#WWDC19

Designing for Adverse Network and Temperature Conditions

Alexander Karapetian, iOS Performance Engineer
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Understanding device conditions

Handling realistic network links

New tools for varying temperatures

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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

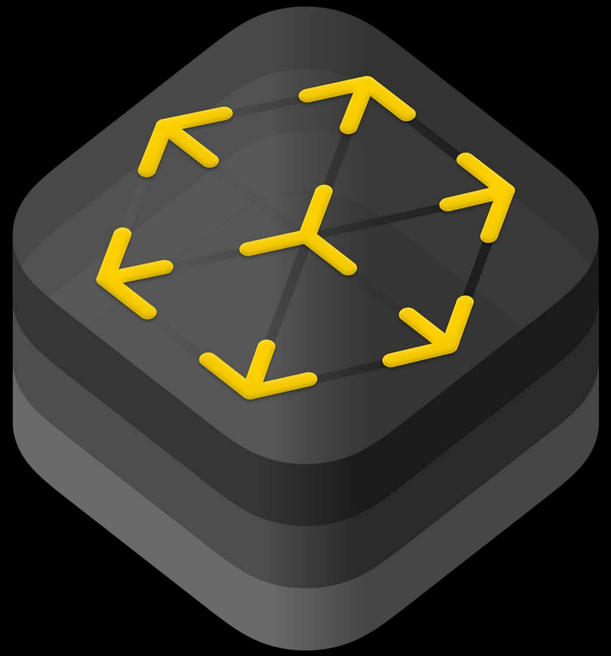
In a climate controlled area

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.”

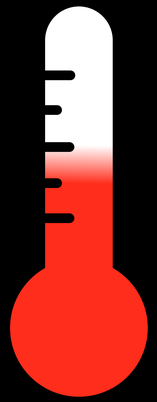
“Music stopped on our road trip. What a let-down!”

Adverse Device Conditions

Network Link

3G

LTE



Temperature

Thermal state

Debugging in Xcode 11

Thursday, 10:00

Network Link


9:41
FaceTime
Thursday
30
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Notes
Reminders
Stocks
News
tv
TV
iTunes Store
App Store
Books
Health
Home
Wallet
Settings
SlowNewsDay

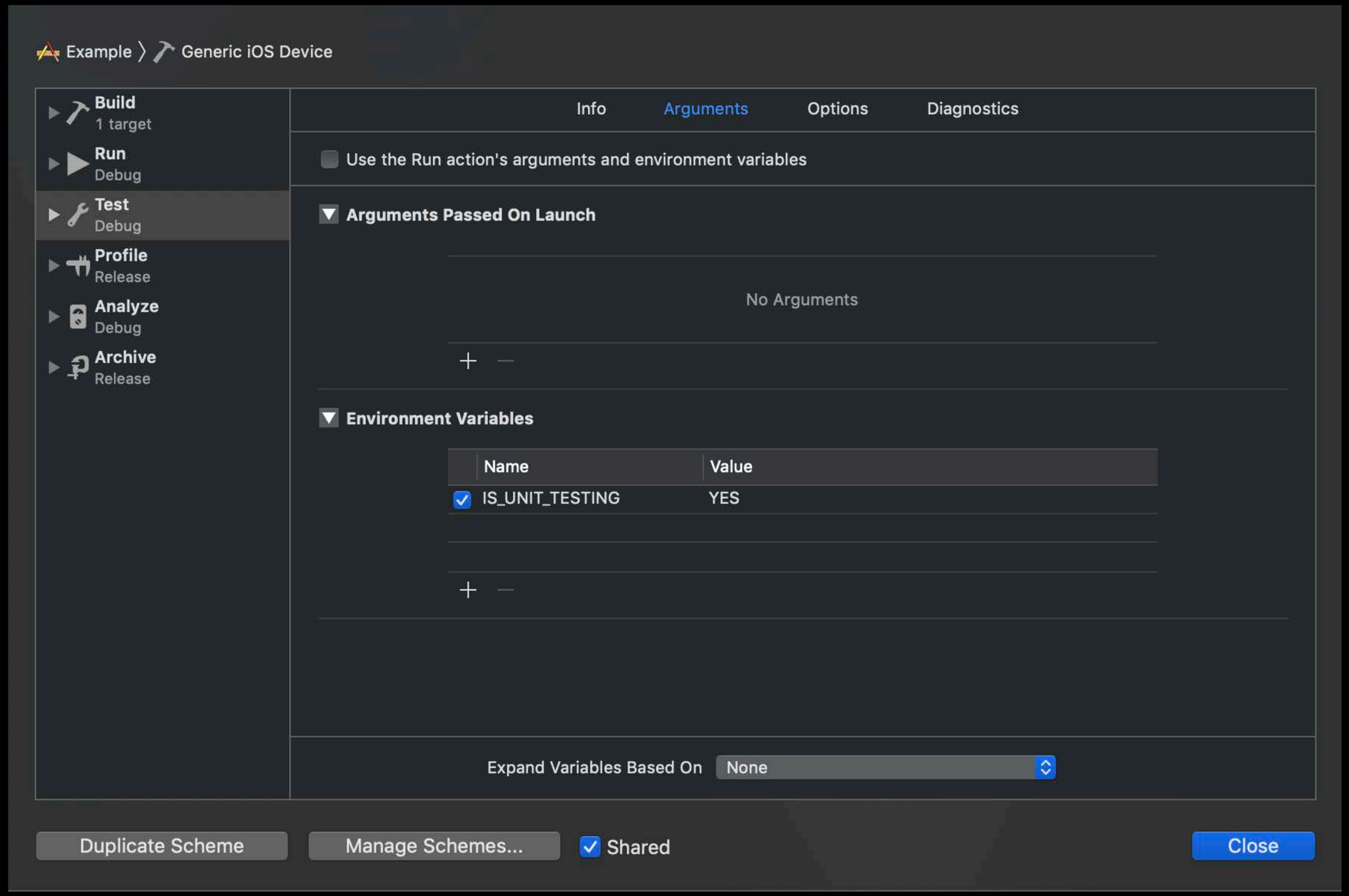

9:41
FaceTime
Thursday
30
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Notes
Reminders
Stocks
News
tv
TV
iTunes Store
App Store
Books
Health
Home
Wallet
Settings
SlowNewsDay

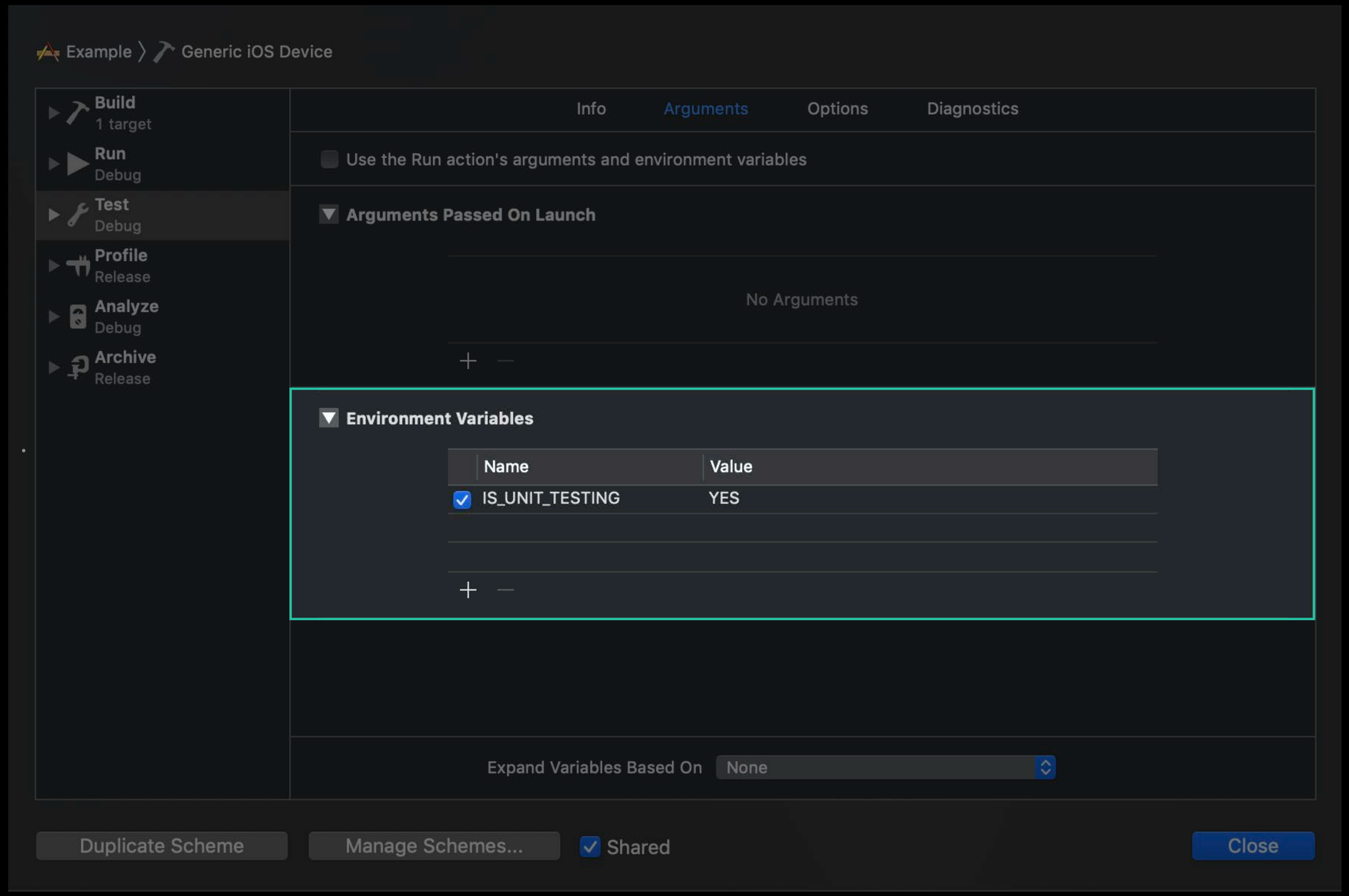
Real-World Network Conditions

Reduced responsiveness

Perceived app freezing

Functional problems


Example 〉 Generic iOS Device
Build
1 target
Run
Debug
Test
Debug
Profile
Release
Analyze
Debug
Archive
Release
Info
Arguments
Options
Diagnostics
Use the Run action's arguments and environment variables
Arguments Passed On Launch
No Arguments
Environment Variables
Name
Value
IS_UNIT_TESTING
YES
Expand Variables Based On
None
Duplicate Scheme
Manage Schemes...
Shared
Close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Duplicate Scheme
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Close

