Android Camera HAL3中预览preview模式下的数据流

前沿：

为了更好的梳理preview下buffer数据流的操作过程，前一文中对surface下的buffer相关的操作**架构**进行了描述。本文主要以此为基础，重点分析再Camera2Client和Camera3Device下是如何维护并读写这些视频帧缓存的。

1. Camera3Device::convertMetadataListToRequestListLocked函数

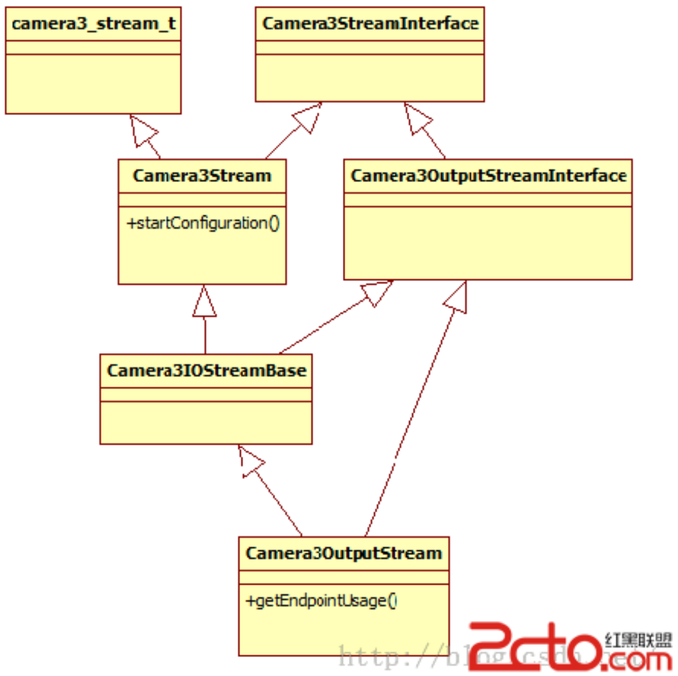
结合上一博文中关于preview的控制流，定位到数据流主要的操作主要是对preview模式下将CameraMetadata mPreviewRequest转换为CaptureRequest的过程之中，回顾到mPreviewRequest是主要包含了当前preview下所需要Camera3Device来操作的OutputStream的index值。

2. Camera3Device::configureStreamsLocked函数

在configureStreamsLocked的函数中，主要关注的是Camera3Device对当前所具有的所有的mInputStreams和mOutputStreams进行Config的操作，分别包括startConfiguration/finishConfiguration两个状态。

2.1 mOutputStreams.editValueAt(i)->startConfiguration()

这里的遍历所有输出stream即最终调用的函数入口为Camera3Stream::startConfiguration()，这里需要先看下Camera3OutputStream的整个结构，出现了Camera3Stream和Camera3IOStreamBase，两者是Input和Output stream所共有的，前者提供的更多的是对buffer的config、get/retrun buffer的操作，后者以维护当前的stream所拥有的buffer数目。另一个支路camera3_stream_t是一个和Camera HAL3底层进行stream信息交互的入口。



startConfiguration函数首先是判断当前stream的状态，对于已经config的不作处理，config的主要操作是getEndpointUsage：

```
status_t Camera3OutputStream::getEndpointUsage(uint32_t *usage) {
    status_t res;
    int32_t u = 0;
    res = mConsumer->query(mConsumer.get(),
            NATIVE_WINDOW_CONSUMER_USAGE_BITS, &u);
    *usage = u;
    return res;
}
```

这里的mConsumer其实就是之前创建的Surface的本体，每一个Stream在建立时createStream，都会传入一个ANativeWIndow类似的Consumer绑定到当前的stream中去。这里主要是完成当前window所管理的buffer的USAGE值，可参看grallo.h中的定义，由Gralloc模块负责指定当前buffer操作是由HW还是SW来完成以及不同的应用场合，在Gralloc模块中不同模块需求的buffer亦会有不同的分配、定义与处理方式：

```
/* buffer will be used as an OpenGL ES texture */
GRALLOC_USAGE_HW_TEXTURE = 0x00000100,
```

```
/* buffer will be used as an OpenGL ES render target */
GRALLOC_USAGE_HW_RENDER = 0x00000200,
/* buffer will be used by the 2D hardware blitter */
GRALLOC_USAGE_HW_2D = 0x00000400,
/* buffer will be used by the HWComposer HAL module */
GRALLOC_USAGE_HW_COMPOSER = 0x00000800,
/* buffer will be used with the framebuffer device */
GRALLOC_USAGE_HW_FB = 0x00001000,
/* buffer will be used with the HW video encoder */
GRALLOC_USAGE_HW_VIDEO_ENCODER = 0x00010000,
/* buffer will be written by the HW camera pipeline */
GRALLOC_USAGE_HW_CAMERA_WRITE = 0x00020000,
/* buffer will be read by the HW camera pipeline */
GRALLOC_USAGE_HW_CAMERA_READ = 0x00040000,
/* buffer will be used as part of zero-shutter-lag queue */
GRALLOC_USAGE_HW_CAMERA_ZSL = 0x00060000,
/* mask for the camera access values */
GRALLOC_USAGE_HW_CAMERA_MASK = 0x00060000,
/* mask for the software usage bit-mask */
GRALLOC_USAGE_HW_MASK = 0x00071F00,
```

