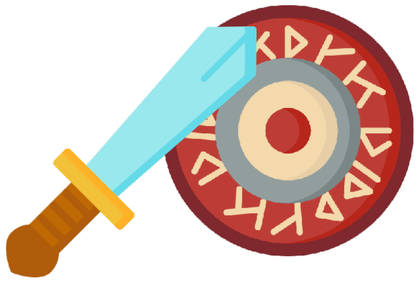
Mitigating exploits using Apple's Endpoint Security



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OFFENSIVE security

VB2021 localhost

MAC DEV OPS YVR

whoami

- author of "macOS Control Bypasses" @ Offensive Security
- ex red/blue teamer
- macOS researcher
- husband, father
- hiking 🥾 🏔️
- yoga 🧘

agenda

1. process injection attacks
2. symlink attacks
3. Endpoint Security framework
4. developing the app
5. the app's logic
6. demos

process injection attacks

why important?

- process injection is a big ⛔ on macOS
- access to process's privileges
  - TCC
  - keychain
- impersonate XPC client (XPC LPEs)
- impersonate KEXT client

DYLD_INSERT_LIBRARIES

```
DYLD_INSERT_LIBRARIES=your.dylib /path/to/your.app/Contents/MacOS/your
```

- classic
- SIP kills it (hardened runtime, platform binaries)
  - still can enable it with entitlement -> if possible don't 🙏

```
com.apple.security.cs.allow-dyld-environment-variables
```

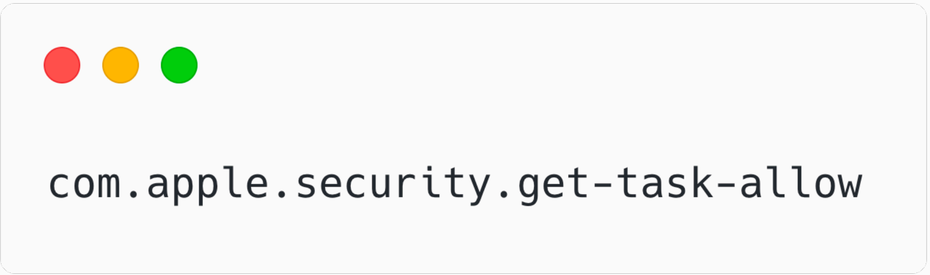
DYLIB hijacking and proxying

- discussed in detail by Patrick Wardle in 2015
- plant a dylib the app looks for, or replace one with your own
- SIP / library validation kills it
  - still can enable it with entitlement -> NOOOO!!!!

- problem: app needs to support 3rd party plugins => bypass TCC (Apple & 3rd parties)

task for pid

- inject by getting the task port
- ⚠️ debug builds with bad entitlement ⚠️
- SIP kills this
- notarization checks for `com.apple.security.get-task-allow`

