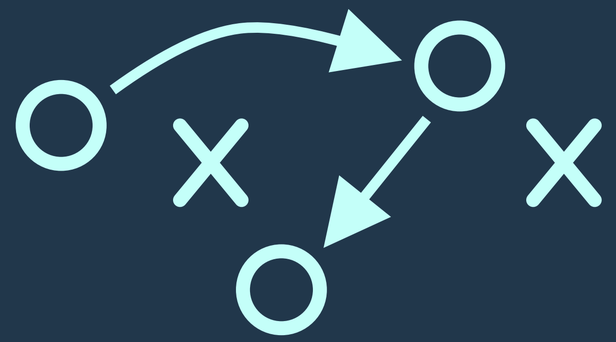
Digita Security

What's Your Game Plan?

Leveraging Apple's Game Engine to Detect macOS Threats



About Us

cybersecurity solutions for the macOS enterprise

@digita_security

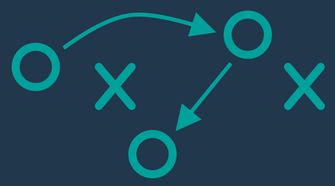
Objective See Tools++

Monitoring Capability + Built-in Detection Logic = New Tool!

Let's Rethink/Redesign this...

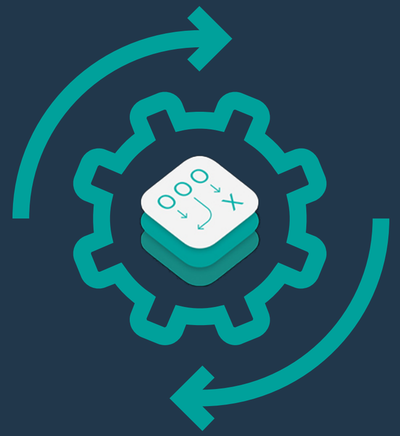
Outline

Today's GamePlan



MonitorKit

macOS monitoring



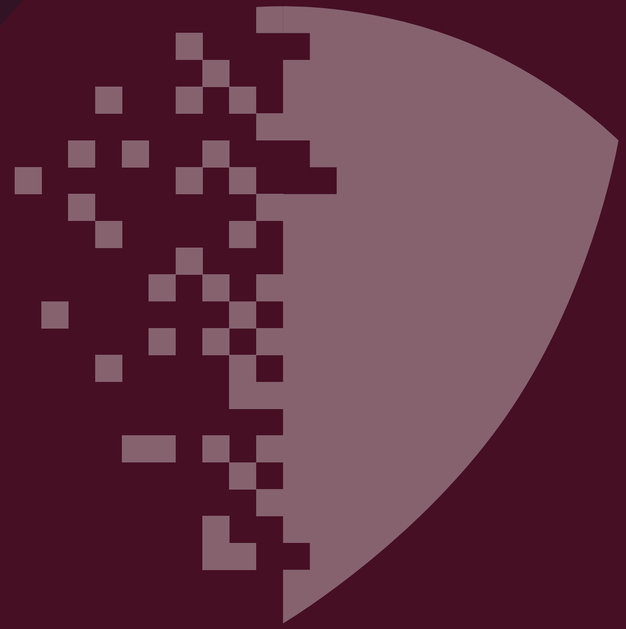
Game Engine-Based Analysis & Detection

macOS threats

MonitorKit

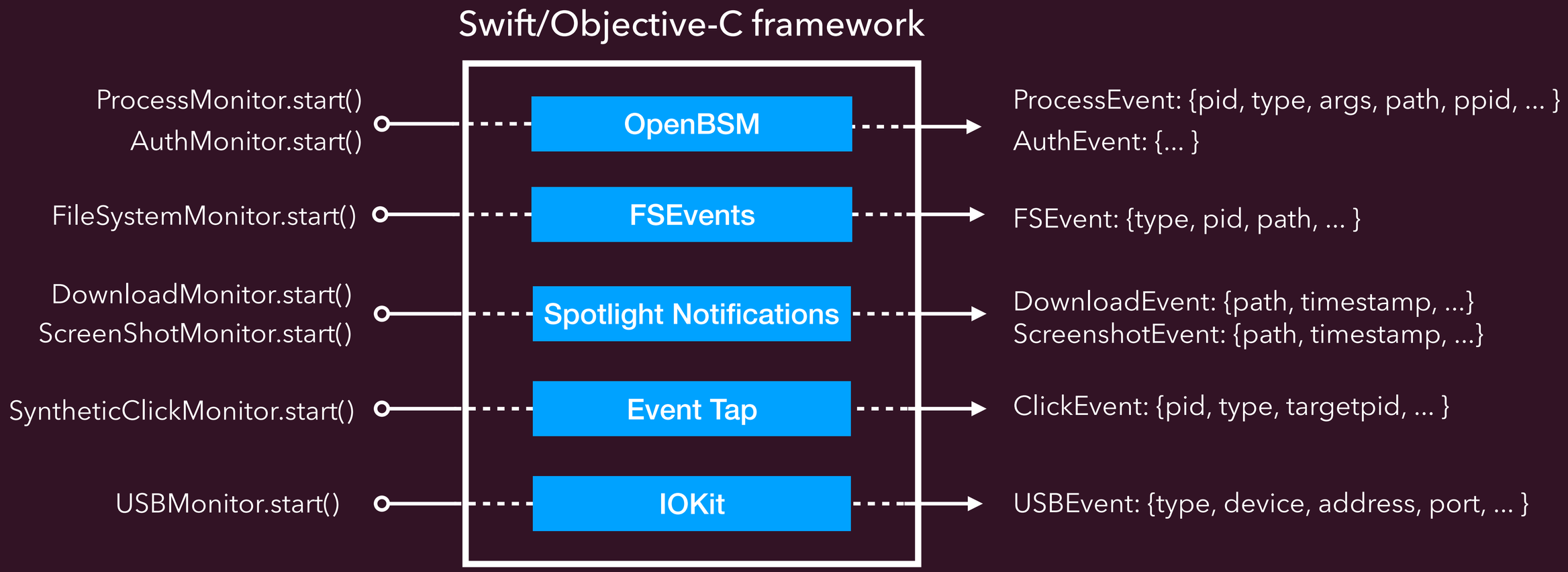
MK

macOS monitoring framework



MonitorKit

macOS monitoring framework



OpenBSM Parsing

Reading and parsing */dev/auditpipe*

Get Cozy with OpenBSM Auditing - Patrick Wardle

*OS Internals – Chapter 2: Auditing - Jonathan Levin

Audit Mask Options:

```
AUDIT_CLASS_FILE_READ
AUDIT_CLASS_FILE_WRITE
AUDIT_CLASS_FILE_ATTR_ACCESS
AUDIT_CLASS_FILE_ATTR_MODIFY
AUDIT_CLASS_FILE_CREATE
AUDIT_CLASS_FILE_DELETE
AUDIT_CLASS_FILE_CLOSE
AUDIT_CLASS_PROCESS
AUDIT_CLASS_NETWORK
AUDIT_CLASS_IPC
AUDIT_CLASS_NON_ATTRIB
AUDIT_CLASS_ADMIN
AUDIT_CLASS_LOGIN_LOGOUT
AUDIT_CLASS_AUTH
AUDIT_CLASS_APP
AUDIT_CLASS_IOCTL
AUDIT_CLASS_EXEC
AUDIT_CLASS_MISC
AUDIT_CLASS_ALL
```

au_read_rec

Audit Record:

