

INDEX

A

Activity Monitor utility, 8, 30–31, 33–34, 46
`addObserver:selector:name:object:` method, 286–287
advanced persistent threats (APTs), 13–14, 104–105.
See also persistence
AF sockets, 105
Alchemist attack framework, 103
AMFI. *See* Apple Mobile File Integrity
analyzing malware safely, xxvii–xxviii
anchor apple generic requirement, 94
anchor apple requirement, 94, 96–97
app IDs, registering, 254–255
Apple File System (APFS), xxviii
Apple Mobile File Integrity (AMFI), 181, 254
 disabling, xxvii, 160, 181
 entitlements and, xxvii
Application Services APIs, 17–19
APTs (advanced persistent threats), 13–14, 104–105.
See also persistence
ARC (automatic reference counting), 18, 211
arguments, process, 9–13, 197–199
ARM binaries, 32
Art of Mac Malware, The, Volume 1 (Wardle), xxv
audio monitoring
 Oversight tool, 282–285
 Shazam widget, 313–315
audit tokens, 5–6
 Endpoint Security process
 monitor, 192
 mute inversion via, 210
 obtaining code object references
 via, 95–96
XPC and, 266–268

authorization events, Endpoint Security, 213–222
blocking Background Task Management bypasses, 219–222
 checking binary origins, 217–219
 meeting message deadlines, 215–217
 origin of, 183
 subscribing to, 213–215
automatic reference counting (ARC), 18, 211
 bridging, 80
AutoRuns tool, 233
`AVFoundationAudioObjectAddProperty ListenerBlock` API, 282
AVFoundation framework, 58
 adding a property listener, 283–284
device enumeration, 281
extracting property values, 285
property listener block, 282
removing a property listener, 294

B

Background Task Management (BTM), 2, 123–136
accessing metadata, 134–135
BlockBlock tool and, 261–265
blocking bypasses, 219–222
deserialization, 130–134
DumpBTM project, 130–137
event monitoring logic, 263
finding database path, 130–131
identifying malware, 135–136
`initWithCoder:` methods, 132–134
interaction with database, 124–127
`ItemRecord` class, 131–133
`itemsByUserIdentifier` dictionary, 131
KnockKnock tool and, 241–242

- Background Task Management
 (continued)
 serialization, 126–127
 sfltool utility, 127–130
 behavior-based heuristics.
 See also heuristic-based detection approach
 defined, xxii
 false positives, 75
 binaries. *See also* Mach-O binaries
 encrypted, 70–71
 packed binaries, 62–70
 universal binaries, 39–50
Black Mirror (TV show), 279
BlockBlock tool, 253–276
 alerts, 257
 Background Task Management, 261–265
 DazzleSpy and, 319
 Endpoint Security and, 181
 entitlements, 254–256
 launch daemon, 257–258
 login item, 257
 message deadlines and, 216
 notarization mode, 213
 plug-ins, 258–261
 3CX supply chain attack, 324–325
 XPC, 265–276
 blocking DNS traffic, 307–310
 closing local flow, 309
 closing remote flow, 309
 extracting answers from A record, 308–309
 name error, 309
 NXDOMAIN response, 309–310
 response packets, 308
 saving DNS questions and answers to cache, 305
 bridging, 80
 browser extensions, 242–245
 BTM. *See* Background Task Management
- C**
- CalendarFree.app*, 10–13
callback logic, 114–115
camera monitoring, 285–286.
 See also Oversight tool
webcam, 142, 279–280
- case studies, 313–326
DazzleSpy malware, 315–319
Shazam, 313–315
3CX supply chain attack, 319–326
certificate authority chain, 80
CFBundleCopyExecutableArchitectures
 ForURL API, 250
chained supply chain attack, 320
checkSignature project, 76, 79, 84, 88, 94–95
Chropex (*ChromeLoader*), 9
clients
 Endpoint Security, 185, 199–200
 XPC, 269–271
CloudMensis malware, 40–41, 44–49, 52, 54, 56
code signing, 75–76
 ad hoc signatures, 81–82
 Apple requirements for, xxvi–xxvii
 defined, 24
 disk images and, 78–84
 Endpoint Security process monitor, 195–197
 error codes, 97
 false positives and, 75, 96–97
 importance of in malware detection, 76–78
 notarization, 77, 82–84
 on-disk Mach-O binaries and, 93–95
 in packages, 84–93
 revocations, 77
 running processes and, 95–96
 XPC and, 268–271
codesign utility, 78–79, 85, 93, 129, 256
CoinMiner malware, 8, 33
CoinTicker malware, 317
Coldroot malware, 28–29, 63
com.apple.developer.endpoint-security.client entitlement, xxvii, 180
com.apple.quarantine extended attribute, 316–317
Contents/Library/SystemExtensions/ directory, 299, 303
CoreMediaIO framework, 285–286
 adding a property listener, 285
core media I/O subsystem, 142, 151–152, 289–291
CPU utilization, processes, 35–36

