Hack in the (sand)Box

(The Apple Sandbox - five years later)

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The Apple Sandbox

- Introduced way back in Mac OS 10.5 as “Seatbelt”
  - Very naive implementation originally, bypassed and opt-in
- Revamped in Mac OS 10.7 as “The App Sandbox”
  - Stronger implementation, introducing containers
  - Opt-in for Apple’s own binaries and apps
  - Mandatory for Mac App Store apps (but not for DMG based)
- Far stronger still in iOS
  - Mandatory for all third party applications
  - Evolved beyond MacOS implementation

Sandbox versions

Version	OS Version	Notable Features
..	OS X 10.5/iOS 1-3	Initial version, white list approach
..	OS X 10.6/iOS 4	
165	OS X 10.7/iOS 5	Basic containers
220	OS X 10.8/iOS 6	Sandbox exceptions
278-300	OS X 10.9/iOS 7	IOKit get property, vnode renaming
358	OS X 10.10/iOS 8	Rootless (introduction, non-enforcing), get-task, AMFI integration (in OS X version), kexts (kind of)
460	OS X 10.11/iOS 9	Rootless enforcement, container manager Host special ports, kexts, OSX NVRAM finally protected Policy moved to __DATA.__const (iOS 9.2)
592	OS X 10.12/iOS 10	Container Manager enforcement (iOS) User data items

So Why Are We Here?

- Last actual research conducted in 2011:
  - Dionysus Balazakis seminal work - “The Apple Sandbox”
- Very little further research – partial, unpublished or both
- Sandbox has evolved by leaps and bounds
  - Further evolves in iOS 10 and MacOS 12
  - Provides “System Integrity Protection” as of MacOS 11 (not yet iOS)
- Provides first, strongest, and sometimes last line of defense
  - Tons of exploitable bugs in services and kexts blocked by sandbox
  - Breaking out of the sandbox is toughest stage of jailbreaking.
  - ... And eight of you here voted for this talk ☺

Plan

- Prerequisite: MACF
- MacOS (“App Sandboxing”)
- *OS (Containers)
- Reversing (MacOS, iOS implementations)
- Sandbox APIs

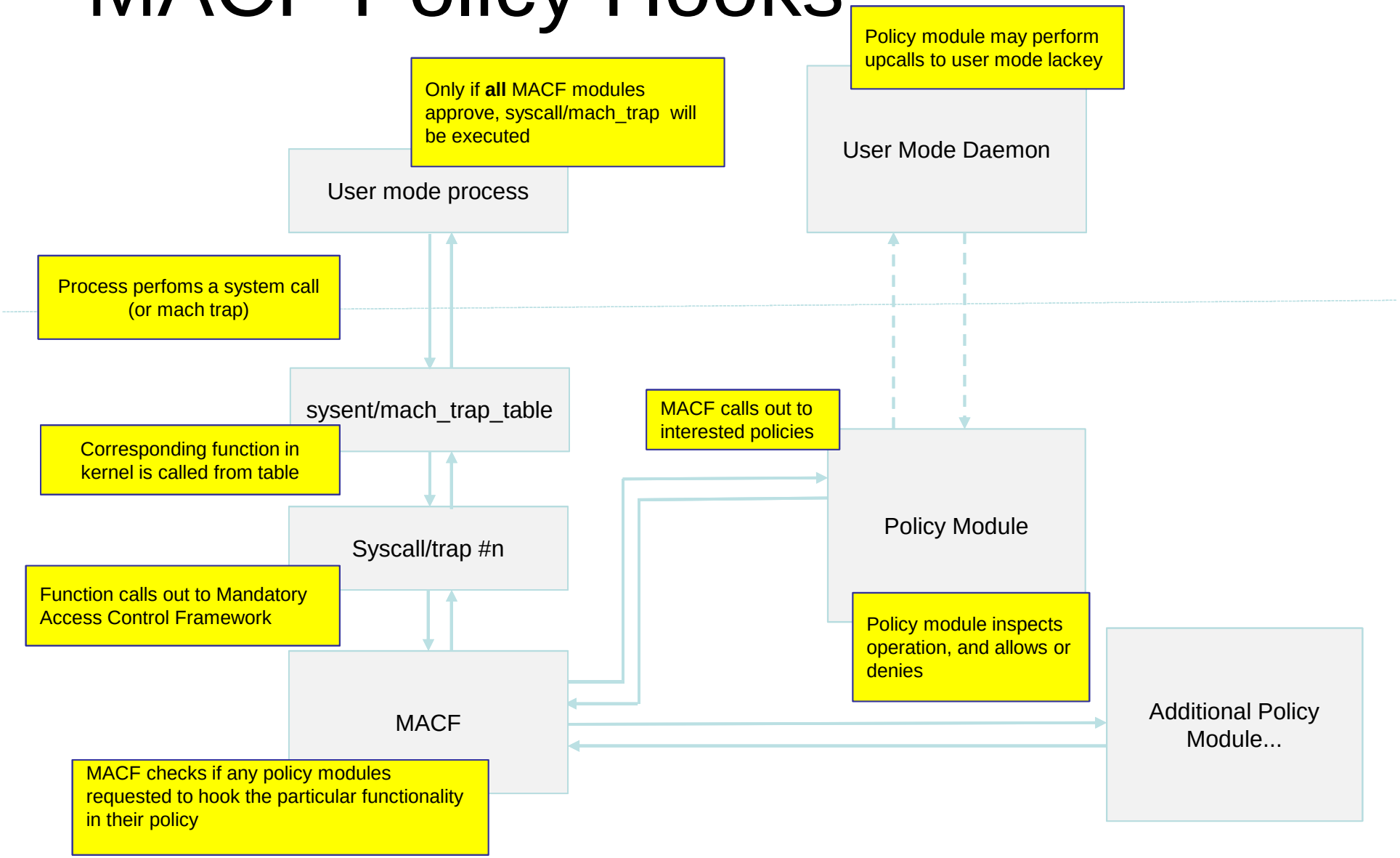
You’re welcome to follow along:

http://NewOSXBook.com/articles/hitsb.html

Prerequisite: MACF

- Mandatory Access Control Framework serves as substrate
  - XNU's implementation modeled after FreeBSD's
  - Compare - SELinux/SEAndroid
- Simple idea, powerful impact:
  - Kernel extensions provide a "policy" and call mac_policy_register
  - Policy contains "hooks" (callbacks)
  - Depending on process label, callbacks get invoked
  - Kernel extension gets to inspect operation arguments
  - Return 0 to allow, non-zero to thwart operation
  - All registered hooks must allow operation.

