

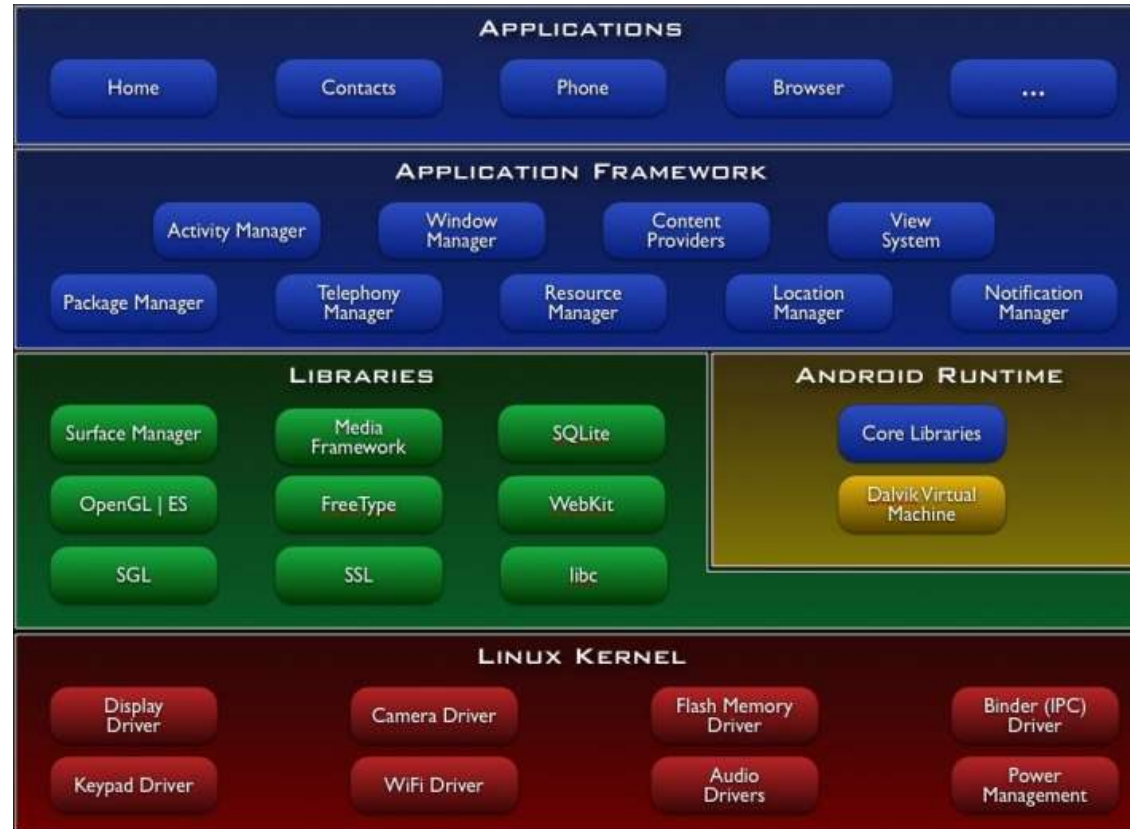


High Performance Graphics on Android

**Cemil Azizoglu, Ph. D.
Vivante Corporation**

What is Android?

