Designing for Adverse Network and Temperature Conditions

Alexander Karapetian, iOS Performance Engineer
Ilya Veygman, iOS Performance Engineer
Understanding device conditions
Handling realistic network links
New tools for varying temperatures
Understanding device conditions
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Understanding device conditions
Handling realistic network links
New tools for varying temperatures
iOS Devices Can Go Anywhere

Environments with sunlight or heat
Areas with weak network reception
Different cellular networks
Typical Development Conditions

At your desk
In a device lab
With fast network connectivity
In a climate controlled area
iOS Devices Can Multitask

Getting turn by turn directions and playing music on a car trip

Using Personal Hotspot while charging

ARKit with object recognition while 3D rendering
App Reviews Highlight Real-World Use

“Great app! Totally unusable on the train, though.”

“Frame rate is awful after I’ve played for half an hour.”

“Does not work in the car park at my work. Very long hangs.”

“Music stopped on our road trip. What a let-down!”
Adverse Device Conditions

Network Link
- 3G
- LTE

Temperature
Thermal state
Network Link
Real-World Network Conditions

Reduced responsiveness
Perceived app freezing
Functional problems
Use the Run action's arguments and environment variables

Arguments Passed On Launch

No Arguments

Environment Variables

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>IS_UNIT_TESTING</td>
<td>YES</td>
</tr>
</tbody>
</table>

Expand Variables Based On: None
Improving App Launch Under Testing

Ensure only unneeded functionality is skipped for unit testing

```swift
func application(_ application: UIApplication, didFinishLaunchingWithOptions opts: ...) -> Bool {
    let isUnitTesting = ProcessInfo.processInfo.environment["IS_UNIT_TESTING"] == "YES"
    if !isUnitTesting {
        // Do UI-related setup, which can be skipped when testing
    }
    return true
}
```
Test Pyramid
Testing fundamentals

User interface
Integration
Unit

Testing in Xcode
WWDC 2019
Test Pyramid
Testing fundamentals

- Unit
- Integration
- User interface
Test Pyramid
Testing fundamentals

- User interface
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Test Pyramid
Testing fundamentals

User interface
Integration
Unit
Qualities of Good Tests

Repeatable

Deterministic

Low variance

Representative
Quality Checkpoints in Development

New Code → Merge to Staging → Merge to Release → Ship!
Quality Checkpoints in Development

- New Code
- Unit Tests
- Merge to Staging
- Merge to Release
- Ship!
Quality Checkpoints in Development

- New Code
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Quality Checkpoints in Development

New Code ➔ Unit Tests ➔ Merge to Staging ➔ Integration Tests ➔ Merge to Release ➔ User interface Tests ➔ Ship!
Testing Under Network Conditions
Some approaches

Conditioning the network infrastructure
• Custom routers
• Can be prohibitively complex
Network Link Conditioner for macOS

EDGE
3G
DSL
Wi-Fi
High Latency DNS
Very Bad Network
100% Packet Loss
Bandwidth in Kbps, packet loss rate in percentage, and delay in milliseconds

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>In Bandwidth</td>
<td>780</td>
</tr>
<tr>
<td>In Packet Loss</td>
<td>0</td>
</tr>
<tr>
<td>In Delay</td>
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<tr>
<td>Protocol</td>
<td>Any</td>
</tr>
<tr>
<td>Interface</td>
<td></td>
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Duplicate Profile...
DEVICE CONDITIONS

Condition: Network Link
Profile: 3G Network - average

Name: Average 3G Scenario
Downlink Bandwidth: 0.78 Mbps
Downlink Latency: 100 ms
Downlink Packet Loss Ratio: 0.025%
Uplink Bandwidth: 0.33 Mbps
Uplink Latency: 100 ms
Uplink Packet Loss Ratio: 0.025%
100% packet loss
Very poor network
Edge Network - poor
Edge Network - average
Edge Network - good
Edge Network - best
2G Network - poor
2G Network - better
3G Network - average
3G Network - good
3G Network - best
LTE Network
WiFi Network
WiFi Network (802.11ac)
DSL Network
High Latency DNS
Network Link Condition Active

"3G Network - good" is active on this iPhone. Stop running this condition?

Cancel  Stop
Demo

Improvements in network connectivity
Average: ~770ms
Connection Metrics

<table>
<thead>
<tr>
<th>PROBE TYPE</th>
<th>TLS</th>
<th>DTLS</th>
<th>WebSocket</th>
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Host: network-framework.apple.com
Port: 443

Enable Optimistic DNS: Off
Enable TLS 1.3: Off

Run Probe

RESULTS
Connected in 0.737s
Resolved from cache in 0.0s
TLS took 0.501s
### Connection Metrics

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#### Host
- **network-framework.apple.com**

#### Port
- **443**

#### Enable Optimistic DNS
- **Off**

#### Enable TLS 1.3
- **Off**

---

**Average:** ~500ms

**Results:**
- Connected in 0.737s
- Resolved from cache in 0.0s
- TLS took 0.501s
Designing for Adverse Network Conditions

- Use Optimistic DNS and TLS 1.3
- Set reasonable timeouts
- Use HTTP/2
- Avoid reachability checks

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Optimizing Your App for Today’s Internet  
WWDC 2018

Introducing Network.framework: A Modern Alternative to Sockets  
WWDC 2018

Advances in Networking, Parts 1 and 2  
WWDC 2019
Designing for Adverse Network Conditions