- computing CPU percentage in use, 35–36
- flavor** argument, 35
- streaming log messages, 151
- CreativeUpdate malware, 79, 84
- Crisis malware, 142, 280, 314
- CrowdStrike, 9, 320
- CSCommon.h* file, 97
- ## D
- DA*** APIs, 56–57
- data collection, 1–2. *See also* code
- signing; network state and statistics; parsing binaries; processes
 - persistence, 119–137
 - Background Task Management, 123–136
 - DazzleSpy malware, 121–123
 - DumpBTM* project, 130–137
 - LaunchAgents* directories, 121–123
 - WindTail malware, 120–121
- DazzleSpy malware, 7, 23, 33, 127, 220
- code signing, 324
 - exploit detection, 315–317
 - extracting symbols, 59–60, 62
 - network access, 319
 - persistence and, 121–123, 317–319
- default mute set, 210
- delegates and delegate methods
- DNSMonitor, 301
 - network monitoring, 168, 172
 - system extensions, 161, 163
 - XPC, 266
- dependencies, binary
- analyzing, 56–59
 - finding dependency paths, 54–56
 - packer detection and, 63
- deserialization, 130–134
- detection heuristics. *See* heuristic-based detection approach
- device connections and disconnections, 286–288
- disabling
- Apple Mobile File Integrity, xxvii, 160, 181
 - System Integrity Protection, xxvii, 160, 181
- DiskArbitration* framework, 54, 56
- disk images
- ad hoc signatures, 80
 - certificate authority chain, 81
 - code object references, 80–81
 - code signing and, 78–84
 - extracting code signing information, 79–82
 - manually verifying signatures, 78–79
 - notarization status, 82–84
 - static code reference, 80
 - verbose output, 79
- dispatch_semaphore_wait** API, 216
- DNS cache dumping, 304–307
- DNSMonitor, 297–311
- blocking DNS traffic, 307–310
 - classifying endpoints, 310
 - DNS cache dumping, 304–307
 - domain name registrar, 310
 - historical DNS records, 310
 - interprocess communication, 303–304
 - network extensions, 298–303
 - printing DNS packet to universal log, 303–304
 - provisioning profiles, 298–299
- DNS monitoring, 157–169
- activating system extensions, 160–161
 - identifying responsible processes, 168–169
 - NetworkExtension* framework, 159–160
 - parsing DNS requests, 164–165
 - parsing DNS responses, 165–168
 - writing system extensions, 162–169
- DNSProxyProvider class, 303
- Dock, 19, 301
- Documents* directory
- monitoring file-open events in, 211–212
 - WindTail malware and, 227
- domain name registrar, 310
- Dummy malware, 102–103, 111, 117, 159, 169
- DumpBTM* project, 130–137
- accessing metadata, 134–135
 - deserializing files, 131–134

