Debugging Energy Issues

Session 708

Abhinav Pathak iOS Power Team
Pai-Han Huang iOS Power Team
Survey finds battery life is most important for iPhone owners

GIZMODO
Battery Life Is the Only Spec That Matters

J.D. POWER: CONSUMERS MOST DISSATISFIED WITH SMARTPHONE BATTERY LIFE

By Jeff Saginor — March 15, 2012
<table>
<thead>
<tr>
<th>App Name</th>
<th>Energy Impact</th>
<th>Avg Energy Impact</th>
<th>App Nap</th>
<th>Requires High Perf</th>
<th>Preventing Sleep</th>
<th>User</th>
</tr>
</thead>
<tbody>
<tr>
<td>iTunes</td>
<td>0.9</td>
<td>2.40</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>John</td>
</tr>
<tr>
<td>Activity Monitor</td>
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<td>2.24</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>John</td>
</tr>
<tr>
<td>Spotlight</td>
<td>0.0</td>
<td>1.86</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>John</td>
</tr>
<tr>
<td>Photo Booth</td>
<td>0.0</td>
<td>0.64</td>
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<td>No</td>
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<tr>
<td>App Store</td>
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<td>0.54</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>Numbers</td>
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<td>No</td>
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<td>John</td>
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<tr>
<td>iPhoto</td>
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<td>0.34</td>
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<td>Yes</td>
<td>No</td>
<td>John</td>
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<tr>
<td>Mail</td>
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<td>0.23</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>John</td>
</tr>
<tr>
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</tr>
<tr>
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<td>John</td>
</tr>
<tr>
<td>Maps</td>
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</tr>
<tr>
<td>Contacts</td>
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<td>No</td>
<td>John</td>
</tr>
<tr>
<td>Disk Utility</td>
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<td>John</td>
</tr>
<tr>
<td>FaceTime</td>
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<td>0.13</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>John</td>
</tr>
<tr>
<td>Calendar</td>
<td>0.0</td>
<td>0.12</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>John</td>
</tr>
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<td>iCloud Photos</td>
<td>0.0</td>
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<td>-</td>
<td>John</td>
</tr>
<tr>
<td>iBooks</td>
<td>0.0</td>
<td>0.11</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>John</td>
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**ENERGY IMPACT**

- Remaining charge: 13%
- Time remaining: 0.38
- Time on battery: 0.15

**BATTERY (Last 12 hours)**
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<th>Usage (%)</th>
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</tr>
<tr>
<td>Facebook</td>
<td>17%</td>
</tr>
<tr>
<td>Phone</td>
<td>14%</td>
</tr>
<tr>
<td>Mail Background Activity</td>
<td>13%</td>
</tr>
<tr>
<td>Maps Location</td>
<td>11%</td>
</tr>
<tr>
<td>Pandora Audio</td>
<td>9%</td>
</tr>
<tr>
<td>Messages</td>
<td>6%</td>
</tr>
<tr>
<td>Photos AirPlay</td>
<td>4%</td>
</tr>
<tr>
<td>App Store</td>
<td>2%</td>
</tr>
<tr>
<td>Weather Background Activity</td>
<td>2%</td>
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<tr>
<td>Calendar</td>
<td>1%</td>
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Show proportion of battery used by each app when iPhone was not charging.
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Shows proportion of battery used by each app when iPhone was not charging.
1. Energy Fundamentals and Best Practices
2. Energy Debugging Workflow and Tools
3. Demo: Fixing Energy Issues on iOS
4. Final Thoughts
Energy 101

Energy = power * time
Energy 101

Energy = power * time
Energy 101

Energy = power * time

- App Launch
- App Activities
- App Backgrounded
- App Suspended
Energy 101
Minimizing overhead cost

- App Launch
- Fixed
- Dynamic
- App Activities
- App Backgrounded
- App Suspended
Reducing Energy Use

What it comes down to...