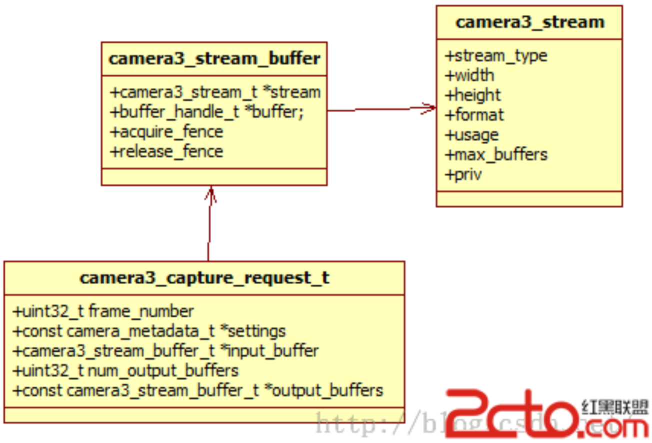
2.2 mHal3Device->ops->configure_streams(mHal3Device, &config);

config是一个camera3_stream_configuration**数据结构**，他记录了一次和HAL3交互的stream的数量，已经当前每一个stream的属性配置相关的信息camer3_stream_t，包括stream中每一个buffer的属性值，stream的类型值等等，提交这些信息供hal3去分析处理。在高通平台中你可以看到，对于每一个stream在HAL3平台下均以一个Channel的形式存在。

?

```
typedef struct camera3_stream_configuration {
    uint32_t num_streams;
    camera3_stream_t **streams;
```

```
}
camera3_stream_configuration_t;
```



stream_type包括：CAMERA3_STREAM_OUTPUT、CAMERA3_STREAM_INPUT、CAMERA3_STREAM_BIDIRECTIONAL。

format主要是指当前buffer支持的像素点存储格式，以HAL_PIXEL_FORMAT_IMPLEMENTATION_DEFINED居多，表明数据格式是由Gralloc模块来决定的。

对于HAL3中对configureStreams接口的实现会放在后续介绍高通平台的实现机制时再做分析。

2.3 Camera3Stream::finishConfiguration

该函数主要执行configureQueueLocked和registerBuffersLocked两个函数

```
status_t Camera3OutputStream::configureQueueLocked() {
    status_t res;

    mTraceFirstBuffer = true;
    if ((res = Camera3IOStreamBase::configureQueueLocked()) != OK) {
        return res;
    }

    ALOG_ASSERT(mConsumer != 0, mConsumer should never be NULL);

    // Configure consumer-side ANativeWindow interface
    res = native_window_api_connect(mConsumer.get(),
```

```
            NATIVE_WINDOW_API_CAMERA);
    if (res != OK) {
        ALOGE(%s: Unable to connect to native window for stream %d,
                __FUNCTION__, mId);
        return res;
    }

    res = native_window_set_usage(mConsumer.get(), camera3_stream::usage);
    if (res != OK) {
        ALOGE(%s: Unable to configure usage %08x for stream %d,
                __FUNCTION__, camera3_stream::usage, mId);
        return res;
    }

    res = native_window_set_scaling_mode(mConsumer.get(),
            NATIVE_WINDOW_SCALING_MODE_SCALE_TO_WINDOW);
    if (res != OK) {
        ALOGE(%s: Unable to configure stream scaling: %s (%d),
                __FUNCTION__, strerror(-res), res);
        return res;
    }

    if (mMaxSize == 0) {
        // For buffers of known size
        res = native_window_set_buffers_dimensions(mConsumer.get(),
                camera3_stream::width, camera3_stream::height);
    }
```

```
else
{
        //
 For buffers with bounded size
        res
 = native_window_set_buffers_dimensions(mConsumer.get(),
                mMaxSize,
1);
    }
    if
(res != OK) {
        ALOGE(%s:
 Unable to configure stream buffer dimensions
                %d
 x %d (maxSize %zu) for
stream %d,
                __FUNCTION__,
 camera3_stream::width, camera3_stream::height,
                mMaxSize,
 mId);
        return
res;
    }
    res
 = native_window_set_buffers_format(mConsumer.get(),
            camera3_stream::format);
    if
(res != OK) {
        ALOGE(%s:
 Unable to configure stream buffer format %#x for
stream %d,
                __FUNCTION__,
 camera3_stream::format, mId);
        return
res;
    }

    int
maxConsumerBuffers;
    res
 = mConsumer->query(mConsumer.get(),
            NATIVE_WINDOW_MIN_UNDEQUEUED_BUFFERS,
 &maxConsumerBuffers);//支持的最大buffer数量
    if
(res != OK) {
        ALOGE(%s:
 Unable to query consumer undequeued
                buffer
 count for
stream %d, __FUNCTION__, mId);
```

```
        return
res;
    }

    ALOGV(%s:
 Consumer wants %d buffers, HAL wants %d, __FUNCTION__,
            maxConsumerBuffers,
 camera3_stream::max_buffers);
    if
(camera3_stream::max_buffers == 0)
 {
        ALOGE(%s:
 Camera HAL requested max_buffer count: %d, requires at least 1,
                __FUNCTION__,
 camera3_stream::max_buffers);
        return
INVALID_OPERATION;
    }

    mTotalBufferCount
 = maxConsumerBuffers + camera3_stream::max_buffers;//至少2个buffer
    mHandoutTotalBufferCount
 = 0;
    mFrameCount
 = 0;
    mLastTimestamp
 = 0;

    res
 = native_window_set_buffer_count(mConsumer.get(),
            mTotalBufferCount);
    if
(res != OK) {
        ALOGE(%s:
 Unable to set buffer count for
stream %d,
                __FUNCTION__,
 mId);
        return
res;
    }

    res
 = native_window_set_buffers_transform(mConsumer.get(),
            mTransform);
    if
(res != OK) {
        ALOGE(%s:
 Unable to configure stream transform to %x: %s (%d),
```

```
                    __FUNCTION__,
 mTransform, strerror(-res), res);
    }

    return
 OK;
 }
```

