Slice buffer design

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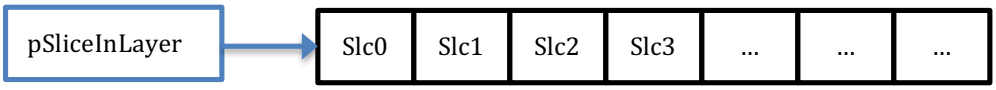
1. Overview for new design

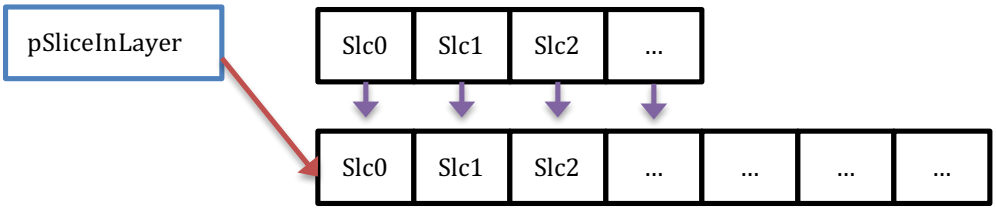
1.1. Origin design

SSlice* pSliceInLayer // slice buffer for all slices in layer

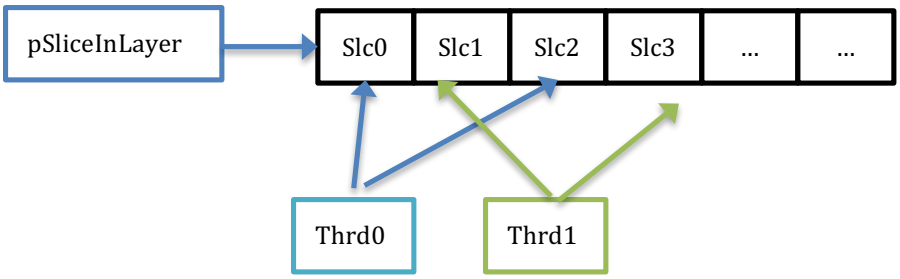
1.1.1. Single thread



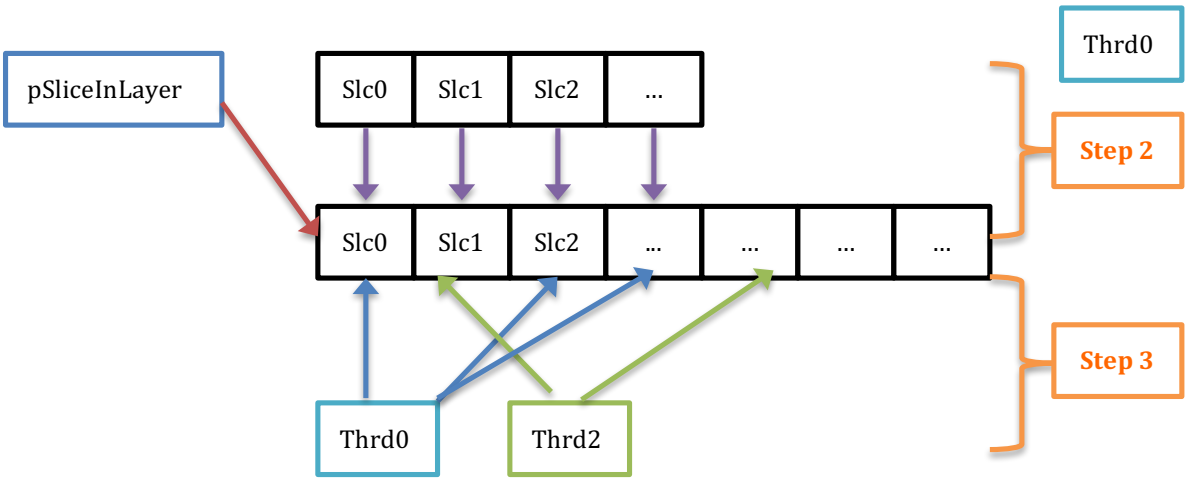
reallocate when current slice index larger than max slice num



