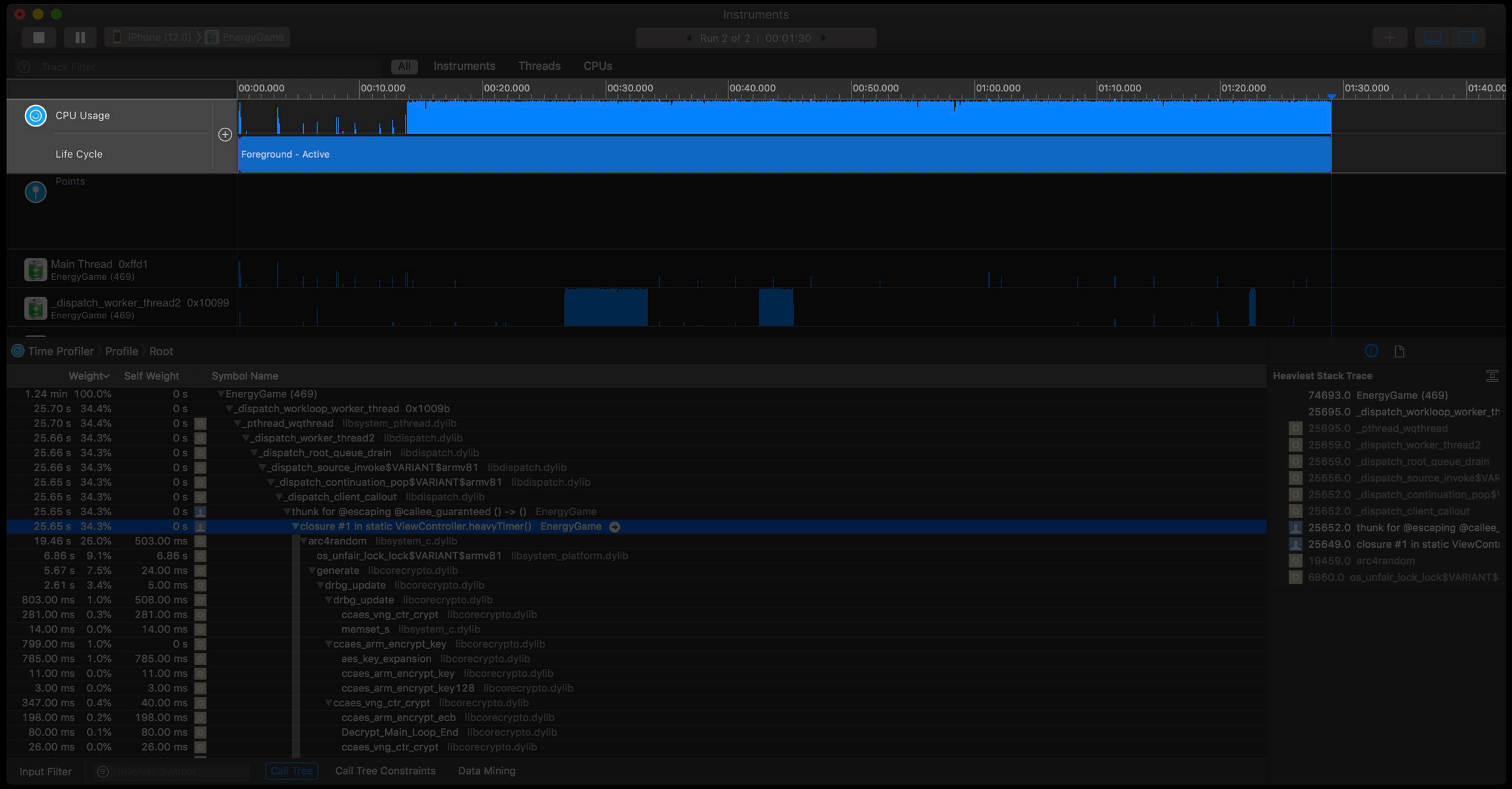
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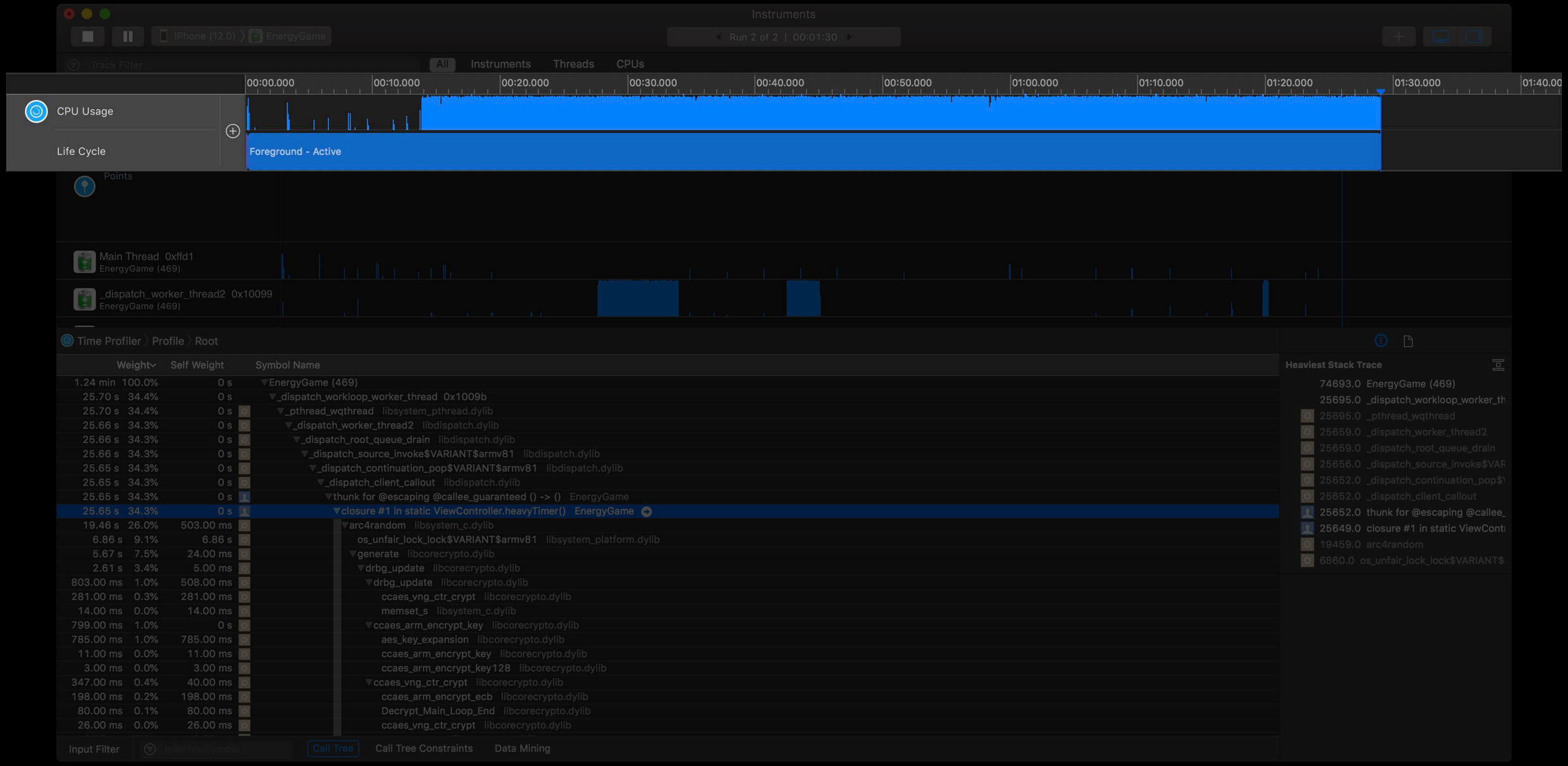
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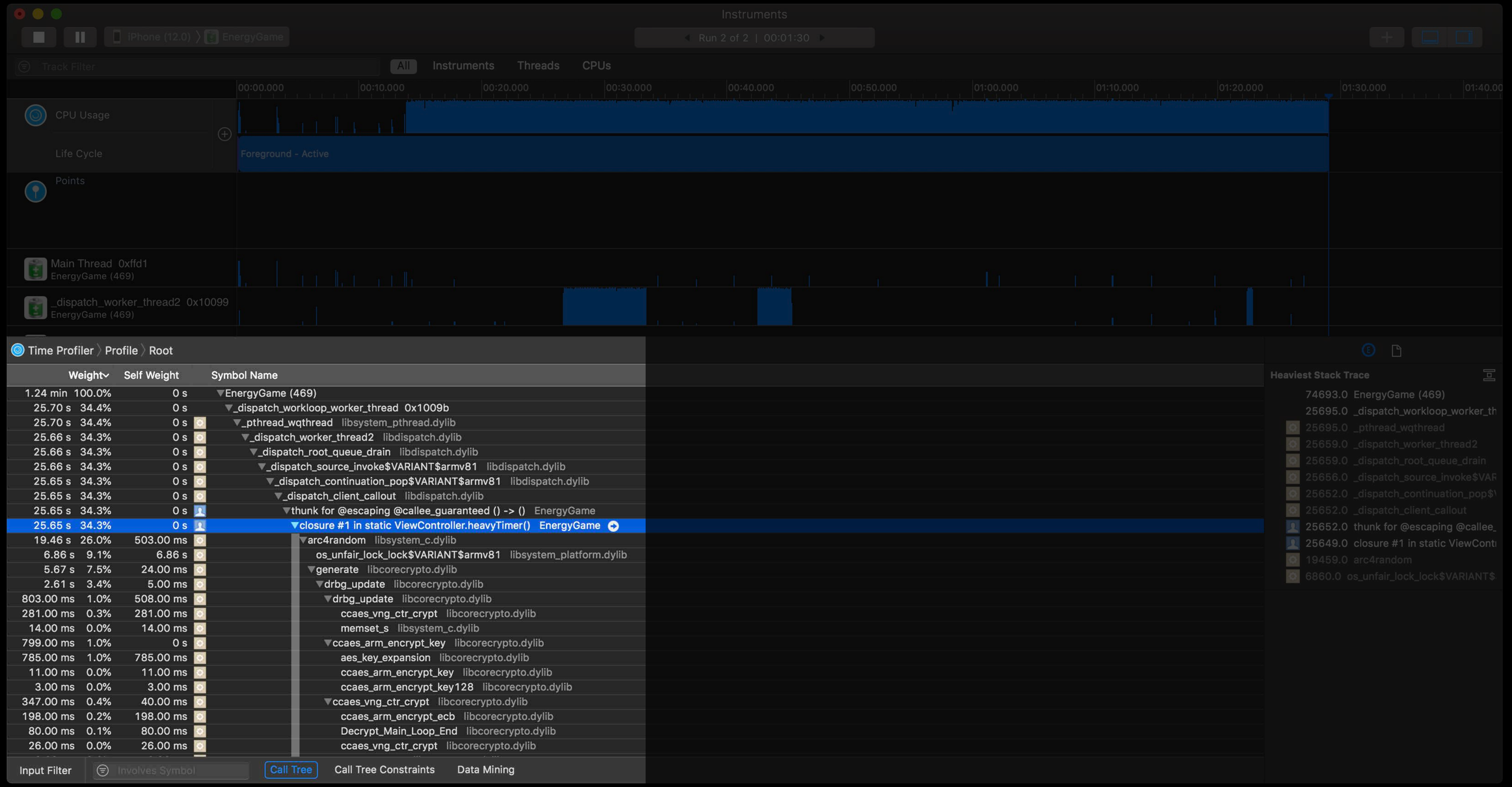
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198.00 ms 0.2% 198.00 ms ccaes_arm_encrypt_ecb libcorecrypto.dylib
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26.00 ms 0.0% 26.00 ms ccaes_vng_ctr_crypt libcorecrypto.dylib
Heaviest Stack Trace
74693.0 EnergyGame (469)
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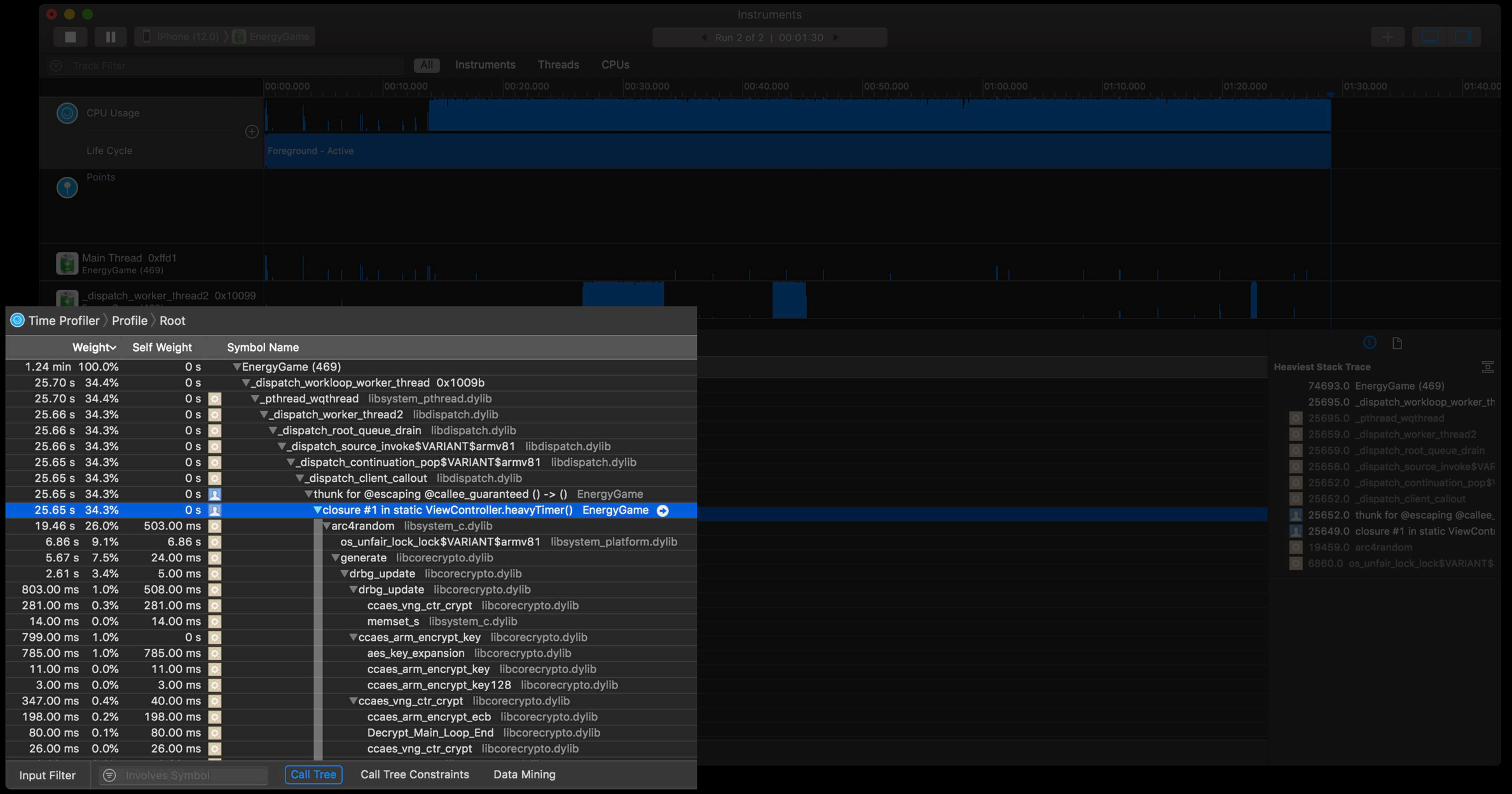
Instruments
iPhone (12.0) EnergyGame
Run 2 of 2 | 00:01:30