MACF Policy Hooks



MACF Policy Modules

- Serves as basis for virtually all of Apple's OS Security
- Currently 5 known policy modules:

Kext	Oses	# Ops	Purpose
Quarantine	MacOS	~15-17	Gatekeeper. Sort of.
MCXALR	MacOS	1	Managed Client Extensions (MDM/Parental Controls)
TMSafetyNet	MacOS	~26	TimeMachine hooks on file access
AMFI	All (OSX >=10.10)	~8-13	Enforce code signing, some entitlements & Mach ports
Sandbox	All	130+	Confine, strangle and block Applications at every turn

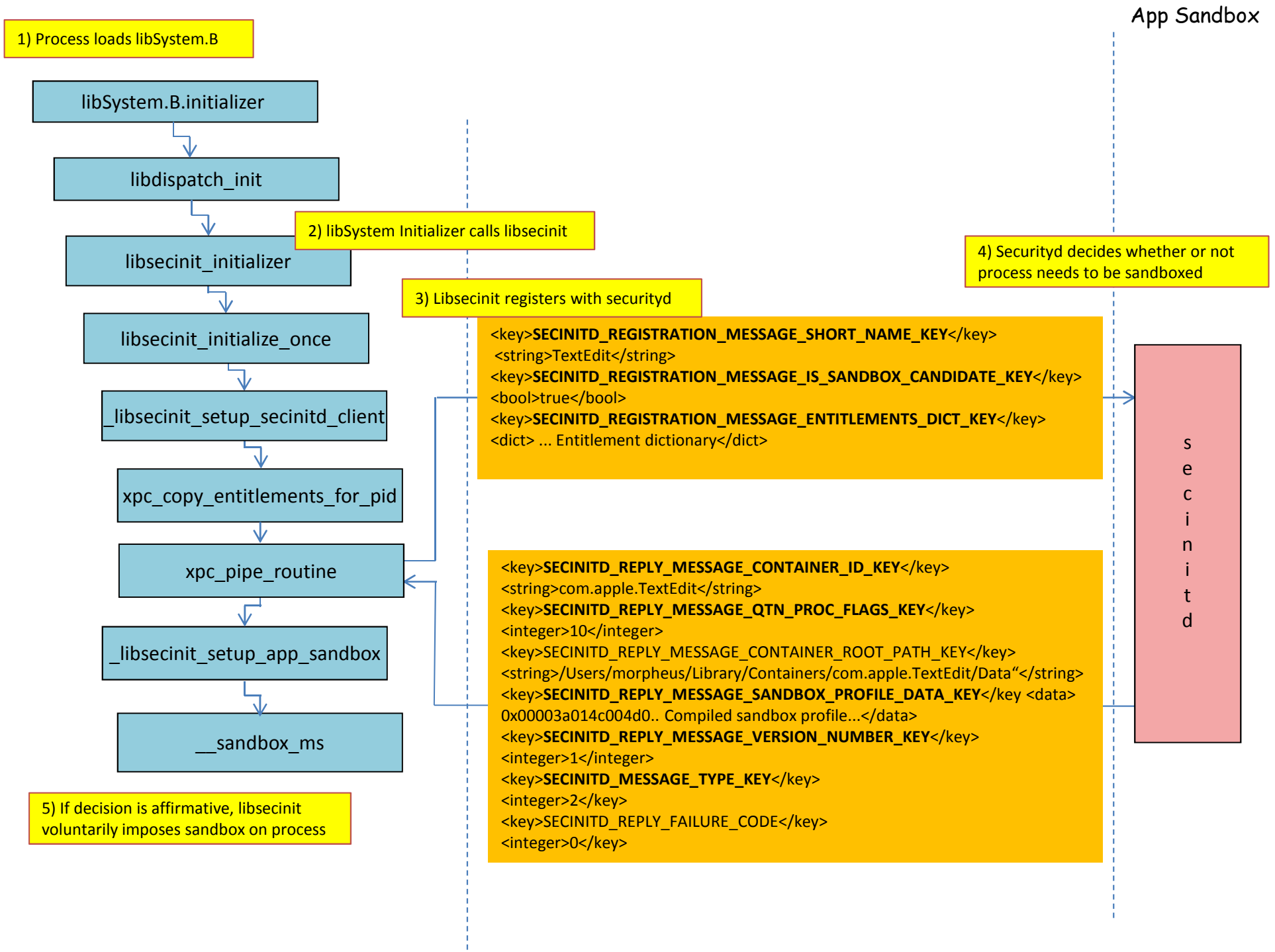
- Labels can define which policy, if any, will take effect
  - Process can be execed into label with mac_execve(#380)
  - posix_spawnattrs can similarly enforce sandbox
  - Sandbox has own spawnattrs (for specific container or profile)