如果你对SurfaceFlinger的架构熟悉的话，该代码会相对比较好理解。本质是根据当前stream设置的buffer属性，将这些属性值通过ANativeWindow这个接口传递给Consumer侧去维护：

这里重点关注以下几个buffer的相关属性信息：

比如native_window_set_buffer_count是设置当前Window所需要的buffer数目：

总的当前stream下的buffer个数总数为mTotalBufferCount = maxConsumerBuffers + camera3_stream::max_buffers。其中camera3_stream::max_buffer需要的buffer总数由configureStreams时HAL3底层的Device来决定的，高通平台下定义的camera3_stream::max_buffer数为7个，而maxConsumerBuffers指的是在所有buffer被dequeue时还应该保留的处于queue操作的buffer个数，即全dequeue时至少有maxConsumerBuffers个buffer是处于queue状态在被Consumer使用的。通过query NATIVE_WINDOW_MIN_UNDEQUEUED_BUFFERS来完成，一般默认是1个，即每个stream可以认为需要由8个buffer缓存块组成，实际可dequeue的为8个。

比如native_window_set_buffers_transform一般是指定buffer的Consumer，即当前buffer显示的90/180/270°角度。

该过程本质是结合HAL3的底层buffer配置需求，反过来请求Buffer的Consumer端BufferQueueConsumer来设置相关的buffer属性。