Track Filter
All
Instruments
Threads
CPUs
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00:10.000
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01:00.000
01:10.000
01:20.000
01:30.000
01:40.000
CPU Usage
Life Cycle
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Main Thread 0xffd1
EnergyGame (469)
_dispatch_worker_thread2 0x10099
Time Profiler 〉 Profile 〉 Root
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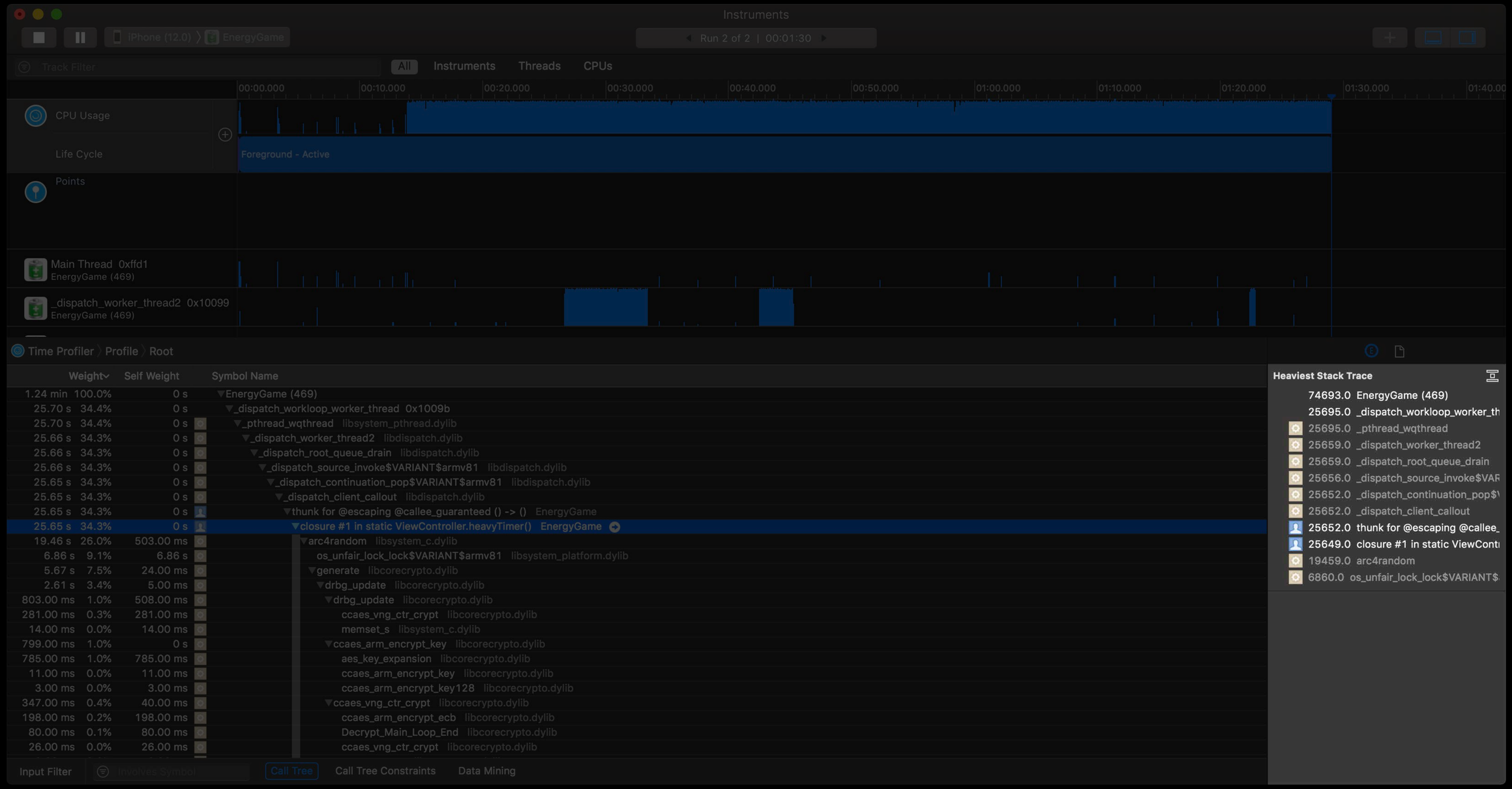
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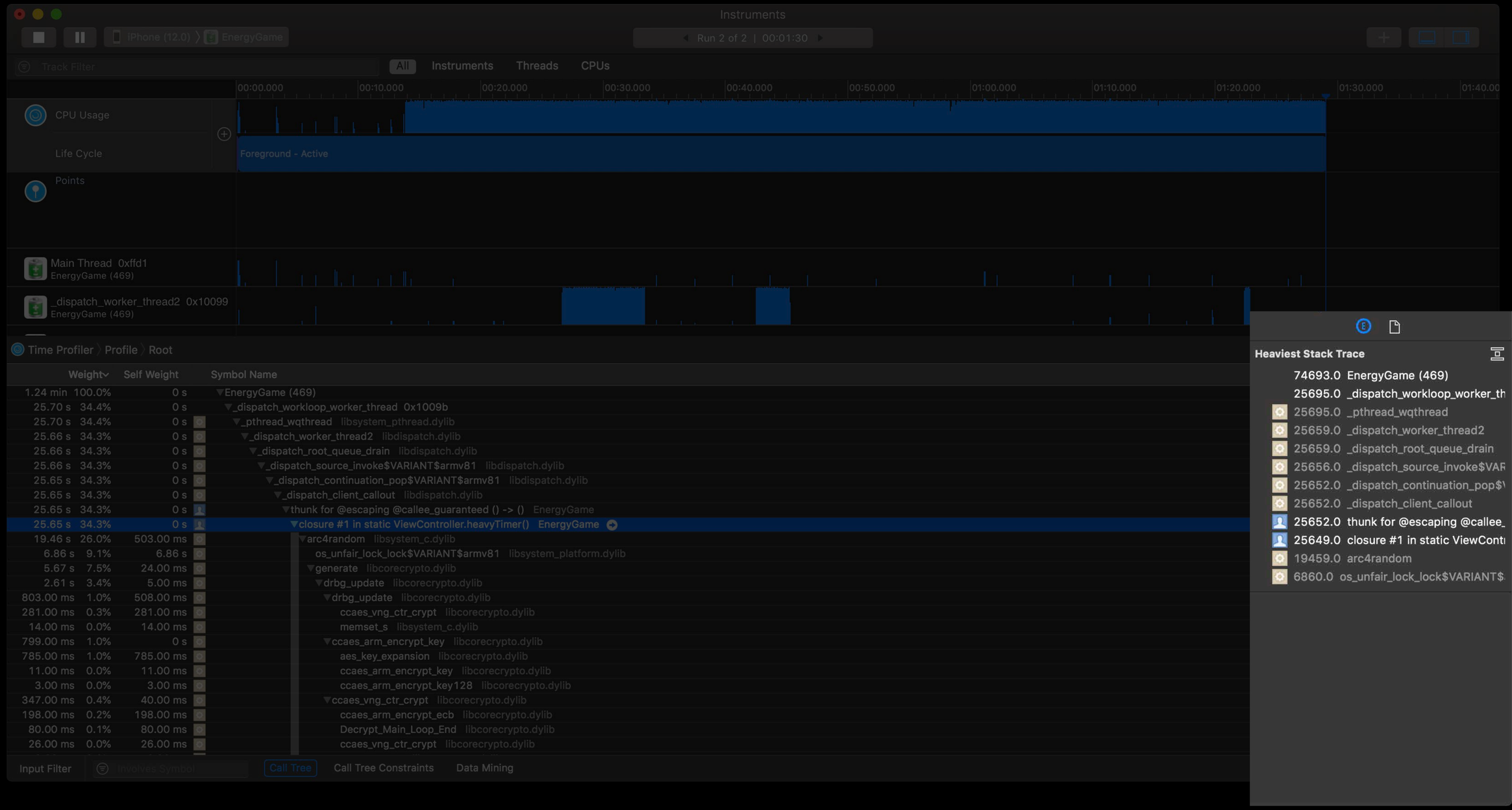
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Other Profiling Templates and Instruments

