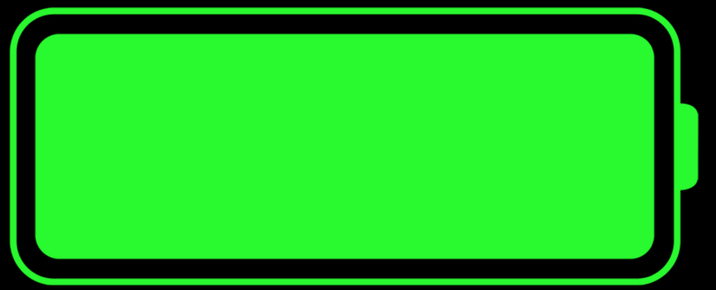
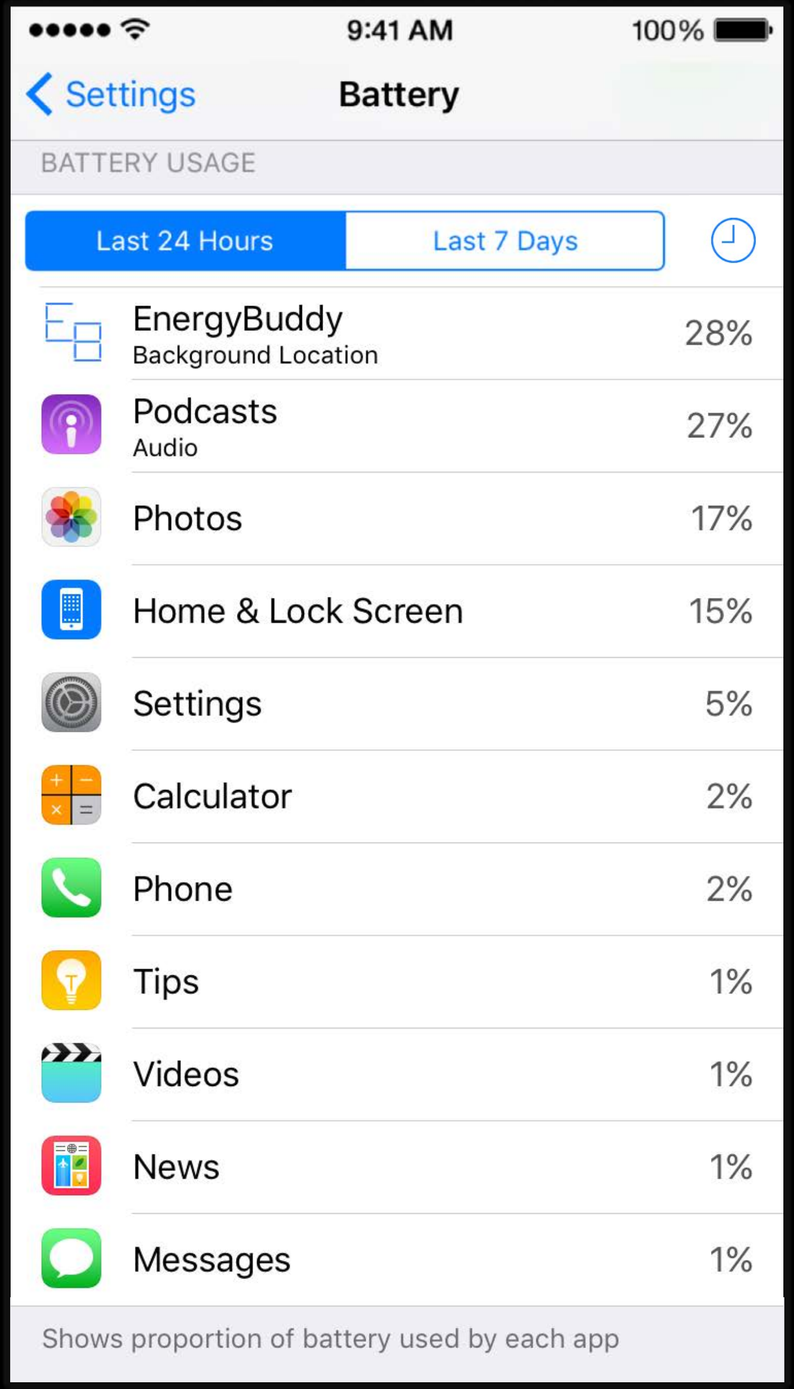
Writing Energy Efficient Apps

Session 238

Daniel Schucker, Software Power Engineer
Prajakta Karandikar, Software Power Engineer




9:41 AM
100%
Settings
Battery
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Last 7 Days
EnergyBuddy
Background Location
28%
Podcasts
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Photos
17%
Home & Lock Screen
15%
Settings
5%
Calculator
2%
Phone
2%
Tips
1%
Videos
1%
News
1%
Messages
1%
Shows proportion of battery used by each app

Battery Life Concepts

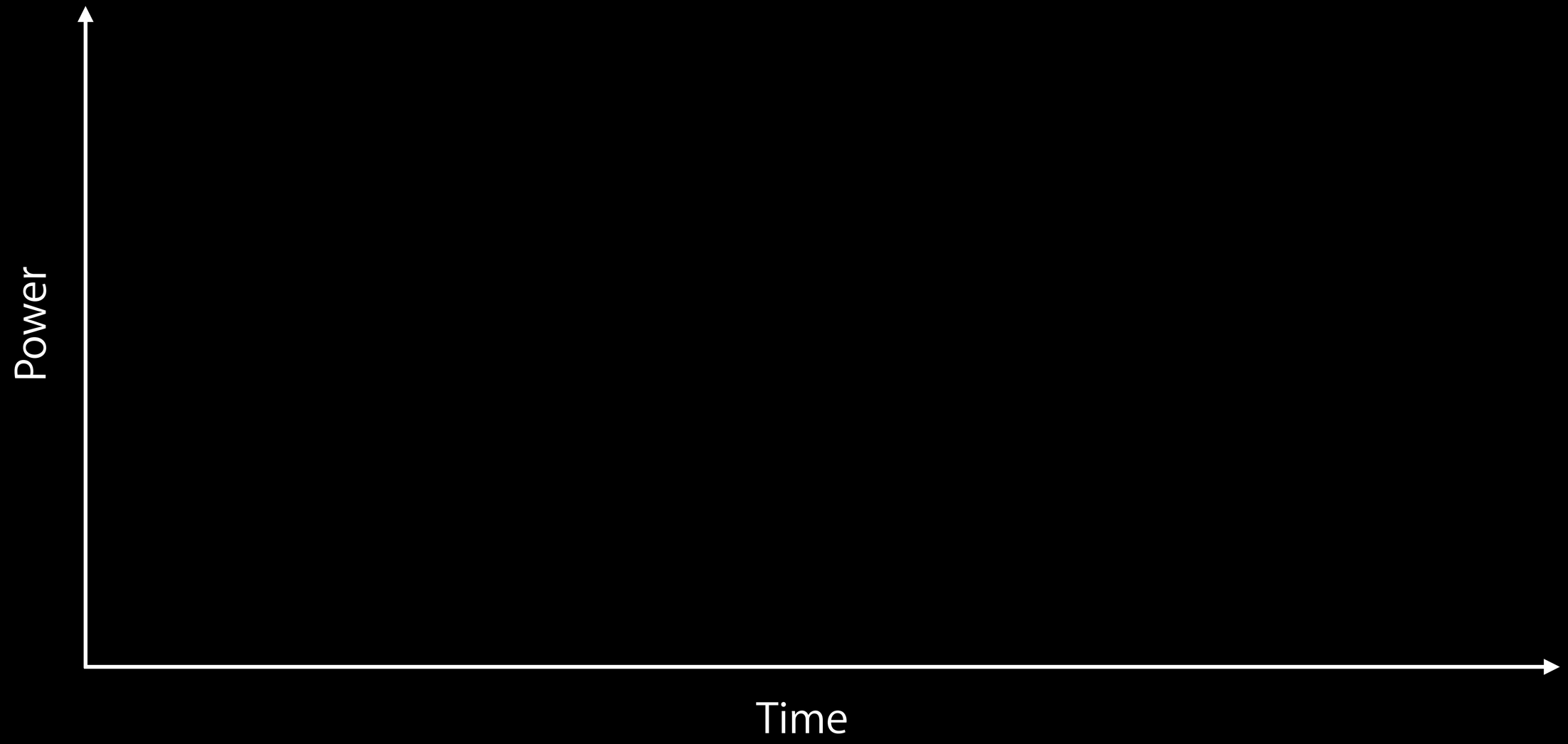
Energy Efficient Coding

Energy Debugging Tools and Demo

Final Thoughts

General Battery Life Concepts

What Is Energy?



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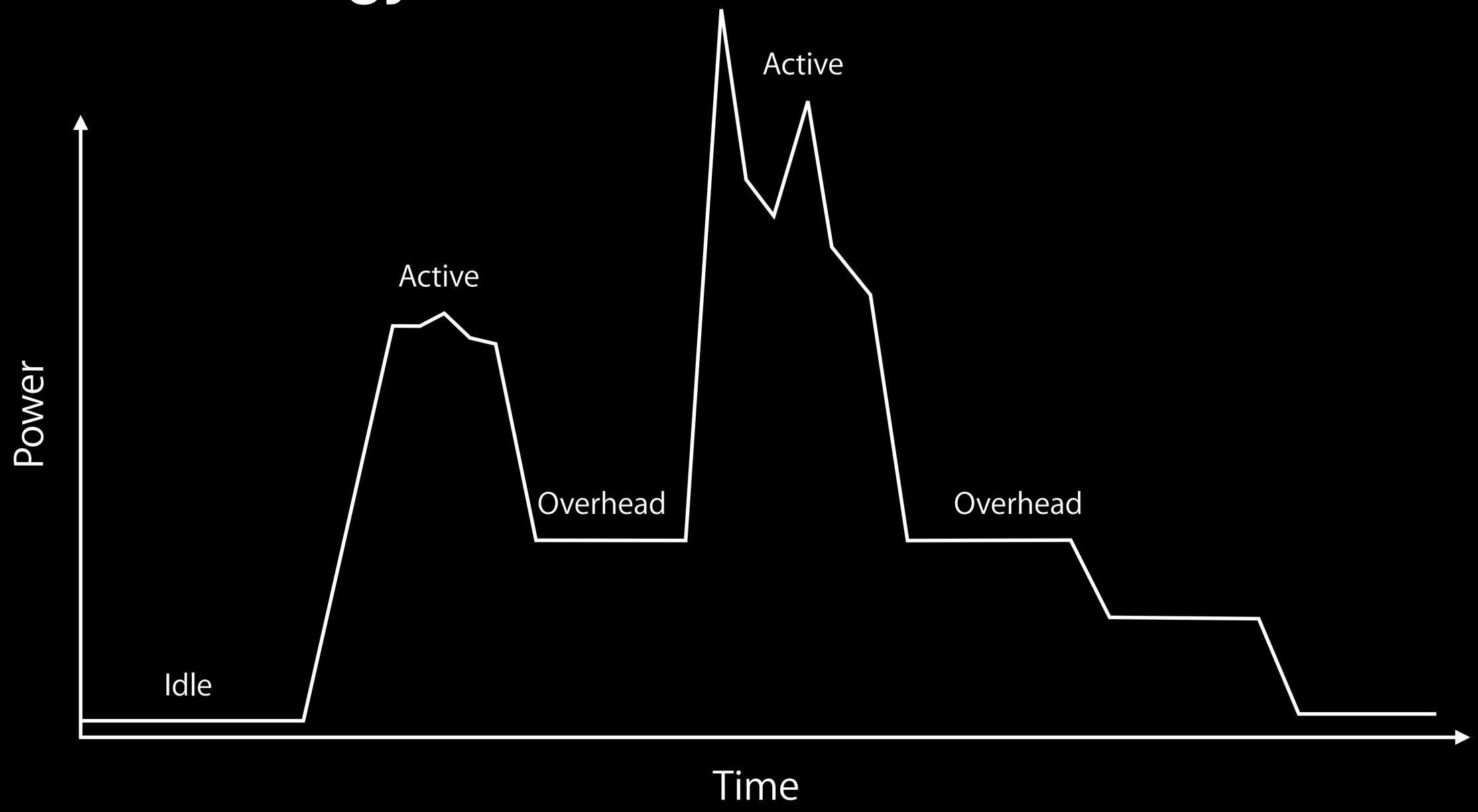

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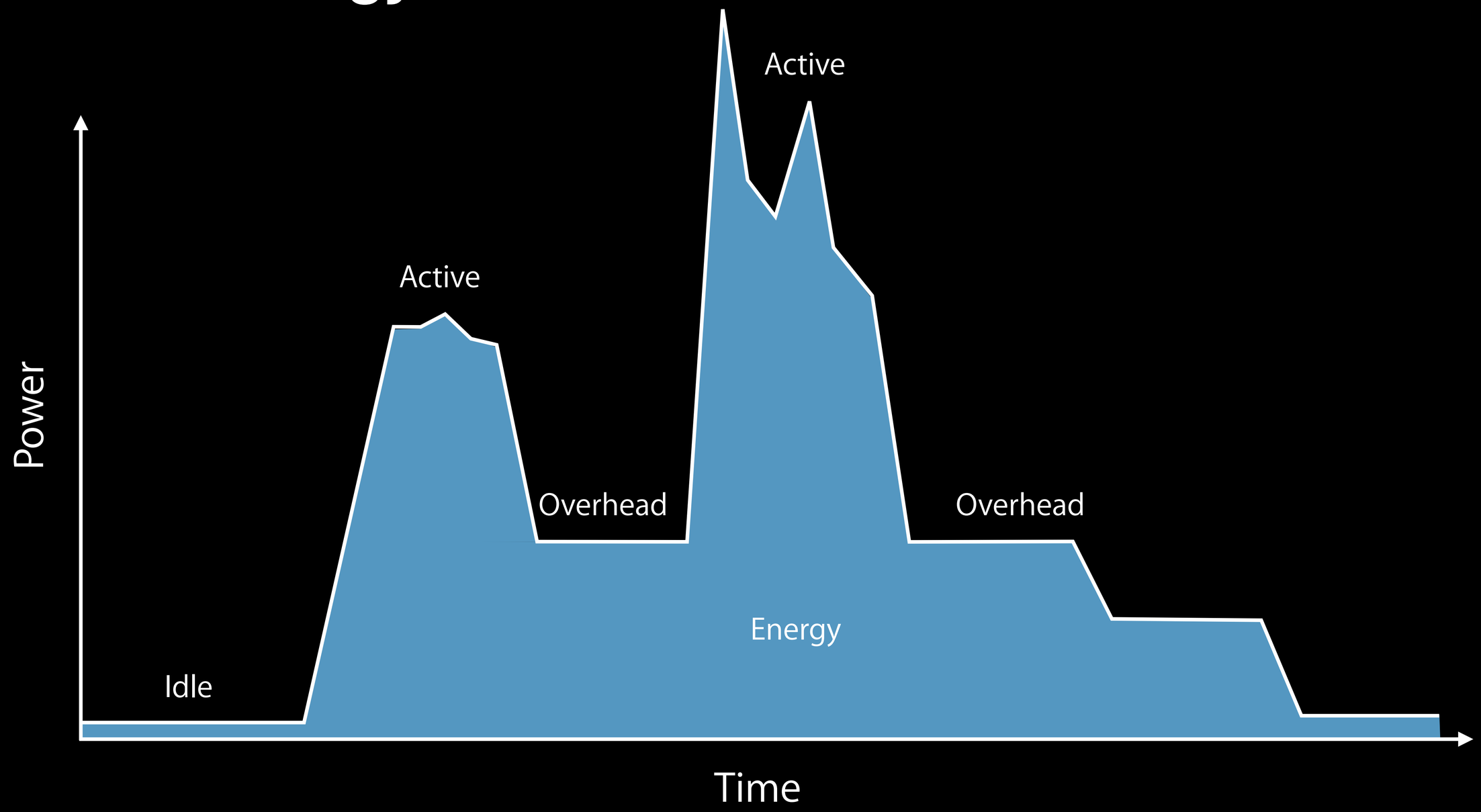

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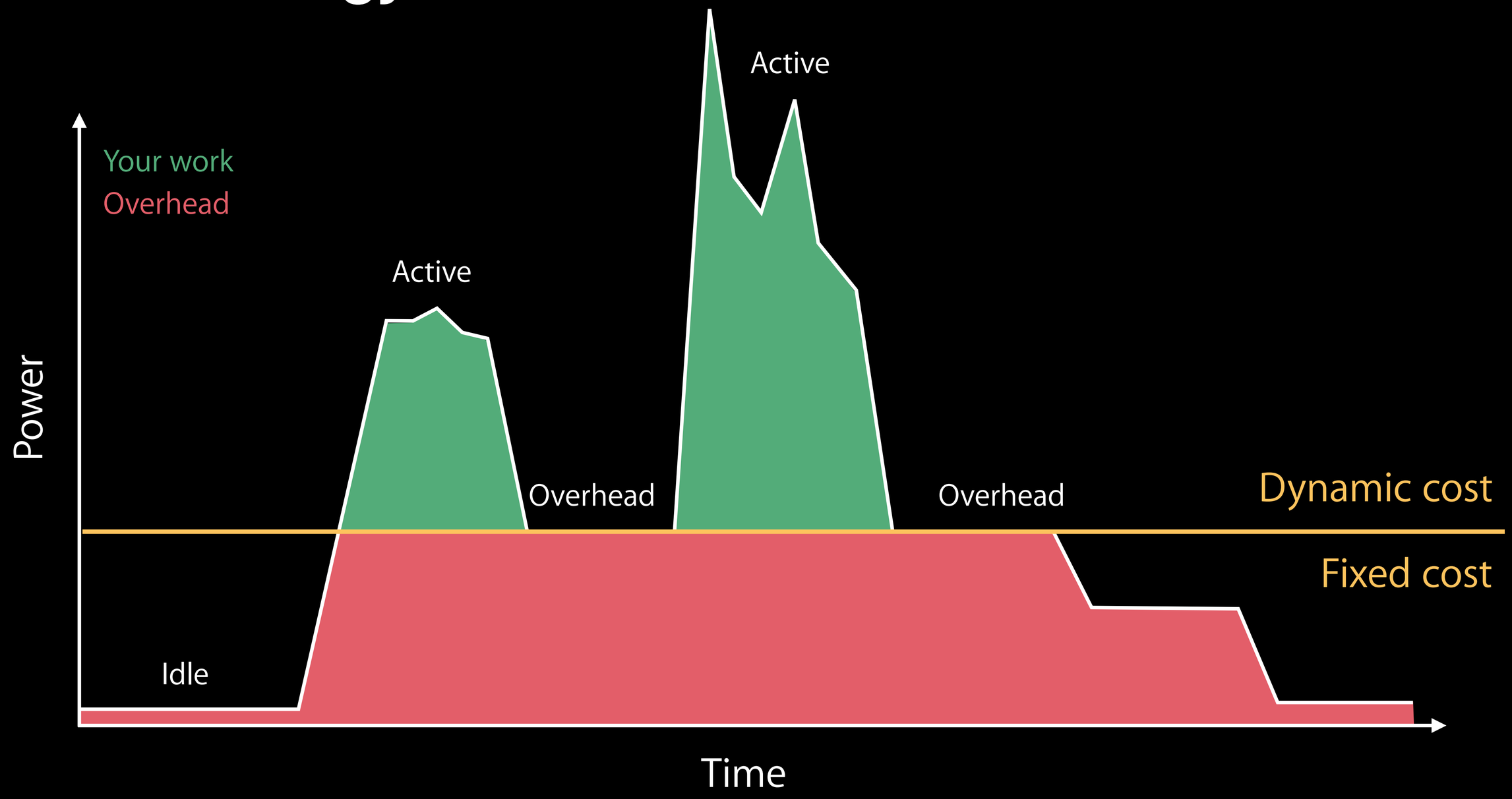
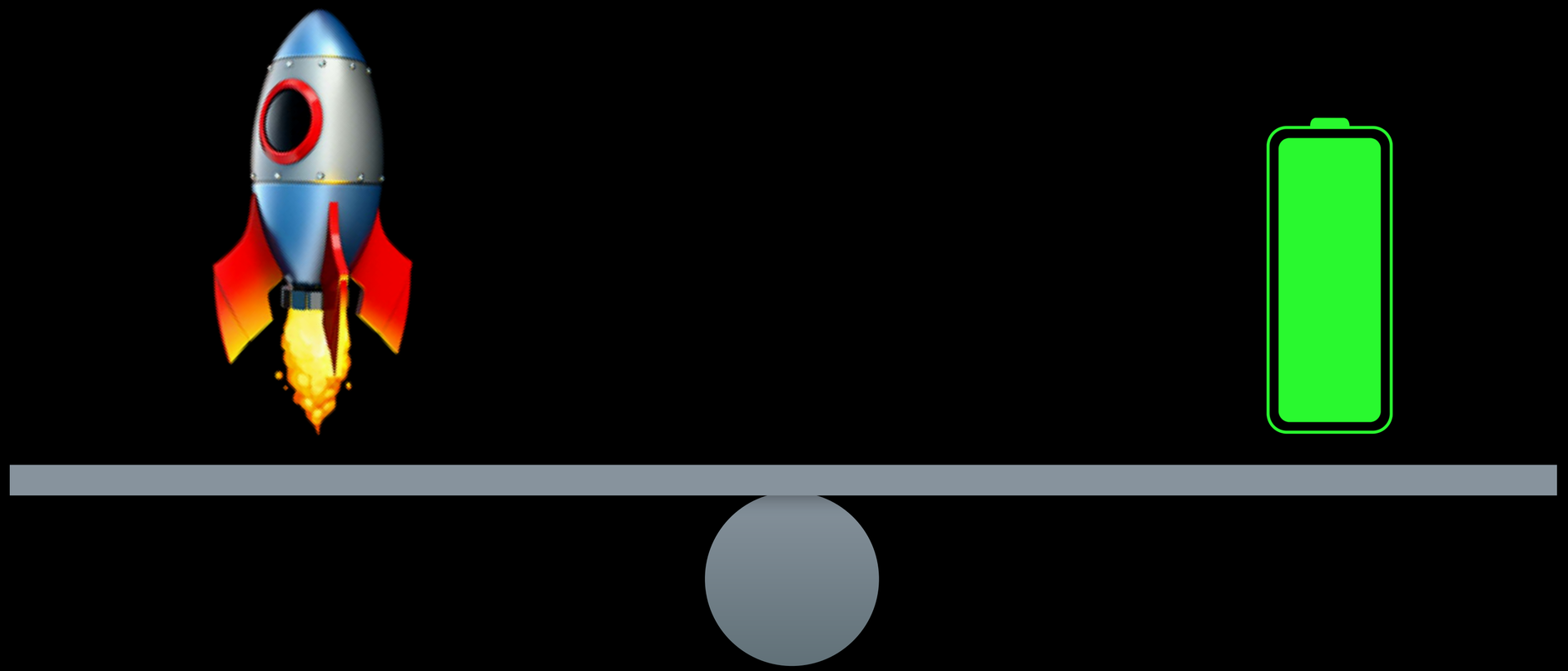
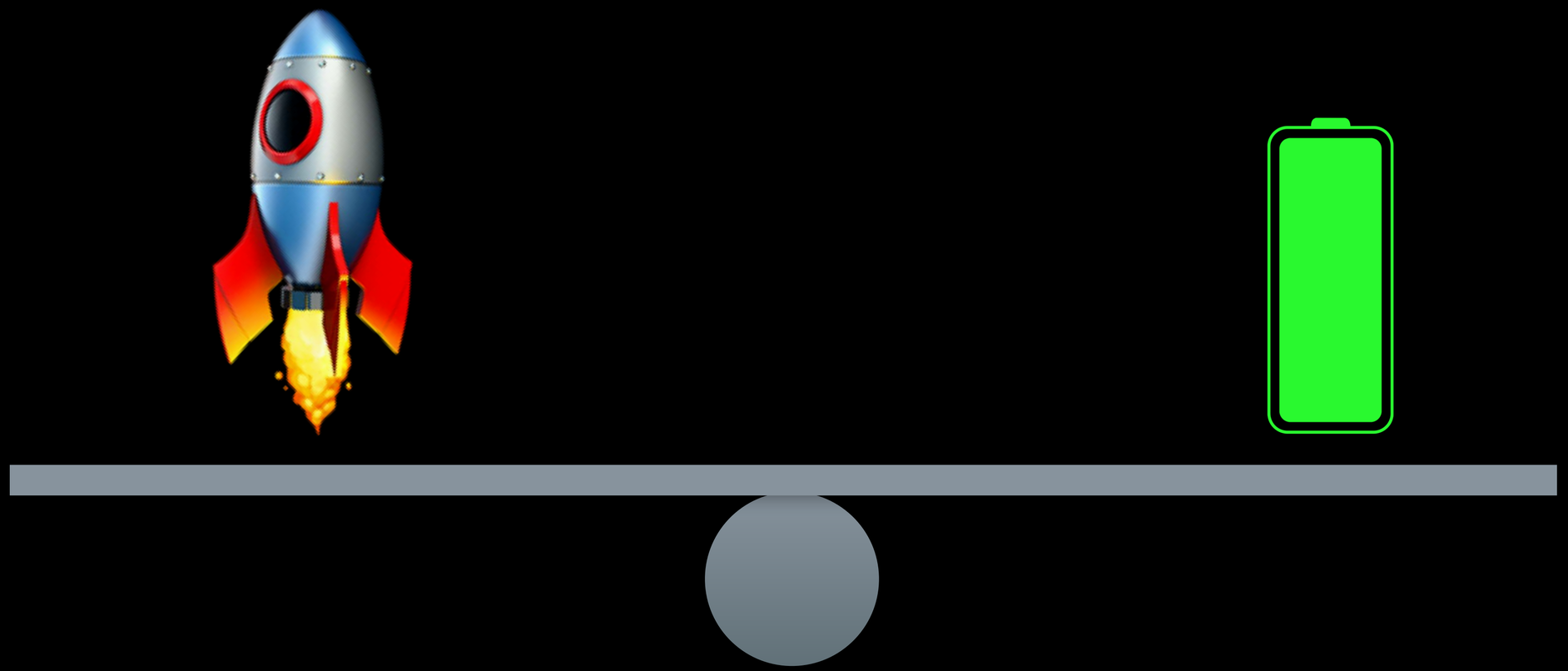


Balancing Power and Battery Life



Balancing Power and Battery Life



What Consumes Energy?

What Consumes Energy?