- AUT_HEADER32
  Type: AUT_EXEC
- AUT_EXEC_ARGS
- AUT_PATH
- AUT_ATTR32
- AUT_SUBJECT32
- AUT_SUBJECT32
- AUT_TRAILER

Audit Token:

```
Token AUT_EXEC_ARGS:
arg          : system_profiler
arg          : -xml
arg          : SPMemoryDataType
```

au_fetch_tok

Audit Token:

```
Token AUT_ATTR32:
mode         : 33261
uid          : 0
gid          : 0
fsid         : 16777223
nid          : 34010260
dev          : 0
```

OpenBSM

Open Source Event Auditing

MonitorKit wraps Process and Auth events to simplify usage

Raw OpenBSM Monitoring:

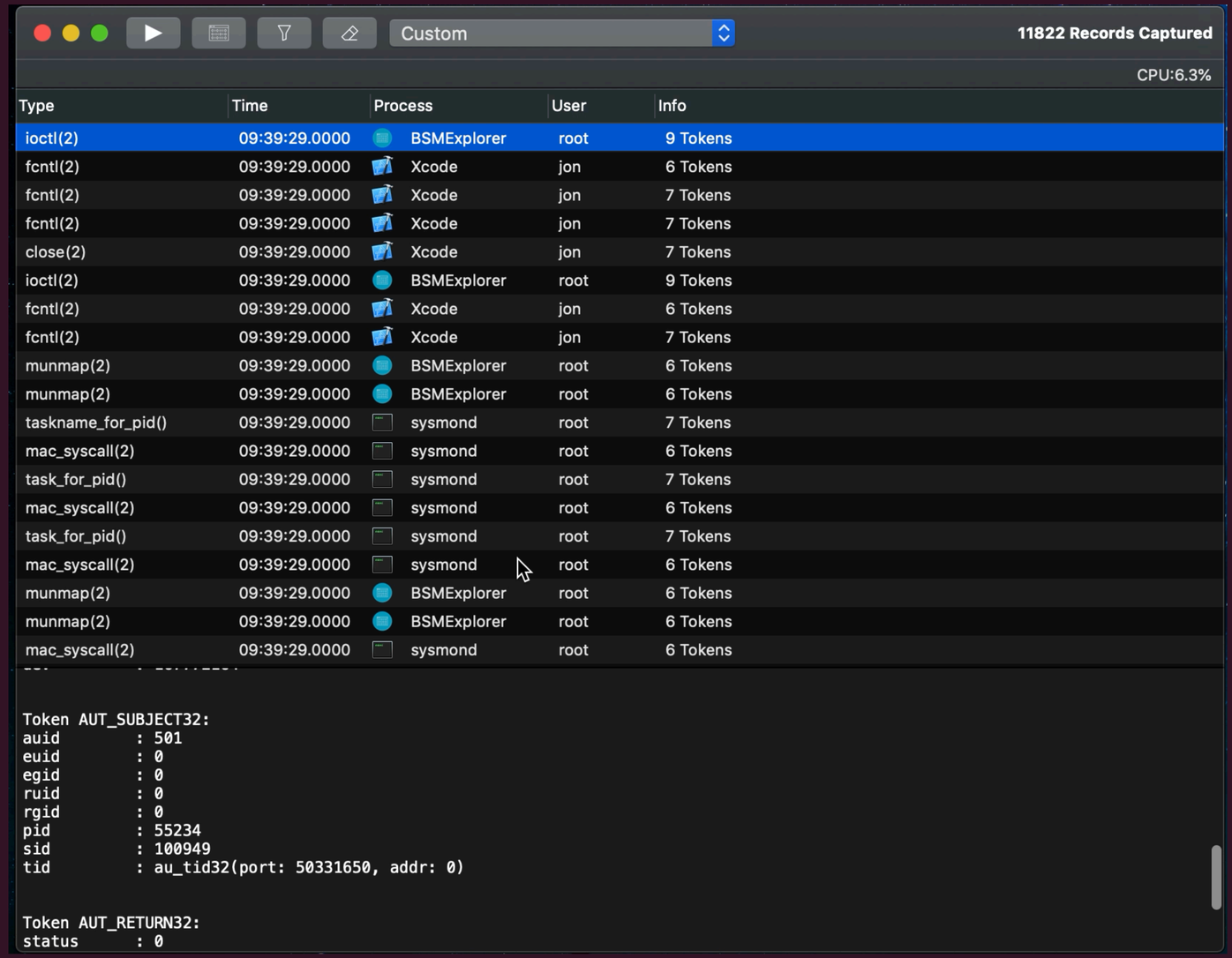
```
let mask: u_int = AuditConstants.AUDIT_CLASS_PROCESS | AuditConstants.AUDIT_CLASS_EXEC

let filter: [UInt16] = [
    UInt16(AUE_EXEC),
    UInt16(AUE_EXIT),
    UInt16(AUE_FORK),
    UInt16(AUE_EXECVE),
    UInt16(AUE_POSIX_SPAWN)
]

if let monitor = try? BSMMonitor(mask, recordFilter: filter) {
    monitor.start { (record: BSMRecord) in
        for token in record.tokens {
            print("Token \(token.tokenString()):\n \(token.stringValue())"
        }
    }
}
```

Process Monitoring:

```
if let monitor = try? ProcessMonitor() {
    monitor.start { (event: ProcessEvent) in
        if event.type == .CREATE {
            print("Process with pid \(event.pid) created")
        } else if event.type == .EXIT {
            print("Process with pid \(event.pid) exited")
        }
    }
}
```

BSMExplorer

BSMExplorer - Open source application that utilizes MonitorKit to provide GUI for filtering and viewing BSM records.