- DumpBTM* project (*continued*)
 - finding database path, 130–131
 - identifying malicious items, 135–136
 - KnockKnock tool and, 241
 - using *DumpBTM* in your own code, 136–137
- dyld* cache, 86–87, 145
- dyld-shared-cache-extractor* tool, 87
- dylib hijacking, 217, 249
- dylib insertions, 246–248
- dylib proxying, 249–252
- E**
- Eleanor malware, 280
- Electron* framework, 249
- ElectroRAT, 8
- encrypted binaries, 70–71
- endianness, 41, 43, 50–51
- endpoints, DNSMonitor, 310
- Endpoint Security, 179–203
 - authorization events, 213–222
 - clients, 185
 - detecting removal of quarantine attribute, 316
 - entitlements, 254–256
 - events, 182–184
 - authorization events, 183, 213–222
 - event handling, 185–190
 - mute inversion, 209–212
 - muting, 206–212
 - printing out file-open Endpoint Security event, 212
 - proof-of-concept file protector, 223–228
 - file monitoring, 200–203
 - handler blocks, 185
 - header files, 182–183
 - mute inversion, 209–212
 - muting events, 206–212
 - prerequisites, 191
 - process monitor, 190–200
 - proof-of-concept file protector, 223–228
 - workflow, 180–190
- EndpointSecurity.h* header file, 182
- entitlements
 - applying for, 254
 - BlockBlock tool and, 254–256
 - com.apple.developer.endpoint-security.client*, xxvii, 180
 - enabling in Xcode, 255–256
 - provisioning profiles, 255
 - registering App ID, 254–255
- entropy
 - encrypted binaries, 70
 - packed binaries, 67–70
- enumerateProcesses* project, 4
 - See also* processes
- environment information, processes, 19–24
 - converting process information into string object, 22–23
 - creating shared memory object, 20
 - declaring required variables, 20
 - extracting global data, 21
 - extracting size of response data, 22
 - resolving function pointer, 21
 - tracing process ID back to launch item property list, 23–24
- e_ppid* member, process hierarchies, 14–15
- error codes, code signing, 97
- ESClient.h* header file, 182
- ES_EVENT_TYPE_AUTH_DELETEEXTATTR* event, 219
- ES_EVENT_TYPE_AUTH_** events, 201–202
- ES_EVENT_TYPE_NOTIFY_BTM_LAUNCH_ITEM_ADD* event, 261–262
- ES_EVENT_TYPE_NOTIFY_BTM_LAUNCH_ITEM_REMOVE* event, 261
- ES_EVENT_TYPE_NOTIFY_CLOSE* event, 202
- ES_EVENT_TYPE_NOTIFY_CREATE* event, 201
- ES_EVENT_TYPE_NOTIFY_EXEC* event, 184–186, 193–194, 197–198, 221
- ES_EVENT_TYPE_NOTIFY_RENAME* event, 202
- ES_EVENT_TYPE_NOTIFY_UNLINK* event, 202
- es_invert_muting* API, 210
- eslogger* utility, 183–184, 186
- ESMessage.h* header file, 182, 185, 201
- es_message_t* structure, 185–186, 201, 216
- es-muted-paths-events* API, 210

`es_mute_process` API, 208
`es_mute_process_events` API, 208
ESPlayground project, 180–182, 190, 205, 207, 211–213, 215, 223, 227
ESTypes.h header file, 182, 206, 210, 215
EvilQuest malware, 79, 84–85, 93
executable packers, xxii, 62–67
execution architecture, processes, 32–34
execution state, processes, 32
exfiltration of data, 157, 326
exit status, Endpoint Security process monitor, 199
exploit detection, 315–317

F

false positives, code signing, 75, 96–97
fat binaries. *See* universal binaries
file monitoring
 Endpoint Security, 200–203
 3CX supply chain attack, 320–322
file protector, Endpoint Security, 223–228
 allowing all file accesses, 224–225
 denying all file accesses, 225
 extracting process paths and filepaths, 225–226
 granting file access for platform and notarized processes, 226–227

file utility, 40
filter data providers, 159, 170–176
 enabling, 170–171
 querying the flow, 173–174
 running monitor, 174–176
 writing extension for, 171–172
Finder, 19, 212, 301
Flashback malware, 246, 248
FruitFly malware, xxii, 142, 279–280, 314
fully qualified domain name (FQDN), 164