Sandboxing

- Original sandbox approach – “seatbelt” – opt in:
  - You’d have to ask to confined (like, want to go to jail!)
  - Like its namesake, most people find it borderline troublesome.
- Contemporary sandbox approach is radically different:
  - You are either containerized or you are not:
    - Voluntary: because you are a responsible developer
    - Semi-voluntary: Code signature or location (Apple controlled)
    - Non-voluntary: Based on install location (*OS)
  - If containerized, Sandbox intercepts all important operations
    - Definition of important keeps increasing to include more..
    - Operation assessed versus a profile, or entitlements

MacOS : App Sandboxing

- Sandbox no longer requires sandbox_init – but signature
  - This way Apple, not developer, can enforce sandboxing
  - In iOS, /var/mobile/Containers/Bundle location auto-sandboxes
- In MacOS, com.apple.security.app-sandbox sandboxes
- com.apple.application-identifier for container
  - Otherwise defaults to CFBundleIdentifier from App's Info.plist
- com.apple.application-groups (~10.7.5, 10.8.3 and later)
  - ~/Library/Group Containers/…


App Sandbox
1) Process loads libSystem.B
libSystem.B.initializer
libdispatch_init
libsecinit_initializer
2) libSystem Initializer calls libsecinit
libsecinit_initialize_once
_libsecinit_setup_secinitd_client
xpc_copy_entitlements_for_pid
xpc_pipe_routine
_libsecinit_setup_app_sandbox
__sandbox_ms
5) If decision is affirmative, libsecinit voluntarily imposes sandbox on process
3) Libsecinit registers with securityd
<key>SECINITD_REGISTRATION_MESSAGE_SHORT_NAME_KEY</key>
<string>TextEdit</string>
<key>SECINITD_REGISTRATION_MESSAGE_IS_SANDBOX_CANDIDATE_KEY</key>
<bool>true</bool>
<key>SECINITD_REGISTRATION_MESSAGE_ENTITLEMENTS_DICT_KEY</key>
<dict> ... Entitlement dictionary</dict>
<key>SECINITD_REPLY_MESSAGE_CONTAINER_ID_KEY</key>
<string>com.apple.TextEdit</string>
<key>SECINITD_REPLY_MESSAGE_QTN_PROC_FLAGS_KEY</key>
<integer>10</integer>
<key>SECINITD_REPLY_MESSAGE_CONTAINER_ROOT_PATH_KEY</key>
<string>/Users/morpheus/Library/Containers/com.apple.TextEdit/Data“</string>
<key>SECINITD_REPLY_MESSAGE_SANDBOX_PROFILE_DATA_KEY</key <data>
0x00003a014c004d0.. Compiled sandbox profile...</data>
<key>SECINITD_REPLY_MESSAGE_VERSION_NUMBER_KEY</key>
<integer>1</integer>
<key>SECINITD_MESSAGE_TYPE_KEY</key>
<integer>2</key>
<key>SECINITD_REPLY_FAILURE_CODE</key>
<integer>0</key>
4) Securityd decides whether or not process needs to be sandboxed
secinitd

MacOS : App Sandboxing

- Containers created at ~/Library/Containers/{CFBundleIdentifier}
- All Structured the same way:
  - Container.plist: metadata (in bplist00 format)
    - Identity (Unicode, Base64)
    - Compiled profile (SandboxProfileData, base64)
    - SandboxProfileDataValidationInfo (long dict...)
    - Version (36 = MacOS 10, 38 = MacOS 11, 39 = MacOS 12)
  - Data: Directory structure, mimicking user's home directory:
    - .CFUserTextEncoding
    - Documents
    - Library
    - Music
    - Desktop
    - Downloads
    - Movies
    - Pictures

MacOS : App Sandboxing

- Data directories are often symbolic links(!)
  - SandboxProfileDataValidationRedirectablePathsKey limits links
- Metadata also holds entitlements, and other parameters
  - SandboxProfileDataValidationEntitlementsKey
  - SandboxProfileDataValidationParametersKey

iOS: Containers

Listing xx-conta: Traditional App directories vs. the Containers of iOS 8-9

```
                                                /var/mobile/Containers/
                                                 +--> Bundle/
/var/mobile/Applications                             +--> Application/
 +--> UUID-OF-APP                                    |       +---> UUID-OF-APP
     +---> appName.app/                              |             +---> appName.app/
     |                                               +--> Data/
     |                                                   +--> Application/
     |                                                        +---> UUID2-OF-APP/
     +---> Documents/                                         +---> Documents/
     +---> Library/                                           +---> Library/
         +---> Application Support/                           |
         +---> Caches/                                        |
         +---> Cookies/                                       |
         +---> Preferences/                                   |
     +---> StoreKit/                                          +---> StoreKit
     +---> iTunesArtwork                                            +---> iTunesArtwork
     +---> iTunesMetadata.plist                                     +---> iTunesMetadata.plist
     +---> tmp/                                               +---> tmp;
```

- Also allows for shared containers
  - Apps with same team-id can share data

iOS 10 Containers

iOS 10 continues the evolution of containers, by once again moving Application static data to /var/containers, leaving /var/mobile/Containers with just Data/ and Shared/. The Application/ sub-directory structure has also been `chown(2)`ed to `_installd`. This is likely in anticipation of full multi-user capabilities.

