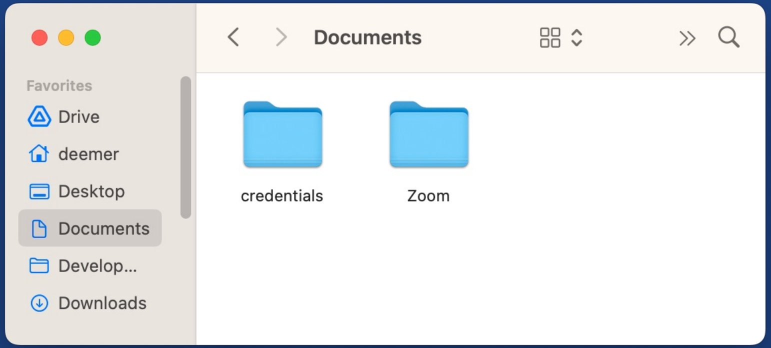
Operating Systems Security III

CS 1660: Introduction to Computer Systems Security



=> How many of these can read your browser history?

…. all of them?!?!

```
deemer@ceres:~$ ls –la cookies.sqlite
rwxr-x--- 1 deemer deemer 9 Mar 12 16:40 cookies.sqlite


deemer@ceres$ some_random_app cookies.sqlite
```

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```
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deemer@ceres$ some_random_app cookies.sqlite
```

