The Android Linux Kernel (Part 1): Primary & Secondary Storage Mechanisms

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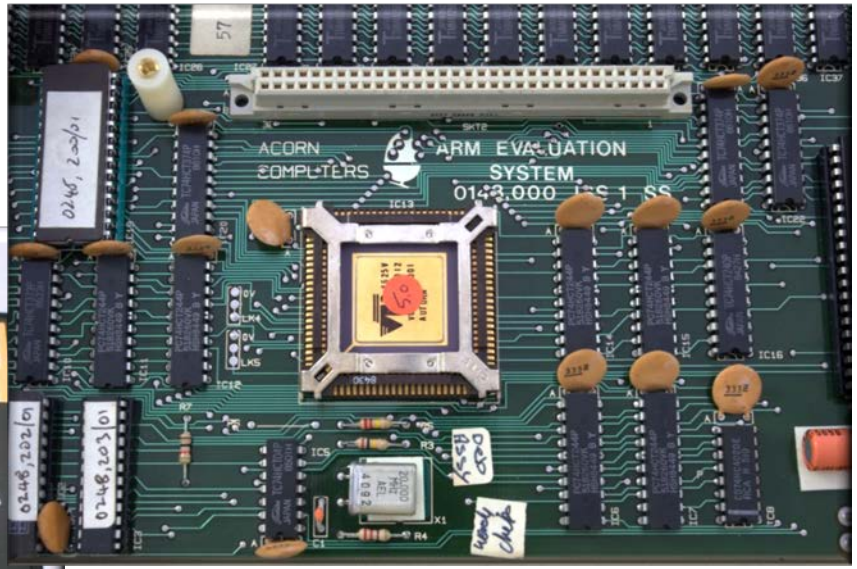
Learning Objectives in this Part of the Lesson

1. Recognize the two types of storage supported by Android Linux: *primary* & *secondary storage*



Overview of Android Linux Primary & Secondary Storage Mechanisms

Android Linux Kernel: Primary & Secondary Storage

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- Android's software instructions & data reside in two different types of storage

See en.wikipedia.org/wiki/Computer_data_storage

Android Linux Kernel: Primary & Secondary Storage

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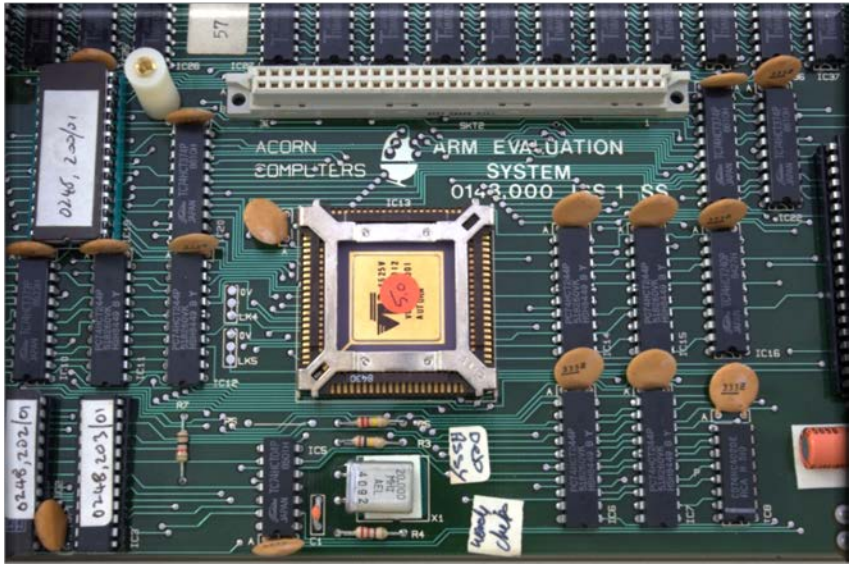
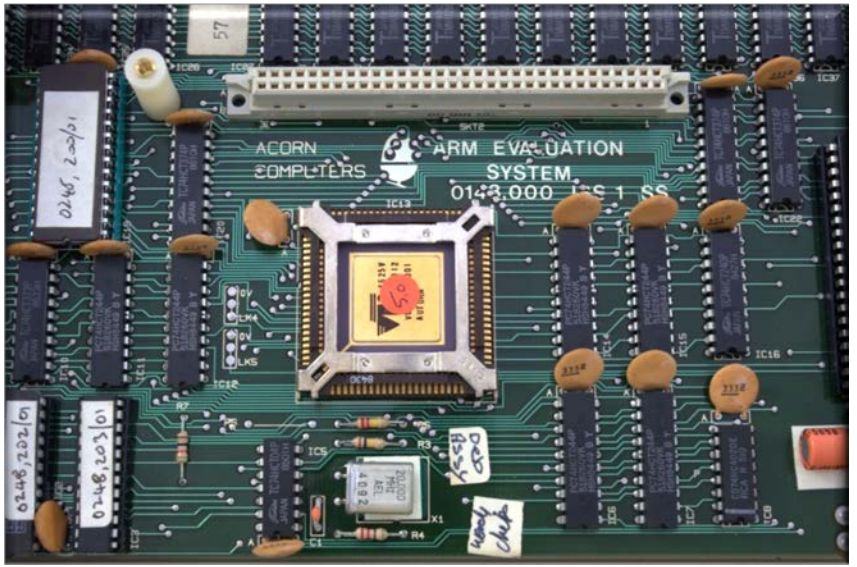
  - **Primary storage** – Fast random access memory (RAM)



