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Android Camera HAL3中预览preview模式下的数据流

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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。

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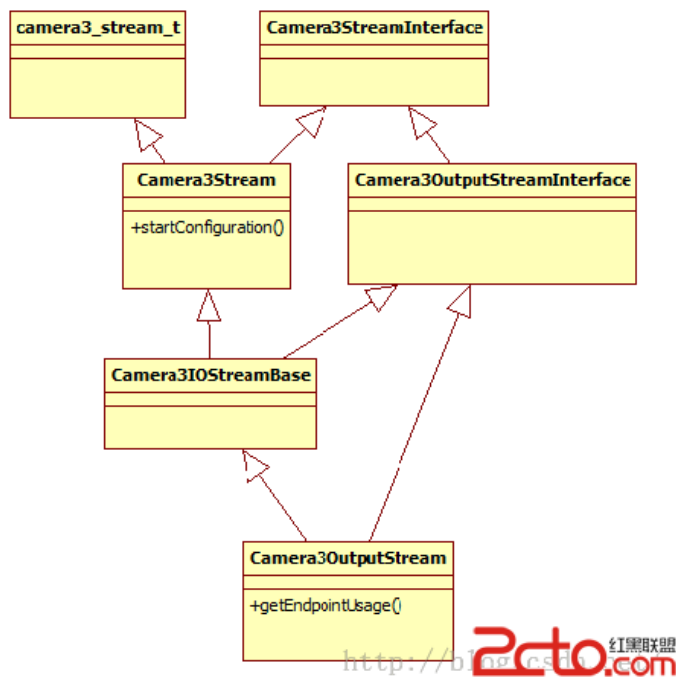
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startConfiguration函数首先是判断当前stream的状态, 对于已经config的不作处理, config的主要操作是getEndpointUsage:

```
1  status_t  
2  Camera3OutputStream::getEndpointUsage(uint32_t *usage) {  
3  
4      status_t  
5      res;  
6  
7      int32_t  
8      u = 0;  
9  
10     res  
11     = mConsumer->query(mConsumer.get(),  
12         NATIVE_WINDOW_CONSUMER_USAGE_BITS,  
13         &u);  
14  
15     *usage  
16     = u;  
17  
18     return  
19     res;  
20 }
```

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:

```
1  /*  
2   * buffer will be used as an OpenGL ES texture */  
3  GRALLOC_USAGE_HW_TEXTURE  
4  = 0x00000100,
```

摸屏的问题，那到底该怎么改啊，求指教？

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```

4  /*
5     buffer will be used as an OpenGL ES render target */
6  GRALLOC_USAGE_HW_RENDER
7     = 0x00000200,
8  /*
9     buffer will be used by the 2D hardware blitter */
10 GRALLOC_USAGE_HW_2D
11     = 0x00000400,
12 /*
13     buffer will be used by the HWComposer HAL module */
14 GRALLOC_USAGE_HW_COMPOSER
15     = 0x00000800,
16 /*
17     buffer will be used with the framebuffer device */
18 GRALLOC_USAGE_HW_FB
19     = 0x00001000,
20 /*
21     buffer will be used with the HW video encoder */
22 GRALLOC_USAGE_HW_VIDEO_ENCODER
23     = 0x00010000,
24 /*
25     buffer will be written by the HW camera pipeline */
26 GRALLOC_USAGE_HW_CAMERA_WRITE
27     = 0x00020000,
28 /*
29     buffer will be read by the HW camera pipeline */
30 GRALLOC_USAGE_HW_CAMERA_READ
31     = 0x00040000,
32 /*
33     buffer will be used as part of zero-shutter-lag queue */
34 GRALLOC_USAGE_HW_CAMERA_ZSL
35     = 0x00060000,
36 /*
37     mask for the camera access values */
38 GRALLOC_USAGE_HW_CAMERA_MASK
39     = 0x00060000,
40 /*
41     mask for the software usage bit-mask */
42 GRALLOC_USAGE_HW_MASK
43     = 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camera3_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Channel的形式存在。

```

1  typedef
2     struct camera3_stream_configuration {
3         uint32_t
4         num_streams;
5         camera3_stream_t
6         **streams;

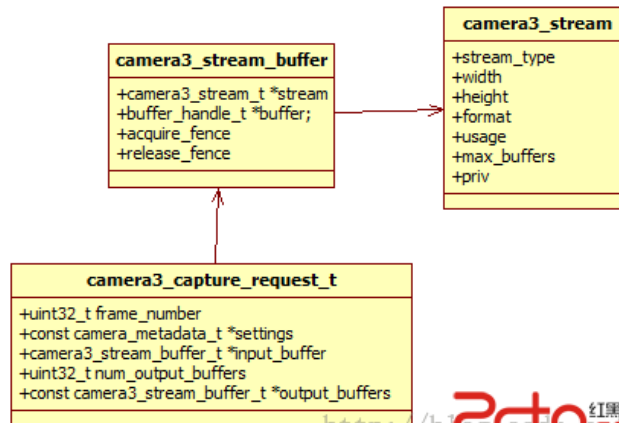
```