```
. . .
access("cookies.sqlite", F_OK)            = 0
openat(AT_FDCWD, "cookies.sqlite", O_RDONLY) = 3
. . .
```

=> Access is just a syscall!
Works as long as permissions check out 😮

Discretionary Access Control

Owner of a resource decides on how it’s used

- Privileges depend on current user (and some groups)
- To elevate: admin user (root) vs. other users

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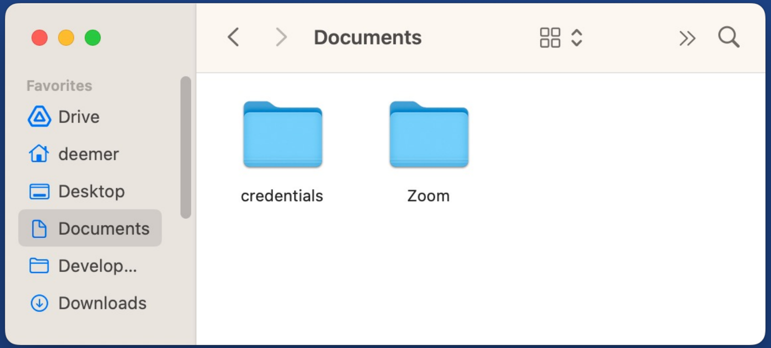
Is this really what we want?



How many of these should be able to read your browser history?

And why?

Why?

Would like to get closer to…

Why?

- File permissions are very coarse
- Apps might not be trusted
- Apps might get compromised

Would like to get closer to…

✨ ✨ ✨ ***Principle of Least Privilege*** ✨ ✨ ✨

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An application should only be able to perform the operations necessary for its intended purpose

Isolation and Sandboxing

Run (untrusted) application in such a way that it has limited access to resources => only what it needs

Examples we've been discussing

Isolation and Sandboxing

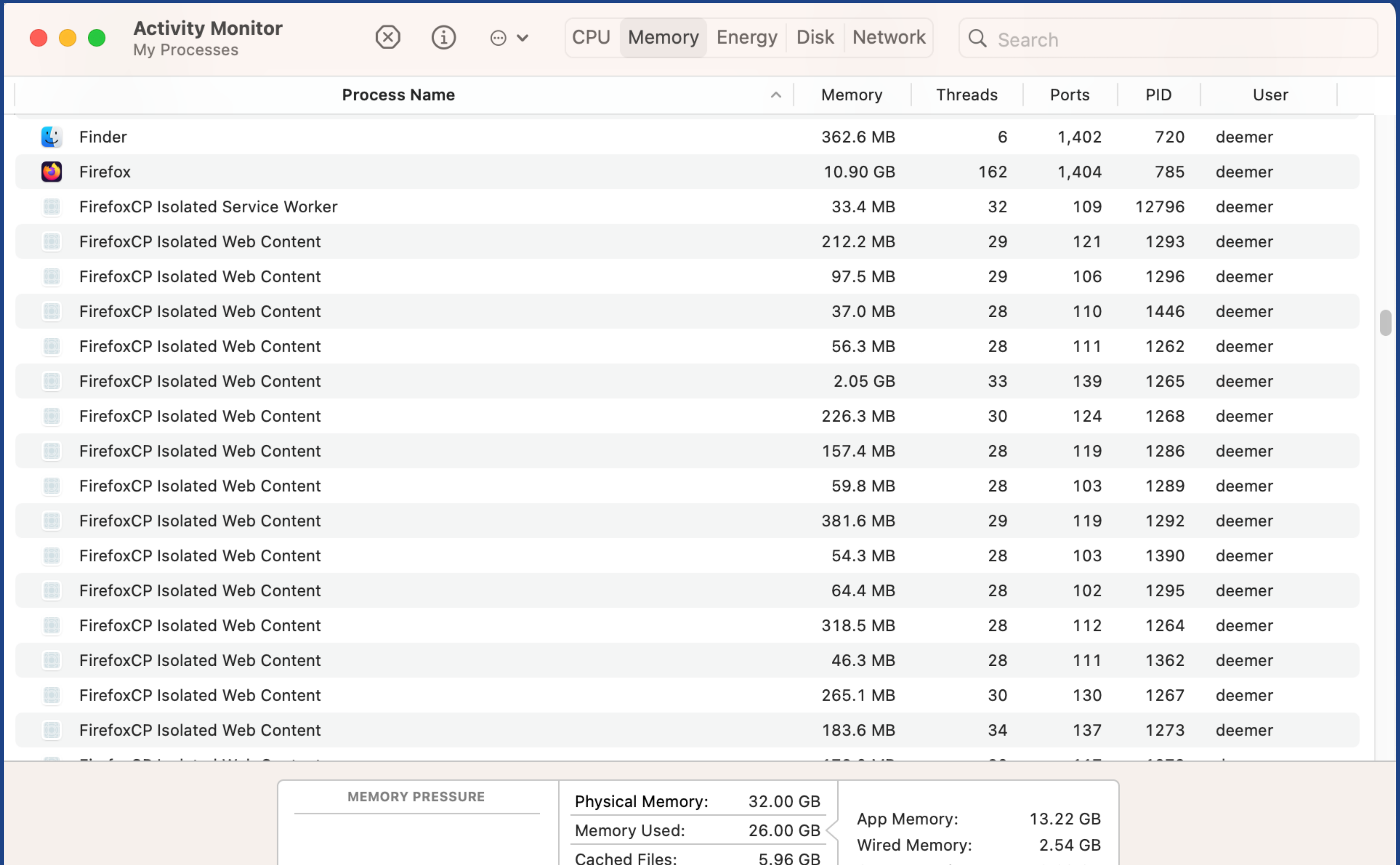