See en.wikipedia.org/wiki/Computer_data_storage#Primary_storage

Android Linux Kernel: Primary & Secondary Storage

- Android's software instructions & data reside in two different types of storage
  - **Primary storage** – Fast random access memory (RAM)
    - The contents of volatile RAM are wiped out whenever a device is rebooted or loses power



See en.wikipedia.org/wiki/Volatile_memory

Android Linux Kernel: Primary & Secondary Storage

- Android's software instructions & data reside in two different types of storage
  - **Primary storage** – Fast random access memory (RAM)
  - **Secondary storage** – Slower flash memory

See en.wikipedia.org/wiki/Computer_data_storage#Secondary_storage

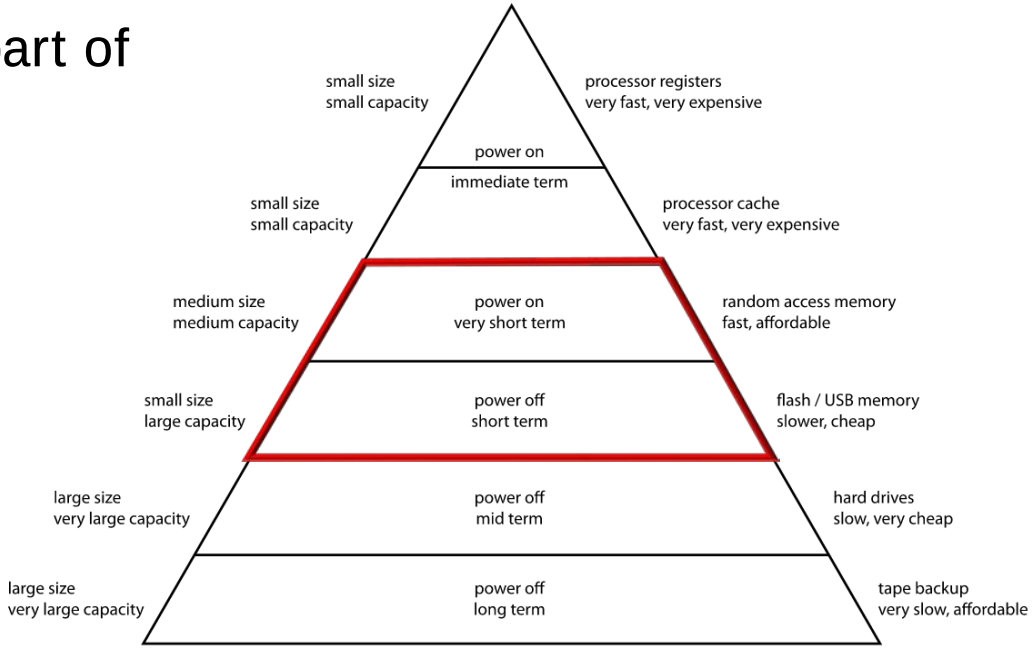
Android Linux Kernel: Primary & Secondary Storage

- Android's software instructions & data reside in two different types of storage
  - **Primary storage** – Fast random access memory (RAM)
  - **Secondary storage** – Slower flash memory
    - Flash is persistent storage that can be erased & reprogrammed electronically