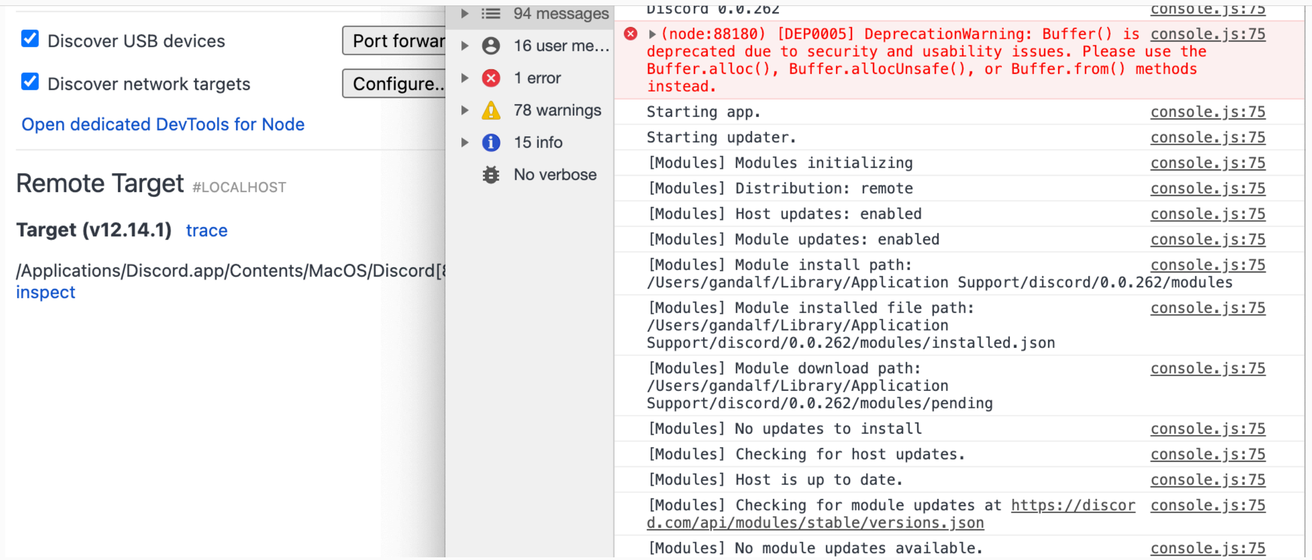


Electron

- so much broken
- env vars
- debug ports

```
csaby@mac ~ % ELECTRON_RUN_AS_NODE=1 /Applications/Discord.app/Contents/MacOS/Discord
Welcome to Node.js v12.14.1.
Type ".help" for more information.
>
```

```
csaby@mac ~ % /Applications/Discord.app/Contents/MacOS/Discord --inspect
Debugger listening on ws://127.0.0.1:9229/8967d388-33a2-4f9f-82bc-19072a7c8e76
For help, see: https://nodejs.org/en/docs/inspector
Discord 0.0.262
```



vulnerabilities

- CVE-2020-26893 - ClamXAV AntiVirus XPC LPE
- CVE-2020-29621 - coreaudiod TCC bypass
- CVE-2020-25736 - Acronis True Image 2021 XPC LPE
- CVE-2020-24259 - Signal macOS TCC bypass
- CVE-2020-14978 - F-Secure XPC
- ...

symlink attacks

the approach

- process running as root writes or modifies files at a user controllable location
- place a symlink or hardlink, pointing to a root accessible location

vulnerabilities

- CVE-2020-9900 - Crash Reporter LPE
- CVE-2021-1786 - Crash Reporter arbitrary file deletion
- CVE-2020-3855 - macOS DiagnosticMessages arbitrary file overwrite
- CVE-2020-3762 - Adobe installer LPE
- ...