?

```

    }
    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

```

1  status_t
   Camera3OutputStream::configureQueueLocked() {
2
3      status_t
       res;
4
5      mTraceFirstBuffer
       = true;
6
7      if
8      ((res = Camera3IOStreamBase::configureQueueLocked()) != OK) {
9
10         return
11     }
12
13     ALOG_ASSERT(mConsumer
14                 != 0,
15                 mConsumer should never be NULL);
16
17     //
18     Configure consumer-side ANativeWindow interface
19
20     res
21     = native_window_api_connect(mConsumer.get(),

```

```
        NATIVE_WINDOW_API_CAMERA);
19
    if
20    (res != OK) {
21        ALOGE("%s:
22        Unable to connect to native
23        window for
24        stream %d,
25        __FUNCTION__,
26        mId);
27        return
28        res;
29    }
30
31    res
32    = native_window_set_usage(mConsumer.get(), camera3_stream::usage);
33    if
34    (res != OK) {
35        ALOGE("%s:
36        Unable to configure usage %08x for
37        stream %d,
38        __FUNCTION__,
39        camera3_stream::usage, mId);
40        return
41        res;
42    }
43
44    res
45    = native_window_set_scaling_mode(mConsumer.get(),
46        NATIVE_WINDOW_SCALING_MODE_SCALE_TO_WINDOW);
47    if
48    (res != OK) {
49        ALOGE("%s:
50        Unable to configure stream scaling: %s (%d),
51        __FUNCTION__,
52        strerror(-res), res);
53        return
54        res;
55    }
56
57    if
58    (mMaxSize == 0)
59    {
60        //
61        For buffers of known size
62
63        res
64        = native_window_set_buffers_dimensions(mConsumer.get(),
65            camera3_stream::width,
66            camera3_stream::height);
67    }
```

```
61     else
62     {
63         //
64         For buffers with bounded size
65         res
66         = native_window_set_buffers_dimensions(mConsumer.get(),
67         mMaxSize,
68         1);
69     }
70     if
71     (res != OK) {
72         ALOGE("%s:
73         Unable to configure stream buffer dimensions
74         %d
75         x %d (maxSize %zu) for
76         stream %d,
77         __FUNCTION__,
78         camera3_stream::width, camera3_stream::height,
79         mMaxSize,
80         mId);
81         return
82         res;
83     }
84     res
85     = native_window_set_buffers_format(mConsumer.get(),
86     camera3_stream::format);
87     if
88     (res != OK) {
89         ALOGE("%s:
90         Unable to configure stream buffer format %#x for
91         stream %d,
92         __FUNCTION__,
93         camera3_stream::format, mId);
94         return
95         res;
96     }
97     int
98     maxConsumerBuffers;
99     res
100     = mConsumer->query(mConsumer.get(),
101     NATIVE_WINDOW_MIN_UNDEQUEUED_BUFFERS,
102     &maxConsumerBuffers); // 支持的最大buffer数量
103     if
104     (res != OK) {
105         ALOGE("%s:
106         Unable to query consumer undequed
107         buffer
108         count for
109         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：

```

1      status_t
2      Camera3Stream::registerBuffersLocked(camera3_device *hal3Device) {
3
4          ATRACE_CALL();
5
6          /**
7           *
8           * >= CAMERA_DEVICE_API_VERSION_3_2:
9           *
10          camera3_device_t->ops->register_stream_buffers() is not called and
11          be NULL.
12          */
13
14          if
15
16      (hal3Device->common.version >= CAMERA_DEVICE_API_VERSION_3_2) {
17
18          ALOGV("%s:
19          register_stream_buffers unused as of HAL3.2,
20          __FUNCTION__);
21
22      }
23
24      return
25      OK;
26  }