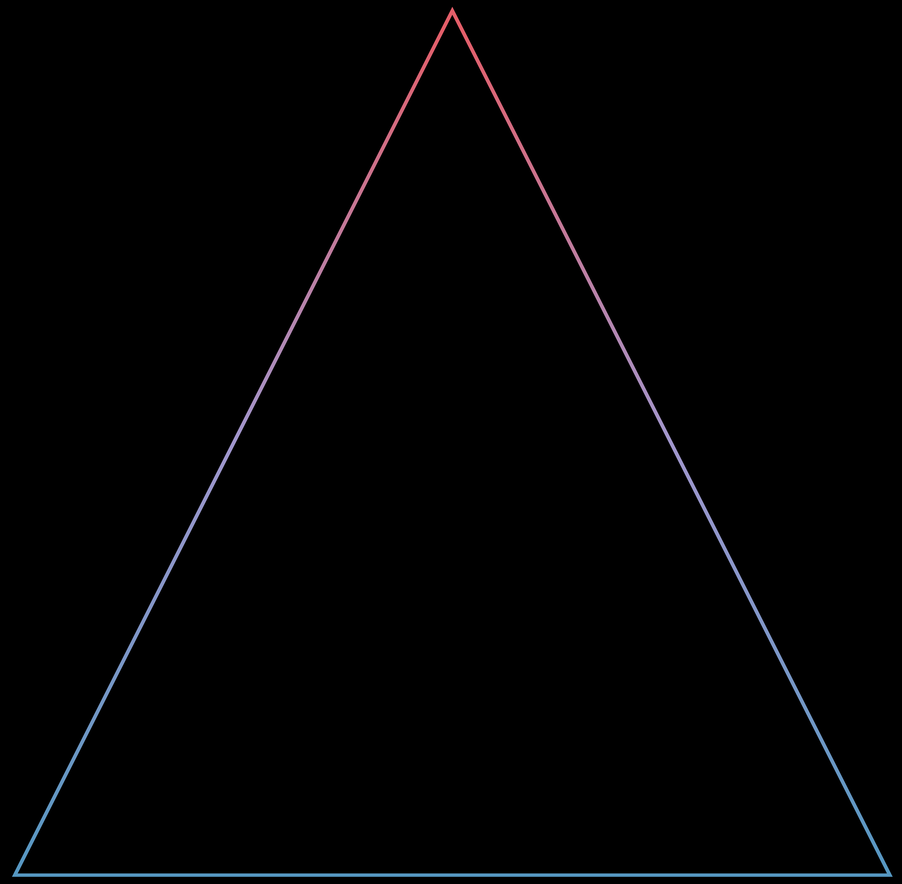
Improving App Launch Under Testing

Ensure only unneeded functionality is skipped for unit testing

```
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



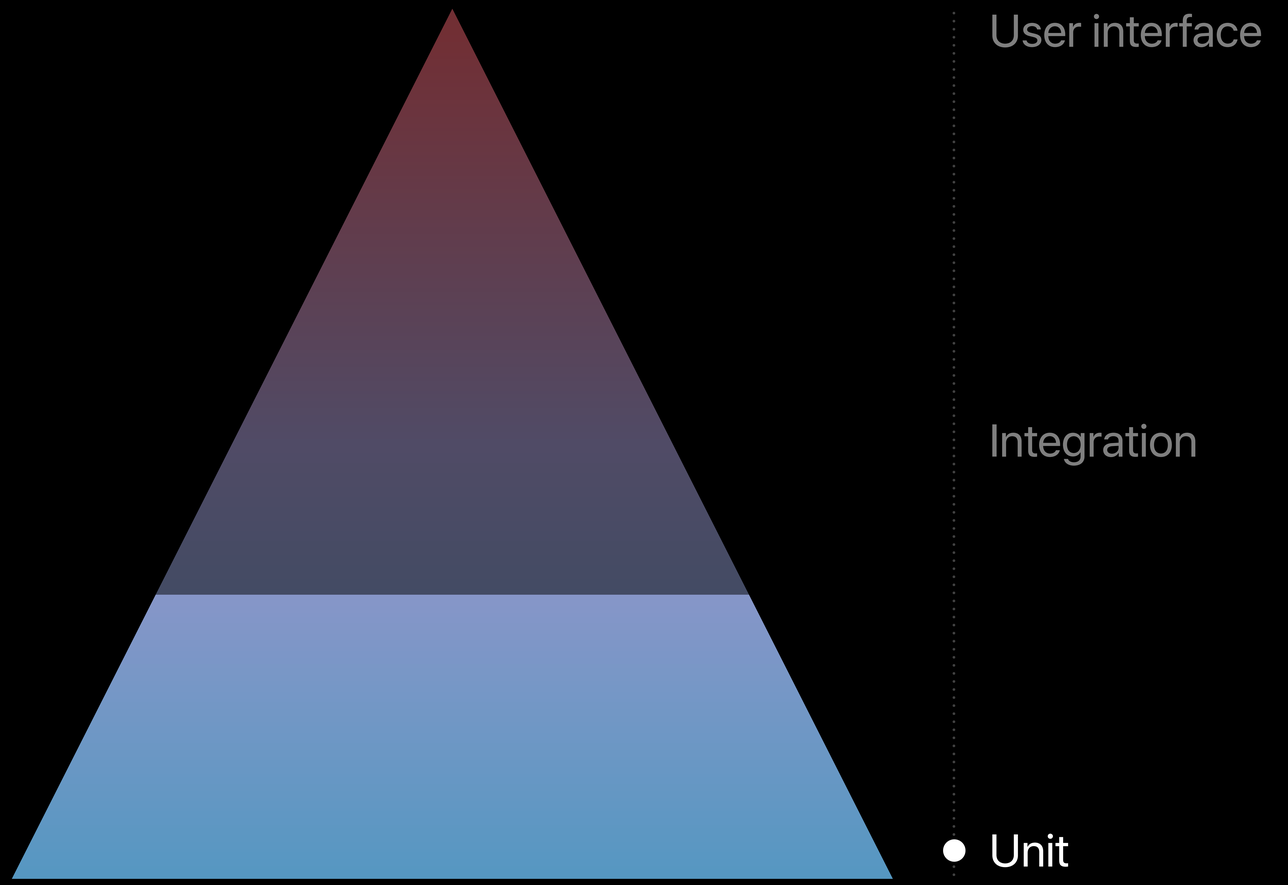
User interface

Integration

Unit

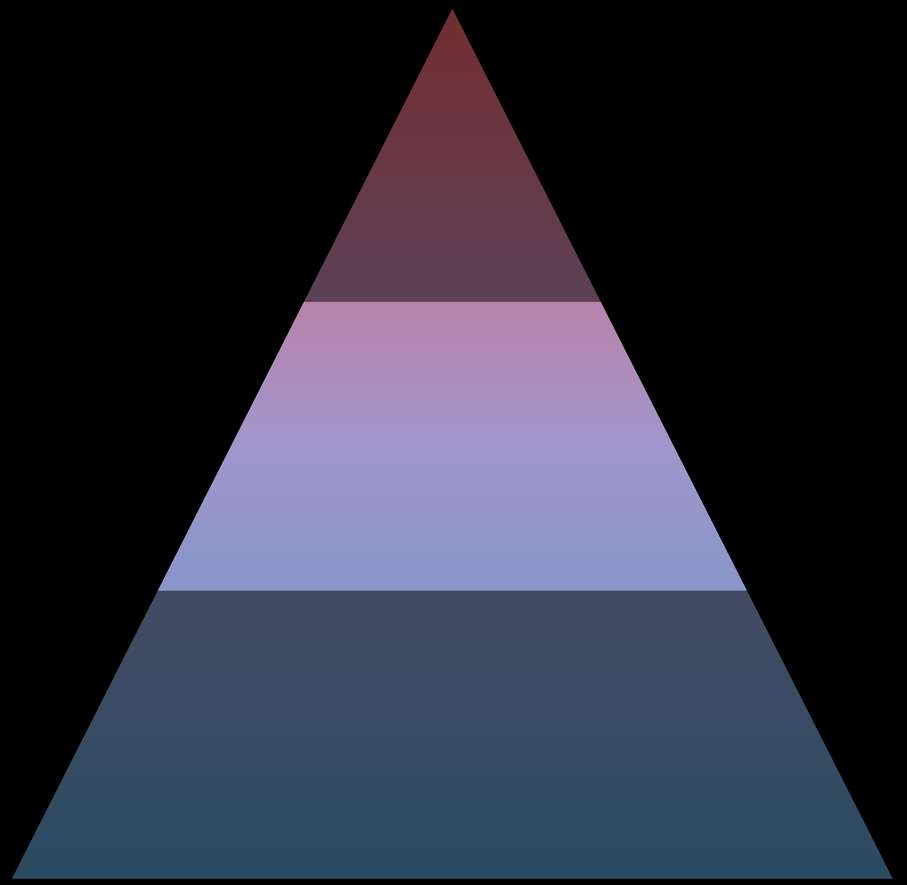
Test Pyramid

Testing fundamentals



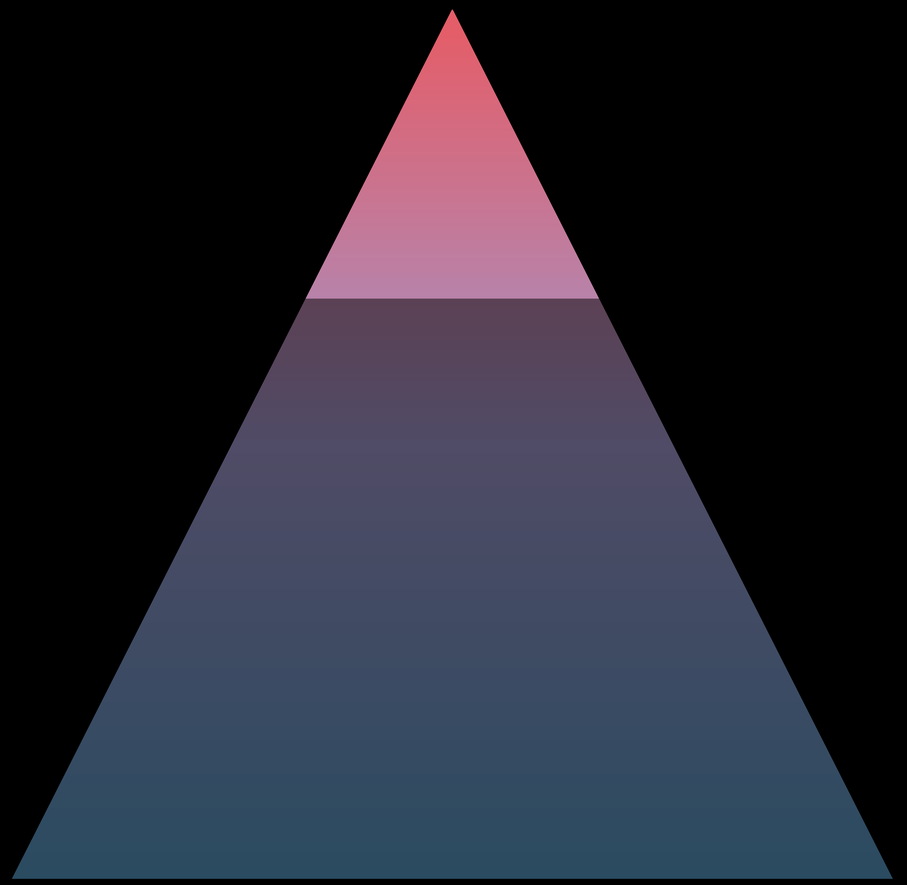
Test Pyramid

Testing fundamentals



Test Pyramid

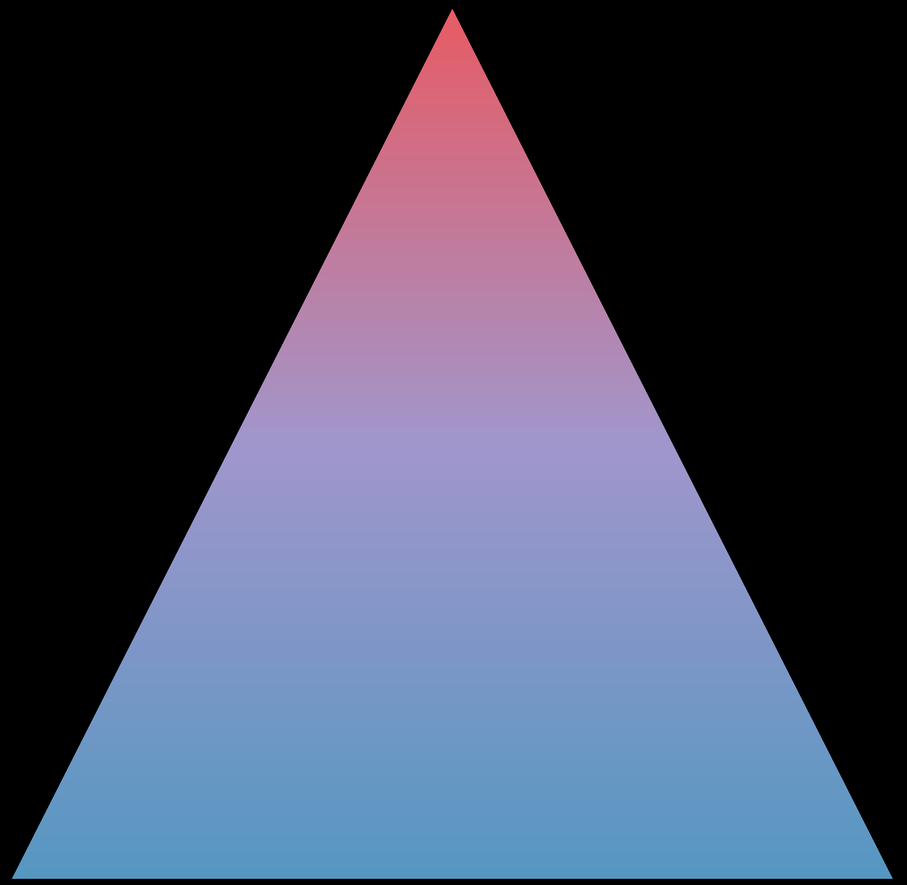
Testing fundamentals



- User interface
- Integration
- Unit

Test Pyramid

Testing fundamentals



User interface

Integration

Unit

Qualities of Good Tests

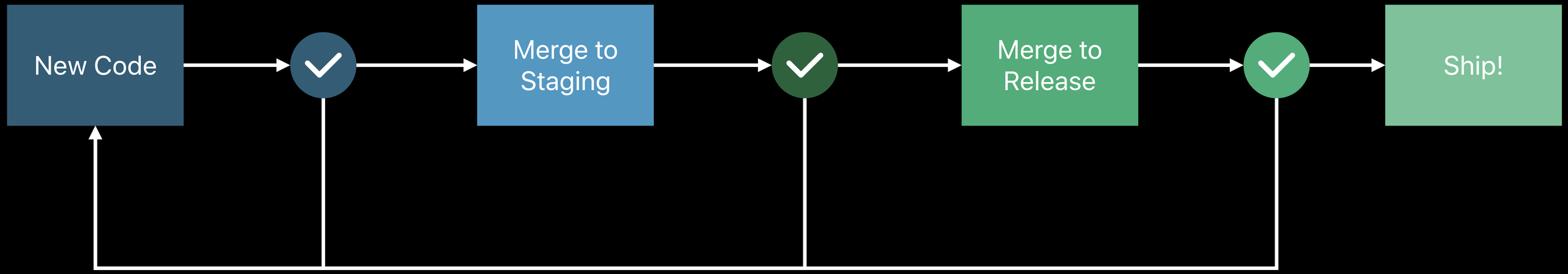
Repeatable

Deterministic

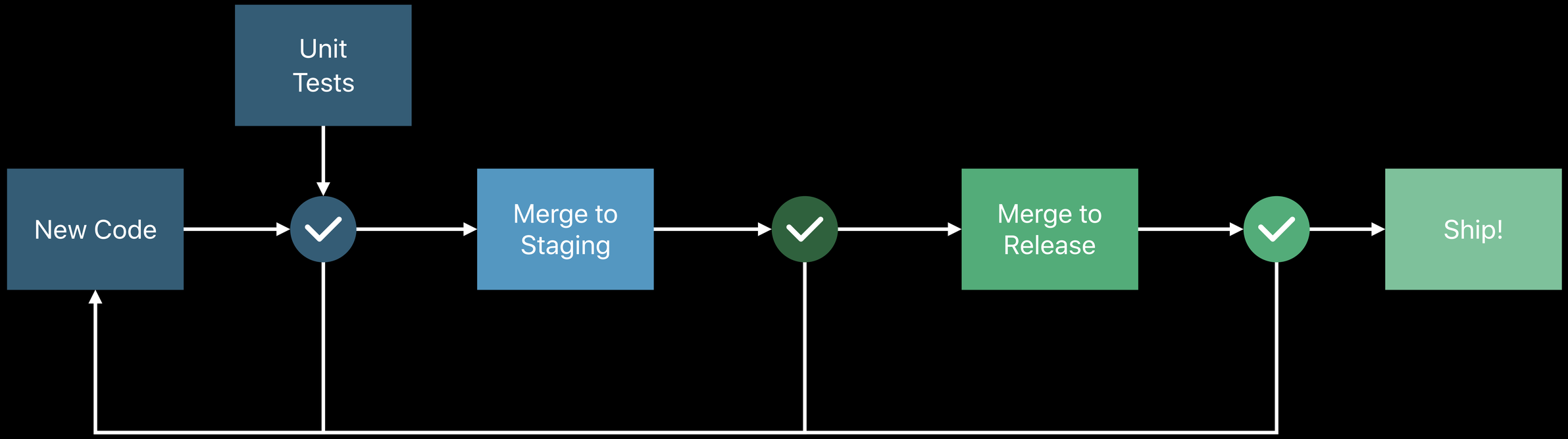
Low variance

Representative

Quality Checkpoints in Development



Quality Checkpoints in Development



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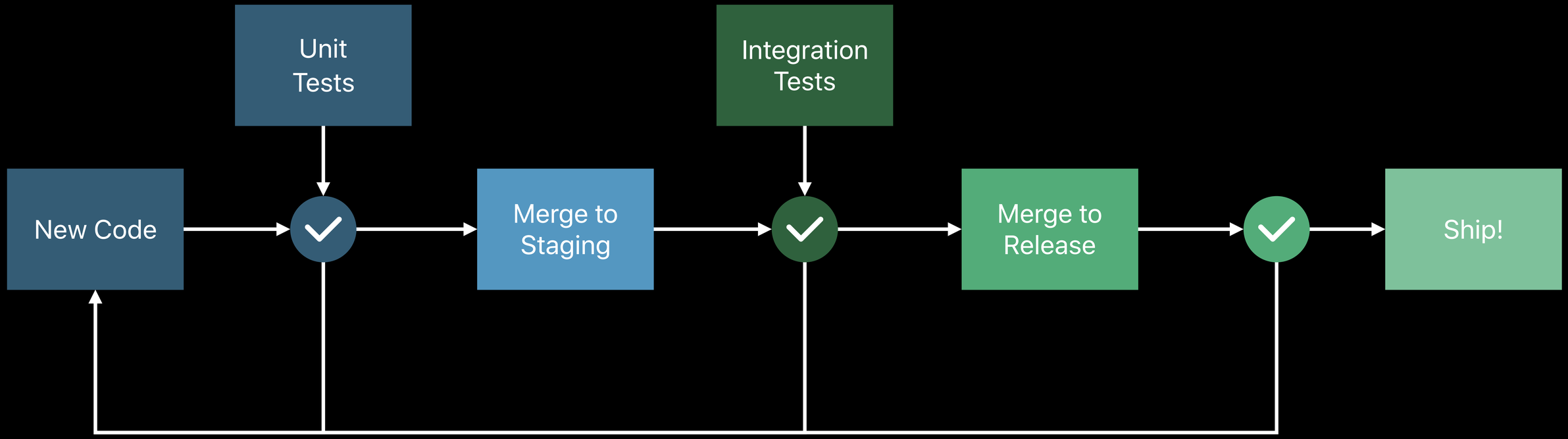

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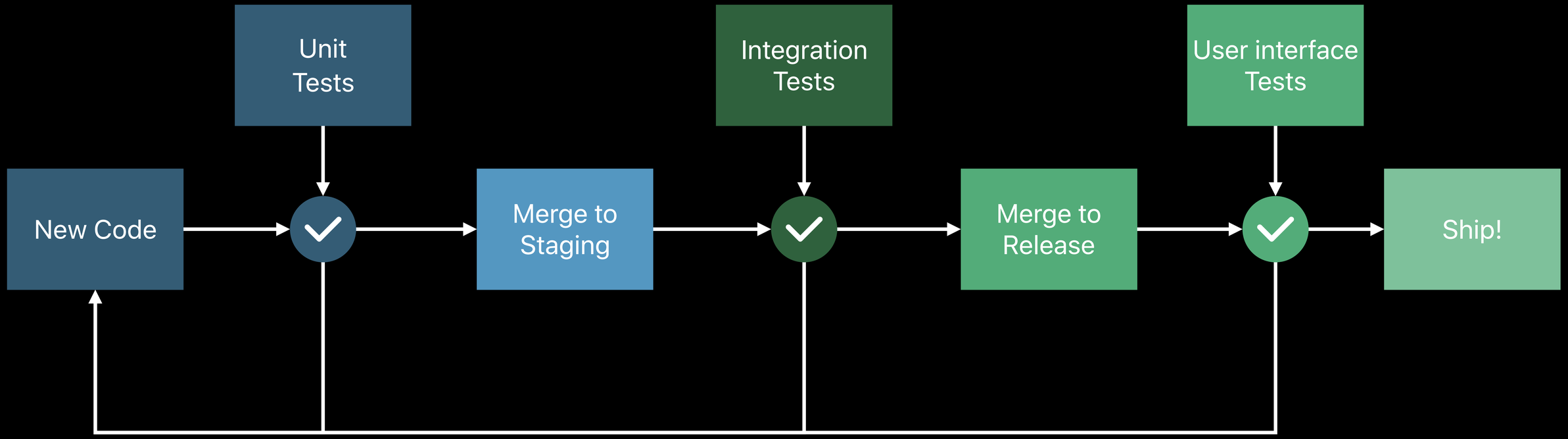


Testing Under Network Conditions

Some approaches

Conditioning the network infrastructure

- Custom routers
- Can be prohibitively complex

Network Link Conditioner for macOS

EDGE

3G

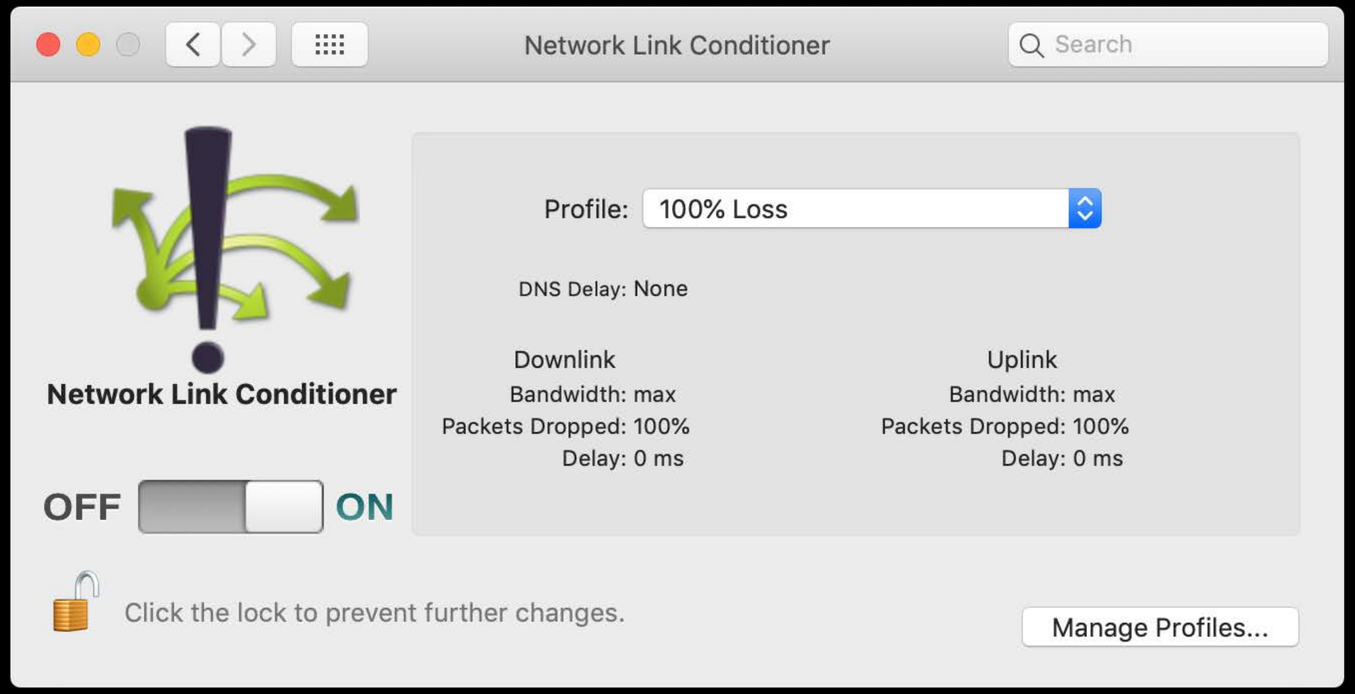
DSL

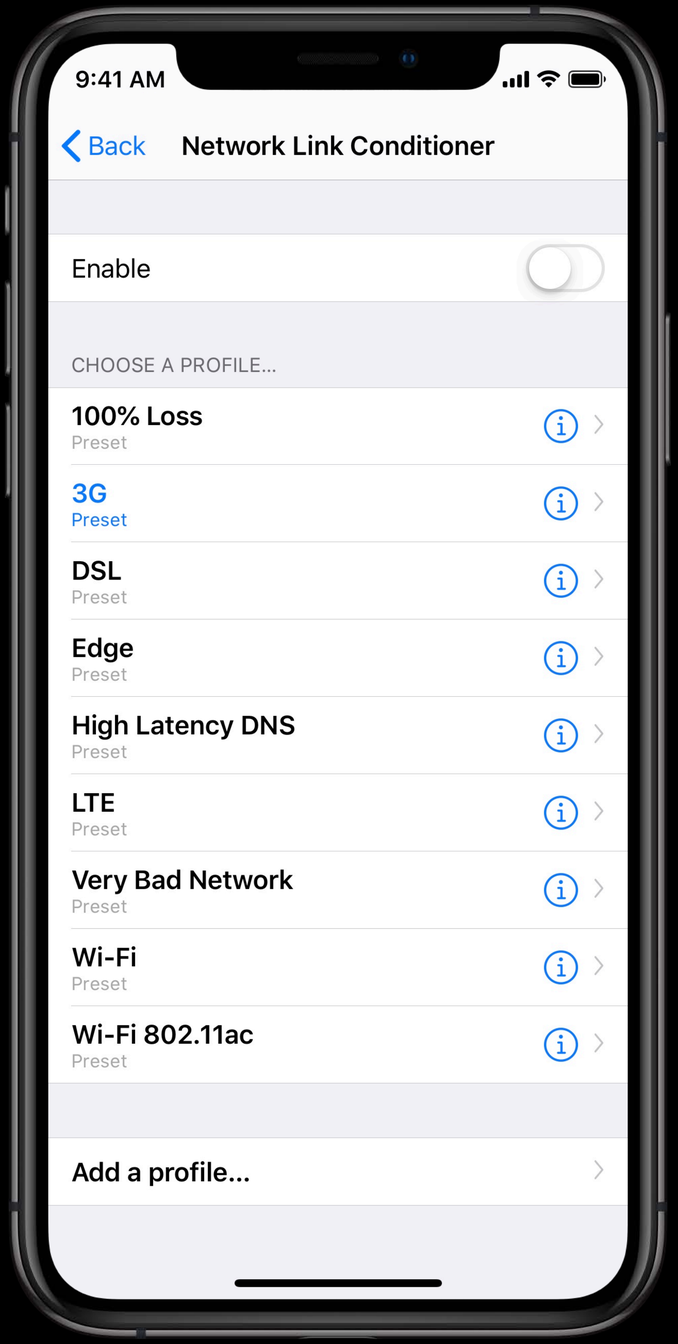
Wi-Fi

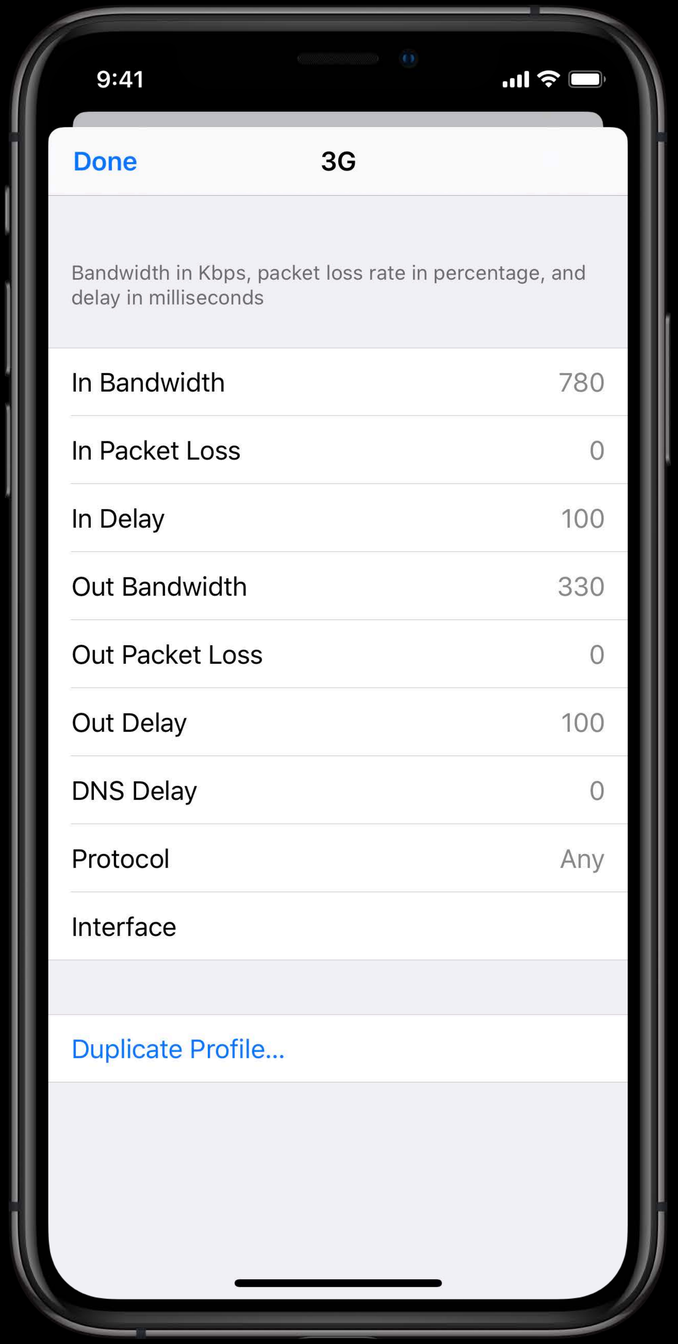
High Latency DNS

Very Bad Network

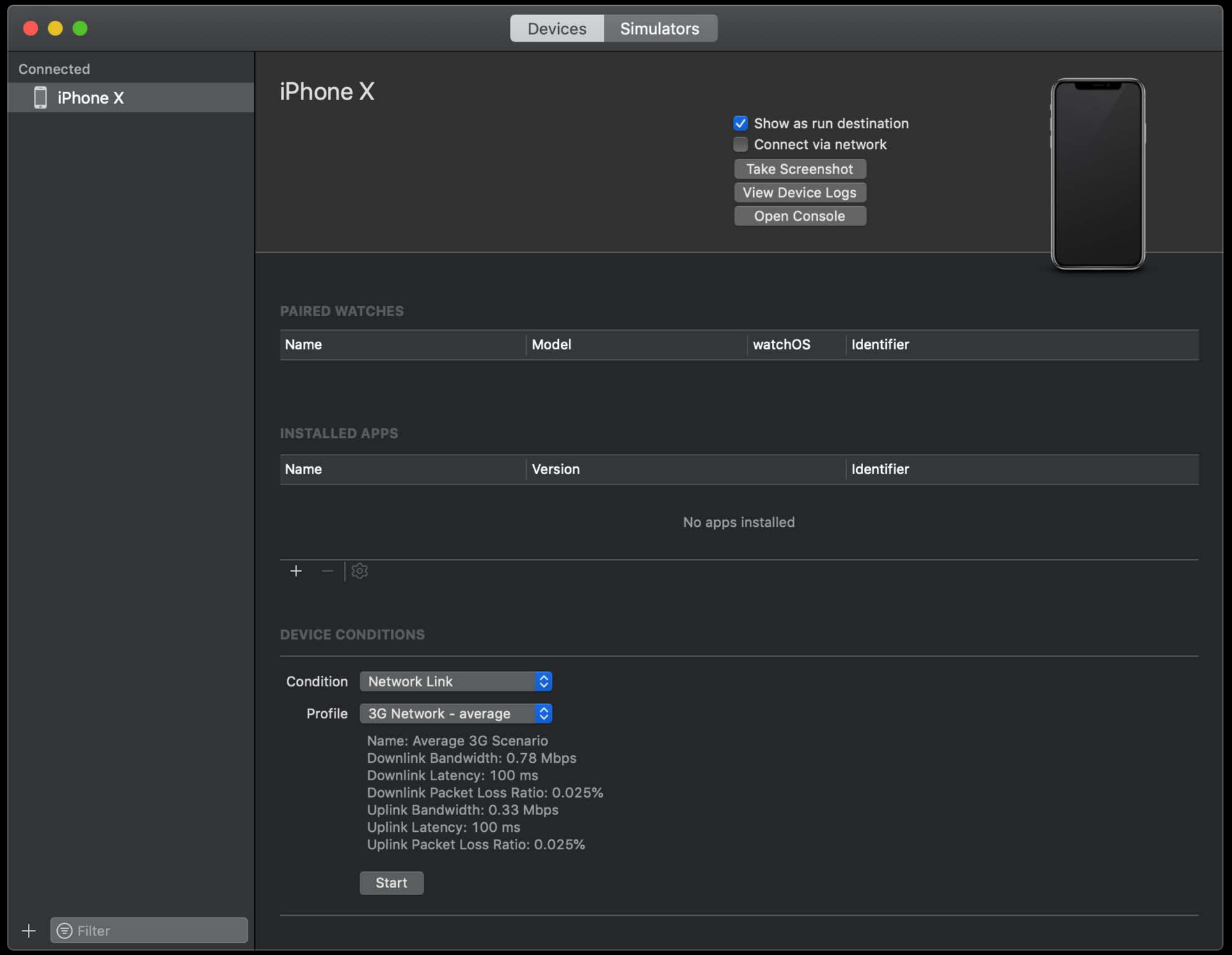
100% Packet Loss



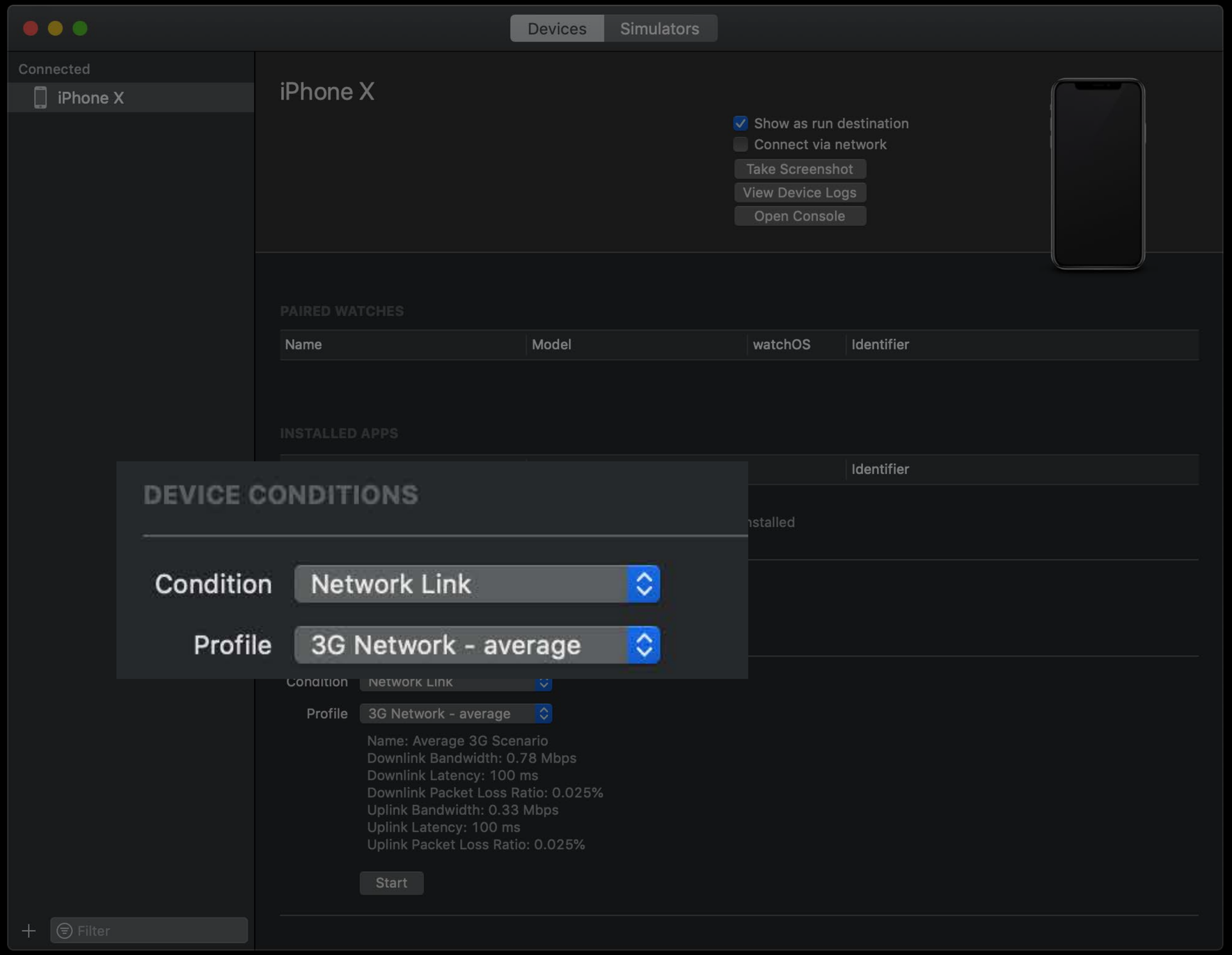

9:41 AM
Back
Network Link Conditioner
Enable
CHOOSE A PROFILE...
100% Loss
Preset
3G
Preset
DSL
Preset
Edge
Preset
High Latency DNS
Preset
LTE
Preset
Very Bad Network
Preset
Wi-Fi
Preset
Wi-Fi 802.11ac
Preset
Add a profile...


9:41
Done
3G
Bandwidth in Kbps, packet loss rate in percentage, and delay in milliseconds
In Bandwidth 780
In Packet Loss 0
In Delay 100
Out Bandwidth 330
Out Packet Loss 0
Out Delay 100
DNS Delay 0
Protocol Any
Interface
Duplicate Profile...


XCODE


Devices
Simulators
Connected
iPhone X
iPhone X
Show as run destination
Connect via network
Take Screenshot
View Device Logs
Open Console
PAIRED WATCHES
Name
Model
watchOS
Identifier
INSTALLED APPS
Name
Version
Identifier
No apps installed
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%
Start
Filter

NEW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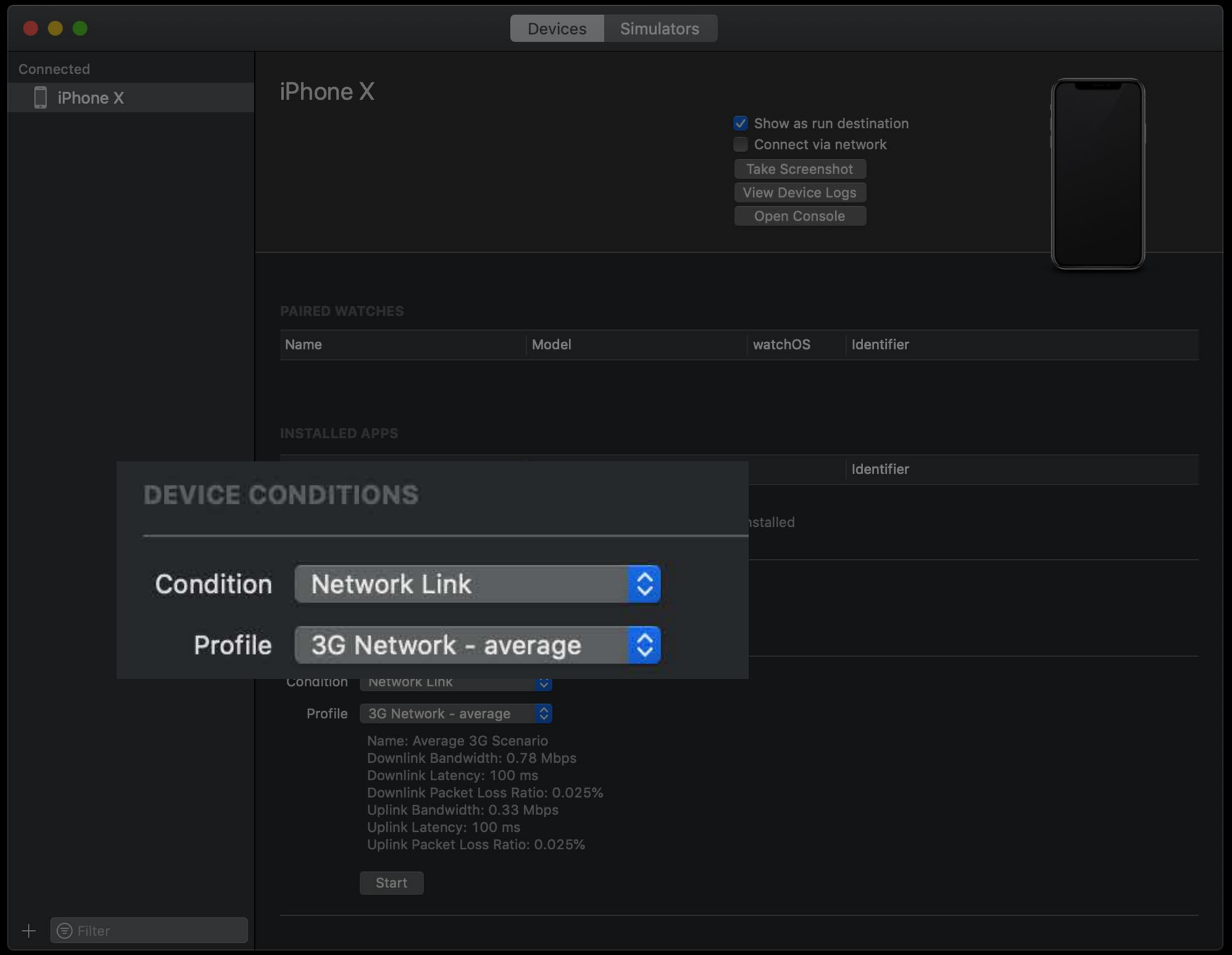
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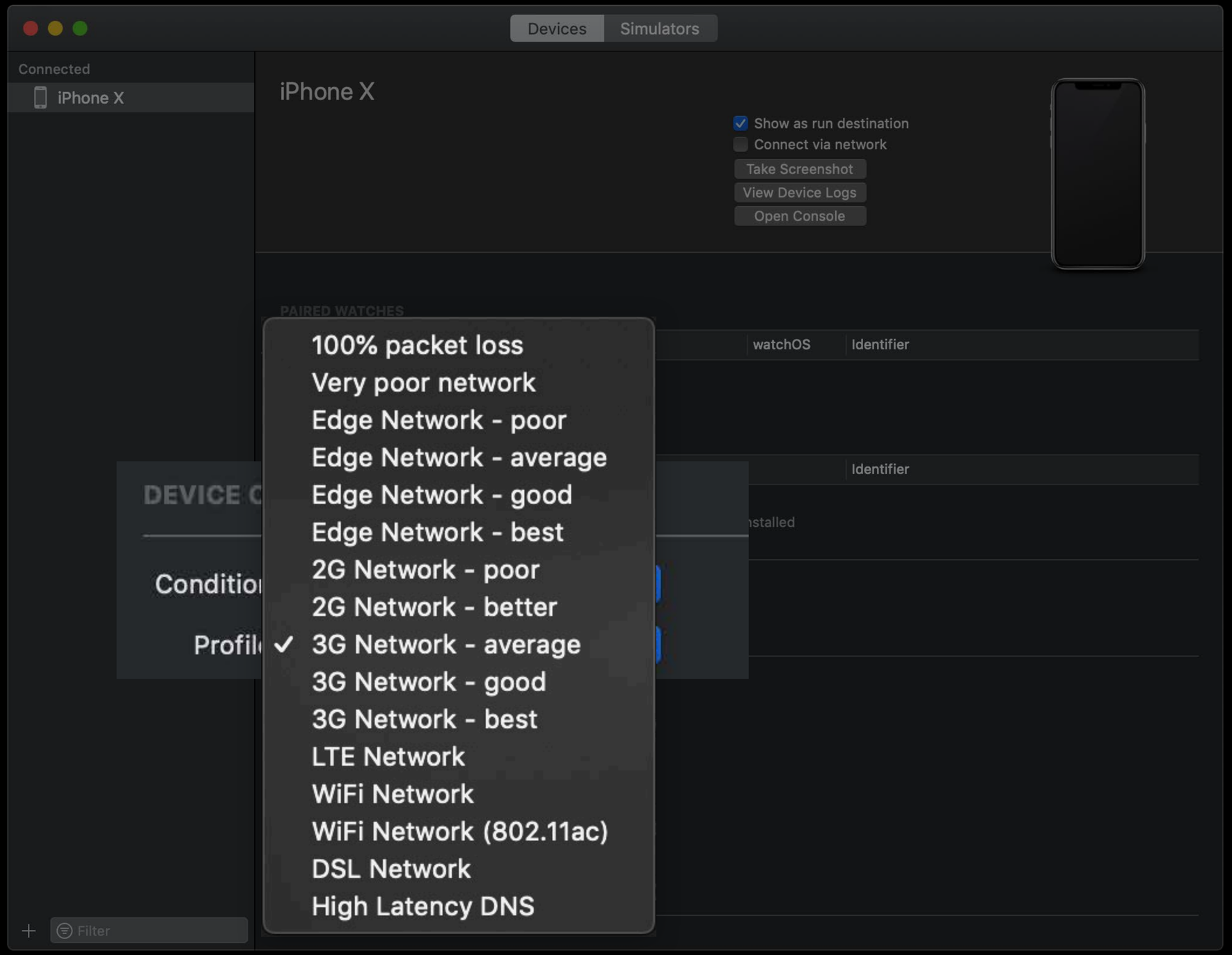