FSEvents

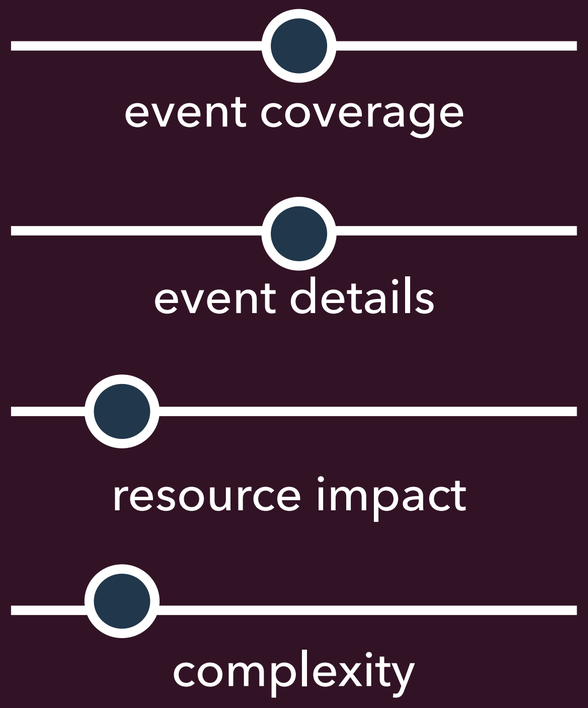
Direct Use of */dev/fsevents*

Apple's FSEvents API does not provide the responsible pid for the file i/o, so direct access (/dev/fsevents) is leveraged

```
let monitor = FileMonitorFSE()

public static let filter = [
    FSEventTypes.CREATE_FILE.rawValue,
    FSEventTypes.DELETE.rawValue,
    FSEventTypes.STAT_CHANGED.rawValue,
    FSEventTypes.RENAME.rawValue,
    FSEventTypes.CONTENT_MODIFIED.rawValue,
    FSEventTypes.EXCHANGE.rawValue,
    FSEventTypes.FINDER_INFO_CHANGED.rawValue,
    FSEventTypes.CREATE_DIR.rawValue,
    FSEventTypes.CHOWN.rawValue,
    FSEventTypes.XATTR_MODIFIED.rawValue,
    FSEventTypes.XATTR_REMOVED.rawValue
]

monitor.start(eventFilterInclude: filter) { event in
    print("\(event.pid) \(event.type.string) \(event.path)")
}
```

Spotlight Notifications

Extended Attributes (xattrs) Monitor



Register observers and get notified of user behaviors such as screenshots and downloads

Raw Spotlight Monitoring:

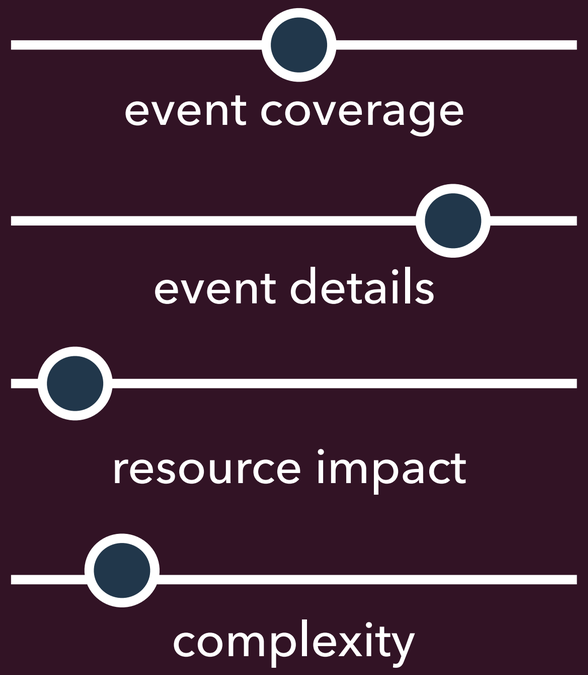
```
@objcMembers public class ScreenshotEvent: NSObject {
    public let timestamp: Date
    public let path: String
}

let predicate = NSPredicate(fromMetadataQueryString: "kMDItemIsScreenCapture = 1")

public class ScreenshotMonitor: BaseSpotlightMonitor<ScreenshotEvent> {
    public init() {
        super.init(
            predicate: predicate,
            forNotification: NSNotification.Name.NSMetadataQueryDidUpdate)
    }
}

monitor.start() { event in
    print("Screenshot \(event.path)")
}
```

Download Monitoring:

```
let monitor = DownloadMonitor()

monitor.start() { event in
    print("Downloaded File \(event.path)")
}
```

CoreGraphics Event Taps

Programatic Input Monitoring



Monitor more obscure system events such as synthetic/ programatic mouse or keyboard clicks

Synthetic Click Monitoring:

```
let monitor = SyntheticClickMonitor()

monitor.start() { event in
    print("Detectected click from pid \(event.pid)")
}
```

