内容目录

[一 显示系统框架 1](#__RefHeading___Toc248_2054555503)

[a. 显示驱动framebuffer(fb)的原理及改进 1](#__RefHeading___Toc250_2054555503)

[b. 多任务系统的显示: 必定有一个显示管理者 2](#__RefHeading___Toc252_2054555503)

[二 修改源码禁用hwc和GPU 2](#__RefHeading___Toc254_2054555503)

[2.1 tiny4412 2](#__RefHeading___Toc256_2054555503)

[2.2 qcom 4](#__RefHeading___Toc258_2054555503)

[三 最简单的Surface测试程序 5](#__RefHeading___Toc840_1903101977)

[四 SurfaceFlinger内部机制分析 6](#__RefHeading___Toc1263_1273687975)

[4.1 APP跟SurfaceFlinger之间的重要数据结构 6](#__RefHeading___Toc1265_1273687975)

[4.2 APP创建SurfaceFlinger客户端(client)的过程 6](#__RefHeading___Toc1267_1273687975)

[4.3 APP申请创建Surface的过程 6](#__RefHeading___Toc1269_1273687975)

[4.4 APP申请(lock)Buffer的过程\_框架 + 7](#__RefHeading___Toc1271_1273687975)

[4.5 APP申请(lock)Buffer的过程\_分配buffer + 7](#__RefHeading___Toc1273_1273687975)

[4.6 APP申请(lock)Buffer的过程\_获得buffer信息 7](#__RefHeading___Toc1275_1273687975)

[4.7 APP提交(unlockAndPost)Buffer的过程\_框架 + 7](#__RefHeading___Toc1277_1273687975)

[4.8 APP提交(unlockAndPost)Buffer的过程\_消费者创建过程 + 7](#__RefHeading___Toc1279_1273687975)

[4.9 APP提交(unlockAndPost)Buffer的过程\_提交过程 7](#__RefHeading___Toc1281_1273687975)

[五. Vsync机制 7](#__RefHeading___Toc1283_1273687975)

[5.1 黄油计划\_三个方法改进显示系统 7](#__RefHeading___Toc1285_1273687975)

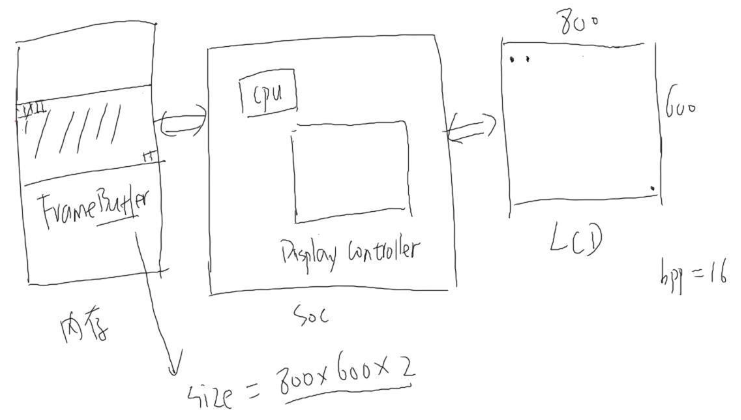
[5.2 Vsync框架 7](#__RefHeading___Toc1764_1519259852)

[5.3 初始化代码分析 7](#__RefHeading___Toc1766_1519259852)

# 一 显示系统框架

显示系统001\_框架.jpg

## a. 显示驱动framebuffer(fb)的原理及改进

只有1个fb的缺点

(1) 如果APP写fb速度慢，LCD图像变化慢

(2) 如果APP写fb速度不快不慢，闪烁

(3) APP写fb速度快--OK

改进：使用多个FB，循环 while(1) {

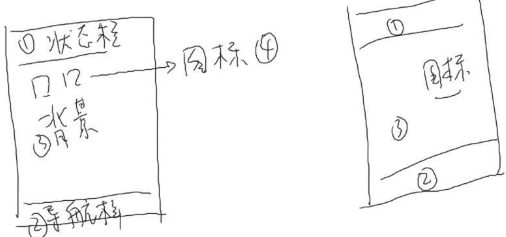
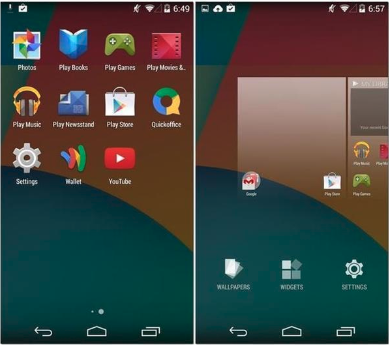
(1) Display Controller使用FB0