Consider differences between testing conditions and the real world

Use your app with different Network Link conditions

Be aware of functional and performance degradation

Include 3G Network Link in test runs

Optimize towards progressing app behavior
Temperature
Temperature Conditions Are Typical User Conditions
Temperature Conditions Are Typical User Conditions

Direct sunlight
Temperature Conditions Are Typical User Conditions

Direct sunlight
Wireless charging
Tethering
Gaming
Hot weather
Temperature

iPhone needs to cool down before you can use it.
Defensive Design

Reduce your app’s energy impact and contribution to excessive thermal states

Implement progressive optimizations under elevated thermal states

Listen to `ProcessInfo.ThermalState` notifications
# Actions on ProcessInfo.ThermalState

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Restore from iCloud backup is paused |
| Critical      | - | - |
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ProcessInfo.ThermalState

Values used to indicate the system’s thermal state.

### Declaration

```swift
enum ThermalState : Int
```

### Overview

These values are used by the ProcessInfo class as return values for `thermalState`. For information about testing your app under different thermal states, see **Test under adverse device conditions.**
Demo

Improvements in ARKit interactions

Ilya Veygman
Designing for Adverse Thermal Conditions

Register for `ProcessInfo.thermalStateDidChangeNotification`

Use the `ProcessInfo.ThermalState` cases to react to thermal state changes

Switch off background and unneeded functionality when thermal state is elevated
NotificationCenter.default.addObserver(
    self,
    selector: #selector(reactToThermalStateChange(_:)),
    name: ProcessInfo.thermalStateDidChangeNotification,
    object: nil
)

@objc func reactToThermalStateChange(_ notification : Notification) {
    thermalState = ProcessInfo.processInfo.thermalState
}
```swift
var thermalState = ProcessInfo.ThermalState.nominal {
    didSet {
        switch thermalState {
        case .nominal, .fair:
            // Enable all features as long as we are not thermally constrained
            configuration.userFaceTrackingEnabled = true
            configuration.frameSemantics = .personSegmentation
            sceneView.rendersMotionBlur = true
        case .serious:
            // Disable face tracking and person segmentation to help reduce power
            configuration.userFaceTrackingEnabled = false
            configuration.frameSemantics = .init()
            sceneView.rendersMotionBlur = true
        case .critical:
            // Disable everything possible
            configuration.userFaceTrackingEnabled = false
            configuration.frameSemantics = .init()
            sceneView.rendersMotionBlur = false
        }
    }
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        }
    }
}
Test your defenses
Testing Under Temperature Conditions

Prior approaches

Don’t extrapolate behavior from nominal conditions

Avoid running a dummy CPU load to warm the device

Don’t overlook the energy impact of your app
PAIRED WATCHES

<table>
<thead>
<tr>
<th>Name</th>
<th>Model</th>
<th>watchOS</th>
<th>Identifier</th>
</tr>
</thead>
</table>

INSTALLED APPS

<table>
<thead>
<tr>
<th>Name</th>
<th>Version</th>
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No apps installed

DEVICE CONDITIONS

<table>
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The system behaves as though under slightly elevated thermal state

Start
### Device Conditions

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Device Conditions: Thermal

How it works

Temperature
Condition
ThermalState

Nominal
Fair
Serious
Critical
Device Conditions: Thermal

How it works

Temperature
Condition
Thermal State

- Nominal
- Fair
- Serious
- Critical
Device Conditions: Thermal

How it works

Temperature Condition ThermalState
Nominal Fair Serious Critical
Device Conditions: Thermal

How it works

Temperature
Condition
ThermalState
Nominal  Fair  Serious  Critical
Device Conditions: Thermal

How it works
Device Conditions: Thermal

How it works

Temperature

Condition

Thermal State

Nominal  Fair  Serious  Critical
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How it works

Temperature

Condition

Thermal State

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Fair

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Device Conditions: Thermal

How it works

- **Temperature**
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Device Conditions: Thermal

How it works

Temperature

Condition

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How it works

Temperature

Condition

Thermal State

Nominal | Fair | Serious | Critical
Demo
Optimizing for elevated thermal states

Jay Khandhar, Core OS Energy Technologies Engineer
class GameSettings_iPadPro {
    var thermalState = ProcessInfo.ThermalState.nominal {
        didSet {
            switch thermalState {
            case .nominal, .fair:
                setRenderSettings([.HDR, .depthOfField, .softShadows], postProcessing: .high)
            case .serious:
                setRenderSettings([.depthOfField, .blobShadows], postProcessing: .medium)
            case .critical:
                setRenderSettings([ ], postProcessing: .disabled)
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No Optimizations

Optimized
No Optimizations

Optimized
No Optimizations

Energy

Average Energy Impact

Very High
Energy Impact

Average Component Utilization

- Overhead: 0%
- CPU: 28.3%
- Network: 0%
- GPU: 71.7%

Energy

Average Energy Impact

Low
Energy Impact

Average Component Utilization

- Overhead: 0%
- CPU: 17.3%
- Network: 0%
- GPU: 82.7%

Optimized
Recap
Debugging in Xcode

Device conditions

Environment overrides
Designing for Adverse Conditions

Use the Test Pyramid model
Skip only truly unneeded code in unit tests
Set acceptable thresholds under conditions
Summary

Add test runs with adverse device conditions

Look for progressions in your application behavior

Activate different Network Links such as 3G

Activate elevated temperature states such as the Serious state
More Information

developer.apple.com/wwdc19/422

Xcode Open Hours  Friday, 5:00