registerBuffersLocked是一个比较重要的处理过程：

?

```
status_t
 Camera3Stream::registerBuffersLocked(camera3_device *hal3Device) {
    ATRACE_CALL();

    /**
     *
 >= CAMERA_DEVICE_API_VERSION_3_2:
     *
     *
 camera3_device_t->ops->register_stream_buffers() is not called anc
     *
 be NULL.
     */
    if
 (hal3Device->common.version >= CAMERA_DEVICE_API_VERSION_3_2) {
        ALOGV(%s:
 register_stream_buffers unused as of HAL3.2,
 __FUNCTION__);
```

```
        if
(hal3Device->ops->register_stream_buffers != NULL) {
            ALOGE(%s:
 register_stream_buffers is deprecated in HAL3.2;
                    must
 be set to NULL in camera3_device::ops, __FUNCTION__);
            return
INVALID_OPERATION;
        }
else
{
            ALOGD(%s:
 Skipping NULL check for
deprecated register_stream_buffers, __FUNCTION__);
        }

        return
OK;
    }
else
{
        ALOGV(%s:
 register_stream_buffers using deprecated code path, __FUNCTION__);
    }


    status_t
 res;


    size_t
 bufferCount = getBufferCountLocked();//获取buffer的数量,mTotalBuffe:


    Vector<buffer_handle_t*>
 buffers;

    buffers.insertAt(/*prototype_item*/NULL,
/*index*/0,
 bufferCount);


    camera3_stream_buffer_set
 bufferSet = camera3_stream_buffer_set();

    bufferSet.stream
 = this;//新的bufferset指向camera3_stream_t

    bufferSet.num_buffers
 = bufferCount;//当前stream下的buffer数

    bufferSet.buffers
 = buffers.editArray();


    Vector<camera3_stream_buffer_t>
 streamBuffers;

    streamBuffers.insertAt(camera3_stream_buffer_t(),
/*index*/0,
 bufferCount);
```

```
    // Register all buffers with the HAL. This means getting all the buff
    // from the stream, providing them to the HAL with the
    // register_stream_buffers() method, and then returning them back to
    // stream in the error state, since they won't have valid data.
    //
    // Only registered buffers can be sent to the HAL.

    uint32_t bufferIdx = 0;
    for (; bufferIdx < bufferCount; bufferIdx++) {
        res = getBufferLocked( &streamBuffers.editItemAt(bufferIdx) );//返回de
buffer出来的所有buffer
        if (res != OK) {
            ALOGE(%s: Unable to get buffer %d for registration with HAL,
                    __FUNCTION__, bufferIdx);
            // Skip registering, go straight to cleanup
            break;
        }

        sp<fence> fence = new Fence(streamBuffers[bufferIdx].acquire_fence);
        fence->waitForever(Camera3Stream::registerBuffers);//等待可

        buffers.editItemAt(bufferIdx) = streamBuffers[bufferIdx].buffer;//dequeue
buffer出来的buffer handle
    }
    if (bufferIdx == bufferCount) {
        // Got all buffers, register with HAL
        ALOGV(%s: Registering %zu buffers with camera HAL,
                __FUNCTION__, bufferCount);
        ATRACE_BEGIN(camera3->register_stream_buffers);
        res = hal3Device->ops->register_stream_buffers(hal3Device,
```

```
                          &bufferSet);//buffer绑定并register到hal层
                  ATRACE_END();
              }

              //
          Return all valid buffers to stream, in ERROR state to indicate
              //
          they weren't filled.
              for
         (size_t i = 0;
          i < bufferIdx; i++) {
                  streamBuffers.editItemAt(i).release_fence
          = -1;
                  streamBuffers.editItemAt(i).status
          = CAMERA3_BUFFER_STATUS_ERROR;
                  returnBufferLocked(streamBuffers[i],
         0);//register后进行queue
          buffer
              }

              return
         res;
         }
         </fence></camera3_stream_buffer_t></buffer_handle_t*>
```

a 可以明确看到CAMERA_DEVICE_API_VERSION_3_2的版本才支持这个Device ops接口

b getBufferCountLocked

获取当前stream下的允许的buffer总数

c camera3_stream_buffer_t、camera3_stream_buffer_set和buffer_handle_t

首先需要关注的结构是camera3_stream_buffer_t，用于描述每一个stream下的buffer自身的特性值，其中关键结构是buffer_handle_t值是每一个buffer在不同进程间共享的handle，此外acquire_fence和release_fence用来不同硬件模块对buffer读写时的同步。

camera3_stream_buffer_set是封装了当前stream下所有的buffer的信息：

?

```
typedef
 struct camera3_stream_buffer_set {
    /**
     *
 The stream handle for the stream these buffers belong to
     */
    camera3_stream_t
 *stream;
    /**
     *
```

```
     * The number of buffers in this stream. It is guaranteed to be at le
     * stream->max_buffers.
     */
    uint32_t num_buffers;
    /**
     * The array of gralloc buffer handles for this stream. If the stream
     * is set to HAL_PIXEL_FORMAT_IMPLEMENTATION_DEFINED, the camera HAL
     * should inspect the passed-in buffers to determine any platform-pri
     * pixel format information.
     */
    buffer_handle_t **buffers;

} camera3_stream_buffer_set_t;
```