```



```
17         if
18         (hal3Device->ops->register_stream_buffers != NULL) {
19             ALOGE("%s:
20             register_stream_buffers is deprecated in HAL3.2;
21             must
22             be set to NULL in camera3_device::ops, __FUNCTION__);
23             return
24             INVALID_OPERATION;
25         }
26     else
27     {
28         ALOGD("%s:
29         Skipping NULL check for
30         deprecated register_stream_buffers, __FUNCTION__);
31     }
32     return
33     OK;
34 }
35 else
36 {
37     ALOGV("%s:
38     register_stream_buffers using deprecated code path, __FUNCTION__);
39 }
40
41     status_t
42     res;
43
44     size_t
45     bufferCount = getBufferCountLocked(); //获取buffer的数量, mTotalBuffer
46
47     Vector<buffer_handle_t*>
48     buffers;
49     buffers.insertAt(/*prototype_item*/NULL,
50     /*index*/0,
51     bufferCount);
52
53     camera3_stream_buffer_set
54     bufferSet = camera3_stream_buffer_set();
55     bufferSet.stream
56     = this; //新的bufferSet指向camera3_stream_t
57     bufferSet.num_buffers
58     = bufferCount; //当前stream下的buffer数
59     bufferSet.buffers
60     = buffers.editArray();
61
62     Vector<camera3_stream_buffer_t>
63     streamBuffers;
64     streamBuffers.insertAt(camera3_stream_buffer_t(),
65     /*index*/0,
66     bufferCount);
```

```

60     //
61     Register all buffers with the HAL. This means getting all the buff
62     //
63     from the stream, providing them to the HAL with the
64     //
65     register_stream_buffers() method, and then returning them back to
66     //
67     stream in the error state, since they won't have valid data.
68     //
69     Only registered buffers can be sent to the HAL.
70
71     uint32_t
72     bufferIdx = 0;
73
74     for
75     (; bufferIdx < bufferCount; bufferIdx++) {
76
77         res
78         = getBufferLocked( &streamBuffers.editItemAt(bufferIdx) );//返回dec
79         buffer出来的所有buffer
80
81         if
82         (res != OK) {
83
84             ALOGE("%s:
85             Unable to get buffer %d for
86             registration with HAL,
87             __FUNCTION__,
88             bufferIdx);
89
90             //
91             Skip registering, go straight to cleanup
92
93             break;
94         }
95
96         sp<fence>
97         fence = new
98         Fence(streamBuffers[bufferIdx].acquire_fence);
99
100         fence->waitForever(Camera3Stream::registerBuffers);//等待可
101
102         buffers.editItemAt(bufferIdx)
103         = streamBuffers[bufferIdx].buffer;//dequeue
104         buffer出来的buffer handle
105     }
106
107     if
108     (bufferIdx == bufferCount) {
109
110         //
111         Got all buffers, register with HAL
112
113         ALOGV("%s:
114         Registering %zu buffers with camera HAL,
115         __FUNCTION__,
116         bufferCount);
117
118         ATRACE_BEGIN(camera3->register_stream_buffers);
119
120         res
121         = 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：

```

1  typedef
2      struct camera3_stream_buffer_set {
3          /**
4           *
5           * The stream handle for the stream these buffers belong to
6           */
7          camera3_stream_t
8          *stream;
9          /**
10         *

```

?

```

9      The number of buffers in this stream. It is guaranteed to be at le
10      *
11      stream->max_buffers.
12      */
13      uint32_t
14      num_buffers;
15      /**
16      *
17      The array of gralloc buffer handles for this stream. If the stream
18      *
19      is set to HAL_PIXEL_FORMAT_IMPLEMENTATION_DEFINED, the camera HAL
20      *
21      should inspect the passed-in buffers to determine any platform-pri
22      *
23      pixel format information.
24      */
25      buffer_handle_t
26      **buffers;
27
28      }
29      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

```

1      status_t
2      Camera3OutputStream::getBufferLocked(camera3_stream_buffer *buffer
3
4      ATRACE_CALL();
5
6      status_t
7      res;
8
9      if
10
11      ((res = getBufferPreconditionCheckLocked()) != OK) {
12
13      return
14
15      res;
16      }
17
18      ANativeWindowBuffer*
19      anb;
20
21      int
22      fenceFd;
23
24      /**
25      *
26      Release the lock briefly to avoid deadlock for below scenario:
27      *