Other Profiling Templates and Instruments

Energy diagnostics profiling template

Activity monitor profiling template

Core animation profiling template

GPU driver profiling template

Location energy instrument

Network profiling template

Instruments Are Great for...

Instruments Are Great for...

Root cause analysis

In depth profiling

Instruments Are Great for...

Root cause analysis

In depth profiling

Untethered profiling

Working Demo

Energy Debugging

Working Demo

Takeaways

Energy Gauges for rapid iteration

Instruments for root cause analysis

Make energy a top priority

You’ve shipped your app.
Whats next?

NEW

Review general battery life concepts

Review tools for energy debugging

New features for energy debugging

New Features for Energy Debugging

David Choi, Battery Life

Now that You've Shipped Your App...

How do you know if your customers are experiencing energy issues?

How do you debug a customer energy issue?

A New Way of Debugging Energy Issues

NEW

Xcode Energy Logs

Xcode Energy Organizer

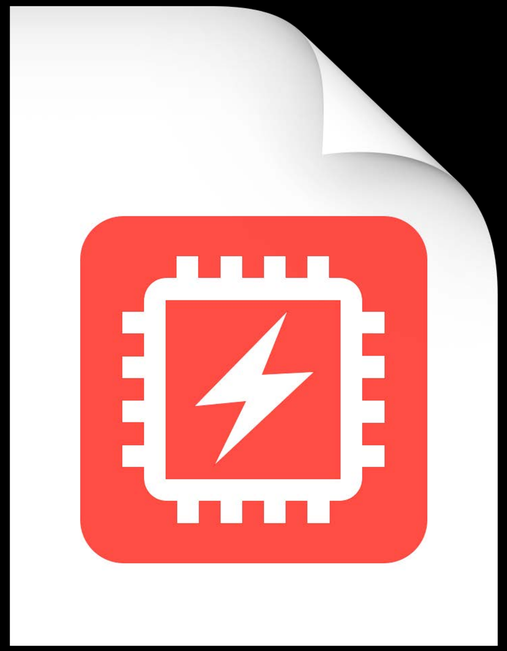
Xcode Energy Logs

NEW

Reports high CPU energy events

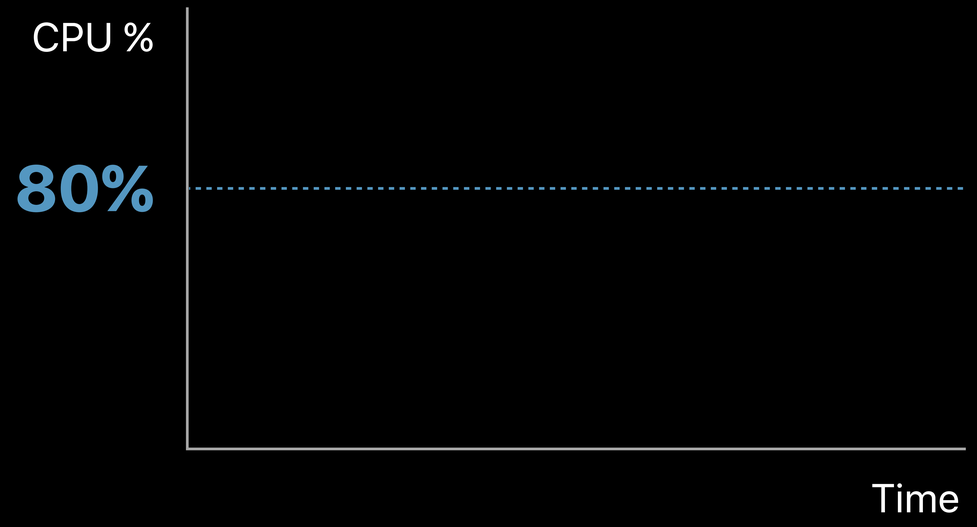
Points out energy hotspots in code

Data from TestFlight and App Store



When Are Xcode Energy Logs Generated?

NEW

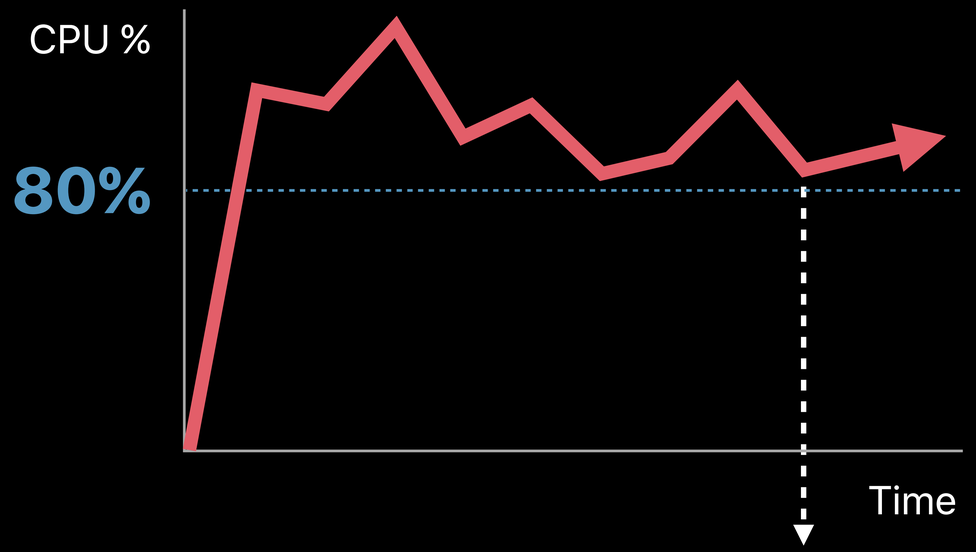


High CPU Energy Events

- 80% CPU spin over 3 minutes in foreground
- 80% CPU spin over 1 minutes in background

When Are Xcode Energy Logs Generated?