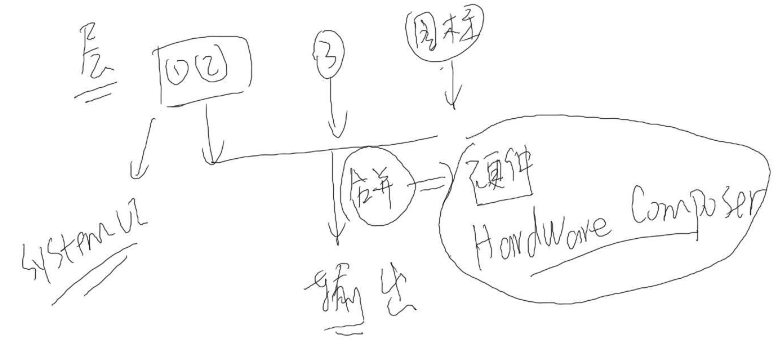
(2) APP写fb1

(3) Display Controller使用FB1

(4) APP写fb0

}

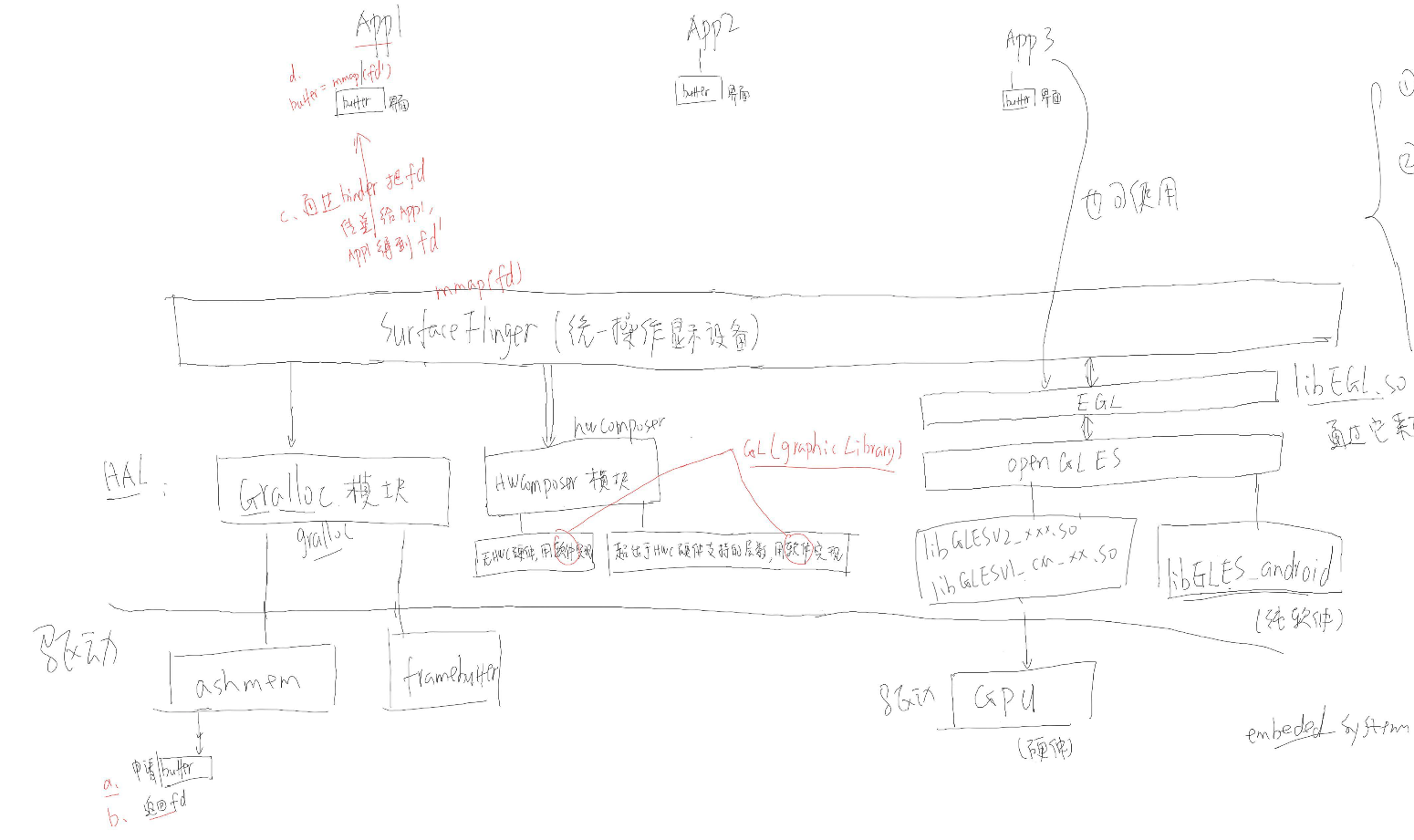


 重复工作1、2、3，其中1和2是systemUI进程，3是进程2，图标是进程3，如果芯片支持合成HardwareComposer那么可以提升性能。

驱动支持HWC:

每一层对应一个驱动/dev/fbx，APP操作某层，直接写对应的framebuffer，硬件自动合成他们。

## b. 多任务系统的显示: 必定有一个显示管理者

 跟高通文档的架构很相近，只不过高通底层是SDM，这边是通用的framebuffer

sufraceflinger:

(1)给APP提供buffer

a.通过gralloc模块向ashmem申请内存

b.得到一个fd

c.通过binder把fd传给某个APP，APP得到fd’

d.APP再mmap(fd’)

(2)APP1、2、3把各自界面发给它，它根据层次、大小进行合成、显示

a.根据各个界面的Z值决定前后顺序，由WindowManagerService确定

b.把这些排序后的buffer传给HWComposer

(3)当HWC不能处理(无HWC硬件/超出HWC层数)buffer时，使用GL(GraphicLibrary)来处理

libEGL硬件GL库、软件GL库

# 二 修改源码禁用hwc和GPU

厂家一般不会提供硬件合成器和GPU源代码，无法分析

## 2.1 tiny4412

git clone https://github.com/weidongshan/SYS\_0003\_Patch\_Disable\_HWC\_GPU\_tiny4412.git

git checkout v1

android-5.0.2\_no\_hwc\_no\_gpu.patch

这个补丁做了3件事:

**a. 去掉厂家提供的gralloc, hwcompser HAL模块**

hardware/libhardware/hardware.c

#if defined(\_\_LP64\_\_)

#define HAL\_LIBRARY\_PATH1 "/system/lib64/hw"

#define HAL\_LIBRARY\_PATH2 "/vendor/lib64/hw"

#define HAL\_LIBRARY\_PATH3 "/odm/lib64/hw"

#else

#define HAL\_LIBRARY\_PATH1 "/system/lib/hw"

#define HAL\_LIBRARY\_PATH2 "/vendor/lib/hw"

#define HAL\_LIBRARY\_PATH3 "/odm/lib/hw"

#endif

static const char \*variant\_keys[] = {

"ro.hardware", /\* This goes first so that it can pick up a different

file on the emulator. \*/

"ro.product.board",

"ro.board.platform",

"ro.arch"

};

hw\_get\_module\_by\_class //查找，load so库

文件名gralloc.属性值.so: gralloc.tiny4412.so, gralloc.exynos4.so，最后 gralloc.default.so

**a.1 删除单板上/system/lib/hw**

gralloc.tiny4412.so

hwcomposer.exynos4.so

adb reboot之后，黑屏一片

查看错误信息

logcat \*:E

hwcomposer module not found

invalid buffer handle given //这个错误视频中查找不到源代码，是厂家另外一个库文件，把相关的都可以干掉/system/lib/egl/，不干掉也没事，因为后续要修改属性

**a.2 修改源码使得编译结果中不含上述文件 (修改vendor/friendly-arm/tiny4412/device-tiny4412.mk, 参考补丁)**

-

**b. 添加属性让android系统认为自己运行于"没有GPU的模拟器"**

修改libagl/Android.mk，给系统添加libGLES\_android.so (软件实现的GL)

**b.1 添加软件GPU库**

开发板: su, mount -o remount /system

在服务器编译软件GPU库: mmm frameworks/native/opengl/libagl

把得到的libGLES\_android.so复制到单板/system/lib/eg/，并添加读属性

adb reboot之后

couldn’t find an OpenGL ES implementation

搜索之后，错误文件

frameworks/native/opengl/libs/EGL/Loader.cpp

找到加载libGLES\_android.so的代码，发现需要修改属性值

**b.2 修改frameworks/native/opengl/libagl/Android.mk (参考补丁)**

-

**b.3 修改属性文件 , 单板 adb shell 进去修改 /system/build.prop，添加:**

ro.kernel.qemu=1

ro.kernel.qemu.gles=0

或修改源码 device/friendly-arm/tiny4412/system.prop 同样添加上述属性, 然后重新编译系统

adb reboot之后

no suitable EGLConfig found, giving up

**c. 修改系统自带的gralloc模块的BUG**

**c.1 查找错误文件**

frameworks/native/services/surfaceflinger/RenderEngine/RenderEngine.cpp

EGLConfig RenderEngine::chooseEglConfig(EGLDisplay display, int format, bool logConfig) {

尝试获得ES2的配置，如果失败尝试获得ES1的配置(硬线相关的)，否则使用简单查询方式来获得配置

}

经过debug，怀疑是配置问题

hardware/libhardware/modules/gralloc/Framebuffer.cpp

HAL\_PIXEL\_FORMAT\_BGRA\_8888

改为：

HAL\_PIXEL\_FORMAT\_RGBA\_8888

mmm hardware/libhardware/modules/gralloc/

把gralloc.default.so复制到单板/system/lib/hw

adb reboot之后，出错:

E/BufferQueueProducer( 2320): [FramebufferSurface] dequeueBuffer: createGraphicBuffer failed

W/GraphicBufferAllocator( 1918): alloc(800, 480, 1, 00001a33, ...) failed -12 (Out of memory)

**c.2 继续修改 hardware\libhardware\modules\gralloc\Framebuffer.cpp**

frameworks/native/libs/ui/GraphicBufferAllocator.cpp

const std::unique\_ptr<const Gralloc2::Allocator> mAllocator;

status\_t GraphicBufferAllocator::allocate(uint32\_t width, uint32\_t height,

PixelFormat format, uint32\_t layerCount, uint64\_t usage,

buffer\_handle\_t\* handle, uint32\_t\* stride,

uint64\_t /\*graphicBufferId\*/, std::string requestorName)