Run (untrusted) application in such a way that it has limited access to resources => only what it needs

<u>Examples we've been discussing</u>

- Application sandboxing
- Namespaces (sort of)
- Containers (sort of)
- Virtual machines

Example: Gradescope

Example: web browsers



Process Name	Memory	Threads	Ports	PID	User
Finder	362.6 MB	6	1,402	720	deemer
Firefox	10.90 GB	162	1,404	785	deemer
FirefoxCP Isolated Service Worker	33.4 MB	32	109	12796	deemer
FirefoxCP Isolated Web Content	212.2 MB	29	121	1293	deemer
FirefoxCP Isolated Web Content	97.5 MB	29	106	1296	deemer
FirefoxCP Isolated Web Content	37.0 MB	28	110	1446	deemer
FirefoxCP Isolated Web Content	56.3 MB	28	111	1262	deemer
FirefoxCP Isolated Web Content	2.05 GB	33	139	1265	deemer
FirefoxCP Isolated Web Content	226.3 MB	30	124	1268	deemer
FirefoxCP Isolated Web Content	157.4 MB	28	119	1286	deemer
FirefoxCP Isolated Web Content	59.8 MB	28	103	1289	deemer
FirefoxCP Isolated Web Content	381.6 MB	29	119	1292	deemer
FirefoxCP Isolated Web Content	54.3 MB	28	103	1390	deemer
FirefoxCP Isolated Web Content	64.4 MB	28	102	1295	deemer