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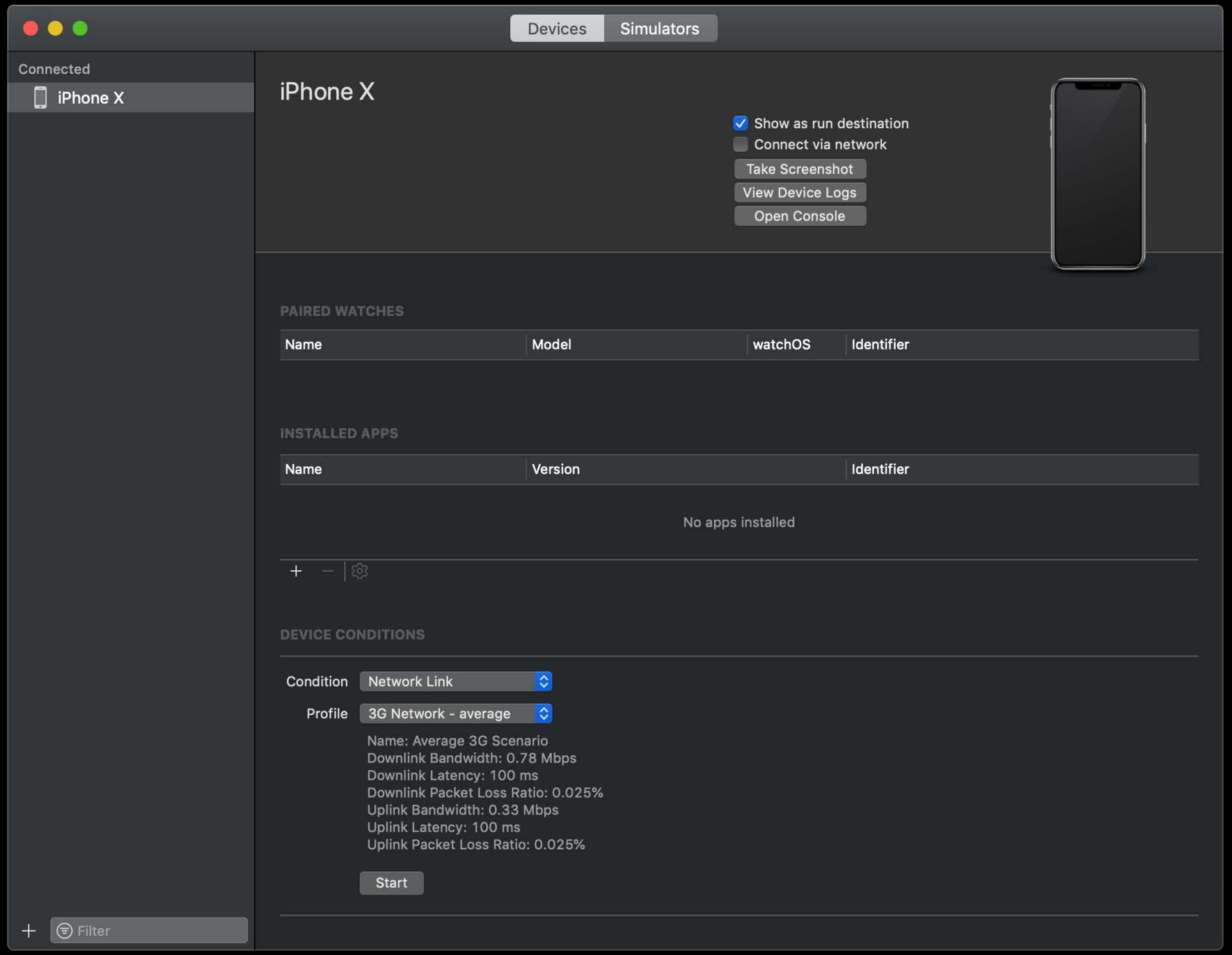
Connect via network
Take Screenshot
View Device Logs
Open Console
PAIRED WATCHES
watchOS
Identifier
Identifier
DEVICE C
Conditio
Profil
100% packet loss
Very poor network
Edge Network - poor
Edge Network - average
Edge Network - good
Edge Network - best
2G Network - poor
2G Network - better
3G Network - average
3G Network - good
3G Network - best
LTE Network
WiFi Network
WiFi Network (802.11ac)
DSL Network
High Latency DNS
Filter

NEW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iPhone X
Show as run destination
Connect via network
Take Screenshot
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Open Console
PAIRED WATCHES
Name
Model
watchOS
Identifier
INSTALLED APPS
Name
Version
Identifier
No apps installed
DEVICE CONDITIONS
Condition
Network Link
Profile
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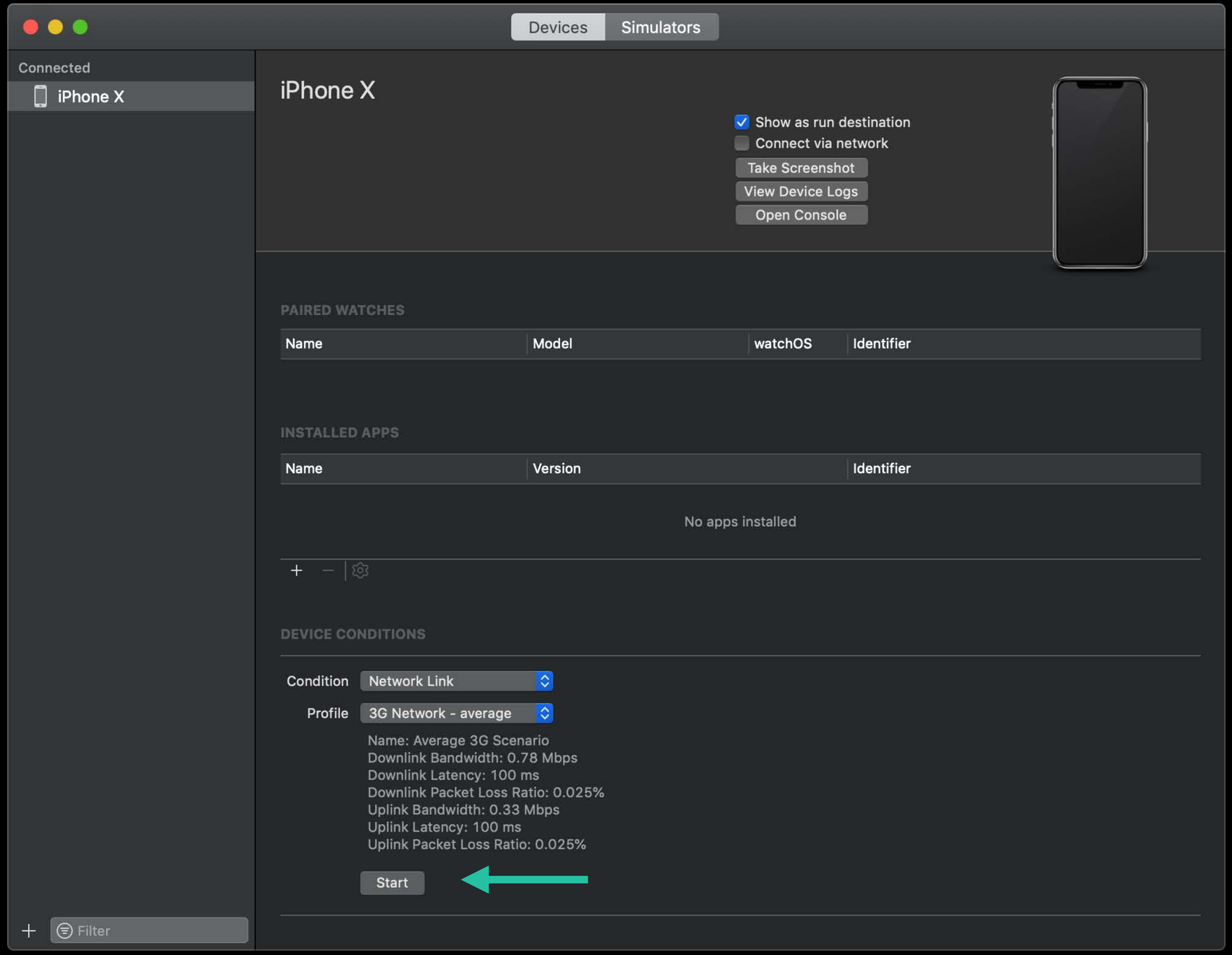
Start
Filter

NEW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Uplink Bandwidth: 0.33 Mbps
Uplink Latency: 100 ms
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Start
Filter

NEW

NEW

NEW


9:41
FaceTime
Friday
7
Calendar
Photos
Camera
Mail
Clock
Maps
Weather
Notes
Videos
Network Link
Condition Active
"3G Network - good" is active on this iPhone. Stop running this condition?
Cancel
Stop
iTunes S
Health
Home
Wallet
Settings

NEW

Demo

Improvements in network connectivity

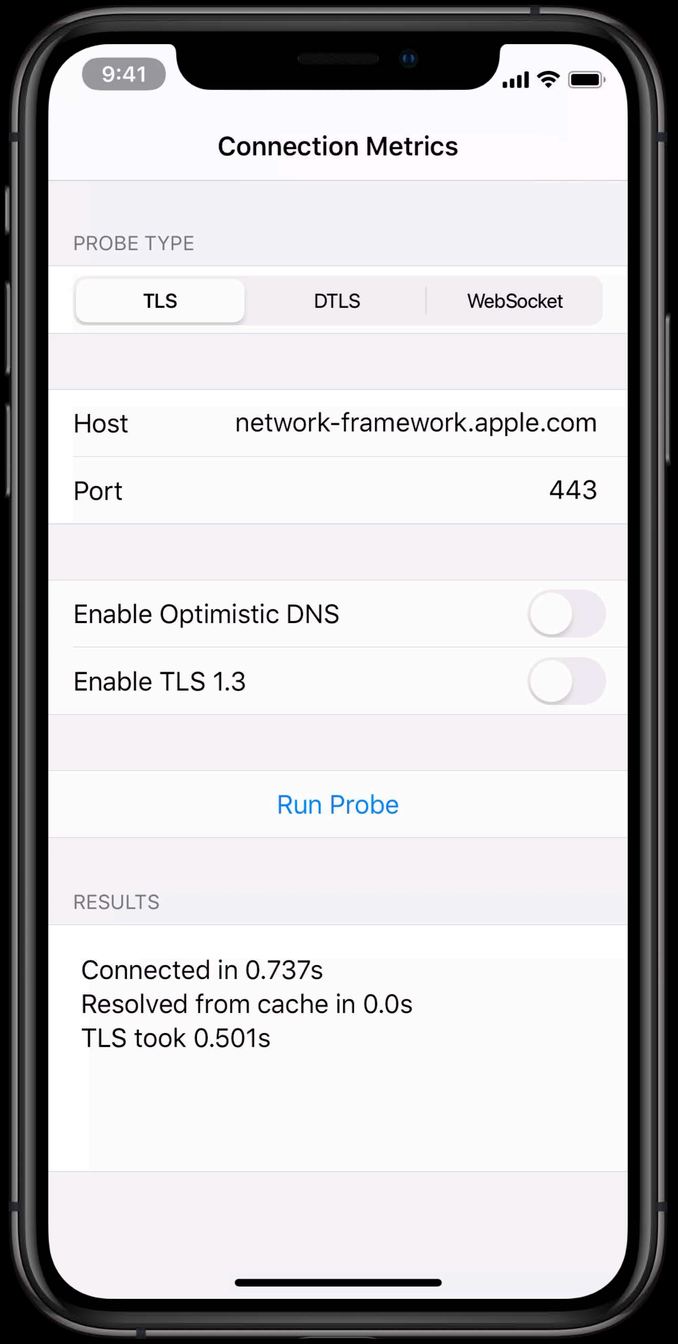
Ilya Veygman

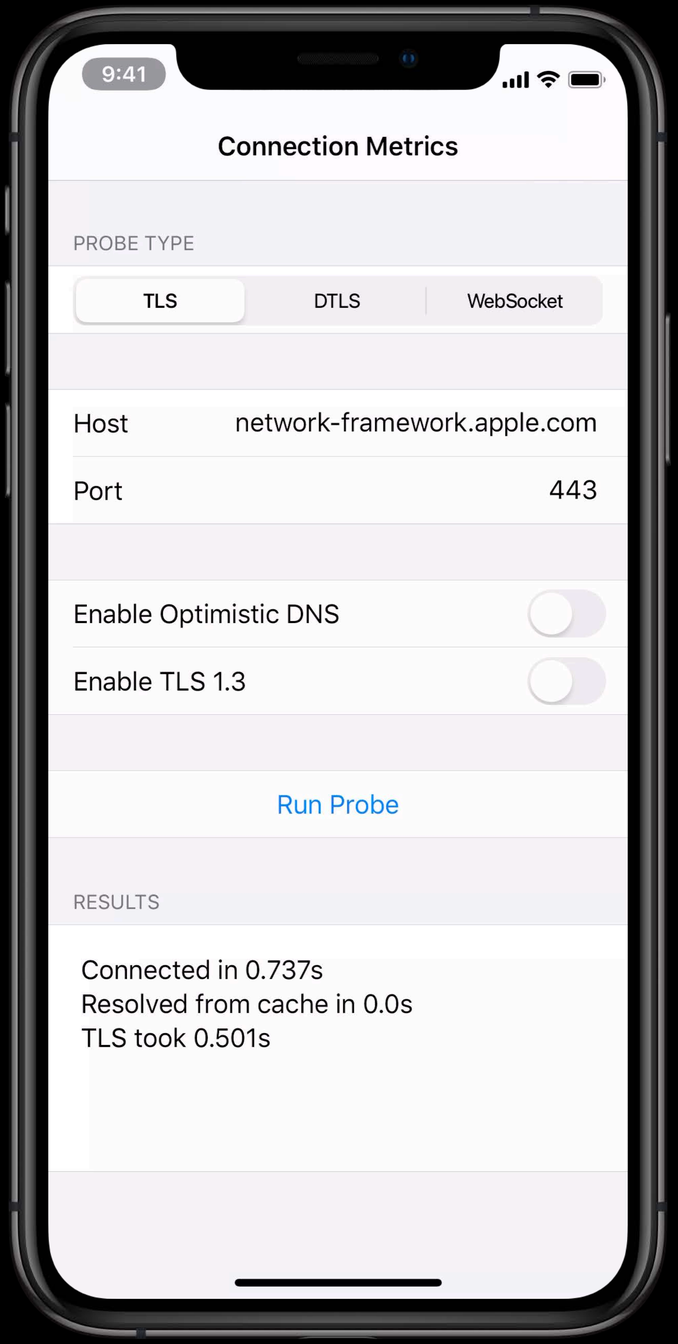

9:41
FaceTime
Tuesday
28
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Notes
Reminders
Stocks
News
tv
TV
iTunes Store
App Store
Books
Health
Home
Wallet
Settings
Connection

Average: ~150ms


9:41
FaceTime
Tuesday
28
Calendar
Photos
Camera
Mail
Clock
Maps
280
Weather
Notes
Reminders
Stocks
News
tv
TV
iTunes Store
App Store
Books
Health
Home
Wallet
Settings
Connection

Average: ~770ms


9:41
Connection Metrics
PROBE TYPE
TLS
DTLS
WebSocket
Host
network-framework.apple.com
Port
443
Enable Optimistic DNS
Enable TLS 1.3
Run Probe
RESULTS
Connected in 0.737s
Resolved from cache in 0.0s
TLS took 0.501s



Average: ~500ms

Designing for Adverse Network Conditions

Use Optimistic DNS and TLS 1.3

Use HTTP/2

Set reasonable timeouts

Avoid reachability checks

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

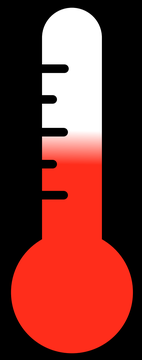
Consider differences between testing conditions and the real world