NEW



Xcode Energy Log

High CPU Energy Events

- 80% CPU spin over 3 minutes in foreground
- 80% CPU spin over 1 minutes in background

Xcode Energy Logs: Impact on User Battery Life

Up to 1% battery drop

Xcode Energy Logs: Impact on User Battery Life

Up to 1% battery drop

8 minutes
of talk time

6 minutes
of browsing

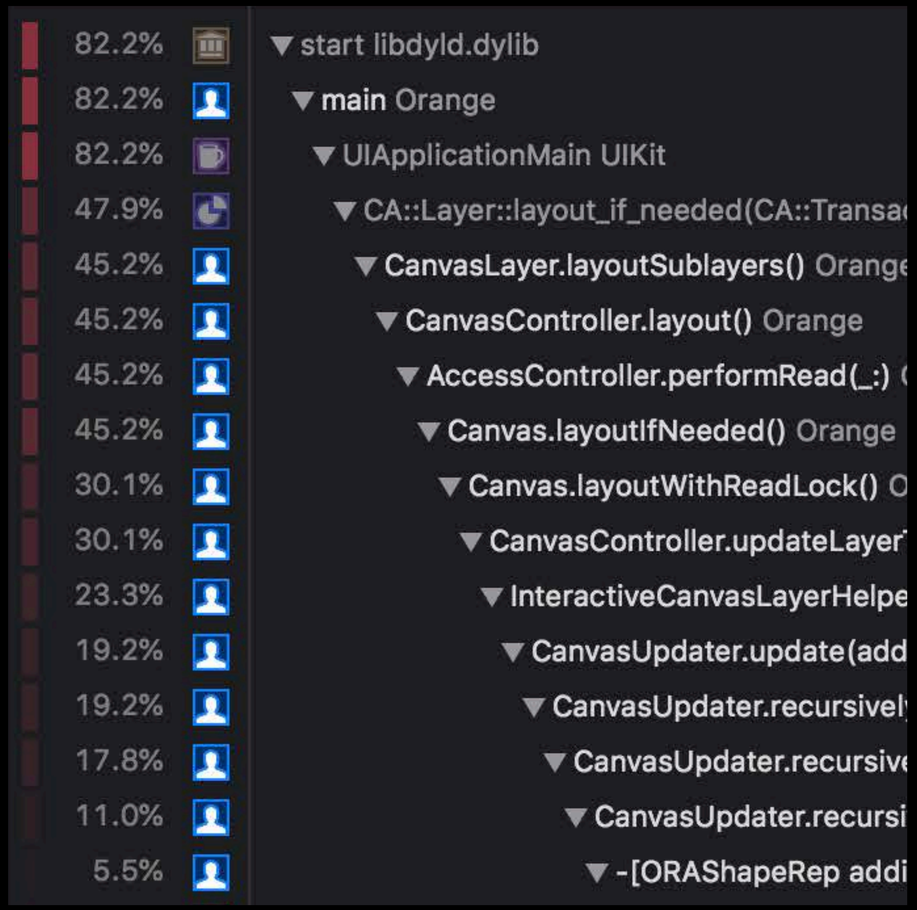
30 minutes
of music

What's in an Energy Log?

