High Performance Graphics on Android

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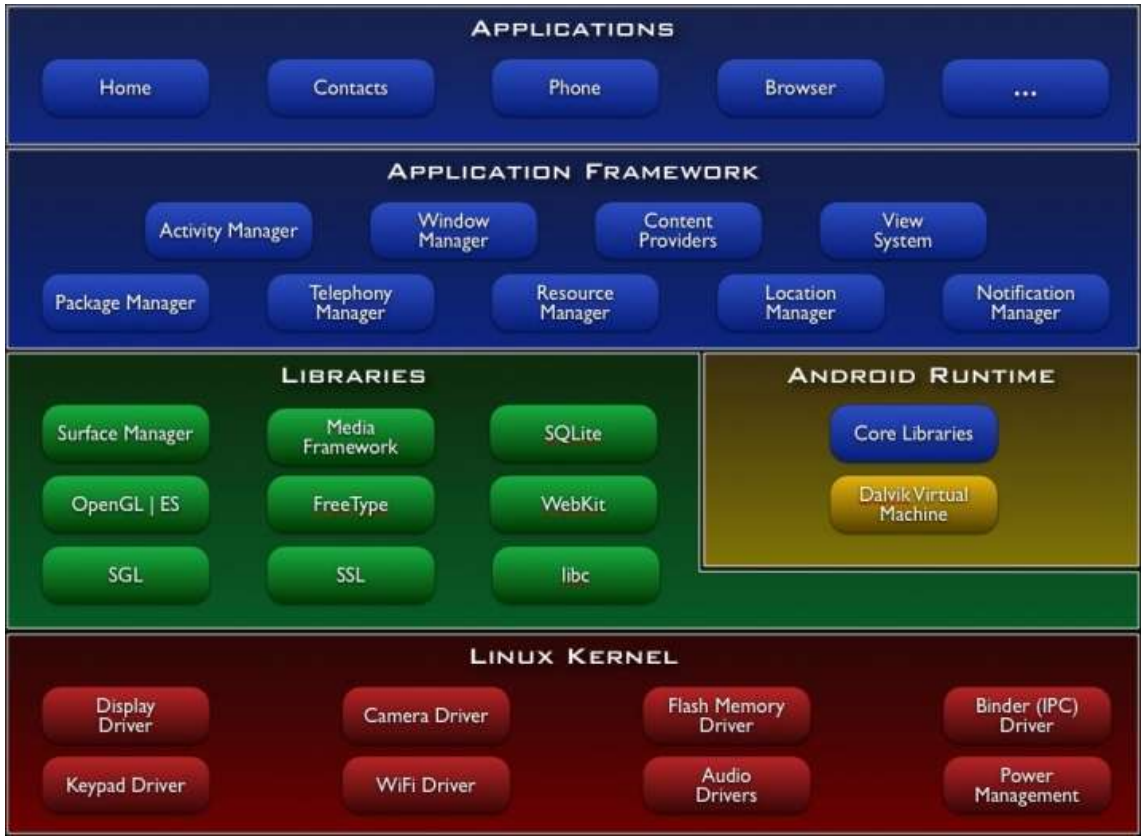
What is Android?

- **"Android is a software stack that includes an operating system, middleware and key applications."**



Android Facts

- **Open source**
- **Apache Public License v2**
  - Allows new files to be kept proprietary
  - Kernel-side is General Public License v2
- **Apps normally developed using SDK (Java)**
- **NDK also provided**
  - does not mean app can be implemented entirely in native code… just portions of it

Supported Graphics APIs

- **EGL 1.4**
- **OpenGL ES 1.1**
  - CPU-based implementation provided
    - … optionally can use copybit API for acceleration
- **OpenGL ES 2.0**
  - no CPU-based version
- **No OpenVG support**
  - Skia has some vector graphics functionality