Do it never/do it less
Do it at a better time
Do it efficiently
1. Energy Fundamentals and Best Practices
2. Energy Debugging Workflow and Tools
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Energy Debugging WorkFlow
## Energy Debugging WorkFlow

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</tr>
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<tbody>
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<td></td>
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</table>
Energy Debugging WorkFlow

Write Code and Build  General Debugger

Issue Found
Energy Debugging WorkFlow

Write Code and Build → General Debugger → Focused Debugger

Issue Found
Energy Debugging WorkFlow

- Write Code and Build
- General Debugger
- Focused Debugger
- Customers

Issue Found
Energy Debugging Workflow

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Energy Debugging WorkFlow

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2. General Debugger
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Energy Debugging Priorities on OS X

Priorities on OS X are CPU and GPU

High fixed cost: let giant compute units rest! (sleep)
Energy Gauges on OS X
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App Nap
To allow inactive applications to remain running while minimizing their impact on battery life, the system may lower execution priority and rate limit timers.

Idle Prevention
Maximizing CPU idle time is an important part of energy efficiency. Timers can prevent CPU idle and should be avoided when other alternatives are available.

CPU Wake Overhead
Each time the CPU wakes from idle, there is an incurred energy penalty. If the wakes are high, and the CPU utilization per wake is low, then you should consider batching work.

High CPU Utilization
Periods of high CPU utilization will rapidly drain a laptop's battery. This indicates CPU utilization of greater than 20%.
Reducing Energy on OS X

Do it never/do it less
- Coalesce timers => let CPU idle
- Minimize CPU wakes

Do it at a better time
- **Scheduling** with NSBackgroundActivityScheduler

Do it efficiently
- Set appropriate QoS **work priorities**
Energy Debugging Priorities in iOS
Energy Debugging Priorities in iOS

- CPU
- Location
- Networking
- Background
Location Energy

![Graph showing Power over Time](image)
Energy Efficient Location

Concepts to remember

Do it never/do it less

- Continuous location only if *absolutely needed*
- *Stop* location when you’re done with it
Energy Efficient Location

Concepts to remember

Do it never/do it less

• Continuous location only if **absolutely needed**
• **Stop** location when you’re done with it

Do it efficiently

• What accuracy is actually required for app?
• Which location API to use?
  - Deferred location updates, significant location change, region monitoring
  - iBeacons, AutoPause, significant locations visited
Energy Efficient Networking

Concepts to remember

Do it never/do it less

- **Cut down** transfers: caching, compression, media quality, etc.
Energy Efficient Networking

Concepts to remember

Do it never/do it less

- **Cut down** transfers: caching, compression, media quality, etc.

Do it at a better time

- **Consider** tolerance: when is it needed, is it discretionary, etc.
Energy Efficient Networking

Concepts to remember

Do it never/do it less

• **Cut down** transfers: caching, compression, media quality, etc.

Do it at a better time

• **Consider** tolerance: when is it needed, is it discretionary, etc.

Do it more efficiently

• **Coalesce** transfers
Networking Application

Requirements

• Sync data to server
Networking Application

Requirements

• Sync data to server

Simple solution

• Sync data as it comes
Networking Application

Requirements

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Requirements
- Sync data to server

Simple solution
- Sync data as it comes

Energy efficient solution
- Buffer data before syncing
Networking Application

Requirements

• Sync data to server

Simple solution

• Sync data as it comes

Energy efficient solution

• Buffer data before syncing
Energy Efficient Background Activity

Concepts to remember

Do it never/do it less

• Do not run in background

• Call Background Task Completion Handler as soon as work is completed
Energy Efficient Background Activity

Concepts to remember

Do it never/do it less

• Do not run in background
• Call Background Task Completion Handler as soon as work is completed

Do it efficiently

• Call energy-efficient background APIs
• Ex: - application:performFetchWithCompletionHandler:
# Energy Debugging WorkFlow

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<th>General Debugger</th>
<th>Focused Debugger</th>
<th>Customers</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="" alt="Xcode Logo" /></td>
<td><img src="" alt="Graph Logo" /></td>
<td><img src="" alt="Graph Logo" /></td>
<td><img src="" alt="Analysis Logo" /></td>
</tr>
<tr>
<td><img src="" alt="iOS Logo" /></td>
<td><img src="" alt="iOS Logo" /></td>
<td><img src="" alt="iOS Logo" /></td>
<td><img src="" alt="iOS Logo" /></td>
</tr>
</tbody>
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Issue Found
Energy Debugging WorkFlow

