Breaking the iOS Sandbox

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Apple iOS 3rd Party Apps

AppStore

Installed on user devices

Vetted by Apple

Protected by: sandboxing, Preferences settings

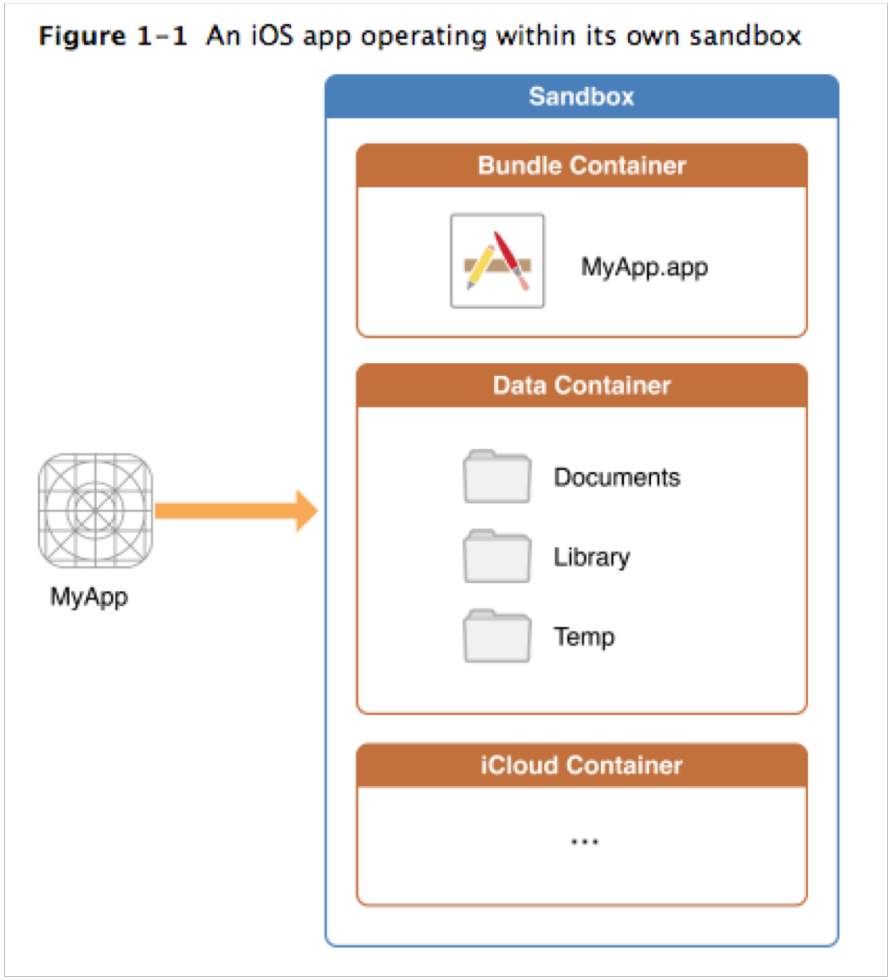
Jekyll Apps

Malicious apps disguised as benign apps

Abused features that should not be exposed

https://www.usenix.org/conference/usenixsecurity13/technical-sessions/presentation/wang_tielei