G

Genieo malware, 11
`getaddrinfo` API, 110
`GetProcessForPID` API, 17–19

H

HackingTeam installer, 70–71
handler blocks, Endpoint Security, 185
header files, Endpoint Security, 182–183
heuristic-based detection approach.
 See also code signing; Objective-See tools
 code signing and, 76
 CPU utilization, 35–36
 detecting obfuscation, 62
 downsides of, xxii
 false positives, xxii, 75, 96–97
 file monitoring, 200
 hidden directories and, 6–7
 network monitoring, 174
 protecting files in user’s home directory, 225
hierarchies, process, 13–19
Endpoint Security process monitor, 193
parent, 14–17
retrieving information with Application Services APIs, 17–19
historical DNS records, 310
Hopper, 87, 145
host-based data collection, 102
How to Reverse Malware on macOS Without Getting Infected (Stokes), xxviii

I

Info.plist file
 browser extensions, 245–246
 checking binary origins, 218
 DNSMonitor, 299–300, 303
 dynamic library insertion, 248
 writing system extensions, 171
integrated development environment (IDE), xxvi
Intel binaries, 32
Internet Protocol (IP) sockets, 107, 109–110
interprocess communication (IPC)
 AF sockets, 105
 DNSMonitor, 303–304
 XPC, 265

Invisible Internet Project (I2P), 8
IPStorm malware, 63, 66, 69, 142
iWebUpdate binary, 11, 158, 167–168

J

JSON

building JSON-ified string, 240
converting object properties to,
238–240
output from KnockKnock, 247

K

KeRanger malware, 7
KERN_PROCARGS2 value, 11–12
KeySteal malware, 86, 93
kill system API, 32
kinfo_proc structure, process
hierarchies, 14–15
KnockKnock tool, 233–252
Background Task Management,
241–242
browser extensions, 242–245
building list of loaded libraries
with, 249
command line options, 235
DazzleSpy and, 319
determining whether item is a
binary, 250
dylib hijacking, 249
dylib insertions, 246–248
dylib proxying, 249–252
enumerating dependencies of
running processes, 251
ItemBase class, 238
persistent item types, 238–240
plug-ins, 235–237, 240–252
positive detections/antivirus
engines, 240
system_profiler approach, 247
user interface, 234–235
kNStatSrcKeyRxBytes key, 117
kNStatSrcKeyTxBytes key, 117
kp_eproc structure, process hierarchies,
14–15
kSecCodeInfoCertificates key,
81–82
kSecCodeInfoFlags key, 82

L

LaunchAgents directories, 121–123
launchctl utility, 19–20
launch daemon, 121, 257–258.
See also persistence
Launch Services APIs, 243, 246
Lazarus APT group, 13–14
LC_SYMTAB load command, 60
leaf signature, 90
libproc APIs, 4
/Library/SystemExtensions/<UUID>/
library, 303
listeners, XPC, 265–266
load commands, Mach-O binaries, 53
loaded libraries
building list of with
KnockKnock, 249
enumerating, 24–28
LoggingSupport framework, 145–146,
148, 152, 289
log monitoring, 141–152
extracting log object properties,
148–151
remote logins, 142
resource consumption, 151–152
streaming log data, 146–148
TCC mechanism, 142–143
unified logging system, 143–146
webcam access, 142
lsof tool, 30–31
LSSharedFileListCreate API, 120
LSSharedFileListInsertItemURL
API, 120
LuLu software, 78–79, 84, 170, 307,
319, 326

M

Macho* APIs, 47–50
Mach-O binaries
code signing and, 93–95
extracting dependencies, 54–59
extracting symbols, 59–62
load commands, 53
Mach-O headers, 50–52
slices, 40, 43, 47–50
universal binaries, 39–50
mach_timebase_info API, 216