{

。。。

Gralloc2::Error error = mAllocator->allocate(info, stride, handle);//打开Gralloc模块涉及的结构体

if (error == Gralloc2::Error::NONE) {

Mutex::Autolock \_l(sLock);

KeyedVector<buffer\_handle\_t, alloc\_rec\_t>& list(sAllocList);

uint32\_t bpp = bytesPerPixel(format);

alloc\_rec\_t rec;

rec.width = width;

rec.height = height;

rec.stride = \*stride;

rec.format = format;

rec.layerCount = layerCount;

rec.usage = usage;

rec.size = static\_cast<size\_t>(height \* (\*stride) \* bpp);

rec.requestorName = std::move(requestorName);

list.add(\*handle, rec);

return NO\_ERROR;

} else {

ALOGE("Failed to allocate (%u x %u) layerCount %u format %d "

"usage %" PRIx64 ": %d",

width, height, layerCount, format, usage,

error);

return NO\_MEMORY;

}

}

经过code flow追查

hardware/libhardware/modules/gralloc/gralloc.cpp

dev->device.alloc = gralloc\_alloc;

static int gralloc\_alloc(alloc\_device\_t\* dev,

int width, int height, int format, int usage,

buffer\_handle\_t\* pHandle, int\* pStride)

{

。。。

int err;

if (usage & GRALLOC\_USAGE\_HW\_FB) {

err = gralloc\_alloc\_framebuffer(dev, size, usage, pHandle);//从framebuffer里面分配内存，错误信息usage=1a33

if (bufferMask >= ((1LU<<numBuffers)-1)) {

// We ran out of buffers.

return -ENOMEM;//-12

}

} else {

err = gralloc\_alloc\_buffer(dev, size, usage, pHandle);//从ashmem里面分配内存

}

if (err < 0) {

return err;

}

\*pStride = stride;

return 0;

}

hardware/libhardware/modules/gralloc/framebuffer.cpp

+#if 0//不需要再申请framebuffer

/\*

\* Request NUM\_BUFFERS screens (at lest 2 for page flipping)

\*/

info.yres\_virtual = info.yres \* NUM\_BUFFERS;

- uint32\_t flags = PAGE\_FLIP;

#if USE\_PAN\_DISPLAY

if (ioctl(fd, FBIOPAN\_DISPLAY, &info) == -1) {

ALOGW("FBIOPAN\_DISPLAY failed, page flipping not supported");

@@ -195,6 +206,16 @@

info.yres\_virtual = info.yres;

flags &= ~PAGE\_FLIP;

}

+#endif//直接获取即可

+

+ if (ioctl(fd, FBIOGET\_VSCREENINFO, &info) == -1)

+ return -errno;

+ info.yres\_virtual = info.yres\_virtual;//虚拟分辨率，比如800×600，虚拟y可以分配3个800，而yres为800

+ if (info.yres\_virtual > info.yres)

+ flags |= PAGE\_FLIP;

+ else

+ flags &= ~PAGE\_FLIP;

+

hardware/libhardware/modules/gralloc/framebuffer.cpp

+#if 0

if (ioctl(m->framebuffer->fd, FBIOPUT\_VSCREENINFO, &m->info) == -1) {

ALOGE("FBIOPUT\_VSCREENINFO failed");

m->base.unlock(&m->base, buffer);

return -errno;

}

+#else

+ if (ioctl(m->framebuffer->fd, FBIOPAN\_DISPLAY, &m->info) == -1) {//通过FBIOPAN\_DISPLAY 来确定使用那个buffer

+ ALOGE("FBIOPAN\_DISPLAY failed");

+ m->base.unlock(&m->base, buffer);

+ return -errno;

+ }

+#endif

+

**重启之后成功!**

## **2.2 qcom**

**gralloc**

源码位置

hardware/qcom/display/gralloc

LOCAL\_MODULE := gralloc.$(TARGET\_BOARD\_PLATFORM)

库位置

sm6150\_au:/vendor/lib64/hw # ls gralloc.\*.so

gralloc.default.so gralloc.sm6150.so

sm6150\_au:/ # getprop ro.hardware

qcom

sm6150\_au:/ # getprop ro.product.board

sm6150

sm6150\_au:/ # getprop ro.board.platform

sm6150

sm6150\_au:/ # getprop ro.arch

属性值

ro.kernel.qemu

qemu.gles

# 三 最简单的Surface测试程序

git clone https://github.com/weidongshan/APP\_0010\_SurfaceTest.git

Display/APP\_0010\_SurfaceTest

参考demo

frameworks/native/services/surfaceflinger/tests/resize

错误fix

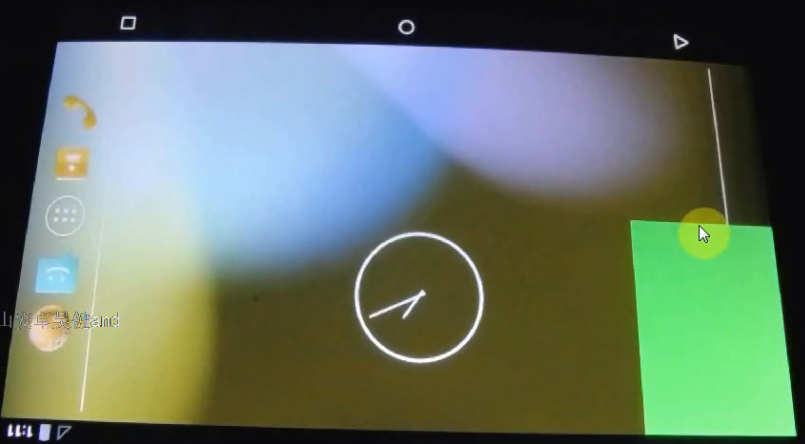
<http://www.aichengxu.com/android/8815305.htm>

取出指定版本:

git checkout v1 // v1, correct the bugs from frameworks/native/services/surfaceflinger/tests/resize

git checkout v2 // v2, display B,G,R color

git checkout v3 // v3, print the buffer address



v1版本编译后多了一个绿色的长方块

int main(int argc, char\*\* argv)

{

// set up the thread-pool

sp<ProcessState> proc(ProcessState::self());

ProcessState::self()->startThreadPool();

// create a client to surfaceflinger

sp<SurfaceComposerClient> client = new SurfaceComposerClient();//获得surface服务

sp<SurfaceControl> surfaceControl = client->createSurface(String8("resize"),//创建surface

160, 240, PIXEL\_FORMAT\_RGB\_565, 0);

sp<Surface> surface = surfaceControl->getSurface();//获得surface

SurfaceComposerClient::openGlobalTransaction();

surfaceControl->setLayer(100000);//设置Z轴，为了覆盖用，dumpsys SurfaceFlinger可以查看到z轴的大小

SurfaceComposerClient::closeGlobalTransaction();

ANativeWindow\_Buffer outBuffer;

surface->lock(&outBuffer, NULL);//获得surface的一个buffer

ssize\_t bpr = outBuffer.stride \* bytesPerPixel(outBuffer.format);

android\_memset16((uint16\_t\*)outBuffer.bits, 0xF800, bpr\*outBuffer.height);//填充buffer，0xF800一种颜色

surface->unlockAndPost();//把buffer提交给surfaceflinger让它显示出来

+ sleep(3);//加入休眠，为了看出变化(v2版本主要改动，也加入了其他颜色)

surface->lock(&outBuffer, NULL);//获得surface的另一个buffer

android\_memset16((uint16\_t\*)outBuffer.bits, 0x07E0, bpr\*outBuffer.height);//填充buffer，另外一种颜色

surface->unlockAndPost();//再次提交

+ sleep(3);

SurfaceComposerClient::openGlobalTransaction();

surfaceControl->setSize(320, 240);

SurfaceComposerClient::closeGlobalTransaction();

+ for (int i = 0; i < 100; i++) {//v3

+ surface->lock(&outBuffer, NULL);

+ printf("%03d buff addr = 0x%x\n", i, (unsigned int)outBuffer.bits);

+ surface->unlockAndPost();

+ }

输出结果，应用程序对于一个surface，分配了三个buffer

000 buff addr = 0x4003e000

001 buff addr = 0x40083000

002 buff addr = 0x403be000

003 buff addr = 0x4003e000

004 buff addr = 0x40083000

005 buff addr = 0x403be000

...