See en.wikipedia.org/wiki/Flash_memory

Android Linux Kernel: Primary & Secondary Storage

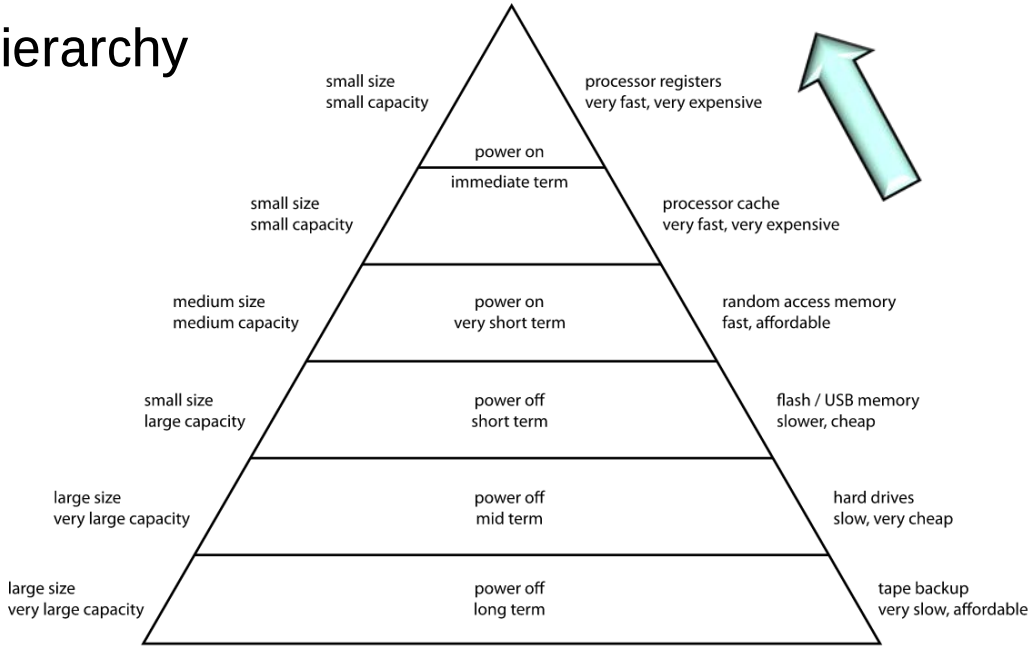
- Primary & secondary storage are part of a “memory hierarchy”



See en.wikipedia.org/wiki/Memory_hierarchy

Android Linux Kernel: Primary & Secondary Storage

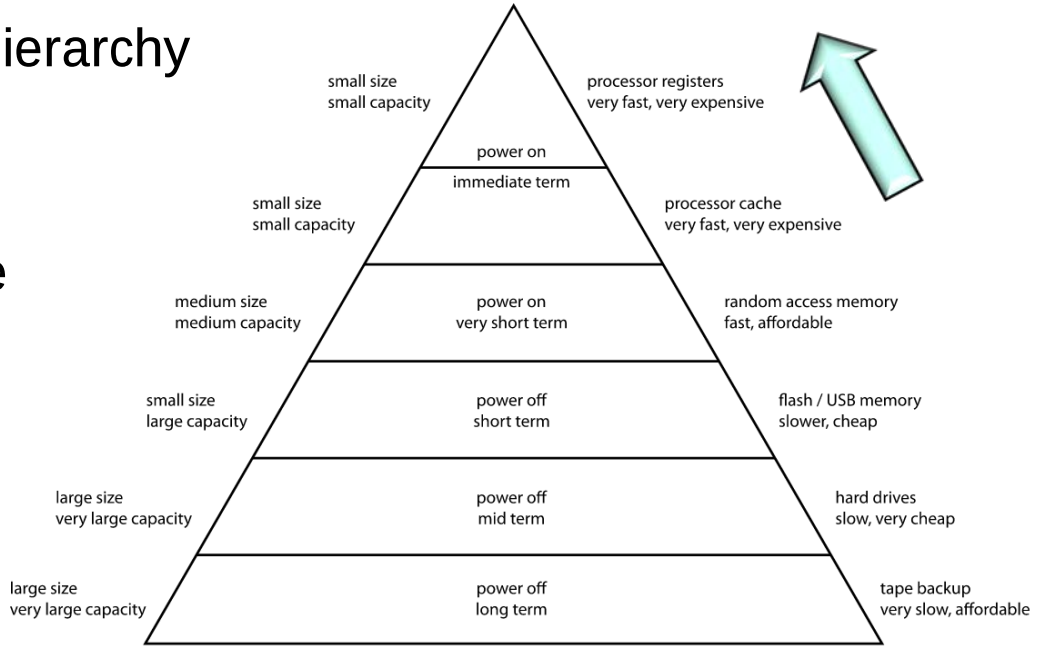
- In general, being “higher” in this hierarchy has several implications