Processing

Networking

Location

Graphics

How to Reduce Energy Consumption

Identify

Optimize

Coalesce

Reduce

Energy Efficient Coding

Social Networking App

Main feed

Post a photo

Analytics

Social Networking App

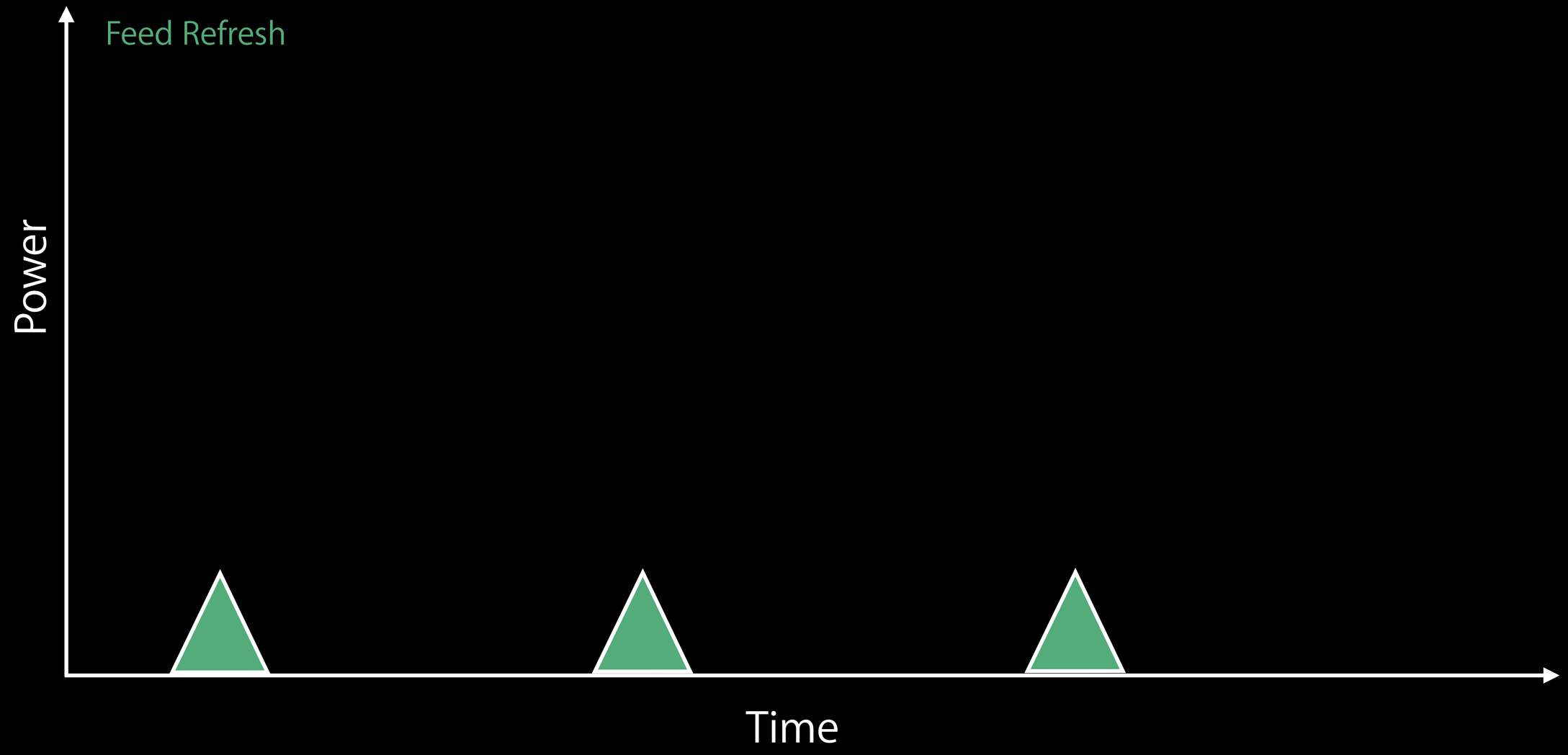
Main Feed

Current implementation

- Reloads on a timer

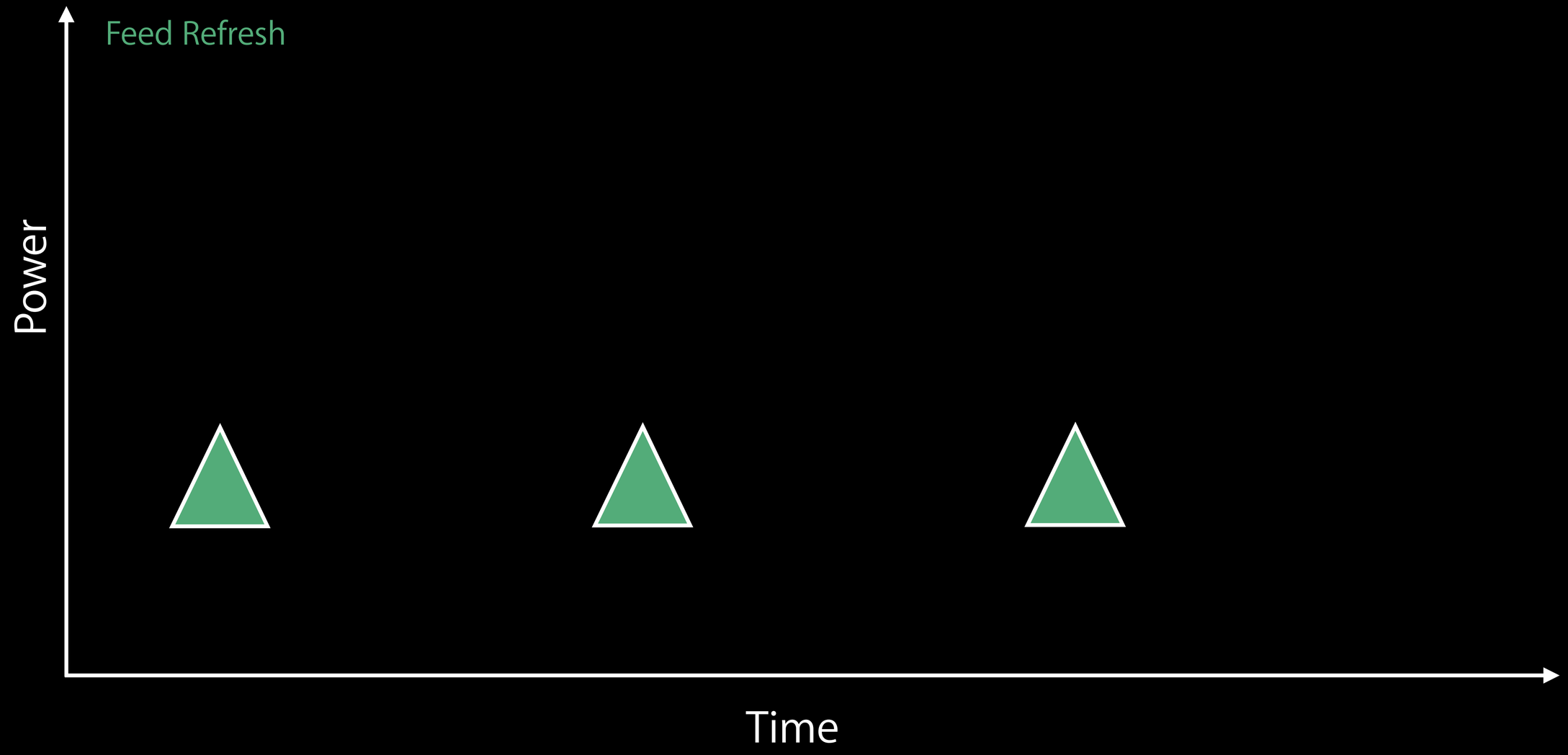
Social Networking App

Energy Impact



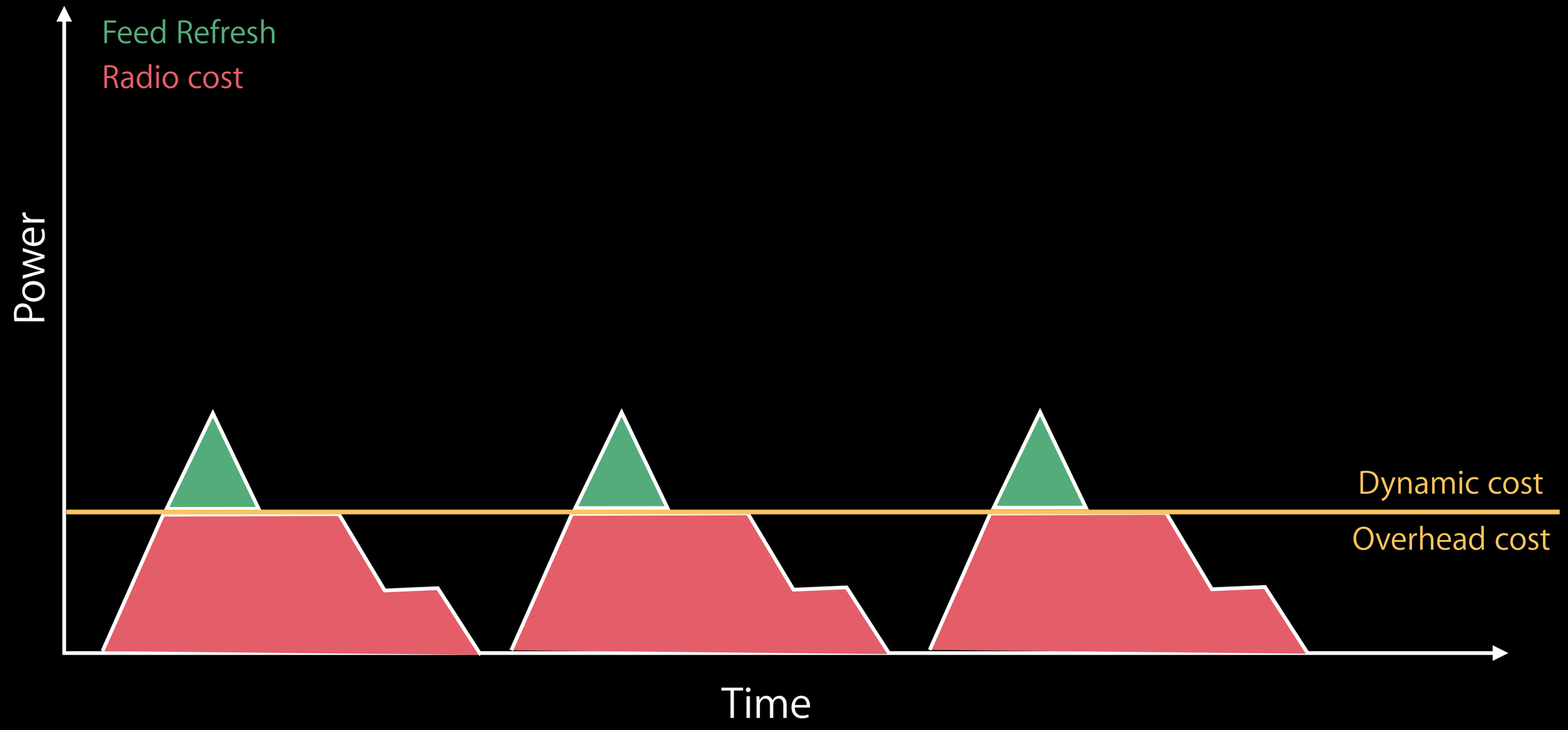
Social Networking App

Energy Impact



Social Networking App

Energy Impact



Social Networking App

Main Feed

Reload only when needed

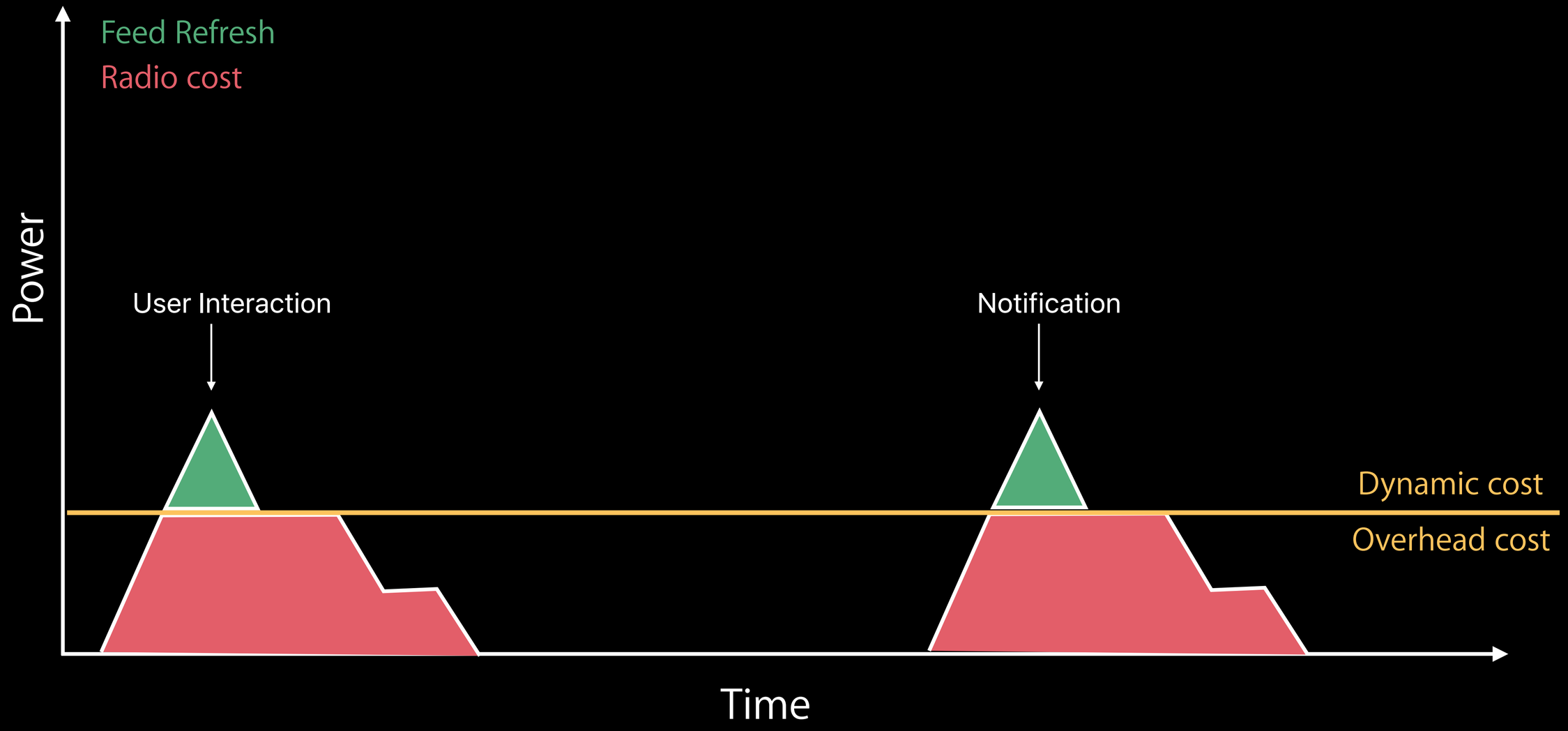
- User interaction
- Notification

Use NSURLSession Default Session

- New: WaitsForConnectivity
- Cache

Social Networking App

Energy Impact



```
// Setup NSURLSession Default Session
let config = URLSessionConfiguration.default()

// Use WaitsForConnectivity
config.waitsForConnectivity = true

// NSURLSession Cache
let cachesDirectoryURL = FileManager.default().urlsForDirectory(.cachesDirectory,
inDomains: .userDomainMask).first!
let cacheURL = try! cachesDirectoryURL.appendingPathComponent("MyCache")
var diskPath = cacheURL.path

let cache = URLCache(memoryCapacity:16384, diskCapacity: 268435456, diskPath: diskPath)
config.urlCache = cache
config.requestCachePolicy = .useProtocolCachePolicy
```

```swift
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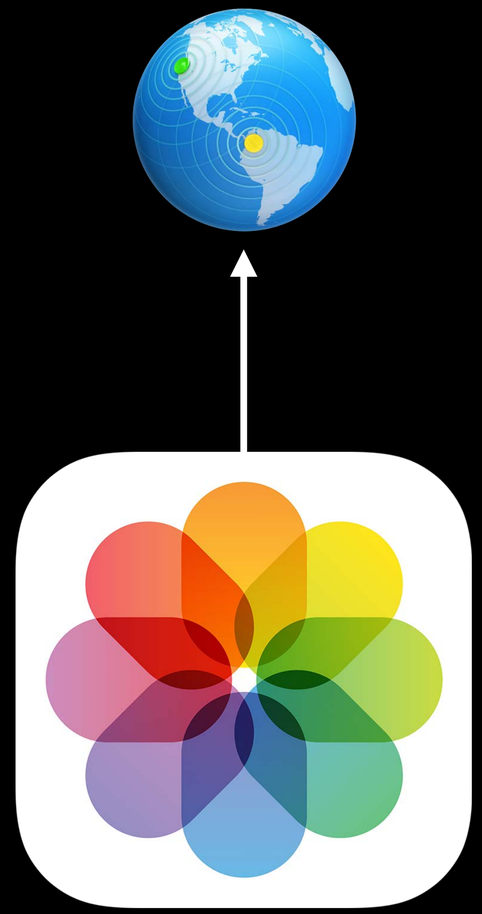
Social Networking App

Posting a Photo

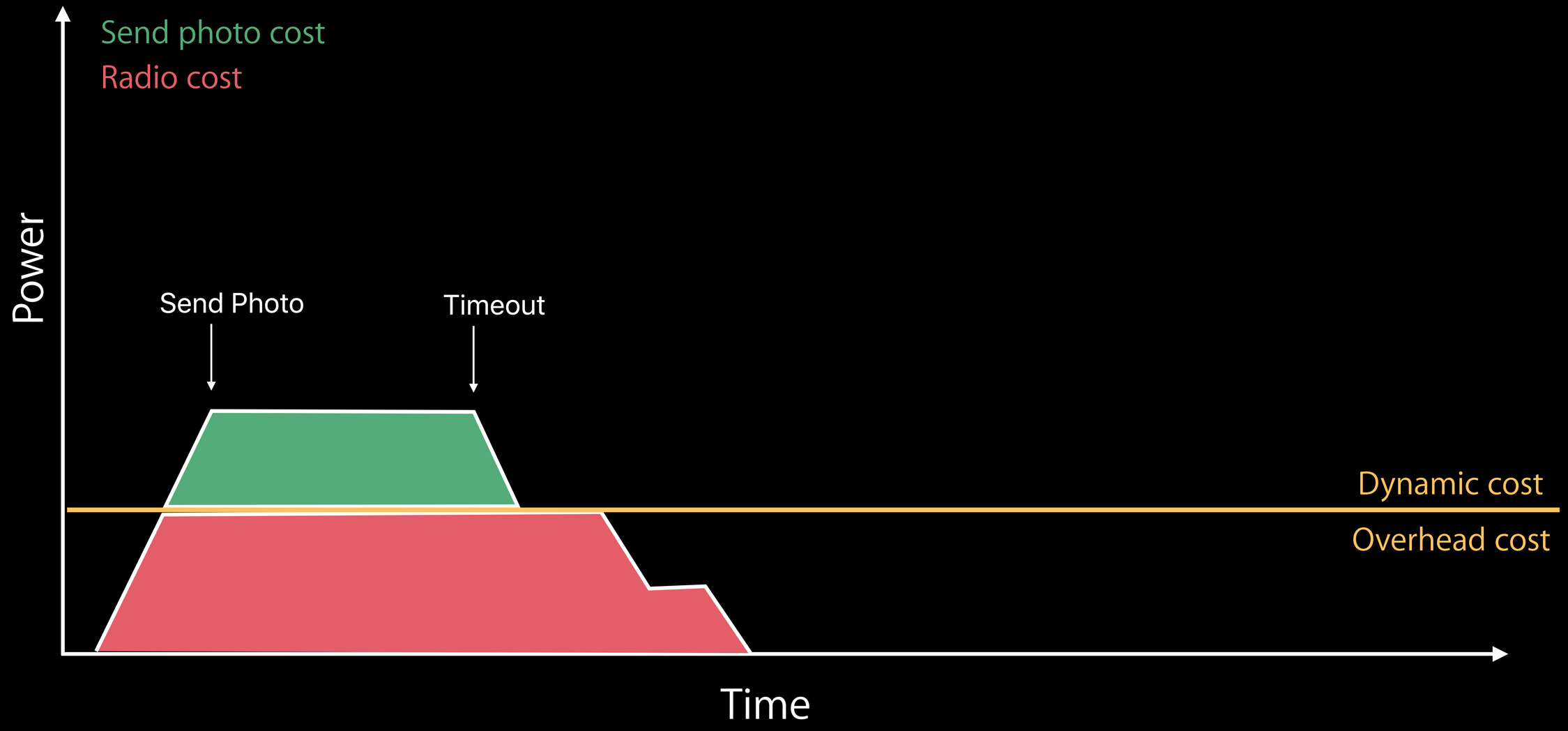
Current implementation

- Send immediately
- Retry on failure



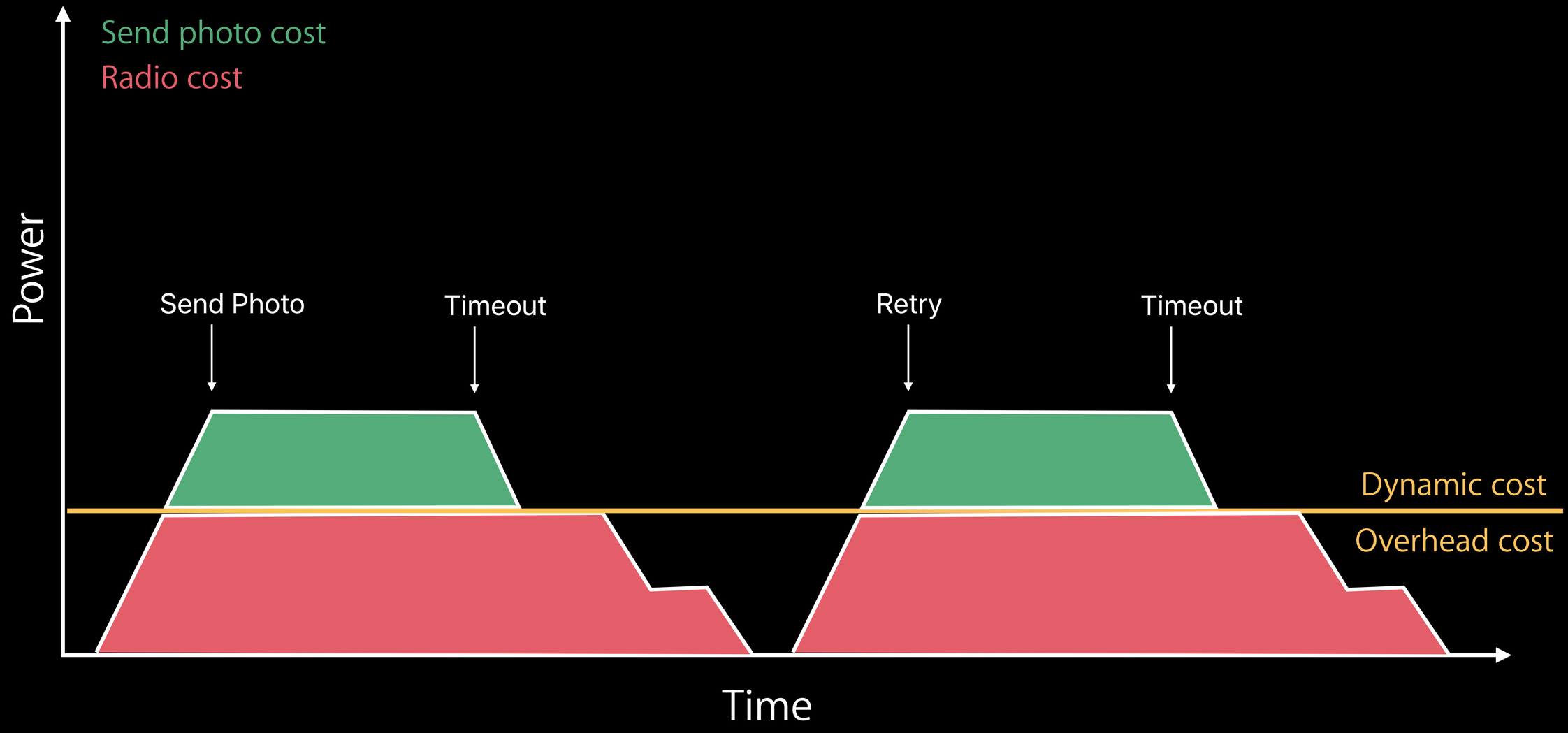
Social Networking App

Energy Impact



Social Networking App

Energy Impact



Social Networking App

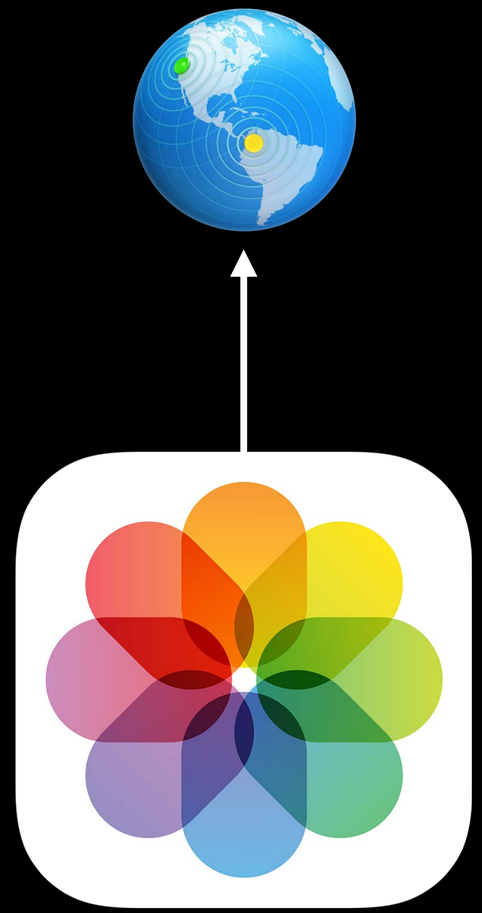
Posting a Photo

Use NSURLSession Default Session

- Minimize retries
- Set timeouts
- Batch Transactions

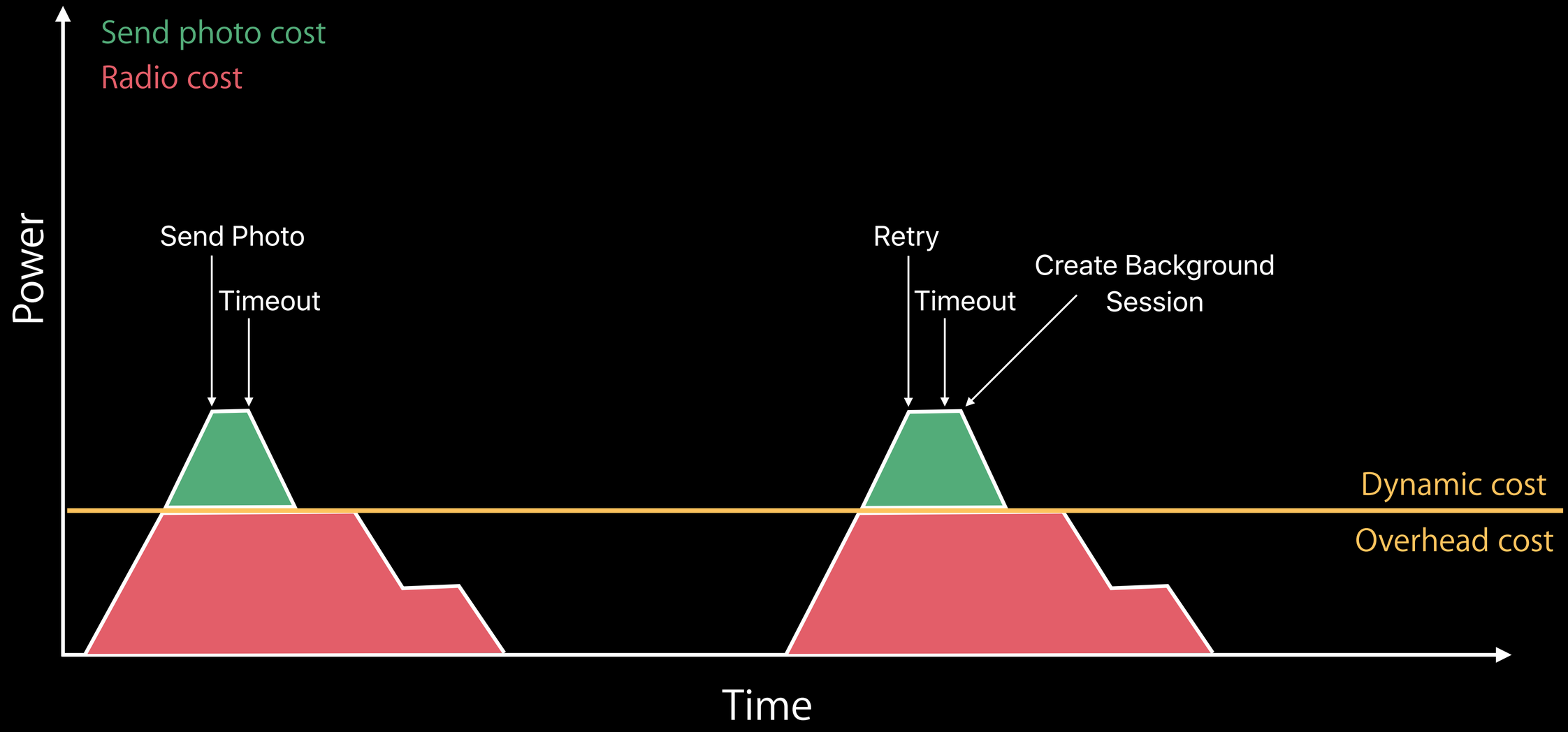
When retry limit hit

- Use Background Session



Social Networking App

Energy Impact



Social Networking App

Sending analytics data

Use NSURLSession Background Session

- Automatic retries
- Throughput monitoring

Properties

- New
  - Start time
  - Workload size
- Discretionary

Social Networking App

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Social Networking Application

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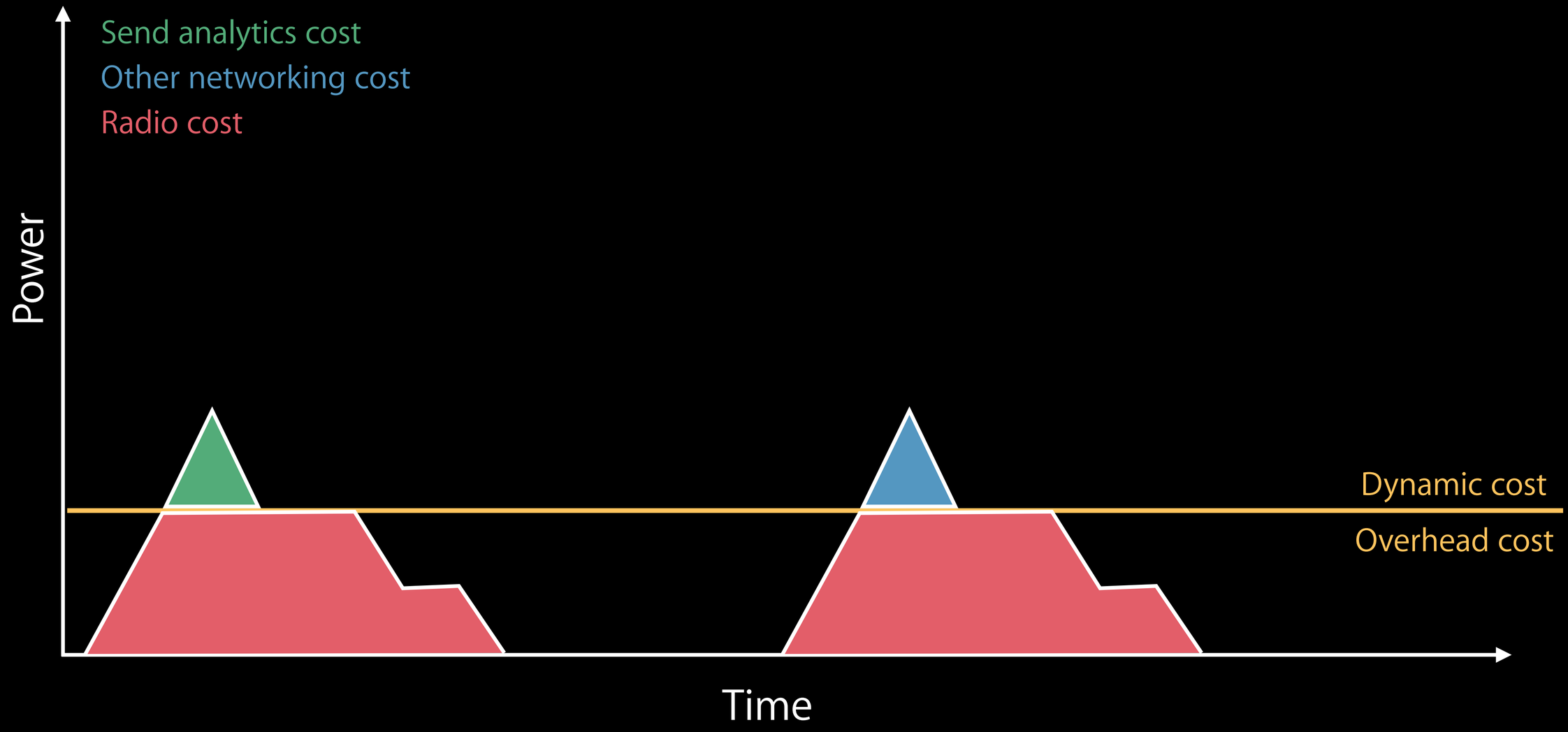
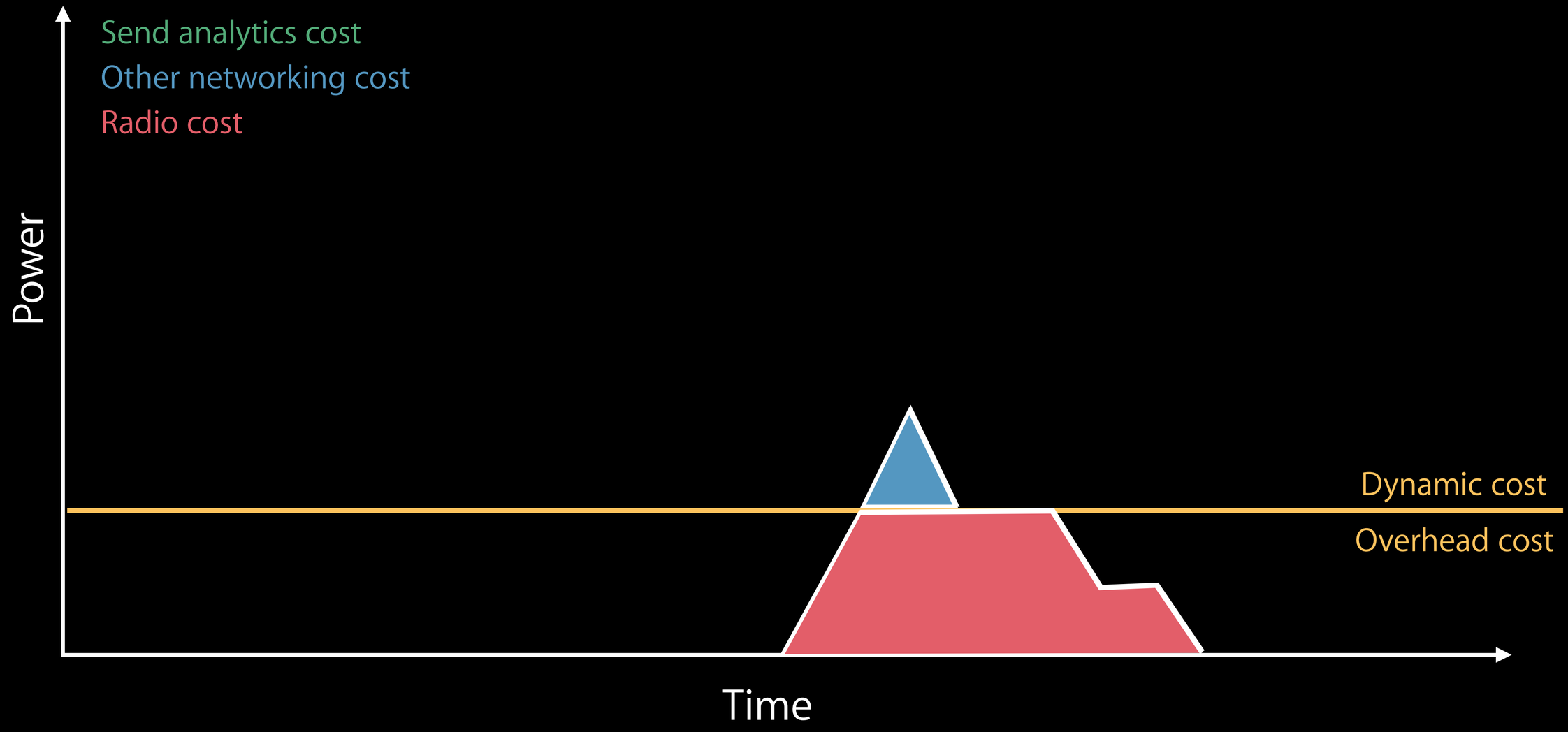


Social Networking Application

Energy Impact