三个变量分别保存stream的buffer个数，当前这个set集合所属的stream，以及他所包含的所有buffer的handle信息列表。

d getBufferLocked获取当前buffer

?

```
status_t Camera3OutputStream::getBufferLocked(camera3_stream_buffer *buffer
    ATRACE_CALL();
    status_t res;

    if ((res = getBufferPreconditionCheckLocked()) != OK) {
        return res;
    }

    ANativeWindowBuffer* anb;
    int fenceFd;

    /**
     * Release the lock briefly to avoid deadlock for below scenario:
     *
```

```
 Thread 1: StreamingProcessor::startStream -> Camera3Stream::isConf
     *
 This thread acquired StreamingProcessor lock and try to lock Camer
     *
 Thread 2: Camera3Stream::returnBuffer->StreamingProcessor::onFrame
     *
 This thread acquired Camera3Stream lock and bufferQueue lock, and
     *
 StreamingProcessor lock.
     *
 Thread 3: Camera3Stream::getBuffer(). This thread acquired Camera3
     *
 and try to lock bufferQueue lock.
     *
 Then there is circular locking dependency.
     */
    sp
 currentConsumer = mConsumer;
    mLock.unlock();


    res
 = currentConsumer->dequeueBuffer(currentConsumer.get(), &anb, &fen
    mLock.lock();
    if
(res != OK) {
        ALOGE(%s:
 Stream %d: Can't dequeue next output buffer: %s (%d),
                __FUNCTION__,
 mId, strerror(-res), res);
        return
res;
    }


    /**
     *
 FenceFD now owned by HAL except in case of error,
     *
 in which case we reassign it to acquire_fence
     */
    handoutBufferLocked(*buffer,
 &(anb->handle), /*acquireFence*/fenceFd,
                       /*releaseFence*/-1,
 CAMERA3_BUFFER_STATUS_OK, /*output*/true);


    return
OK;
}
</anativewindow>
```

该函数主要是从由ANativeWindow从Consumer端dequeue获取一个buffer，本质上这个过程中首次执行是会有Consumer端去分配一个由实际物理空间的给当前的一个buffer的。

接着执行handoutBufferLocked，填充camera3_stream_buffer这个结构体，其中设置的acquireFence为-1值表明hal3的这个buffer可被Framewrok直接使用，而acquireFence表示HAL3如何想使用这个buffer时需要等待其变为1，因为buffer分配和handler返回不一定是一致同步的。还会切换当前buffer的状态CAMERA3_BUFFER_STATUS_OK。

?

```
void
Camera3IOStreamBase::handoutBufferLocked(camera3_stream_buffer &buf
                                              buffer_handle_t *handle,
                                              int acquireFence,
                                              int releaseFence,
                                              camera3_buffer_status status,
                                              bool output) {
    /**
     * Note that all fences are now owned by HAL.
     */

    // Handing out a raw pointer to this object. Increment internal refcc
    incStrong(this);
    buffer.stream = this;
    buffer.buffer = handle;
    buffer.acquire_fence = acquireFence;
    buffer.release_fence = releaseFence;
    buffer.status = status;

    // Inform tracker about becoming busy
    if (mHandoutTotalBufferCount == 0 && mState != STATE_IN_CONFIG &&
            mState != STATE_IN_RECONFIG) {
        /**
         * Avoid a spurious IDLE->ACTIVE->IDLE transition when using buffers
         * before/after register_stream_buffers during initial configuration
```

```
         *
 or re-configuration.
         *
         *
 TODO: IN_CONFIG and IN_RECONFIG checks only make sense for
<hal3.2
statustracker="">
 statusTracker = mStatusTracker.promote();
        if
(statusTracker != 0)
 {
            statusTracker->markComponentActive(mStatusId);
        }
    }
    mHandoutTotalBufferCount++;//统计dequeuebuffer的数量

    if
(output) {
        mHandoutOutputBufferCount++;
    }
}</hal3.2>
```

e hal3Device->ops->register_stream_buffers(hal3Device,&bufferSet);//buffer绑定并register到hal层

将所属的stream下的所有buffer有关的信息，主要是每个buffer的buffer_handle_t值，交给HAL3层去实现。比如高通HAL3平台每一个Channel对应于Camera3Device端的stream，而每一个stream的buffer在不同的Channel下面却是一个个的stream，这是高通的实现方式。

f 在完成register所有buffer后，设置每一个buffer状态为从CAMERA3_BUFFER_STATUS_OK切换到CAMERA3_BUFFER_STATUS_ERROR表明这个buffer都是可用的，目的在于执行returnBufferLocked是为了将这些因为register而出列的所有buffer再次cancelbuffer操作。

Camera3OutputStream::returnBufferLocked->Camera3IOStreamBase::returnAnyBufferLocked->Camera3OutputStream::returnBufferCheckedLocked