See en.wikipedia.org/wiki/Memory_bandwidth

Android Linux Kernel: Primary & Secondary Storage

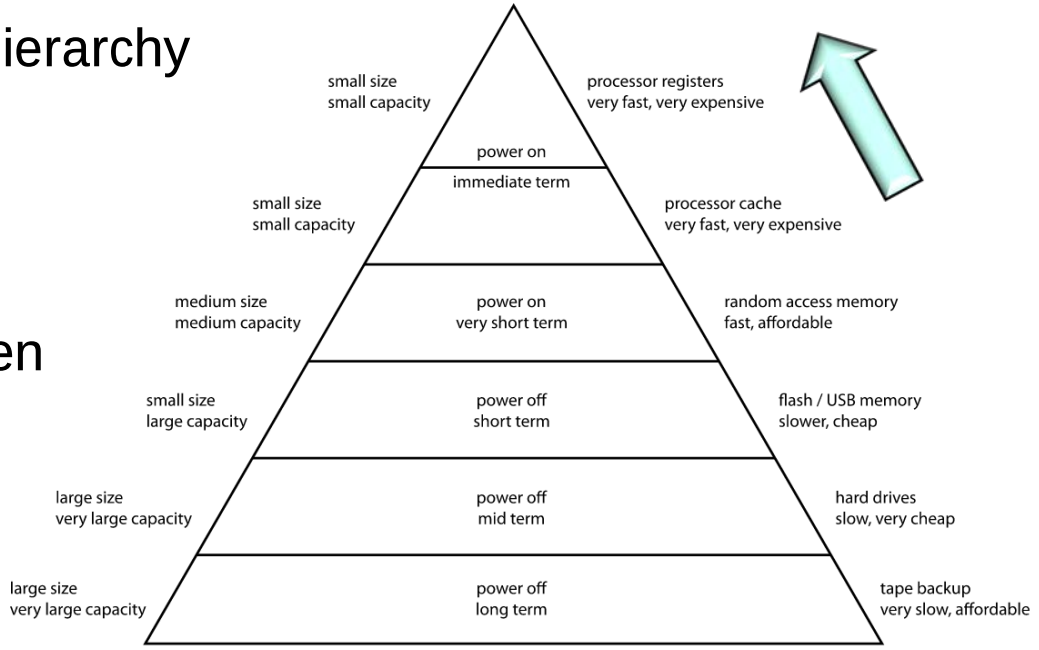
- In general, being “higher” in this hierarchy has several implications, e.g.
  - Memory bandwidth is faster
    - i.e., rate at which data can be read from or stored into



See en.wikipedia.org/wiki/Memory_bandwidth

Android Linux Kernel: Primary & Secondary Storage

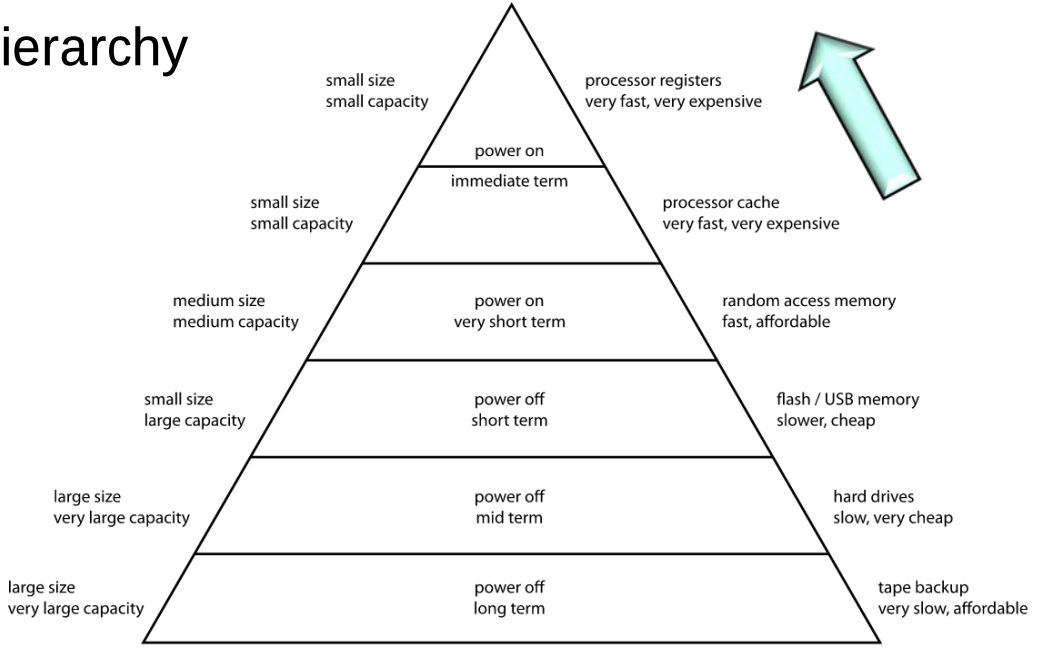
- In general, being "higher" in this hierarchy has several implications, e.g.
  - Memory bandwidth is faster
  - CPU access latency is lower
    - i.e., time interval between when CPU initiates a call for fetch or store data & when the call completes