```
// Setup NSURLSession Background Session
let config = URLSessionConfiguration.background(withIdentifier: "com.socialapp.background")
let session = URLSession(configuration: config, delegate: …, delegateQueue: …)


// Set discretionary property

config.discretionary = true


// Create Request and Task

var request = URLRequest(url: URL(string: "https://www.example.com/")!)
request.addValue("…", forHTTPHeaderField: “…”)
let task = session.downloadTask(with: request)


// Set time window
task.earliestBeginDate = Date(timeIntervalSinceNow: 2 * 60 * 60)


// Set workload size
task.countOfBytesClientExpectsToSend = 80
task.countOfBytesClientExpectsToReceive = 2048

task.resume()
```

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Social Networking Application

WatchOS

Use background session for screen off work

- Complication updates
- Background app refresh
- Runtime when task completes

Networking Best Practices

Identify

- Ensure transactions not repeated

Optimize

- Use background session

Coalesce

- Batch transactions

Reduce

- Minimize retries

Location Best Practices

Location APIs

- Continuous location
- Quick location update
- Region monitoring
- Visit monitoring
- Significant location change

Location Best Practices

Continuous Location

Navigate to a destination

- Continuous location updates
- Prevents device sleep

Stop location updates

- Allows device to sleep

```
// Create location manager
locationManager = CLLocationManager()
locationManager.delegate = self
locationManager.requestWhenInUseAuthorization()

// Set desired accuracy, auto-pause, and activity type appropriately
locationManager.desiredAccuracy = kCLLocationAccuracyThreeKilometers
locationManager.pausesLocationUpdatesAutomatically = true
locationManager.activityType = CLActivityTypeNavigation

// Set allows background if its needed
locationManager.allowsBackgroundLocationUpdates = true

// Start location updates
locationManager.startUpdatingLocation()
```

```
// Create location manager
locationManager = CLLocationManager()
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// Start location updates
locationManager.startUpdatingLocation()
```

```
// Start location updates
locationManager.startUpdatingLocation()

// Get location updates
…

// Disable background updates when no longer needed
locationManager.allowsBackgroundLocationUpdates = false

// Stop location when no longer needed
locationManager.stopUpdatingLocation()
```

```
// Start location updates
locationManager.startUpdatingLocation()

// Get location updates
…

// Disable background updates when no longer needed
locationManager.allowsBackgroundLocationUpdates = false

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locationManager.stopUpdatingLocation()
```

Location Best Practices

Request location

Get news based on current location

- Use quick location update

```
locationManager.requestLocation()
```

Location Best Practices

Request location

Get news based on current location

- Use quick location update

```
locationManager.requestLocation()
```

Location Best Practices

Region monitoring

Updating content when arriving at home

- Use region monitoring

```
// Create the geographic region to be monitored.
let geoRegion = CLCircularRegion(center: overlay.coordinate, radius: radius, identifier:
identifier)
        locationManager.startMonitoring(for: geoRegion)
```

Location Best Practices

Region monitoring

Updating content when arriving at home

- Use region monitoring

```
// Create the geographic region to be monitored.
let geoRegion = CLCircularRegion(center: overlay.coordinate, radius: radius, identifier:
identifier)
        locationManager.startMonitoring(for: geoRegion)
```

Location Best Practices

Visit monitoring

Updating content when arriving at frequently visited locations

- Use visit monitoring

```
// Start monitoring
locationManager.startMonitoringVisits()

// Stop monitoring when no longer needed
locationManager.stopMonitoringVisits()
```

Location Best Practices

Visit monitoring

Updating content when arriving at frequently visited locations

- Use visit monitoring

```
// Start monitoring
locationManager.startMonitoringVisits()

// Stop monitoring when no longer needed
locationManager.stopMonitoringVisits()
```

Location Best Practices

Visit monitoring

Updating content when arriving at frequently visited locations

- Use visit monitoring

```
// Start monitoring
locationManager.startMonitoringVisits()

// Stop monitoring when no longer needed
locationManager.stopMonitoringVisits()
```

Location Best Practices

Significant location change

Updating content based user location

- Use significant location change

```
// Start monitoring
locationManager.startMonitoringSignificantLocationChanges()

// Stop monitoring when no longer needed
locationManager.stopMonitoringSignificantLocationChanges()
```

Location Best Practices

Significant location change

Updating content based user location

- Use significant location change

```
// Start monitoring
locationManager.startMonitoringSignificantLocationChanges()

// Stop monitoring when no longer needed
locationManager.stopMonitoringSignificantLocationChanges()
```

Location Best Practices

Significant location change

Updating content based user location

- Use significant location change

```
// Start monitoring
locationManager.startMonitoringSignificantLocationChanges()

// Stop monitoring when no longer needed
locationManager.stopMonitoringSignificantLocationChanges()
```

Location Best Practices

Identify:

- Accuracy level needed

Optimize:

- Use alternatives to continuous location

Reduce:

- Stop location when not used

Coalesce:

- Defer location updates

Graphics

Minimize screen updates

- Ensure screen updates provide needed changes

Review blur usage

- Avoid placing blurs over updating elements

Graphics

MacOS

Minimize use of Discrete GPU

Use Discrete GPU only when:

- Animation performance suffers
- Functionality isn't supported

Graphics

MacOS—Metal

MTLCreateSystemDefaultDevice()

- Always uses Discrete GPU

Use Integrated GPU when possible

- MTLCopyAllDevices
  - Select device with isLowPower attribute set

Graphics

MacOS—OpenGL

Make your app mux-aware by either:

- Adding NSSupportsAutomaticGraphicsSwitching to your info.plist

- Creating an OpenGL context with the automatic graphics switching attribute

```
let attributes3 : [CGLPixelFormatAttribute] = [
            kCGLPFASupportsAutomaticGraphicsSwitching,
            kCGLPFAAllowOfflineRenderers,
            CGLPixelFormatAttribute(0)
        ]
        CGLChoosePixelFormat(attributes3, &pix, &npix)
CGLCreateContext(pPixelFmt, nil, &pContext)
```

Graphics Best Practices

Identify:

- Blur usage

Optimize:

- Only use discrete GPU when needed (macOS)

Reduce:

- Minimize screen updates


CPU

Processing Best Practices

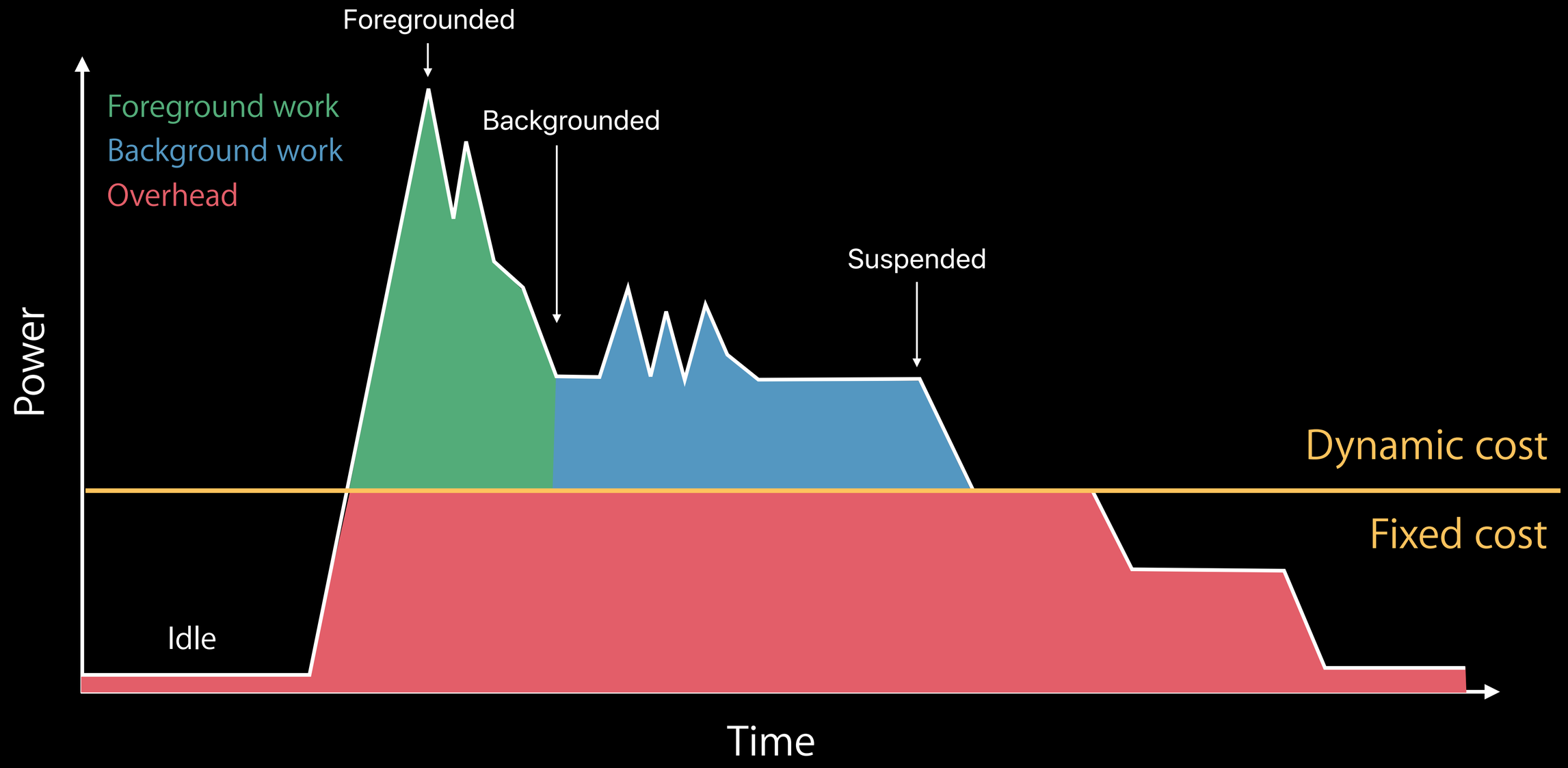
Identify tasks

Do work quickly and efficiently

Avoid timers

Set leeway

Background Processing

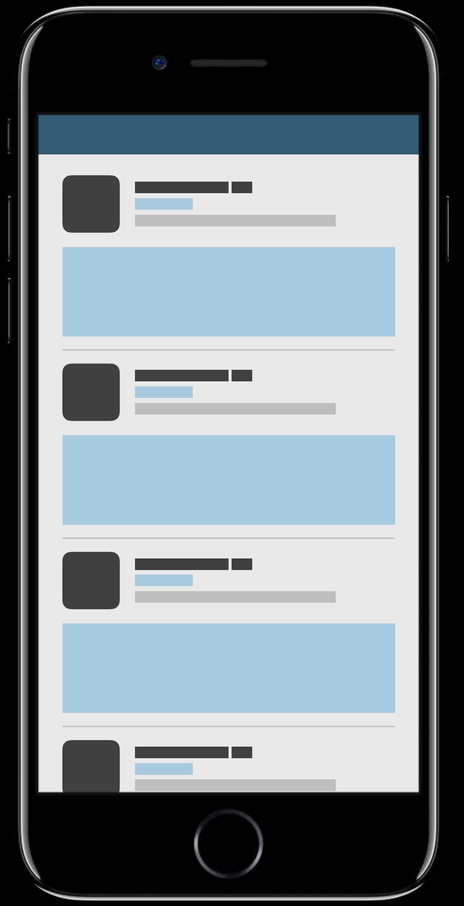


Background Processing

Finish work quickly

Use background app refresh

Call completion handler



Background Processing

iOS

PushKit API

- Now has completion handler
- Call after handling push

```
func pushRegistry(_ registry: PKPushRegistry, didReceiveIncomingPushWith payload:
PKPushPayload, forType type: PKPushType, withCompletionHandler completion: @escaping () ->
Void) {
        // Process the incoming push payload here...

        // Then signal that processing has completed
        completion()
    }
```

Background Processing

iOS

PushKit API

- Now has completion handler
- Call after handling push

```
func pushRegistry(_ registry: PKPushRegistry, didReceiveIncomingPushWith payload:
PKPushPayload, forType type: PKPushType, withCompletionHandler completion: @escaping () ->
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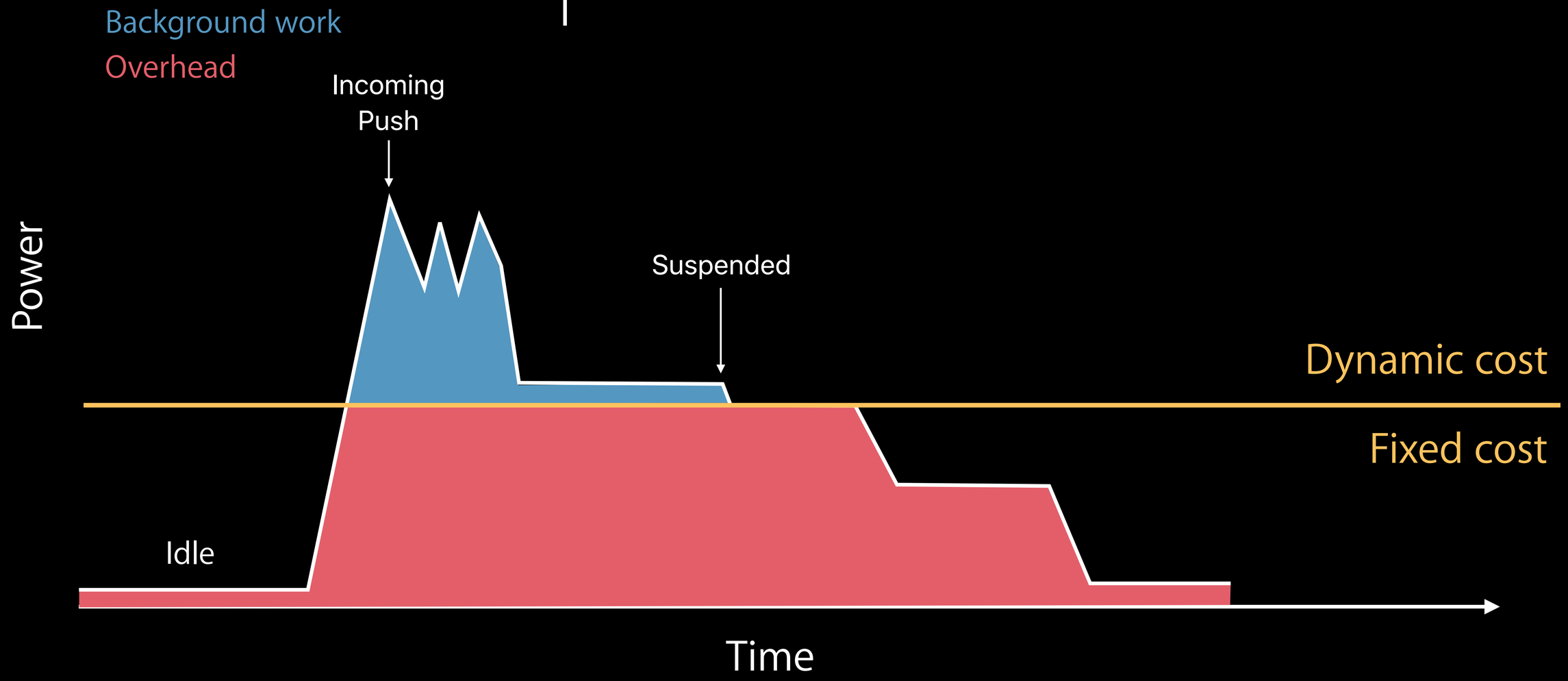
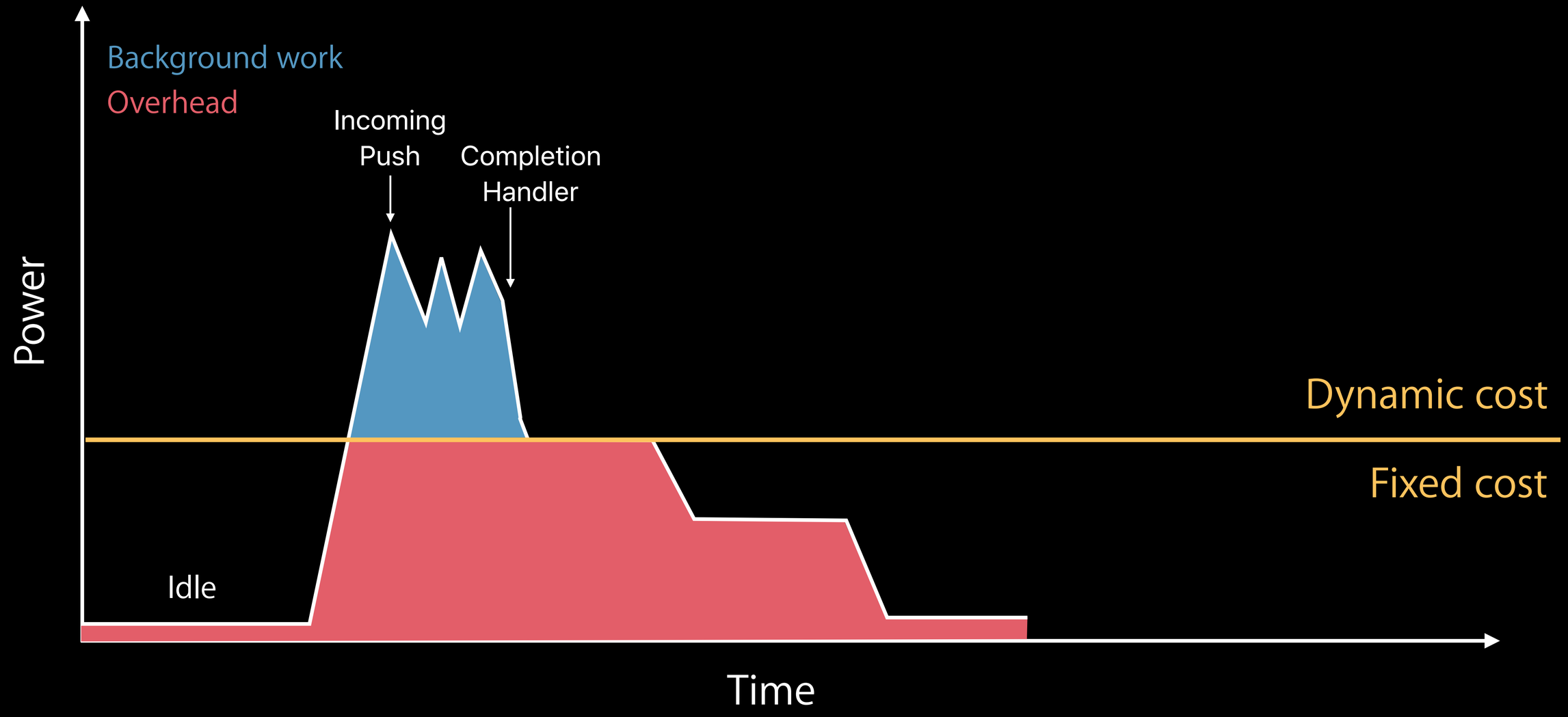
Background Processing