- MacStealer malware, 209–210, 212, 225
malicious networking activity, 102–105
Malware Removal Tool (MRT), 76–77
management information base (MIB)
 array, 11
metadata, accessing, 134–135
microphone, 282–285. *See also* audio monitoring
Microsoft AutoRuns tool, 233
Mokes malware, 57–58, 142, 280, 314
MRT (Malware Removal Tool), 76–77
mute inversion, Endpoint Security,
 209–212
 audit tokens and, 210
 default mute set and, 210
 monitoring directory access,
 211–212
muting events, Endpoint Security,
 206–212
- N**
- name error, DNS traffic, 309
names, process, 8–9
NEDNSProxyManager object, 161–162
NEFilterFlow objects, 172–174
NEFilterManager object, 170–171
NEFilterSocketFlow objects, 174
NENetworkRule object, 172
netbottom command line tool, 112
Netiquette tool, 104
nettop utility, 112, 156
network access, DazzleSpy, 319
network-centric data collection, 102
network extension, DNSMonitor,
 302–303
NetworkExtension framework, xxiii,
 111–117, 159–160,
 297–301
 activation, 159–160
 DNS monitoring, 157–169
 filter data providers, 169–175
 identifying responsible process,
 168–169
 methods, 163
 prerequisites, 159, 298
network monitoring, 155–176
 DNS monitoring, 157–169
 filter data providers, 169–175
snapshots, 156–157
3CX supply chain attack, 322–323
network sockets, 106–111
network state and statistics, 101–118.
 See also NetworkStatistics
framework
capturing, 105–111
extracting network sockets,
 106–107
host-based vs. network-centric
 collection, 102
malicious networking activity,
 102–105
retrieving process file
 descriptors, 106
socket details, 107–111
NetworkStatistics framework, 111–112
callback logic, 114–115
creating network statistic
 managers, 113–114
kNStatSrcKeyRxBytes key, 117
kNStatSrcKeyTxBytes key, 117
linking to, 113
queries, 115
notarization
 detecting, 77
 disk images, 82–84
 packages, 91–92
notification events, 183–184, 200–203
 device added, 286–287
 device removed, 286–287
NSRunningApplication object, 8–9
NSTask API, 26
NStatManagerCreate API, 113
NStatManagerQueryAllSources
 Descriptions API, 156–157
NSUserDefaults class, 292
NSXPCConnection class, 267
NSXPCLListenerDelegate protocol,
 265–266
NukeSped malware, 7
NX* APIs, 42–47
NXDOMAIN response, DNS traffic, 309–310
- O**
- Objective-C language, xxvi, 59
 extracting log object properties,
 148–151

- Objective-C language (*continued*)
 performSelector: method, 134
 private classes, 89
- Objective-See tools, xxiv, 231–232
 BlockBlock tool, 253–276
 DNSMonitor, 297–311
 KnockKnock tool, 233–252
 LuLu software, 78–79, 84, 170, 307, 319, 326
 Oversight tool, 280–295
 TaskExplorer, 25
- OceanLotus malware, 317
- open files, 28–31
 lsof tool, 30–31
 proc_pidinfo API, 29–30
- oRAT malware, 33, 63, 104–105
- os_log_create** API, 303
- OSLogEventProxy** object properties, 150–151
- OSSystemExtensionRequest** class, 161
- OSSystemExtensionRequestDelegate** protocol, 161
- otool** command
 confirming code accuracy, 45
 detecting encrypted binaries, 70
 enumerating network
 connections, 112
 finding dependency paths, 56
 Mach-O headers and, 52
 reverse engineering log APIs, 145
- OverSight tool, 280–295
 Block option, 280
 camera monitoring, 285–286
 device connections and
 disconnections, 286–288
 disabling, 293–294
 executing user actions, 292–293
 extracting property values, 285
 filtering **cmlc** and **coremedia**
 messages, 290
 LogMonitor class, 289–290
 mic monitoring, 282–284
 parsing messages to detect
 responsible process, 291
 predicate evaluation, 151–152
 property listener, 281–286
 responsible process identification, 288–291
- sample utility, 288
- scripts and, 291–293
- stopping, 293
- P**
- PackageKit* framework, 86–89
- packages
 accessing framework functions, 88–89
 code signing and, 84–93
 notarization status, 91–92
 reverse engineering **pkgutil** utility, 86–88
 validating, 90–91
- packed binaries, 62–70
 calculating entropy, 67–70
 dependencies, 63
 section and segment names, 63–67
 symbols, 63
- packers (executable packers), xxii, 62–67
- Palomino Labs, 105
- Parallels, xxviii
- parent hierarchy, 14–17
- ParentPSN** key, 19
- parsing binaries
 extracting dependencies, 54–59
 extracting symbols, 59–62
 load commands, 53
 Mach-O binaries, 50
 packed binaries, 62–70
 universal binaries, 39–50
- paths, process, 6–8
 of deleted binaries, 7–8
 identifying hidden files and
 directories, 6–7
- persistence, 119–137
 Background Task Management, 123–136
- BlockBlock, 258–264
- DazzleSpy malware, 121–123, 317–319
- DumpBTM* project, 130–137
- KnockKnock, 240–251
- LSSharedFileListCreate** API, 120
- LSSharedFileListInsertItemURL** API, 120
- ProgramArguments** key, 122