See en.wikipedia.org/wiki/Access_time

Android Linux Kernel: Primary & Secondary Storage

- In general, being “higher” in this hierarchy has several implications, e.g.
  - Memory bandwidth is faster
  - CPU access latency is lower
  - Cost is greater
    - i.e., “faster” == “costlier”



See www.differencebetween.com/difference-between-primary-and-vs-secondary-memory

Android Linux Kernel: Primary & Secondary Storage

- Processor cores operate on instructions & their associated data that reside in RAM

See en.wikipedia.org/wiki/Central_processing_unit#Operation

Android Linux Kernel: Primary & Secondary Storage

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  - Android Linux executes in kernel space RAM

See www.linfo.org/kernel_space.html

Android Linux Kernel: Primary & Secondary Storage

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    - Kernel space is a protected region of RAM for running privileged operations

See en.wikipedia.org/wiki/CPU_modes

Android Linux Kernel: Primary & Secondary Storage

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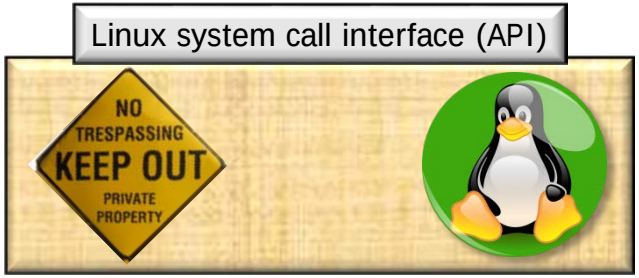
    - Kernel space is a protected region of RAM for running privileged operations
    - Kernel space can be accessed by user processes only via *system calls*



See en.wikipedia.org/wiki/System_call

Android Linux Kernel: Primary & Secondary Storage

- Processor cores operate on instructions & their associated data that reside in RAM
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  - All Android apps execute in user space RAM

See en.wikipedia.org/wiki/User_space

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    - User space is a more restrictive protection domain than kernel space