Write Code and Build  General Debugger  Focused Debugger  Customers

Issue Found

[Images of tools and apps related to the process]
Energy Debugging Workflow

1. Write Code and Build
2. General Debugger
3. Focused Debugger
4. Customers

Issue Found
Energy Debugging WorkFlow

- Write Code and Build
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Issue Found
Energy Diagnostics
Settings > Developer > Logging
Energy Diagnostics
Settings > Developer > Logging
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Energy Diagnostics
Energy Diagnostics
Energy Debugging WorkFlow

- Write Code and Build
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Issue Found

- Issue Found

### Operating Systems
- iOS

### Platforms
- System

### Debugging Tools
- Debugger

### Status Indicators
- Battery Status
Energy Debugging WorkFlow

Write Code and Build → General Debugger → Focused Debugger → Customers

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Demo

Pai-Han Huang
iOS Power Team
Energy Report

Energy

Utilization

Very High

Energy Impact

Average

High

60%

Overhead

Energy Impact

Legend
Cost represents energy use resulting from the work your app performs. Overhead represents energy use as a result of bringing up radios and other system resources required to perform that 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.

Network
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.

Location
Location activity performed by your app. More precise and frequent locating uses more energy. Request location and increase precision only when truly necessary.
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Time Profile

Network Profile

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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.

Network
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.

Location
Location activity performed by your app. More precise and frequent locating uses more energy. Request location and increase precision only when truly necessary.
Energy

Utilization

Very High

Energy Impact

60% Overhead

Legend
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### Energy Report

#### Energy

- **Utilization**
  - Very High
  - Energy Impact

- **Average**
  - High
  - Energy Impact
  - 60% Overhead

#### Energy Impact

- **Legend**
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Location Energy Impact

<table>
<thead>
<tr>
<th>Time</th>
<th>Duration</th>
<th>Energy Impact</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00.000.000</td>
<td>9.44 s</td>
<td>None</td>
<td>Initial assumption</td>
</tr>
<tr>
<td>00:09.443.910</td>
<td>30.49 s</td>
<td>High</td>
<td>CLLocationManager&lt;0x14d6da9d0&gt; changed accuracy to kCLLocationAccuracyBest</td>
</tr>
</tbody>
</table>
Instruments
Run 2 of 2 00:00:40

Details  Energy Impact
Time  Duration  Energy Impact  Cause
00:00.000.000  9.44 s  None  initial assumption
00:09.443.910  30.48 s  High  CLLocationManager changed accuracy to kCLLocationAccuracyBest

Backtrace
- _kdebug_trace64
- 0x184321c70
- EnergyBuddy.PreciseLocationManager.requestLocation(EnergyBuddy.PreciseLocationManager)
- EnergyBuddy.ConfirmViewController.acceptImage(EnergyBuddy.ConfirmViewController)
- EnergyBuddy.MainViewController.prepareForSegue(EnergyBuddy.MainViewController)
- obj EnergyBuddy.MainViewController.prepareForSegue(EnergyBuddy.MainViewController)
- [UIStoryboardSegueTemplate _perform]
- [UIViewController performSegueWithIdentifier:sender]
- EnergyBuddy.MainViewController.imagePickerController(EnergyBuddy.MainViewController)
- objc EnergyBuddy.MainViewController.imagePickerController(EnergyBuddy.MainViewController)
- [UIImagePickerController _imagePickerControllerDidCompleteWithInfo]
- PLNotifyImagePickerControllerOffImageAvailability
- [UIImagePickerControllerHelper _notifyImagePickerControllerOfAssetAvailability]
- UIApplicationMain
- main
- start
Energy Impact