- RunAtLoad key, 122–123
WindTail malware, 120–121
- persistence enumerator.
See KnockKnock tool
- persistence monitor. *See* BlockBlock tool
- persistent item types, KnockKnock tool, 238–240
- pkgutil utility, 78
package notarization, 91
reverse engineering, 86–89
verifying signature, 84–86
- plug-ins
BlockBlock tool, 258–261
KnockKnock tool, 235–237
base scan method, 236
initializing by name, 237
methods of base class
 plug-in, 236
properties of base class
 plug-in, 236
updating global list of persistent items, 237
- positive detections/antivirus engines, 240
- processes, 3–38
 arguments, 9–13
 audit tokens, 5–6
 code signing and, 24, 95–96
 CPU utilization, 35–36
 enumerating, 4–5
 environment information, 19–24
 execution architecture, 32–34
 execution state, 32
 loaded libraries, 24–28
 open files, 28–31
 paths, 6–8
 process hierarchies, 13–19
 start time, 34–35
 validating names, 8–9
- process file descriptors, retrieving, 106
- `ProcessInformationCopyDictionary` API, 18–19
- process monitor, Endpoint Security, 190–200
 arguments, 197–199
 audit tokens, 192
 binary architecture, 194–195
- code signing, 195–197
exit status, 199
extracting process information, 192
- extracting process objects, 191–192
- hierarchies, 193
- process paths, 192–193
script paths, 193–194
stopping the client, 199–200
subscribing to events, 191
- process monitoring, 3CX supply chain attack, 323–325
- process serial numbers, 17–19
- `procinfo` command line option, 19–20
- `proc_listallpids` API, 4–5
- `proc_pid*` APIs, 102, 105–107, 111
- `proc_pidinfo` API, 29–30
- `PROC_PIDPATHINFO_MAXSIZE` constant, 6
- `proc_pid_rusage` API, 35
- `ProgramArguments` key, 122
- property listeners, 281–286
 audio monitoring, 282–285
 camera monitoring, 285–286
- provisioning profiles
 BlockBlock tool, 255–256
 DNSMonitor, 298–299
 NetworkExtension framework, 160
- `psi` structure, 108
- Q**
- `qtn_file_*` APIs, 218
- R**
- ransomware, 7, 120, 139, 200
redacted WHOIS data, 310
remote access tools (RATs)
 CoinMiner, 8
 ColdRoot, 28–29, 63
 ElectroRAT, 8
- remote connections, enabling, 271–272
- `remoteEndpoint` instance variable, 173–174
- remote logins, 142
- remote methods, XPC, 275–276
- `request:actionForReplacingExtension:`
 `withExtension: delegate`
 method, 161

`request:didFailWithError:` delegate method, 161

`request:didFinishWithResult:` delegate method, 161

`requestNeedsUserApproval:` delegate method, 161

resources, xxix

`respondsToSelector:` method, 89

response packets, DNS traffic, 308

`responsibility_get_pid_responsible_for_pid` API, 16–17

responsible process identification, 16–19, 168–169, 174, 188–189, 193, 226, 288–291

reverse engineering

- Activity Monitor utility, 30
- log APIs, 145–146
- `pkgutil` utility, 86–89

revocations, 77

rShell malware, 33

RunAtLoad key, 122–123

S

Safari browser extensions, 243–245

- enumerating, 243
- parsing output containing, 245
- `URLsForApplicationsToOpenURL:` method, 243