Listing xx-conta: Containers in iOS 8-9 vs. those in 10

```
/var/mobile
+---> Containers
+--------> Bundle
         +----> Application
         +----> Framework
         +----> PluginKitPlugin
         +----> VPNPlugin
+--------> Data
         +----> Application
         +----> InternalDaemon
         +----> PluginKitPlugin
         +----> TempDir
         +----> VPNPlugin
         +----> XPCService
+--------> Shared
         +----> AppGroup
```

```
/var/mobile
|    +---> Containers
|    |
|    |
|    |
|    |
|    +--------> Data
|    |          +----> Application
|    |          +----> InternalDaemon
|    |          +----> PluginKitPlugin
|    |          +----> TempDir
|    |          +----> VPNPlugin
|    |          +----> XPCService
|    +--------> Shared
|                    +---> AppGroup
/var/containers
     +---> Bundle _installd:_installd
     |       +---> Application
     |       +---> Framework
     |       +---> PluginKitPlugin
     |       +---> VPNPlugin
     +---> Data root:wheel
     +---> Shared root:wheel
        +---> SystemGroup ACLs
```

Another interesting change in iOS10 is the inclusion of a new SystemGroup/ shared container, which uses for the first time Access Control Lists (ACLs), as shown in Output xx-1:

Output xx-contacls: Access Control Lists on the Shared/SystemGroup containers

```
# As of iOS 10, shared system group containers also have ACLs
iPhone:/var/containers root# ls -le Shared/SystemGroup/
drwxr-xr-x+ 3 root  wheel  136 Jul  7 12:40 6244C5EB-F346-43B5-A6A9-C269A6D02730
 0: allow list,add_file,search,delete,add_subdirectory,delete_child,readattr,writeattr,
 readextattr,writeextattr,readsecurity,writesecurity,chown,file_inherit,directory_inherit,only_inherit
 1: allow add_file,add_subdirectory,readextattr,writeextattr
...
drwxr-xr-x+ 3 root  wheel  136 Jul  7 12:40 systemgroup.com.apple.pisco.suinfo
 0: allow list,add_file,search,delete,add_subdirectory,delete_child,readattr,writeattr,
 readextattr,writeextattr,readsecurity,writesecurity,chown,file_inherit,directory_inherit,only_inherit
 1: allow add_file,add_subdirectory,readextattr,writeextattr
```

iOS: Containers

- The sandboxd has been entirely removed in iOS as of 9.x
  - Still used in MacOS, primarily for tracing

- New daemon – `containermanagerd` – takes over
  - Part of `MobileContainer` private framework
  - Communicates with user mode (installd, etc) over XPC port
  - Communicates with kernel mode (kext) over Special Port #25
    - MIG message 0x13392fd4 (322514900)
    - Contains sb_packbuff payload of kernel requests

#	CM_KERN_REQUEST_..
0	.._CODE_SIGNATURE_ID
1	.._CONTAINER_ID
2	.._APPLICATION_ID
3	.._UID
4	.._APP_GROUP_ID
5	.._CONTAINER_TYPE
6?	.._PERSONA_ID
7?	.._SYSTEM_GROUP_CONTAINER_ID

AMFI

- Sandbox and AMFI make good bedfellows
- AMFI ensures signature, provides entitlement services
- Sandbox depends on AMFI (as of 358 in MacOS)

```
morpheus@Zephyr(~)$ kextstat
19 2 0xffffff7f8100f000 0xd000   0xd000   com.apple.driver.AppleMobileFileIntegrity (1.0.5) <7 6 5 4 3 2 1>
22 2 0xffffff7f8101c000 0x5000   0x5000   com.apple.kext.AppleMatch (1.0.0d1) <4 1>
23 1 0xffffff7f81021000 0x17000  0x17000  com.apple.security.sandbox (300.0) <22 19 7 6 5 4 3 2
```

- iOS Sandbox uses specific entitlements:
  - `seatbelt-profiles` – assign a particular profile to binary
  - `com.apple.private.security.container-required` - Sandboxes built-in apps

Deconstructing Sandbox

- MacOS Sandbox.kext can serve as a good reference
  - Largely same codebase, with some differences, but symbolicated
- Joker can auto-symbolicate plenty*:
  - Stubs to kernel functions
  - Entire MACF Policy (120+ functions!)
- Can get other functions (no names, yet) with jtool:
  - `grep BL.*0x | cut -dx -f2` then feedback to companion file
  - About 150 additional functions revealed by this method
- Important functions (e.g. smalloc, sfree) yield rest.
  - Hook_policy_syscall especially important (for mac_policy_syscall)

*** - Joker 3 can now handle split kexts from XNU 3750+!**

Sandbox MACF Policy Hooks

- Most MACF Policy hooks call `cred_sb_evaluate`
  - 1st argument (in R0/X0/RDI) is MACF's
  - 2nd argument (in R1/X1/ESI) encodes operation number

```
morpheus@Zephyr (../10) %jtool -d _mpo_priv_check com.apple.security.sandbox.kext
Opened companion File: ./com.apple.security.sandbox.kext.ARM64.D6145CC4-1EDA-34AF-A613-A0E613FE791F
Disassembling from file offset 0x75304, Address 0xffffff006b9a304  to next function
_mpo_priv_check:
ffffff006b9a304         STP     X28, X27, [SP,#-48]!      ;
ffffff006b9a308         STP     X20, X19, [SP,#16]        ;
ffffff006b9a30c         STP     X29, X30, [SP,#32]        ;
ffffff006b9a310         ADD     X29, SP, #32          ; $$ R29 = SP + 0x20
ffffff006b9a314         SUB     SP, SP, 224           ; SP -= 0xe0 (stack frame)
ffffff006b9a318         MOV     X19, X1             ; --X19 = X1 = ARG1
ffffff006b9a31c         MOV     X20, X0             ; --X20 = X0 = ARG0
ffffff006b9a320         ADD     X0, SP, #0            ; $$ R0 = SP + 0x0
ffffff006b9a324         ORR     W2, WZR, #0xe0        ; ->R2 = 0xe0
ffffff006b9a328         MOVZ    W1, 0x0               ; ->R1 = 0x0
ffffff006b9a32c         BL      _memset.stub  ; 0xffffffff006ba834c
;  R0 = _memset.stub(SP + 0x0,0x0,224);
ffffff006b9a330   ORR     W8, WZR, #0xf       ; ->R8 = 0xf
ffffff006b9a334         STR     W8, [SP, #96]             ; *(SP + 0x60) =
ffffff006b9a338         STR     W19, [SP, #104]           ; *(SP + 0x68) =
ffffff006b9a33c         ORR     W1, WZR, #0x7c        ; ->R1 = 0x7c
ffffff006b9a340         ADD     X2, SP, #0            ; $$ R2 = SP + 0x0
ffffff006b9a344         MOV     X0, X20             ; --X0 = X20 = ARG0
ffffff006b9a348         BL      _cred_sb_evaluate     ; 0xffffffff006b96c70
;  R0 = _cred_sb_evaluate(ARG0,0x7c,SP + 0x0);
ffffff006b9a34c   SUB     X31, X29, #32       ; SP = R29 - 0x20
ffffff006b9a350         LDP     X29, X30, [SP,#32]        ;
ffffff006b9a354         LDP     X20, X19, [SP,#16]        ;
ffffff006b9a358         LDP     X28, X27, [SP],#48        ;
ffffff006b9a35c         RET                       ;
_mpo_priv_grant:
```