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


9:41
1x
Temperature
iPhone needs to cool down
before you can use it.
Emergency

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

Thermal State	Recommendations	System Actions
Nominal	No corrective action needed	
Fair		
Serious		
Critical		

Actions on ProcessInfo.ThermalState

Thermal State	Recommendations	System Actions
Nominal	No corrective action needed	
Fair	Slightly elevated thermal state Apps can proactively start energy-saving measures	Photos analysis pauses
Serious		
Critical		

Actions on ProcessInfo.ThermalState

Thermal State	Recommendations	System Actions
Nominal	No corrective action needed	
Fair	Slightly elevated thermal state Apps can proactively start energy-saving measures	Photos analysis pauses
Serious	System performance is impacted Apps should reduce CPU, GPU, and I/O usage	ARKit and FaceTime reduce FPS rate Restore from iCloud backup is paused
Critical		

Actions on ProcessInfo.ThermalState

Thermal State	Recommendations	System Actions
Nominal	No corrective action needed	
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Serious	System performance is impacted Apps should reduce CPU, GPU, and I/O usage	ARKit and FaceTime reduce FPS rate Restore from iCloud backup is paused
Critical	Apps should reduce CPU, GPU, and I/O usage, and stop using peripherals such as the camera	ARKit drops FPS rate FaceTime drops FPS rate

Actions on ProcessInfo.ThermalState

Thermal State	Recommendations	System Actions
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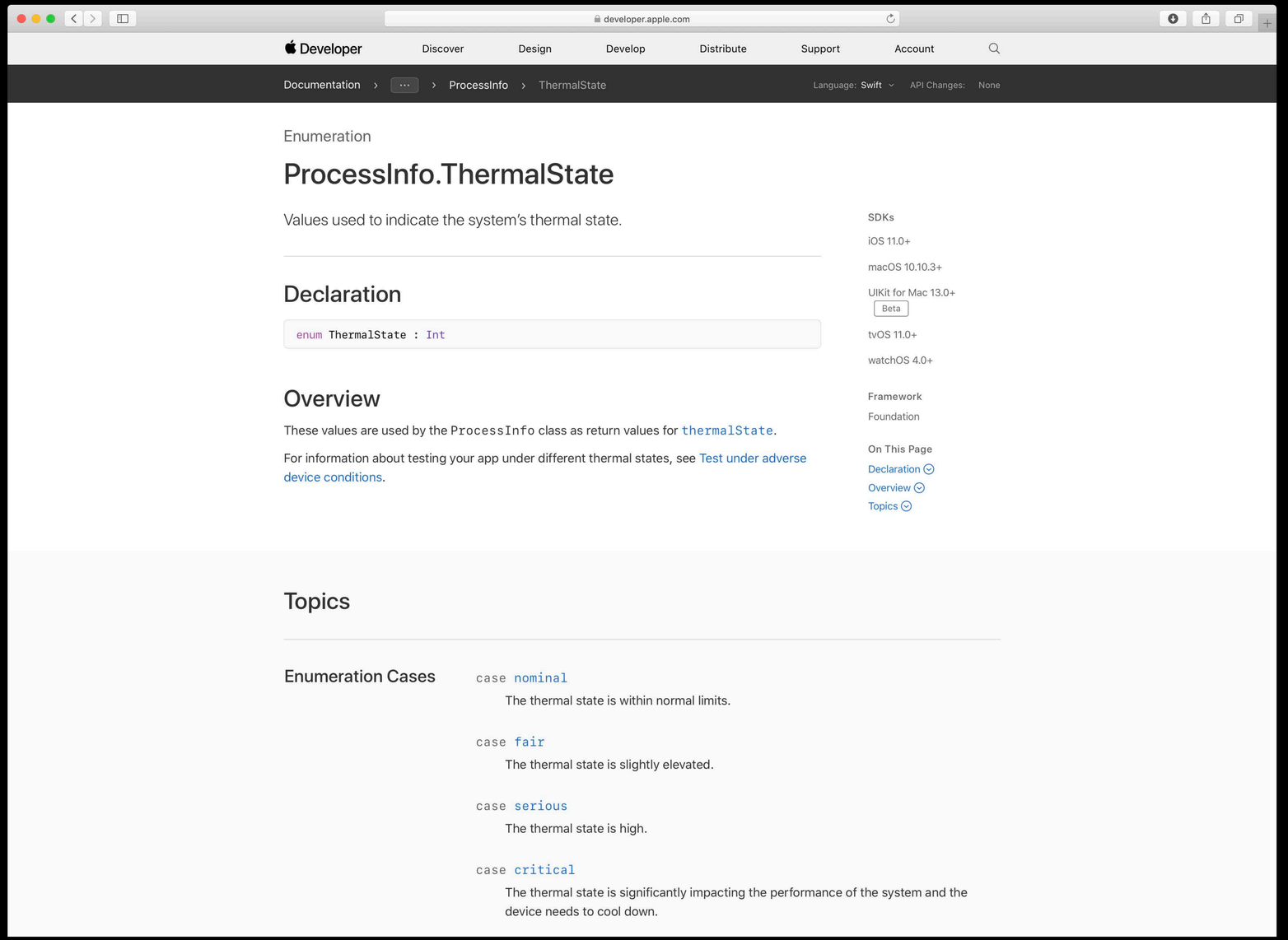

https://developer.apple.com/documentation/foundation/processinfo/thermalstate

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
}
```

```
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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                configuration.frameSemantics = .personSegmentation
                sceneView.rendersMotionBlur = true
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                configuration.frameSemantics = .init()
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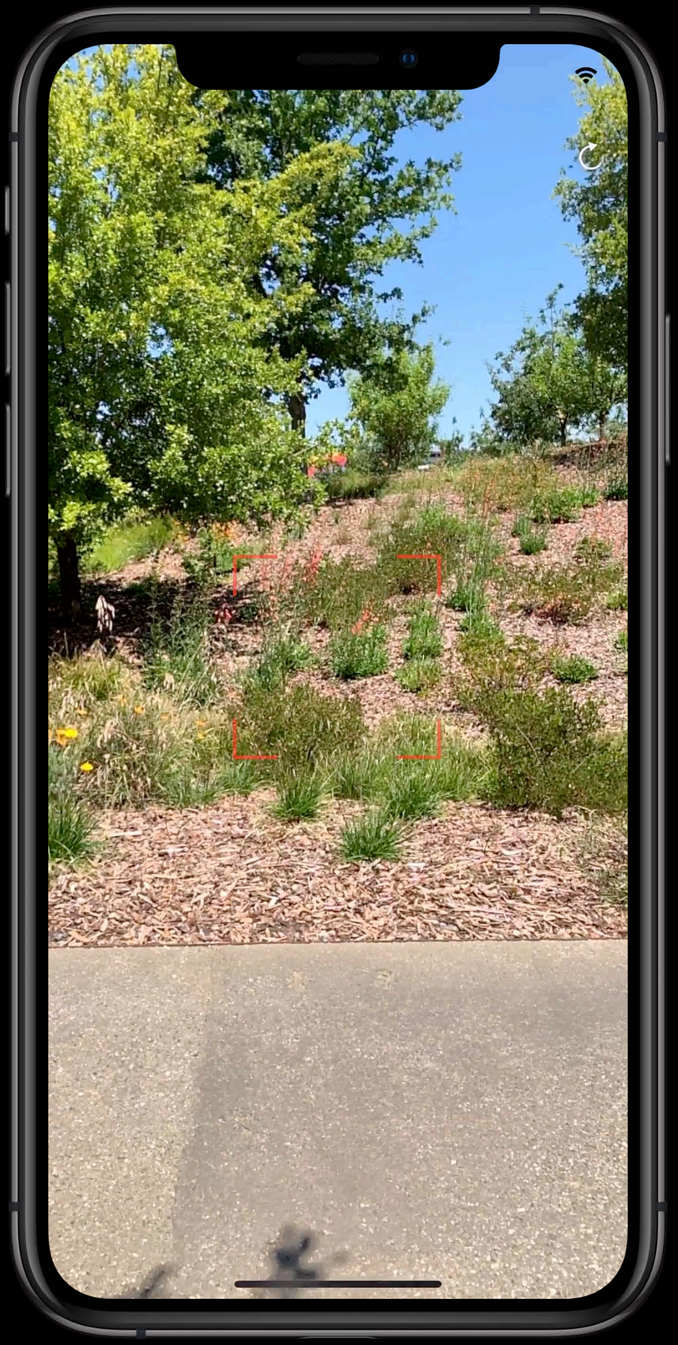
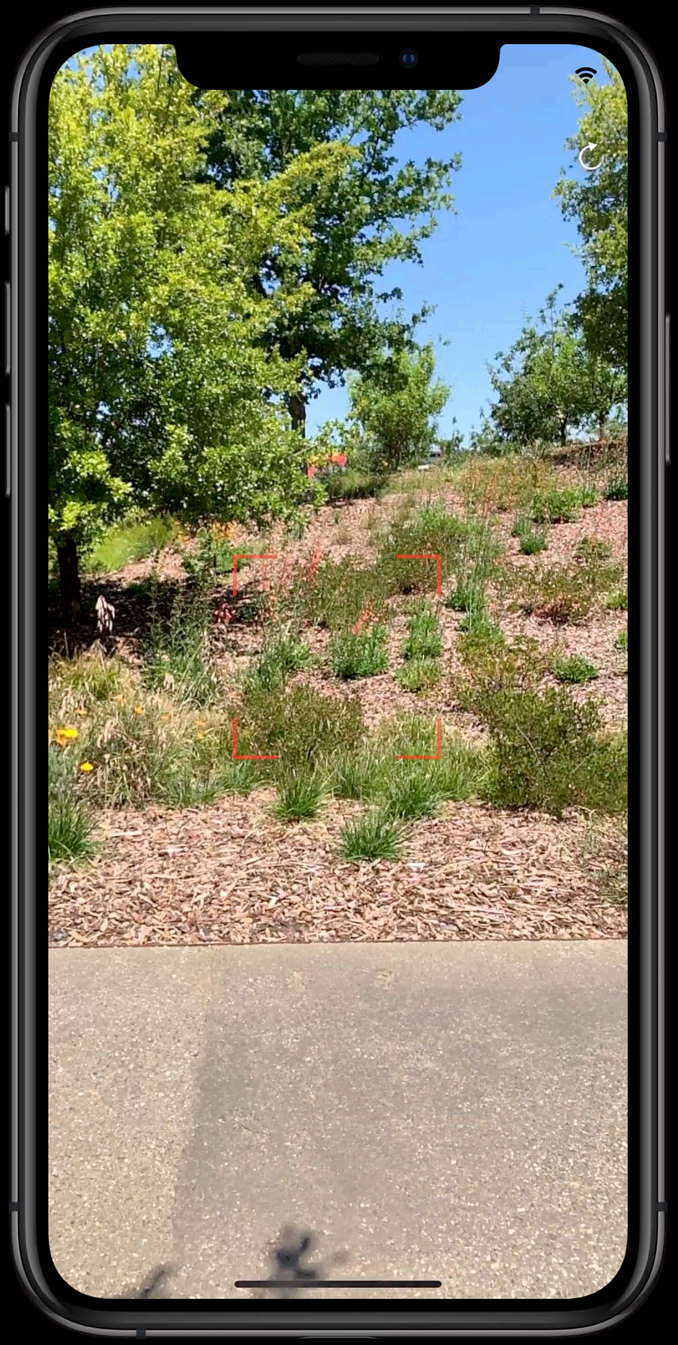
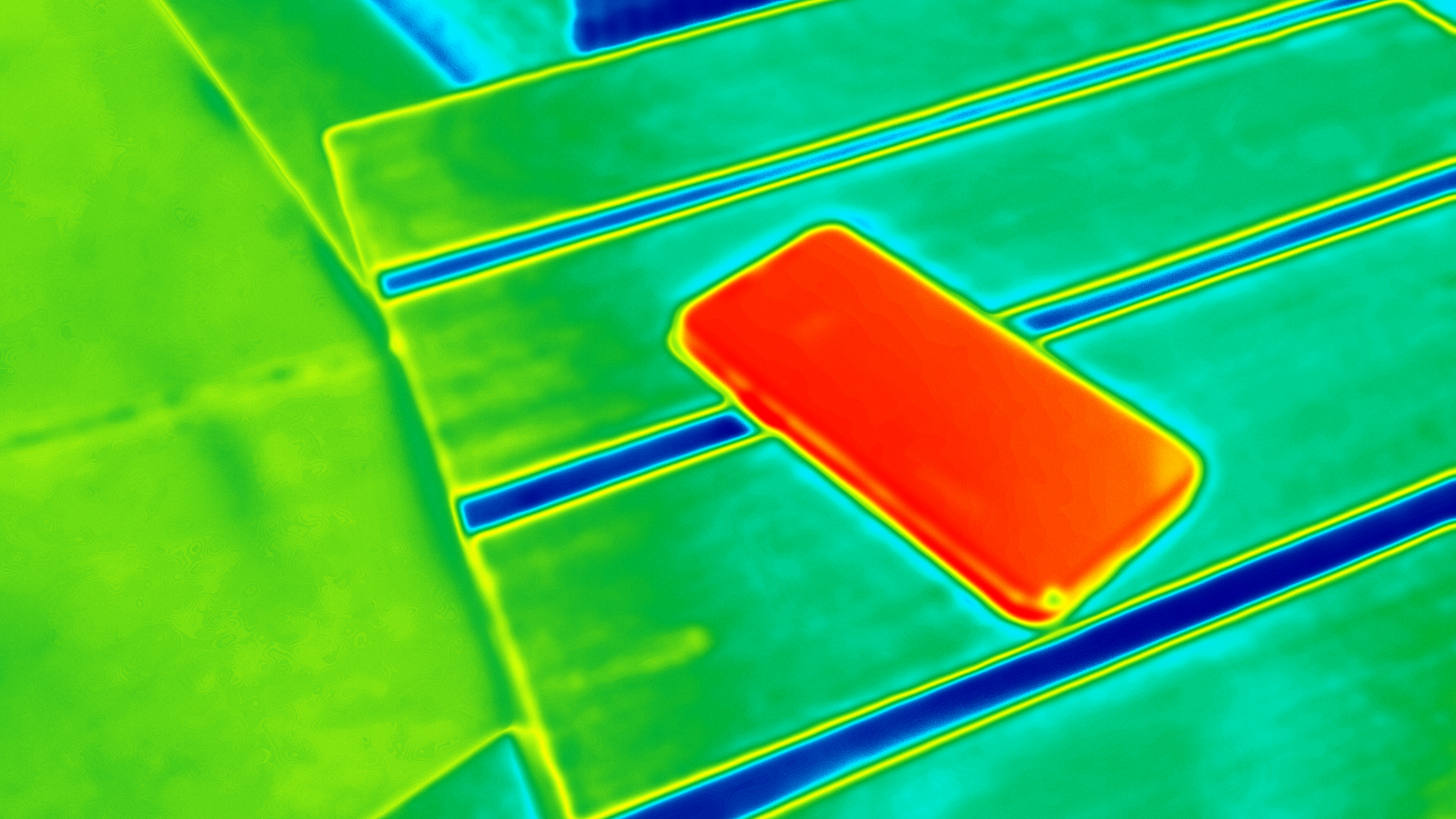
         case .critical:
                // Disable everything possible
                configuration.userFaceTrackingEnabled = false
                configuration.frameSemantics = .init()
                sceneView.rendersMotionBlur = false
        }
     }
 }
```






