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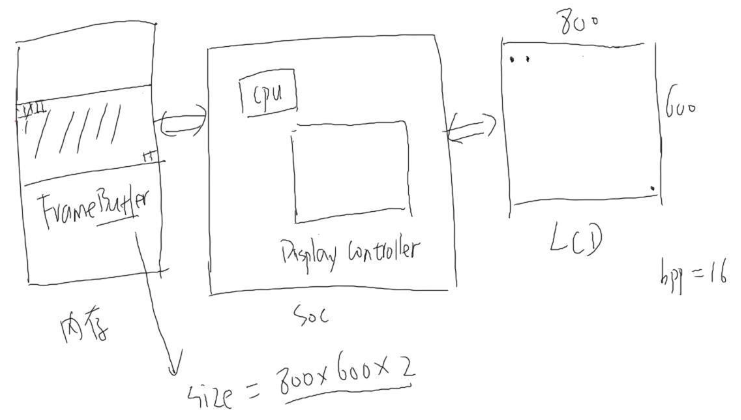
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# 一 显示系统框架

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) {

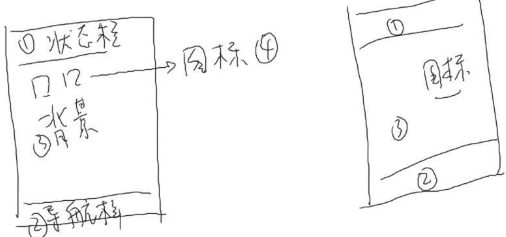
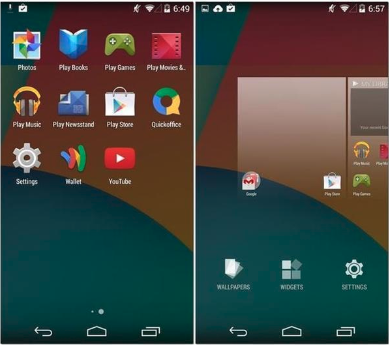
(1) Display Controller使用FB0