Energy condition that triggered the report

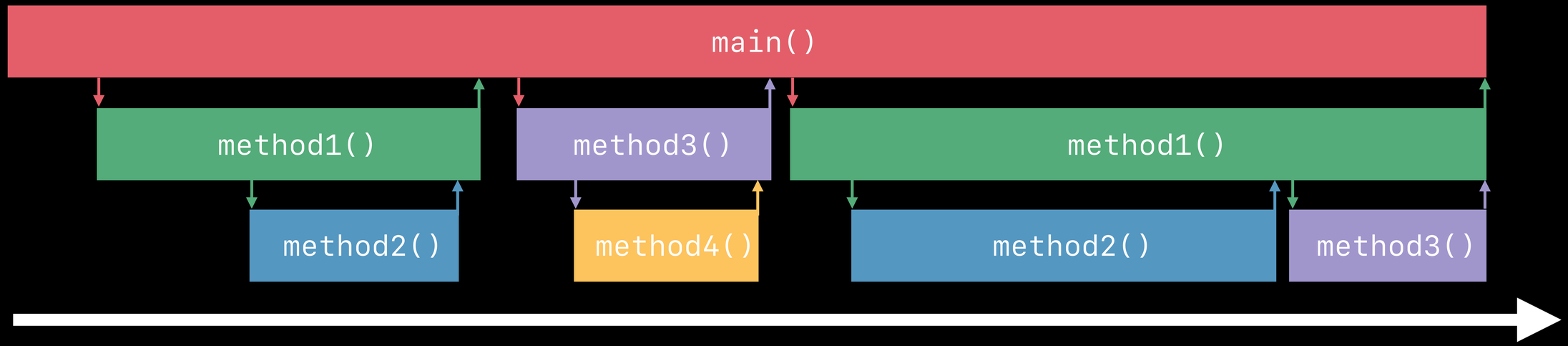
Device type and app build number

Weighted call graph that shows energy hotspots

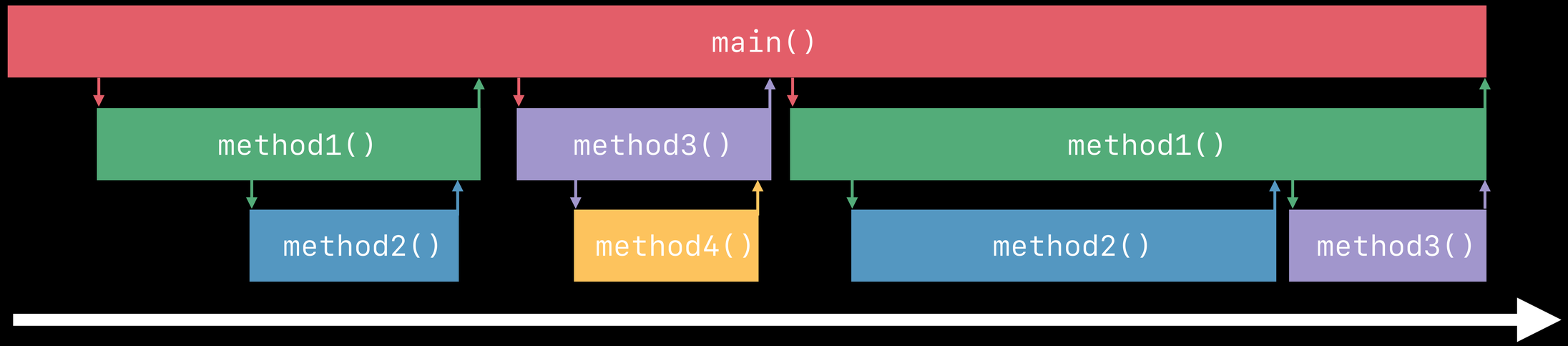


Xcode Energy Log: Weighted Call Graph

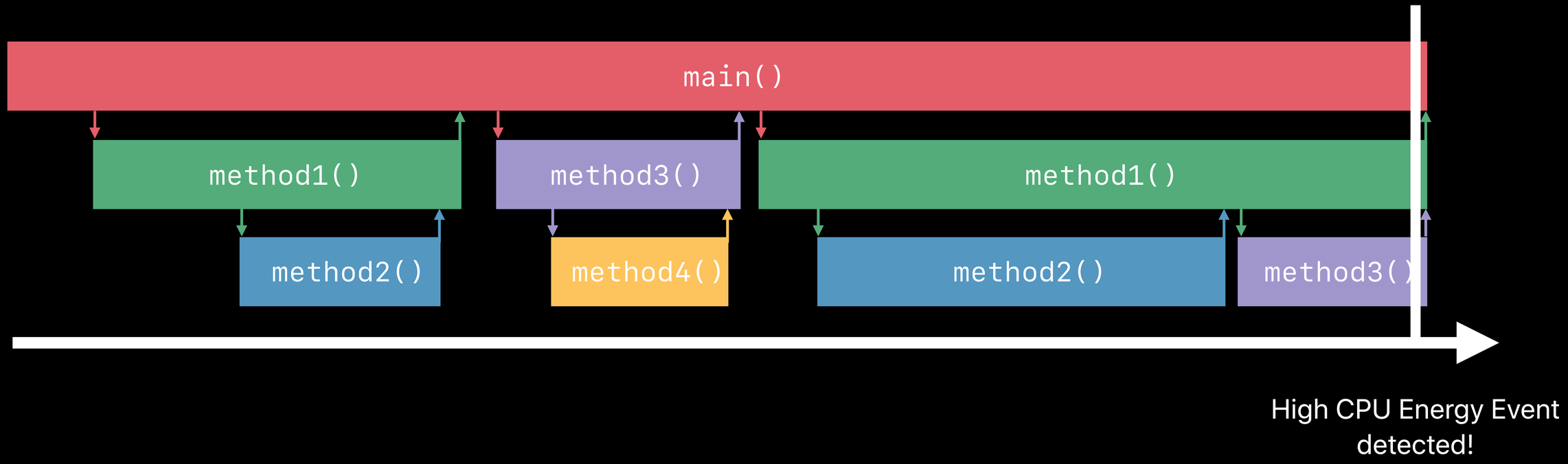
Xcode Energy Log: Weighted Call Graph



Xcode Energy Log: Weighted Call Graph



Xcode Energy Log: Weighted Call Graph



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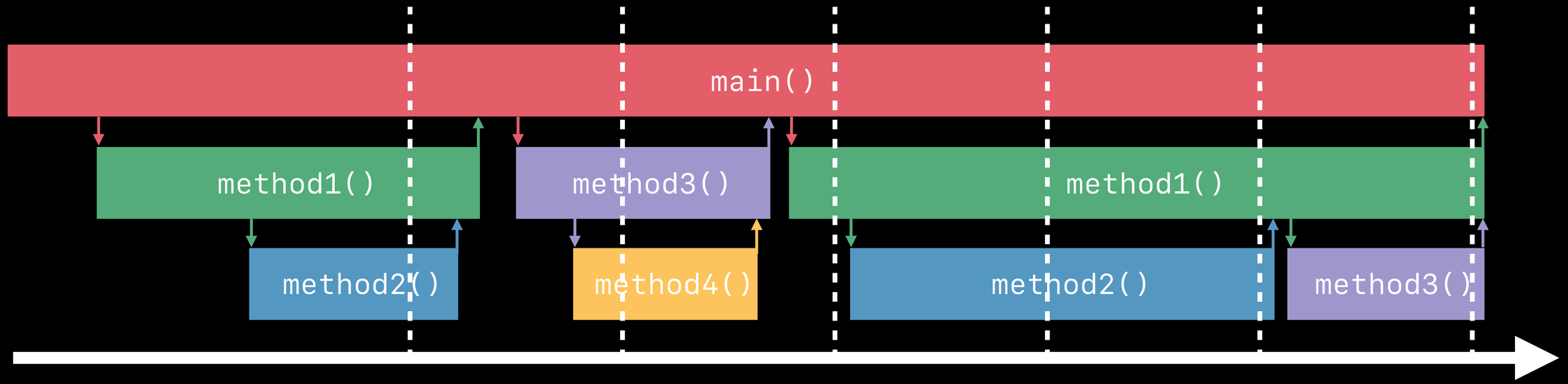

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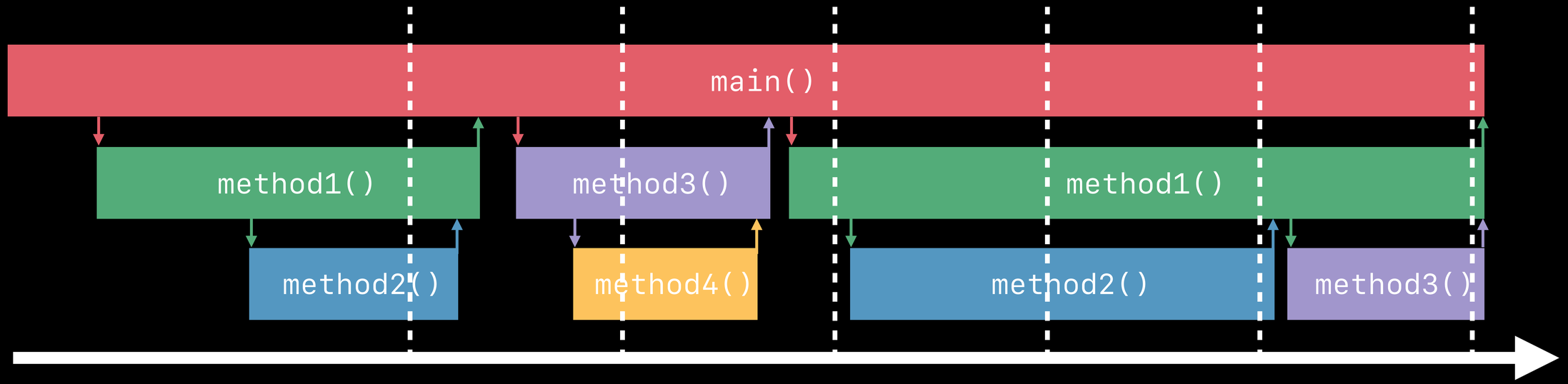

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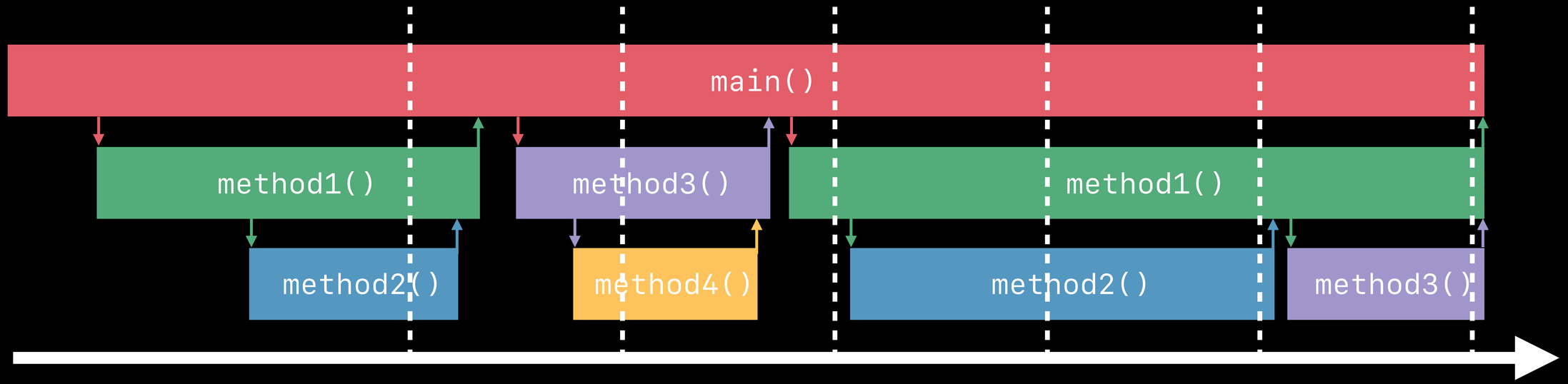
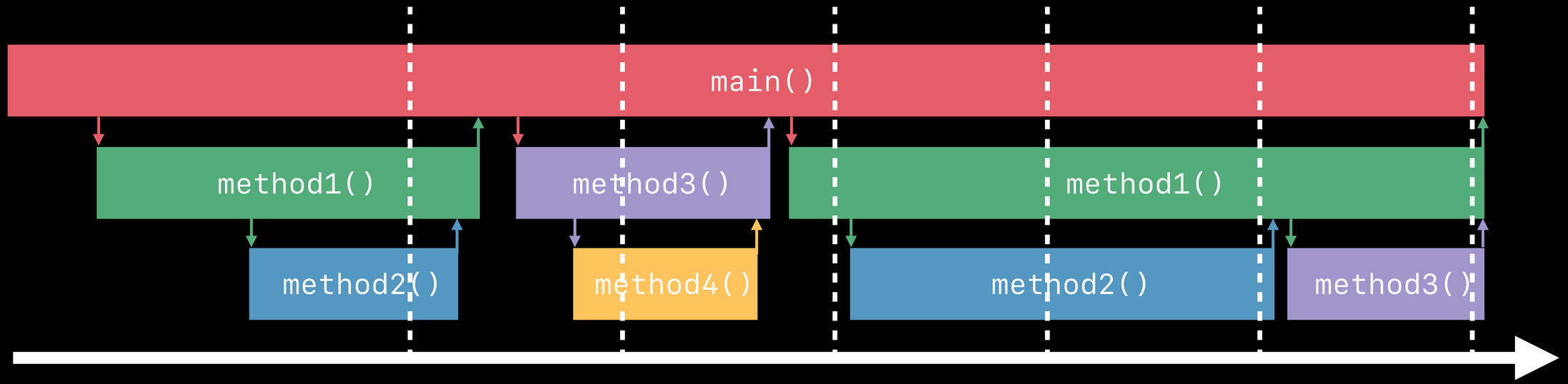



```
main()
 method1()
 method2()
```

Xcode Energy Log: Weighted Call Graph




```
main()
 method1()
 method2()
```

```
main()
 method3()
 method4()
```

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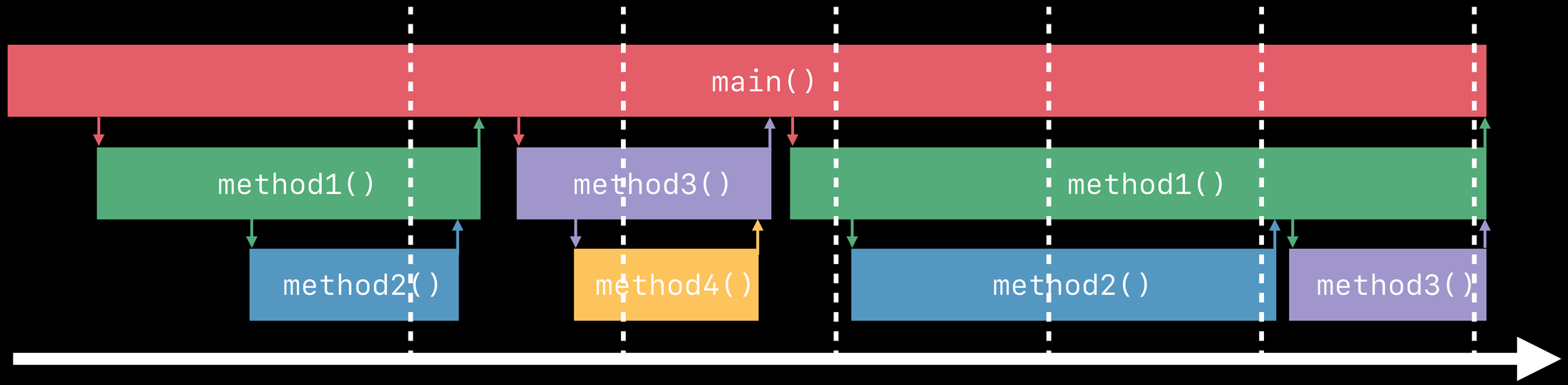