IPCThreadState::self()->joinThreadPool();

return 0;

}

# 四 SurfaceFlinger内部机制分析

调用关系uml工程: uml\_tmp\_file\uml\_tmp\_file\surface\_uml\surface\_uml.prj

## 4.1 APP跟SurfaceFlinger之间的重要数据结构

一个应用程序可以构造多个surface，一般来说只有一个surface，一个surface里面可以有多个buffer

这些buffer需要向SurfaceFlinger来申请

先写出结论:

用client表示APP，多个APP那就有多个client，

client中用Layer，用来表示APP的SurfaceControl

frameworks/native/services/surfaceflinger/Layer.h

Layer{

生产者 -- sp<IGraphicBufferProducer> mProducer;

消费者 -- sp<SurfaceFlingerConsumer> mSurfaceFlingerConsumer;

}//生产者从buffer中放入data，消费者从buffer中取出data

从本文来说，Layer里面的生产者和消费者拥有的是同一个BufferQueueCore

mProducer和mSurfaceFlingerConsumer有同一个mCore(sp<BufferQueueCore> mCore;)

frameworks/native/include/gui/BufferQueueCore.h

BufferQueueCore有一个mSlots(BufferSlot[64]数组)，这意味着APP里每一个surface里面最多可以有64个buffer，这个BufferSlot每一项中有一个mGraphicBuffer，用来表示buffer

BufferQueueDefs::SlotsType mSlots;//SlotsType是一个数组

frameworks/native/libs/gui/include/gui/BufferQueueDefs.h

typedef BufferSlot SlotsType[NUM\_BUFFER\_SLOTS];

frameworks/native/include/gui/BufferSlot.h

sp<GraphicBuffer> mGraphicBuffer;//用来表示一个buffer

打开之前的SurfaceFlinger测试程序，

sp<SurfaceComposerClient> client = new SurfaceComposerClient();//每个APP跟SurfaceFlinger都有一个连接，表示这个连接

native/include/gui/SurfaceComposerClient.h

sp<ISurfaceComposerClient> mClient;//有一个mClient(APP里)，它指向的就是SurfaceFlinger的client

sp<SurfaceContorl> surfaceControl = client->createSurface(String8("resize"), 160, 240, PIXEL\_FORMAT\_RGB\_565, 0)//每一个Surface对应有一个SurfaceControl

sp<Surface> surface = surfaceControl->getSurface();//再从SurfaceContorl里面得到我们的surface，所以说surface是用SurfaceContorl来管理的，SurfaceControl对应SurfaceFlinger的Layer

surface->lock(&outBuffer, NULL);//从surface里面取出buffer

frameworks/native/include/gui/Surface.h

BufferSlot mSlots[NUM\_BUFFER\_SLOTS];//一个surface里有一个数组对应SurfaceFlinger的mSlots BufferSlot[64]数组，每一个数组项含有一个mGraphicBuffer，表示buffer，双方的buffer指向同一个物理内存

小结:

APP发起请求，SurfaceFlinger接收到请求之后，使用Gralloc模块从匿名共享内存中分配出一块内存，然后记录在mGraphicBuffer的buffer里面，将这个信息返回给APP，APP再根据这个信息构造出对应的mGraphicBuffer

## 4.2 APP创建SurfaceFlinger客户端(client)的过程

//创建client

sp<SurfaceComposerClient> client = new SurfaceComposerClient();//获得surfaceflinger服务, class Client : public BnSurfaceComposerClient

uml\_tmp\_file\uml\_tmp\_file\surface\_uml\surface\_uml.prj -- 001\_create\_client A1.

## 4.3 APP申请创建Surface的过程

//1 创建surfaceControl

sp<SurfaceControl> surfaceControl = client->createSurface(String8("resize"), 160, 240, PIXEL\_FORMAT\_RGB\_565, 0);

sp<Surface> surface = surfaceControl->getSurface();

binder proxy端发起createSurface{

mClient->createSurface(..., &handle, &gpb)//主要就是这个代理类gpb最终指向的是surfaceflinger端的BufferQueueProducer，他们都遵守了IGraphicBufferProducer

}

生产者(代理类){

1. APP - surfaceflinger与之对应一个client

2. SurfaceControl - surfaceflinger与之对应一个Layer(本例是createNormalLayer-> new Layer){.mProducer(MonitorProducer); .mProducer里面还有一个mProducer(BufferQueueProducer)}

3. .gpb指向mProducer(BufferQueueProducer)，

}

//2 获得surface，surface里面封装有一个生产者，还有一个mSlot[64]，后续的获得buffer、提交buffer肯定都跟他有关

sp<Surface> surface = surfaceControl->getSurface();

-> mSurfaceData = new Surface(mGraphicBufferProducer, false);//mGraphicBufferProducer就是gpb，这个就是后续操作显存的核心

## 4.4 APP申请(lock)Buffer的过程\_框架 +

## 4.5 APP申请(lock)Buffer的过程\_分配buffer +

## 4.6 APP申请(lock)Buffer的过程\_获得buffer信息

surface->lock(&outBuffer, NULL);

APP获得Surface中的Buffer，猜测一下：

a. 查看mSlots中有无空余项(代码里没有这一项)

b. 若无，向生产者申请，SurfaceFlinger进程的动作

b.1 查看mSlots中有无空余项

b.2 若无，向Gralloc HAL申请

b.3 返回fd给APP

c. 获得fd'，mmap获得地址，通过Gralloc HAL来mmap

//以上是一系列复杂调用，最终导致APP获得了SurfaceFlinger端的分配的虚拟地址和显存信息

## 4.7 APP提交(unlockAndPost)Buffer的过程\_框架 +

## 4.8 APP提交(unlockAndPost)Buffer的过程\_消费者创建过程 +

## 4.9 APP提交(unlockAndPost)Buffer的过程\_提交过程

surface->unlockAndPost();

猜测unlockAndPost会做什么事情: 入队列，通知消费者，消费者通知Layer，Layer通知client，client通知SurfaceFlinger，SurfaceFlinger是消费者