Current



Background Processing

With Completion Handler



Background Processing

WatchOS

New: Navigation background mode

- CPU limits like Workout
- Minimize networking
- Ensure work is relevant to the user

Use background app refresh and complication updates to refresh data

Background Processing

Identify:

- Work done in the background

Optimize:

- Use Background App Refresh

Reduce:

- Limit transactions

Coalesce:

- Use NSURLSession background session

Battery Life Concepts

Energy Efficient Coding

Energy Debugging Tools and Demo

Final Thoughts

Overview

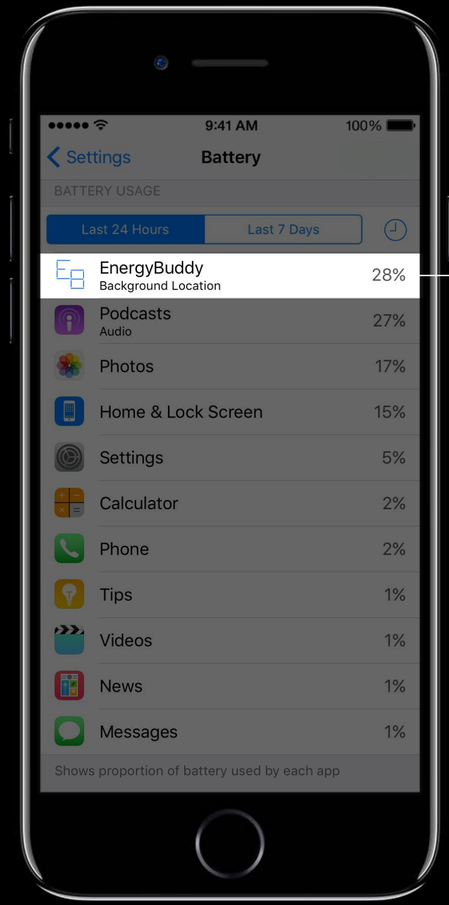
Energy debugging tools

Measuring energy impact of your apps

Demo

Settings: Battery

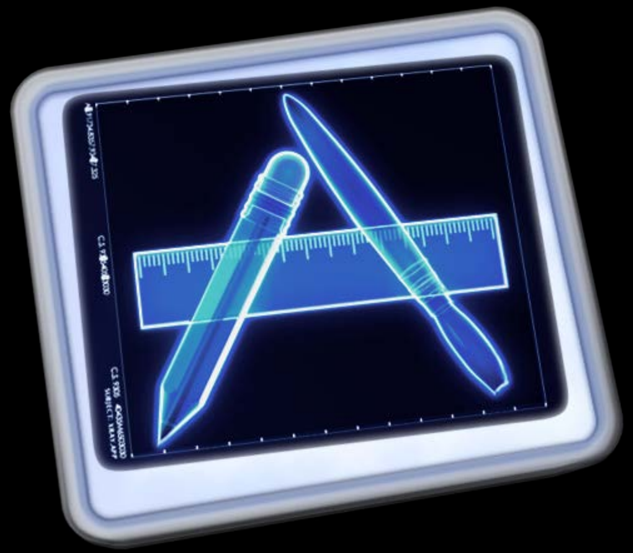
Settings: Battery

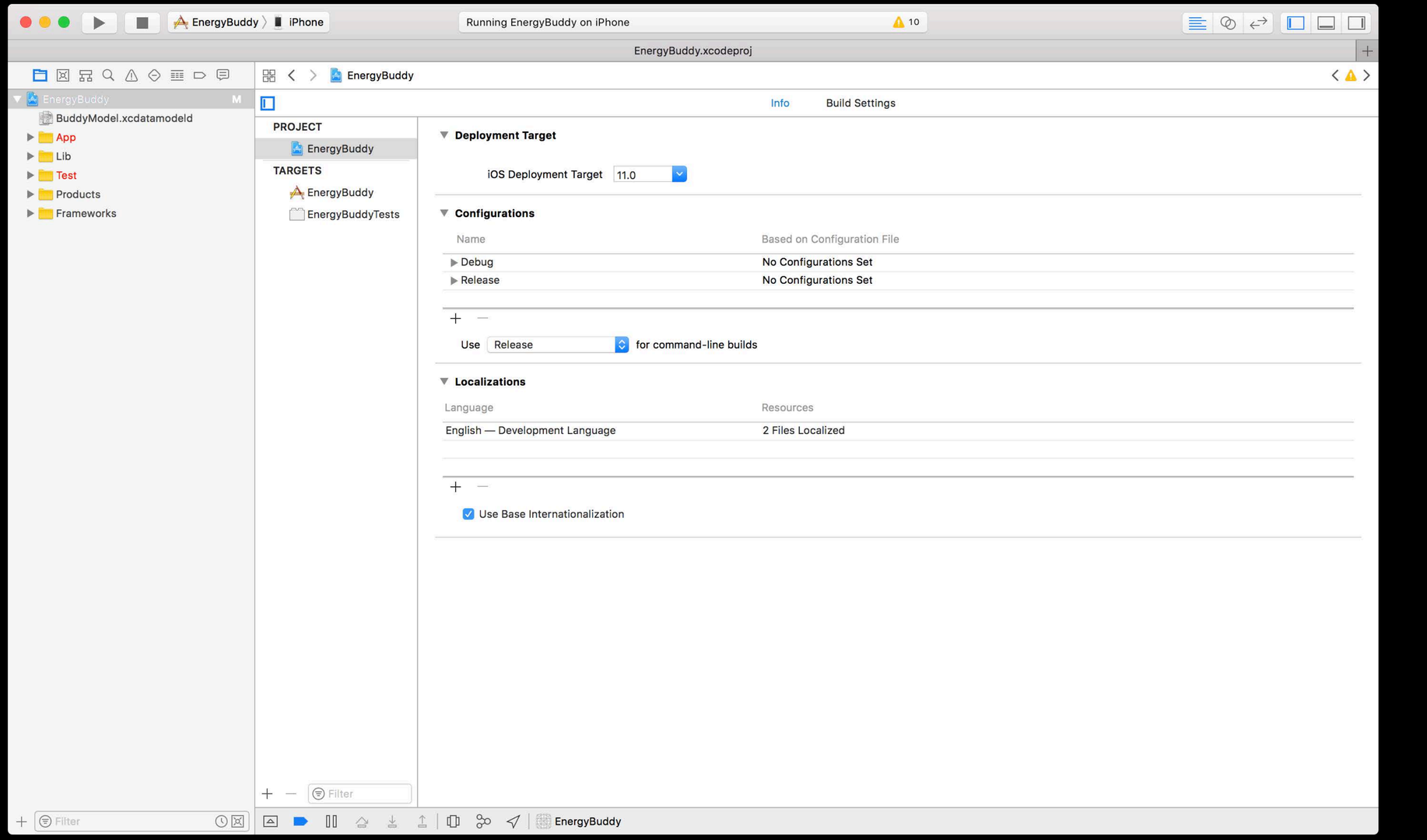


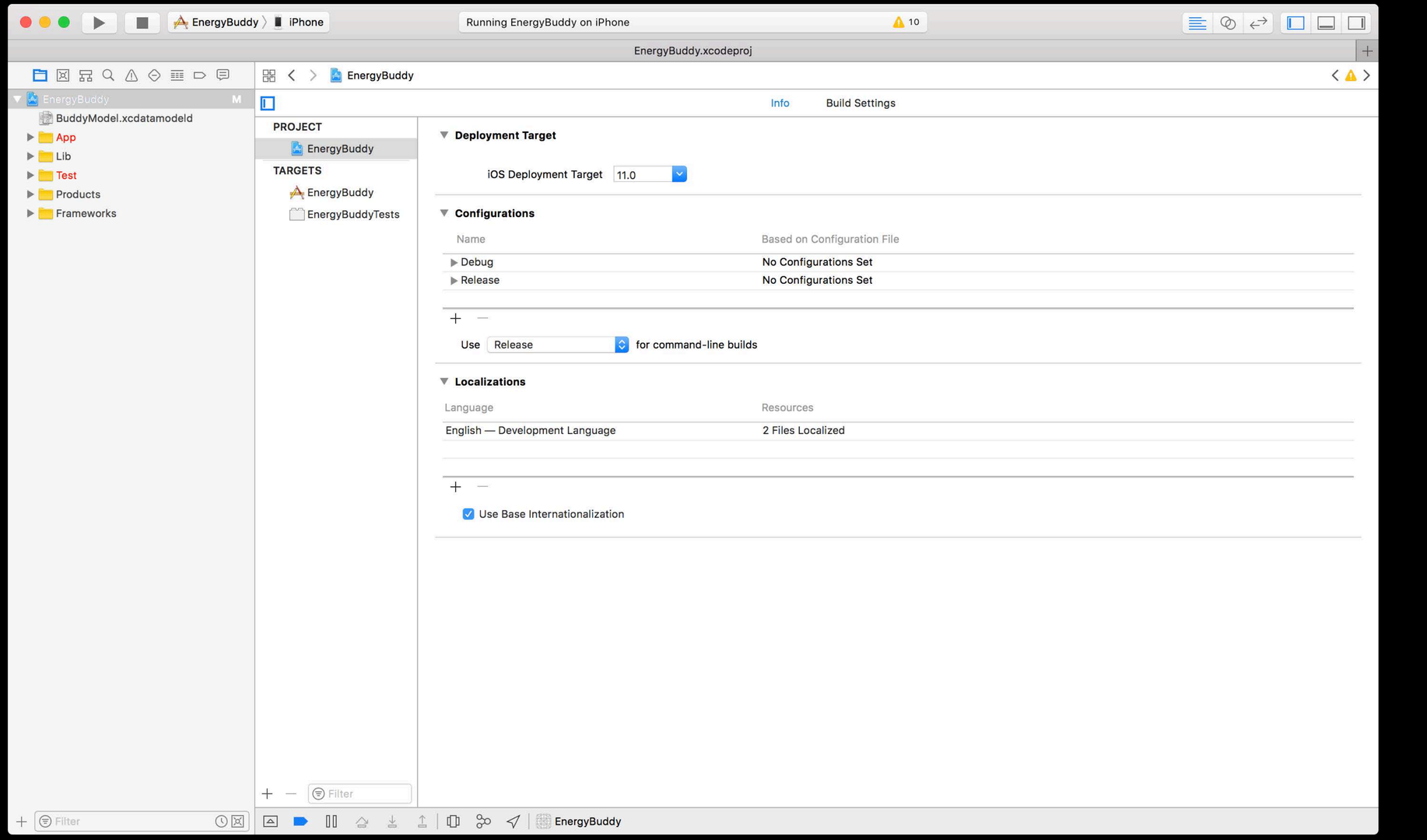
Can be deleted by users

Energy Debugging Workflow

Energy Gauges




EnergyBuddy 〉 iPhone
Running EnergyBuddy on iPhone
10
EnergyBuddy.xcodeproj
EnergyBuddy
M
BuddyModel.xcdatamodeld
App
Lib
Test
Products
Frameworks
Filter
EnergyBuddy
Info
Build Settings
PROJECT
EnergyBuddy
TARGETS
EnergyBuddy
EnergyBuddyTests
Filter
Deployment Target
iOS Deployment Target
11.0
Configurations
Name
Based on Configuration File
Debug
No Configurations Set
Release
No Configurations Set
Use
Release
for command-line builds