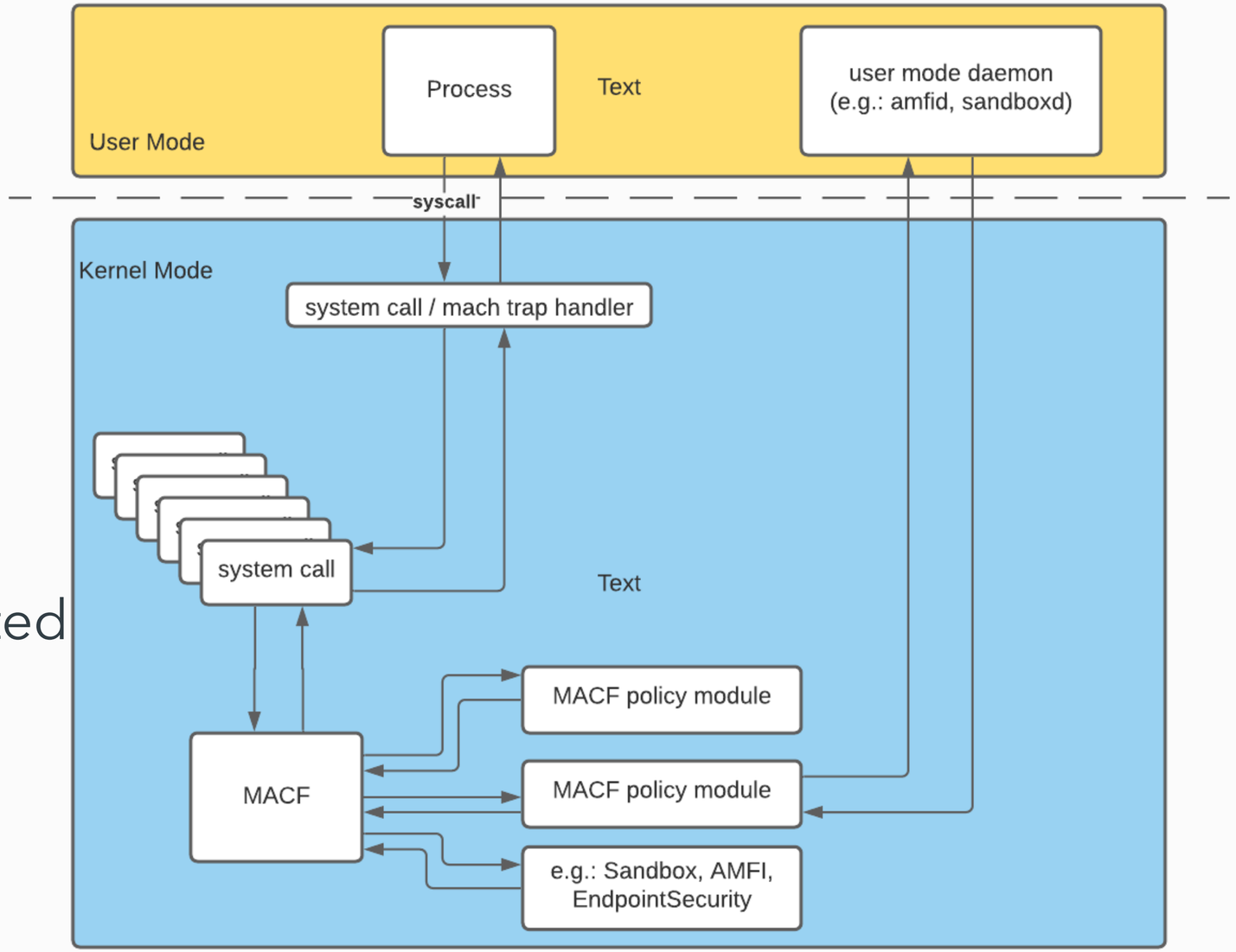
MACF

-

Mandatory Access Control Framework

MACF

- origin: TrustedBSD MAC
- implemented in kernel
- policy modules extend the kernel
- can place hooks in supported location
- very powerful



MACF

- very - very powerful
- was part of KDK till OS X 10.12 (never officially supported)
- mac.h header was removed
- available in xnu: `security/mac.h`, `security/mac_framework.h`
- examples: AppleMobileFileIntegrity, Sandbox, EndpointSecurity, Quarantine (=Gatekeeper)

MACF

- typical callout from xnu: mac_.....

```
static int
snapshot_mount(int dirfd, user_addr_t name, user_addr_t directory,
    __unused user_addr_t mnt_data, __unused uint32_t flags, vfs_context_t ctx)
{
  ...
#if CONFIG_MACF
    error = mac_mount_check_snapshot_mount(ctx, rvp, vp, &dirndp->ni_cnd, snapndp->ni_cnd.cn_nameptr,
        mp->mnt_vfsstat.f_fstypename);
    if (error) {
        goto out2;
    }
#endif
 ...
}
```