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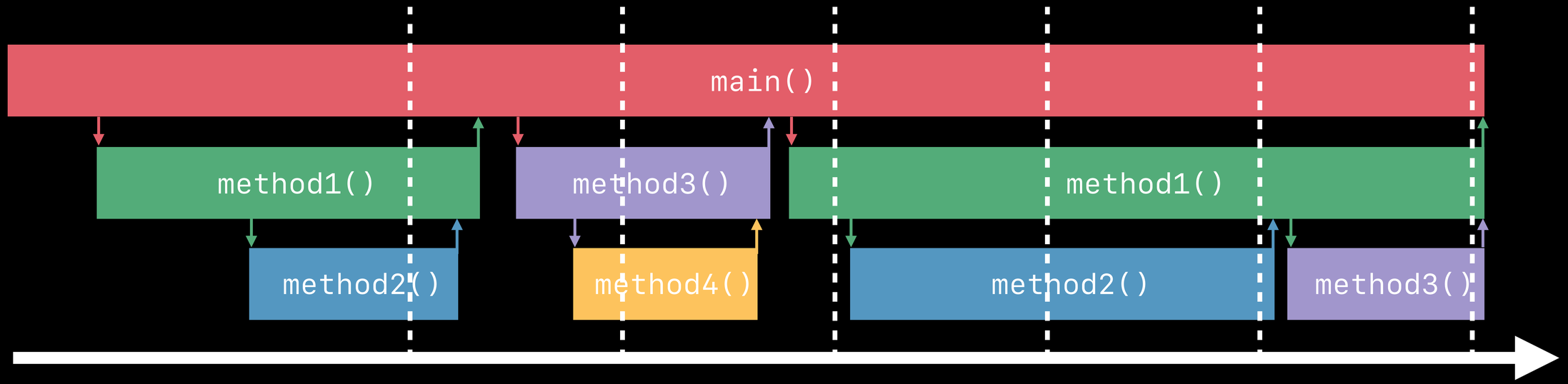


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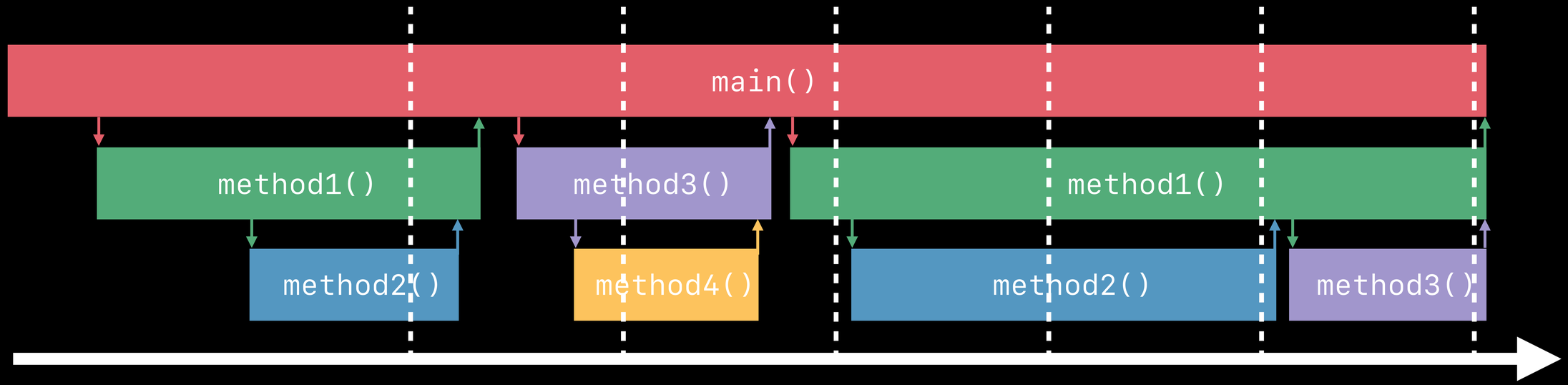


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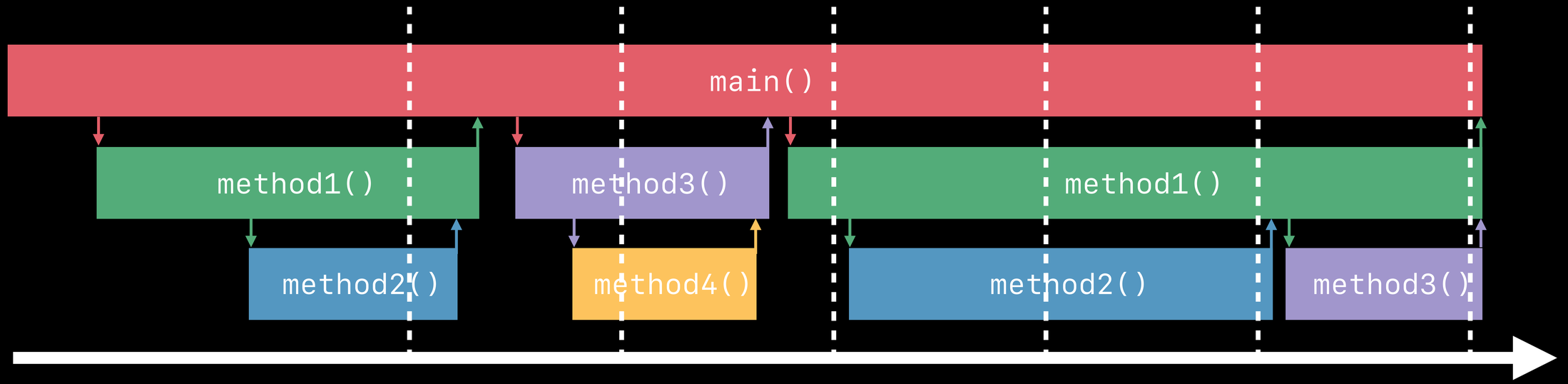


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  method3()
  method4()
```

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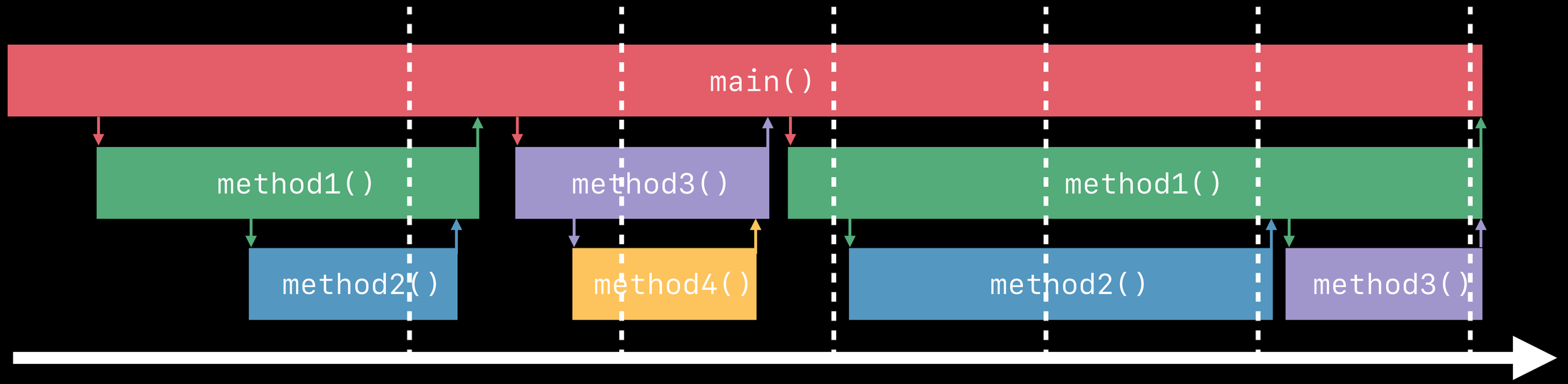
Xcode Energy Log: Weighted Call Graph

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  method2()
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  method1()
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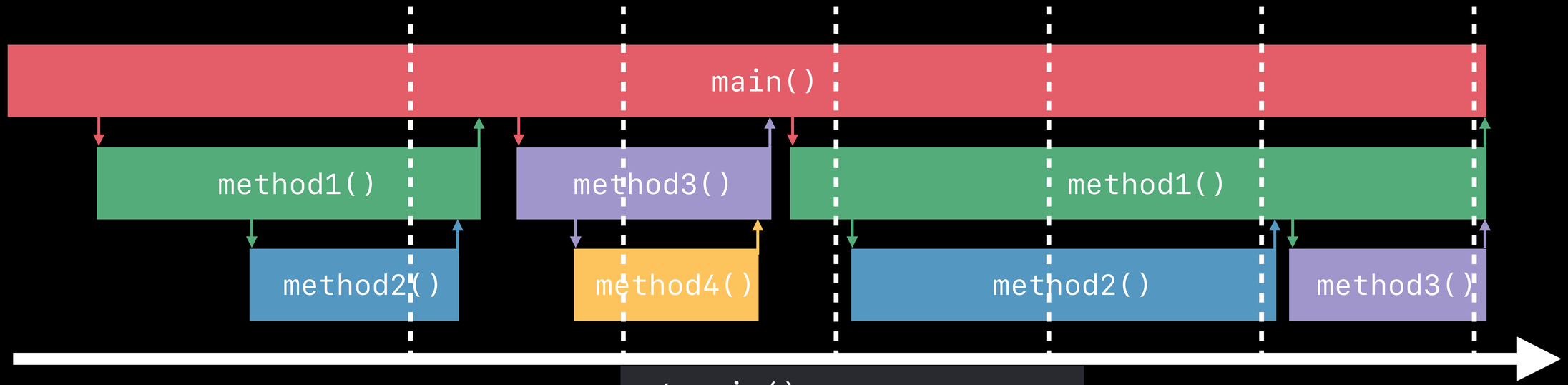
Xcode Energy Log: Weighted Call Graph