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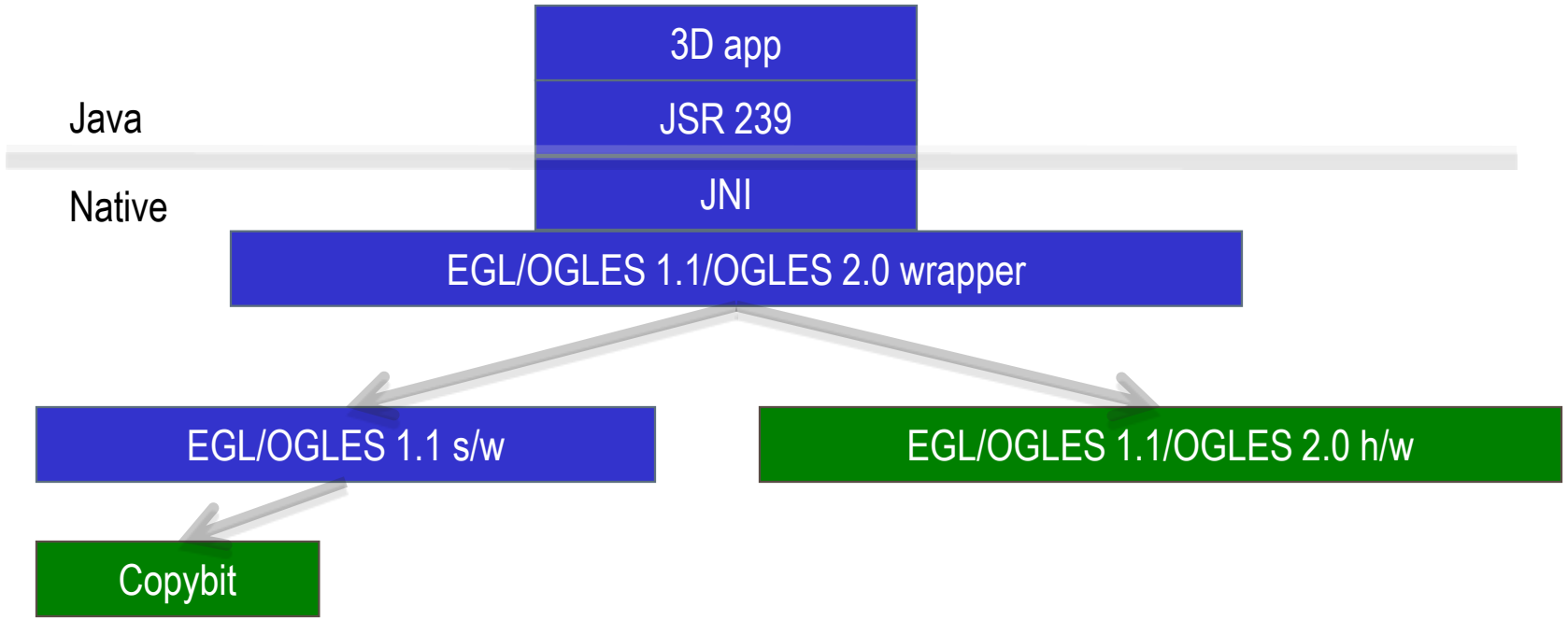
Android 3D Graphics Stack