Test your defenses



Testing Under Temperature Conditions

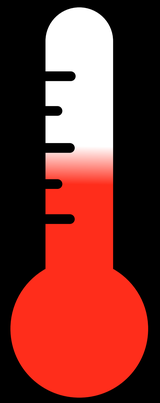
Prior approaches

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


XCODE



Devices | Simulators

Connected

iPhone X

PAIRED WATCHES

Name	Model	watchOS	Identifier

INSTALLED APPS

Name	Version	Identifier

No apps installed

DEVICE CONDITIONS

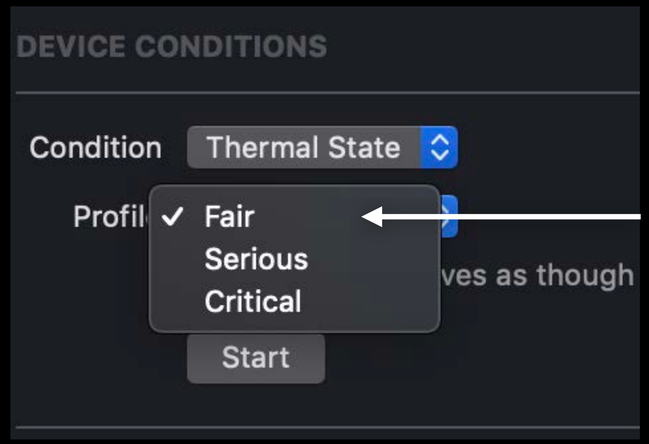
Condition: Thermal State

Profile: Fair

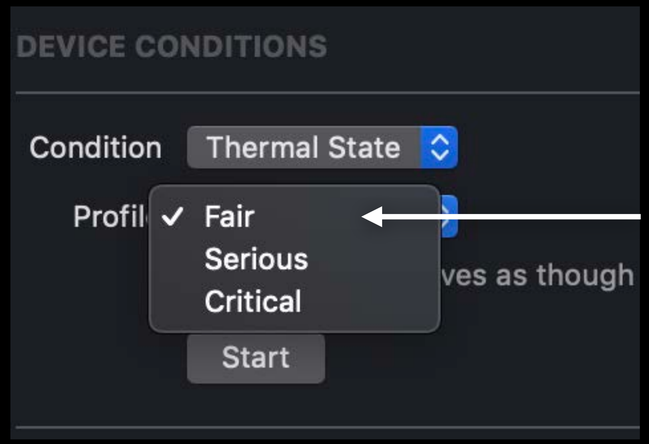
The system behaves as though under slightly elevated thermal state

Start

Filter



Nominal	No corrective action needed
Fair	Slightly elevated thermal state Apps can proactively start energy-saving measures
Serious	System performance is impacted Apps should reduce CPU, GPU, and I/O usage
Critical	Apps should reduce CPU, GPU, and I/O usage, and stop using peripherals such as the camera



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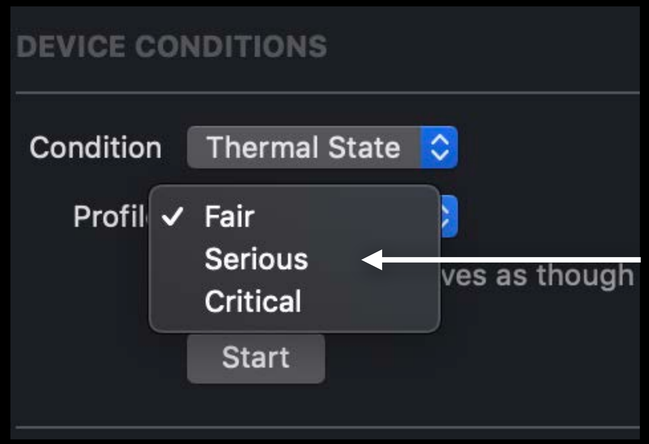