MACF

```
mac_mount_check_snapshot_mount(vfs_context_t ctx, struct vnode *rvp, struct vnode *vp, struct componentname *cnp,
    const char *name, const char *vfc_name)
{
    kauth_cred_t cred;
    int error;

#if SECURITY_MAC_CHECK_ENFORCE
    /* 21167099 - only check if we allow write */
    if (!mac_vnode_enforce) {
        return 0;
    }
#endif
    cred = vfs_context_ucred(ctx);
    if (!mac_cred_check_enforce(cred)) {
        return 0;
    }
    VFS_KERNEL_DEBUG_START1(92, vp);
    MAC_CHECK(mount_check_snapshot_mount, cred, rvp, vp, cnp, name, vfc_name);
    VFS_KERNEL_DEBUG_END1(92, vp);
    return error;
}
```

MACF

- MAC_CHECK
- iterates over all policy frameworks
- mpo_... (mac_policy.h)

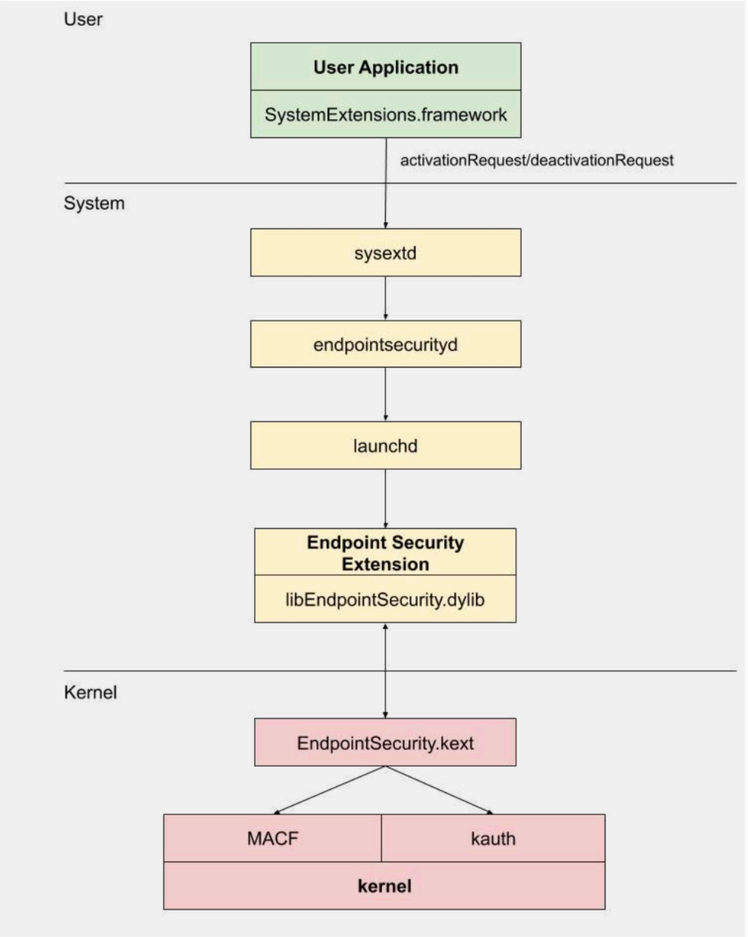
```
typedef int mpo_mount_check_snapshot_mount_t(
    kauth_cred_t cred,
    struct vnode *rvp,
    struct vnode *vp,
    struct componentname *cnp,
    const char *name,
    const char *vfc_name
    );
```

```
#define MAC_CHECK(check, args...) do {                                  \
    struct mac_policy_conf *mpc;                                        \
    u_int i;                                                            \
                                                                        \
    error = 0;                                                          \
    for (i = 0; i < mac_policy_list.staticmax; i++) {                   \
            mpc = mac_policy_list.entries[i].mpc;                       \
            if (mpc == NULL)                                            \
                    continue;                                           \
                                                                        \
            if (mpc->mpc_ops->mpo_ ## check != NULL)                    \
                    error = mac_error_select(                           \
                        mpc->mpc_ops->mpo_ ## check (args),             \
                        error);                                         \
    }                                                                   \
    if (mac_policy_list_conditional_busy() != 0) {                      \
            for (; i <= mac_policy_list.maxindex; i++) {                \
                    mpc = mac_policy_list.entries[i].mpc;               \
                    if (mpc == NULL)                                    \
                            continue;                                   \
                                                                        \
                    if (mpc->mpc_ops->mpo_ ## check != NULL)            \
                            error = mac_error_select(                   \
                                mpc->mpc_ops->mpo_ ## check (args),     \
                                error);                                 \
            }                                                           \
            mac_policy_list_unbusy();                                   \
    }                                                                   \
} while (0)
```