The Mouse is Mightier than the Sword - Patrick Wardle

IOKit Notifications

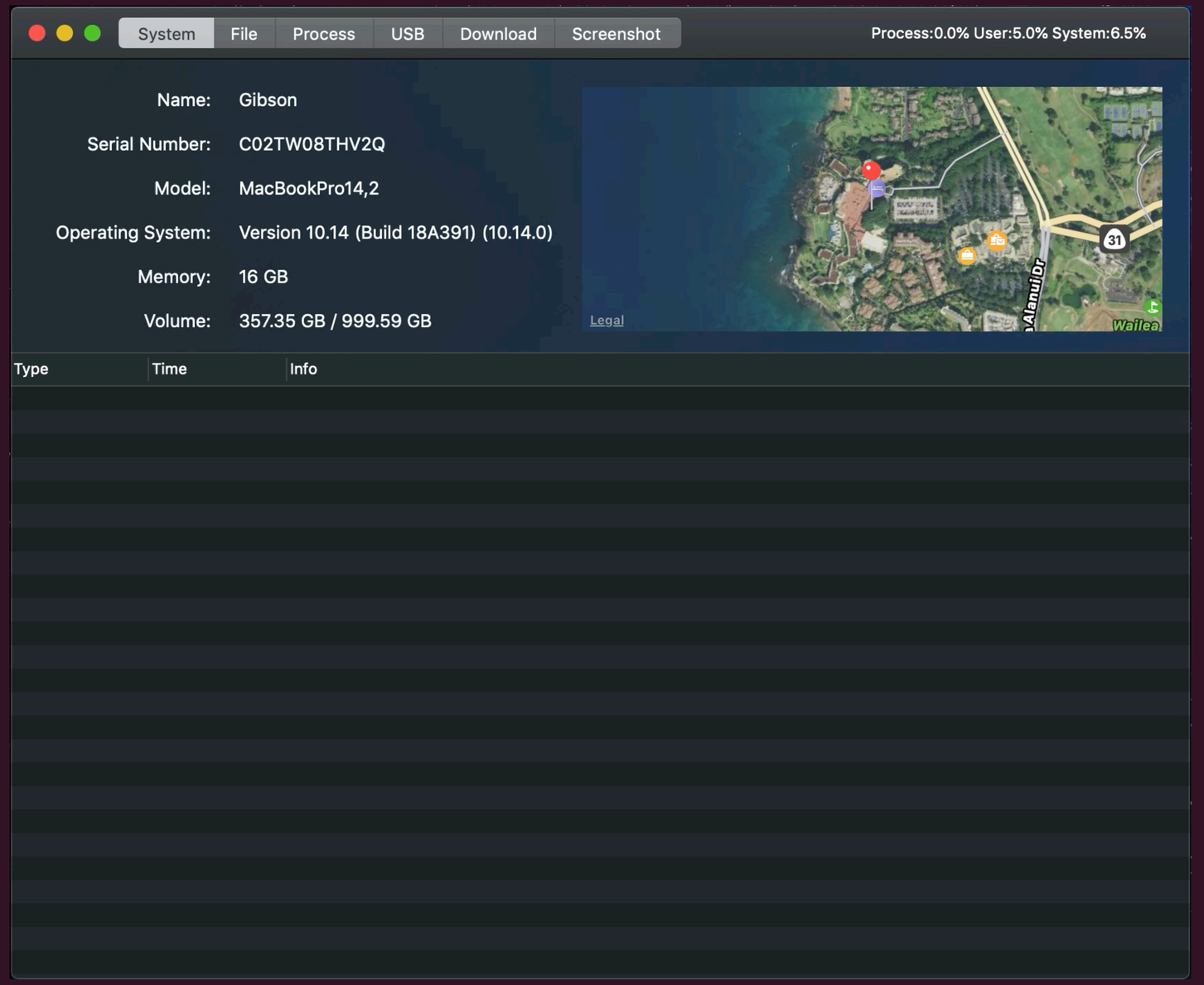
Monitoring for New Hardware

Register observers and get notified of new hardware such as USB Devices.

USB Monitoring:

```
let monitor = USBMonitor()

monitor.start() { event in
    print("Detectected usb device \(event.device.serialNumber)")
}
```

monitorKit UI



Check out MonitorKit

MonitorKit

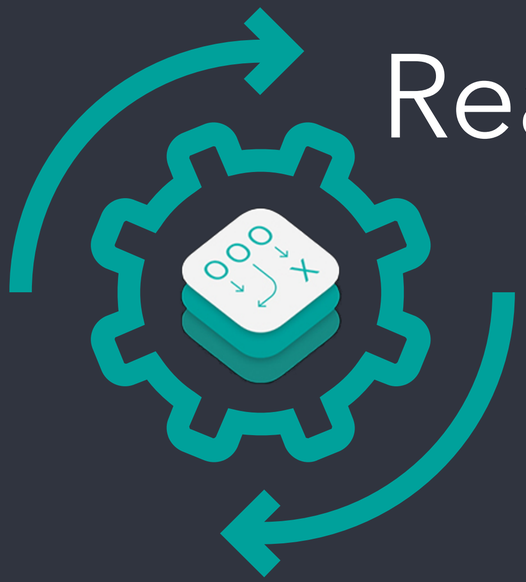
Future Monitors:

Do Not Disturb laptop open events

Oversight microphone and video camera access events

Keylogger detections

Will be released to our github account (https://github.com/DigitaSecurity)

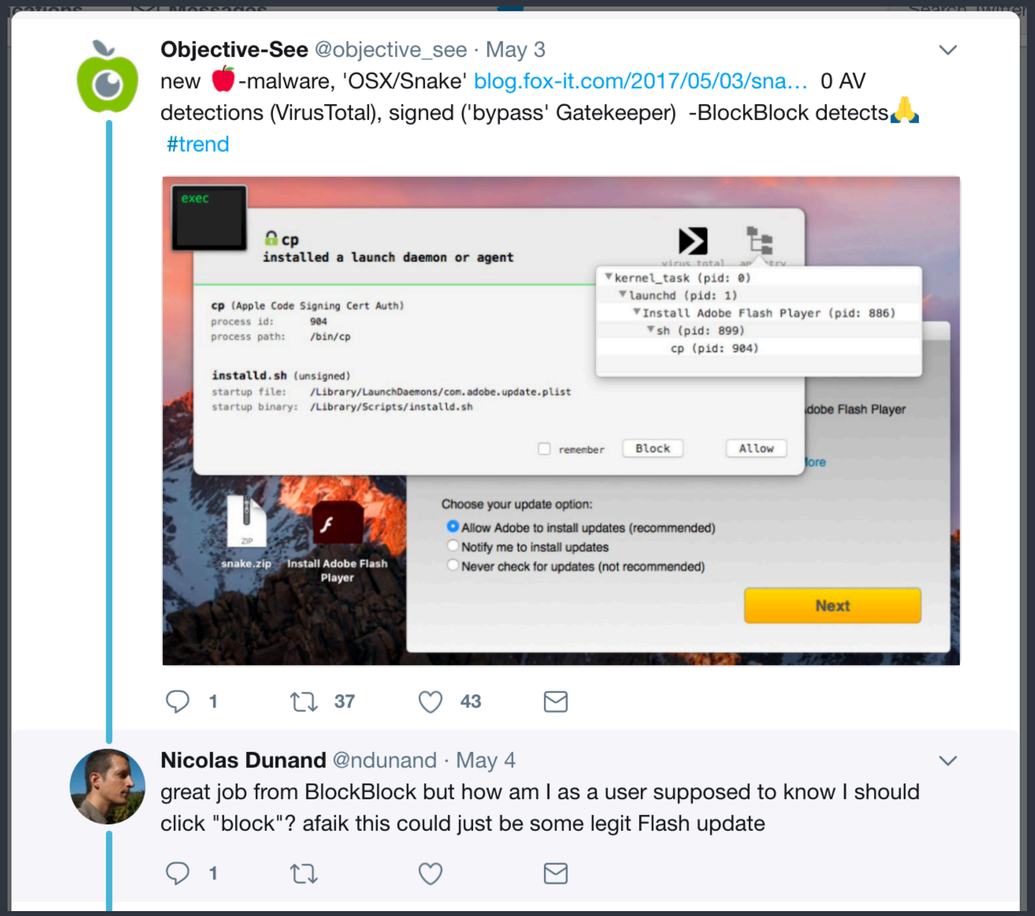


Real Time Analysis

Using Apple's GameplayKit

Goals: Context + Flexible analysis

Adjust and extend detections without core modification

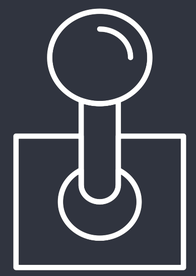


Provide structured output and configurable logic to allow admins to make better, perhaps automated decisions

!BlackBox and !Rigid. Allow the system to be adjusted, and extended in the enterprise without core modifications or new code.