Localizations
Language
Resources
English — Development Language
2 Files Localized
Use Base Internationalization
EnergyBuddy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Running EnergyBuddy on iPhone
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EnergyBuddy.xcodeproj
EnergyBuddy
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BuddyModel.xcdatamodeld
App
Lib
Test
Products
Frameworks
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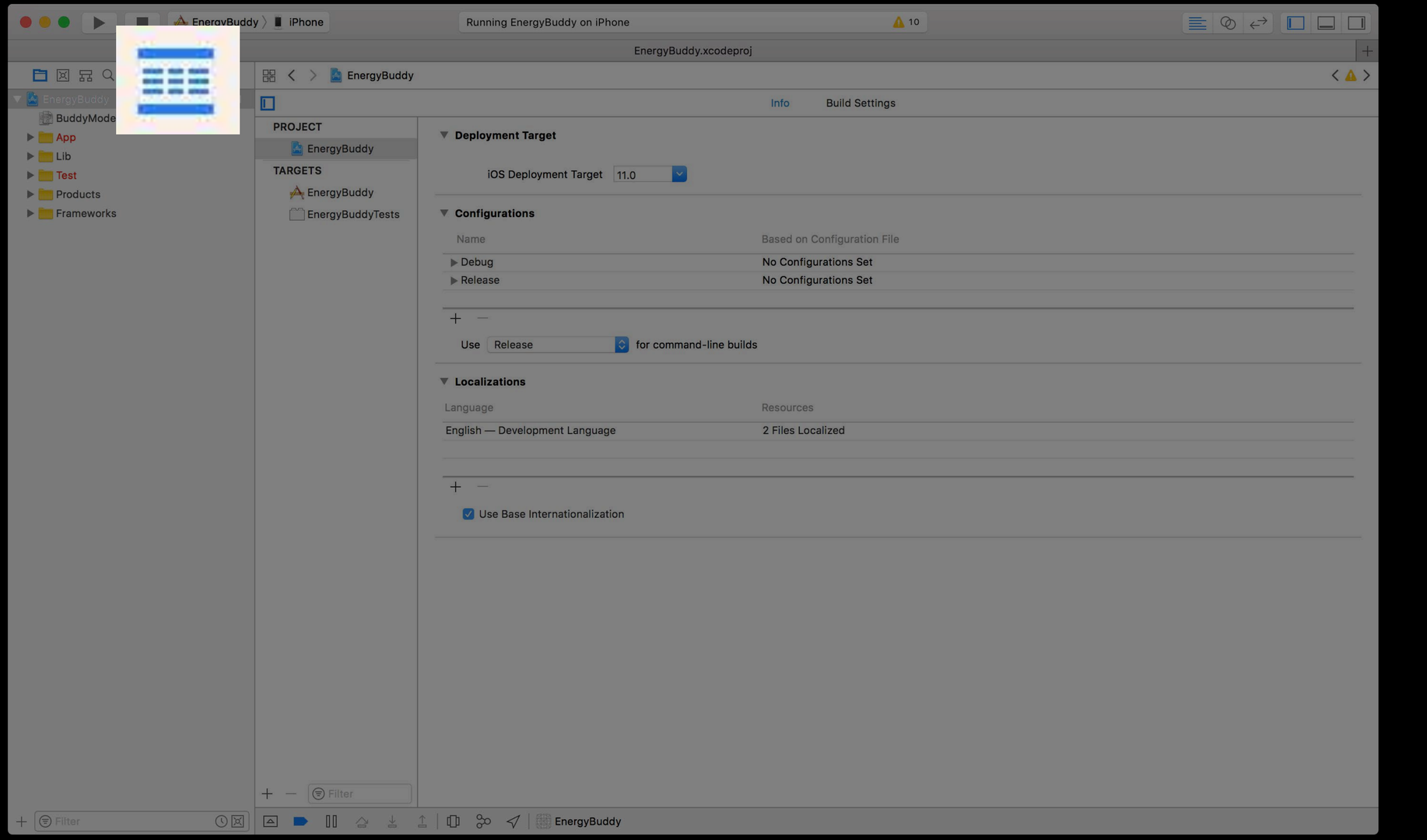
EnergyBuddy
Info
Build Settings
PROJECT
EnergyBuddy
TARGETS
EnergyBuddy
EnergyBuddyTests
Filter
Deployment Target
iOS Deployment Target
11.0
Configurations
Name
Based on Configuration File
Debug
No Configurations Set
Release
No Configurations Set
Use
Release
for command-line builds
Localizations
Language
Resources
English — Development Language
2 Files Localized
Use Base Internationalization
EnergyBuddy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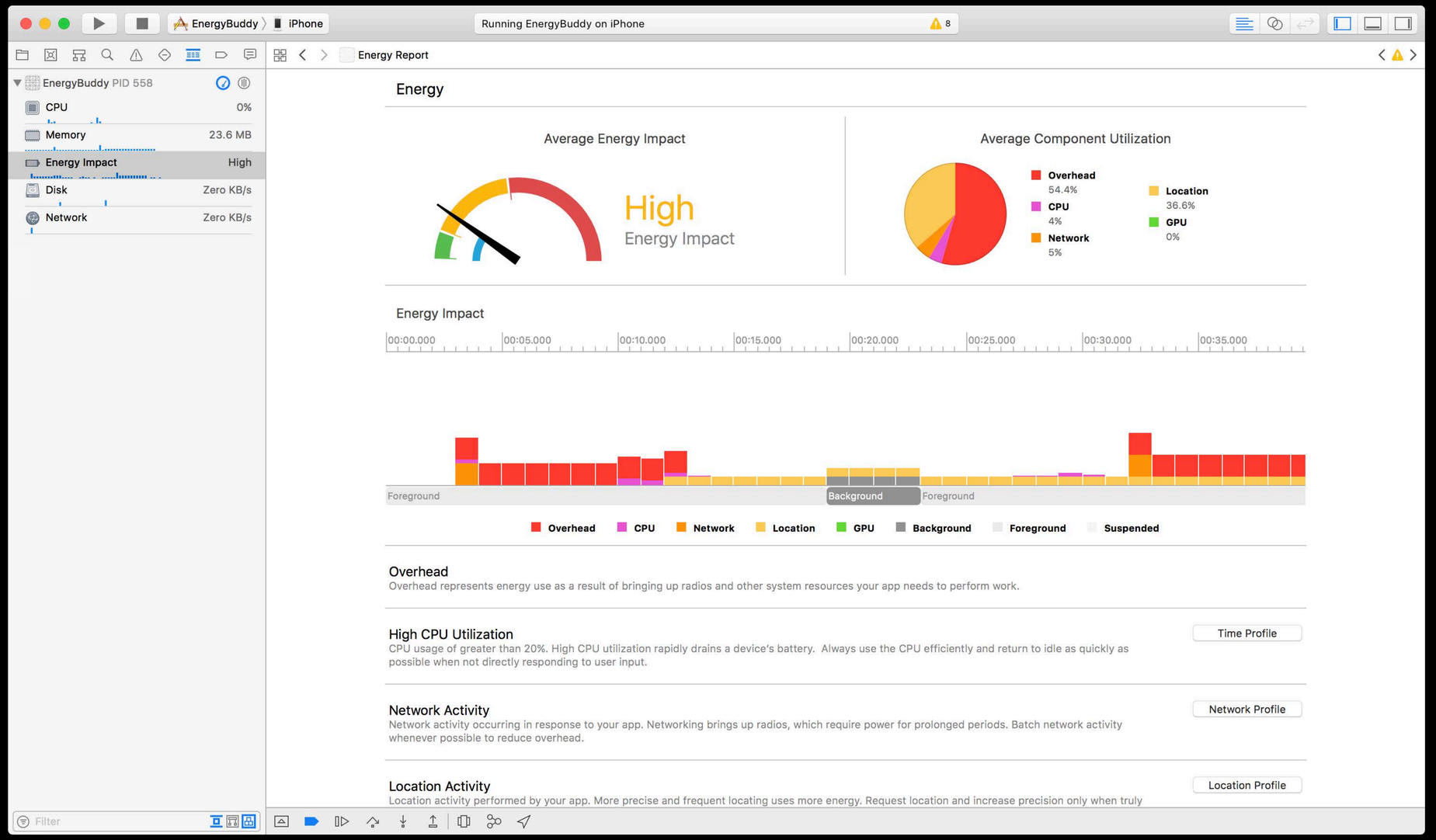
EnergyBuddy
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Energy Report
EnergyBuddy PID 558
CPU 0%
Memory 23.6 MB
Energy Impact High
Disk Zero KB/s
Network Zero KB/s
Filter
Energy
Average Energy Impact
High
Energy Impact
Average Component Utilization
Overhead 54.4%
CPU 4%
Network 5%
Location 36.6%
GPU 0%
Energy Impact