```

```

20     Thread 1: StreamingProcessor::startStream -> Camera3Stream::isConf
21     *
22     This thread acquired StreamingProcessor lock and try to lock Camer
23     *
24     Thread 2: Camera3Stream::returnBuffer->StreamingProcessor::onFrame
25     *
26     This thread acquired Camera3Stream lock and bufferQueue lock, and
27     StreamingProcessor lock.
28     *
29     Thread 3: Camera3Stream::getBuffer(). This thread acquired Camera3
30     and try to lock bufferQueue lock.
31     *
32     Then there is circular locking dependency.
33     */
34     sp
35     currentConsumer = mConsumer;
36     mLock.unlock();
37
38     res
39     = currentConsumer->dequeueBuffer(currentConsumer.get(), &anb, &fen
40     mLock.lock();
41
42     if
43     (res != OK) {
44         ALOGE("%s:
45         Stream %d: Can't dequeue next output buffer: %s (%d),
46         __FUNCTION__,
47         mId, strerror(-res), res);
48
49         return
50
51     res;
52     }
53
54     /**
55     *
56     FenceFD now owned by HAL except in case of error,
57     *
58     in which case we reassign it to acquire_fence
59     */
60
61     handoutBufferLocked(*buffer,
62     &(anb->handle), /*acquireFence*/fenceFd,
63
64     /*releaseFence*/-1,
65     CAMERA3_BUFFER_STATUS_OK, /*output*/true);
66
67     return
68
69     OK;
70
71 }
72
73 </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Framework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。

```
1 void                                     ?
2 Camera3IOStreamBase::handoutBufferLocked(camera3_stream_buffer &buf
3                                     buffer_handle_t
4     *handle,
5                                     int
6     acquireFence,
7                                     int
8     releaseFence,
9                                     camera3_buffer_status
10    status,
11                                     bool
12    output) {
13    /**
14     *
15     * Note that all fences are now owned by HAL.
16     */
17    //
18    // Handing out a raw pointer to this object. Increment internal refcc
19    incStrong(this);
20    buffer.stream
21    = this;
22    buffer.buffer
23    = handle;
24    buffer.acquire_fence
25    = acquireFence;
26    buffer.release_fence
27    = releaseFence;
28    buffer.status
29    = status;
30
31    //
32    // Inform tracker about becoming busy
33    if
34    (mHandoutTotalBufferCount == 0
35    && mState != STATE_IN_CONFIG &&
36    mState
37    != STATE_IN_RECONFIG) {
38        /**
39         *
40         * Avoid a spurious IDLE->ACTIVE->IDLE transition when using buffers
41         *
42         * before/after register_stream_buffers during initial configuration
```

```

37      *
      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

```

1      status_t
      Camera3OutputStream::returnBufferCheckedLocked(//result返回时调用
2
      const
3
      camera3_stream_buffer &buffer,
4
      nsecs_t
5
      timestamp,
6
      bool
7
      output,
      /*out*/
8
      sp<fence>
9
      *releaseFenceOut) {

```

```
10
11     (void) output;
12     ALOG_ASSERT(output,
13     Expected output to be true);
14
15     status_t
16     res;
17
18     sp<fence>
19     releaseFence;
20
21     /**
22     *
23     Fence management - calculate Release Fence
24     */
25
26     if
27     (buffer.status == CAMERA3_BUFFER_STATUS_ERROR) {
28
29         if
30         (buffer.release_fence != -1)
31         {
32             ALOGE("%s:
33             Stream %d: HAL should not set release_fence(%d) when
34             there
35             is an error, __FUNCTION__, mId, buffer.release_fence);
36             close(buffer.release_fence);
37         }
38
39         /**
40         *
41         Reassign release fence as the acquire fence in case of error
42         */
43
44         releaseFence
45         = new
46         Fence(buffer.acquire_fence);
47     }
48     else
49     {
50
51         res
52         = native_window_set_buffers_timestamp(mConsumer.get(), timestamp);
53
54         if
55         (res != OK) {
56             ALOGE("%s:
57             Stream %d: Error setting timestamp: %s (%d),
58             __FUNCTION__,
59             mId, strerror(-res), res);
60
61             return
62             res;
63         }
64
65         releaseFence
```



```
52     = new
53     Fence(buffer.release_fence);
54     }
55
56     int
57     anwReleaseFence = releaseFence->dup();
58
59     /**
60      *
61      * Release the lock briefly to avoid deadlock with
62      *
63      * StreamingProcessor::startStream -> Camera3Stream::isConfiguring (t
64      *
65      * thread will go into StreamingProcessor::onFrameAvailable) during
66      *
67      * queueBuffer
68      */
69
70     sp
71     currentConsumer = mConsumer;
72     mLock.unlock();
73
74     /**
75      *
76      * Return buffer back to ANativeWindow
77      */
78
79     if
80     (buffer.status == CAMERA3_BUFFER_STATUS_ERROR) {
81         //
82         Cancel buffer
83
84         res
85         = currentConsumer->cancelBuffer(currentConsumer.get(),
86             container_of(buffer.buffer,
87                 ANativeWindowBuffer, handle),
88                 anwReleaseFence); //Register
89         buffer locked所在的事情, cancelbuffer dequeue的buffer
90
91         if
92         (res != OK) {
93             ALOGE("%s:
94                 Stream %d: Error cancelling buffer to native
95                 window:
96
97                 %s
98                 (%d), __FUNCTION__, mId, strerror(-res), res);
99             }
100         }
101     }
102     else
103     {
104         if
105         (mTraceFirstBuffer && (stream_type == CAMERA3_STREAM_OUTPUT)) {
106             {
```

```

        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：