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



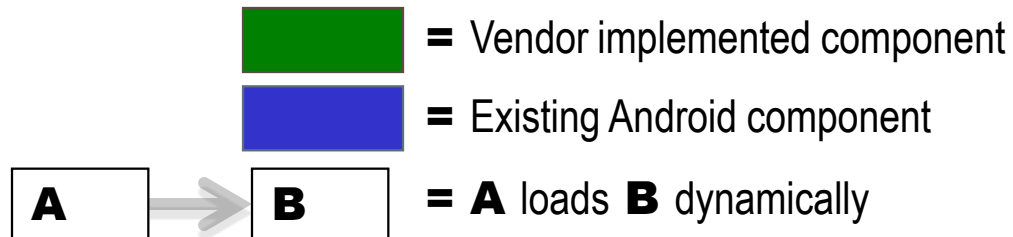
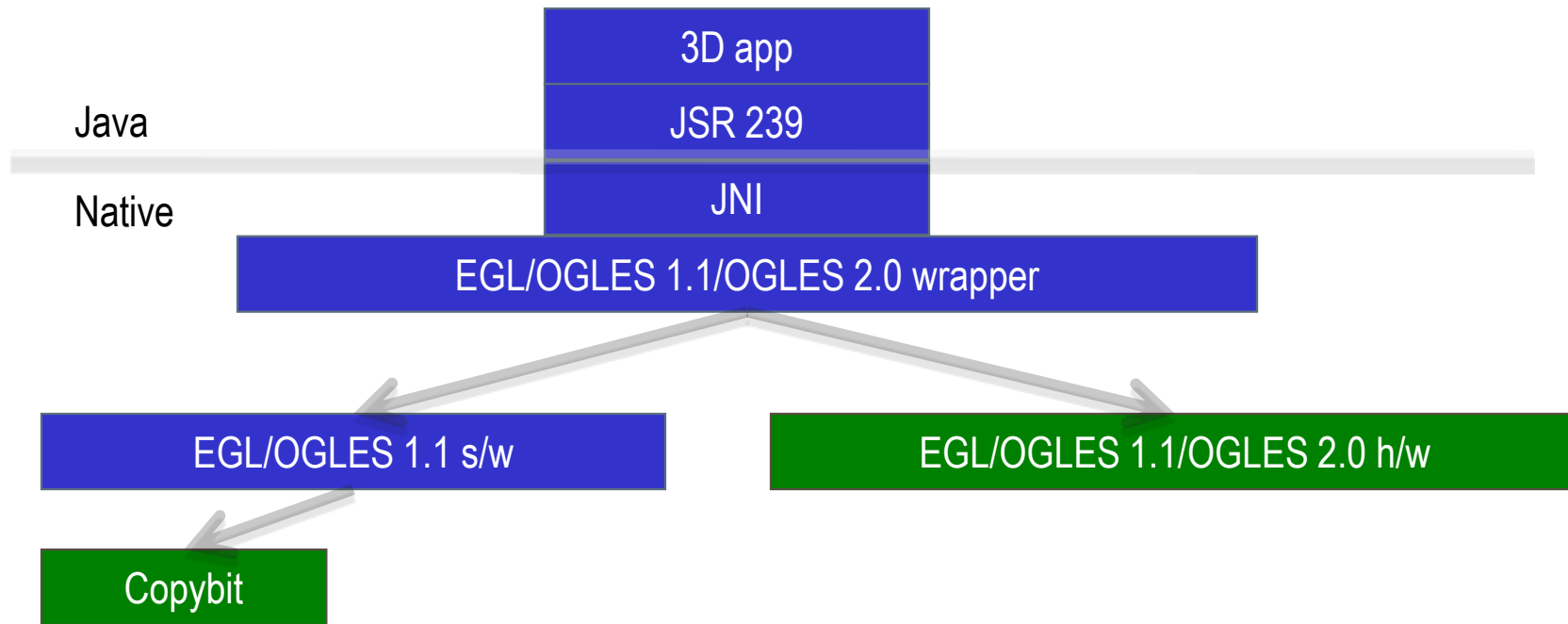
Android Facts