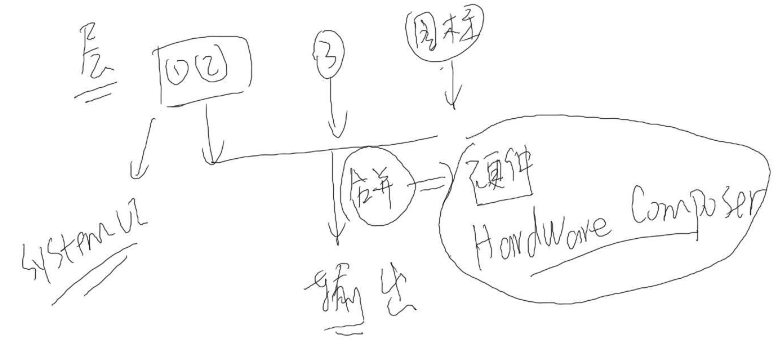
(2) APP写fb1

(3) Display Controller使用FB1

(4) APP写fb0

}

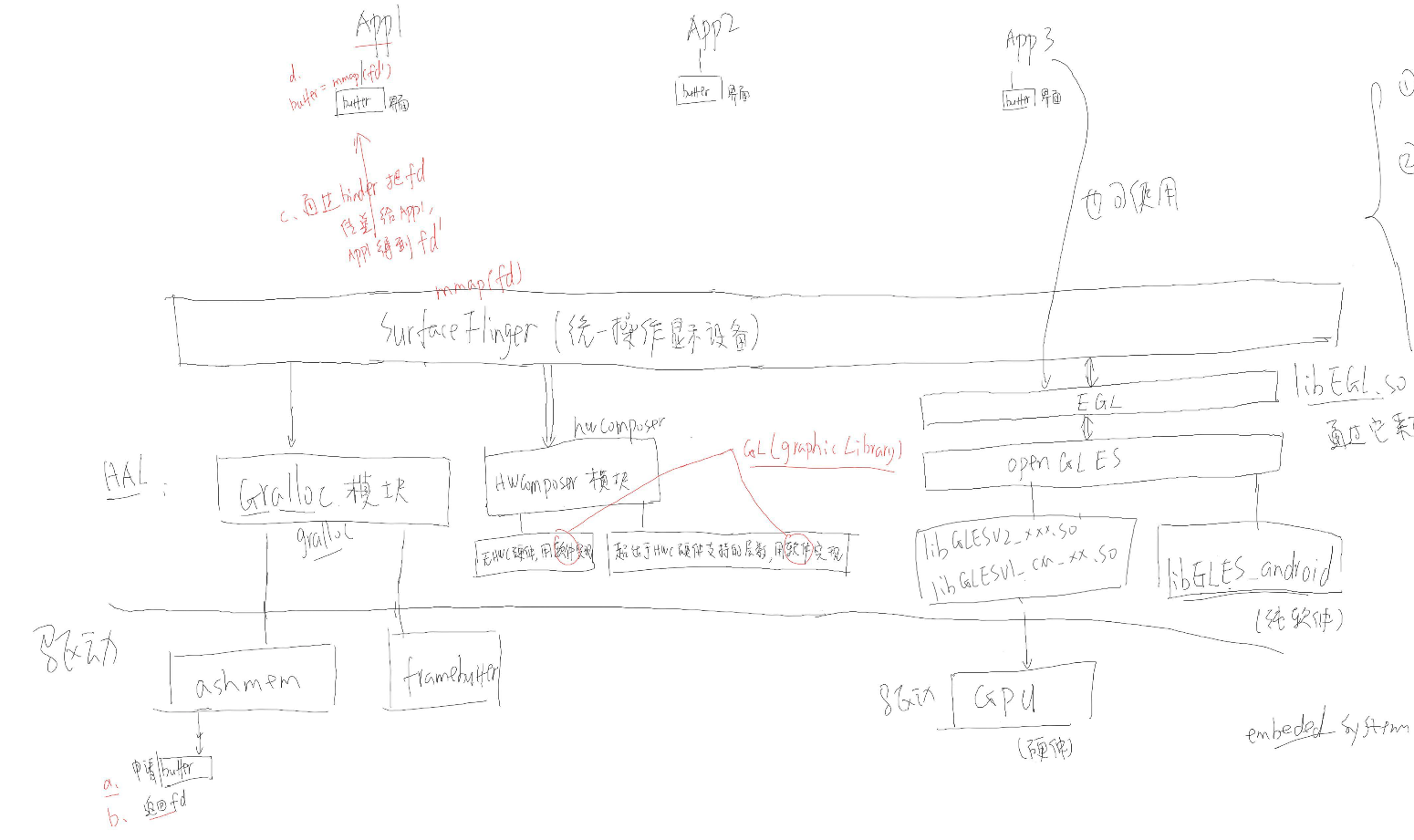


 重复工作1、2、3，其中1和2是systemUI进程，3是进程2，图标是进程3，如果芯片支持合成HardwareComposer那么可以提升性能。

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

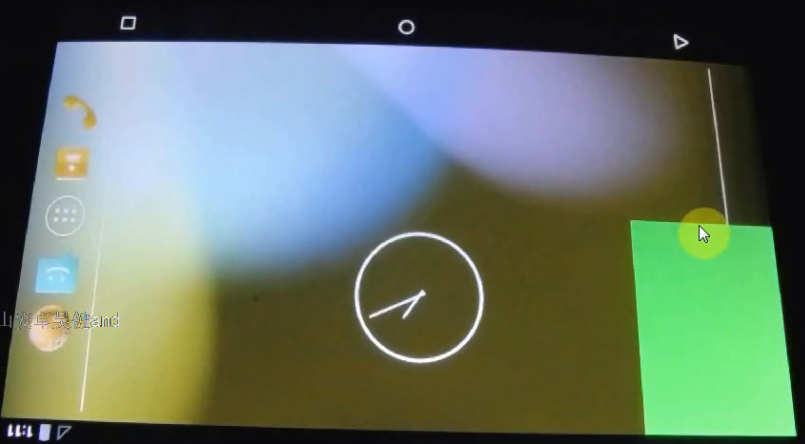
<http://www.aichengxu.com/android/8815305.htm>

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。

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sync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);

}