FirefoxCP Isolated Web Content	318.5 MB	28	112	1264	deemer
FirefoxCP Isolated Web Content	46.3 MB	28	111	1362	deemer
FirefoxCP Isolated Web Content	265.1 MB	30	130	1267	deemer
FirefoxCP Isolated Web Content	183.6 MB	34	137	1273	deemer

MEMORY PRESSURE

Physical Memory:	32.00 GB
Memory Used:	26.00 GB
Cached Files:	5.96 GB

App Memory:	13.22 GB
Wired Memory:	2.54 GB

Example: web browsers

Browsers run a lot of untrusted code…

=> Worker processes that render pages run with fewer privileges

=> Site isolation: one process per site (or per tab)

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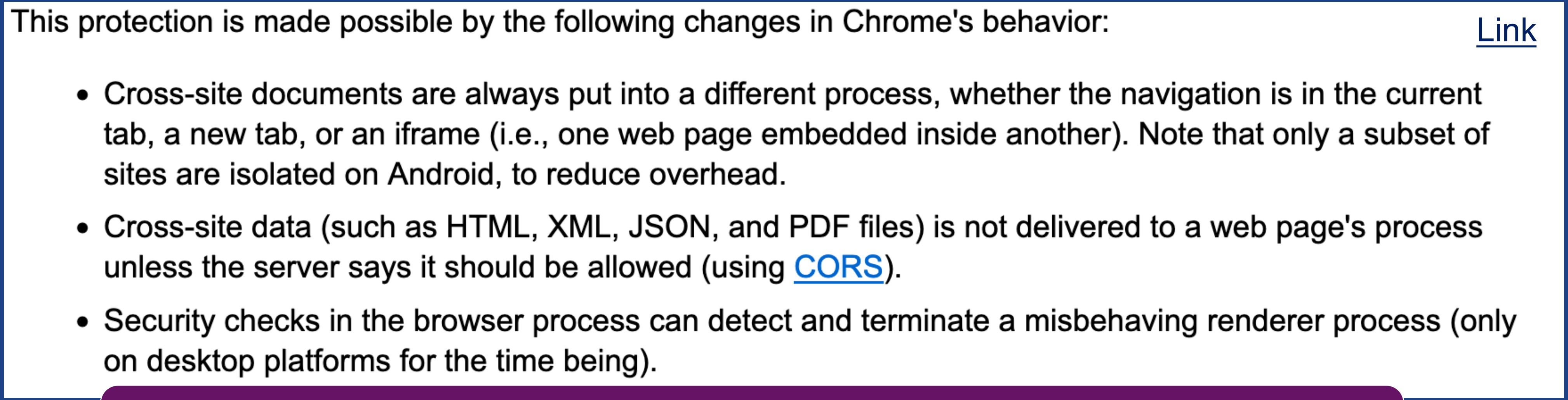
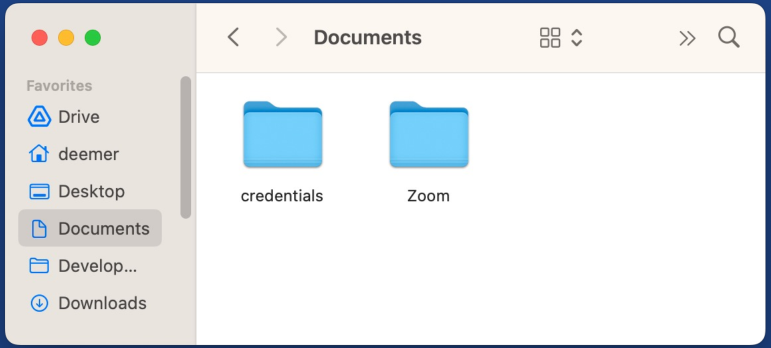


This protection is made possible by the following changes in Chrome's behavior:

- Cross-site documents are always put into a different process, whether the navigation is in the current tab, a new tab, or an iframe (i.e., one web page embedded inside another). Note that only a subset of sites are isolated on Android, to reduce overhead.
- Cross-site data (such as HTML, XML, JSON, and PDF files) is not delivered to a web page's process unless the server says it should be allowed (using CORS).