The Apple Sandbox



Goal and Steps

Evaluate Apple iOS sandbox

Reverse Apple sandbox

Model the sandbox

Detect policy flaws

Let Apple know

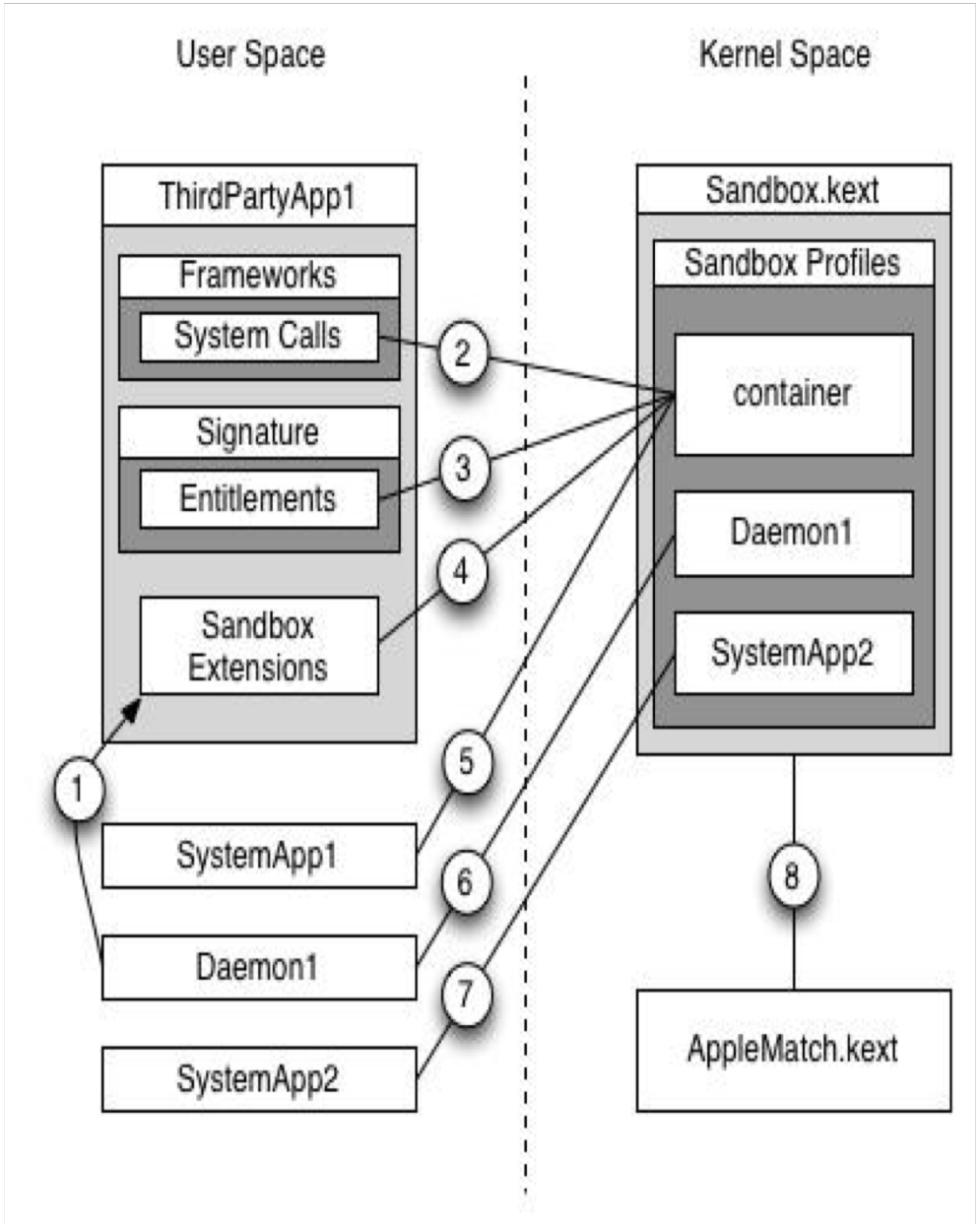
Provide lessons learned

Challenges in Evaluating iOS Sandbox

- iOS is closed source
- Limited documentation
- Kernel is encrypted
- No root access
- Sandbox policies are hidden and compiled
- Sandbox policies are large and complex
- Potential flaws need to be tested

Sandbox Architecture

1. Privileged apps grant extensions
2. Sandbox allows or denies system calls
3. Entitlements satisfy conditions
4. Extensions satisfy conditions
5. Some system apps use container profile
6. Daemons have unique profiles
7. Some system apps have unique profiles
8. AppleMatch processes regular expressions



SandBox Profile Language (SBPL)

```
( allow file-read*
  ( require-all
    ( subpath "/Media/Safari" )
    ( require-not
      ( literal "/Media/Safari/secret.txt" )
    )
    ( require-entitlement
      "private.signing-identifier"
      ( require-any
        (entitlement-value "mobilesafari" )
        (entitlement-value "safarifetcherd" )
) ) ) )
```