```
6 main()
    5 method1()
        3 method2()
        1 method3()
    1 method3()
        1 method4()
```

Weighted Call Graph

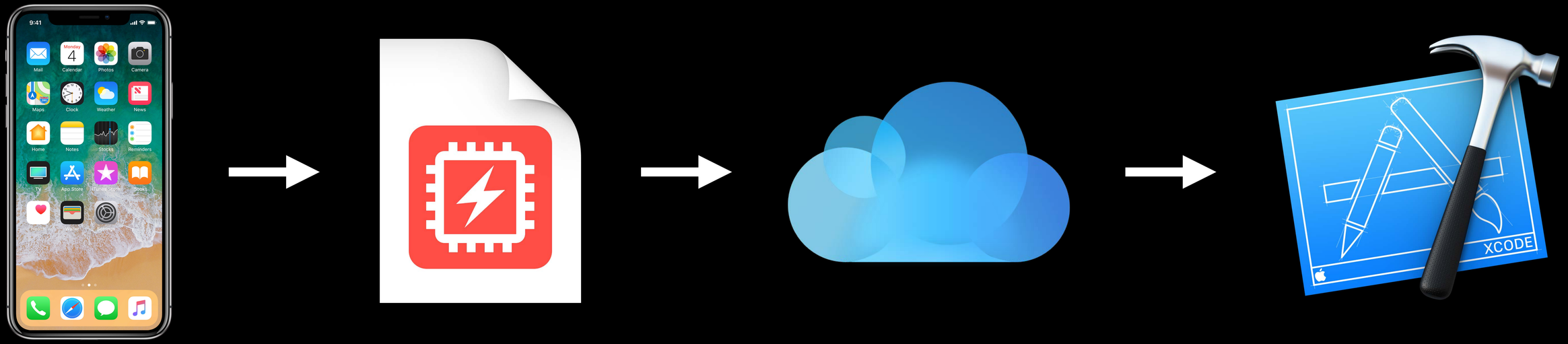
Collection of backtrace samples

Aggregated by sample counts

More samples mean heavily executed code

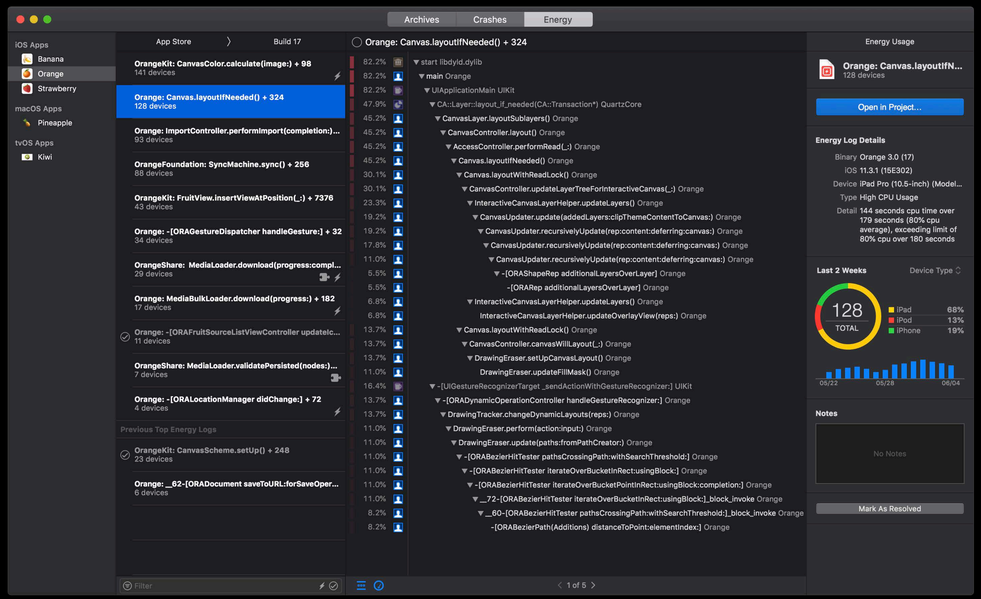
```
6 main()
    5 method1()
        3 method2()
        1 method3()
    1 method3()
        1 method4()
```

How to Access Energy Logs?



Xcode Energy Organizer

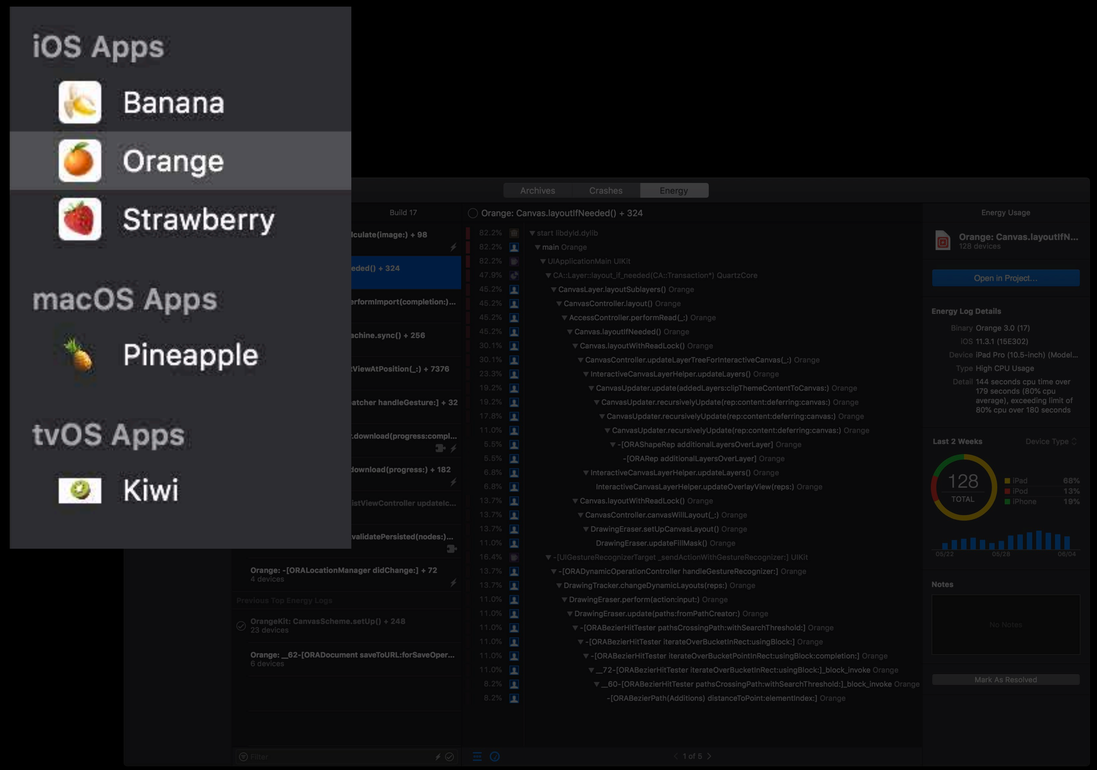
NEW



Xcode Energy Organizer

NEW

Test Flight and App Store iOS apps

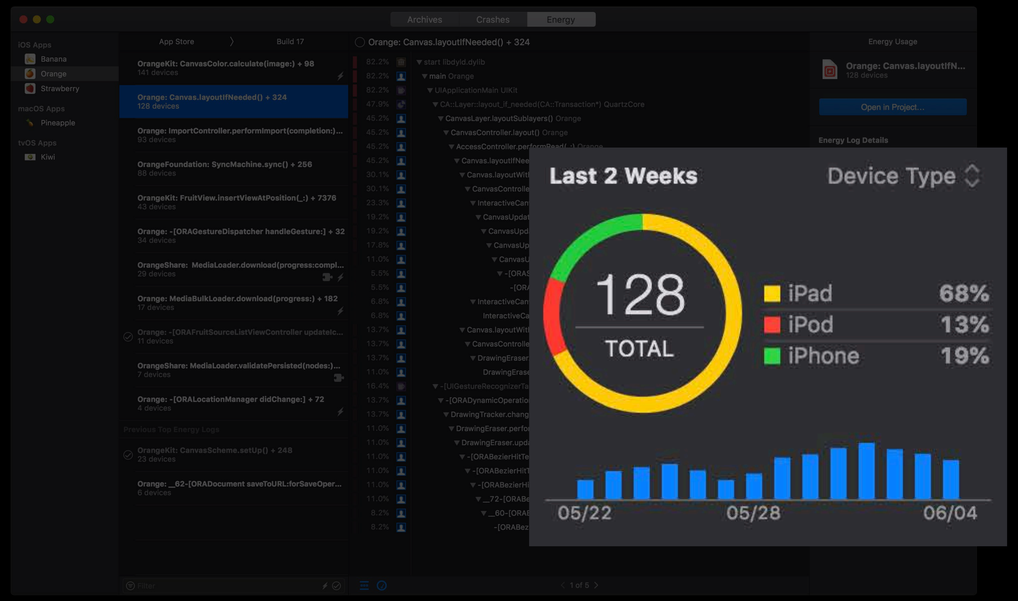


Xcode Energy Organizer

NEW

Test Flight and App Store iOS apps

Recent statistics



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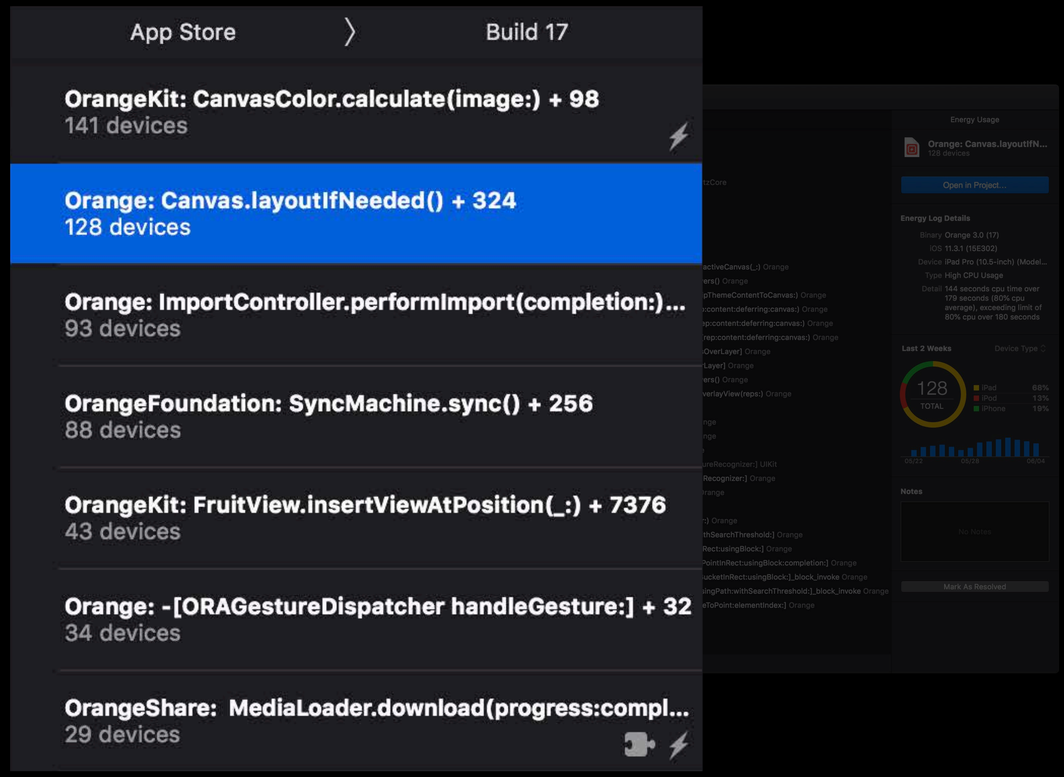
Recent statistics

List of top issues



Xcode Energy Organizer