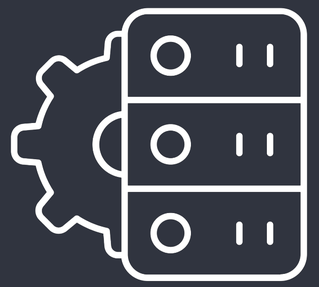
Game Logic Engine

the traditional pieces

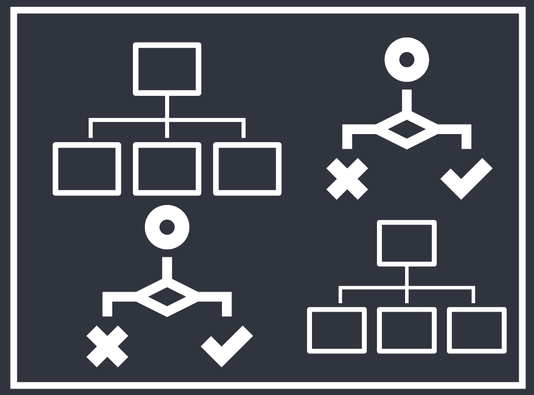


sensor(s)

modelled events

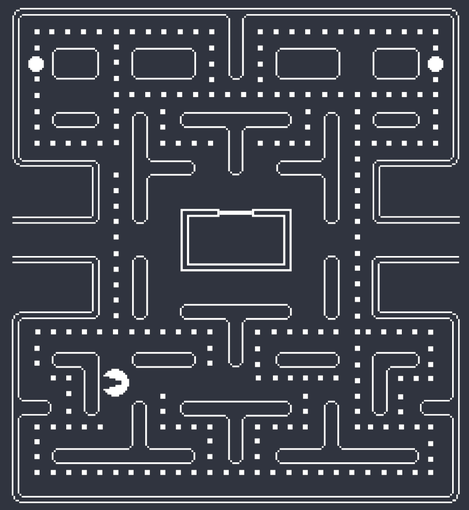


state



logic controller = Σ logic blocks

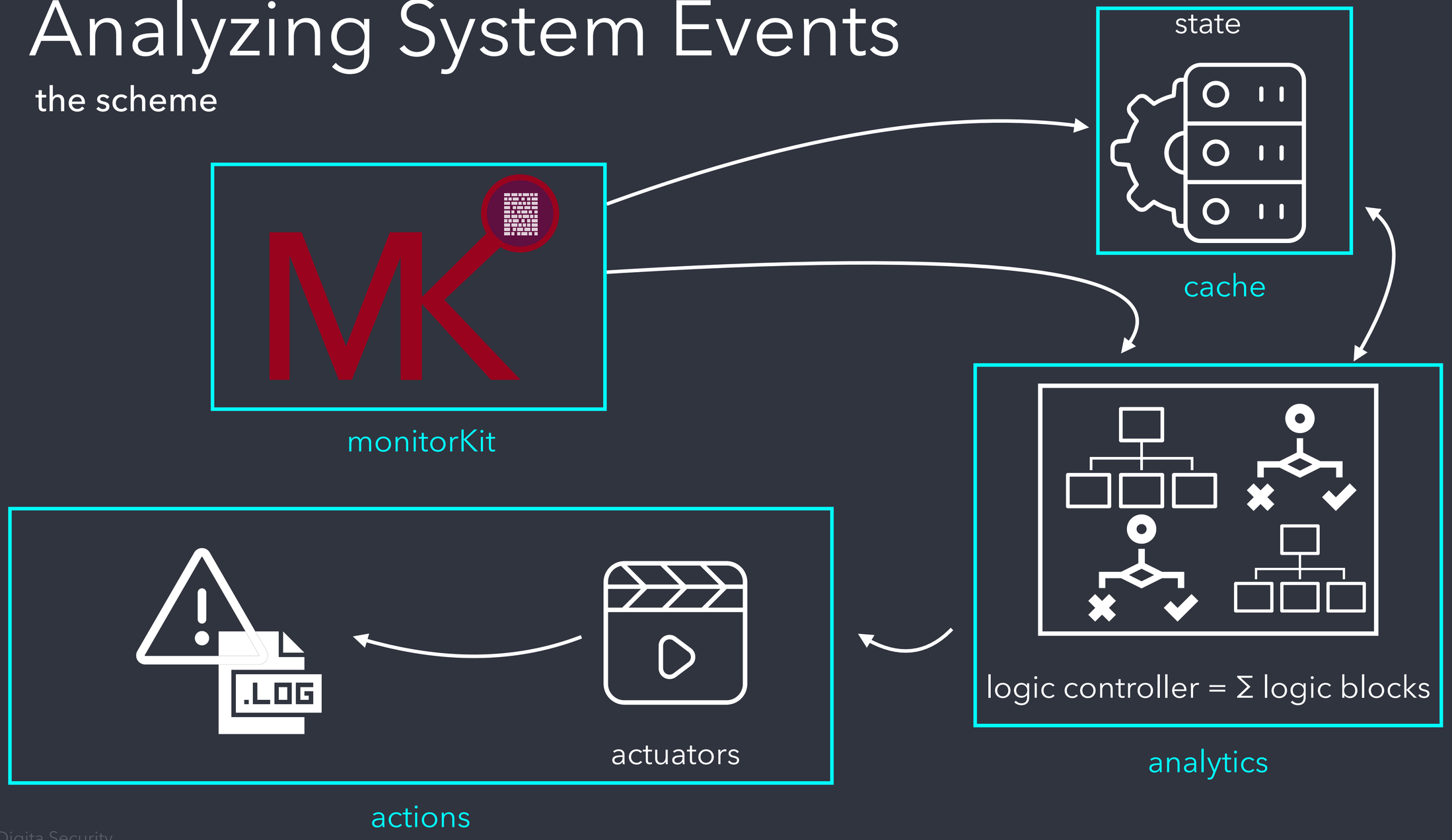
actuators



https://docs.blender.org/manual/en/latest/game_engine/logic/index.html

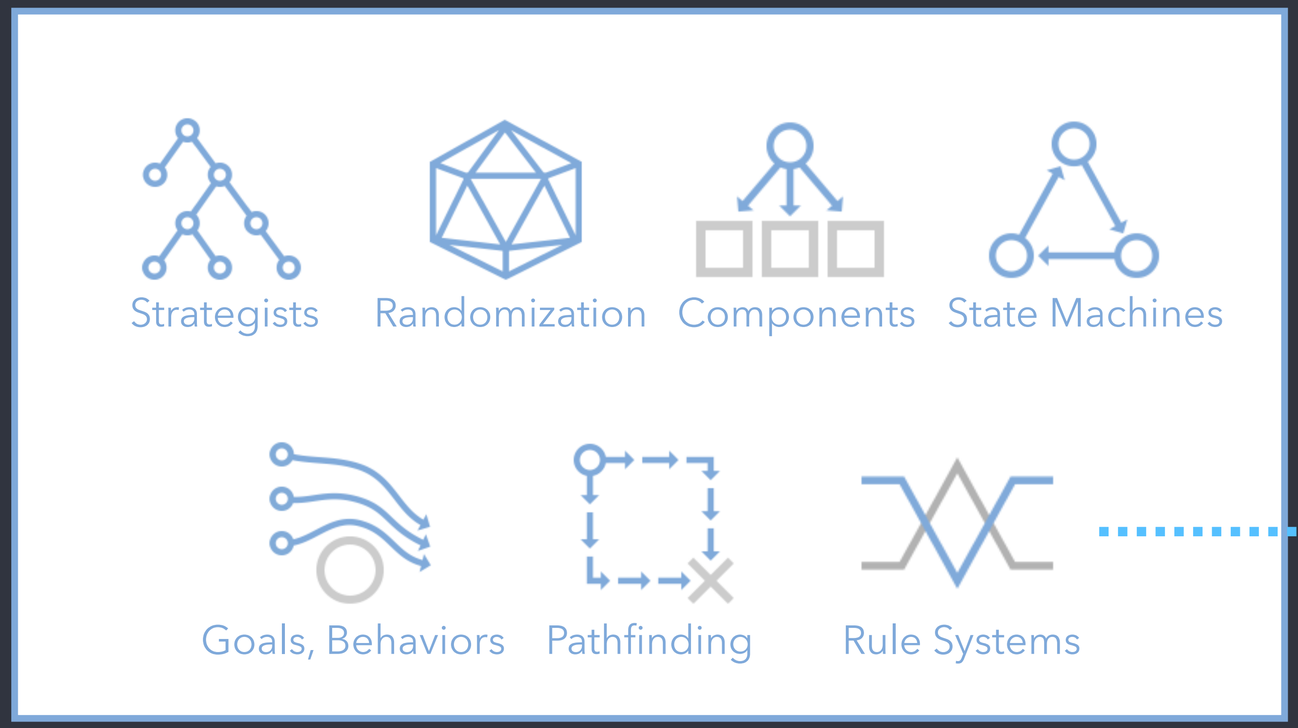
Analyzing System Events

the scheme



GameplayKit

Apple's Game Engine Framework == logic controller



Logic
GKRuleSystem

“allows a list of [logic blocks], together with context for evaluating them and interpreting results, for use in constructing data-driven logic or fuzzy logic systems”

+

"Separate game design from executable code"

https://developer.apple.com/library/archive/documentation/General/Conceptual/GameplayKit_Guide/index.html#//apple_ref/doc/uid/TP40015172

GKRuleSystem

A simple example

```
import Foundation
import GameplayKit

class SimpleLogicSystem {
    let system: GKRuleSystem

    init() {
        self.system = GKRuleSystem()

        // Define the game logic
        let hunt = NSPredicate(format: "$invincible == false")
        let retreat = NSPredicate(format: "$invincible == true")

        // Load it into the "rule system"
        self.system.add(GKNSPredicateRule(predicate: hunt, assertingFact: "hunt" as NSObjectProtocol, grade: 1.0))
        self.system.add(GKNSPredicateRule(predicate: retreat, retractingFact: "hunt" as NSObjectProtocol, grade:
            1.0))
    }

    // Call update on a timer, or when the event occurs