sample utility, 288

`SCDynamicStoreCopyConsoleUser` API, 211

scripts, 193–194, 291–293

`SecAssessmentCreate` API, 83, 94

`SecAssessmentTicketLookup` API, 83, 91–92

`SecCodeCopyGuestWithAttributes` API, 95

`SecCodeCopyPath` API, 96

`SecCodeCopySigningInformation` API, 81

`SecRequirementCreateWithString` API, 82

`SecStaticCodeCheckValidity` API, 81–83, 93–94, 97

`SecStaticCodeCreateWithPath` API, 80

section and segment names, packed binaries, 63–67

`SecTranslocateIsTranslocatedURL` API, 217–218

self-deleting malware, 325

serialization, 126–127

`sfltool` utility, 127–130

Shazam, 313–315

Shlayer malware, 9, 213, 242

`SIGUSR1` signal, DNS traffic, 305–306

SIP. *See* System Integrity Protection

slices, Mach-O binaries, 40, 43, 47–50

snapshots, xxviii, 101, 112, 115, 139, 155–157

`soi_proto` structure, sockets, 108

Spotlight service, 206–207, 246

`startSystemExtensionMode` method, 162–163

start time, processes, 34–35

`swap_*` APIs, 43–44

Swift language, xxvi

symbols, binary

- extracting, 59–62
- packed binaries, 63

`sysctl` API, 11, 15, 34

`sysctlbyname` API, 4

`sysctlnametomib` API, 34

system extensions. *See also*

- NetworkStatistics*
- framework
- activating, 160–161
- entitlements, 298–300
- identifying responsible processes, 168–169
- prerequisites for, 160
- writing, 162–169

System Integrity Protection (SIP), 254

- disabling, xxvii, 160, 181
- entitlements and, xxvii
- re-enabling in Recovery Mode, xxviii

system monitoring. *See* Endpoint Security; log monitoring; network monitoring

System Preferences application, 123–124

`system_profiler`, 247

T

TAOMM repository, xxv

TaskExplorer tool, 25

TCC (Transparency, Consent, and Control) mechanism, 142–143, 223, 292

TCP protocol

- querying for statistics about
 - network events, 115
 - sockets, 105, 108

3CX supply chain attack, 310, 319–326

- BlockBlock tool, 324–325
- code signing, 323–324
- DNS monitoring and, 158–159
- exfiltration, 326
- file monitoring, 320–322
- network monitoring, 322–323
- process monitoring, 323–325
- self-deletion, 325

translocation, 217–218

Transport Layer Security (TLS)

- package, 105

U

UDP protocol

- DNS traffic, 163
- querying for statistics about
 - network events, 115
 - sockets, 105, 108

universal binaries, 39–50

- `fat_arch` structures, 41–47
- `FAT_CIGAM` value, 41, 43–44
- `fat_header` structure, 40–41, 43–47
- inspecting, 40–42
- Macho* APIs, 47–50
- NX* APIs, 42–47
- parsing, 42
- `swap_*` APIs, 43–44

universal logging subsystem, 143–146

- DNSMonitor, 303–304
- manually interfacing with, 144–145
- Oversight tool and, 288–289
- reverse engineering log APIs, 145–146

`URLsForApplicationsToOpenURL:`

- method, 243

V

`verifyReturningError:` method, 90

virtual machines

- analyzing malware safely, xxvii–xxviii
- disabling SIM and AMFI, 160

VirusTotal, 168, 234, 239–240, 242, 319

`vmmmap` tool, 24–26

VMware, xxviii

W

webcam access, 142.

See also Oversight tool

WindTail malware, 95, 120–121, 227, 242

Wireshark, 127, 135, 158

workflow, Endpoint Security, 180–190

- clients, 185
- event handling, 185–190
- events of interest, 182–184
- handler blocks, 185

X

Xcode, xxvi, 255–256

XCSSET malware, 142, 223, 317

XPC, 265–275

- authorizing clients, 269–271
- client requirements, 270–271
- delegates, 266
- extracting audit tokens, 266–268
- initiating connections, 274
- listeners, 265–266
- methods, 272–274
- protocols, 271–273
- remote connections, 271–272
- remote methods, 275–276
- verifying clients, 268–271

XProtect, 150, 183, 280

Y

Yort malware, 13–14

Z

zombie processes, 32

ZuRu malware, 24–28, 58–59, 63