# 五. Vsync机制

## 5.1 黄油计划\_三个方法改进显示系统

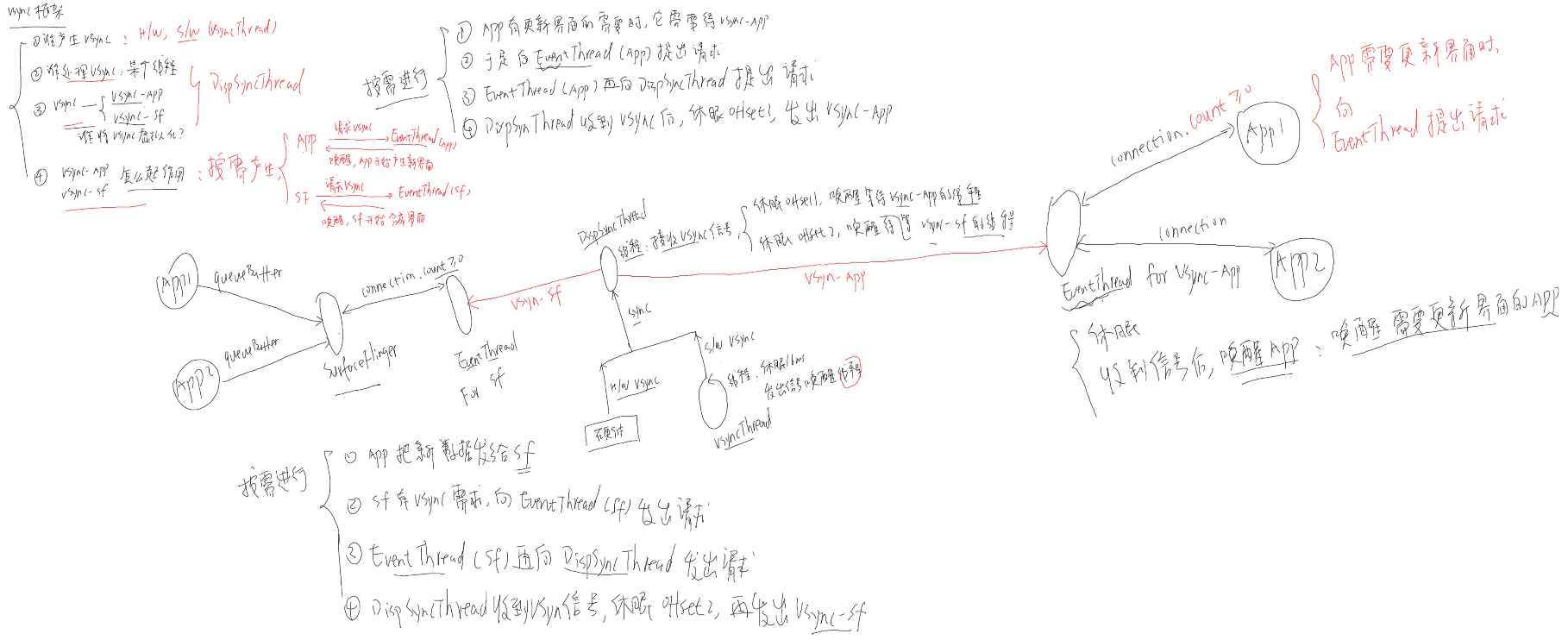
高清电影或者玩游戏的时候，帧率要达到60fps以上，才比较舒服比较流畅，即1秒要显示60幅图像，也就是16毫秒要显示一幅图像

利用vsync机制，vysnc到来时各单位必须及时工作；三个buffer；vsync分为两路，一路是app(vsync+offset1)，一路是sf(sync+offset2)，这样使得app构造好的新画面，sf紧接着合成

## 5.2 Vsync框架

## 5.3 初始化代码分析

显示系统009\_VSYNC机制\_框架.jpg，图中s/w vsync线程、DispSyncThread、eventThread-for-vsync-app、eventThread-for-vsync-sf、surfaceflinger线程，都在surfaceflinger进程中。这节主要目的就是看看以上这五个线程的创建。



frameworks/native/services/surfaceflinger/main\_surfaceflinger.cpp

int main(int, char\*\*) {

signal(SIGPIPE, SIG\_IGN);

hardware::configureRpcThreadpool(1 /\* maxThreads \*/,

false /\* callerWillJoin \*/);

startGraphicsAllocatorService();

// When SF is launched in its own process, limit the number of

// binder threads to 4.

ProcessState::self()->setThreadPoolMaxThreadCount(4);

// start the thread pool

sp<ProcessState> ps(ProcessState::self());

ps->startThreadPool();

// instantiate surfaceflinger，创建surfaceflinger对象

sp<SurfaceFlinger> flinger = DisplayUtils::getInstance()->getSFInstance();

setpriority(PRIO\_PROCESS, 0, PRIORITY\_URGENT\_DISPLAY);

set\_sched\_policy(0, SP\_FOREGROUND);

// Put most SurfaceFlinger threads in the system-background cpuset

// Keeps us from unnecessarily using big cores

// Do this after the binder thread pool init

if (cpusets\_enabled()) set\_cpuset\_policy(0, SP\_SYSTEM);

// initialize before clients can connect

flinger->init();// DispSyncThread创建出来，找到第一个

// publish surface flinger

sp<IServiceManager> sm(defaultServiceManager());

sm->addService(String16(SurfaceFlinger::getServiceName()), flinger, false);

// publish GpuService

sp<GpuService> gpuservice = new GpuService();

sm->addService(String16(GpuService::SERVICE\_NAME), gpuservice, false);

startDisplayService(); // dependency on SF getting registered above

struct sched\_param param = {0};

param.sched\_priority = 2;

if (sched\_setscheduler(0, SCHED\_FIFO, &param) != 0) {

ALOGE("Couldn't set SCHED\_FIFO");

}

// run surface flinger in this thread

flinger->run();//找到第五个

return 0;

}

frameworks/native/services/surfaceflinger/SurfaceFlinger.h

class SurfaceFlinger

{

DispSync mPrimaryDispSync;

mutable MessageQueue mEventQueue;

}

frameworks/native/services/surfaceflinger/DispSync.cpp

DispSync::DispSync(const char\* name) :

mName(name),

mRefreshSkipCount(0),

mThread(new DispSyncThread(name)) {

}

void DispSync::init(bool hasSyncFramework, int64\_t dispSyncPresentTimeOffset) {

mIgnorePresentFences = !hasSyncFramework;

mPresentTimeOffset = dispSyncPresentTimeOffset;

mThread->run("DispSync", PRIORITY\_URGENT\_DISPLAY + PRIORITY\_MORE\_FAVORABLE);

…

}

frameworks/native/services/surfaceflinger/SurfaceFlinger.cpp

void SurfaceFlinger::onFirstRef()

{

mEventQueue.init(this);//sp被首次引用时，初始化一个消息队列

}

void SurfaceFlinger::init() {//我们只看vsync相关的

// start the EventThread，offset和名字不一样，找到第三个，第四个

sp<VSyncSource> vsyncSrc = new DispSyncSource(&mPrimaryDispSync,

vsyncPhaseOffsetNs, true, "app");

mEventThread = new EventThread(vsyncSrc, \*this, false);

sp<VSyncSource> sfVsyncSrc = new DispSyncSource(&mPrimaryDispSync,

sfVsyncPhaseOffsetNs, true, "sf");

mSFEventThread = new EventThread(sfVsyncSrc, \*this, true);

mEventQueue.setEventThread(mSFEventThread);

mHwc.reset(new HWComposer(false));

}

void SurfaceFlinger::run() {

do {

waitForEvent();

} while (true);

}

frameworks/native/services/surfaceflinger/DisplayHardware/HWComposer\_hwc1.cpp – 版本比较旧了

HWComposer::HWComposer(…) {

...