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  - Android Linux executes in kernel space RAM
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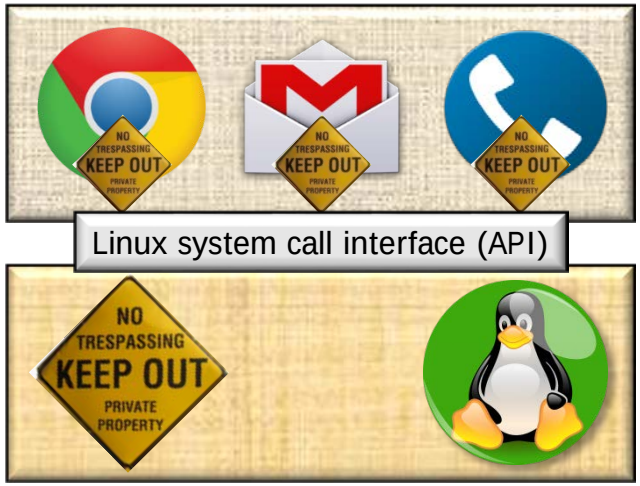
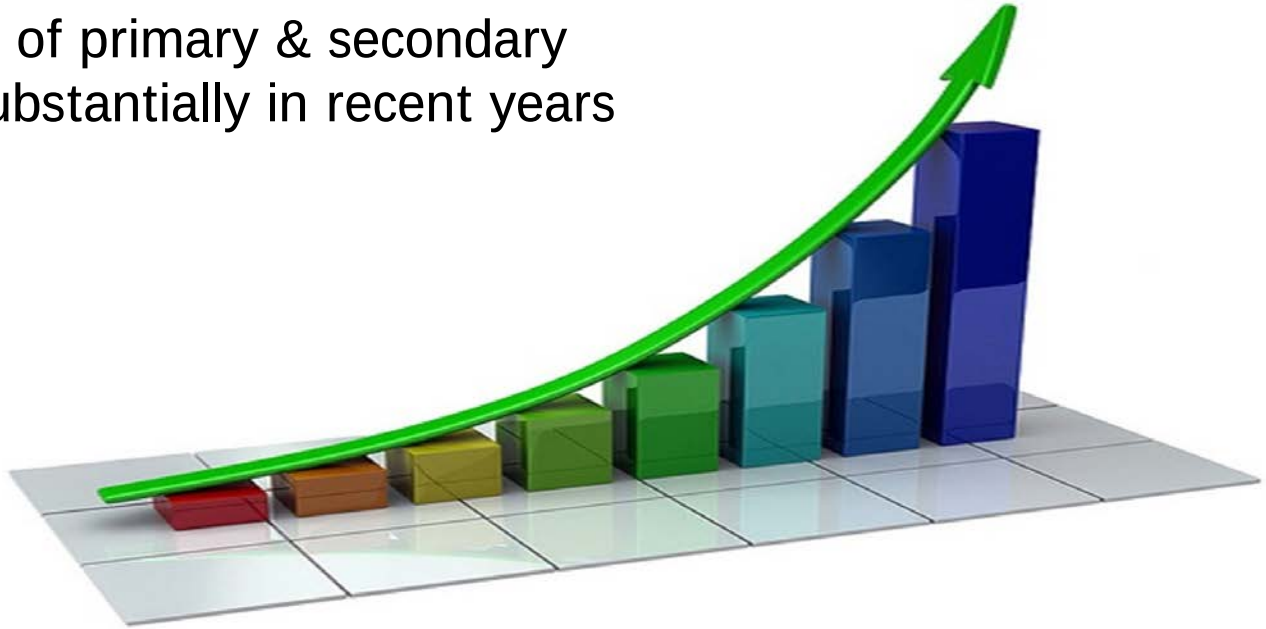
    - User space is a more restrictive protection domain than kernel space
    - Apps running in user space normally can't access RAM of other apps, unless explicitly allowed



See "anonymous shared memory" discussion in part 3 of this lesson

Android Linux Kernel: Primary & Secondary Storage

- The cost & performance of primary & secondary storage has improved substantially in recent years



See en.wikipedia.org/wiki/Random-access_memory#Recent_developments

Android Linux Kernel: Primary & Secondary Storage

- Primary storage (RAM) on Android mobile devices is constrained

See developer.android.com/training/articles/memory.html

Android Linux Kernel: Primary & Secondary Storage

- Primary storage (RAM) on Android mobile devices is constrained, e.g.
  - Form factor

In 2017 2-4 GB is common for mobile devices versus 8-64 GB on a desktop or laptop

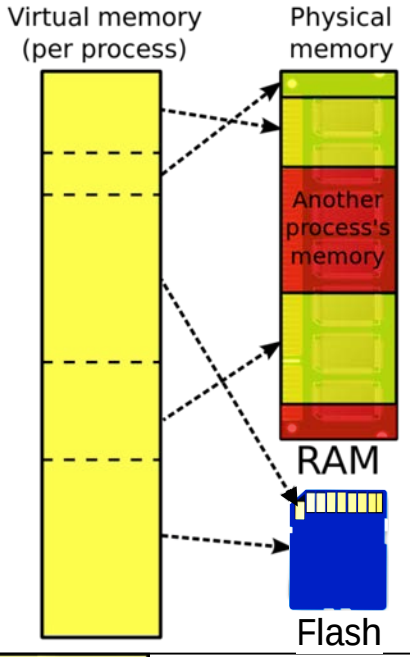
Android Linux Kernel: Primary & Secondary Storage

- Primary storage (RAM) on Android mobile devices is constrained, e.g.
  - Form factor
  - Price points