?

```
status_t
 Camera3OutputStream::returnBufferCheckedLocked(//result返回时调用
            const
camera3_stream_buffer &buffer,
            nsecs_t
 timestamp,
            bool
 output,
            /*out*/
            sp<fence>
 *releaseFenceOut) {
```

```
    (void)output;
    ALOG_ASSERT(output,
 Expected output to be true);

    status_t
 res;
    sp<fence>
 releaseFence;

    /**
     *
 Fence management - calculate Release Fence
     */
    if
(buffer.status == CAMERA3_BUFFER_STATUS_ERROR) {
        if
(buffer.release_fence != -1)
 {
            ALOGE(%s:
 Stream %d: HAL should not set release_fence(%d) when
                there
 is an error, __FUNCTION__, mId, buffer.release_fence);
            close(buffer.release_fence);
        }

        /**
         *
 Reassign release fence as the acquire fence in case of error
         */
        releaseFence
 = new
Fence(buffer.acquire_fence);
    }
else
{
        res
 = native_window_set_buffers_timestamp(mConsumer.get(), timestamp);
        if
(res != OK) {
            ALOGE(%s:
 Stream %d: Error setting timestamp: %s (%d),
                  __FUNCTION__,
 mId, strerror(-res), res);
            return
res;
        }

        releaseFence
```

```
 = new
Fence(buffer.release_fence);
    }

    int
anwReleaseFence = releaseFence->dup();

    /**
     *
 Release the lock briefly to avoid deadlock with
     *
 StreamingProcessor::startStream -> Camera3Stream::isConfiguring (t
     *
 thread will go into StreamingProcessor::onFrameAvailable) during
     *
 queueBuffer
     */
    sp
 currentConsumer = mConsumer;
    mLock.unlock();

    /**
     *
 Return buffer back to ANativeWindow
     */
    if
(buffer.status == CAMERA3_BUFFER_STATUS_ERROR) {
        //
 Cancel buffer
        res
 = currentConsumer->cancelBuffer(currentConsumer.get(),
                container_of(buffer.buffer,
 ANativeWindowBuffer, handle),
                anwReleaseFence);//Register
 buffer locked所在的事情，cancelbuffer dequeue的buffer
        if
(res != OK) {
            ALOGE(%s:
 Stream %d: Error cancelling buffer to native
window:
                   %s
 (%d), __FUNCTION__, mId, strerror(-res), res);
        }
    }
else
{
        if
(mTraceFirstBuffer && (stream_type == CAMERA3_STREAM_OUTPUT)) {
            {
```

```
                char
        traceLog[48];
                snprintf(traceLog,
 sizeof(traceLog), Stream %d: first full buffer
,
 mId);
                ATRACE_NAME(traceLog);
            }
            mTraceFirstBuffer
 = false;
        }


        res
 = currentConsumer->queueBuffer(currentConsumer.get(),
                container_of(buffer.buffer,
 ANativeWindowBuffer, handle),
                anwReleaseFence);//queuebuffer，送显ANativeWindowBuf
        if
 (res != OK) {
            ALOGE(%s:
 Stream %d: Error queueing buffer to native
window:
                  %s
 (%d), __FUNCTION__, mId, strerror(-res), res);
        }
    }
    mLock.lock();
    if
 (res != OK) {
        close(anwReleaseFence);
    }


    *releaseFenceOut
 = releaseFence;


    return
res;
}
</anativewindow></fence></fence>
```

该函数对于首次register的处理来说，他处理的buffer均是CAMERA3_BUFFER_STATUS_ERROR，调用了cancelBuffer将所有buffer的状态都还原为free的状态，依次说明目前的buffer均是可用的，之前均不涉及到对buffer的数据流的操作。

3 buffer数据流的dequeue操作

上述步骤2主要是将每一个Stream下全部的buffer信息全部register到下层的HAL3中，为后续对buffer的数据流读

写操作奠定基础。

那么preview模式下我们又是如何去获得一帧完成的视频流的呢?

触发点就是preview模式下的Request，前面提到过一个mPreviewRequest至少包含一个StreamProcessor和一个CallbackProcessor的两路stream，每路stream拥有不同的buffer数量。比如要从HAL3获取一帧图像数据，最简单的思路就是从StreamProcessor下的Outputstream流中下发一个可用的buffer地址，然后HAL3填充下数据，Framework就可以拥有一帧数据了。

根据这个思路，回顾到前一博文中每次会不断的下发一个Request命令包到HAL3中，在这里我们就可以看到这个buffer地址身影。

Camera3Device::RequestThread::threadLoop() 下的部分代码：

```
outputBuffers.insertAt(camera3_stream_buffer_t(), 0,
        nextRequest->mOutputStreams.size());//Streamprocess,Callbac
request.output_buffers = outputBuffers.array();//camera3_stream_buffer_t
for (size_t i = 0; i < nextRequest->mOutputStreams.size(); i++) {
    res = nextRequest->mOutputStreams.editItemAt(i)->
            getBuffer(&outputBuffers.editItemAt(i));//等待获取buffer
    if (res != OK) {
        // Can't get output buffer from gralloc queue - this could be due to
        // abandoned queue or other consumer misbehavior, so not a fatal
        // error
        ALOGE(RequestThread: Can't get output buffer, skipping request:
                %s (%d), strerror(-res), res);
        Mutex::Autolock l(mRequestLock);
        if (mListener != NULL) {
            mListener->notifyError(
                    ICameraDeviceCallbacks::ERROR_CAMERA_REQUEST,
                    nextRequest->mResultExtras);
        }
        cleanUpFailedRequest(request, nextRequest, outputBuffers);
        return true;
    }
    request.num_output_buffers++;//一般一根OutStream对应一个buffer,故总
```

```
        }
```