Endpoint Security

ES

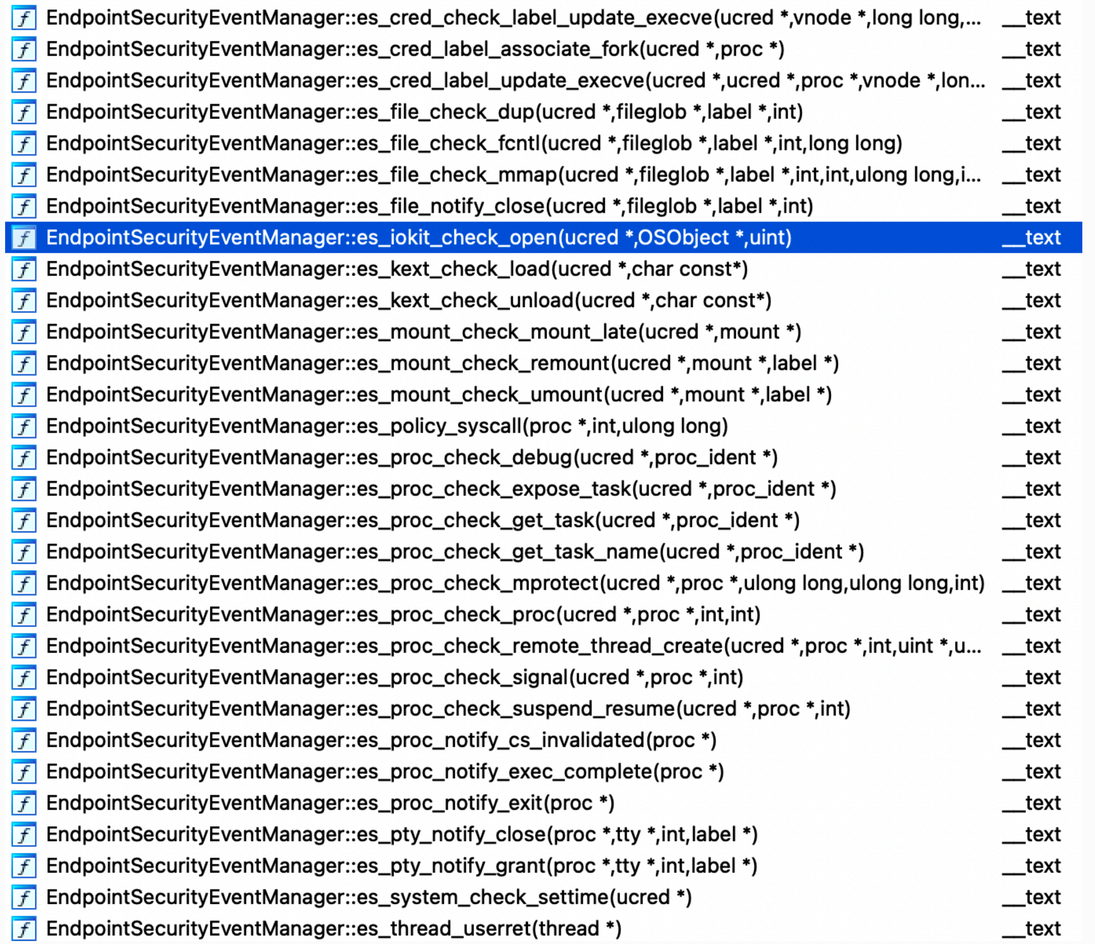
- KEXT - MACF, kauth
- dylib - C API for clients
- endpointsecurityd - loading SEXT via launchd
- sysextd - validation and copy
- SystemExtension.framework - activation and deactivation of the extension
- systemextensionsctl - basic control of sysxextd
- more: Scott Knight's OBTS talk