- Security checks in the browser process can detect and terminate a misbehaving renderer process (only on desktop platforms for the time being).

Link

=> Can enforce Same-Origin Policy with separate processes!



How many of these <u>should</u> be able to read your browser history?

Typical desktop environment: User has a lot of freedom, can modify system

=> Built in an era where we weren't downloading lots of untrusted code…

What if we could start over?
(sort of)

Mobile Operating System (iOS, Android)

=> Does user have root?

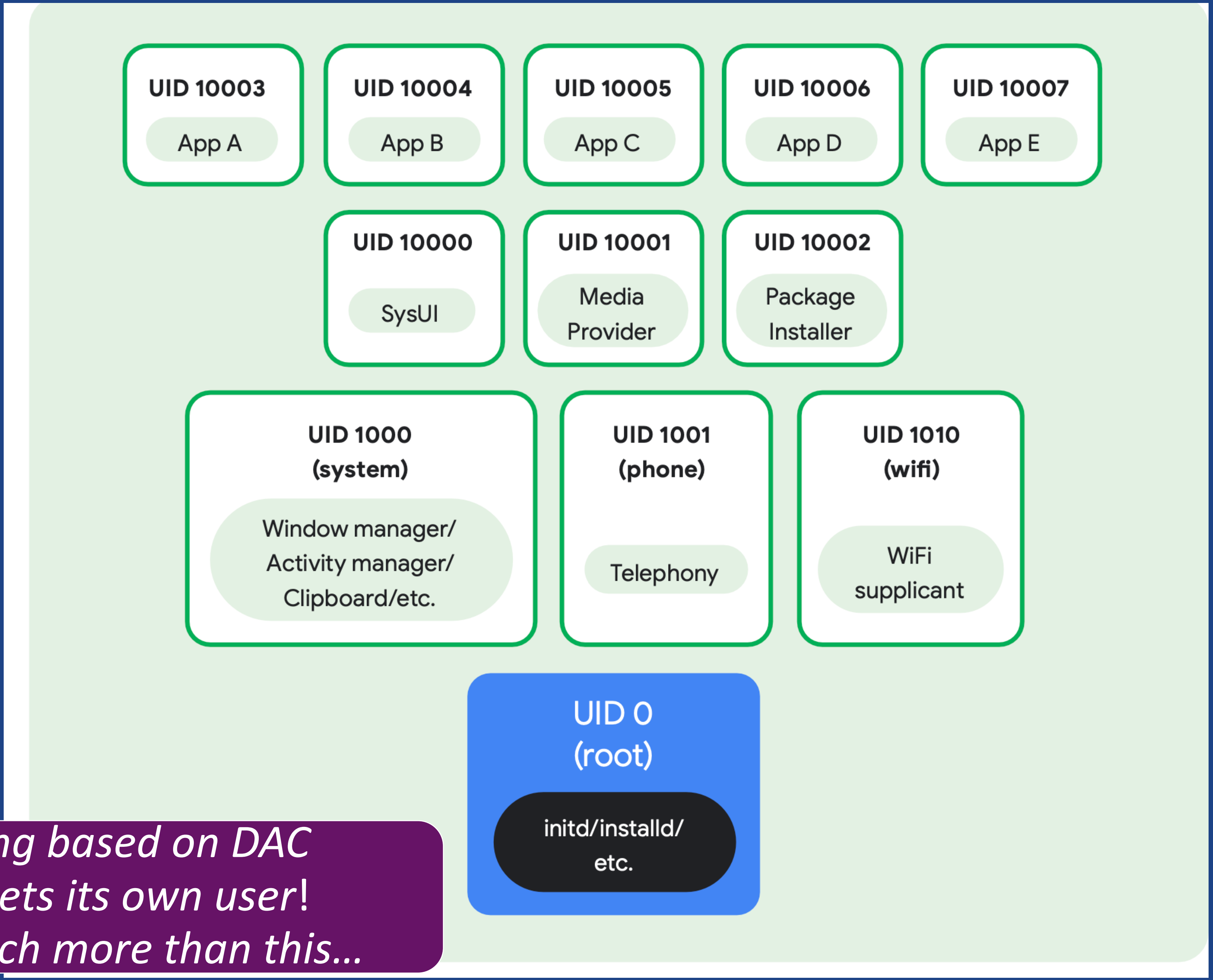
Mobile Operating Systems (iOS, Android)

=> Designed more as “secure by default” to restrict app privileges

Example: Android

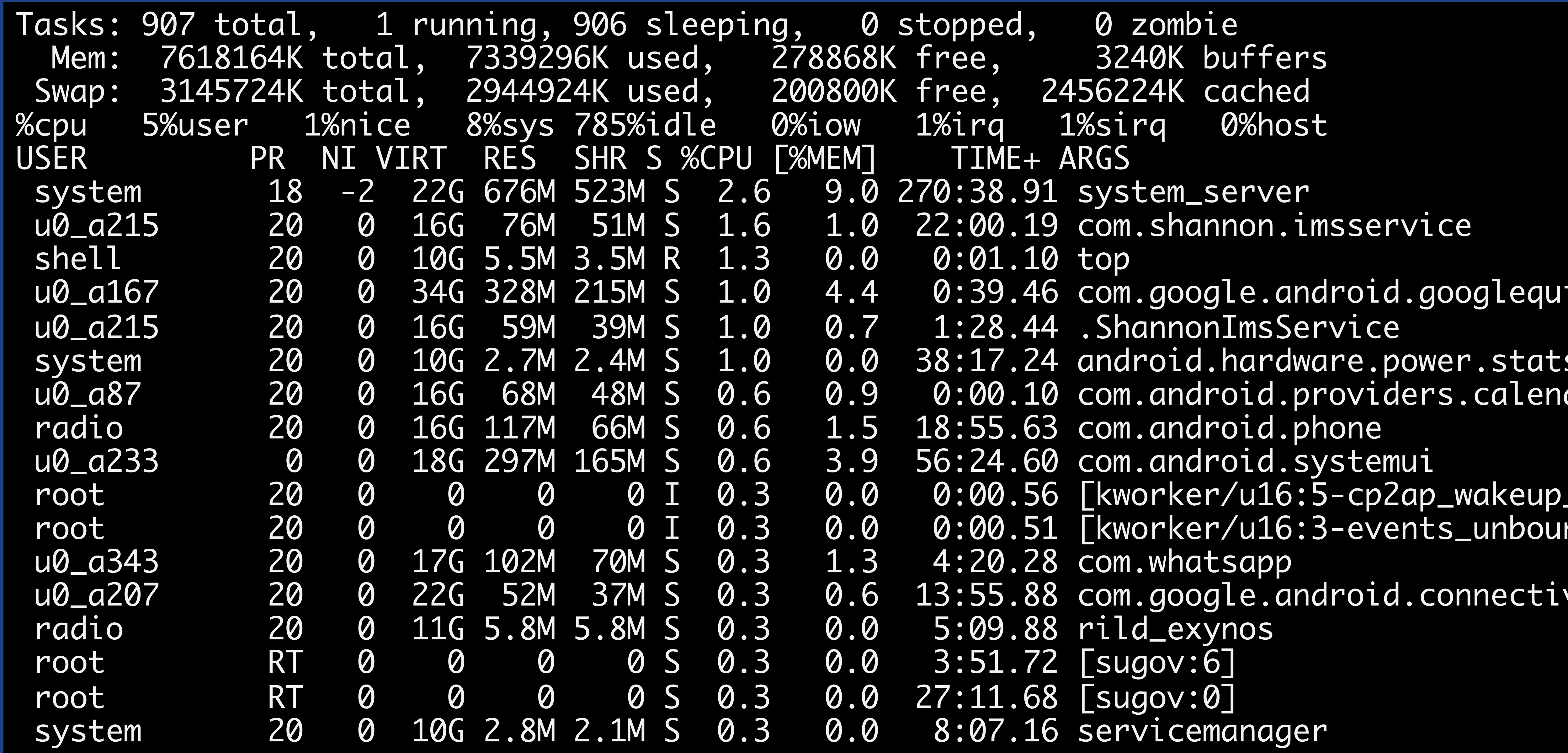
- Based on Linux
- Many levels of application *sandboxing*
- Applications request permissions at installation and runtime
  => OS and Android Platform provides access

Nice writeups you can read:
- Android Security Paper 2023
- The Android Platform Security Model



Core sandboxing based on DAC
=> Every app gets its own user!
=> There is much more than this...

Process list