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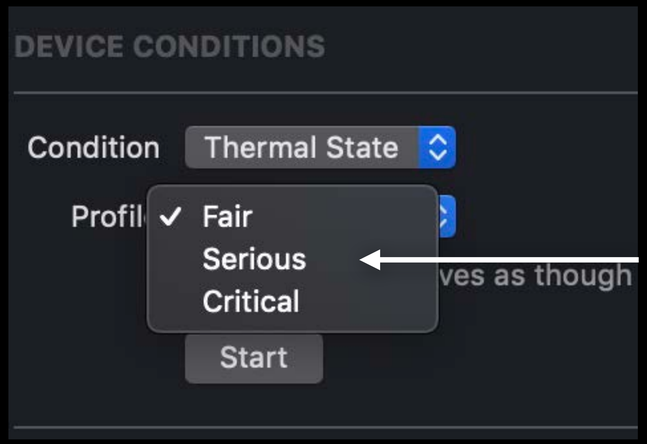
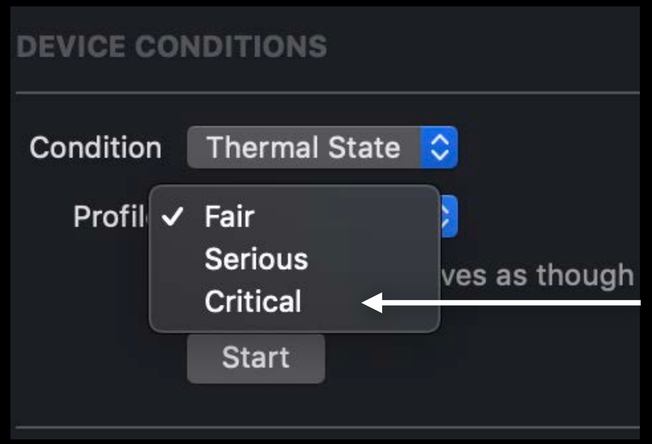


Nominal	No corrective action needed
Fair	Slightly elevated thermal state Apps can proactively start energy-saving measures
Serious	System performance is impacted Apps should reduce CPU, GPU, and I/O usage
Critical	Apps should reduce CPU, GPU, and I/O usage, and stop using peripherals such as the camera



Nominal	No corrective action needed
Fair	Slightly elevated thermal state Apps can proactively start energy-saving measures
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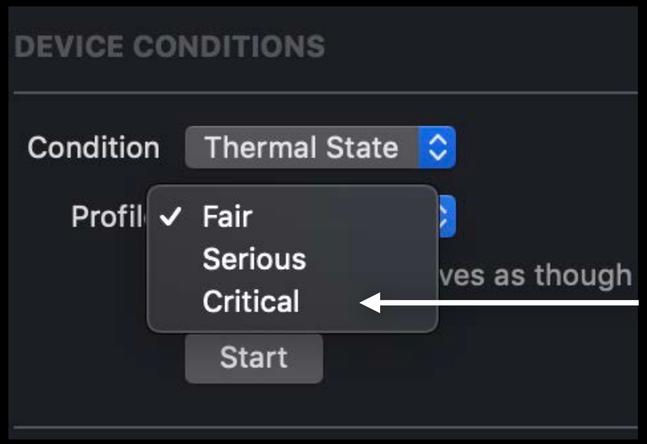

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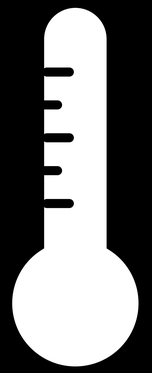
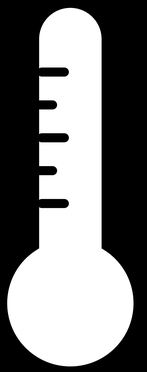
Device Conditions: Thermal