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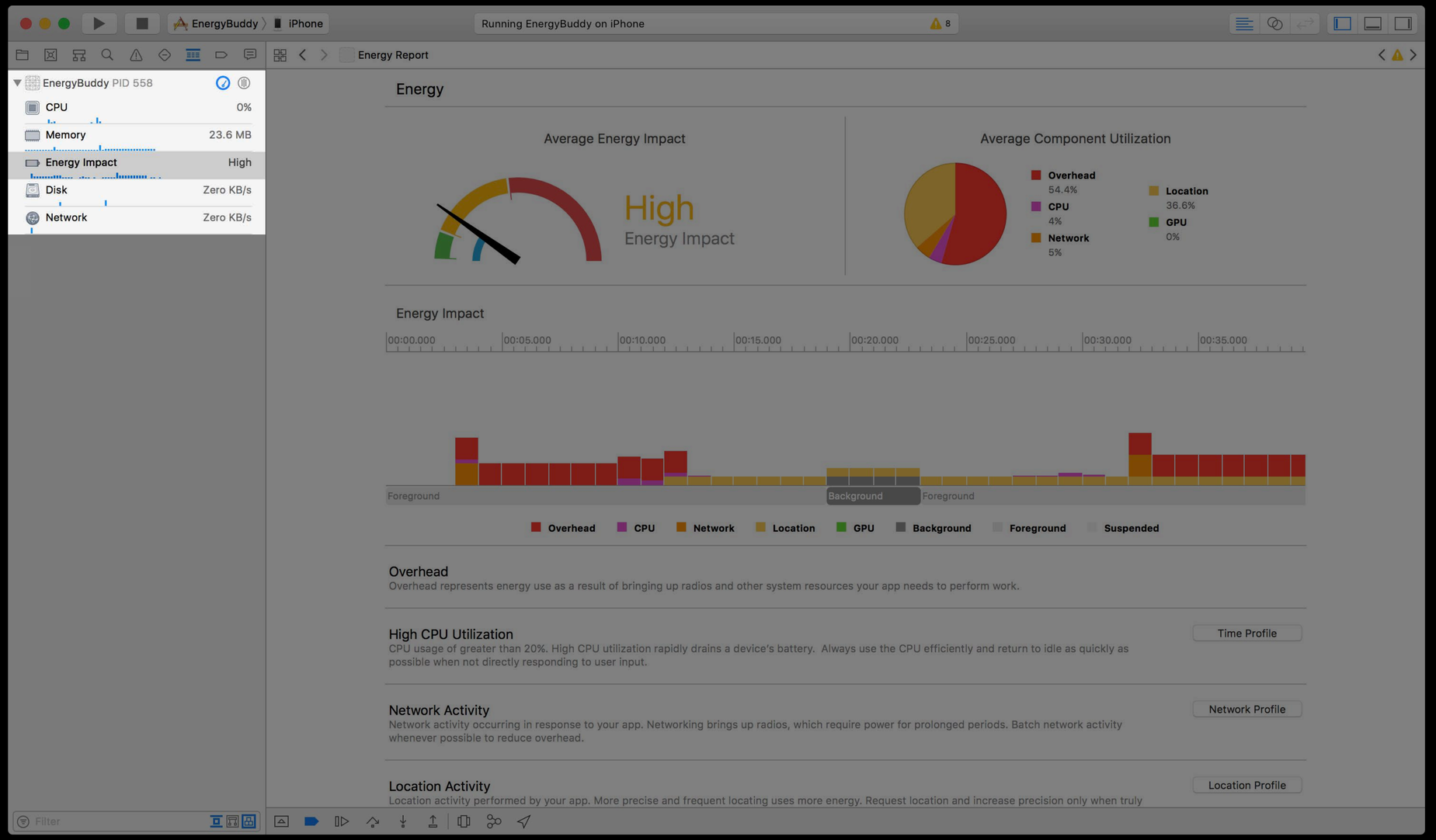
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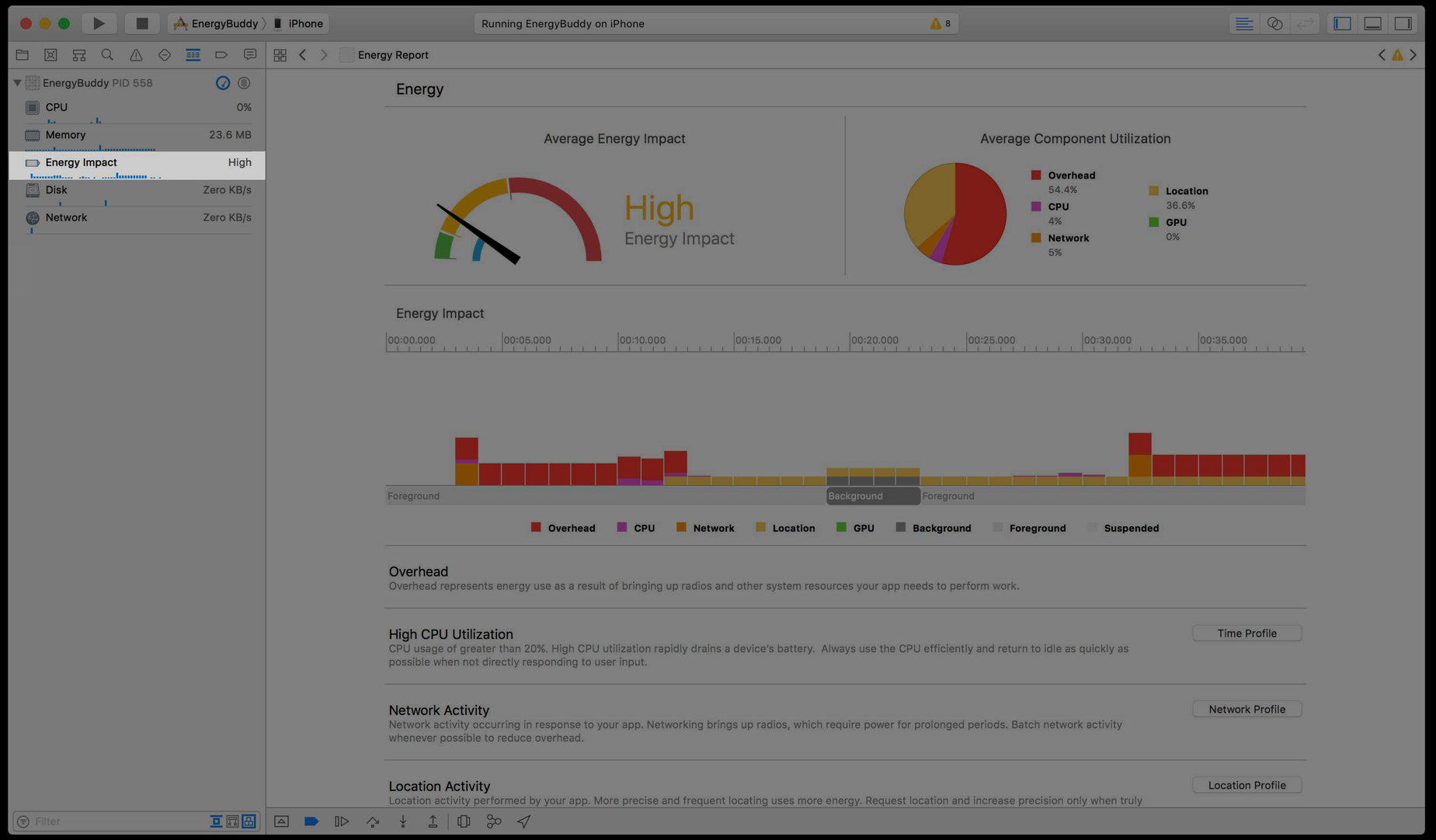
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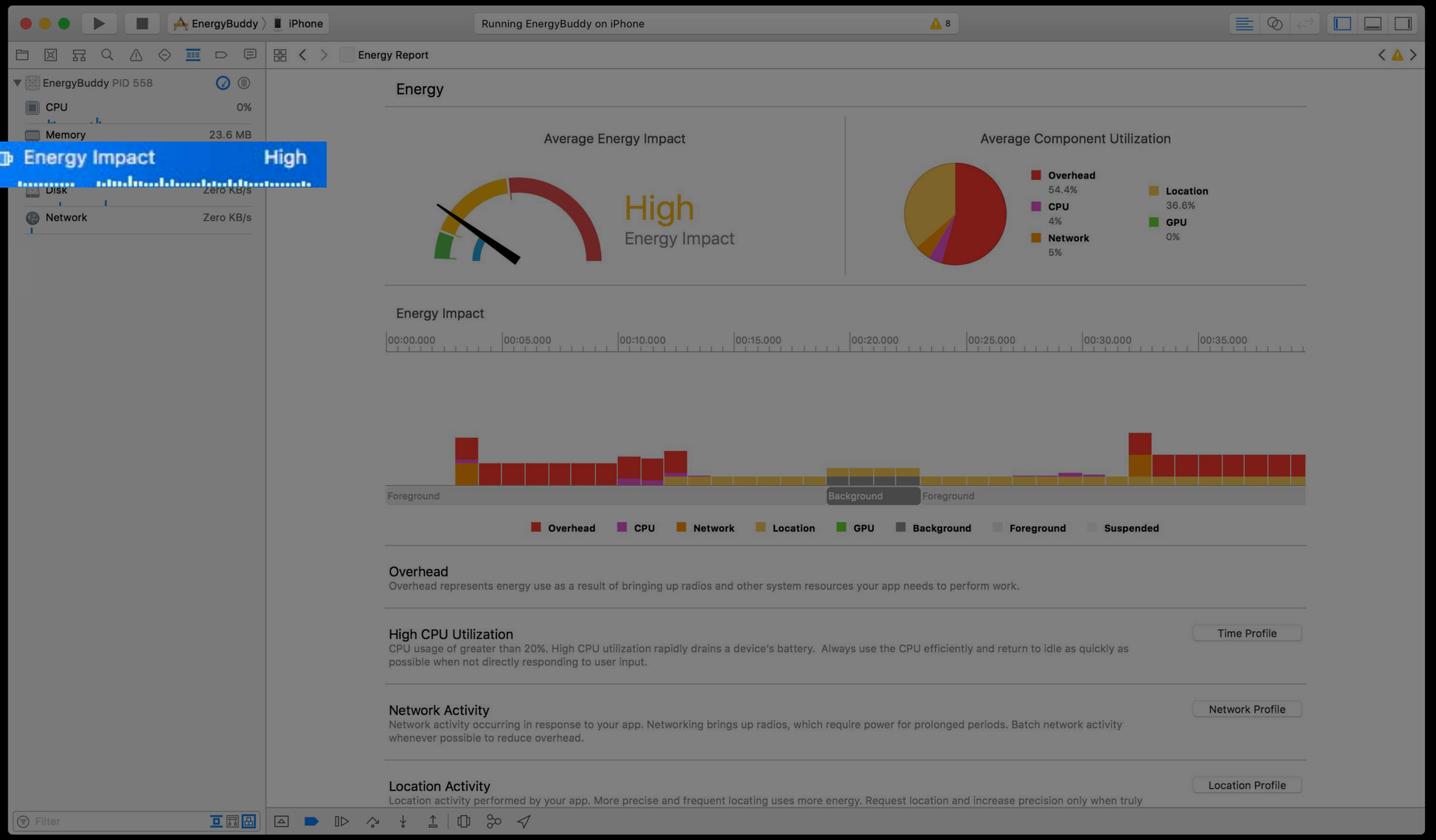
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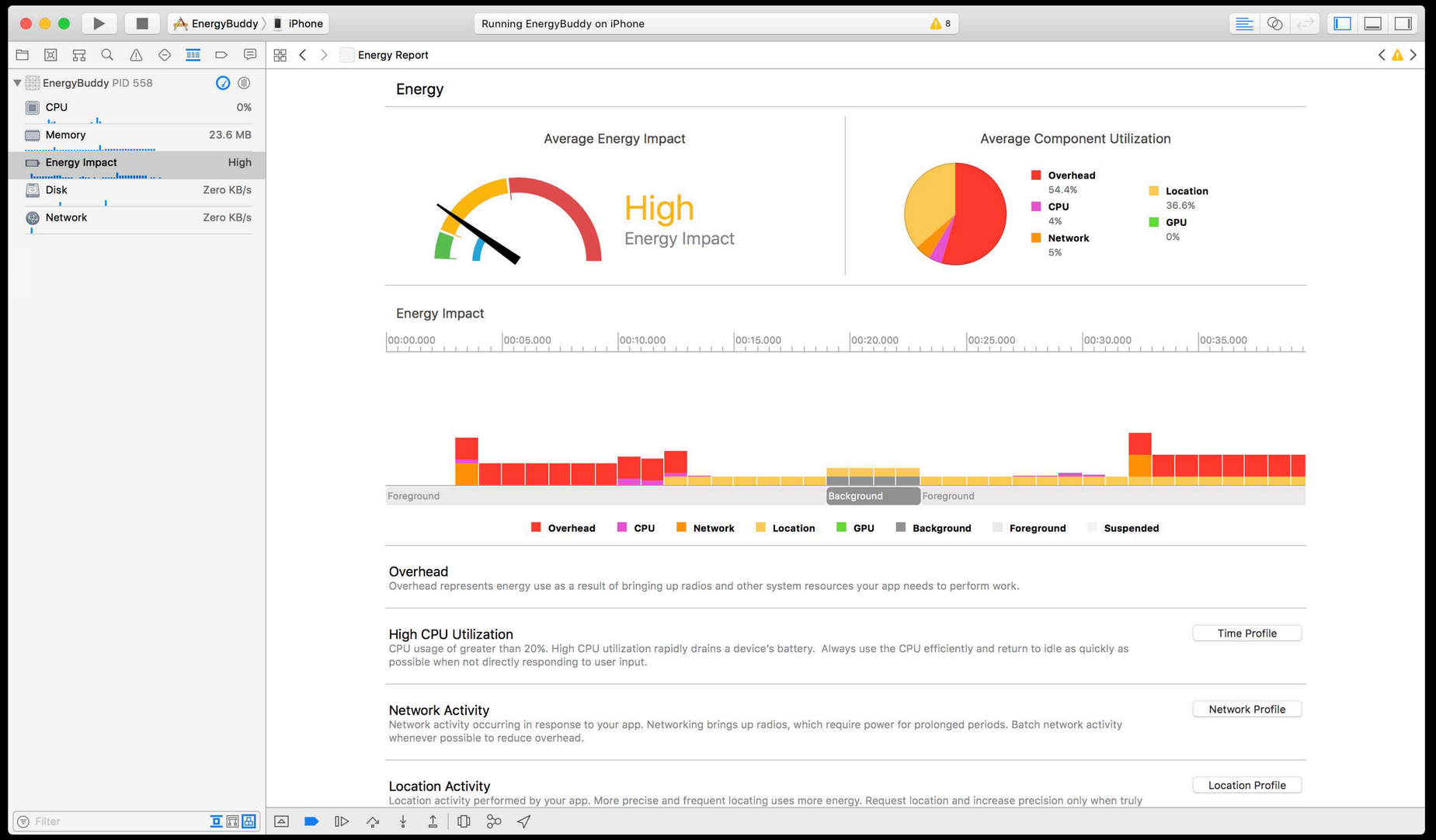
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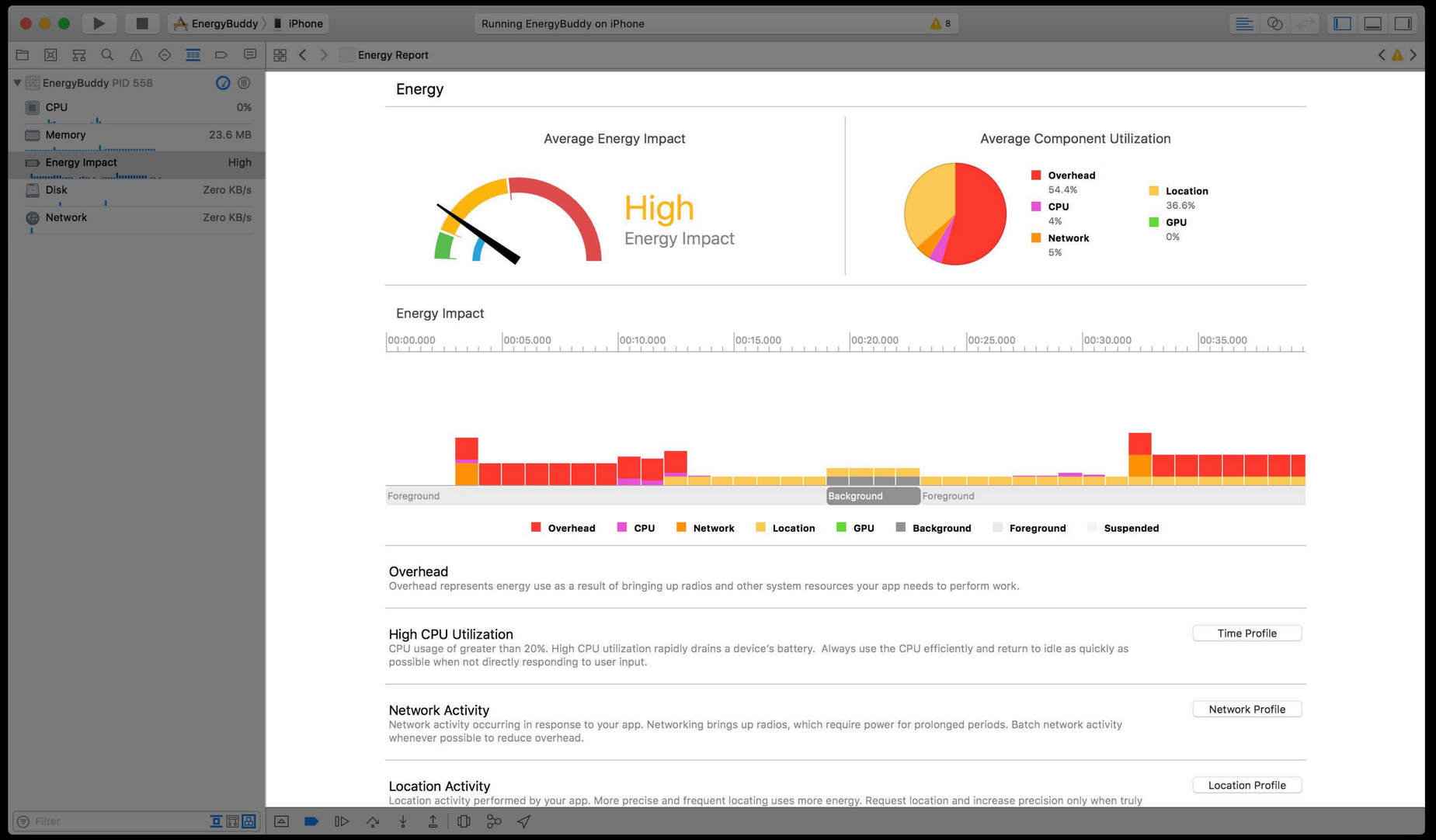
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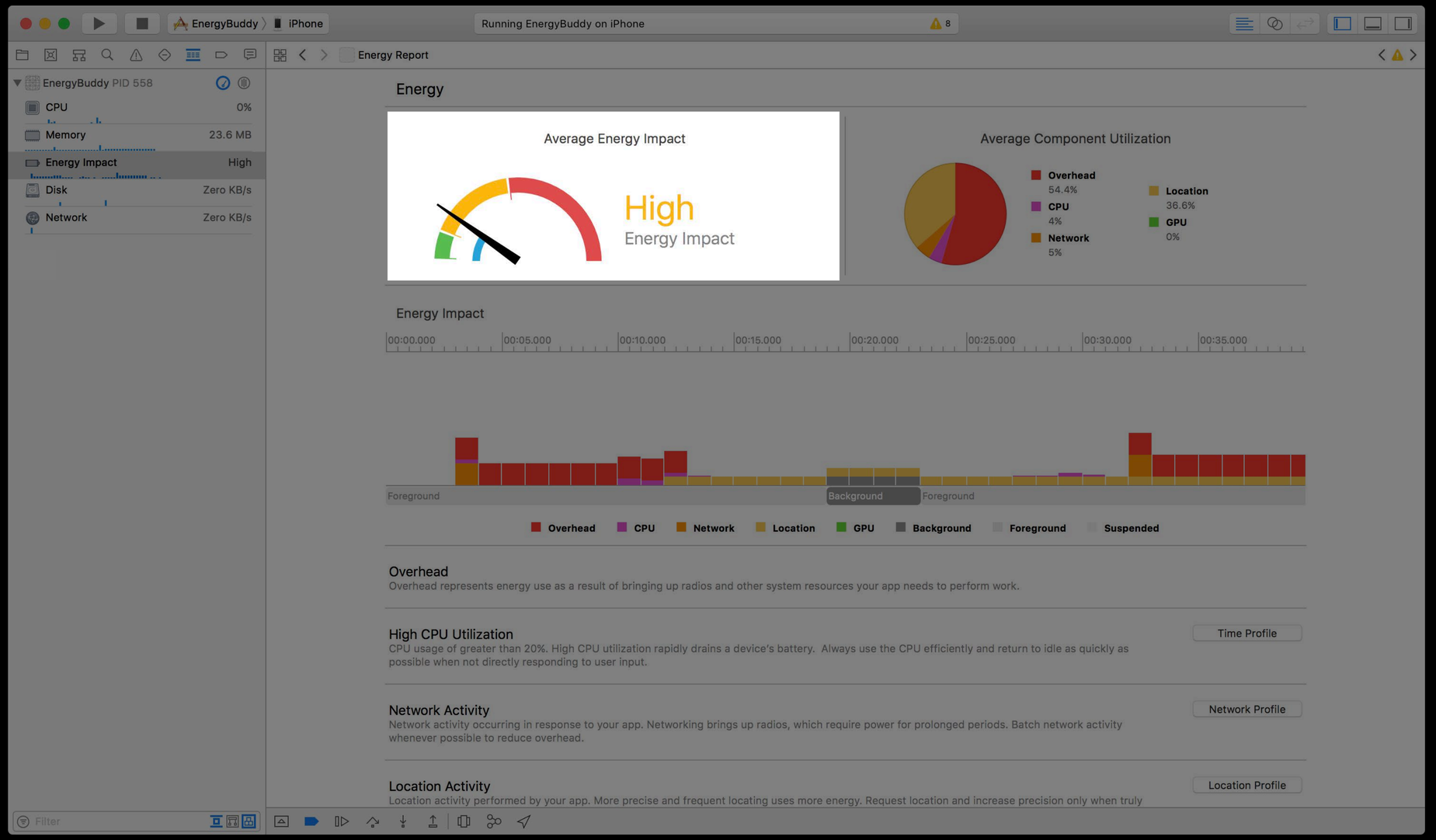
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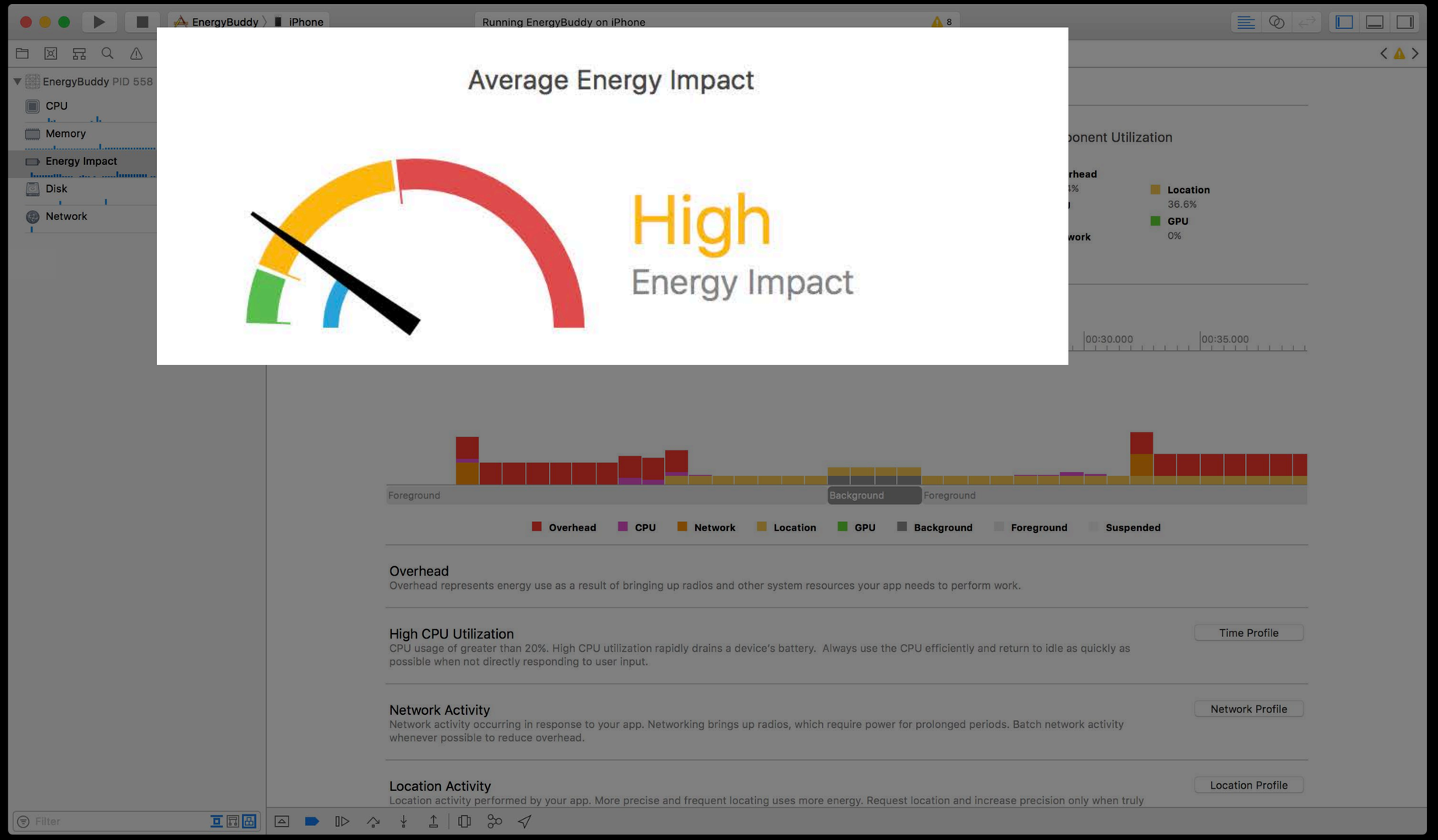
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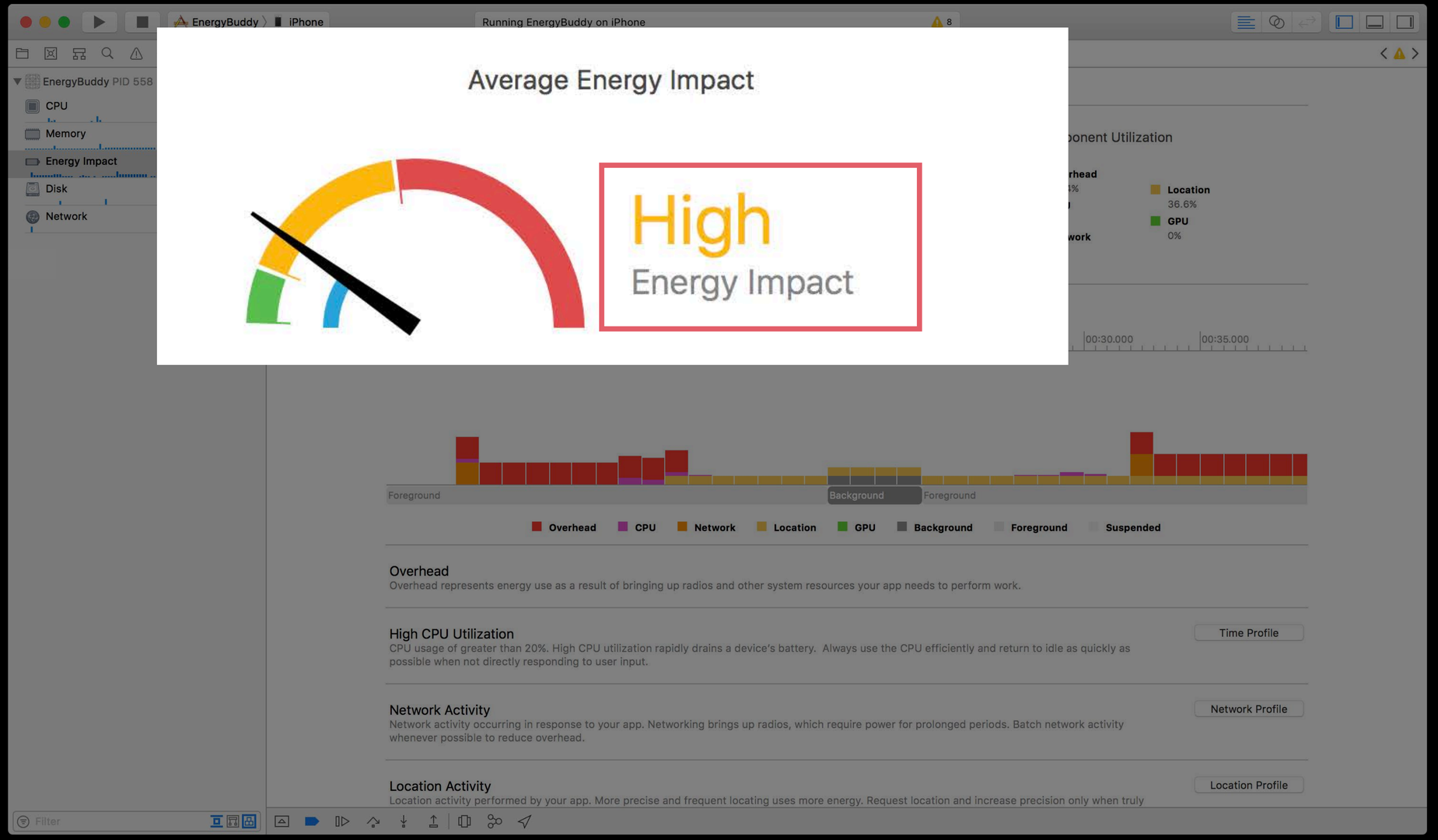
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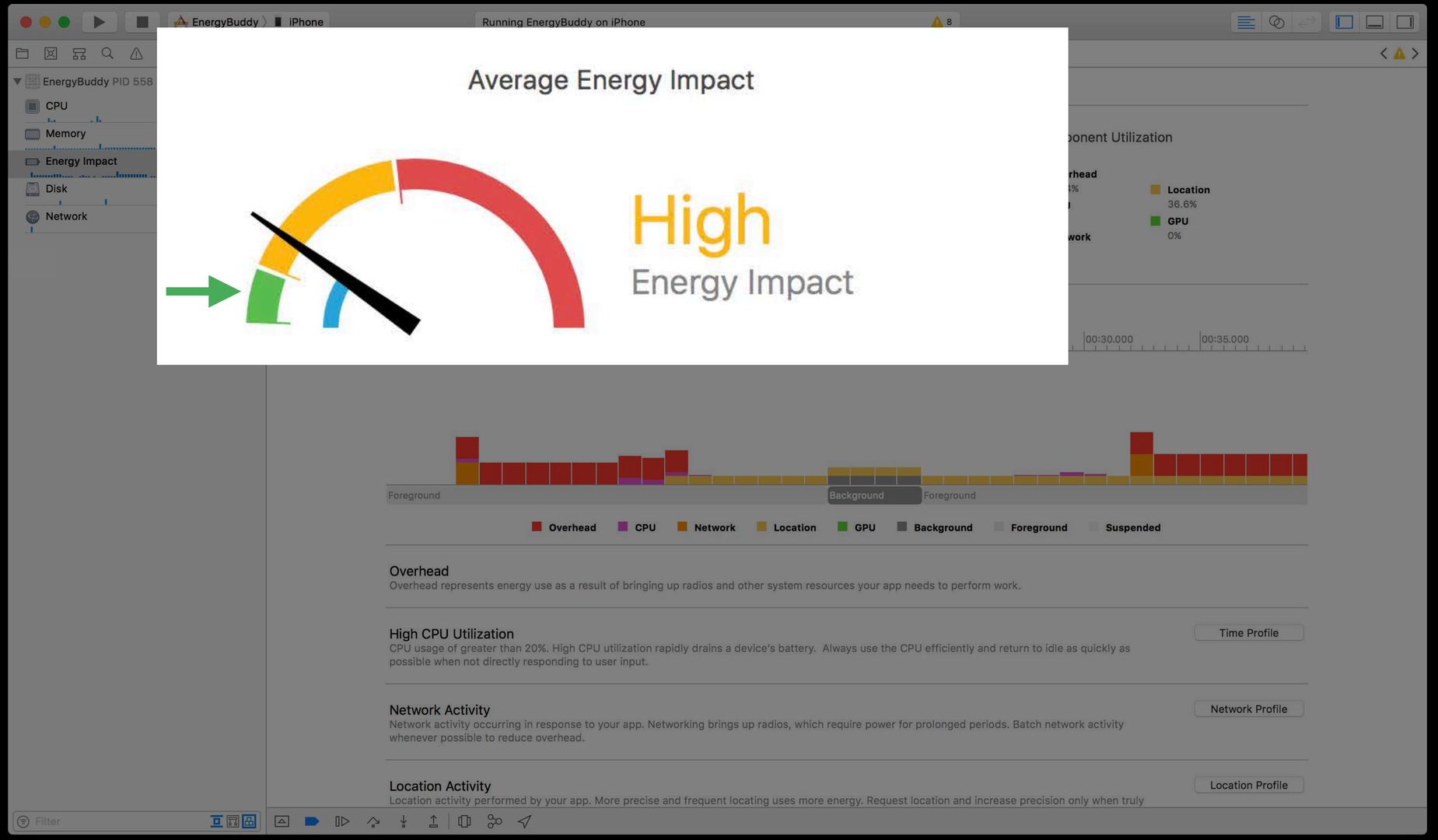
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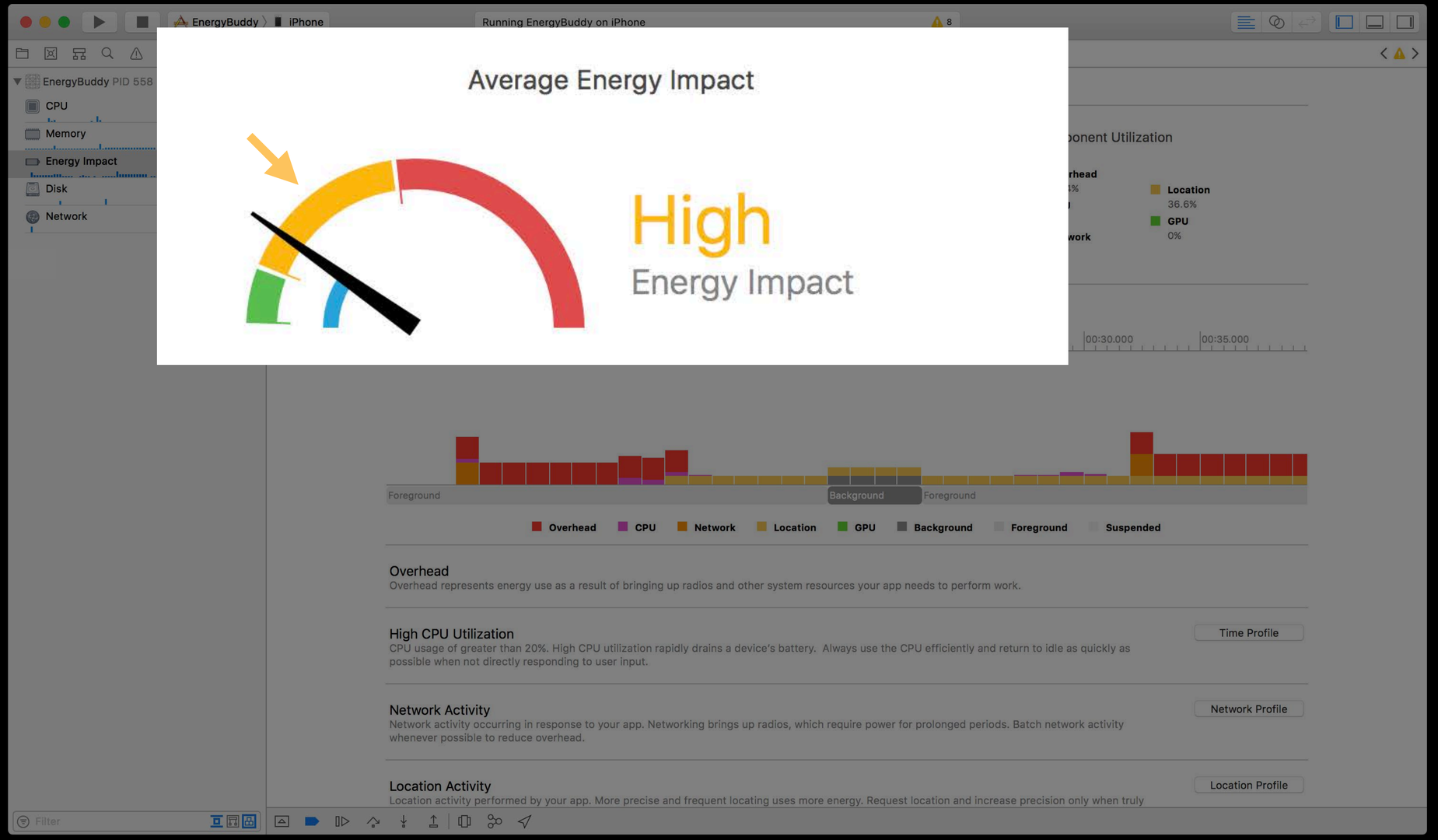
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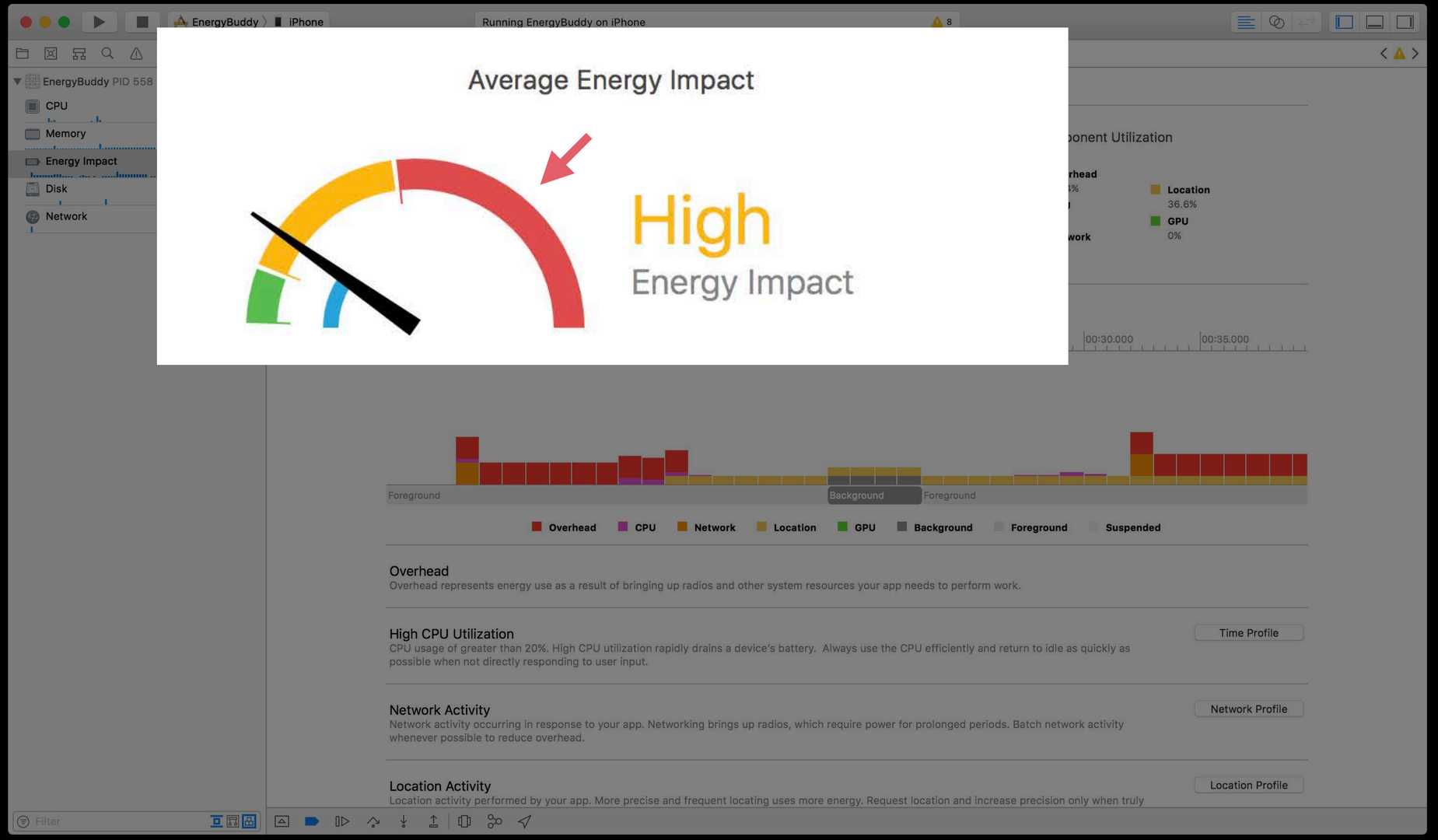
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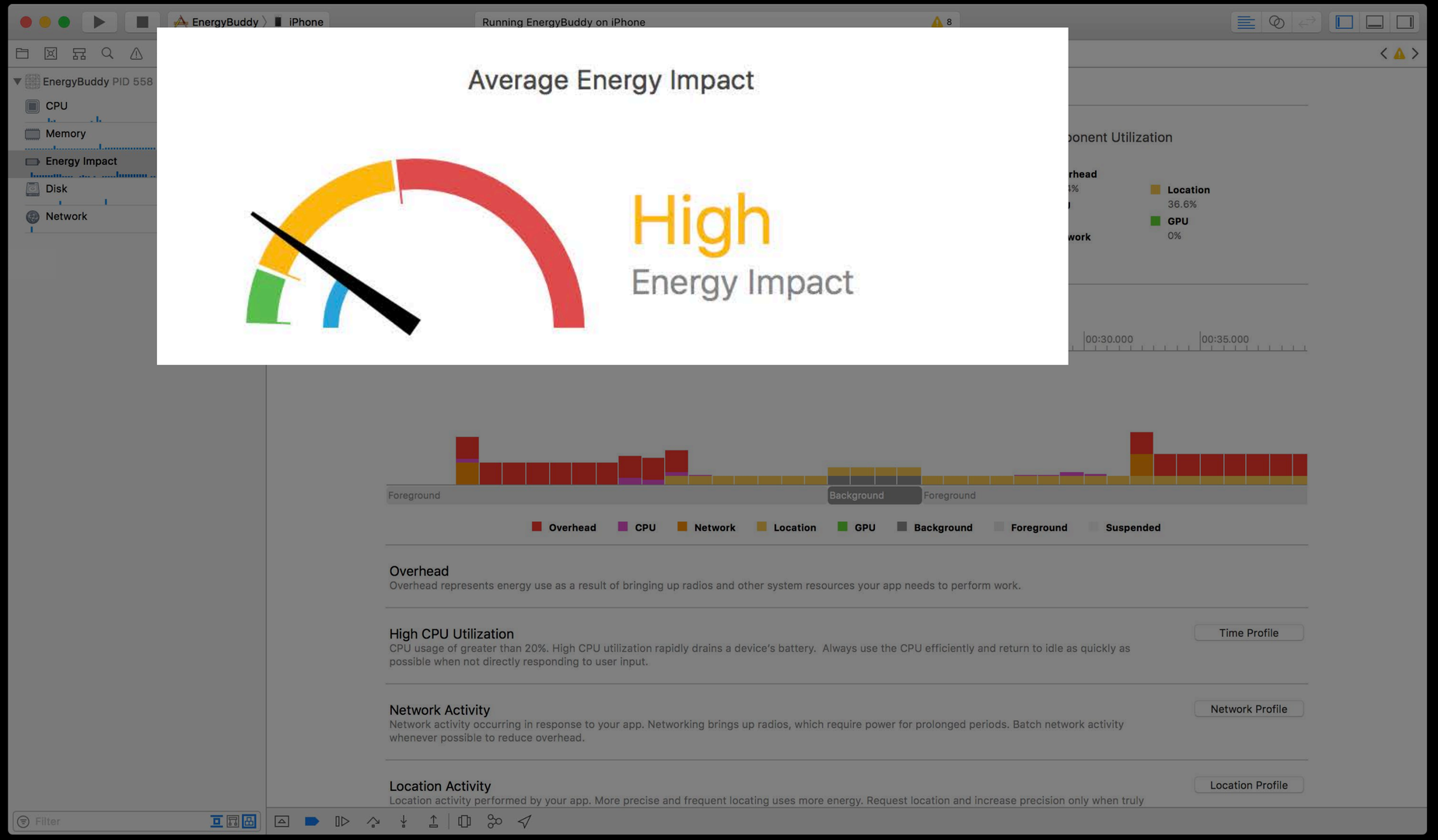
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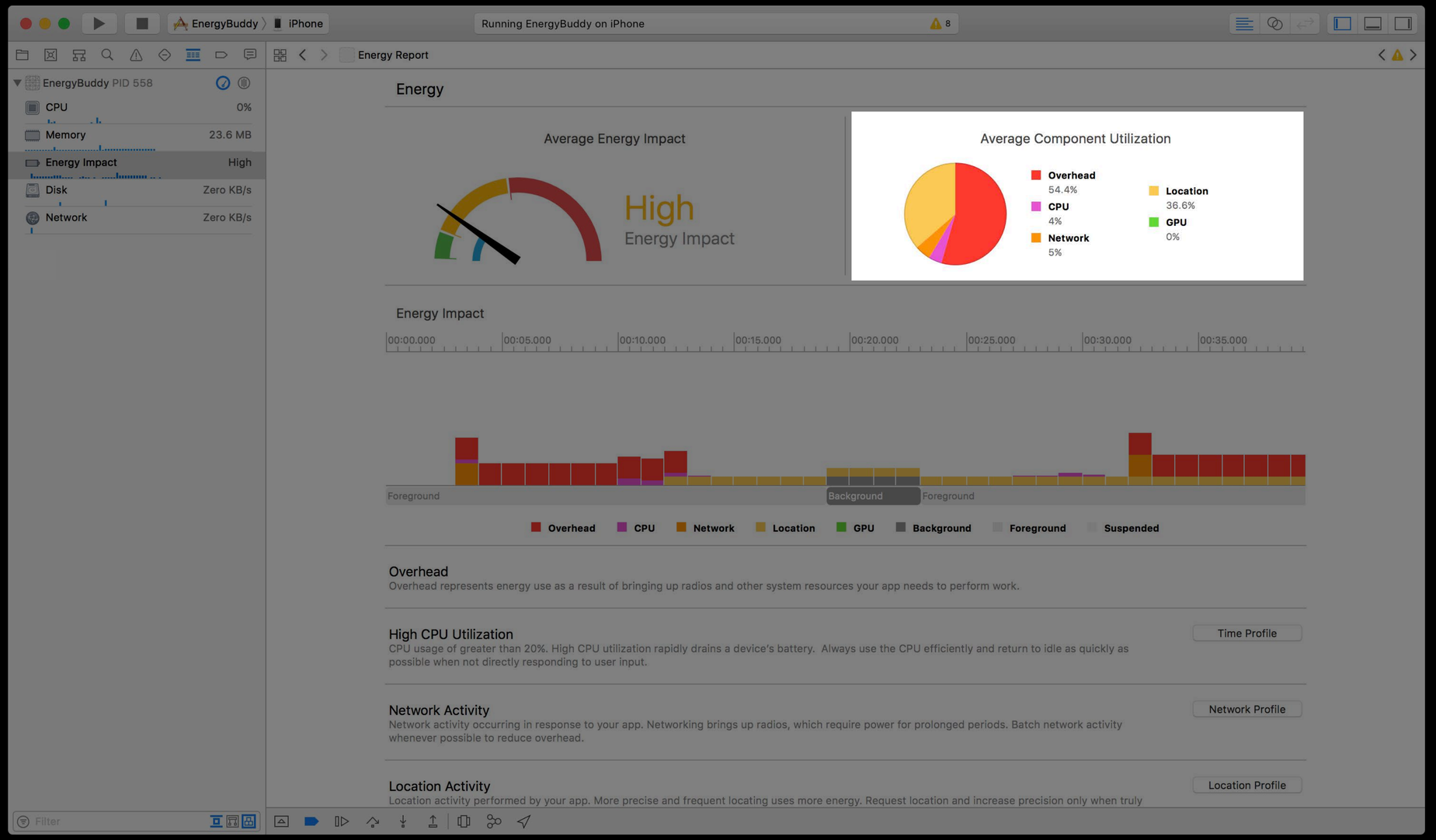
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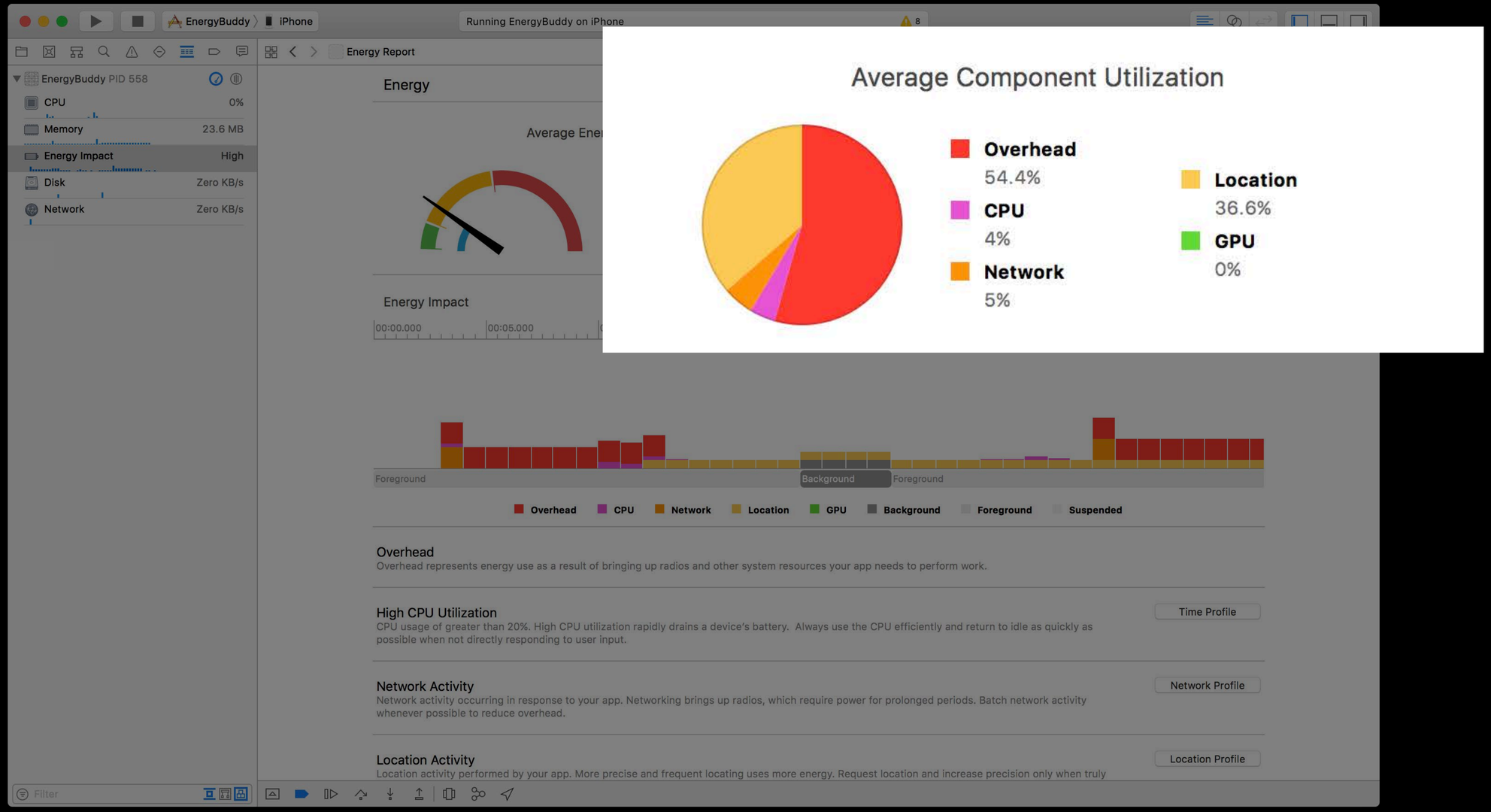
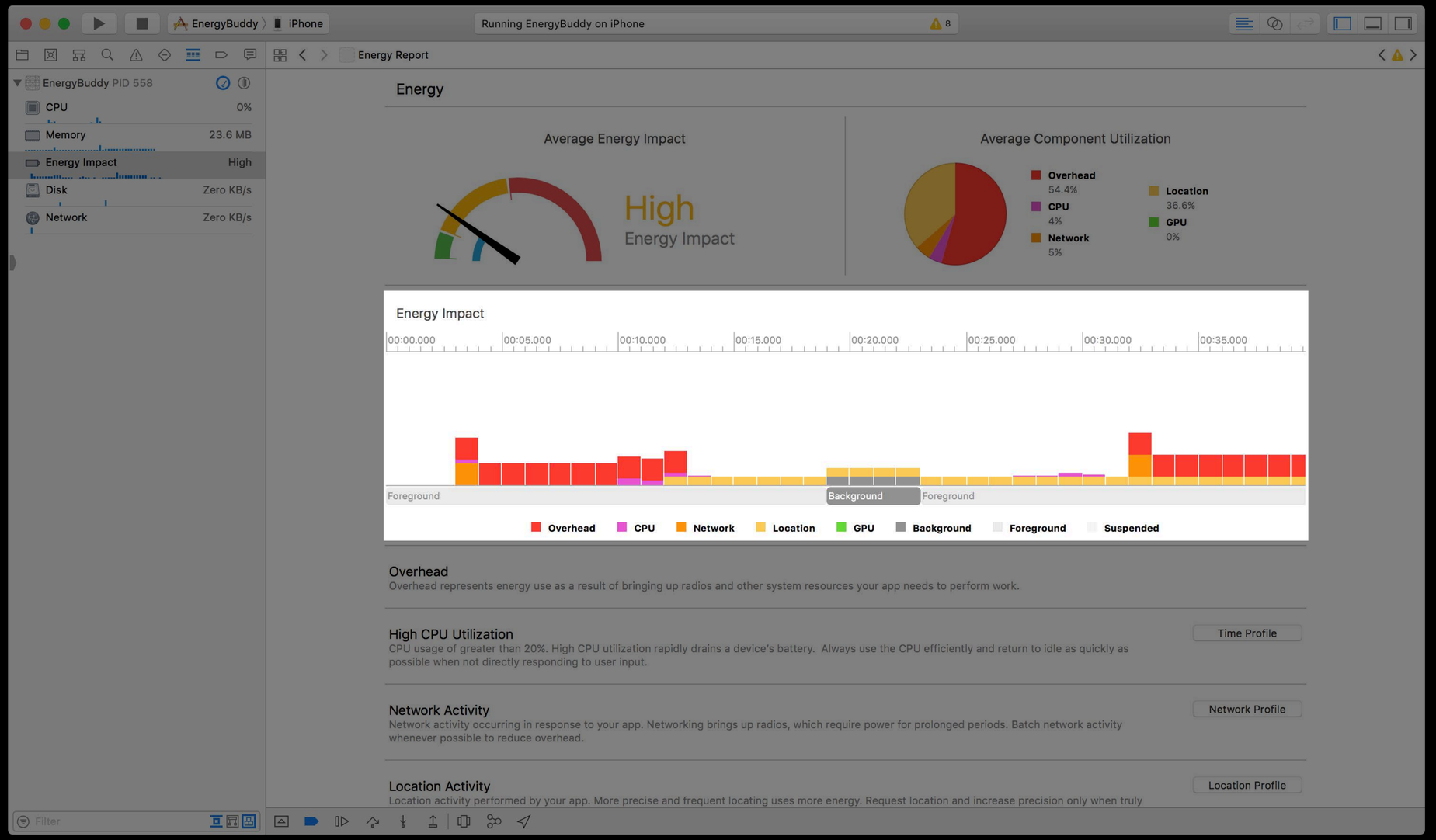