if (needVSyncThread) {

// we don't have VSYNC support, we need to fake it

mVSyncThread = new VsyncThread(\*this);//软件模拟产生vsync信号，找到第二个

}

}

void HWComposer::VSyncThread::onFirstRef() {

run("VSyncThread", PRIORITY\_URGENT\_DISPLAY + PRIORITY\_MORE\_FAVORABLE);

}

frameworks/native/services/surfaceflinger/MessageQueue.cpp

void MessageQueue::setEventThread(const sp<EventThread>& eventThread)

{

if (mEventThread == eventThread) {

return;

}

if (mEventTube.getFd() >= 0) {

mLooper->removeFd(mEventTube.getFd());

}

mEventThread = eventThread;

mEvents = eventThread->createEventConnection();

mEvents->stealReceiveChannel(&mEventTube);

mLooper->addFd(mEventTube.getFd(), 0, Looper::EVENT\_INPUT,//sf和EventThread之间通过文件句柄进行数据count的传递

MessageQueue::cb\_eventReceiver, this);

}

聂神给的一块代码

if (!timestamp && !eventPending) {

// wait for something to happen

if (waitForVSync) {

bool softwareSync = mUseSoftwareVSync;//这里只考虑硬件vsync的情况,软件模拟的暂时不考虑

nsecs\_t timeout = softwareSync ? ms2ns(16) : ms2ns(1000);

//如注释所说的，如果是driver的bug，如果硬件一直不上报vsync事件怎么办？？难道就一直等下去？？那client不就饿死了么？

//所以这里如果driver不报vsync，那么就软件模拟一个vsync事件，这里的timeout是1000ms，发一个

if (mCondition.waitRelative(mLock, timeout) == TIMED\_OUT) {

if (!softwareSync) {

ALOGW("Timed out waiting for hw vsync; faking it");

}

mVSyncEvent[0].header.type = DisplayEventReceiver::DISPLAY\_EVENT\_VSYNC;

mVSyncEvent[0].header.id = DisplayDevice::DISPLAY\_PRIMARY;

mVSyncEvent[0].header.timestamp = systemTime(SYSTEM\_TIME\_MONOTONIC);

mVSyncEvent[0].vsync.count++;

}

} else {

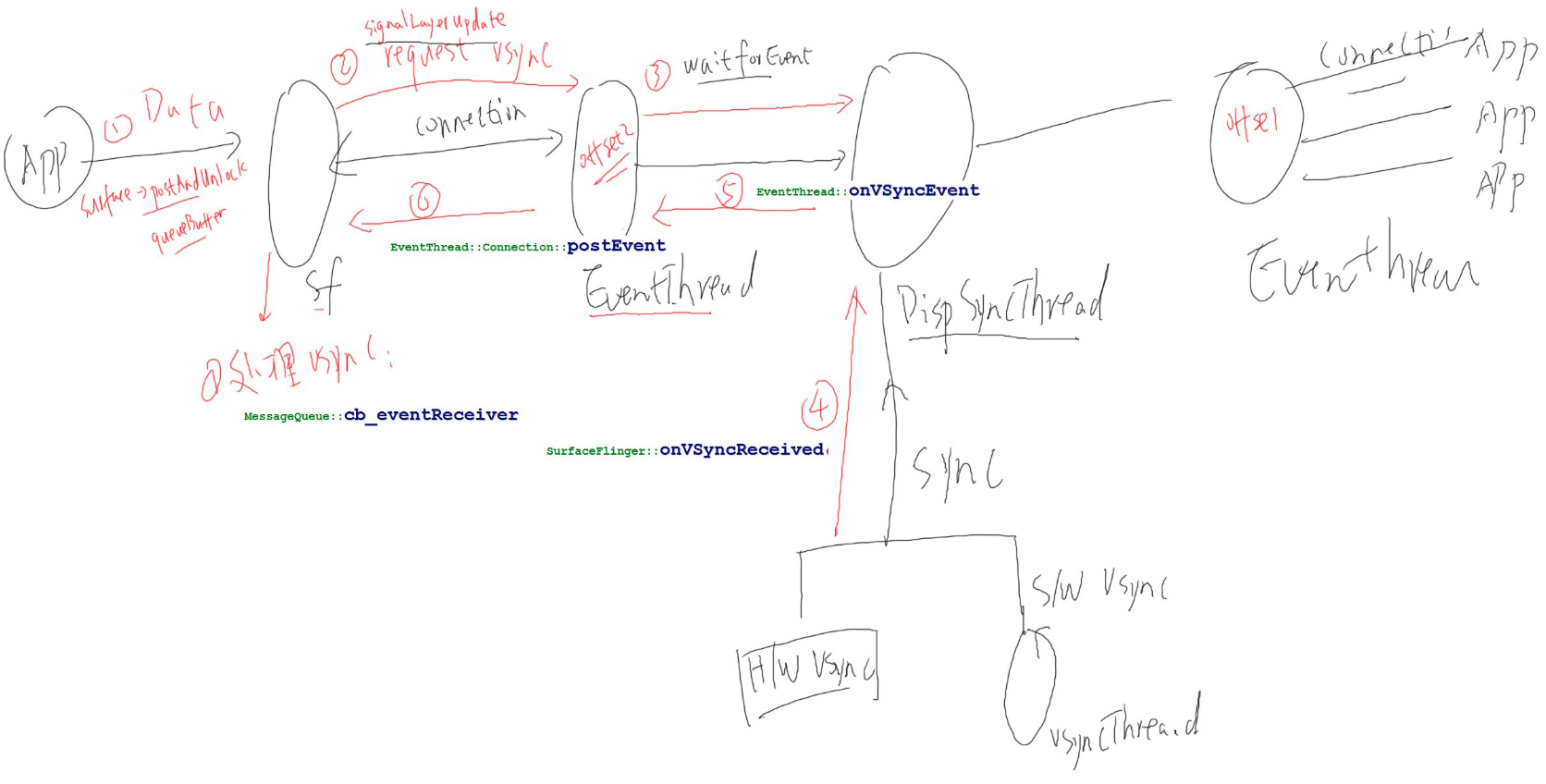
//既没有client, 又没有硬件vsync事件，那么就死等下去了。

mCondition.wait(mLock);

}

}

## 5.4 surfaceflinger使用vsync过程代码分析



### 5.4.1 APP->SF

步骤一，app是怎么提交buf到sf的，在《显示系统007\_APP提交buffer的过程.jpg》已经分析完了，不再赘述

### 5.4.2 SF->EventThread

步骤二，发送vsync请求，从mFlinger->singnalLayerUpdate()开始看，我们尽量看HWC2版本的代码。

frameworks/native/services/surfaceflinger/SurfaceFlinger.cpp

void SurfaceFlinger::signalLayerUpdate() {

mEventQueue.invalidate();

}

frameworks/native/services/surfaceflinger/MessageQueue.cpp

void MessageQueue::invalidate() {

mEvents->requestNextVsync();//请求得到下一个vsync信号

}

frameworks/native/services/surfaceflinger/EventThread.cpp

void EventThread::Connection::requestNextVsync() {

mEventThread->requestNextVsync(this);