```
Tasks: 907 total,   1 running, 906 sleeping,   0 stopped,   0 zombie
  Mem:  7618164K total,  7339296K used,   278868K free,     3240K buffers
 Swap:  3145724K total,  2944924K used,   200800K free,  2456224K cached
%cpu   5%user   1%nice   8%sys 785%idle   0%iow   1%irq   1%sirq   0%host
USER         PR  NI VIRT  RES  SHR S %CPU [%MEM]    TIME+ ARGS
 system       18  -2  22G 676M 523M S  2.6   9.0 270:38.91 system_server
 u0_a215      20   0  16G  76M  51M S  1.6   1.0  22:00.19 com.shannon.imsservice
 shell        20   0  10G 5.5M 3.5M R  1.3   0.0   0:01.10 top
 u0_a167      20   0  34G 328M 215M S  1.0   4.4   0:39.46 com.google.android.googlequ
 u0_a215      20   0  16G  59M  39M S  1.0   0.7   1:28.44 .ShannonImsService
 system       20   0  10G 2.7M 2.4M S  1.0   0.0  38:17.24 android.hardware.power.stats
 u0_a87       20   0  16G  68M  48M S  0.6   0.9   0:00.10 com.android.providers.calen
 radio        20   0  16G 117M  66M S  0.6   1.5  18:55.63 com.android.phone
 u0_a233       0   0  18G 297M 165M S  0.6   3.9  56:24.60 com.android.systemui
 root         20   0    0    0    0 I  0.3   0.0   0:00.56 [kworker/u16:5-cp2ap_wakeup_
 root         20   0    0    0    0 I  0.3   0.0   0:00.51 [kworker/u16:3-events_unbou
 u0_a343      20   0  17G 102M  70M S  0.3   1.3   4:20.28 com.whatsapp
 u0_a207      20   0  22G  52M  37M S  0.3   0.6  13:55.88 com.google.android.connecti
 radio        20   0  11G 5.8M 5.8M S  0.3   0.0   5:09.88 rild_exynos
 root         RT   0    0    0    0 S  0.3   0.0   3:51.72 [sugov:6]
 root         RT   0    0    0    0 S  0.3   0.0  27:11.68 [sugov:0]
 system       20   0  10G 2.8M 2.1M S  0.3   0.0   8:07.16 servicemanager
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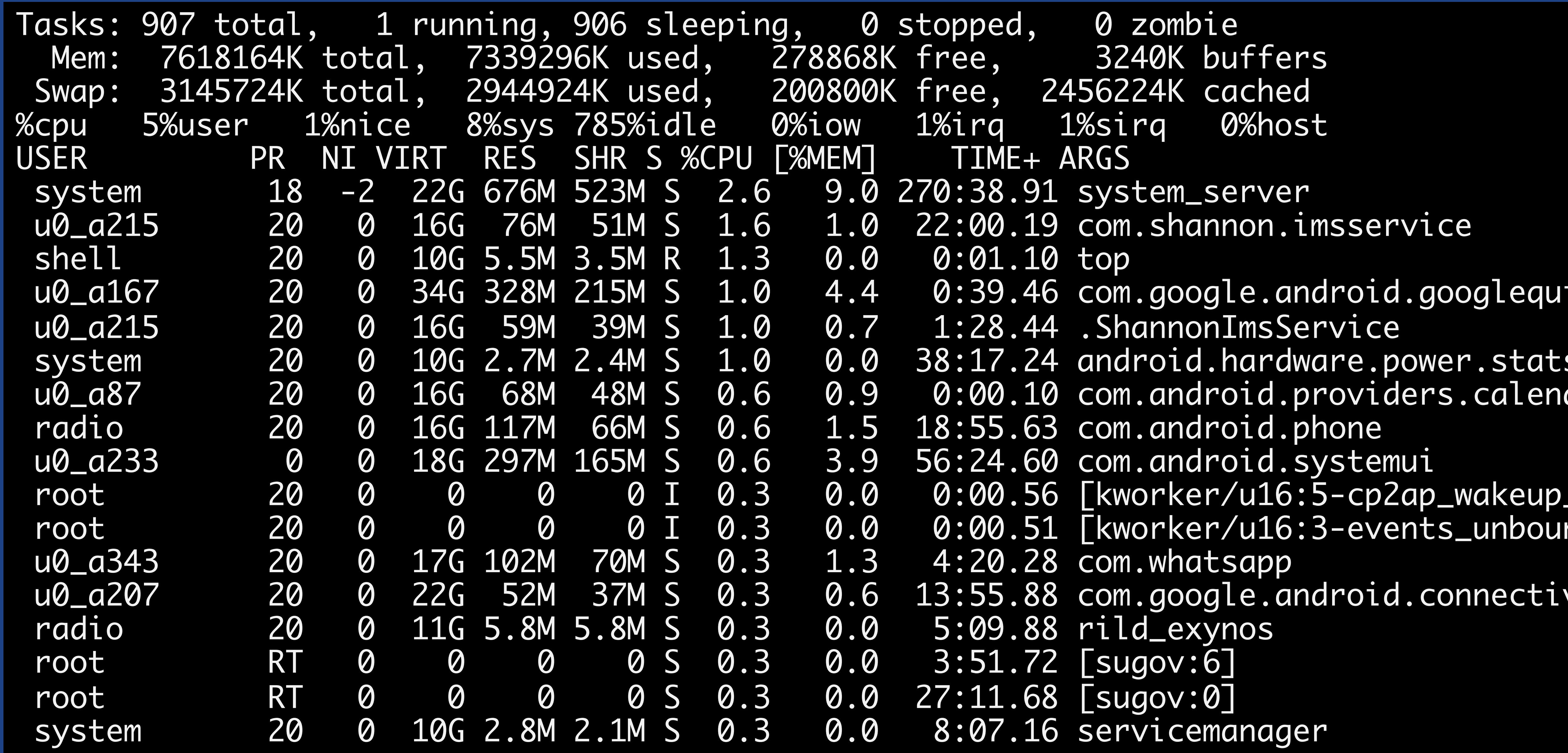
Process list