Sandbox Profiles

Specific rules attached to certain apps

Originally written in SBPL, provided as binary blobs

May be shared by multiple apps

The container Sandbox Profile

Used by all 3rd party apps

Largest sandbox profile

Main target of our analysis due to scope and complexity

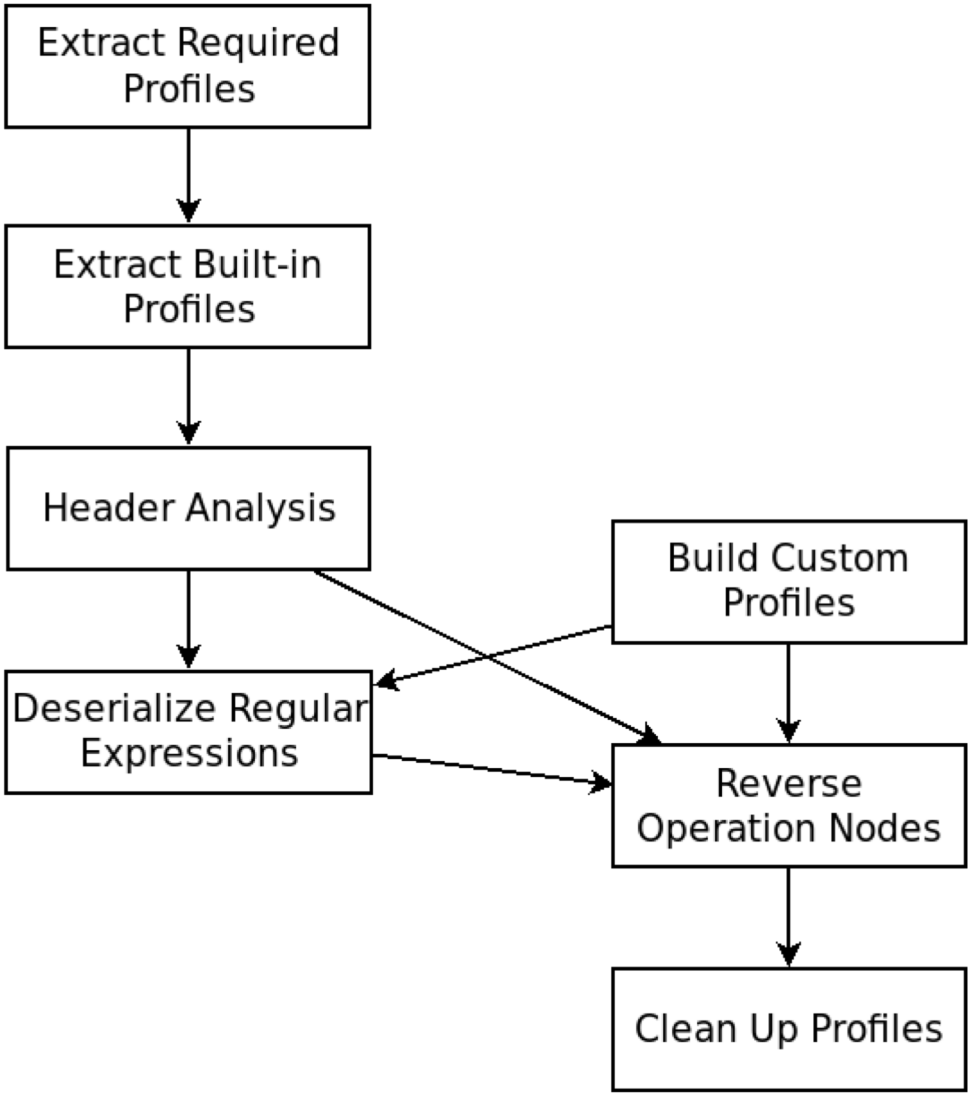
Sandbox Profiles

Previous Work on Reversing the Apple Sandbox

Dionysus Blazakis: https://github.com/dionthegod/XNUSandbox

Stefan Esser: https://github.com/sektioneins/sandbox_toolkit

Reversing Methodology



Current State

https://arxiv.org/abs/1608.04303

https://github.com/malus-security/sandblaster

Works on iOS 7-11, minor issue from 11.1.2

To test on iOS 12

Evaluate iOS Apple Sandbox

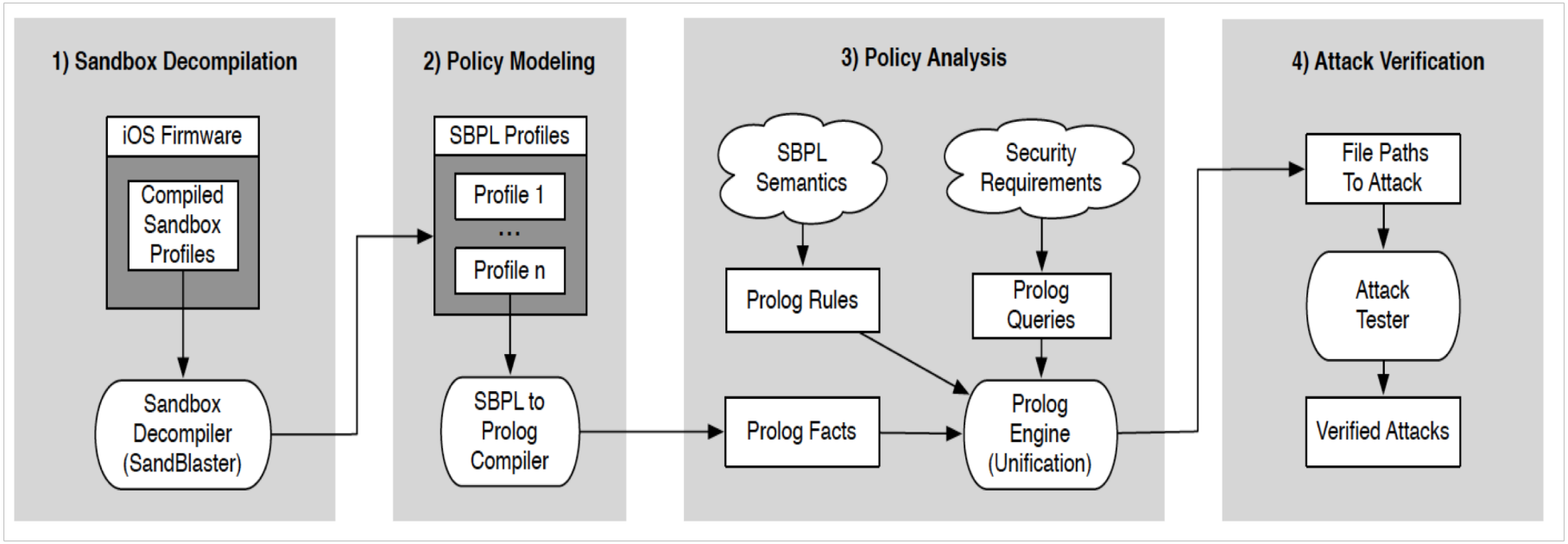
Is a 3rd party app allowed more than necessary? Is this dangerous?

Automated process

Focus on container

SandScout

Overview


1) Sandbox Decompilation
iOS Firmware
Compiled Sandbox Profiles
Sandbox Decompiler (SandBlaster)
2) Policy Modeling
SBPL Profiles
Profile 1
...
Profile n
SBPL to Prolog Compiler
3) Policy Analysis
SBPL Semantics
Security Requirements
Prolog Rules
Prolog Queries
Prolog Facts
Prolog Engine (Unification)
4) Attack Verification
File Paths To Attack
Attack Tester
Verified Attacks

Prolog Facts

SBPL to Prolog Compiler

- Lex
- Yacc
- Context Free Grammar
- Disjunctive Normal Form

```
decision(operation,[listOfFilters]).
```

```
allow(file-readSTAR,
  [literal("/myFile"),extension("A")]).
allow(file-readSTAR,
  [literal("/myFile"),not(extension("B"))]).
```

Prolog Queries