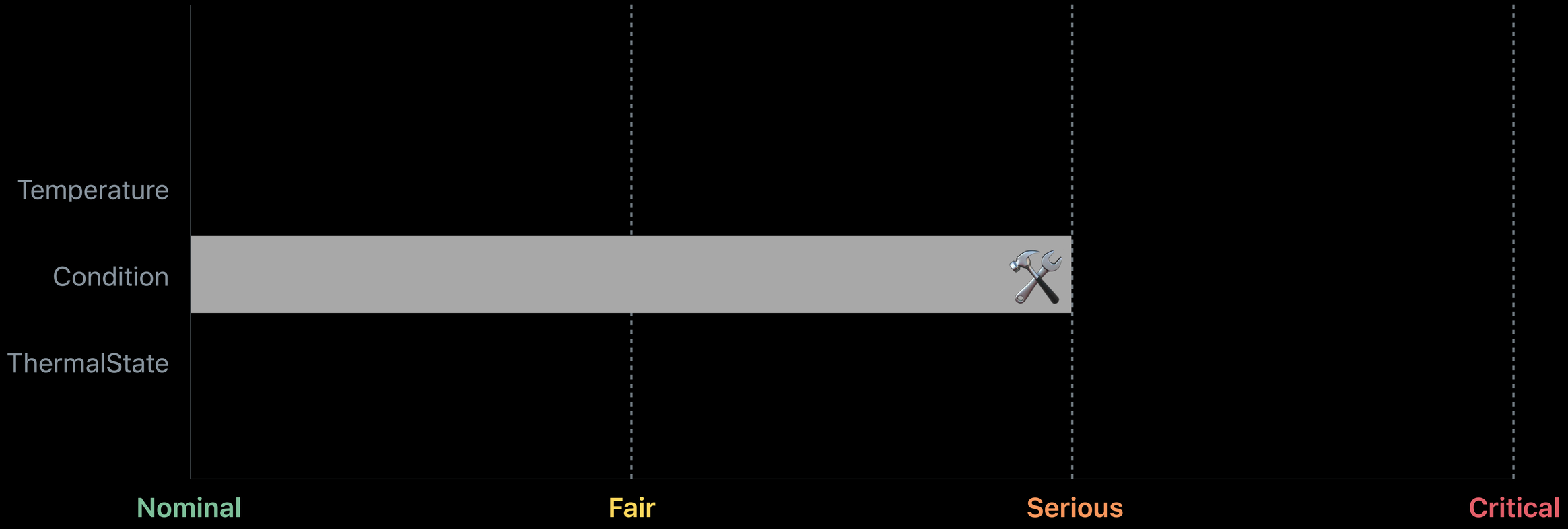
How it works



Device Conditions: Thermal

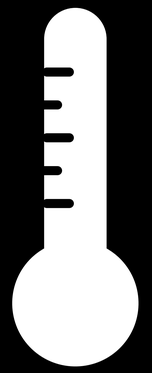
How it works

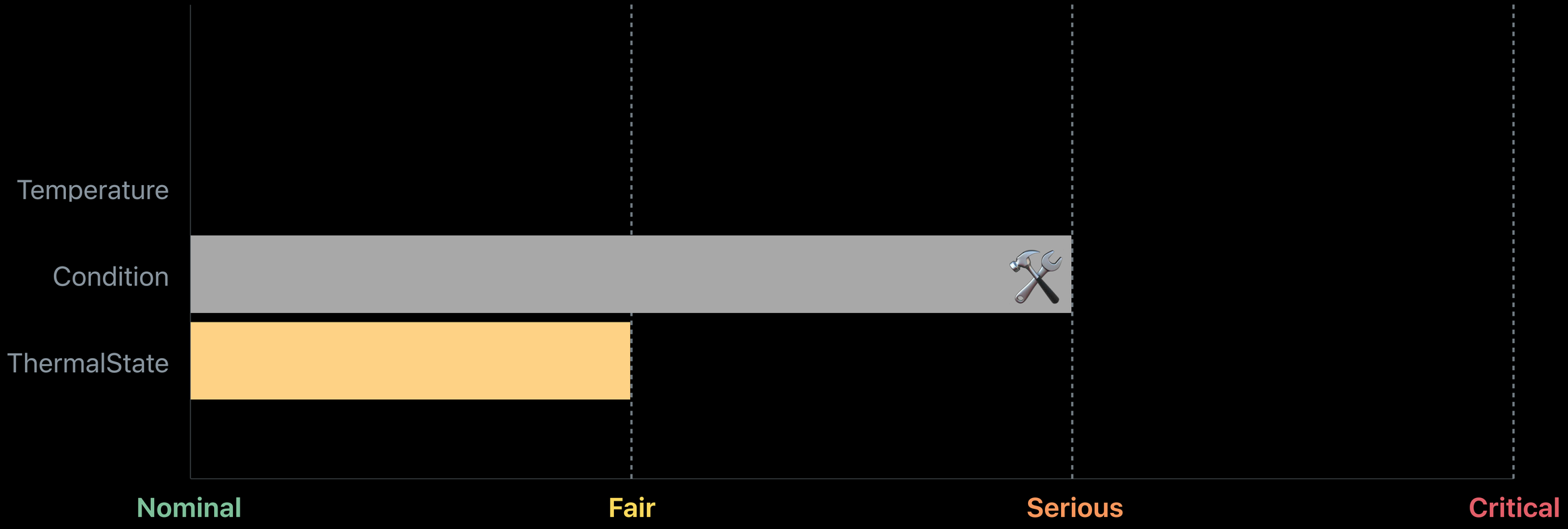




Device Conditions: Thermal

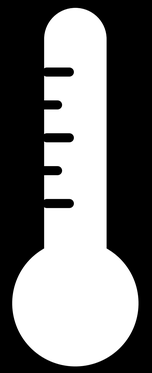
How it works

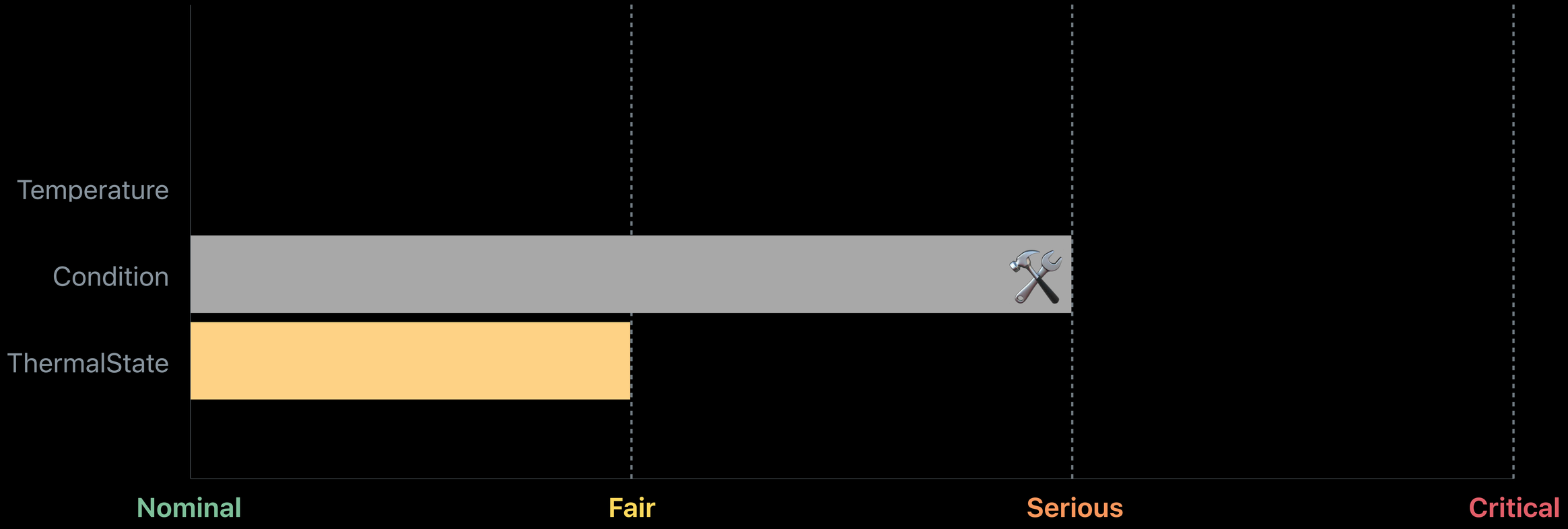




Device Conditions: Thermal

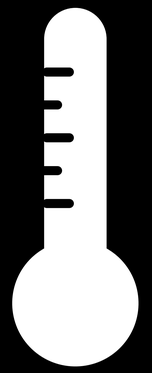
How it works

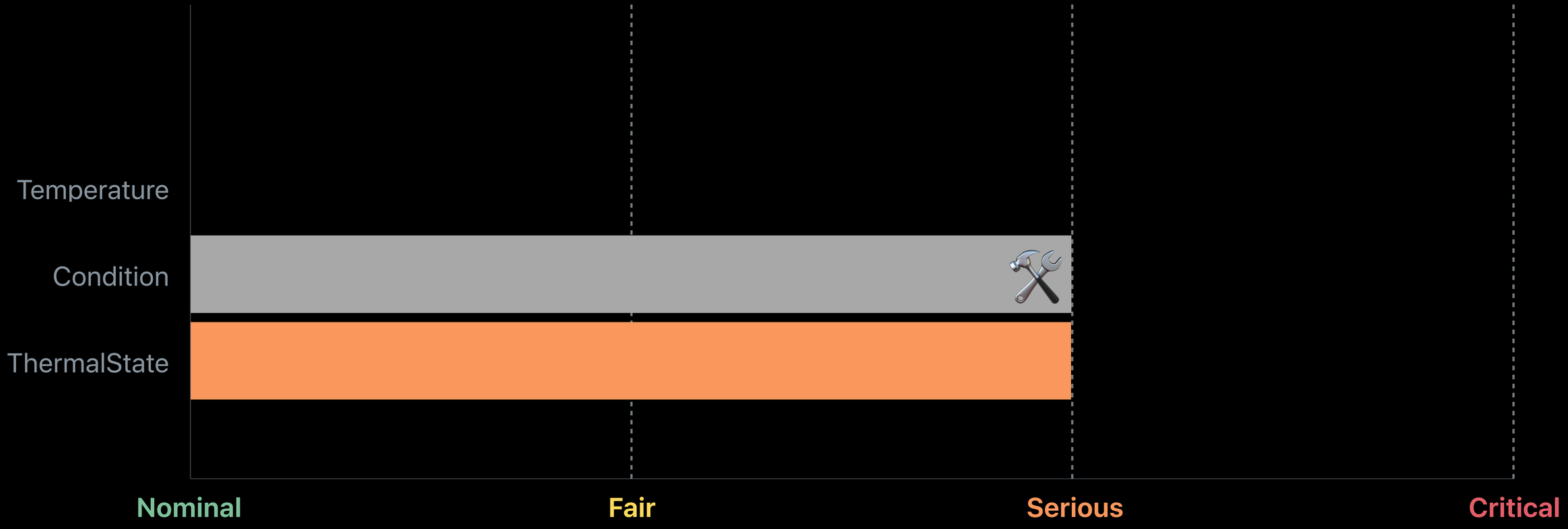




Device Conditions: Thermal

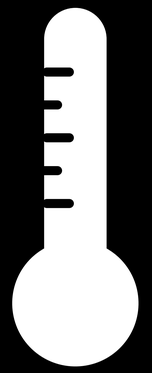
How it works

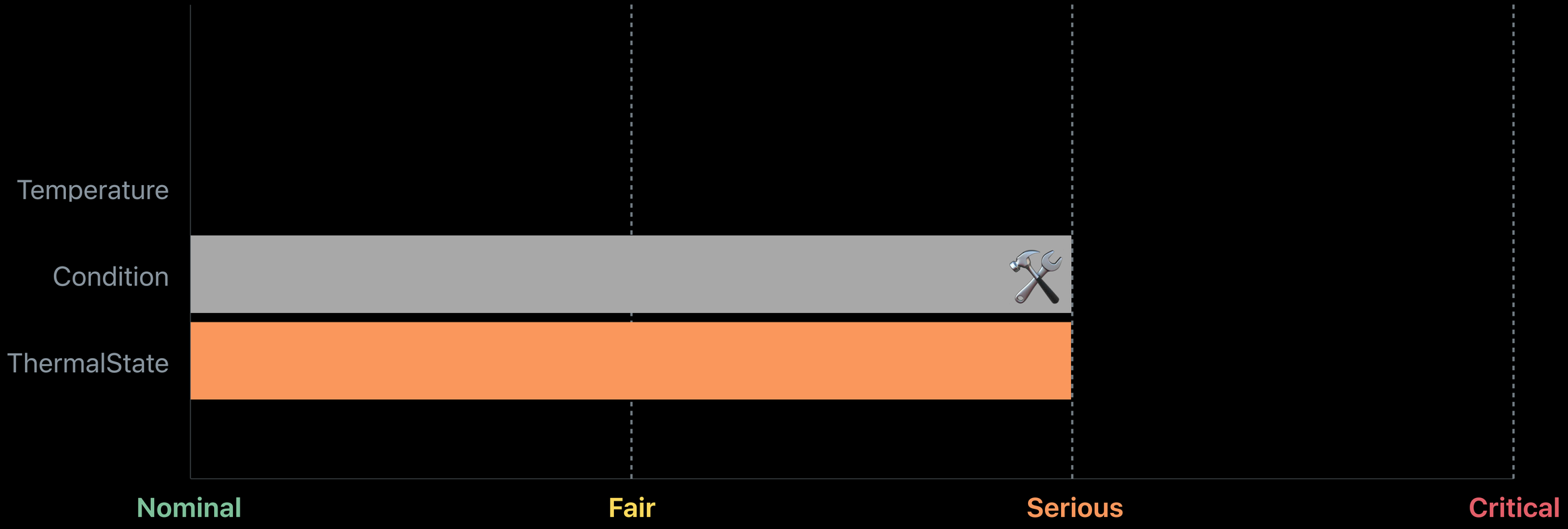




Device Conditions: Thermal

How it works





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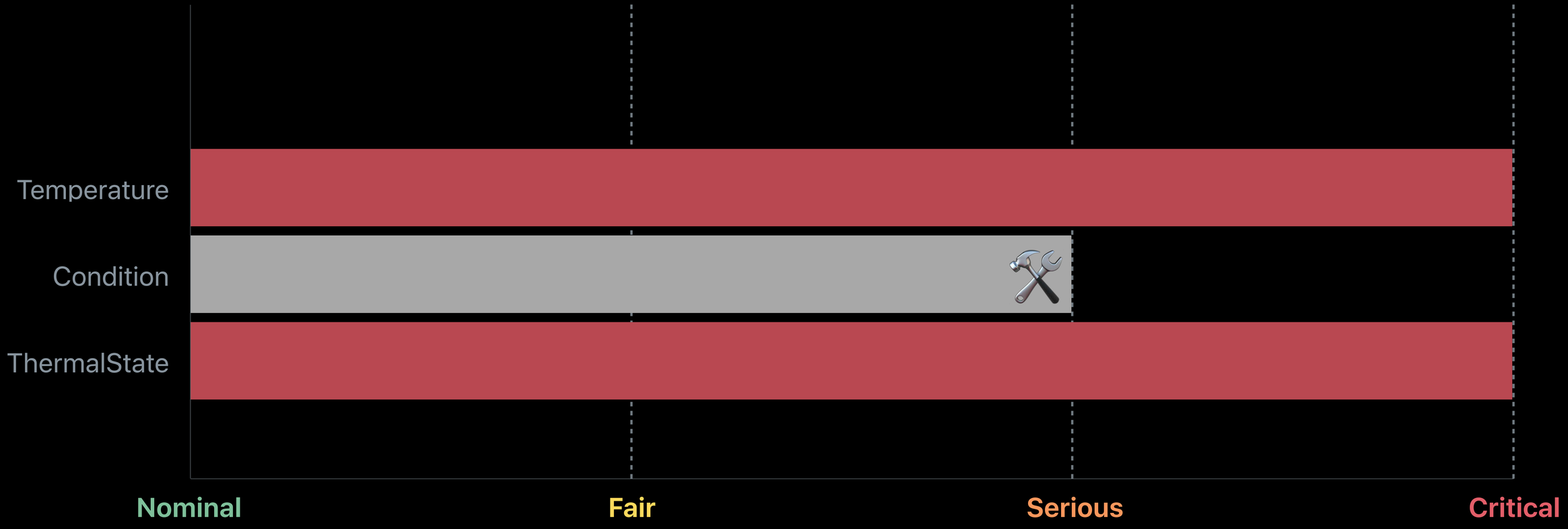
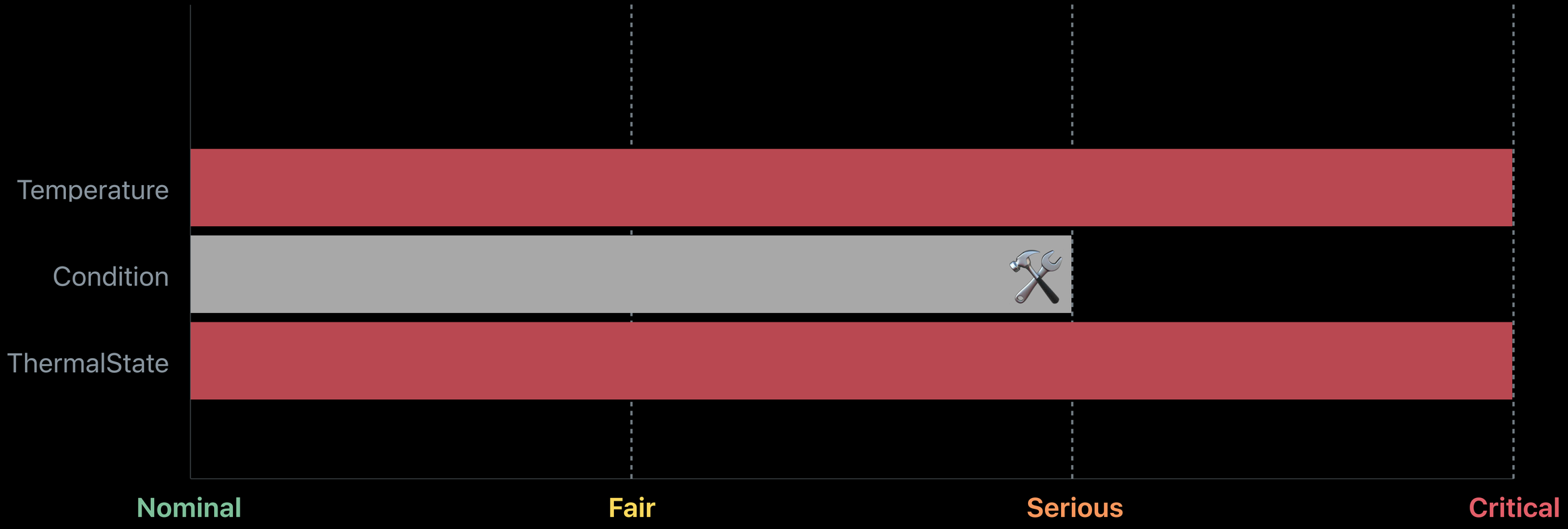


Device Conditions: Thermal

How it works



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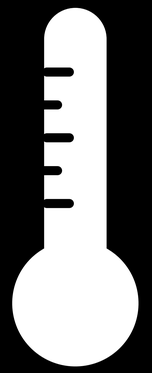
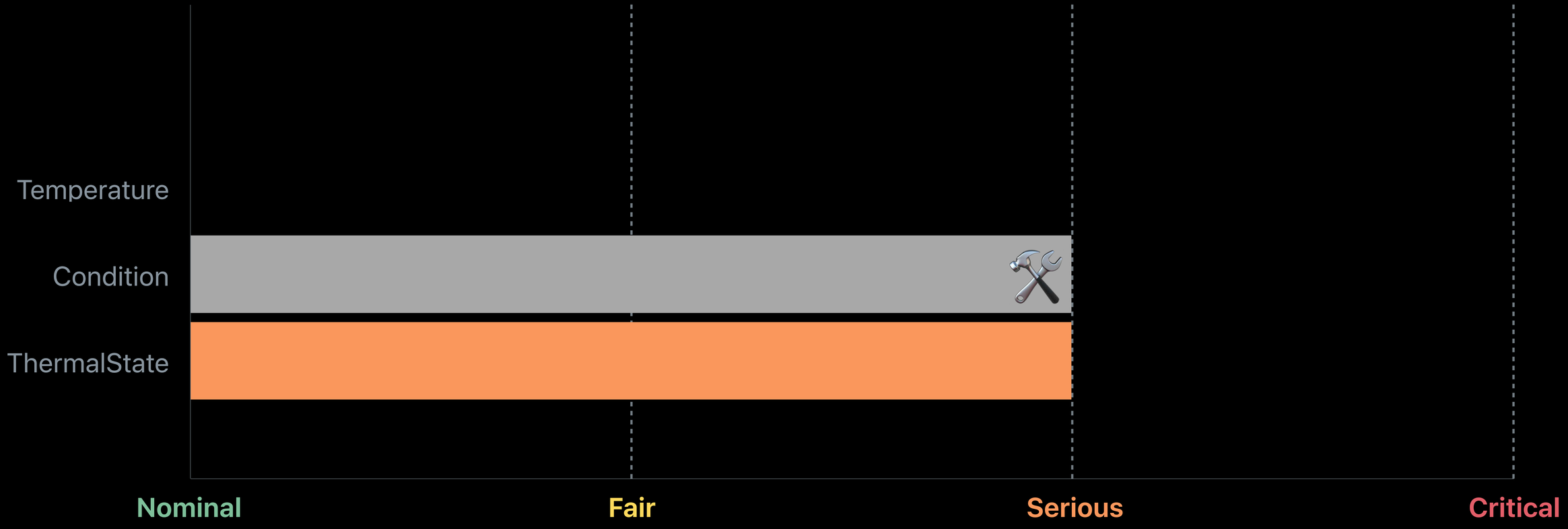
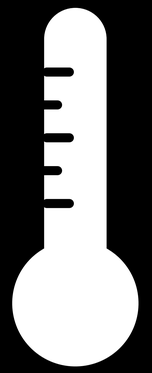
How it works

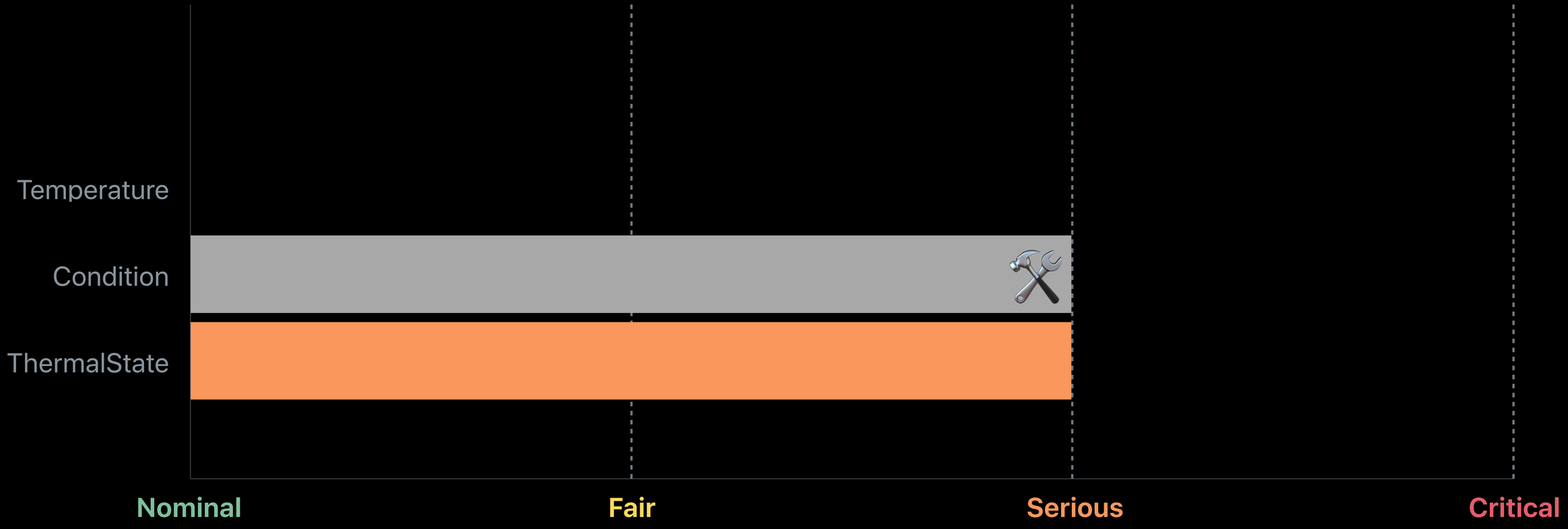




Device Conditions: Thermal

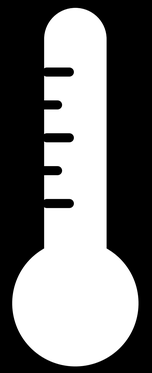
How it works

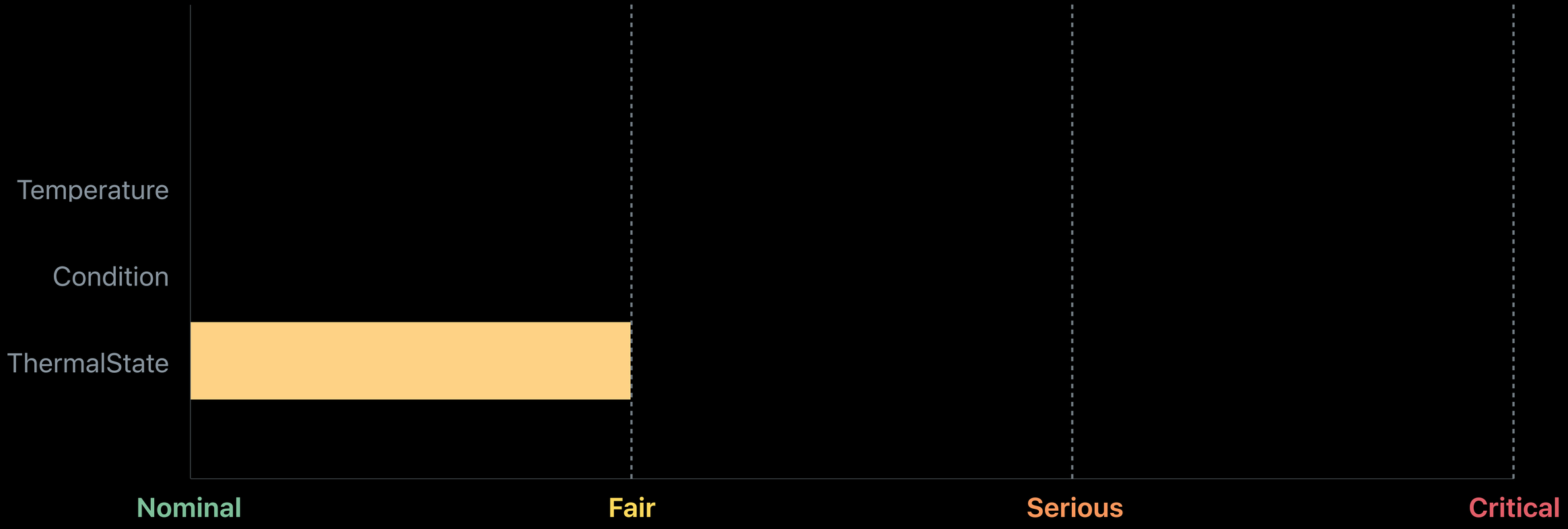




Device Conditions: Thermal

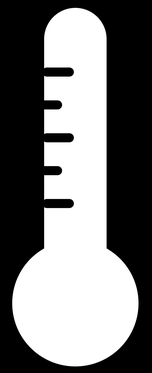
How it works

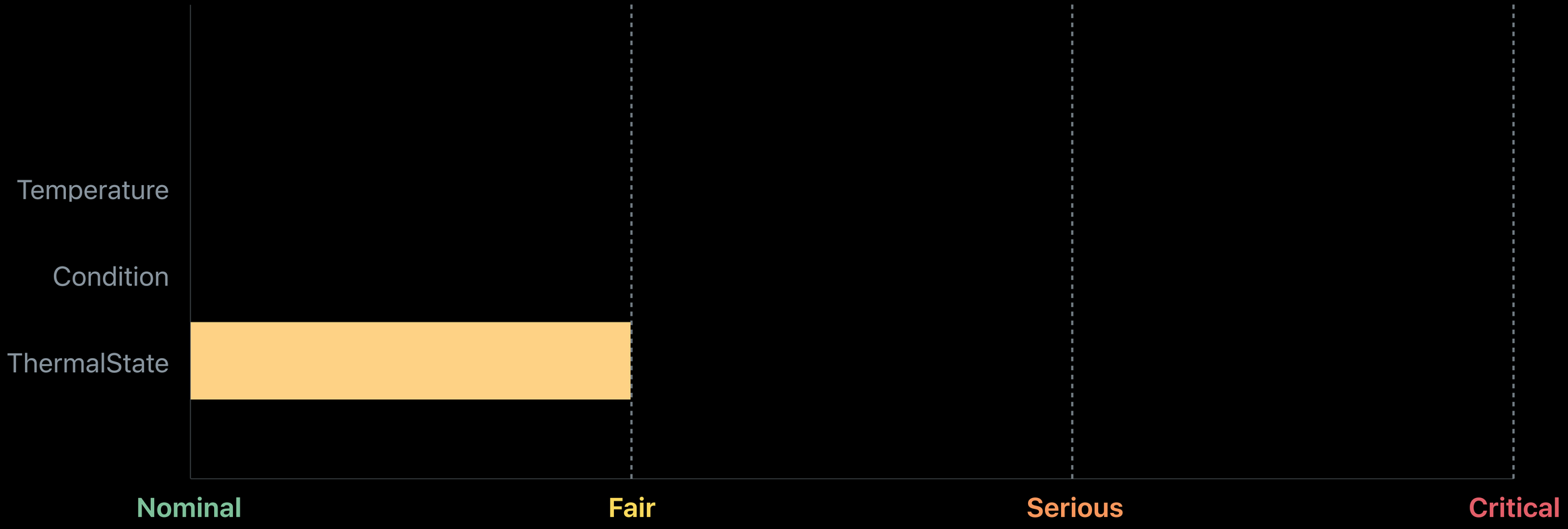




Device Conditions: Thermal

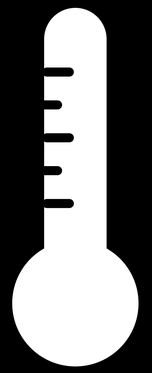
How it works





Device Conditions: Thermal

How it works



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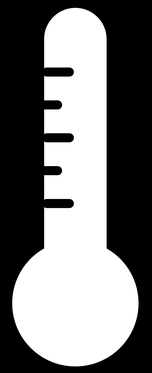
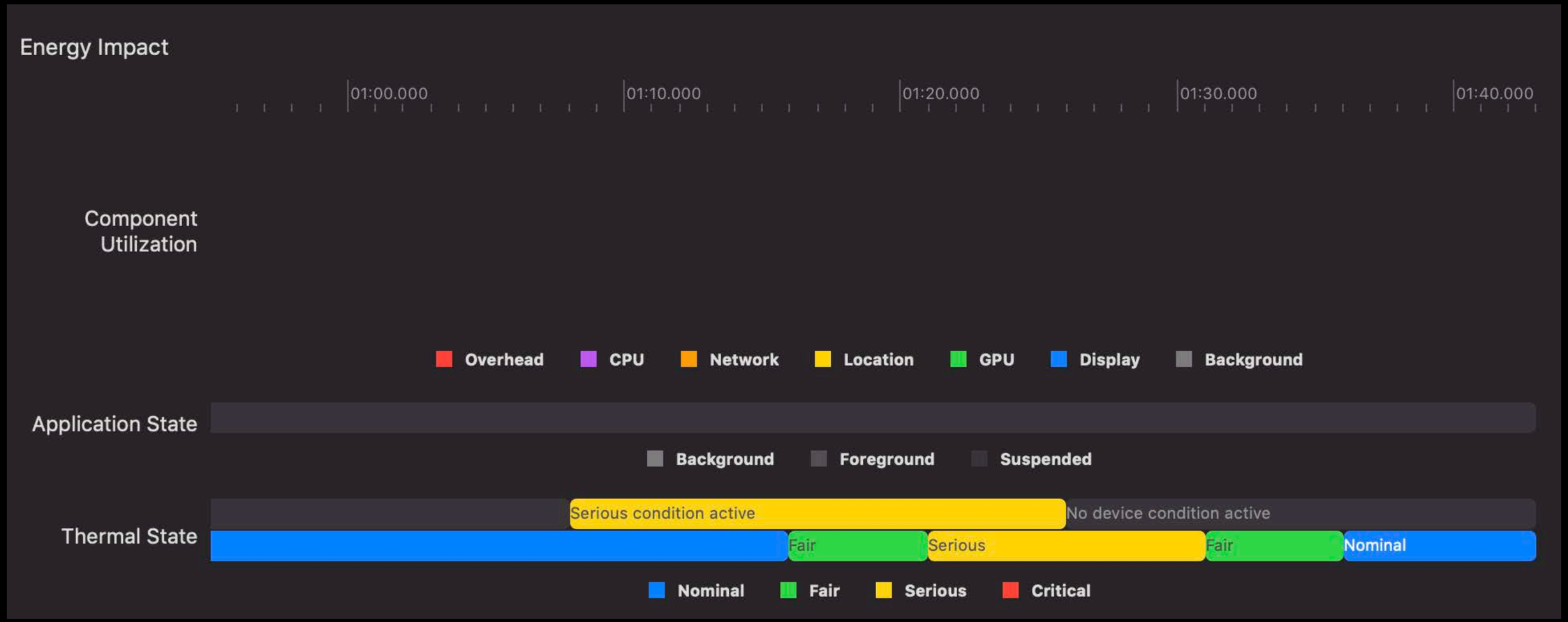