}

void EventThread::requestNextVsync(

const sp<EventThread::Connection>& connection) {

Mutex::Autolock \_l(mLock);

mFlinger.resyncWithRateLimit();

if (connection->count < 0) {

connection->count = 0;//大于等于0时，表示需要vsync信号

mCondition.broadcast();//目的是唤醒EventThread线程

}

}

### 5.4.3 EventThread->DispSyncThread

步骤三，发送vsync请求

frameworks/native/services/surfaceflinger/EventThread.cpp

bool EventThread::threadLoop() {

//1. 向DispSyncThread发出vsync请求

//2. 等待vsync信号

signalConnections = waitForEvent(&event);

status\_t err = conn->postEvent(event);//步骤6

}

Vector< sp<EventThread::Connection> > EventThread::waitForEvent(

DisplayEventReceiver::Event\* event)

{

do {

for (size\_t i=0 ; i<count ; i++) {

sp<Connection> connection(mDisplayEventConnections[i].promote());

if (connection != NULL) {

bool added = false;

if (connection->count >= 0) {//判断每一个connection→count是否大于等于0，标明它需要得到下一个vsync信号，注册回调

// we need vsync events because at least

// one connection is waiting for it

waitForVSync = true;

。。。

} else if (!timestamp && waitForVSync) {

enableVSyncLocked();

}

。。。

mCondition.wait(mLock);//休眠，等待DispSyncThread来唤醒

} while (signalConnections.isEmpty());

}

void EventThread::enableVSyncLocked() {

if (!mUseSoftwareVSync) {

// never enable h/w VSYNC when screen is off

if (!mVsyncEnabled) {

mVsyncEnabled = true;

mVSyncSource->setCallback(static\_cast<VSyncSource::Callback\*>(this));//给DispSyncThread设置callback

mVSyncSource->setVSyncEnabled(true);

}

}

mDebugVsyncEnabled = true;

sendVsyncHintOnLocked();

}

### 5.4.4 H/W vsync->DispSyncThread

软件产生

bool HWComposer::VSyncThread::threadLoop() {

。。。

int err;

do {

err = clock\_nanosleep(CLOCK\_MONOTONIC, TIMER\_ABSTIME, &spec, NULL);//休眠一段时间

} while (err<0 && errno == EINTR);

if (err == 0) {

//发出vsync信号，无论是HW还是SW vsync，最终调用到void SurfaceFlinger::onVSyncReceived，Android 8.1查看code flow，硬件vsync是从hw binder传上来的

mHwc.mEventHandler.onVSyncReceived(&mHwc, 0, next\_vsync);

}

return true;

}

SurfaceFlinger.cpp

void SurfaceFlinger::onVsyncReceived(int32\_t sequenceId, hwc2\_display\_t displayId, int64\_t timestamp)

→ needsHwVsync = mPrimaryDispSync.addResyncSample(timestamp);

→ mThread->updateModel(mPeriod, mPhase, mReferenceTime);

→ void updateModel(nsecs\_t period, nsecs\_t phase, nsecs\_t referenceTime)//DispSync.cpp

→ mCond.signal();//mCond 是class DispSyncThread的成员，来唤醒DispSyncThread

### 5.4.5 + 5.4.6 DispSyncThread->EventThread->SF

DispSync.cpp

virtual bool threadLoop() {

targetTime = computeNextEventTimeLocked(now);//计算最近的EventThread{Listener}的时间，EventThread发现connection->count大于等于0时，向DispSyncThread注册callback，变成listener

if (now < targetTime) {

err = mCond.waitRelative(mMutex, targetTime – now);//休眠，被mCond.signal()唤醒

callbackInvocations = gatherCallbackInvocationsLocked(now);//收集callback

fireCallbackInvocations(callbackInvocations);//调用callback，最终会导致EventThread中onVsyncEvent函数被调用

}

EventThread.cpp

void EventThread::onVSyncEvent(nsecs\_t timestamp) {

Mutex::Autolock \_l(mLock);

mVSyncEvent[0].header.type = DisplayEventReceiver::DISPLAY\_EVENT\_VSYNC;

mVSyncEvent[0].header.id = 0;

mVSyncEvent[0].header.timestamp = timestamp;

mVSyncEvent[0].vsync.count++;

mCondition.broadcast();//还是老套路，条件发送信号，唤醒 EventThread::threadLoop

}

//该到步骤6了

bool EventThread::threadLoop() {

//1. 向DispSyncThread发出vsync请求

//2. 等待vsync信号

signalConnections = waitForEvent(&event);

status\_t err = conn->postEvent(event);//步骤6，向sf发出信号，或者向app发出信号

}

status\_t EventThread::Connection::postEvent(

const DisplayEventReceiver::Event& event) {

ssize\_t size = DisplayEventReceiver::sendEvents(&mChannel, &event, 1);//通过connection里面的fd写给sf，BitTube，封装了unix套接字

return size < 0 ? status\_t(size) : status\_t(NO\_ERROR);

}

### 5.4.7 sf对vsync的处理

在5.3节中 SurfaceFlinger::init会注册cb\_eventReceiver这个回调，

MessageQueue.cpp

int MessageQueue::cb\_eventReceiver(int fd, int events, void\* data) {

MessageQueue\* queue = reinterpret\_cast<MessageQueue \*>(data);

return queue->eventReceiver(fd, events);

→ mHandler->dispatchInvalidate();

→ mQueue.mLooper->sendMessage(this, Message(MessageQueue::INVALIDATE));

}

void MessageQueue::Handler::handleMessage(const Message& message) {

switch (message.what) {

case INVALIDATE:

android\_atomic\_and(~eventMaskInvalidate, &mEventMask);

mQueue.mFlinger->onMessageReceived(message.what);

break;

case REFRESH:

android\_atomic\_and(~eventMaskRefresh, &mEventMask);

mQueue.mFlinger->onMessageReceived(message.what);

break;

}

}

SurfaceFlinger.cpp

void SurfaceFlinger::onMessageReceived(int32\_t what) {//后续章节再分析

ATRACE\_CALL();

switch (what) {

case MessageQueue::INVALIDATE: {

bool refreshNeeded = handleMessageTransaction();

refreshNeeded |= handleMessageInvalidate();

refreshNeeded |= mRepaintEverything;

signalRefresh();

}

break;

}

case MessageQueue::REFRESH: {

handleMessageRefresh();

break;

}

}

}

## 5.5 surfaceflinger对vsync的处理

SurfaceFlinger.h

class State {

public:

explicit State(LayerVector::StateSet set) : stateSet(set) {}

State& operator=(const State& other) {

layersSortedByZ = other.layersSortedByZ;

displays = other.displays;

return \*this;

}

const LayerVector::StateSet stateSet = LayerVector::StateSet::Invalid;

LayerVector layersSortedByZ;//比较它，即知Layer的增/减

DefaultKeyedVector< wp<IBinder>, DisplayDeviceState> displays;//比较它，即知Display的增/减，add/remove

void traverseInZOrder(const LayerVector::Visitor& visitor) const;

void traverseInReverseZOrder(const LayerVector::Visitor& visitor) const;

};

State mDrawingState{LayerVector::StateSet::Drawing};//正在 / 上次使用的状态，SurfaceFlinger下一帧的状态

State mCurrentState{LayerVector::StateSet::Current};//当前的 / 被修改的状态，当前正在绘制的状态，这个是SurfaceFlinger处理完事务后更新出来的状态，是最终的状态

Layer.h

struct State {

Geometry active;

Geometry requested;

int32\_t z;

uint32\_t layerStack;//若和DisplayDeviceState ::layerStack 相等，该Layer可以在这个Display显示

#ifdef USE\_HWC2

float alpha;

#else

uint8\_t alpha;

#endif

uint8\_t flags;

uint8\_t mask;

uint8\_t reserved[2];

int32\_t sequence; // changes when visible regions can change //比较它，即知属性有无变化

bool modified;