1. To prevent damage to the system, full write access to system file paths, is reserved for apps with system capabilities.

```
?- allow(file-writeSTAR,Filters),
   member(X,Filters),member(X,SysPaths),
   intersection(Filters,SysCaps,[]).
```

```
allow(file-writeSTAR,
  [subpath("/Library/AddressBook/"),
    extension("AddressBook")]).
```

Findings

Privacy leaks

- Apple Maps privacy leak
- iTunes privacy leak
- Metadata leak
- Unauthorized Collusion

Storage consumption

Deny access to system files

Hard-link Attack

- Access to AddressBook fails without privacy setting
- Request privacy setting to get access
- User should be able to revoke access by turning off privacy setting
- Create hard link to AddressBook and put the link in /KeyboardCache/
- All apps can read and write in /KeyboardCache/
- Therefore all apps get access to AddressBook regardless of privacy setting
- Hard link changes path while keeping same file inode

Disclosure to Apple

Several calls with Apple Security team

CVE-2016-4686

CVE-2016-4664

CVE-2016-4665

CVE-2015-7001

Current Work

Expanding SandScout to Apple NSXPC

Part of sandbox rules (mach-lookup)

Services provided to 3rd party apps

Summary

First full reversing of the Apple Sandbox

https://arxiv.org/abs/1608.04303

Flaws detected and fixed in the Apple Sandbox

https://dl.acm.org/citation.cfm?id=2978336

Takeaway

Reversing is both hard and rewarding

Complexity is the enemy of security

You need automated verification/validation

Pay attention to access control rules in system security implementation