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- _kdebug_trace64
- 0x1184b2c70
- EnergyBuddy.PreciseLocationManager.requestLocation:EnergyBuddy.PreciseLocationManager
- EnergyBuddy.ConfirmViewController.acceptImage:EnergyBuddy.ConfirmViewController
- EnergyBuddy.MainViewController.prepareForSegue:EnergyBuddy.MainViewController
- obj EnergyBuddy.MainViewController.prepareForSegue:EnergyBuddy.MainViewController
- [UIStoryboardSegueTemplate_perform:]
- [UIViewController performSegueWithIdentifier:sender]
- EnergyBuddy.MainViewController.imageViewPickerController:EnergyBuddy.MainViewController
- objc EnergyBuddy.MainViewController.imageViewPickerController:EnergyBuddy.MainViewController
- -(UIImagePickerControllerDidCompleteWithInfo:) locationManager
- PLNotifyImagePickerControllerOfImageAvailability
- -(邙PULImagePickerControllerHelper_notifyImagePickerControllerOfAssetAvailability:|
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- _kdebug_trace64
- 0x184b21c70
- EnergyBuddy,LocationManager, requestLocation:Location (EnergyBuddy,LocationManager, requestLocation:Location)
- EnergyBuddy,ConfirmViewController,acceptImage: (EnergyBuddy,ConfirmViewController,acceptImage:)
- EnergyBuddy,MainViewController,prepareForSegue: (EnergyBuddy,MainViewController,prepareForSegue:)
- @objc EnergyBuddy,MainViewController,prepareForSegue: (EnergyBuddy,MainViewController,prepareForSegue:)
- [UIStoryboardSegueTemplate,_perform:]
- [UIViewController, performSegueWithIdentifier:identifier:]
- EnergyBuddy,MainViewController,imagePickerController:imagePickerControllerDidCompleteWithImage: (EnergyBuddy,MainViewController,imagePickerController:imagePickerControllerDidCompleteWithImage:)
- @objc EnergyBuddy,MainViewController,imagePickerController:imagePickerControllerDidCompleteWithImage: (EnergyBuddy,MainViewController,imagePickerController:imagePickerControllerDidCompleteWithImage:)
- PLNotificationCenter, imagePickerControllerDidCompleteWithImage: (PLNotificationCenter, imagePickerControllerDidCompleteWithImage:)
- [UIImagePickerController,凫imagePickerController:凫imagePickerControllerDidCompleteWithImage:]
- UIApplicationMain
- main
- start
Energy Buddy: Demo App
Energy Buddy: Demo App
Energy Buddy: Demo App

- New Reading
- Data Manager
- Phone with graph
  - Y-axis: 0 to 100
  - X-axis: Dates from 6/10 to 6/11

Import Photo button
Energy Buddy: Demo App

Diagram:
- New Reading
- Location
- Data Manager
- Location Services
- Import Photo

Graphical representation of the app's functionality:
- New Reading connected to Location
- Location connected to Data Manager
- Location Services connected to Data Manager

Mobile app interface:
- Graph showing energy usage over time
- Import Photo button
Energy Buddy: Demo App

New Reading → Weather

Location → Data Manager

Location Services

Phone Screen: Import Photo
Demo

Pai-Han Huang
iOS Power Team
1. Energy Fundamentals and Best Practices
2. Energy Debugging Workflow and Tools
3. Demo: Fixing Energy Issues on iOS
4. Final Thoughts
Energy Buddy: Demo App

Energy inefficient code
Location

Energy inefficient code

```swift
func locationManager(manager: CLLocationManager, ...) {
    let location = locations[locations.count-1] as! CLLocation
    if let confirmViewController? = self.confirmViewController {
        confirmViewController.handleLocation(location)
    }
}
```
func locationManager(manager: CLLocationManager, ……) {
    let location = locations[locations.count-1] as! CLLocation
    if let confirmViewController? = self.confirmViewController {
        confirmViewController.handleLocation(location)
    }
    self.locationManager.stopUpdatingLocation()
}
Location

Energy Inefficient Code

Energy Optimized Code
Location

Energy Inefficient Code

Energy Optimized Code
Location

Energy Inefficient Code

Energy Optimized Code
Networking

Energy inefficient code

{

      .......
app.dataManager.storeEnergyData(location: location, values: values)

var weather = getWeather()
app.dataManager.storeWeatherData(weather)