Average Component Utilization

- **Overhead** 54.4%
- **CPU** 4%
- **Network** 5%
- **Location** 36.6%
- **GPU** 0%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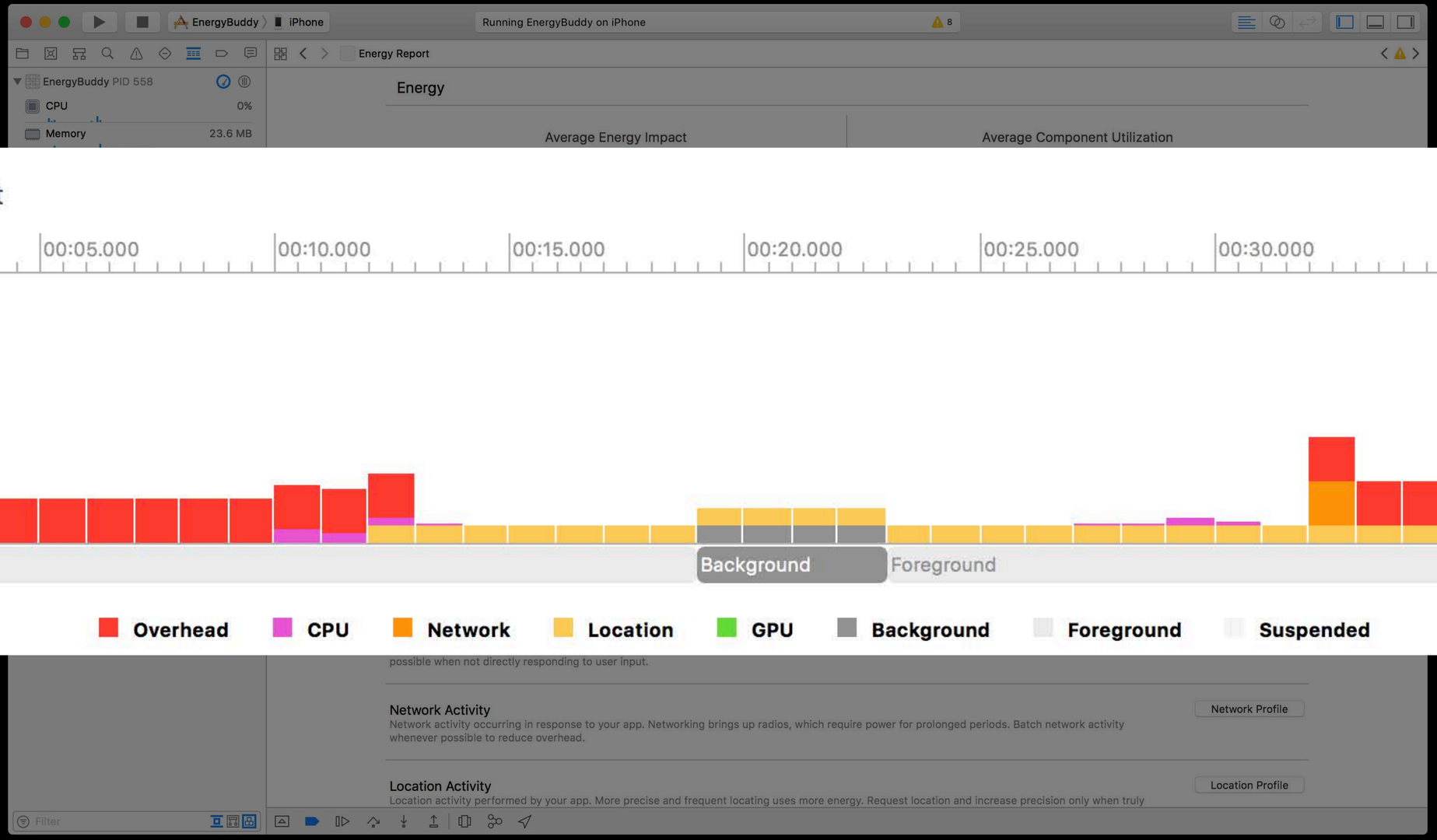
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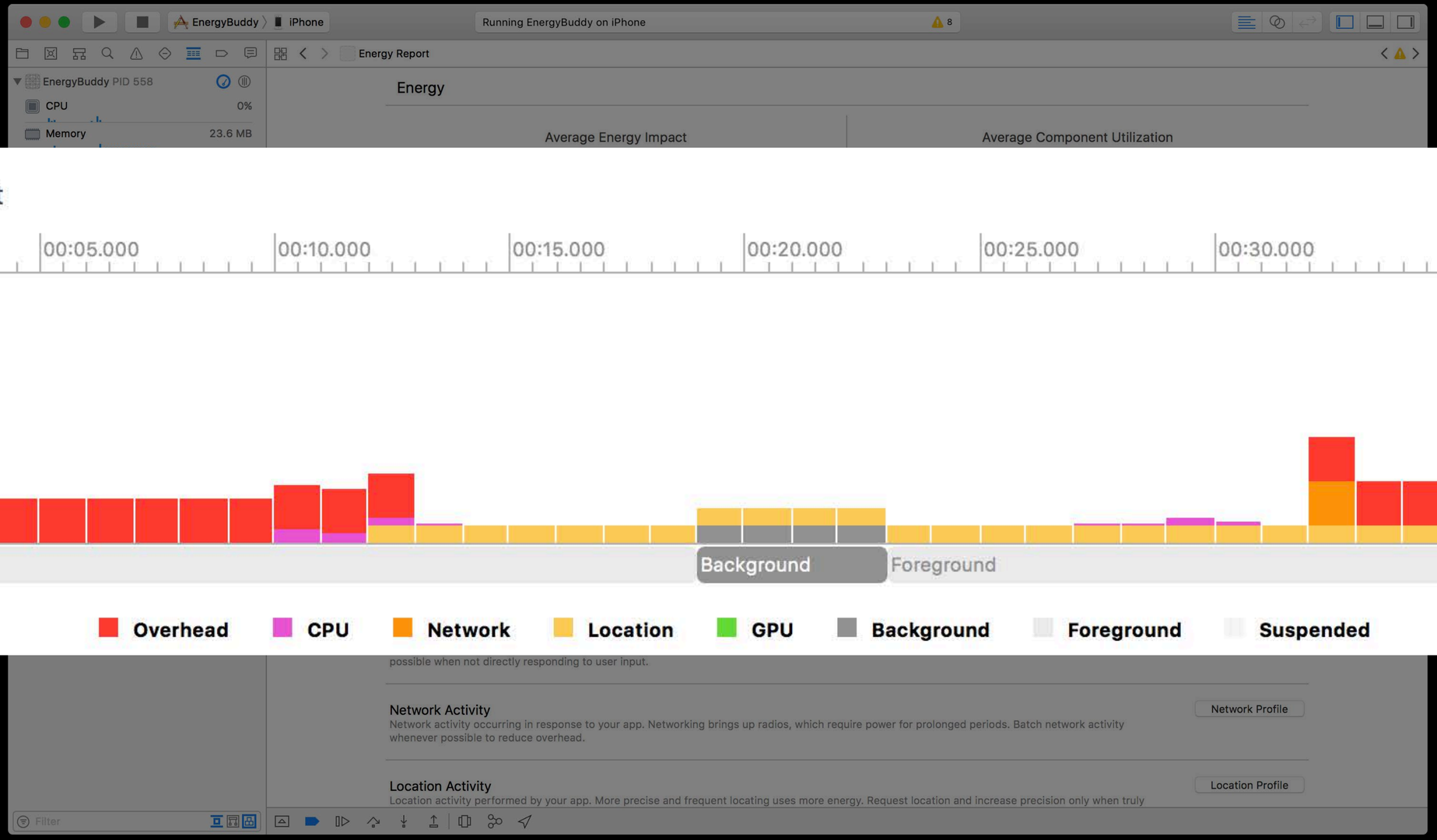
EnergyBuddy
iPhone
Running EnergyBuddy on iPhone
Energy Report
EnergyBuddy PID 558
CPU
0%
Memory
23.6 MB
Energy
Average Energy Impact
Average Component Utilization
Energy Impact
00:00.000
00:05.000
00:10.000
00:15.000
00:20.000
00:25.000
00:30.000
00:35.000
Foreground
Background
Foreground
Overhead
CPU
Network
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GPU
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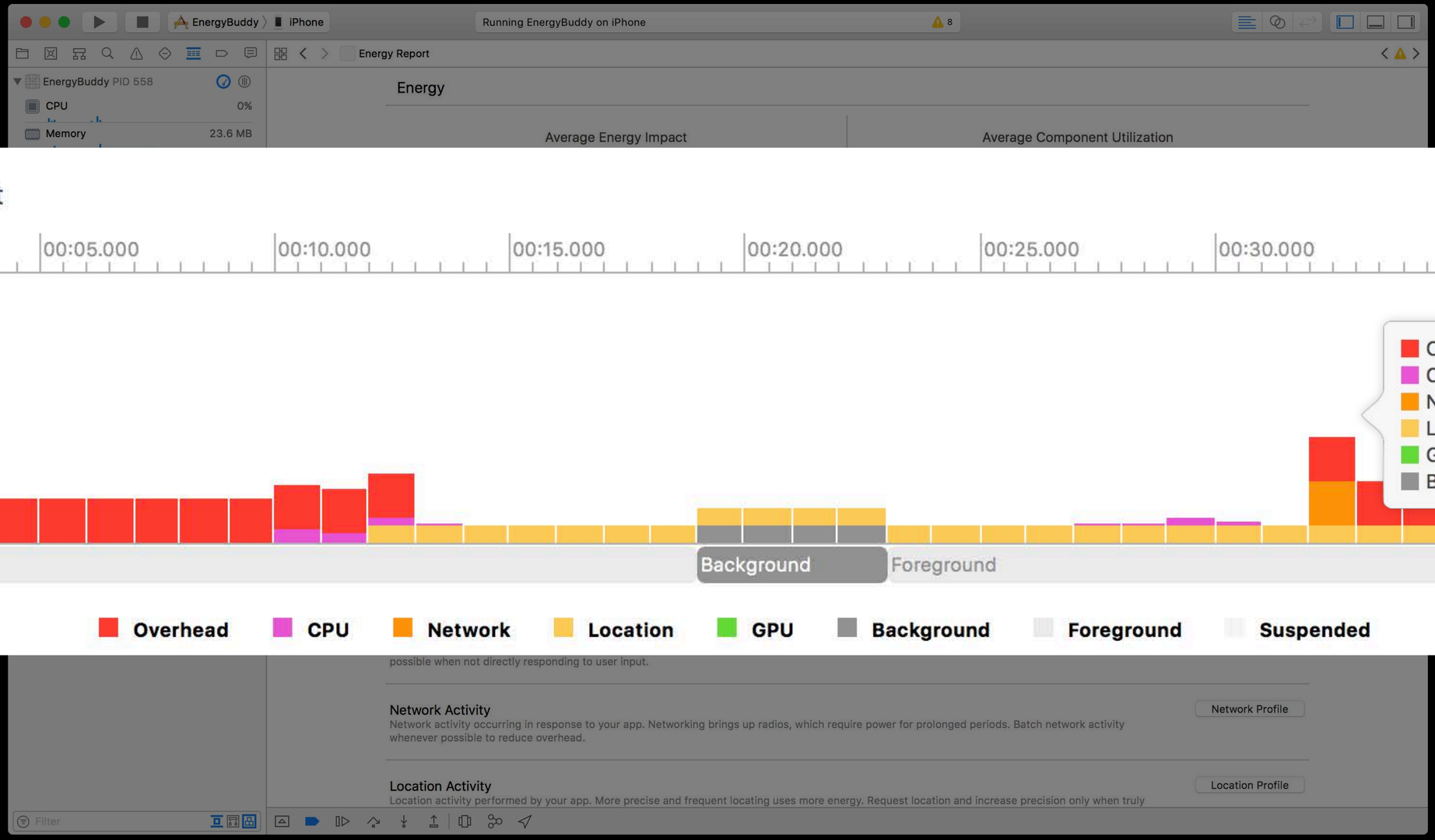
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00:35.000
Overhead 41%
CPU 1%
Network 41%
Location 17%
GPU 0%
Background 0%
Foreground
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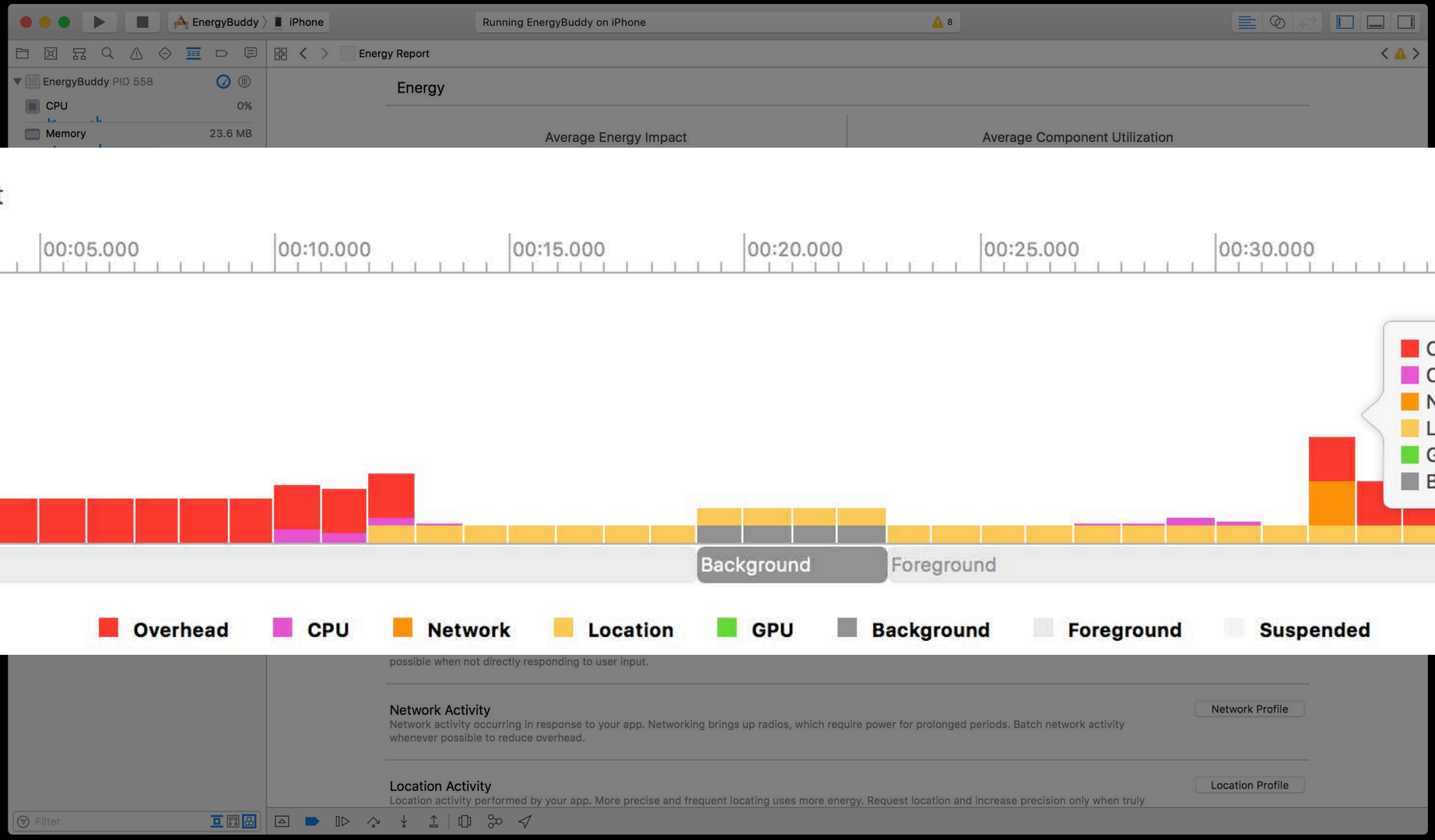
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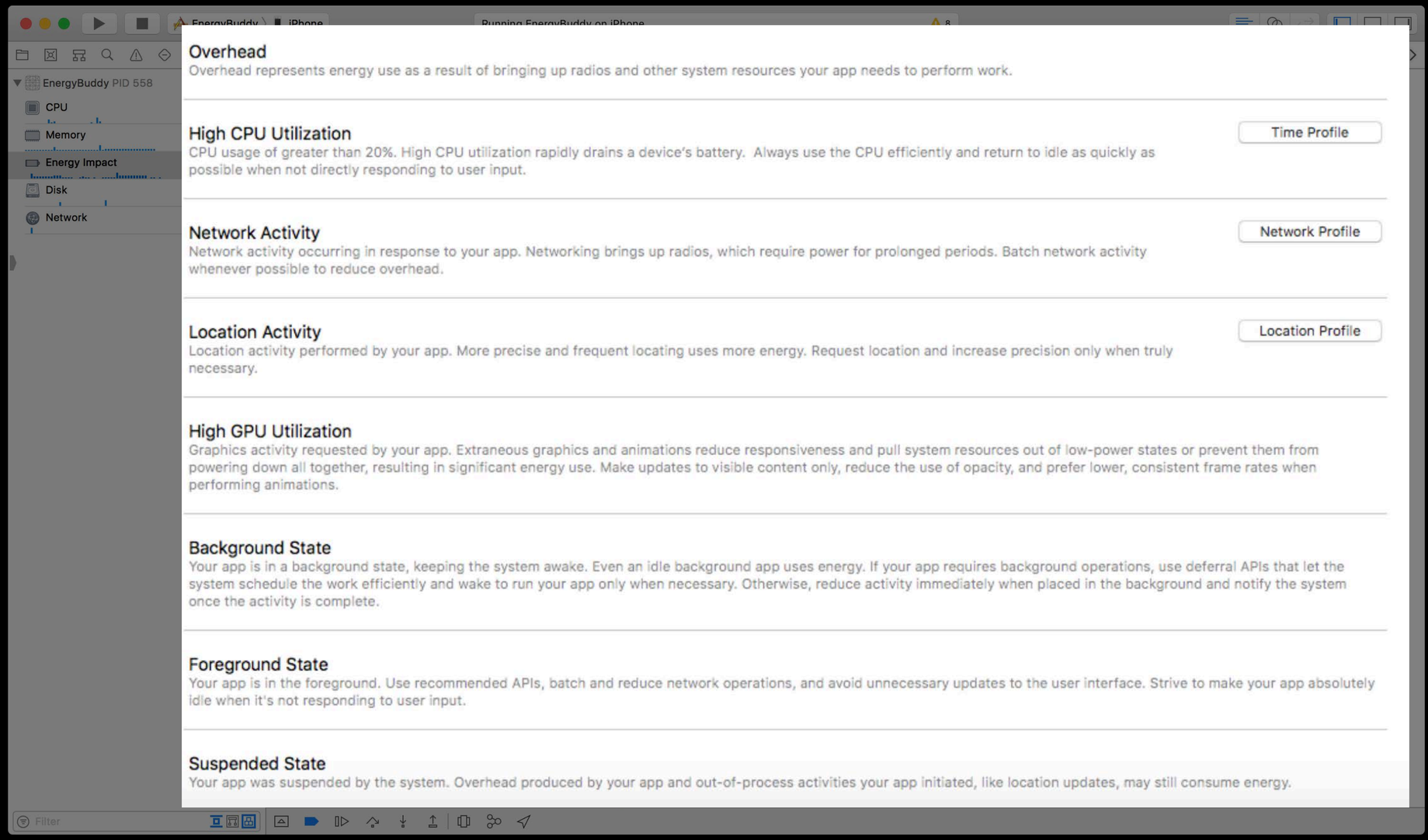
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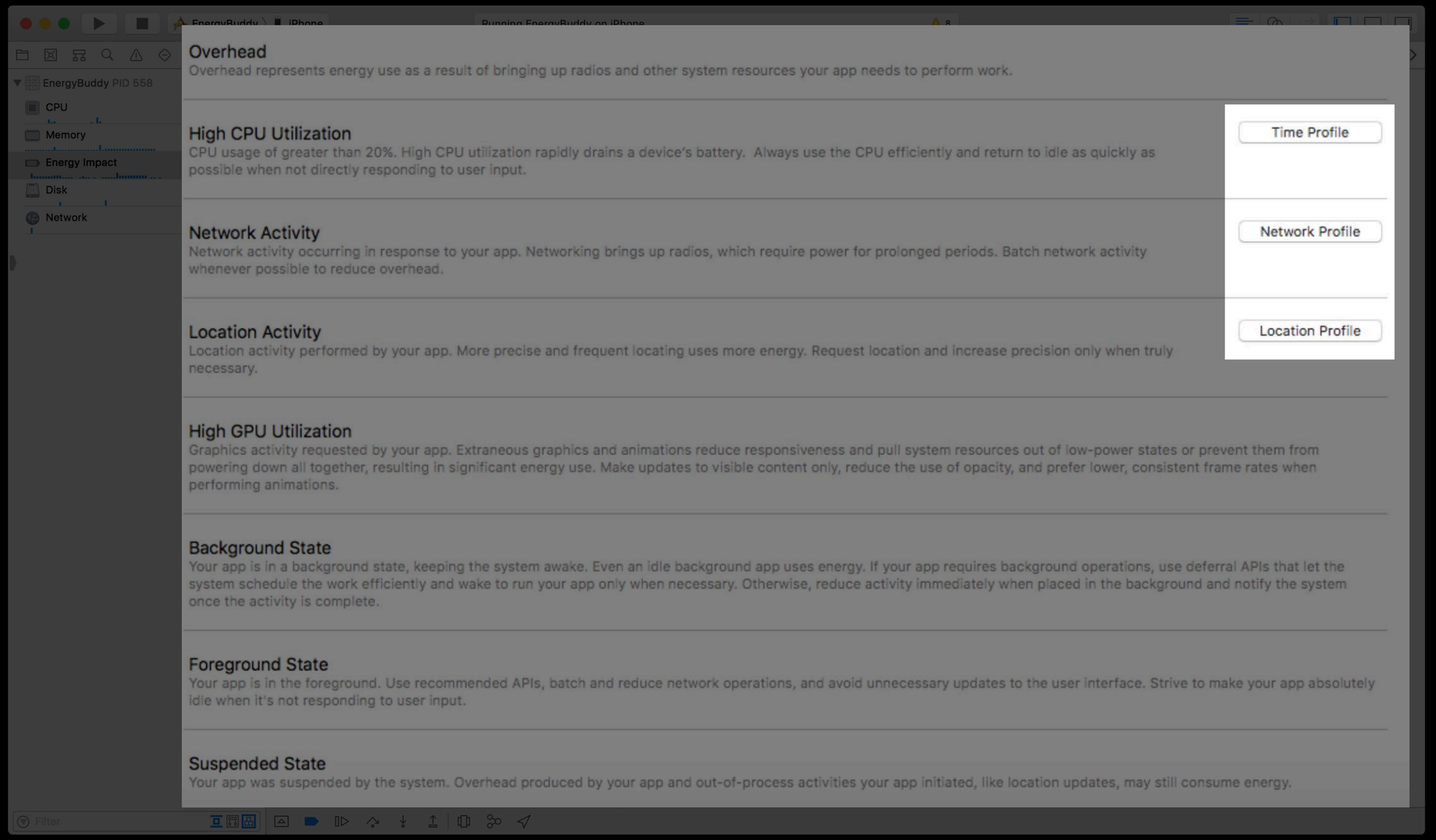
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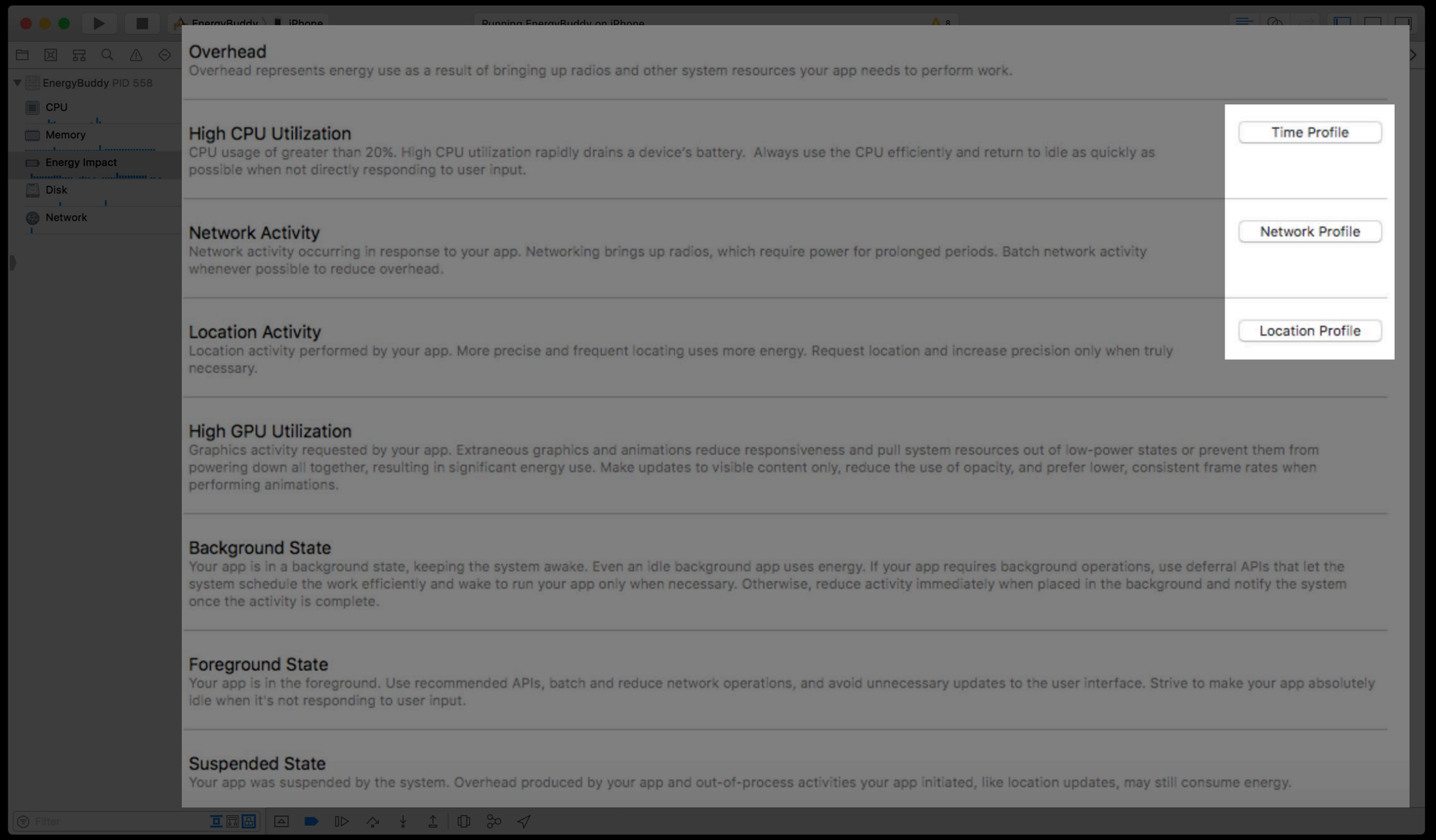
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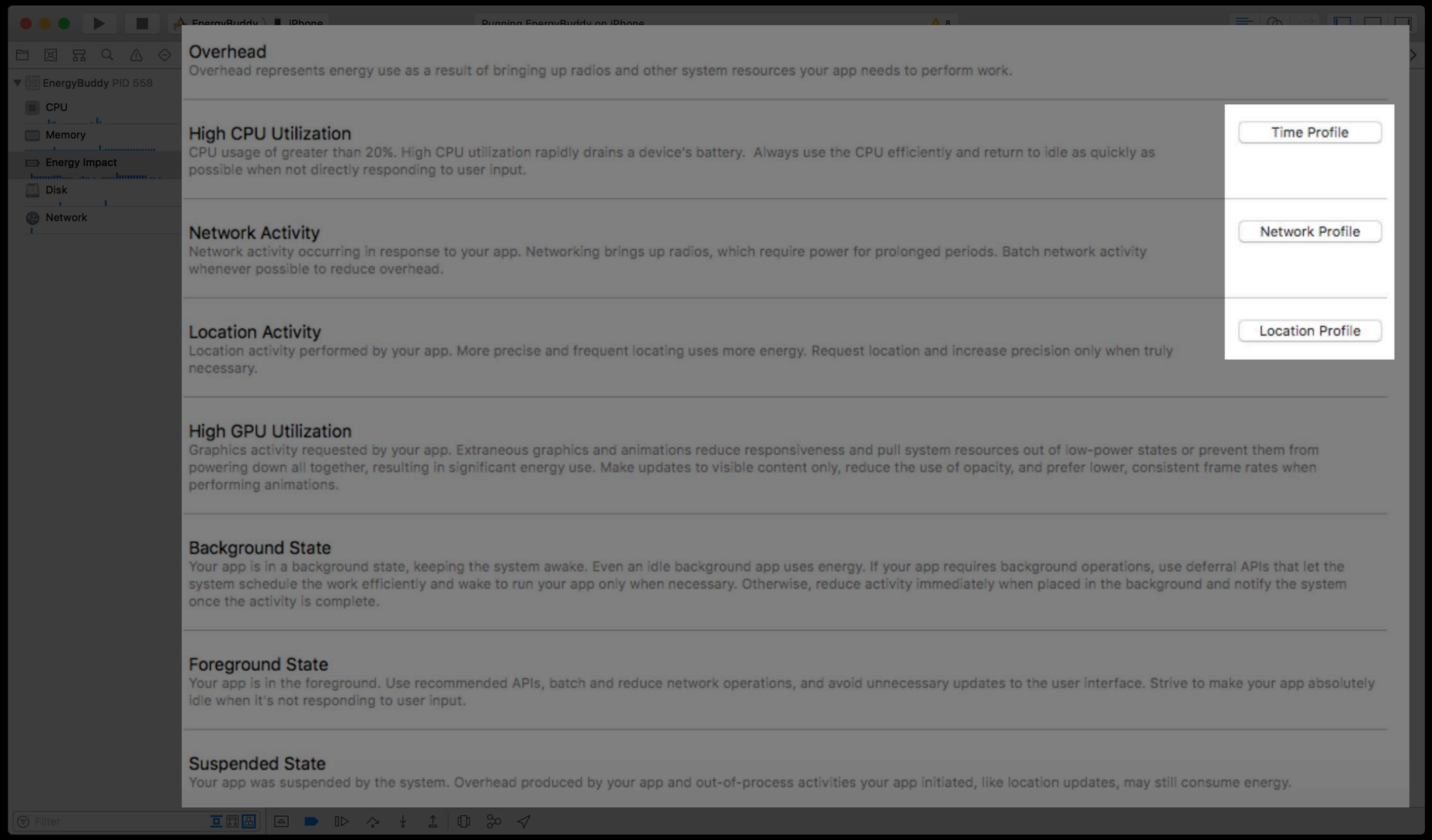
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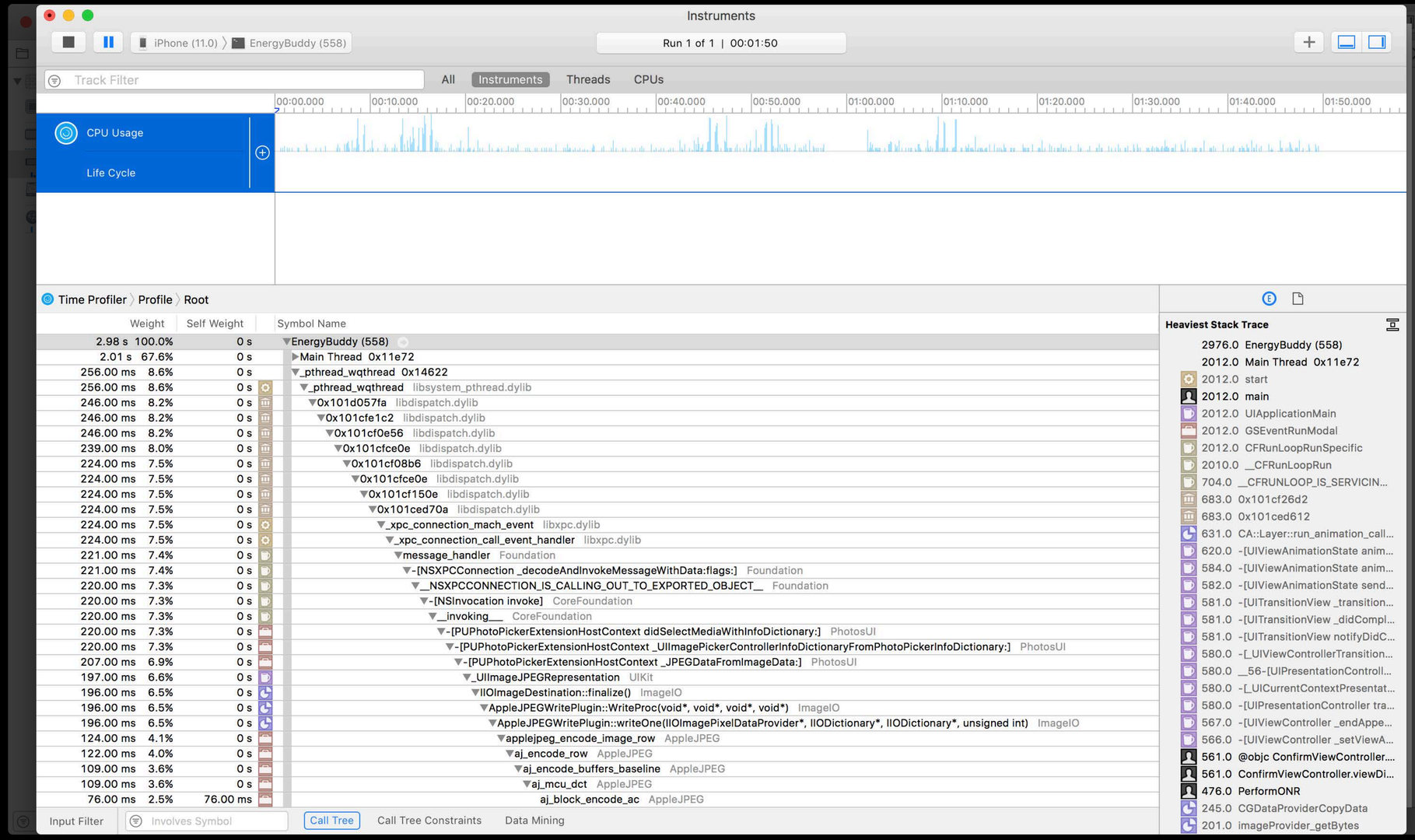
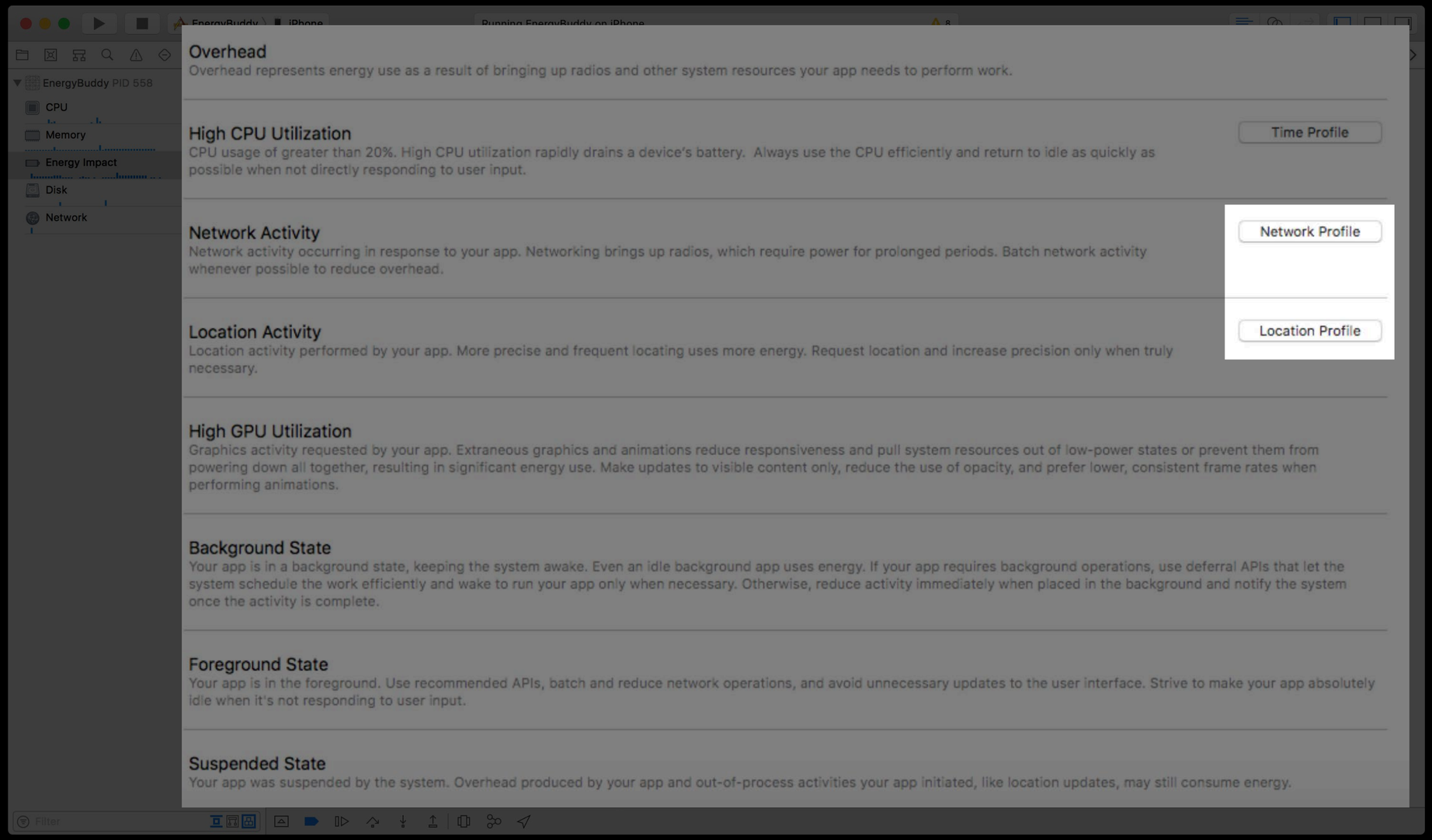