```

1  outputBuffers.insertAt(camera3_stream_buffer_t(),
2  0,
3  nextRequest->mOutputStreams.size()); //Streamprocess, Callbac
4  request.output_buffers
5  = outputBuffers.array(); //camera3_stream_buffer_t
6  for
7  (size_t i = 0;
8  i < nextRequest->mOutputStreams.size(); i++) {
9      res
10     = nextRequest->mOutputStreams.editItemAt(i)->
11     getBuffer(&outputBuffers.editItemAt(i)); //等待获取buffer
12     if
13     (res != OK) {
14         //
15         Can't get output buffer from gralloc queue - this could be due to
16         //
17         abandoned queue or other consumer misbehavior, so not a fatal
18         //
19         error
20         ALOGE(RequestThread:
21         Can't get output buffer, skipping request:
22         %s
23         (%d), strerror(-res), res);
24         Mutex::Autolock
25         l(mRequestLock);
26         if
27         (mListener != NULL) {
28             mListener->notifyError(
29                 ICameraDeviceCallbacks::ERROR_CAMERA_REQUEST,
30                 nextRequest->mResultExtras);
31             }
32             cleanUpFailedRequest(request,
33             nextRequest, outputBuffers);
34             return
35             true;
36         }
37         request.num_output_buffers++; //一般一根OutStream对应一个buffer,故

```

```

    }

```

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。

```

1 | outputBuffers.insertAt(camera3_stream_buffer_t(),
2 | 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：

```

1 | nextRequest->mOutputStreams.editItemAt(i)->
2 |
   |
   | 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。

```

1 | status_t
2 | Camera3Stream::getBuffer(camera3_stream_buffer *buffer) {
3 |
4 |     ATRACE_CALL();
5 |     Mutex::Autolock
6 |     l(mLock);
7 |
8 |     status_t
9 |     res = OK;
10 |
11 |     //
12 |     This function should be only called when the stream is configured
13 |
14 |     if
15 |
16 |     (mState != STATE_CONFIGURED) {
17 |
18 |         ALOGE("%s:
19 |         Stream %d: Can't get buffers if
20 |         stream is not in CONFIGURED state %d,
21 |         mId, mState); __FUNCTION__,
22 |
23 |         return
24 |         INVALID_OPERATION;
25 |     }
26 |
27 |     //
28 |     Wait for new buffer returned back if we are running into the limit
29 |
30 |     if
31 |
32 |     (getHandoutOutputBufferCountLocked() == camera3_stream::max_buffers
33 |
34 |     ALOGV("%s:

```

```

23     Already dequeued max output buffers (%d), wait for
24     next returned one.,
25     __FUNCTION__,
26     camera3_stream::max_buffers);
27     res
28     = mOutputBufferReturnedSignal.waitRelative(mLock, kWaitForBufferDu
29     if
30     (res != OK) {
31         if
32         (res == TIMED_OUT) {
33             ALOGE("%s:
34             wait for
35             output buffer return
36             timed out after %lldms, __FUNCTION__,
37             kWaitForBufferDuration
38             / 1000000LL);
39         }
40         return
41     }
42     res;
43 }
44
45     res
46     = getBufferLocked(buffer);
47     if
48     (res == OK) {
49         fireBufferListenersLocked(*buffer,
50         /*acquired*/true,
51         /*output*/true);
52     }
53     return
54     res;
55 }

```

上述的代码先是检查dequeued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dequeued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dequeued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。