Lower cost mobile devices typically have much less RAM than higher cost devices

Android Linux Kernel: Primary & Secondary Storage

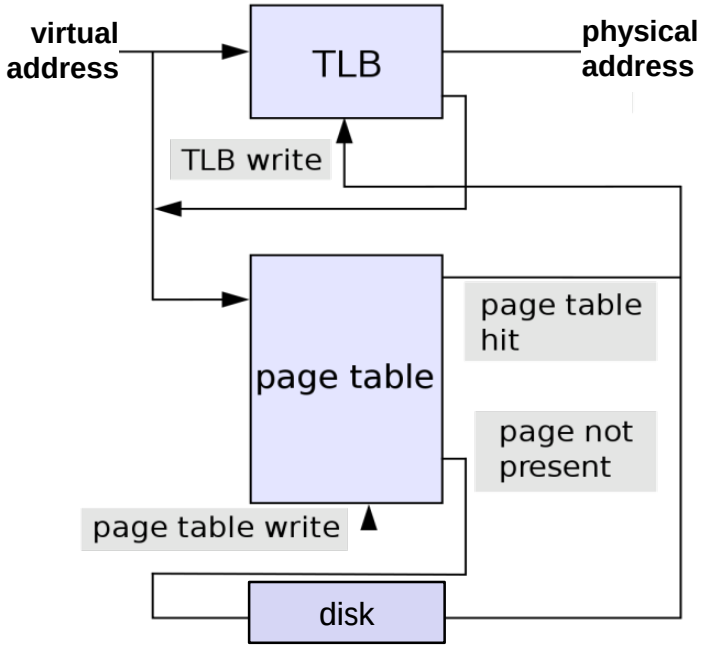
- (Android) Linux's virtual memory manager features address memory constraints



See en.wikipedia.org/wiki/Virtual_memory

Android Linux Kernel: Primary & Secondary Storage

- (Android) Linux's virtual memory manager features address memory constraints, e.g.
  - Helps conserve RAM by not moving app instructions & data from secondary to primary storage until they are accessed



See en.wikipedia.org/wiki/Demand_paging

Android Linux Kernel: Primary & Secondary Storage

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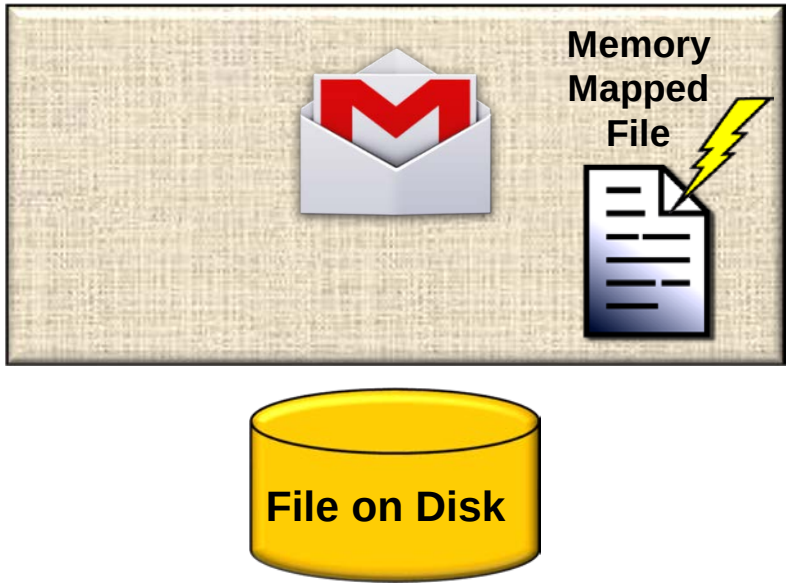
  - Accelerates I/O operations via memory mapping of files & hardware devices



See en.wikipedia.org/wiki/Memory-mapped_file

Android Linux Kernel: Primary & Secondary Storage

- (Android) Linux's virtual memory manager features address memory constraints, e.g.
  - Helps conserve RAM by not moving app instructions & data from secondary to primary storage until they are accessed
  - Accelerates I/O operations via memory mapping of files & hardware devices
  - Protects an app's private data in RAM from other apps

See en.wikipedia.org/wiki/Memory_management_unit

Android Linux Kernel: Primary & Secondary Storage

- Secondary storage in Android Linux is used to save data persistently

Mechanisms	Persistent Capability
Shared Preferences	Store private primitive data in key-value pairs
External Storage	Store public data on the shared external storage
Internal Storage	Store private data on the device memory
SQLite Databases	Store structured data in a private database

See developer.android.com/guide/topics/data/data-storage.html

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Android has been progressively enhancing security of external storage over time..