    func update(powerPellet: Bool) {
        self.system.state["invincible"] = powerPellet
        self.system.reset()
        self.system.evaluate()

        let ghostHunt = self.system.grade(forFact: "hunt" as NSObjectProtocol)
        if ghostHunt > 0.0 {
            print("lets go hunting")
        } else {
            print("run, Forest, run!")
        }
    }
}
```

(1) Define and load the "game" logic

(2) On a timer, or drive-by events, re-evaluate / execute the engine

(3) Respond to the output of the evaluation

```
// Simple example
let sys = SimpleLogicSystem()
sys.update(powerPellet: true)
sys.update(powerPellet: false)
```

```
run, Forest, run!
lets go hunting
```

"GamePlans"

Defining predicates across the Mitre ATT&CK Framework

Initial Access	Execution	Persistence 
Privilege Escalation 	Defense Evasion	Credential Access
Discovery	Lateral Movement	Collection 
Exfiltration 	Command & Control 	

Developing GamePlans

BlockBlock inspired logic blocks

```
$event.isNewDirectory == 1 AND (
$event.path MATCHES[cd] "/System/Library/Extensions/[^/]*" OR
$event.path MATCHES[cd] "/Library/Extensions/[^/]*"
) → Persist, Kext
```

Logic block is NSPredicate over data model

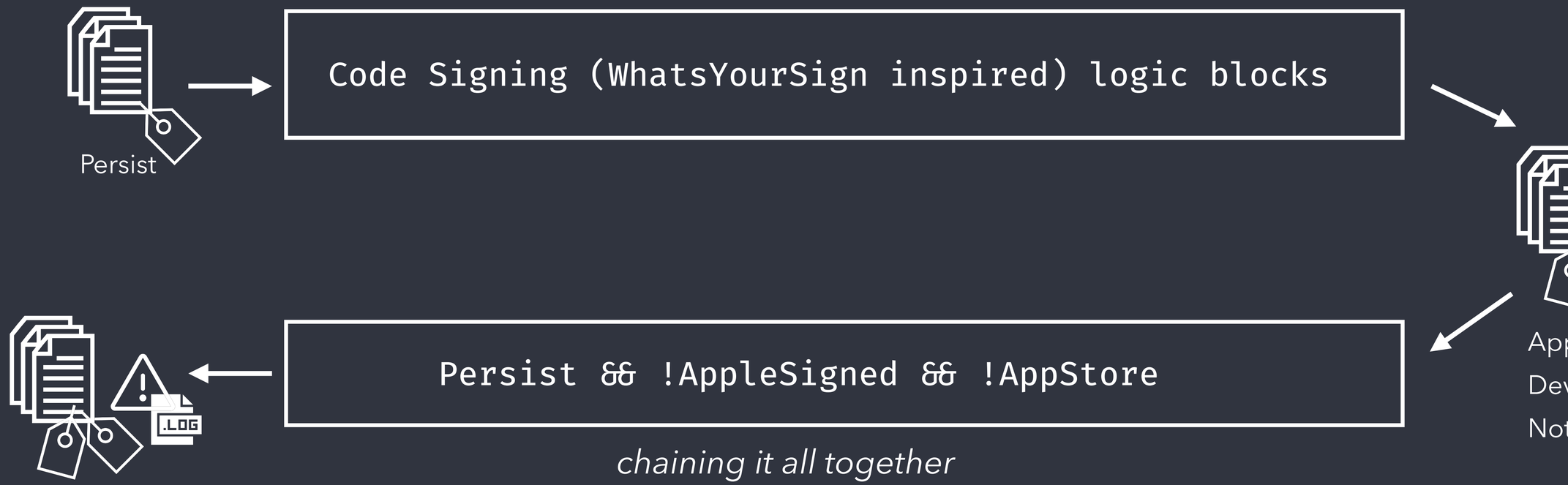
```
... → Persist, Kext
... → Persist, Launch
... → Persist, EventMonitor
... → Persist, AppLoginItem
... → Persist, LoginItem
... → Persist, CronJob
... → Persist, StartupItem
... → Persist, LoginHook
... → Persist, SpotlightImporter
... → Persist, SecurityAgentPlugin
... → Persist, DYLDInsert(App)
... & "Launch" → Persist, DYLDInsert(LaunchD)
```