- **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

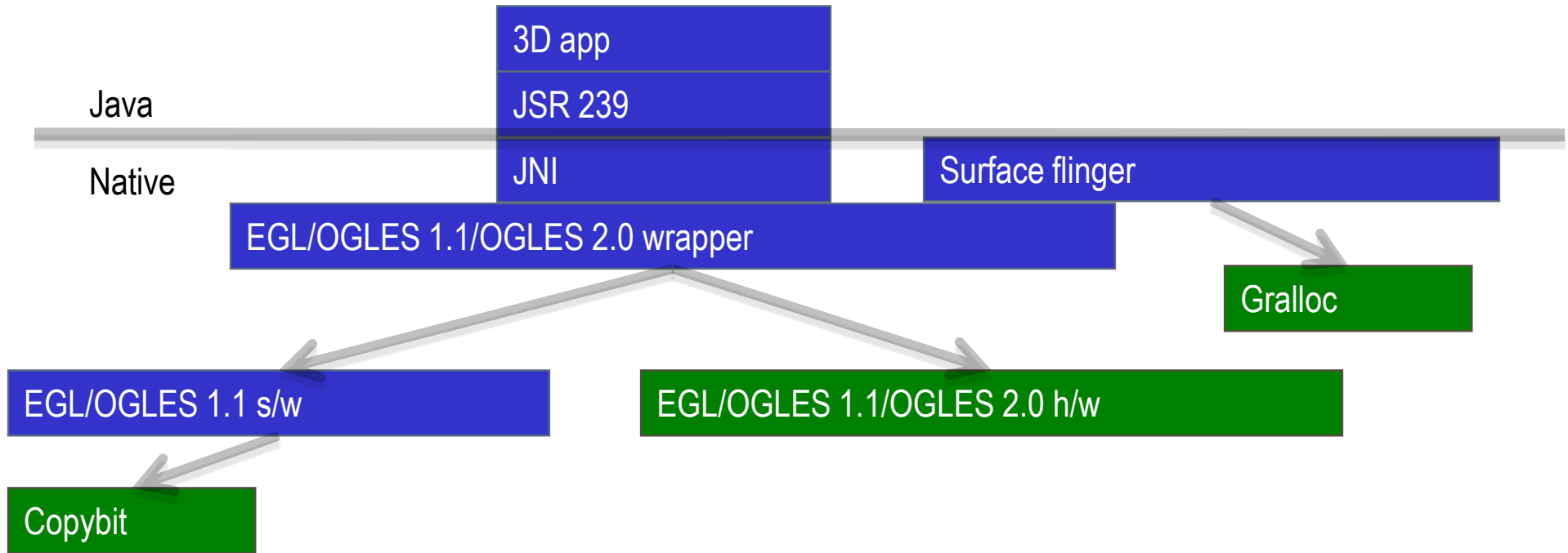
Android 3D Graphics Stack



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



= Vendor implemented component

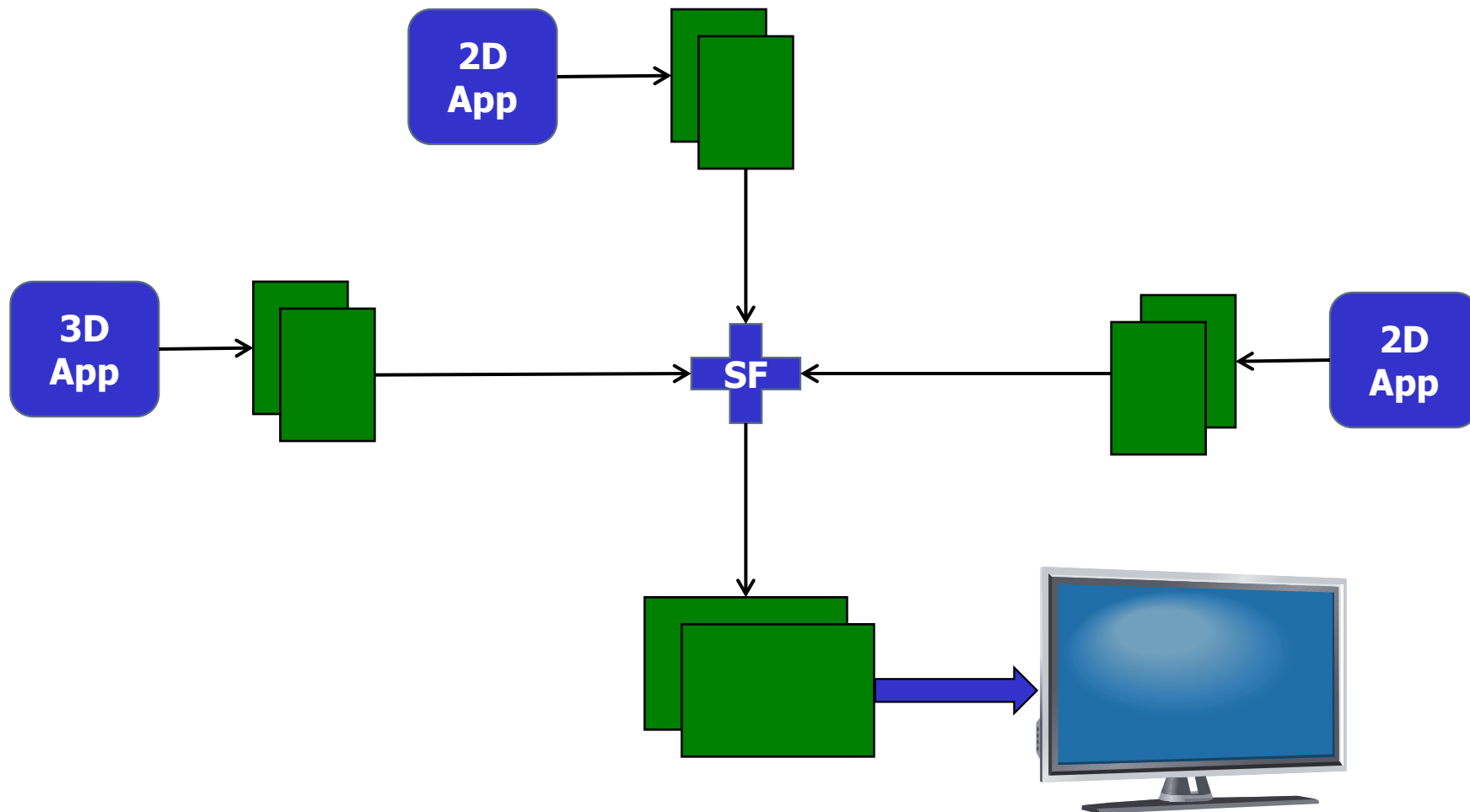


= Existing Android component



= **A** loads **B** dynamically

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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