Sandbox MACF Policy Hooks

- Operation numbers correspond to hard-coded names
  - Can also be found in older libsandbox.1.dylib
    - Removed (precompiled) into 570+
  - Names can be found in kext's __DATA__CONST.__const
    - Not going away since they are needed for APIs
  - There are more operations than there are MACF hooks
    - Some are callable from user mode by apps (e.g. AppleEvents, TCC)

Sandbox MACF Policy Hooks

- `cred_sb_evaluate` calls `sb_evaluate`
  - 1st parameter is sandbox obtained from label_get_sandbox
  - Operation as 2nd Parameter
  - Buffer as 3rd Parameter

```
morpheus@Zephyr (../10) %jtool -d _cred_sb_evaluate com.apple.security.sandbox.kext
Opened companion File: ./com.apple.security.sandbox.kext.ARM64.D6145CC4-1EDA-34AF-A613-A0E613FE791F
Disassembling from file offset 0x71c70, Address 0xfffffff006b96c70  to next function
_cred_sb_evaluate:
fffffff006b96c70        STP     X22, X21, [SP,#-48]!     ;
fffffff006b96c74        STP     X20, X19, [SP,#16]       ;
fffffff006b96c78        STP     X29, X30, [SP,#32]       ;
fffffff006b96c7c        ADD     X29, SP, #32          ; $$ R29 = SP + 0x20
fffffff006b96c80        MOV     X20, X2               ; --X20 = X2 = ARG2
fffffff006b96c84        MOV     X21, X1               ; --X21 = X1 = ARG1
fffffff006b96c88        STR     X0, [X20, #16]        ;= X0 ARG0
fffffff006b96c8c        LDR     X0, [X0, #120]        ;      R0 = *(ARG0 + 120)
fffffff006b96c90        BL      _label_get_sandbox    ; 0xfffffff006b96584
fffffff006b96c94        MOV     X19, X0               ; --X19 = X0 = 0x0
fffffff006b96c98        MOV     X1, X21               ; --X1 = X21 = ARG1
fffffff006b96c9c        MOV     X2, X20               ; --X2 = X20 = ARG2
fffffff006b96ca0        BL      _sb_evaluate  ; 0xfffffff006b9eec0
fffffff006b96ca4        MOV     X20, X0               ; --X20 = X0 = 0x0
; // if (R19  == 0) then goto 0xfffffff006b96cb4
fffffff006b96ca8   CBZ    X19, 0xfffffff006b96cb4  ;
fffffff006b96cac        MOV     X0, X19               ; --X0 = X19 = 0x0
fffffff006b96cb0        BL      _sandbox_release      ; 0xfffffff006b96254
fffffff006b96cb4        MOV     X0, X20               ; --X0 = X20 = 0x0
fffffff006b96cb8        LDP     X29, X30, [SP,#32]       ;
fffffff006b96cbc        LDP     X20, X19, [SP,#16]       ;
fffffff006b96cc0        LDP     X22, X21, [SP],#48       ;
fffffff006b96cc4        RET                              ;
```

Sandbox MACF Policy Hooks

- `cred_sb_evaluate` derives credentials, and calls `eval` *
  - May or may not report sandbox violations (based on argument to check)

```
morpheus@Zephyr (../10) %jtool -d _sb_evaluate com.apple.security.sandbox.kext  | grep BL
Opened companion File: ./com.apple.security.sandbox.kext.ARM64.D6145CC4-1EDA-34AF-A613-A0E613FE791F
Disassembling from file offset 0x79ec0, Address 0xfffffff006b9eec0  to next function
fffffff006b9eeec        BL      _derive_cred       ; 0xfffffff006b9f0fc
fffffff006b9ef20        BL      _kauth_cred_proc_ref.stub  ; 0xfffffff006ba81cc
fffffff006b9ef3c        BL      _OSCompareAndSwapPtr.stub  ; 0xfffffff006ba7f44
fffffff006b9ef48        BL      _kauth_cred_unref.stub     ; 0xfffffff006ba81d8
fffffff006b9ef70        BL      _eval      ; 0xfffffff006b9f164
fffffff006b9efbc        BL      _eval      ; 0xfffffff006b9f164
fffffff006b9f010        BL      _derive_vnode_path ; 0xfffffff006b9e590
fffffff006b9f030        BL      _derive_socket_info        ; 0xfffffff006ba1030
fffffff006b9f070        BL      _sb_trace  ; 0xfffffff006ba1fcc
fffffff006b9f0bc        BL      _sb_report ; 0xfffffff006ba161c
fffffff006b9f0cc        BL      _free_filter_context       ; 0xfffffff006b9e410
morpheus@Zephyr (../10) %
```

- Evaluation first attempted against platform_profile
- Can default to specific process-defined (container) profile