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 u0_a233       0   0  18G 297M 165M S  0.6   3.9  56:24.60 com.android.systemui
 root         20   0    0    0    0 I  0.3   0.0   0:00.56 [kworker/u16:5-cp2ap_wakeup
 root         20   0    0    0    0 I  0.3   0.0   0:00.51 [kworker/u16:3-events_unbou
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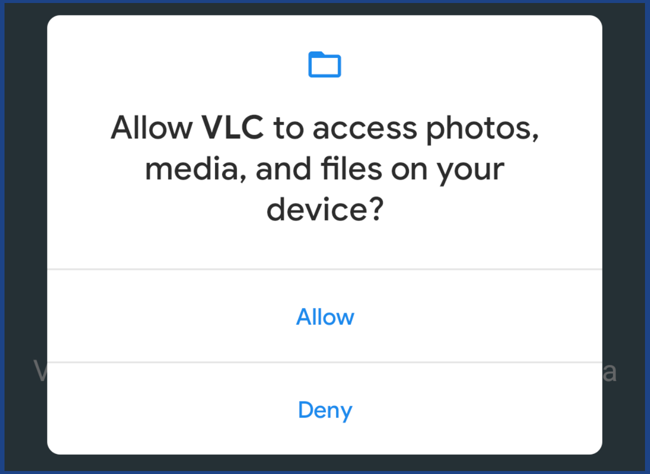
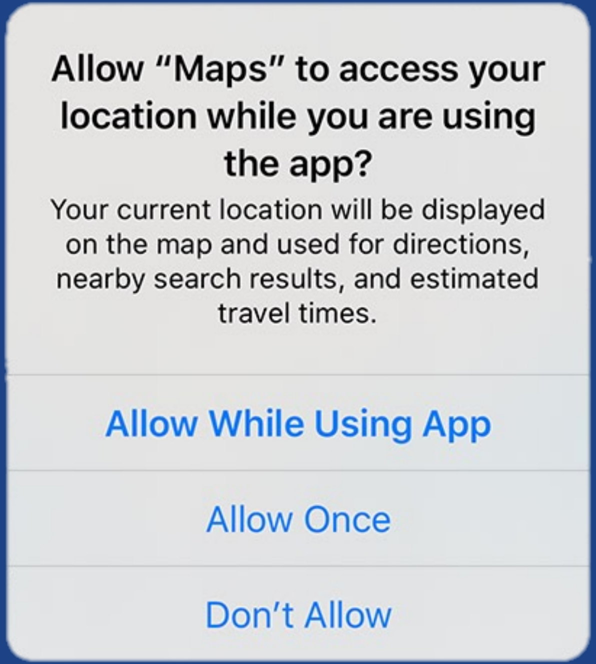
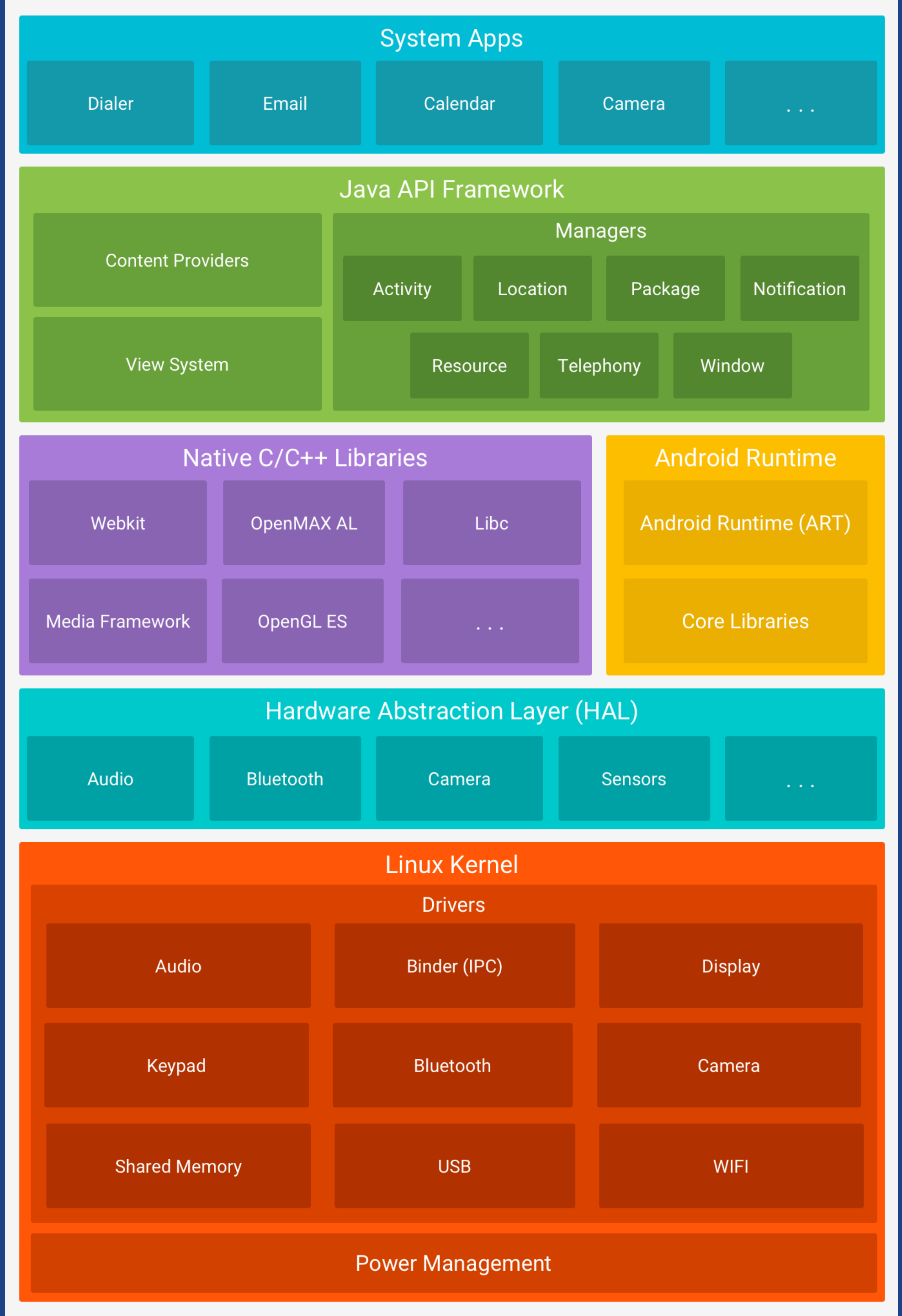