1: Scott Knight, https://knight.sc/reverse%20engineering/2019/10/31/macos-catalina-privilege-escalation.html

ES

- MACF policy (EndpointSecurity)
- ~60 hooks



ES

- user mode events are mapped to kernel MACF hooks
- examples:
  - ES_EVENT_TYPE_NOTIFY_CHROOT - es_vnode_check_chroot
  - ES_EVENT_TYPE_NOTIFY_MOUNT - es_mount_check_mount_late
  - ES_EVENT_TYPE_NOTIFY_MMAP - es_file_check_mmap
  - ES_EVENT_TYPE_AUTH_GET_TASK - es_proc_check_get_task

ES

- very powerful!!!
- extending MACF to user mode
- MACF was never officially supported
- now we have in user mode ❤️

Shield.app development

requirements

- entitlement: com.apple.developer.endpoint-security.client

- Apple's good will

getting entitled

- 2020 March - requested ES entitlement
- 2020 April - got developer version
- 2020 - emails going to "black hole" at Apple
- ...
- 2021 January - got the entitlement
- frustration, demotivation, annoyed, extremely bad experience - luckily I don't do this for living

sources

- used Patrick Wardle's ProcessMonitor and FileMonitor
- also reviewed Stephen Davis’s Crescendo

es_client

```
es_client_t* endpointClient = nil;

es_event_type_t events[] = {ES_EVENT_TYPE_NOTIFY_EXEC, ...};

es_new_client(&endpointClient, ^(es_client_t *client, const es_message_t *message){
              //callback
              switch (message->event_type) {

                  case ES_EVENT_TYPE_NOTIFY_EXEC:
                   //do stuff
        });

es_subscribe(endpointClient, events, sizeof(events)/sizeof(events[0]))
```

the logic

ES_EVENT_TYPE_AUTH_EXEC

- checks:
  - argument
    - --inspect, --inspect-brk, --remote-debugging-port
  - environment variables
    - DYLD_INSERT_LIBRARIES
    - CFNETWORK_LIBRARY_PATH
    - RAWCAMERA_BUNDLE_PATH
    - ELECTRON_RUN_AS_NODE

ES_EVENT_TYPE_AUTH_GET_TASK

ES_EVENT_TYPE_AUTH_MMAP

- dylib injection protection
- "enforce" library validation
- slow - disk I/O

```
//set req string, teamid = of the process
//anchor apple = apple's own binary - safe
//anchor apple generic and certificate leaf [subject.CN] = \"Apple Mac OS Application Signing\" - app store, assume
safe
//anchor apple generic and certificate leaf[subject.OU] = \"%@\" - match dev teamid

NSString *requirementString = [NSString stringWithFormat:@"(anchor apple) or (anchor apple generic and certificate
leaf [subject.CN] = \"Apple Mac OS Application Signing\") or (anchor apple generic and certificate leaf[subject.OU]
= \"%@\")", process.teamID];
```

ES_EVENT_TYPE_AUTH_LINK

```
([file_uid intValue] != file.process.uid)  && !([file_uid intValue] > 0 && file.process.uid == 0)
```

- event for hardlinks
- low privilege process isn't allowed to point to high privilege location

ES_EVENT_TYPE_NOTIFY_CREATE

```
([file_uid intValue] != file.process.uid)  && !([file_uid intValue] > 0 && file.process.uid == 0)
```