*** - MacOS implementation slightly different (includes csr_check, etc). iOS also inlines eval_filter into eval**

Reversing Profiles

- Sandbox Profiles are written in tinyScheme (UGH!)
  - In MacOS – plaintext, in /System/Library/Sandbox/Profiles
    - Per framework profiles also exist for Apple's frameworks
  - in iOS – compiled & built-in!
- The gist:
  - `(version 1)` (only version supported)
  - `(deny default)` (least privilege)
  - `(allow ……)` (selectively allow APIs)
  - `(deny ……)` (selectively disallow APIs)
- Can apply and trace using `sandbox-exec`:

```
(version 1)
(trace "/tmp/appTrace.sb")
```

Sandbox-exec

- Simple binary (300-500 lines of ASM)

```
morpheus@Zephyr (~)$ sandbox-exec
Usage: sandbox-exec [options] command [args]
Options:
  -f profile-file     Read profile from file.
  -n profile-name     Use pre-defined profile.
  -p profile-string   Specify profile on the command line.
  -D key=value        Define a profile parameter.
Exactly one of -f, -n, -p must be specified.
```

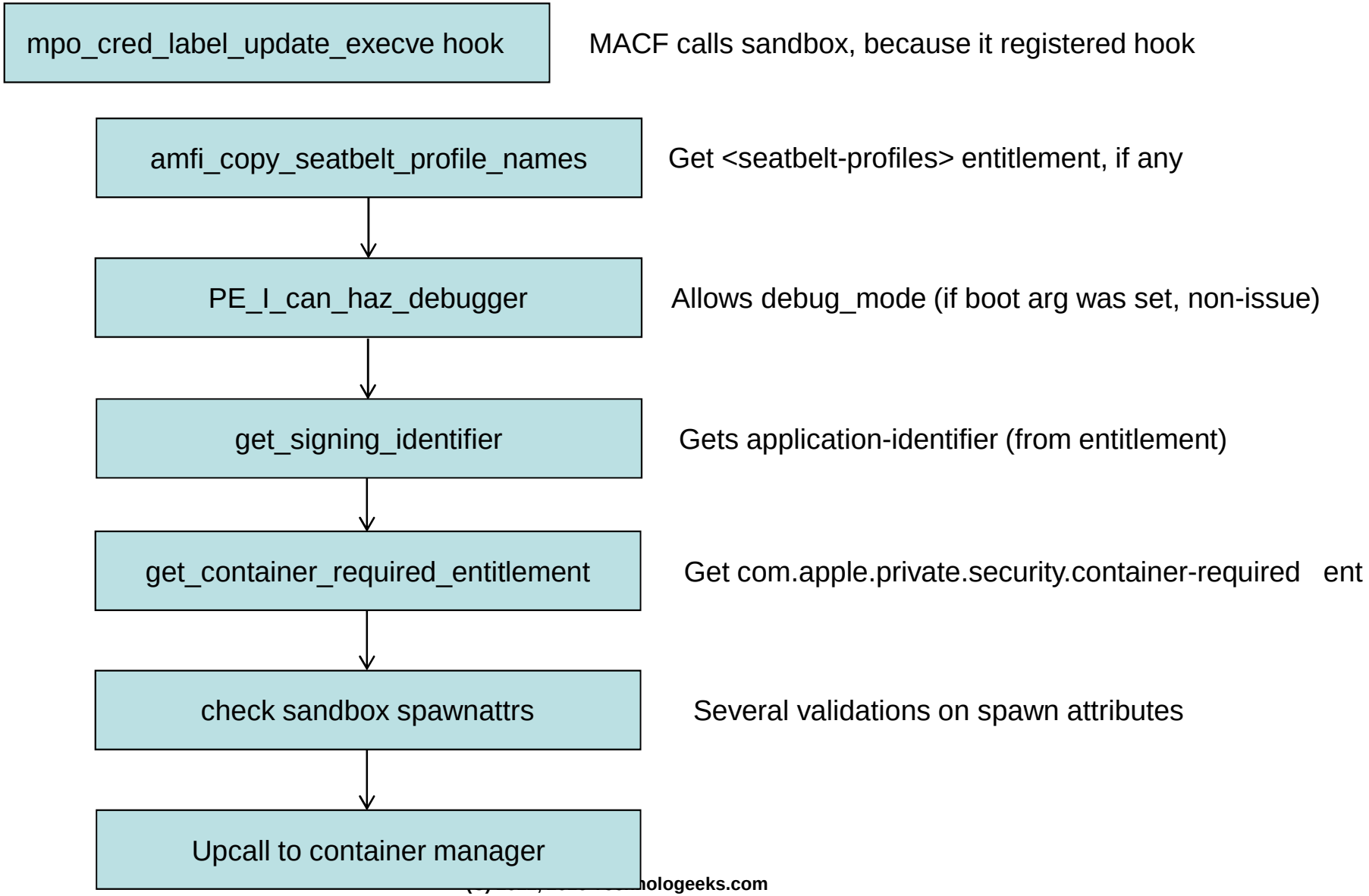
- MacOS 11 adds undocumented “-t” for tracing
  - Tracing broken in iOS with the removal of sandboxd ☹
- Closed source – but....
  - Fully compatible clone at http://NewOSXBook.com/tools/sob.html
  - Wil l also dump compiled profile in /tmp
  - Provides first implementation of sandbox-exec for iOS!