Allow **VLC** to access photos, media, and files on your device?



Allow “Maps” to access your location while you are using the app?

Your current location will be displayed on the map and used for directions, nearby search results, and estimated travel times.



System Apps
Dialer
Email
Calendar
Camera
. . .
Java API Framework
Content Providers
View System
Managers
Activity
Location
Package
Notification
Resource
Telephony
Window
Native C/C++ Libraries
Webkit
OpenMAX AL
Libc
Media Framework
OpenGL ES
. . .
Android Runtime
Android Runtime (ART)
Core Libraries
Hardware Abstraction Layer (HAL)
Audio
Bluetooth
Camera
Sensors
. . .
Linux Kernel
Drivers
Audio
Binder (IPC)
Display
Keypad
Bluetooth
Camera
Shared Memory
USB
WIFI
Power Management

Examining an app…

```
 requested permissions:
      android.permission.ACCESS_WIFI_STATE
      android.permission.INTERNET
      android.permission.ACCESS_NETWORK_STATE
      android.permission.WAKE_LOCK
      android.permission.GET_ACCOUNTS
android.permission.RECEIVE_BOOT_COMPLETED


. . .

install permissions:
      com.google.android.finsky.permission.BIND_GET_INSTALL_REFERRER_SERVICE: granted\
=true
      com.google.android.c2dm.permission.RECEIVE: granted=true
      android.permission.USE_CREDENTIALS: granted=true
      android.permission.MODIFY_AUDIO_SETTINGS: granted=true
      android.permission.FOREGROUND_SERVICE: granted=true
android.permission.CHANGE_WIFI_STATE: granted=true
      android.permission.FOREGROUND_SERVICE_DATA_SYNC: granted=true
      android.permission.ACCESS_NETWORK_STATE: granted=true
      android.permission.USE_FINGERPRINT: granted=true
      android.permission.READ_BASIC_PHONE_STATE: granted=true
```

SELinux Policies on resources

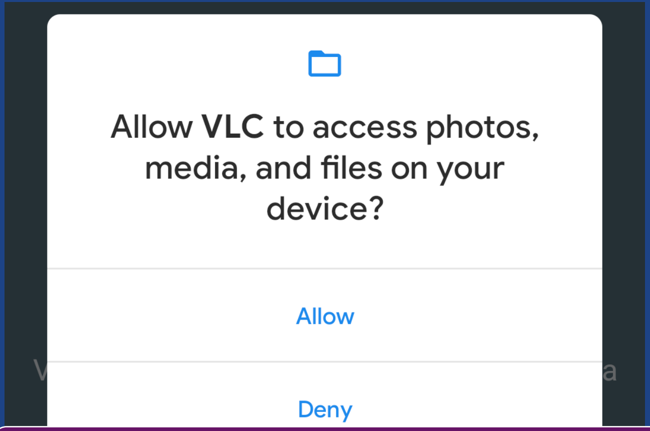
```
$ $ ls -laZ

lrw-r--r--    1 root   root      u:object_r:rootfs:s0          11 bin -> /system/bin
drwxr-xr-x    2 root   root      u:object_r:tmpfs:s0         4096 debug_ramdisk
drwxr-xr-x   24 root   root      u:object_r:device:s0         160 dev
drwxr-xr-x   13 root   shell     u:object_r:vendor_file:s0   4096 vendor
drwxr-xr-x    5 root   root      u:object_r:vendor_file:s0   4096 vendor_dlkm
drwx--x---    4 shell  everybody u:object_r:mnt_user_file:s0   80 storage
```

```
$ sesearch -A selinux_policy

allow adbd adb_keys_file:dir search;
allow adbd adb_keys_file:file { getattr ioctl lock map open read watch watch_reads };
```

```
access("cookies.sqlite", F_OK)                   = 0
openat(AT_FDCWD, "cookies.sqlite", O_RDONLY) = 3
```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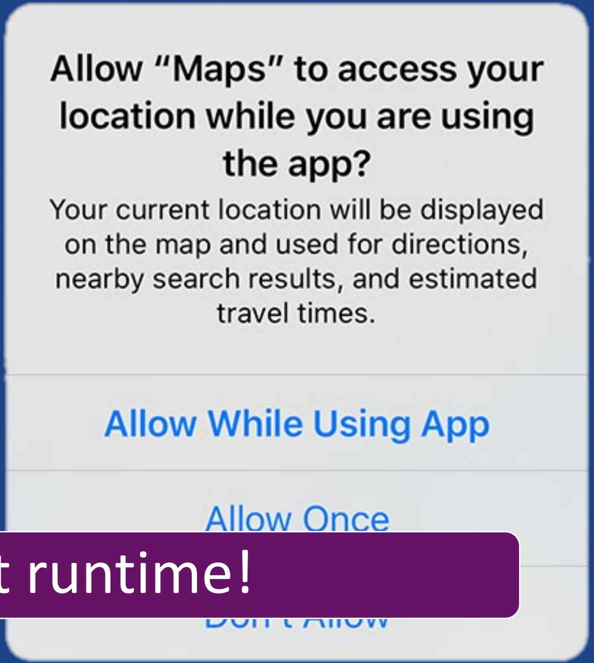
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=> Fine-grained permissions at runtime!

…at compile time?

Other ways?

- What does it mean for the user to be "unprivileged"?
- What does it mean for code run by a user to be "unprivileged"?

- What do we want that code to be able to do?

  => How much do we trust the user? The code?

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- What does it mean for <u>code run by a user</u> to be "unprivileged"?

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- sudo is pretty coarse-grained…