在这个下发到HAL3的camera3_capture_request中，可以看到 const camera3_stream_buffer_t *output_buffers，下面的代码可以说明这一次的Request的output_buffers是打包了当前Camera3Device所拥有的mOutputStreams。

```
outputBuffers.insertAt(camera3_stream_buffer_t(), 0,
        nextRequest->mOutputStreams.size());//Streamprocess,Callback
```

对于每一个OutputStream他会给她分配一个buffer handle。关注下面的处理代码：

```
nextRequest->mOutputStreams.editItemAt(i)->
                getBuffer(&outputBuffers.editItemAt(i))
```

nextRequest->mOutputStreams.editItemAt(i)是获取一个Camera3OutputStream对象，然后对getBuffer而言传入的是这个Camera3OutputStream所对应的这次buffer的输入位置，这个camera3_stream_buffer是需要从Camera3OutputStream对象中去获取的。

```
status_t Camera3Stream::getBuffer(camera3_stream_buffer *buffer) {
    ATRACE_CALL();
    Mutex::Autolock l(mLock);
    status_t res = OK;

    // This function should be only called when the stream is configured
    if (mState != STATE_CONFIGURED) {
        ALOGE("%s: Stream %d: Can't get buffers if stream is not in CONFIGURED state %d",
                __FUNCTION__, mId, mState);
        return INVALID_OPERATION;
    }

    // Wait for new buffer returned back if we are running into the limit
    if (getHandoutOutputBufferCountLocked() == camera3_stream::max_buffers
        ALOGV("%s:
```

```
 Already dequeued max output buffers (%d), wait for
next returned one.,
                __FUNCTION__,
 camera3_stream::max_buffers);
        res
 = mOutputBufferReturnedSignal.waitRelative(mLock, kWaitForBufferDu
        if
(res != OK) {
            if
(res == TIMED_OUT) {
                ALOGE(%s:
 wait for
output buffer return
timed out after %lldms, __FUNCTION__,
                        kWaitForBufferDuration
 / 1000000LL);
            }
            return
res;
        }
    }


    res
 = getBufferLocked(buffer);
    if
(res == OK) {
        fireBufferListenersLocked(*buffer,
/*acquired*/true,
/*output*/true);
    }


    return
res;
}
```

上述的代码先是检查dequeue了的buffer是否已经达到本stream申请的buffer数目的最大值，如果已经全部dequeue的话就得wait到当前已经有buffer return并且queue操作后，在处理完成后才允许将从buffer队列中再次执行dequeue操作。

随后调用getBufferLocked通过2.2(d）小节可以知道是从buffer队列中获取一个可用的buffer，并填充这个camera3_stream_buffer值。

这样处理完的结果是，下发的Request包含所有模块下的outputstream，同时每个stream都配备了一个camera3_stream_buffer供底层HAL3.0去处理，而这个buffer在Camera3Device模式下，可以是交互的是帧图像数据，可以是参数控制命令，也可以是其他的3A信息，这些不同的信息一般归不同的模块管理，也就是不同的stream来处理。

4 buffer数据流的queue操作

dequeue出来的buffer信息已经随着Request下发到了HAL3层，在Camera3Device架构下，可以使用一个Callback接口将数据从HAL3回传到Camera所在的Framework层。Camera3Device私有继承了一个Callback接口camera3_callback_ops数据结构，分别预留了notify和process_capture_result。前者是用于回调一些shutter已经error等信息，后者以Callback数据流为主，这个回调接口通过device->initialize(camera3_device, this)来完成注册。

```
void
Camera3Device::sProcessCaptureResult(const
camera3_callback_ops *cb,
        const
camera3_capture_result *result) {
    Camera3Device
 *d =
            const_cast<camera3device*>(static_cast<const>(cb));
    d->processCaptureResult(result);
}
</const></camera3device*>
```

返回的buffer所有信息均包含在camera3_capture_result中，该函数的处理过程相对比较复杂，如果只定位queue buffer的入口可直接到returnOutputBuffers中去：

```
void
Camera3Device::returnOutputBuffers(
        const
camera3_stream_buffer_t *outputBuffers, size_t numBuffers,
        nsecs_t
 timestamp) {
    for
(size_t i = 0;
 i < numBuffers; i++)//对每一个buffer所属的stream进行分析
    {
        Camera3Stream
 *stream = Camera3Stream::cast(outputBuffers[i].stream);//该buffer对
        status_t
 res = stream->returnBuffer(outputBuffers[i], timestamp);//Camera3C
        //
 Note: stream may be deallocated at this point, if this buffer was
        //
 the last reference to it.
        if
(res != OK) {
            ALOGE(Can't
return
buffer to its stream: %s (%d),
                strerror(-res),
 res);
        }
```

```
        }
    }
```