Built-in Profiles

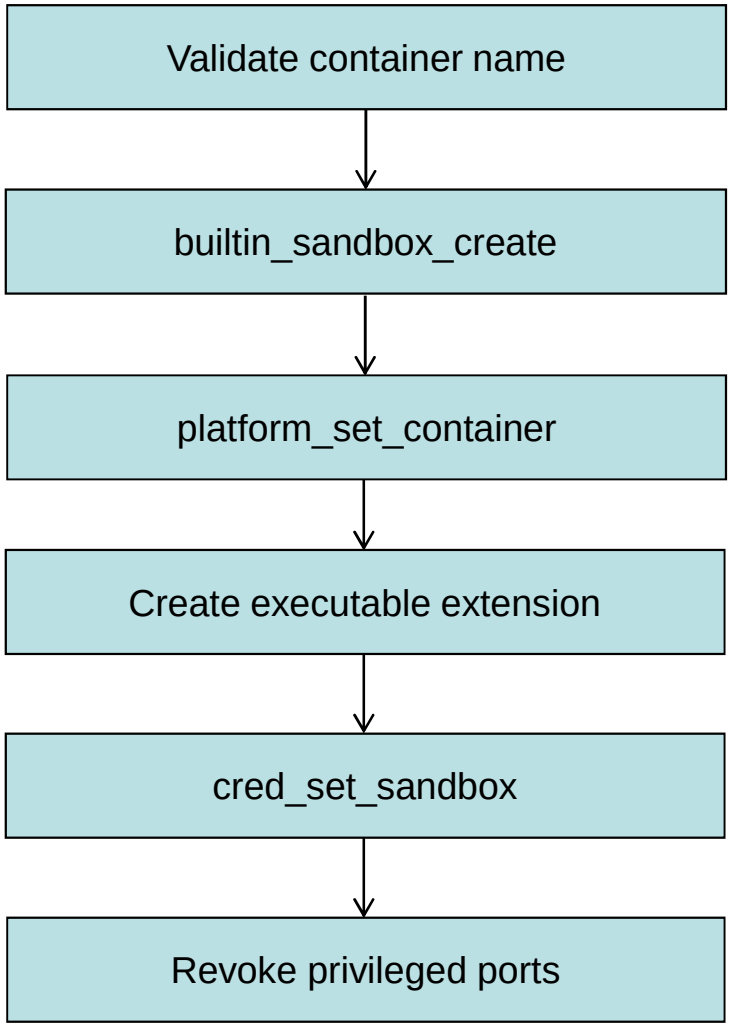
- MacOS originally had 4 “built-in” profiles
  - Weren’t so useful in the first place and largely deprecated
- iOS extends that to dozens of profiles
  - Can be found in kext
  - Can also be found in iOS’s libsandbox.1.dylib
    - AGXCompilerService ... wifiFirmwareLoader
- Built-in profiles are precompiled
  - Originally, maintained by sandboxd
  - In iOS 9+, maintained inside kext (__TEXT.__const)

```
morpheus@Zephyr (../10) %jtool  -v -dD  __TEXT.__const com.apple.security.sandbox.kext | grep  -A 4 -a A.G.X.C
Opened companion File: ./com.apple.security.sandbox.kext.ARM64.D6145CC4-1EDA-34AF-A613-A0E613FE791F
Dumping from address 0xffffff00630e620 (Segment: __TEXT.__const) to end of section
Address : 0xffffff00630e620 = Offset 0x520
0xffffff006353360: 13 00 00 00 41 47 58 43      A G X C
0xffffff006353368: 6f 6d 70 69 6c 65 72 53  o m p i l e r S
0xffffff006353370: 65 72 76 69 63 65 00 00  e r v i c e
0xffffff006353378: 0e 00 00 00 48 2f 64 65      H / d e
0xffffff006353380: 76 2f 70 74 6d 78 0f 00  v / p t m x
```

Containerizing Applications (iOS)



Containerizing Applications (iOS)



No null bytes, special cases for plugins, keyboard, etc..

Create a sandbox object, from a builtin (precompiled) profile

Create com.apple.sandbox.containe Sandbox Extension

Allow App to access and launch own executable

Attach sandbox struct to kauth credentials

Remove access to dangerous Mach Ports

Sandbox APIs

- Sandbox usermode APIs provided by two libraries:
  - /usr/lib/system/libsystem_sandbox.dylib
    - Re-exported by LibSystem.B.dylib
    - Mostly direct APIs to kext
  - /usr/lib/libsandbox.1.dylib
    - Profile compilation
    - TinyScheme implementation statically linked in
    - Plenty of Scheme strings/profile definitions in __TEXT.__const
- Containment (often) performed over mac_execve()
- KEXT APIs invoked over macf_syscall()

Sandbox APIs

- mac_syscall (#381) used extensively:
  - Allows ioctl(2) style multiplexing of syscalls provided by a kext
  - Generic mechanism, used by all policy modules
  - On kext end, hook_policy_syscall enables multiplexing
  - Different offerings in MacOS and *OS

Sandbox APIs

- Syscall implementations differ in between OSes, versions!

Op	Sandbox function	Purpose
0-1	_set_profile[_builtin]	Set a profile (=label & containment) of a process
2	**_check**	**Check if operation is allowed in confines of sandbox**
3	_note	Attaches a note (memory buffer) to sandbox (offset 0x80)
4	**_container_path_for_pid**	**Retrieve container path for a given PID**
5-7	*_extension_issue/consume/release*	*Issue, apply and remove a temporary exception*
8-9	*_extension_update_file[_with_new_type]*	*Update/twiddle extension*
10-11	_suspend/unsuspend	Suspend/resume sandbox checks for PID*
13-15	_policy_syscall related...	iOS, routed to container manager
16	**_inspect**	**Dump tons of great information on SB.**
17	**profile_dump**	**Dumps compiled profile for a PID (MacOS, AppleInternal** ☹)**
19	**_vtrace[|enable|disable|report]**	**Trace operation to a buffer. Not on iOS ☹**
21	_rootless_allows_task_for_pid	Does current policy allow task_for_pid call?