Labels applied by logic blocks

detecting macOS att&ck persistence techniques

Chaining Logic Blocks

For more accurate and actionable detection



chaining it all together

Advanced Behavioral Detections

Ransomwhere? Inspired Detections

File I/O Modification of file in /Users/
+ Process responsible for file modification is not Apple Signed or from App Store
+ File contents now encrypted (Chi Square distribution, Monte Carlo pi approximation,...)
+ Process responsible for file modifications has quickly encrypted several files
= Potential Ransomware

```
$event.isModified == TRUE AND
$event.path MATCHES[cd] "/Users/*" AND
!$event.process.labels.contains("AppleSigned", "AppStore") AND
!$event.contents.encrypted == TRUE
```

UntrustedEncrypt

```
$event.labels.contains("UntrustedEncrypt") AND
@SUBQUERY(cache, $e, $e.date > (X sec ago) AND
$e.process.pid == $event.process.pid).@count > 3 → Ransomware
```

Ransomware

The algorithm (https://objective-see.com/blog/blog_0x0F.html)

MonitorKit

MK

+

Real Time Analysis

vs

macOS threats

Another look at FruitFly

A Better Fly Trap?

A chance for detection on install

```
($event.path MATCHES[cd] "/System/Library/LaunchAgents/.*.plist" OR
$event.path MATCHES[cd] "/Library/LaunchAgents/.*.plist" OR
$event.path MATCHES[cd] "/Users/.*/Library/LaunchAgents/.*.plist") AND
$event.isNewFile == 1
```

Generically Detect a Launch Agent being registered

+

```
$event.label.contains("LaunchAgent") AND
($event.file.contentsAsDict.ProgramArguments)[0].lastPathComponent.startsWith(".")
```

Determine that its a hidden program to be launched

https://blog.malwarebytes.com/threat-analysis/2017/01/new-mac-backdoor-using-antiquated-code/

https://www.virusbulletin.com/uploads/pdf/magazine/2017/VB2017-Wardle.pdf

FruitFly Launch & Behaviors

If persisting a hidden file isn't enough cause for alarm

```
$event.process.path.lastPathComponent.startsWith(".")
```

A hidden file is being executed

```
$event.process.path.startsWith("/tmp")
```

Then extracts and executes a file out of tmp

+

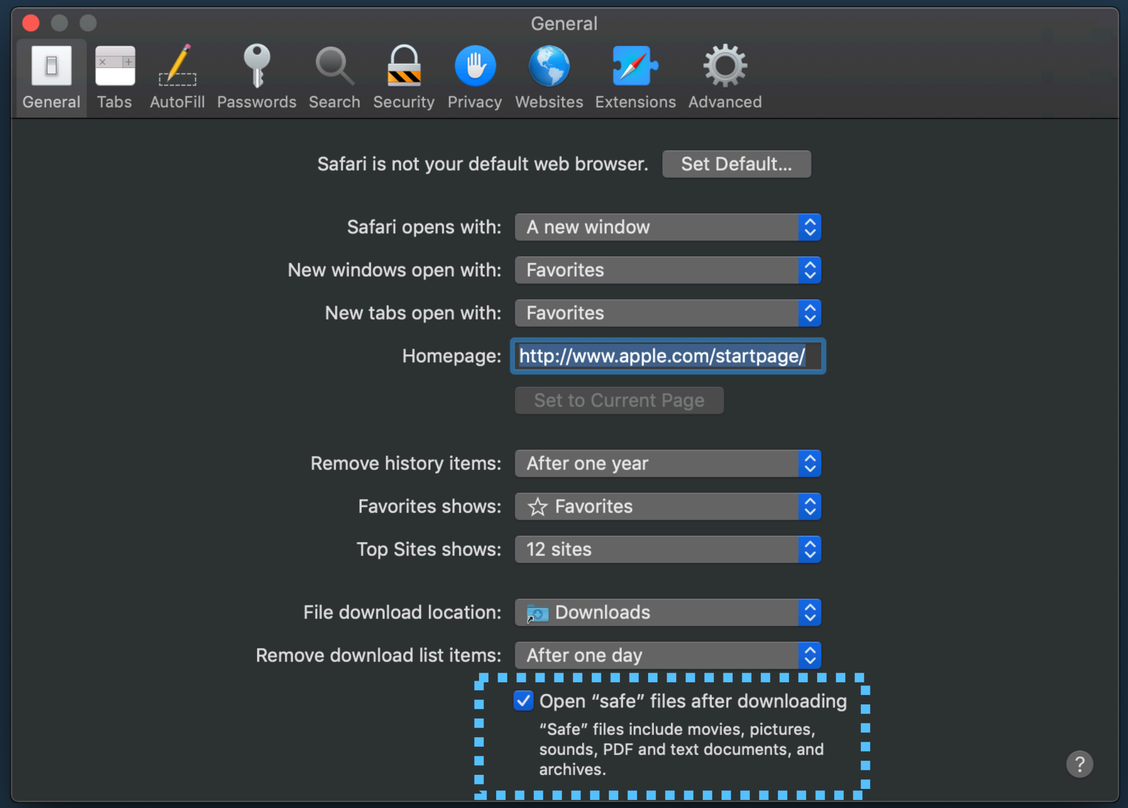
```
+ Controls the camera
+ Issue synthetic clicks
+ Synthetic keyboard events
```

https://blog.malwarebytes.com/threat-analysis/2017/01/new-mac-backdoor-using-antiquated-code/

https://www.virusbulletin.com/uploads/pdf/magazine/2017/VB2017-Wardle.pdf

WindShift Execution Vector

Via Phishing, "Safe" Open, CustomURL Handlers, & Redirects



Open "Safe" files: Including PDFs & Archives?!?