}
Networking

Energy optimized code

{  

    .......
    app.dataManager.storeEnergyData(location: location, values: values)

    if(!recentlyCalled()) {
        var weather = getWeather()
        app.dataManager.storeWeatherData(weather)
    }
}
Networking

Energy optimized code

```swift
{
    ........
    app.dataManager.storeEnergyData(location: location, values: values)

    if (!recentlyCalled()) {
        var weather = getWeather()
        app.dataManager.storeWeatherData(weather)
    }
}
```
Networking

Energy Inefficient Code

Energy Optimized Code
Networking

Energy Inefficient Code

Energy Impact

- GPU
- Network
- Location
- Background

Cost ▶ Overhead

Energy Optimized Code

Energy Impact

- GPU
- Network
- Location
- Background

Cost ▶ Overhead
Networking

Energy Inefficient Code

Energy Optimized Code
func applicationDidEnterBackground(application: UIApplication) {
    ..........
    self.archiveToDataManager()
    self.waitForInput()
}
func applicationDidEnterBackground(application: UIApplication) {
    ........
    self.archiveToDataManager()

    //self.waitForInput()

    UIApplication.sharedApplication().endBackgroundTask(
        self.backgroundTaskIdentifier)
    self.backgroundTaskIdentifier = UIBackgroundTaskInvalid
}

Background

Energy Inefficient Code

Energy Impact

Cost
Overhead

Energy Optimized Code

Energy Impact

Cost
Overhead
Background

Energy Inefficient Code

Energy Optimized Code
Background

Energy Inefficient Code

Energy Optimized Code
Energy Inefficient Code

Energy Optimized Code
Energy Buddy: Demo App
Statistics before/after fixing energy issues

Living on app
• 50% energy reduction
• Battery UI shows app is lower in list
Battery life impacts user experience
Design your apps with the following in mind
  Do it *never/less*
  Do it more *efficiently*
  Do it *at a better time*
Be a considerate background app
Summary

- Try out new energy debugging tools
- Check out energy documentation
- Bring your apps to power lab
More Information

Documentation and Videos

iOS Energy Guide

OS X Energy Guide

Writing Energy Efficient Code, Parts 1 and 2 (2014)
http://developer.apple.com/videos
More Information

Technical Support
Apple Developer Forums
http://developer.apple.com/forums

Developer Technical Support
http://developer.apple.com/support/technical

General Inquiries
Paul Danbold, Core OS Evangelist
danbold@apple.com
## Related Labs

<table>
<thead>
<tr>
<th>Lab</th>
<th>Frameworks Lab</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power and Performance Lab</td>
<td>B</td>
<td>Wednesday 1:30PM</td>
</tr>
<tr>
<td>Networking Lab</td>
<td>E</td>
<td>Thursday 10:00AM</td>
</tr>
<tr>
<td>Core Location Lab</td>
<td>A</td>
<td>Thursday 2:30PM</td>
</tr>
<tr>
<td>Power and Performance Lab</td>
<td>C</td>
<td>Friday 12:00PM</td>
</tr>
<tr>
<td>Networking Lab</td>
<td>B</td>
<td>Friday 1:30PM</td>
</tr>
<tr>
<td>Session</td>
<td>Location</td>
<td>Time</td>
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<tr>
<td>--------------------------------------------------</td>
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<tr>
<td>Achieving All-Day Battery Life</td>
<td>Nob Hill</td>
<td>Wednesday 9:00AM</td>
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<tr>
<td>Networking with NSURLSession</td>
<td>Pacific Heights</td>
<td>Thursday 9:00AM</td>
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<td>What's New in Core Location</td>
<td>Pacific Heights</td>
<td>Thursday 1:30PM</td>
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<tr>
<td>Advanced NSOperations</td>
<td>Presidio</td>
<td>Friday 9:00AM</td>
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<tr>
<td>Building Responsive and Efficient Apps with GCD</td>
<td>Nob Hill</td>
<td>Friday 10:00AM</td>
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<tr>
<td>Performance on iOS and watchOS</td>
<td>Presidio</td>
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