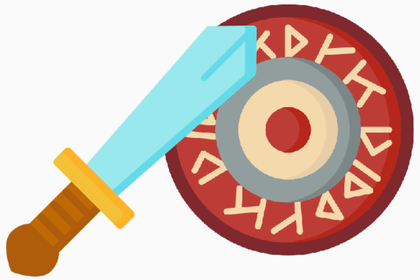
- track symbolic links
- low privilege process isn't allowed to point to high privilege location
- detect only - don't know the target before creation

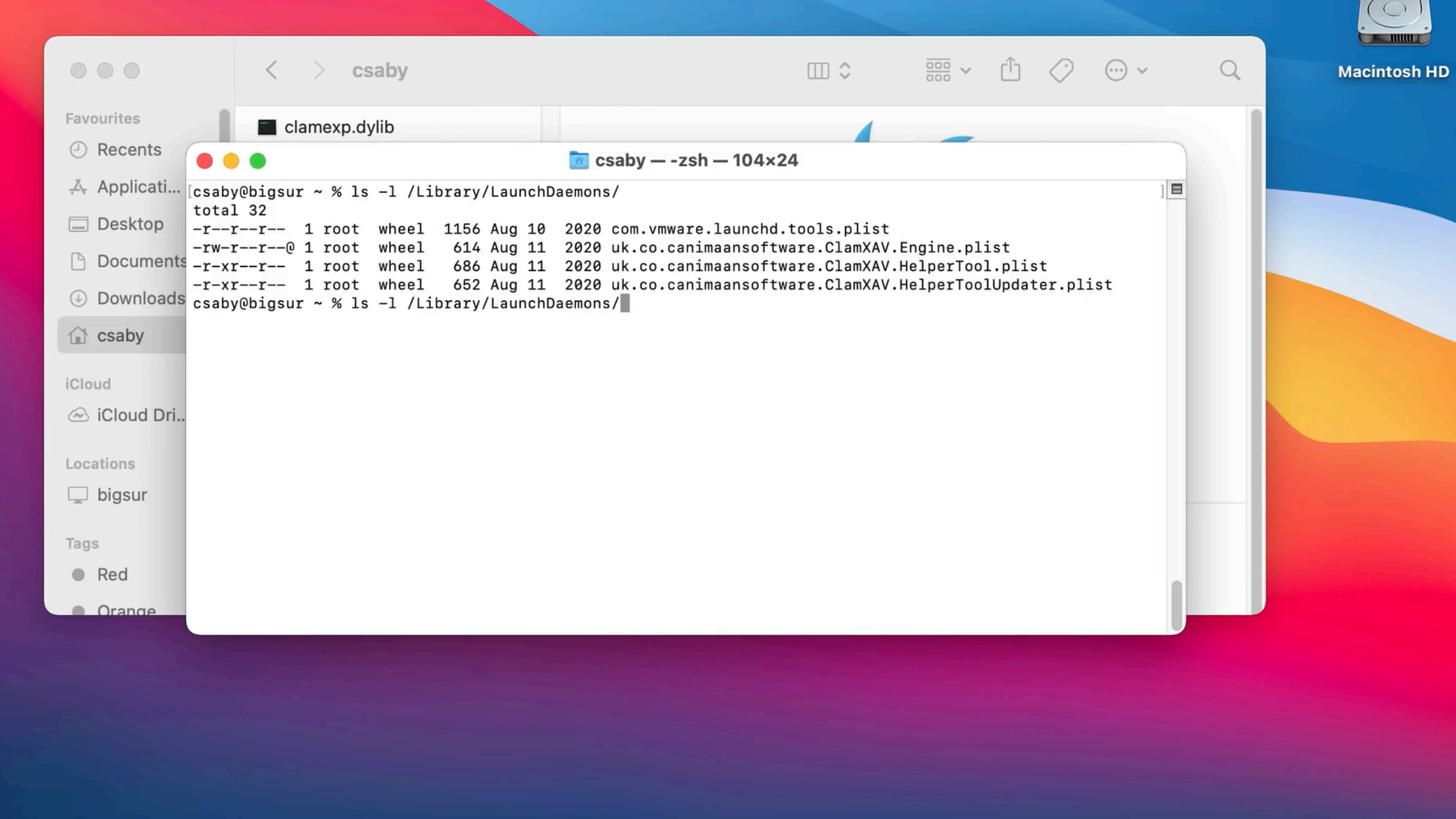
demo - w/o Shield
CVE-2020-26893 - ClamXAV AntiVirus XPC LPE