macOS parses and auto-registers handlers on write.

windshift:// launches app

```
<key>CFBundleURLTypes</key>
<array>
  <dict>
        <key>CFBundleURLSchemes</key>
        <array>
              <string>windshift</string>
        </array>
        <key>CFBundleURLName</key>
      <string>com.foo.bar.WindShift<string>
  </dict>
</array>
```

Extracted App Info.plist

https://digitasecurity.com/blog/2018/08/30/windshift/

https://gsec.hitb.org/sg2018/sessions/commsec-the-trails-of-windshift-apt/

Detecting WindShift Execution Vector

Via "Safe" Open & CustomURL Handlers

```
$event.isNewDirectory == 1 AND
$event.file.isAppBundle == 1 AND
$event.file.bundle.infoDictionary.CFBundleURLTypes ≠ nil
```

Custom URL Handler

+

```
$event.isNewDirectory == 1 AND
$event.process.name == 'SAFARI'
```

File automically written by 'Safari'

or

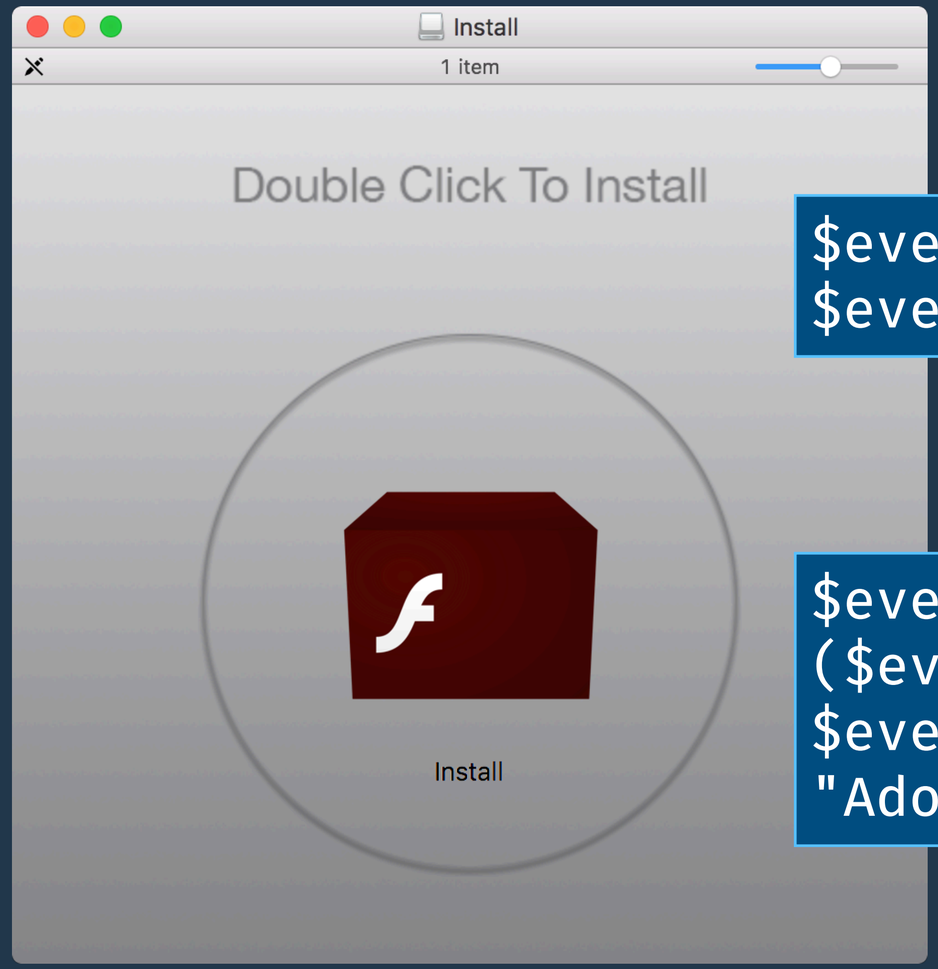
```
$event.signType ≠ 'Apple' OR
$event.signType ≠ 'AppStore'
```

Not distributed by Apple or the App Store

https://digitasecurity.com/blog/2018/08/30/windshift/

https://gsec.hitb.org/sg2018/sessions/commsec-the-trails-of-windshift-apt/

My Favorite Adware Detector!?




```
$event.process.path.contains("Adobe") OR
$event.process.path.contains("Flash")
```

Process path contains Adobe or Flash

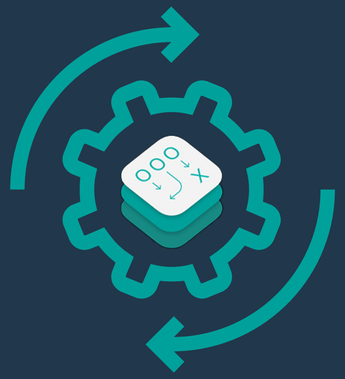
+

```
$event.process.sigtype == Adhoc OR
($event.process.sigtype == Dev AND
$event.process.signer ≠
"Adobe Systems, Inc.")
```

But not validly signed by Adobe!

MonitorKit

+



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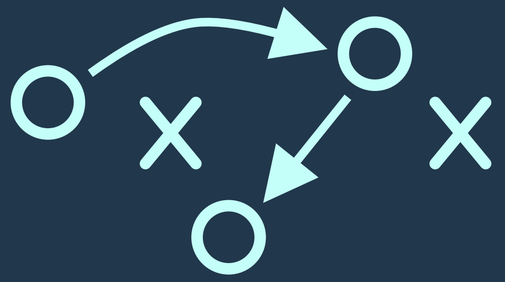
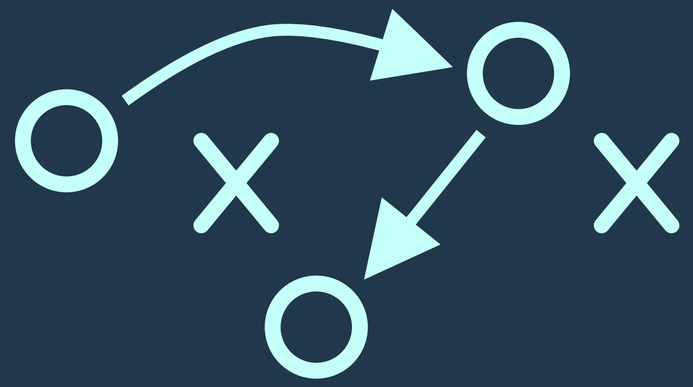


GamePlan



GamePlan

Purpose built macOS endpoint detection, auditing and threat hunting platform with extensible analytics efficiently executed by a game engine

Generally available for the enterprise in 2019!

Questions and Answers

Contact us anytime!

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