Rect crop;

Rect requestedCrop;

Rect finalCrop;

Rect requestedFinalCrop;

wp<Layer> barrierLayer;

uint64\_t frameNumber;

Region activeTransparentRegion;

Region requestedTransparentRegion;

android\_dataspace dataSpace;

uint32\_t appId;

uint32\_t type;

wp<Layer> zOrderRelativeOf;

SortedVector<wp<Layer>> zOrderRelatives;

};

State mCurrentState;//正在 / 上次使用的状态

State mDrawingState;//当前的 / 被修改的状态

DisplayDevice.h

struct DisplayDeviceState {

DisplayDeviceState() = default;

DisplayDeviceState(DisplayDevice::DisplayType type, bool isSecure);

bool isValid() const { return type >= 0; }

bool isMainDisplay() const { return type == DisplayDevice::DISPLAY\_PRIMARY; }

bool isVirtualDisplay() const { return type >= DisplayDevice::DISPLAY\_VIRTUAL; }

static std::atomic<int32\_t> nextDisplayId;

int32\_t displayId = nextDisplayId++;

DisplayDevice::DisplayType type = DisplayDevice::DISPLAY\_ID\_INVALID;

sp<IGraphicBufferProducer> surface;

uint32\_t layerStack = DisplayDevice::NO\_LAYER\_STACK;

Rect viewport;

Rect frame;

uint8\_t orientation = 0;

uint32\_t width = 0;

uint32\_t height = 0;

String8 displayName;

bool isSecure = false;

};

SurfaceFlinger.cpp

void SurfaceFlinger::onMessageReceived(int32\_t what) {

ATRACE\_CALL();

switch (what) {

case MessageQueue::INVALIDATE: {

bool refreshNeeded = handleMessageTransaction();//处理事务

refreshNeeded |= handleMessageInvalidate();//处理各Layer的Buffer更换

refreshNeeded |= mRepaintEverything;

signalRefresh();//发出刷新信号，MessageQueue::REFRESH

break;

}

case MessageQueue::REFRESH: {

handleMessageRefresh();

break;

}

}

}

■ handleMessageTransaction，设置了flag，并未实际操作各个buffer

bool SurfaceFlinger::handleMessageTransaction() {

uint32\_t transactionFlags = peekTransactionFlags();

if (transactionFlags) {

handleTransaction(transactionFlags);

return true;

}

return false;

}

void SurfaceFlinger::handleTransaction(uint32\_t transactionFlags) {

…

handleTransactionLocked(transactionFlags);

...

}

void SurfaceFlinger::handleTransactionLocked(uint32\_t transactionFlags) {

mCurrentState.traverseInZOrder([](Layer\* layer) {//通过Z轴排好序

layer->notifyAvailableFrames();

});

if (transactionFlags & eTraversalNeeded) {

mCurrentState.traverseInZOrder([&](Layer\* layer) {//遍历每个Layer，执行layer->doTransaction()，根据返回值设置mVisibleRegionsDirty

uint32\_t trFlags = layer->getTransactionFlags(eTransactionNeeded);//trFlags == 0表示这个layer没有什么变化

if (!trFlags) return;

const uint32\_t flags = layer->doTransaction(0);//trFlags != 0的话

if (flags & Layer::eVisibleRegion)

mVisibleRegionsDirty = true;//得知确实变化了，标明这块区域脏了，以后要来更新它

});

}

if (transactionFlags & eDisplayTransactionNeeded) {//处理Display事务

add/remove/change

}

if (transactionFlags & (eTraversalNeeded|eDisplayTransactionNeeded)) {//Layer的角度发生了变化

}

if (mLayersAdded) {//处理sf本身的事务，Layer的增/减

mLayersAdded = false;

// Layers have been added.

mVisibleRegionsDirty = true;

}

if (mLayersRemoved) {

mLayersRemoved = false;

。。。

invalidateLayerStack(layer, visibleReg);

}

}

void SurfaceFlinger::invalidateLayerStack(const sp<const Layer>& layer, const Region& dirty) {

for (size\_t dpy=0 ; dpy<mDisplays.size() ; dpy++) {

const sp<DisplayDevice>& hw(mDisplays[dpy]);

if (layer->belongsToDisplay(hw->getLayerStack(), hw->isPrimary())) {

hw->dirtyRegion.orSelf(dirty);//这个显示器上某一个层被删除之后，我们需要更新它的dirtyRegion

}

}

}

Layer.cpp

uint32\_t Layer::doTransaction(uint32\_t flags) {

ATRACE\_CALL();

pushPendingState();

Layer::State c = getCurrentState();

if (!applyPendingStates(&c)) {

return 0;

}

const Layer::State& s(getDrawingState());

if (sizeChanged) {//比较getCurrentState和getDrawingState的变化，比如尺寸

}

。。。

return flags;//如果发生了变化设置flag返回给调用者

}

■ handleMessageInvalidate 使原来的界面数据无效：准备好新数据，用来更换

bool SurfaceFlinger::handleMessageInvalidate() {

ATRACE\_CALL();

return handlePageFlip();

}

bool SurfaceFlinger::handlePageFlip()

{

ALOGV("handlePageFlip");

nsecs\_t latchTime = systemTime();

bool visibleRegions = false;

bool frameQueued = false;

bool newDataLatched = false;

mDrawingState.traverseInZOrder([&](Layer\* layer) {

if (layer->hasQueuedFrame()) {

frameQueued = true;

if (layer->shouldPresentNow(mPrimaryDispSync)) {//收集一下这些需要更新的layer，如果某个layer有新书据要显示的话，里面有已经放在队列里的frame，

mLayersWithQueuedFrames.push\_back(layer);//如果条件成立，会把这个layer push到 mLayersWithQueuedFrames

} else {

layer->useEmptyDamage();

}

} else {

layer->useEmptyDamage();

}

});

for (auto& layer : mLayersWithQueuedFrames) {

const Region dirty(layer->latchBuffer(visibleRegions, latchTime));//锁定这个buffer

layer->useSurfaceDamage();

invalidateLayerStack(layer, dirty);

if (layer->isBufferLatched()) {

newDataLatched = true;

}

}

mVisibleRegionsDirty |= visibleRegions;

if (frameQueued && (mLayersWithQueuedFrames.empty() || !newDataLatched)) {

signalLayerUpdate();

}

return !mLayersWithQueuedFrames.empty() && newDataLatched;

}

Layer.cpp

Region Layer::latchBuffer(bool& recomputeVisibleRegions, nsecs\_t latchTime) {

。。。

status\_t updateResult = mSurfaceFlingerConsumer->updateTexImage(&r,

mFlinger->mPrimaryDispSync, &mAutoRefresh, &queuedBuffer,

mLastFrameNumberReceived);

。。。

}

SurfaceFlingerConsumer.cpp

status\_t SurfaceFlingerConsumer::updateTexImage(BufferRejecter\* rejecter,

const DispSync& dispSync, bool\* autoRefresh, bool\* queuedBuffer,

uint64\_t maxFrameNumber)

{

err = acquireBufferLocked(&item, computeExpectedPresent(dispSync),

maxFrameNumber);

err = updateAndReleaseLocked(item, &mPendingRelease);

err = bindTextureImageLocked();//Texture—纹理，图形界面处理相关术语，最终会调用到GL 函数:

glEGLImageTargetTexture2DOES(texTarget, static\_cast<GLeglImageOES>(mEglImage));

}