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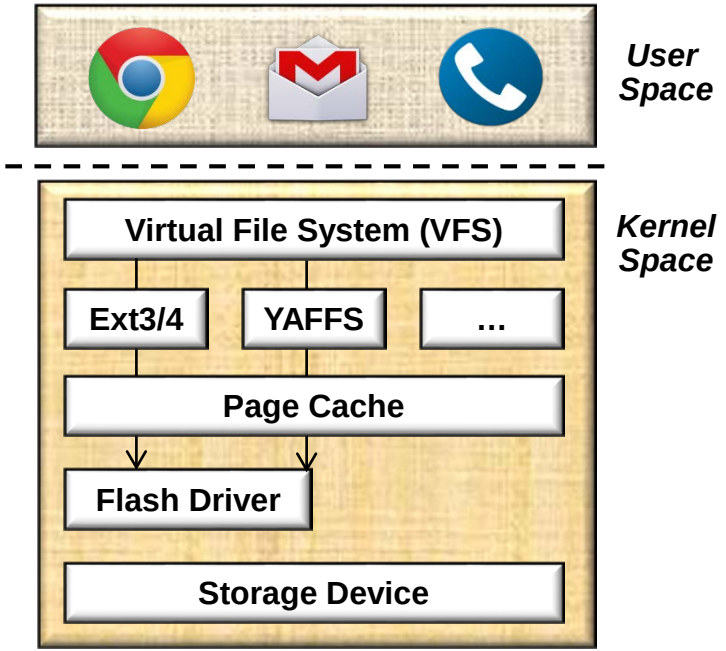

See www.all-things-android.com/content/understanding-android-file-hierarchy

Android Linux Kernel: Primary & Secondary Storage

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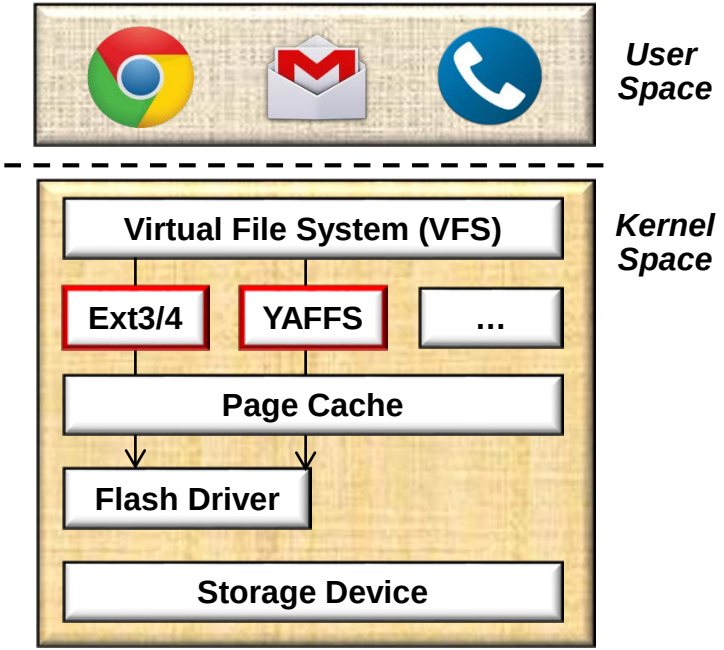
  - Each file system is implemented via a kernel module that registers the operations that it supports with VFS



See en.wikipedia.org/wiki/Loadable_kernel_module

Android Linux Kernel: Primary & Secondary Storage

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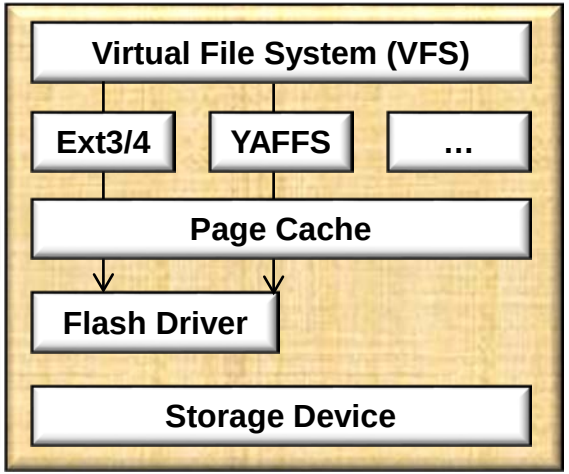
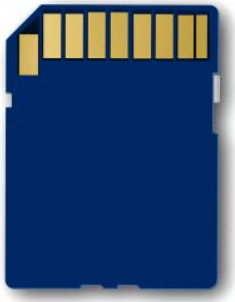
  - Each file system is implemented via a kernel module that registers the operations that it supports with VFS
  - Android Linux file systems support "flash memory" files that can be erased/reprogrammed electronically

User Space

Kernel Space





See en.wikipedia.org/wiki/Flash_memory

End of the Android Linux Kernel: (Part 1) Primary & Secondary Storage Mechanisms