= Vendor implemented component

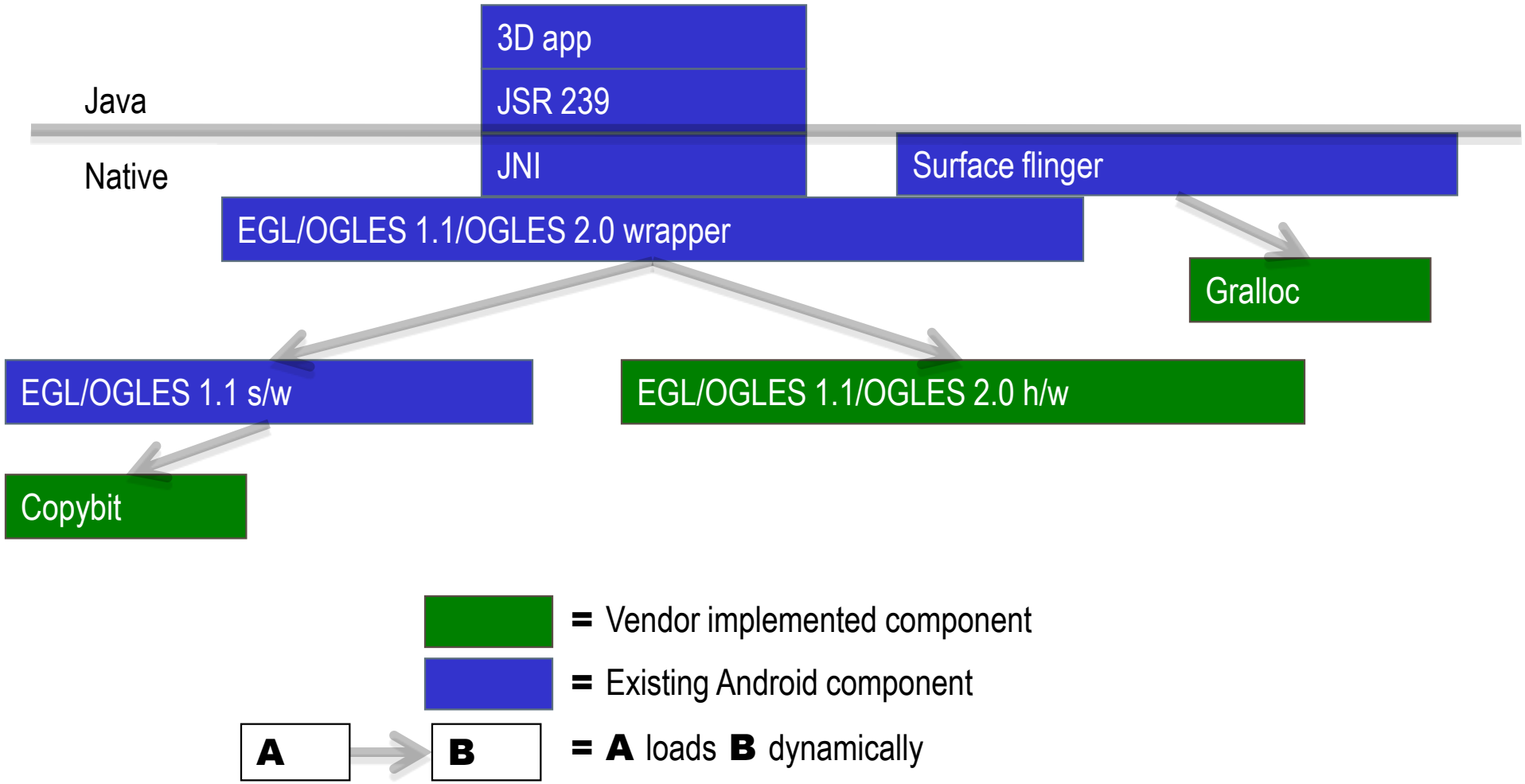
= Existing Android component

A → B = **A** loads **B** dynamically

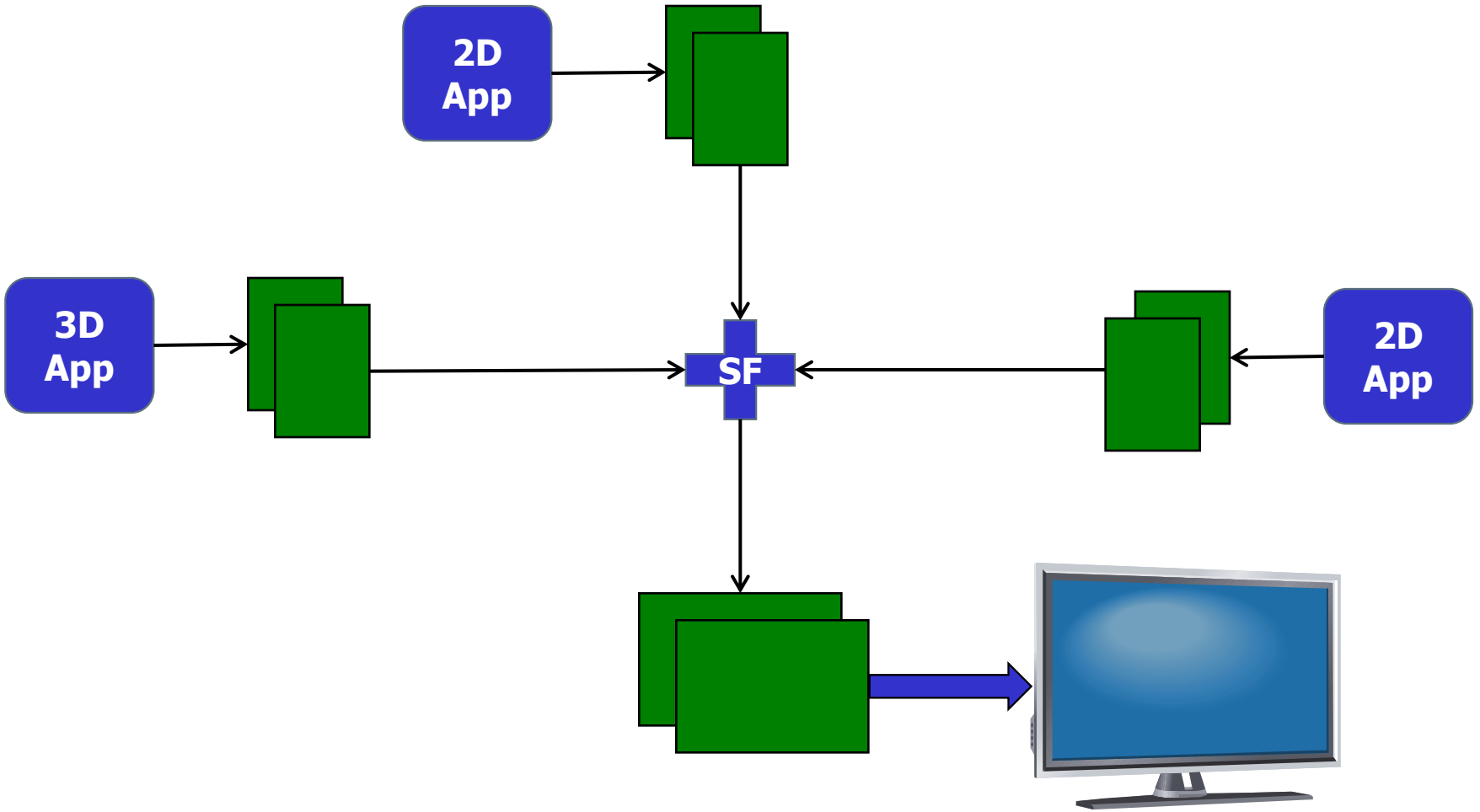
Which EGL/OpenGL ES?