```
1 void
2 Camera3Device::sProcessCaptureResult(const
3 camera3_callback_ops *cb,
4     const
5 camera3_capture_result *result) {
6     Camera3Device
7     *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:

```
1 void
2 Camera3Device::returnOutputBuffers(
3     const
4 camera3_stream_buffer_t *outputBuffers, size_t numBuffers,
5     nsecs_t
6     timestamp) {
7     for
8 (size_t i = 0;
9  i < numBuffers; i++)//对每一个buffer所属的stream进行分析
10    {
11        Camera3Stream
12        *stream = Camera3Stream::cast(outputBuffers[i].stream);//该buffer
13        status_t
14        res = stream->returnBuffer(outputBuffers[i], timestamp);//Camera3C
15        //
16        Note: stream may be deallocated at this point, if this buffer was
17        //
18        the last reference to it.
19        if
20 (res != OK) {
21            ALOGE (Can't
22 return
23 buffer to its stream: %s (%d),
24            strerror(-res),
25            res);
26    }
27 }
```

```

    }
}

```

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。

```

1  status_t
2  Camera3Stream::returnBuffer(const
3  camera3_stream_buffer &buffer,
4  nsecs_t
5  timestamp) {
6      ATRACE_CALL();
7      Mutex::Autolock
8      l(mLock);
9
10     /**
11     *
12     * TODO: Check that the state is valid first.
13     *
14     * <hal3.2 addition="" and="" configured="" in="" in_config="" in_re
15     *
16     * Do this for getBuffer as well.
17     */
18     status_t
19     res = returnBufferLocked(buffer, timestamp); //以queue
20     buffer为主
21
22     if
23     (res == OK) {
24         fireBufferListenersLocked(buffer,
25         /*acquired*/false,
26         /*output*/true);
27         mOutputBufferReturnedSignal.signal();
28     }
29
30     return
31     res;
32 }</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：

```
1 void ?
2 CallbackProcessor::onFrameAvailable(const
3 BufferItem& /*item*/)
4 {
5     Mutex::Autolock
6     l(mInputMutex);
7     if
8     (!mCallbackAvailable) {
9         mCallbackAvailable
10        = true;
11        mCallbackAvailableSignal.signal(); //数据callback线程处理
12    }
13 }
```

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。

```
1 bool ?
2 CallbackProcessor::threadLoop() {
3     status_t
4     res;
5     {
6         Mutex::Autolock
7         l(mInputMutex);
8         while
9         (!mCallbackAvailable) {
10             res
11             = mCallbackAvailableSignal.waitRelative(mInputMutex,
12             kWaitDuration);
13             if
14             (res == TIMED_OUT) return
15             true;
16         }
17         mCallbackAvailable
18         = false;
19     }
20     do
21     {
22         sp<camera2client>
23         client = mClient.promote();
24         if
```

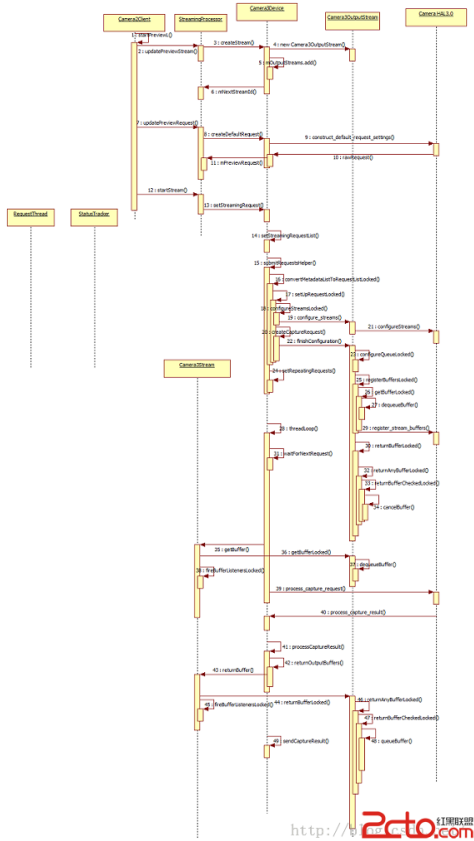


```
24 | (client == 0)
    | {
    |     res
    |     = discardNewCallback();
    | }
    | else
    | {
    |     res
    |     = processNewCallback(client); //callback
    |     处理新的一帧
    | }
    | }
    | while
    | (res == OK);
    |
    | return
    | true;
    | }</camera2client>
    |
1 | 1.mRemoteCallback->dataCallback(CAMERA_MSG_PREVIEW_FRAME,
    |
2 | 2.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的处理流程图:



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