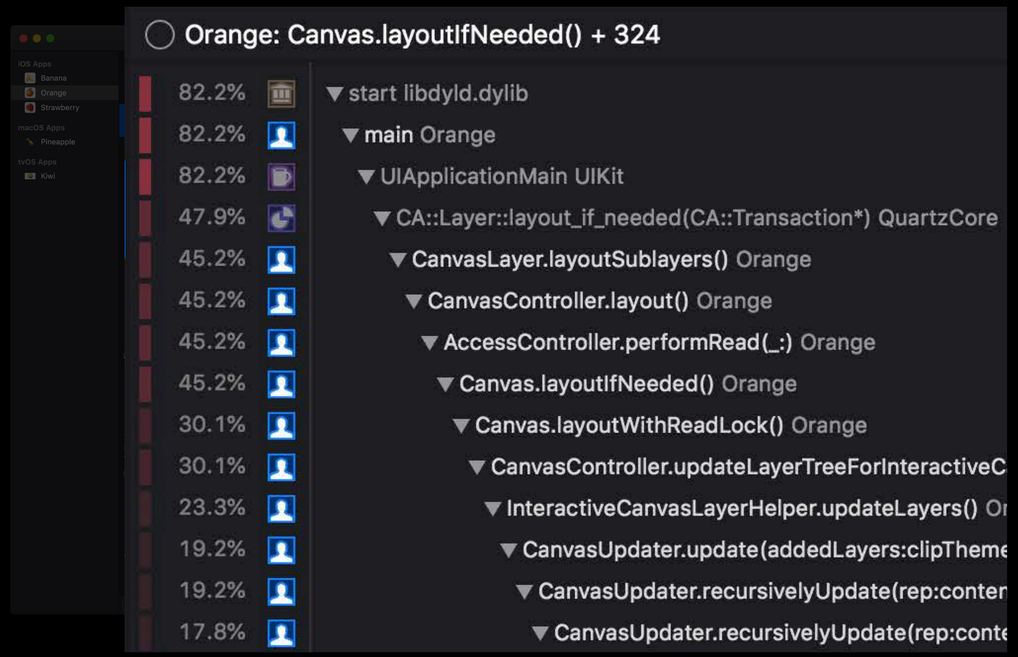
NEW

Test Flight and App Store iOS apps

Recent statistics

List of top issues

Weighted call graph



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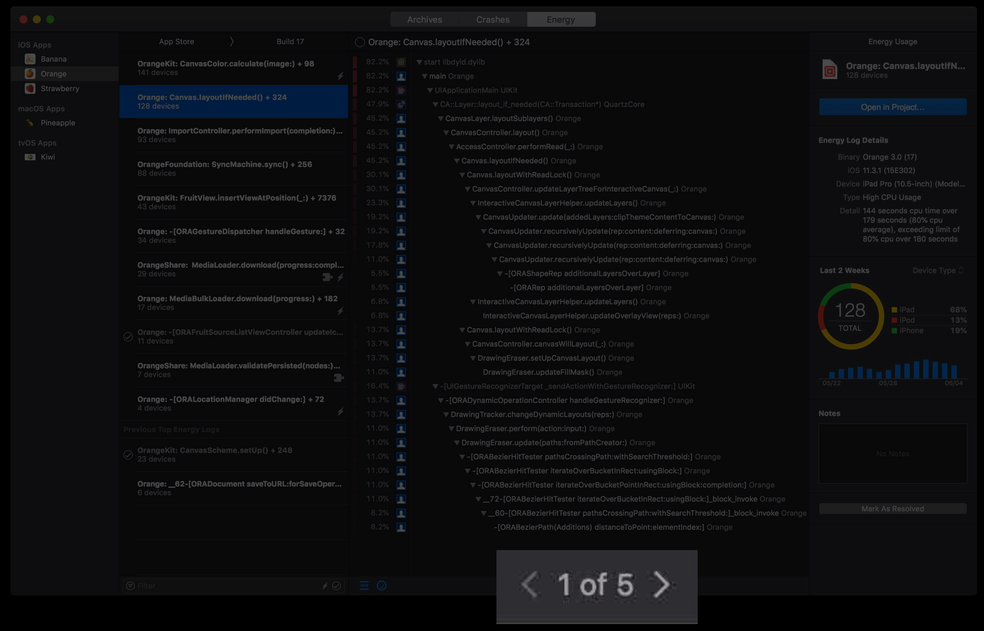
Page through logs



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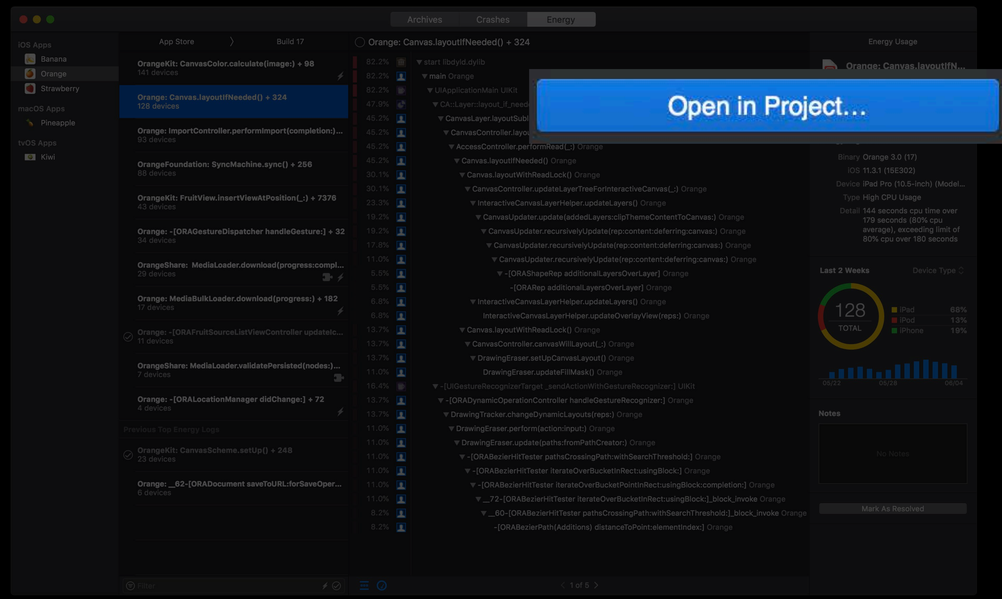
Open in Project



Demo

Xcode Energy Organizer

Energy Organizer

Demo takeaways

Discover top energy issues from the field

View energy hotspots with weighted call graphs

“Open in Project” to debug code

Summary

Think about energy use in design

Use energy gauges and instruments

Explore the new Xcode Energy Organizer

More Information

https://developer.apple.com/go/?id=ios-energy-efficiency-guide

https://developer.apple.com/videos/play/wwdc2017/238/

Power and Performance Lab	Technology Lab 9	Friday 9:00AM


WWDC18