- **Android framework always favors hardware implementation**
  - EGL wrapper stacks hardware EGL configs ahead of software
  - Any (reasonable) config requested would come from hardware implementation
- **Each hardware entry point is dispatched from Android wrapper via trampoline code (~5 ARM instructions)**

Surface Flinger



Composition Process



Surface Flinger

- **Most SF rendering is inherently flat (2D) though it uses OpenGL ES 1.1 for rendering**
  - May be memory limited on devices with small displays
- **Copybit acceleration may be desirable for UI on some devices**
  - E.g. popular Vivante configuration:
    - 3D core for games, 2D core for UI

Gralloc

- Used to allocate and map graphics memory to app processes
- Facilitates graphics memory export via Binder IPC mechanism
- Provides cache synchronization points
- Also used for framebuffer discovery

Overheads

- **Composition overhead**
  - Vivante uses Android extensions such as "EGLImage from Android native buffer", and also can employ copybit (2D) backend to further offload GPU
  - Vivante uses non-linear textures for 3D apps to improve memory access locality
- **JVM overhead**
  - Native code for key operations
  - TraceView tool
- **Cache management overhead**
  - Fast, range-based L1$ and L2$ functions (clean, invalidate, flush)
  - Beware of $ related errata for your CPU

Driver Challenges

- **Thread safety**
  - Normally sufficient if guaranteed at EGL layer
  - Gralloc requires it be pushed lower
- **Cacheable buffers**
  - Normally uncached graphics memory is sufficient for gaming use cases
  - Cached buffers result in higher performance for CPU rendering in compositing systems

Miscellaneous Challenges

- **Component ownership**
  - gralloc co-owned by GPU and SoC vendors
- **Interworking of graphics and video**
  - Accelerators depend on one another (best pixel format, maximum stride supported, etc.)
  - Early engagement between GPU and SoC vendors helps
- **Legal/licensing**
  - Always good to know your license rules
  - APL versus GPL

Tips

- **GPU rendering doesn't mean CPU is offloaded completely**
  - Some operations such as texture uploads heavily use CPU
  - Avoid uploading on every frame
- **Batch your draws**
  - allow GPU to go into sleep mode intraframe as well as interframe
  - allow voltage and frequency scaling to work
- **Test with different pixel formats**
  - GPUs work faster with some than others
- **Know your display refresh rate**
  - apps are usually throttled by VSYNC
  - if you miss a VSYNC, your framerate is halved

Thank You!

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