因为在下发Request时，每一个buffer均包含所述的stream信息，当buffer数据返回到Framework层时，我们又可以转到Camera3OutPutStream来处理这个return的buffer。

```
status_t Camera3Stream::returnBuffer(const camera3_stream_buffer &buffer,
        nsecs_t timestamp) {
    ATRACE_CALL();
    Mutex::Autolock l(mLock);

    /**
     * TODO: Check that the state is valid first.
     *
     * <hal3.2 addition="" and="" configured.="" in="" in_config="" in_re
     *
     * Do this for getBuffer as well.
     */
    status_t res = returnBufferLocked(buffer, timestamp);//以queue buffer为主
    if (res == OK) {
        fireBufferListenersLocked(buffer, /*acquired*/false, /*output*/true);
        mOutputBufferReturnedSignal.signal();
    }

    return res;
}</hal3.2>
```

在这里看看registerBuffersLocked，参考前面对这个函数他是register完所有的buffer时被调用，在这里其本质处理的buffer状态不在是CAMERA3_BUFFER_STATUS_ERROR，而是CAMERA3_BUFFER_STATUS_OK故执行的是将会queuebuffer的操作。

5 buffer数据真正的被Consumer处理

在queuebuffer的操作时，参考前一博文Android5.1中surface和CpuConsumer下生产者和消费者间的处理框架简述

很容易知道真正的Consumer需要开始工作了，对于preview模式下的当然是由SurfaceFlinger的那套机制去处理。而在Camera2Client和Camera3Device下你还可以看到CPUConsumer的存在，比如：

```
void CallbackProcessor::onFrameAvailable(const BufferItem& /*item*/) {
    Mutex::Autolock l(mInputMutex);
    if (!mCallbackAvailable) {
        mCallbackAvailable = true;
        mCallbackAvailableSignal.signal();//数据callback线程处理
    }
}
```

在这里，你就可以去处理那些处于queue状态的buffer数据，比如这里的Callback将这帧数据上传会APP。

```
bool CallbackProcessor::threadLoop() {
    status_t res;

    {
        Mutex::Autolock l(mInputMutex);
        while (!mCallbackAvailable) {
            res = mCallbackAvailableSignal.waitRelative(mInputMutex,
                    kWaitDuration);
            if (res == TIMED_OUT) return true;
        }
        mCallbackAvailable = false;
    }

    do {
        sp<camera2client> client = mClient.promote();
        if
```

```
(client == 0)
 {
              res
 = discardNewCallback();

         }
else

{

              res
 = processNewCallback(client);//callback
 处理新的一帧

         }

     }
while

(res == OK);


    return

true;

}&lt;/camera2client&gt;
```

?

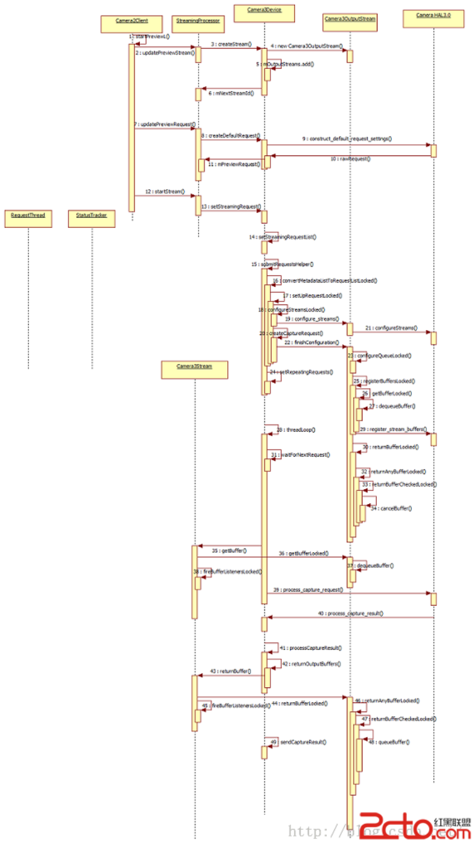
```
l.mRemoteCallback->dataCallback(CAMERA_MSG_PREVIEW_FRAME,

          callbackHeap->mBuffers[heapIdx],
NULL);//处理成API的需求后，回调Preview
frame
```

6 总结

到这里，整个preview预览的视频流基本介绍完毕了，主要框架虽然负责，但仔细看看也就是buffer的queue与dequeue操作，真正的HAL3的实现才是最为复杂的。后续还会简单介绍下整个take picture的过程，数据的回调处理在后续中还会继续分析。

下面贴一图是整个Camera3架构下基于Request和result的处理流序图:



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