csaby — -zsh — 104×24

```
csaby@bigsur ~ % ls -l /Library/LaunchDaemons/
total 32
-r--r--r--  1 root  wheel  1156 Aug 10  2020 com.vmware.launchd.tools.plist
-rw-r--r--@ 1 root  wheel   614 Aug 11  2020 uk.co.canimaansoftware.ClamXAV.Engine.plist
-r-xr--r--  1 root  wheel   686 Aug 11  2020 uk.co.canimaansoftware.ClamXAV.HelperTool.plist
-r-xr--r--  1 root  wheel   652 Aug 11  2020 uk.co.canimaansoftware.ClamXAV.HelperToolUpdater.plist
csaby@bigsur ~ %
```

demo - w/ Shield
CVE-2020-26893 - ClamXAV AntiVirus XPC LPE




Macintosh HD
csaby
clamexp.dylib
Favourites
Recents
Applicati...
Desktop
Documents
Downloads
csaby
iCloud
iCloud Dri...
Locations
bigsur
Tags
Red
Orange
csaby — -zsh — 104×24
csaby@bigsur ~ % ls -l /Library/LaunchDaemons/
total 32
-r--r--r-- 1 root wheel 1156 Aug 10 2020 com.vmware.launchd.tools.plist
-rw-r--r--@ 1 root wheel   614 Aug 11 2020 uk.co.canimaansoftware.ClamXAV.Engine.plist
-r-xr--r-- 1 root wheel   686 Aug 11 2020 uk.co.canimaansoftware.ClamXAV.HelperTool.plist
-r-xr--r-- 1 root wheel   652 Aug 11 2020 uk.co.canimaansoftware.ClamXAV.HelperToolUpdater.plist
csaby@bigsur ~ % ls -l /Library/LaunchDaemons/

wrap up

- injection and file link attacks responsible for many logic bugs
- ES framework is based on MACF
- ES extends MACF to user mode, very powerful
- can be used to detect and block logic attacks
- it's a pain to get the ES entitlement

OFFENSIVE security

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Twitter: @theevilbit

Further resources

- Wojciech Reguła (@_r3ggi): Abusing and Securing XPC in macOS Apps Objective by the Sea v3
- Julia Vashchenko (@iaronskaya): Job(s) Bless Us! Privileged Operations on macOS Objective by the Sea v3
- Tyler Bohan (@1blankwall1): OSX XPC Revisited - 3rd Party Application Flaws OffensiveCon 19
- Ian Beer (@i41nbeer): A deep-dive into the many flavors of IPC available on OS X Jailbreak Security Summit 2015

Links

- http://www.trustedbsd.org/mac.html
- https://blog.xpnsec.com/macos-injection-via-third-party-frameworks/
- https://www.offensive-security.com/offsec/amfi-syscall/
- https://www.semanticscholar.org/paper/New-approaches-to-operating-system-security-Watson/f89682c6cf943ce349031270e685ee2dddee9376
- https://knight.sc/reverse%20engineering/2019/08/24/system-extension-internals.html
- http://newosxbook.com/articles/eps.html
- https://github.com/xorrior/goesf/blob/master/appmon.m
- https://github.com/theevilbit/Shield

Icons

- flaticon.com
  - xnimrodx
  - Freepik