Example 〉 iPhone XS Max
Running Example on iPhone XS Max
Energy Report
Example PID 1415
CPU 0%
Memory 14.8 MB
Energy Impact Low
Disk Zero KB/s
Network Zero KB/s
Energy
Average Energy Impact
Low
Energy Impact
Average Component Utilization
Overhead 0%
Location 0%
CPU 2.9%
GPU 0%
Network 0%
Display 97.1%
Energy Impact
01:00.000
01:10.000
01:20.000
01:30.000
01:40.000
Component Utilization
Overhead CPU Network Location GPU Display Background
Application State
Background Foreground Suspended
Thermal State
Serious condition active
No device condition active
Fair
Serious
Fair
Nominal
Nominal Fair Serious Critical
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
Not Applicable
Filter
Example

NEW

NEW


Energy Impact
01:00.000
01:10.000
01:20.000
01:30.000
01:40.000
Component Utilization
Overhead
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Network
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Fair
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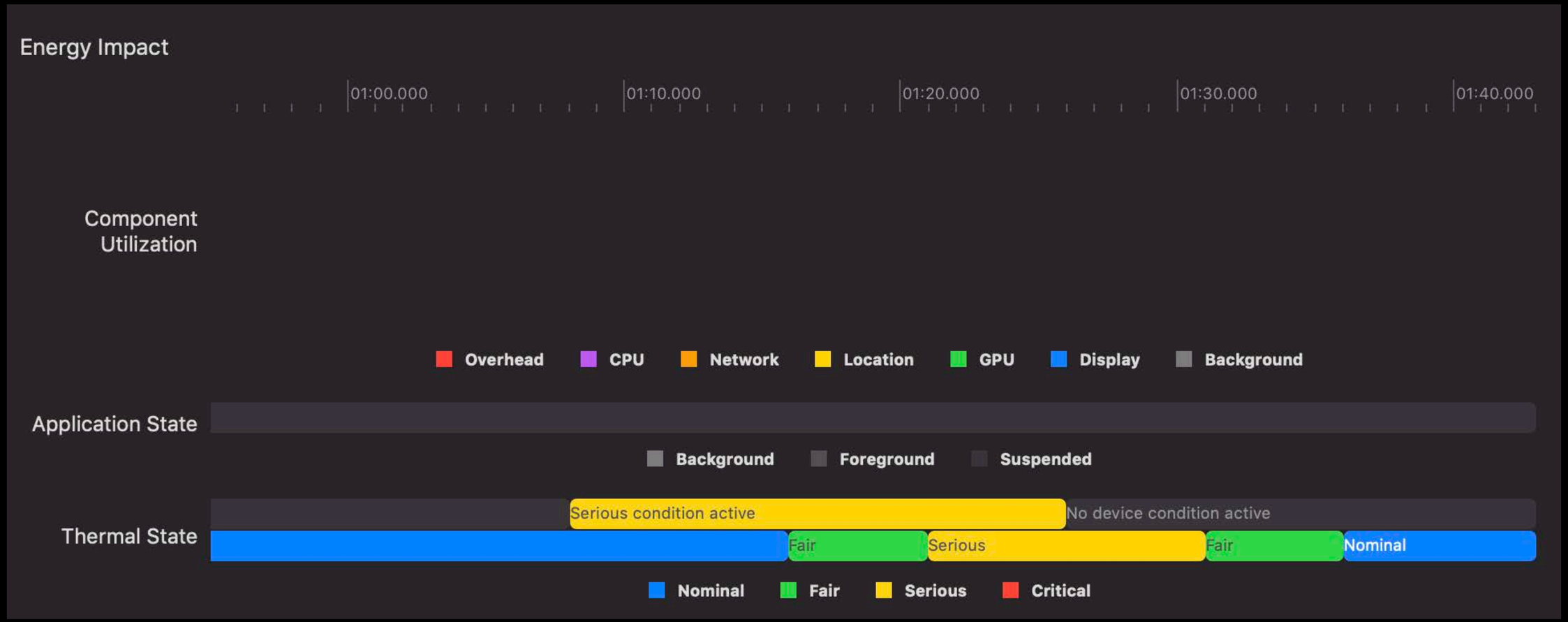
Critical

NEW


Energy Impact
01:00.000
01:10.000
01:20.000
01:30.000
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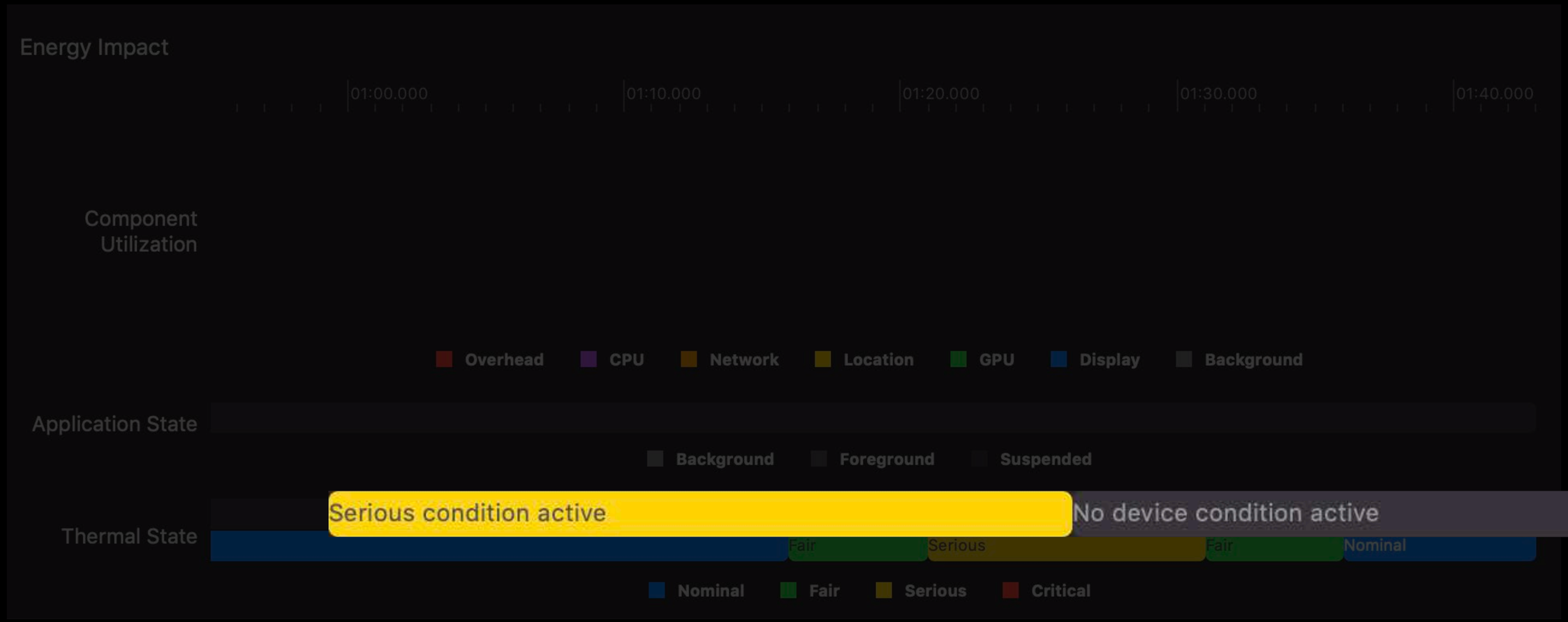
Energy Impact
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01:10.000
01:20.000
01:30.000
01:40.000
Component Utilization
Overhead
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Background
Application State
Background
Foreground
Suspended
Thermal State
Serious condition active
No device condition active
Fair
Serious
Fair
Nominal
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)
            }
        }
    }
}
```

```
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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        }
    }
}
```

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                setRenderSettings([.depthOfField, .blobShadows ], postProcessing: .medium)
            case .critical:
                setRenderSettings([ ], postProcessing: .disabled)
            }
        }
    }
}
```
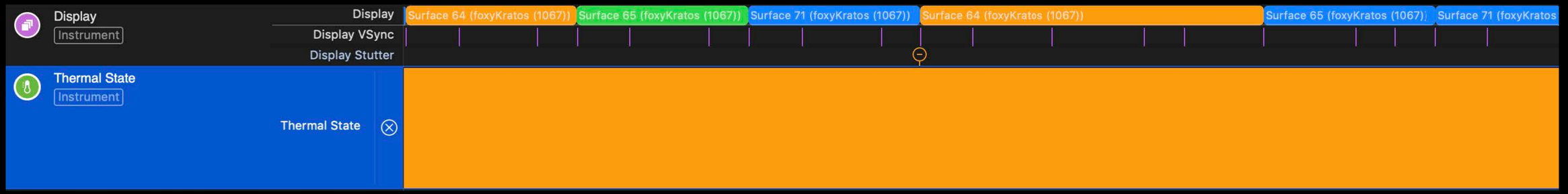

No Optimizations



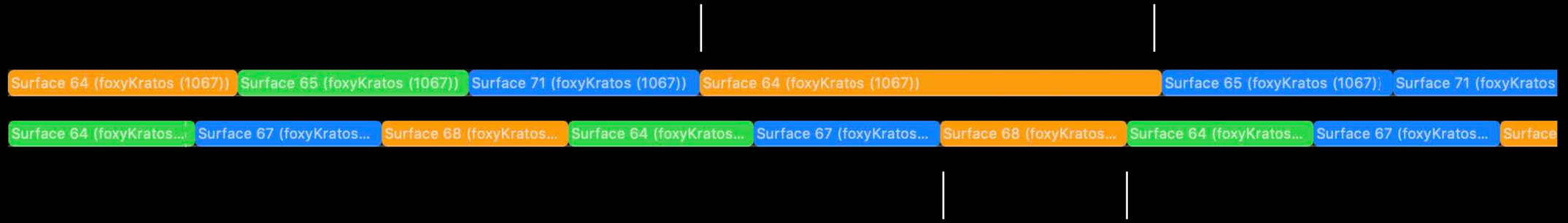
Optimized

No Optimizations

Optimized

No Optimizations

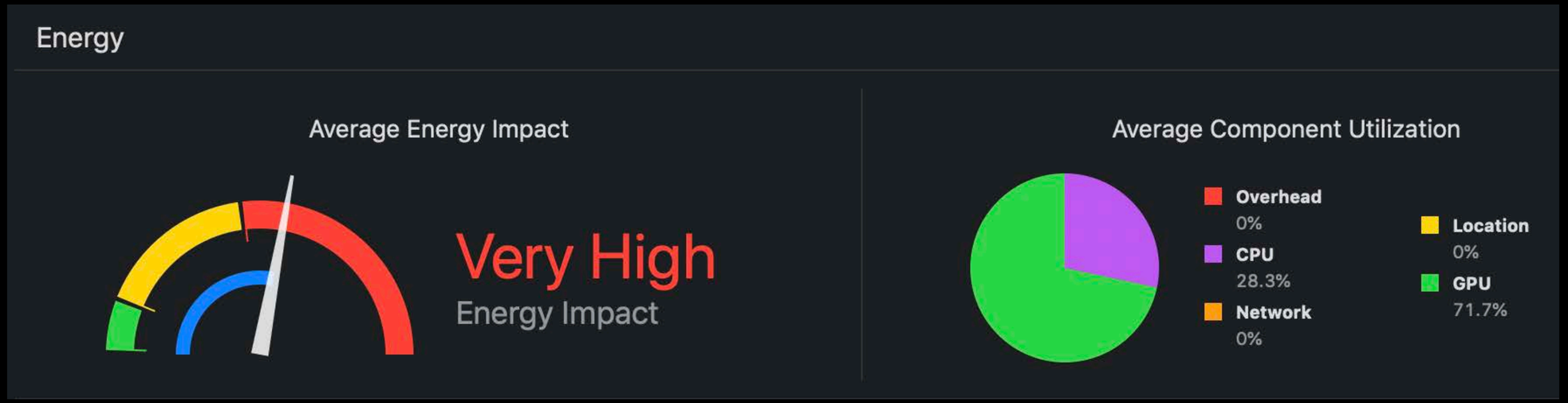
More than 2x

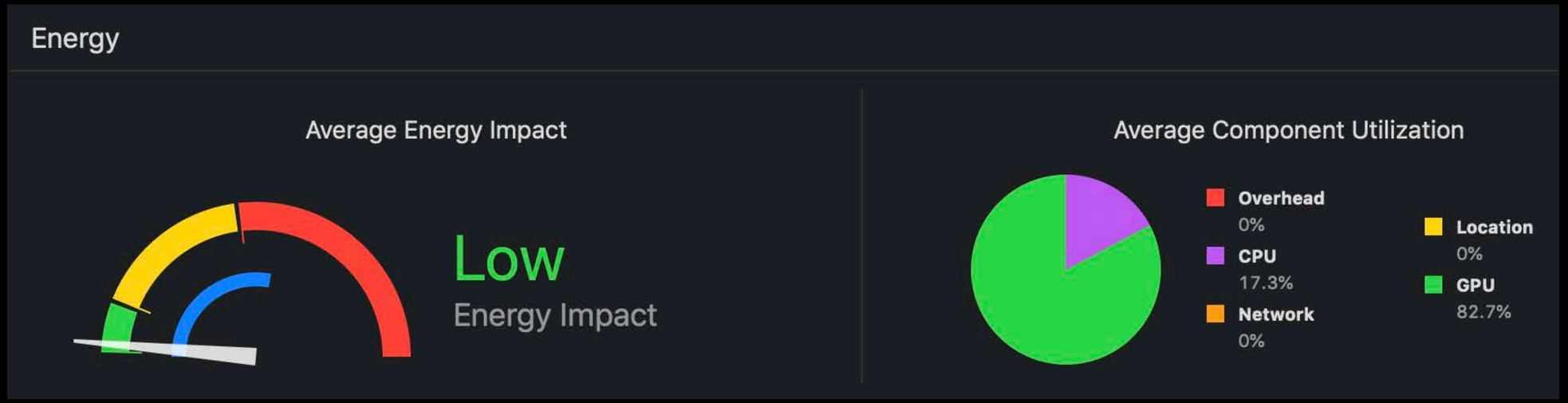


Optimized

No Optimizations

NEW





Optimized

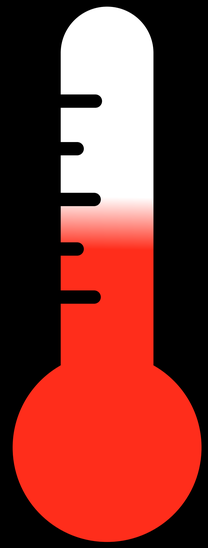
Recap

Alexander Karapetian
Ilya Veygman

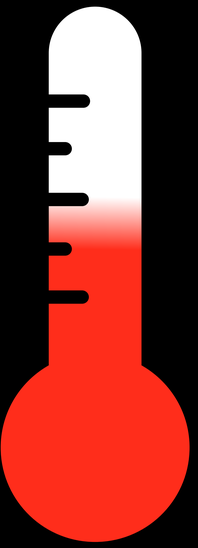
Debugging in Xcode

Device conditions

Environment overrides




XCODE

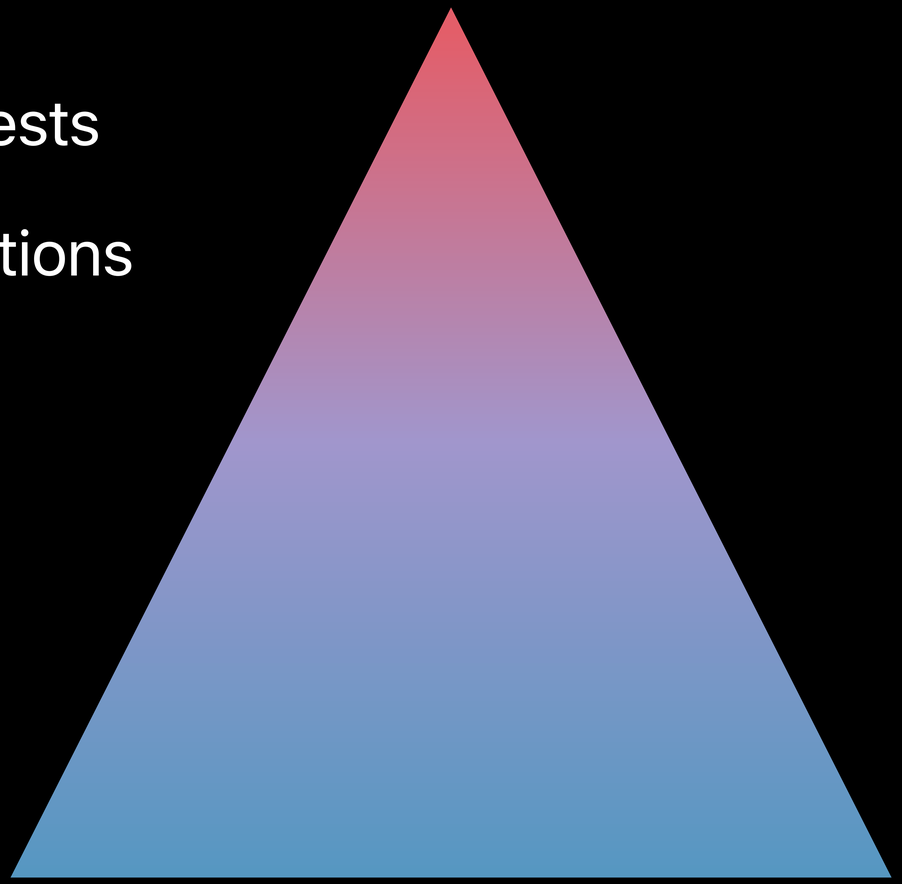


Designing for Adverse Conditions

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


WWDC19