Instruments
iPhone (11.0) 〉 EnergyBuddy (558)
Run 1 of 1 | 00:01:50
Track Filter
All
Instruments
Threads
CPUs
00:00.000
00:10.000
00:20.000
00:30.000
00:40.000
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
01:40.000
01:50.000
CPU Usage
Life Cycle
Time Profiler 〉 Profile 〉 Root
Weight
Self Weight
Symbol Name
2.98 s 100.0% 0 s EnergyBuddy (558)
2.01 s 67.6% 0 s Main Thread 0x11e72
256.00 ms 8.6% 0 s _pthread_wqthread 0x14622
256.00 ms 8.6% 0 s _pthread_wqthread libsystem_pthread.dylib
246.00 ms 8.2% 0 s 0x101d057fa libdispatch.dylib
246.00 ms 8.2% 0 s 0x101cfe1c2 libdispatch.dylib
246.00 ms 8.2% 0 s 0x101cf0e56 libdispatch.dylib
239.00 ms 8.0% 0 s 0x101cfce0e libdispatch.dylib
224.00 ms 7.5% 0 s 0x101cf08b6 libdispatch.dylib
224.00 ms 7.5% 0 s 0x101cfce0e libdispatch.dylib
224.00 ms 7.5% 0 s 0x101cf150e libdispatch.dylib
224.00 ms 7.5% 0 s 0x101ced70a libdispatch.dylib
224.00 ms 7.5% 0 s _xpc_connection_mach_event libxpc.dylib
224.00 ms 7.5% 0 s _xpc_connection_call_event_handler libxpc.dylib
221.00 ms 7.4% 0 s message_handler Foundation
221.00 ms 7.4% 0 s -[NSXPCConnection _decodeAndInvokeMessageWithData:flags:] Foundation
220.00 ms 7.3% 0 s __NSXPCCONNECTION_IS_CALLING_OUT_TO_EXPORTED_OBJECT__ Foundation
220.00 ms 7.3% 0 s -[NSInvocation invoke] CoreFoundation
220.00 ms 7.3% 0 s __invoking___ CoreFoundation
220.00 ms 7.3% 0 s -[PUPhotoPickerExtensionHostContext didSelectMediaWithInfoDictionary:] PhotosUI
220.00 ms 7.3% 0 s -[PUPhotoPickerExtensionHostContext _UIImagePickerControllerInfoDictionaryFromPhotoPickerInfoDictionary:] PhotosUI
207.00 ms 6.9% 0 s -[PUPhotoPickerExtensionHostContext _JPEGDataFromImageData:] PhotosUI
197.00 ms 6.6% 0 s _UIImageJPEGRepresentation UIKit
196.00 ms 6.5% 0 s IIOImageDestination::finalize() ImageIO
196.00 ms 6.5% 0 s AppleJPEGWritePlugin::WriteProc(void*, void*, void*, void*) ImageIO
196.00 ms 6.5% 0 s AppleJPEGWritePlugin::writeOne(IIOImagePixelDataProvider*, IIODictionary*, IIODictionary*, unsigned int) ImageIO
124.00 ms 4.1% 0 s applejpeg_encode_image_row AppleJPEG
122.00 ms 4.0% 0 s aj_encode_row AppleJPEG
109.00 ms 3.6% 0 s aj_encode_buffers_baseline AppleJPEG
109.00 ms 3.6% 0 s aj_mcu_dct AppleJPEG
76.00 ms 2.5% 76.00 ms aj_block_encode_ac AppleJPEG
Input Filter
Involves Symbol
Call Tree
Call Tree Constraints
Data Mining
Heaviest Stack Trace
2976.0 EnergyBuddy (558)
2012.0 Main Thread 0x11e72
2012.0 start
2012.0 main
2012.0 UIApplicationMain
2012.0 GSEventRunModal
2012.0 CFRunLoopRunSpecific
2010.0 __CFRunLoopRun
704.0 __CFRUNLOOP_IS_SERVICIN...
683.0 0x101cf26d2
683.0 0x101ced612
631.0 CA::Layer::run_animation_call...
620.0 -[UIViewAnimationState anim...
584.0 -[UIViewAnimationState anim...
582.0 -[UIViewAnimationState send...
581.0 -[UITransitionView _transition...
581.0 -[UITransitionView _didCompl...
581.0 -[UITransitionView notifyDidC...
580.0 -[_UIViewControllerTransition...
580.0 __56-[UIPresentationControll...
580.0 -[_UICurrentContextPresentat...
580.0 -[UIPresentationController tra...
567.0 -[UIViewController _endAppe...
566.0 -[UIViewController _setViewA...
561.0 @objc ConfirmViewController....
561.0 ConfirmViewController.viewDi...
476.0 PerformONR
245.0 CGDataProviderCopyData
201.0 imageProvider_getBytes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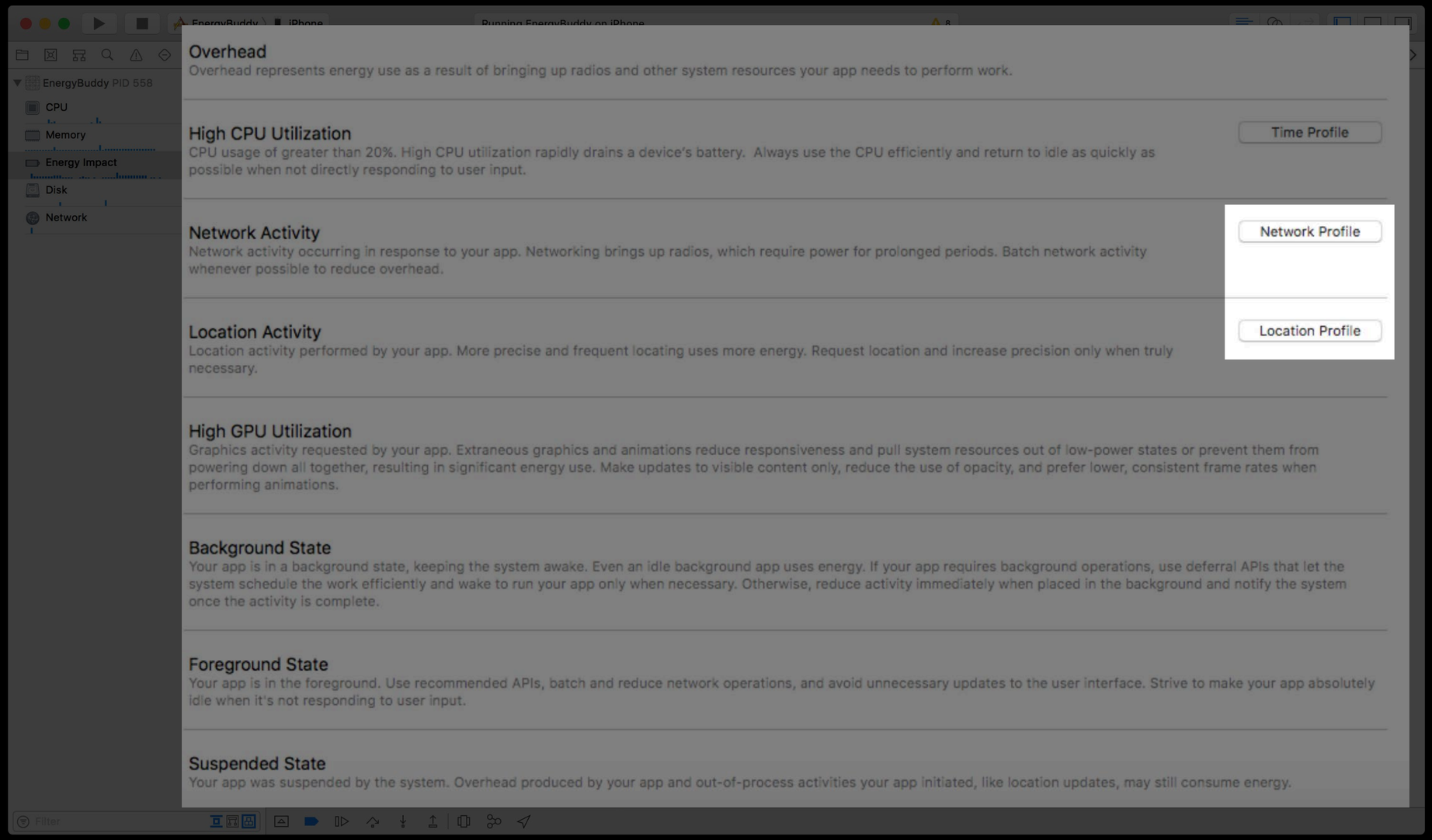
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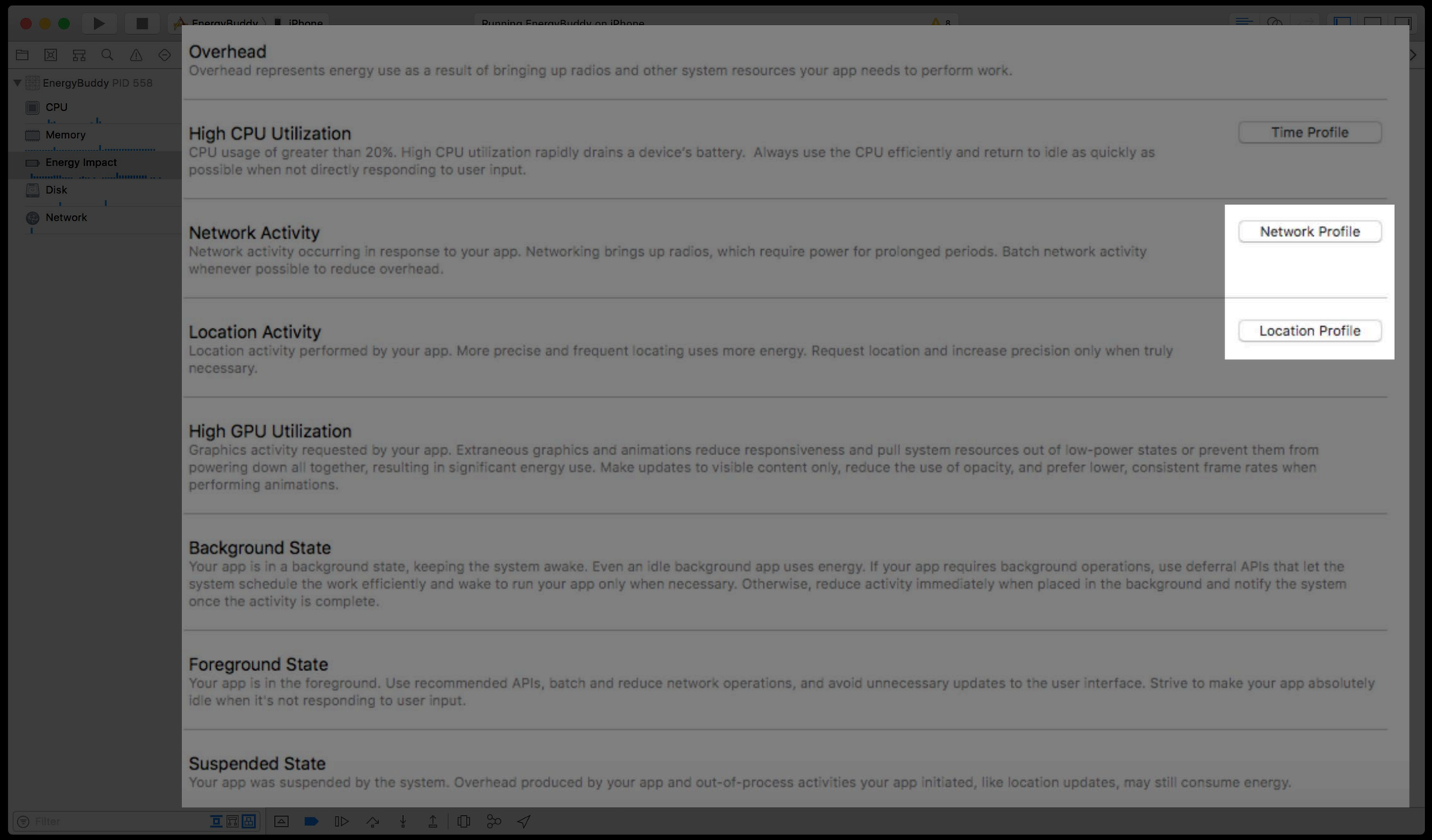
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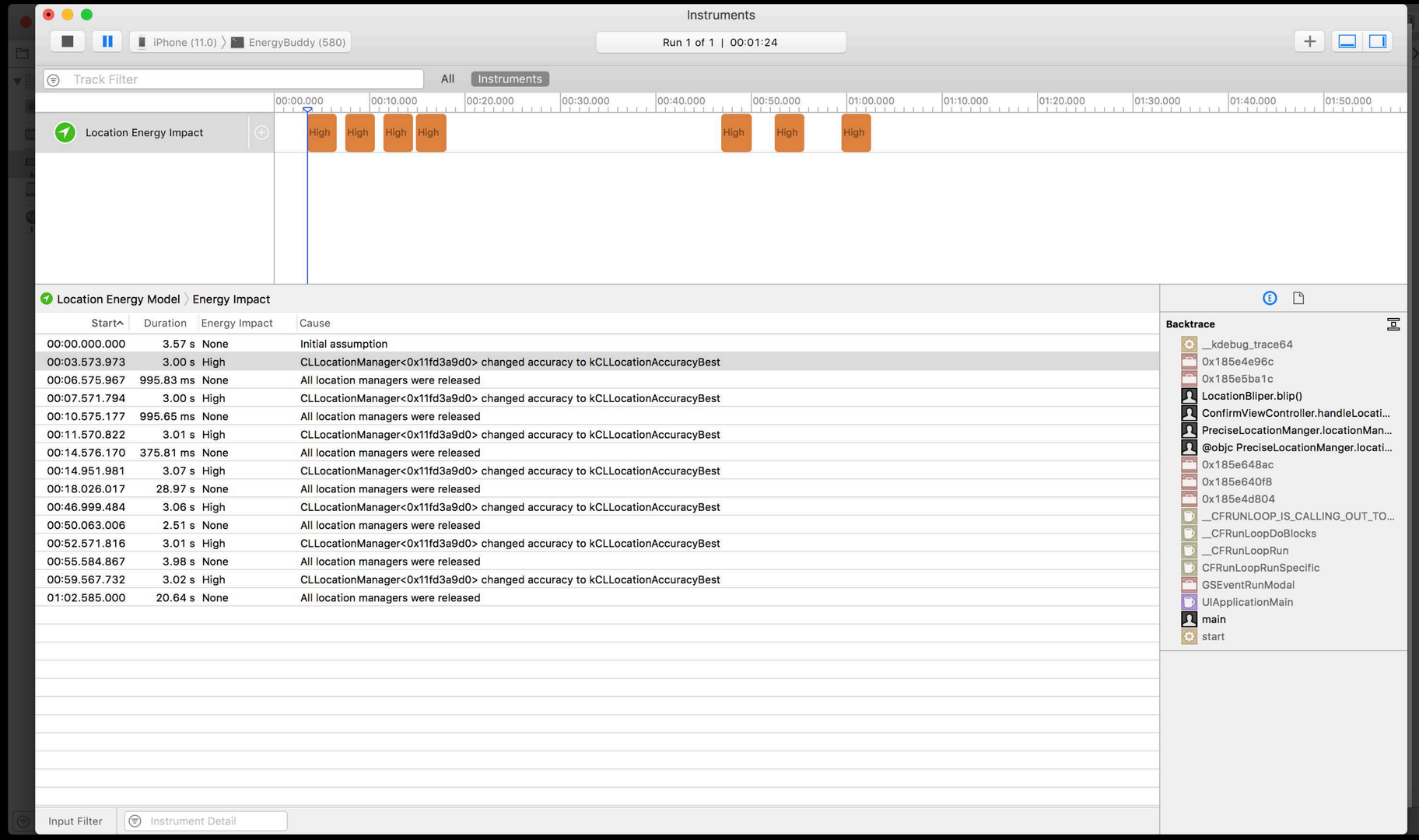
Instruments
iPhone (11.0) 〉 EnergyBuddy (580)
Run 1 of 1 | 00:01:24
Track Filter
All
Instruments
00:00.000
00:10.000
00:20.000
00:30.000
00:40.000
00:50.000
01:00.000
01:10.000
01:20.000
01:30.000
01:40.000
01:50.000
Location Energy Impact
High
High
High
High
High
High
High
Location Energy Model 〉 Energy Impact
Start
Duration
Energy Impact
Cause
00:00.000.000 3.57 s None Initial assumption
00:03.573.973 3.00 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:06.575.967 995.83 ms None All location managers were released
00:07.571.794 3.00 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:10.575.177 995.65 ms None All location managers were released
00:11.570.822 3.01 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:14.576.170 375.81 ms None All location managers were released
00:14.951.981 3.07 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:18.026.017 28.97 s None All location managers were released
00:46.999.484 3.06 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:50.063.006 2.51 s None All location managers were released
00:52.571.816 3.01 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
00:55.584.867 3.98 s None All location managers were released
00:59.567.732 3.02 s High CLLocationManager<0x11fd3a9d0> changed accuracy to kCLLocationAccuracyBest
01:02.585.000 20.64 s None All location managers were released
Backtrace
__kdebug_trace64
0x185e4e96c
0x185e5ba1c
LocationBliper.blip()
ConfirmViewController.handleLocati...
PreciseLocationManger.locationMan...
@objc PreciseLocationManger.locati...
0x185e648ac
0x185e640f8
0x185e4d804
__CFRUNLOOP_IS_CALLING_OUT_TO...
__CFRunLoopDoBlocks
__CFRunLoopRun
CFRunLoopRunSpecific
GSEventRunModal
UIApplicationMain
main
start
Input Filter
Instrument Detail

Scenarios for Energy Debugging

General/common

- Launch and Idle
- Background

Application specific

- For example, Navigation App
  - Search for an address
  - Get directions
  - Navigate

Demo

Battery Life Concepts

Energy Efficient Coding

Energy Debugging Tools and Demo

Final Thoughts

Final Thoughts

Use NSURLSession Background Session

Minimize use of continuous location

Avoid timers

Coalesce work

Use energy gauges

Related Sessions

Advances in Networking, Part 1	Executive Ballroom	Wednesday 3:00PM
Advances in Networking, Part 2	Executive Ballroom	Wednesday 4:00PM
NSURLSession: New Features and Best Practices		WWDC 2016
Networking for the Modern Internet		WWDC 2016

Labs

Power and Performance Lab	Technology Lab I	Fri 11:00AM–1:00PM


WWDC17