- Get a more accurate list with jtool's switch detection (ARM64)

*** - Don't get excited. Process can only do it on itself, if entitled as a sandbox-manager *and* another exception entitlement..**
**** - csr_check(0x01) – can be tweaked via direct access to NVRAM**

Sandbox APIs

- `sandbox_check` especially useful:
  - Widely used in tweaks to gauge sandbox restrictions
  - Commonly used with `SANDBOX_CHECK_NO_REPORT`
    - Performs check silently, without any user-mode output

Listing xx-sbchk: Demonstrating the `sandbox_check` function

```
int port_denied = sandbox_check (pid,
                                 "mach-lookup",
                                 SANDBOX_FILTER_RIGHT_NAME | SANDBOX_CHECK_NO_REPORT,
                                 "com.apple.......";

int read_denied = sandbox_check (pid,
                                 "file-read-data",
                                 SANDBOX_FILTER_PATH  | SANDBOX_CHECK_NO_REPORT,
                                 "path/to/file");
```

- Really useful for probing container XPC/file restrictions
  - Much more reliable than decompiling!
- Sandbox 570+ adds `sandbox_check_bulk`

Demo: sbtool

```
root@Padishah (/var/root)# ps -ef | grep MobileSafari$
  501  3427     1   0 Mon06AM ??         0:00.44 /Applications/MobileSafari.app/MobileSafari
root@Padishah (/var/root)# sbtool 3427 mach | grep No | head -5
Checking Mach services for 3427....
com.apple.Preferences.gsEvents: Nope
com.apple.mobilemail.gsEvents: Nope
com.apple.timezoneupdates.tzd.server: Nope
com.apple.streaming_zip_conduit: Nope
com.apple.pfd: Nope
root@Padishah (/var/root)# sbtool 3427 mach | grep Yep | head -5
Checking Mach services for 3427....
com.apple.voiceservices.tts: Yep
com.apple.nehelper: Yep
com.apple.coremedia.videocompositor: Yep
com.apple.coremedia.mutablecomposition: Yep
com.apple.managedconfiguration.mdmdpush-prod: Yep
```

Sandbox APIs - undocumented

- sandbox_inspect_pid super useful, but undocumented:
  - Available in *OS as of somewhere in 460 (iOS 9.something)

```
int sandbox_inspect_pid(int pid,     /* in  */
                        char **buf,  /* out */
                        int *size);  /* out */
```

  - Implemented via __sandbox_ms (..., 0x10);
  - Very valuable information on process, directly from kext

- Requires root privileges (or AppleInternal build)

Demo: sbtool

```
root@Padishah (/var/root)# sbtool 3427 inspect
MobileSafari[3427] sandboxed.
size = 439166
container = /private/var/mobile/Containers/Data/Application/607D2C61-76F7-49AF-B3FB-B6B4BE45AA47
sb_refcount = 210
profile = container
profile_refcount = 56
extensions (3: class: com.apple.sandbox.executable) {
        file: /Applications/MobileSafari.app (unresolved); flags=0
}
extensions (5: class: com.apple.sandbox.system-container) {
        file: /private/var/containers/Data/System/738391BB-914B-4AEF-88CE-D8758754CCBD (unresolved); flags=0
}
extensions (5: class: com.apple.security.exception.mach-lookup.global-name) {
        mach: com.apple.mobile.keybagd.xpc; flags=0
        mach: com.apple.parsec.subscriptionservice.internal; flags=0
        mach: com.apple.SafariCloudHistoryPushAgent; flags=0
        mach: com.apple.Safari.SafeBrowsing.Service; flags=0
}
extensions (7: class: com.apple.security.exception.files.absolute-path.read-only) {
        file: /private/var/mobile/Library/Caches/com.apple.storeservices (unresolved); flags=0
}
extensions (8: class: com.apple.sandbox.container) {
        file: /private/var/mobile/Containers/Data/Application/607D2C61-76F7-49AF-B3FB-B6B4BE45AA47 (unresolved); flags=0
}
```

Sandbox Extensions

Extensions allow exceptions to a given profile

iOS apps get the “standard extensions”:

- com.apple.sandbox.executable
- com.apple.sandbox.container
- com.apple.sandbox.application-group

Sandbox Extensions

Apple's App provide even more extensions for themselves:

Extension
com.apple.security.exception.shared-preference.read-write
com.apple.sandbox.application-group
com.apple.tcc.kTCCServiceAddressBook
com.apple.sandbox.executable
com.apple.app-sandbox.read
com.apple.security.exception.mach-lookup.global-name
com.apple.security.exception.iokit-user-client-class
com.apple.security.exception.files
com.apple.sandbox.container

Sandbox Extensions

- Before sandboxing, caller can set extensions (unless forbidden)

Table xx-isexts: Extension issuance APIs in libsystem_sandbox.dylib

#	sandbox_extension_issue_...	Provides
0	...file[_with_new_type]	Access to named files/directories
1	...mach	Access to named Mach/XPC ports
2	...iokit_user_client_class	Access named IOUserClient (IOServiceOpen())
	...iokit_registry_entry_class	Permission to iterate the IORegistry for specific class (570)
3	...generic	Extensions which don't fall into other categories
4	...posix_ipc	Access to named POSIX IPC object (UN*X sockets, etc)

- Extensions are issued by sandbox kext as “tokens”
  - Hmac_sha1 with secret value (not exposed to user space)

Take Aways

- If you're even loosely interested in OSX/iOS:
  - The sandbox is the first, possibly last line of security
  - In iOS, provides the most important obstacle to jailbreaking
  - In MacOS, containerizes AppStore Apps, and implements SIP

- http://NewOSXBook.com/articles/hitsb.html
  - Source of sandbox_exec clone
  - Sbtool – open source
  - Ongoing documentation on profile reversing
  - Fully symbolicated companion file for iOS 10 kext

Suggested Links

- http://NewOSXBook.com/ - MOXiI, 2nd Edition
  - Volume III (Security & Insecurity) available for pre-order!
- http://NewOSXBook.com/forum - Open forum for MOXiI
- http://Technologeeks.com/OSXRE - Related Training