1.1.2. Multi thread



reallocate when current slice index larger than max slice num ,
--step 0: thread[0] detect that current slice index larger than max slice num;
--step 1: thread[0] need to wait thread[1] completed current slice encoding task
--step 2: thread[1] stop slice encoding and thread[0] reallocate slice buffer,
--step 3: thread[0]/thread[1] start to encode new slice

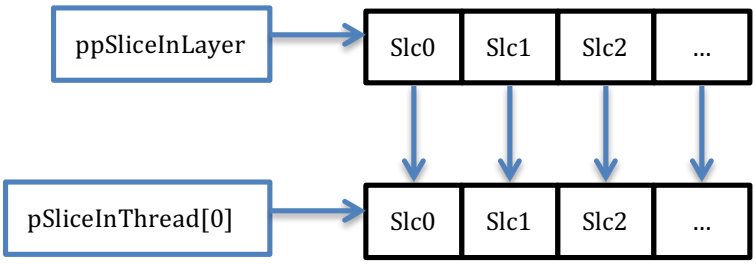


i.

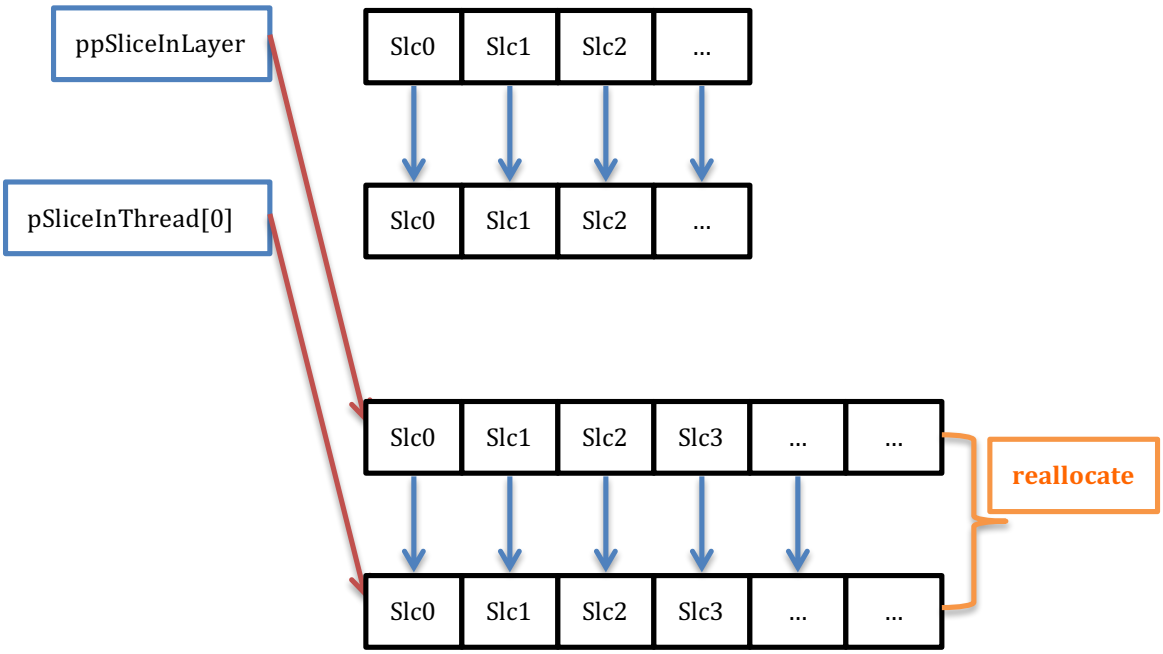
1.2 New design in review

```
SSlice*   pSliceInLayer;      //will be removed and replaced by
pSliceInThread[]
SSlice** ppSliceInLayer;    // point to actual slice buffer
                                    //based on slice index
SSlice* pSliceInThread[MaxThreadNum];  // actual slice buffer
```

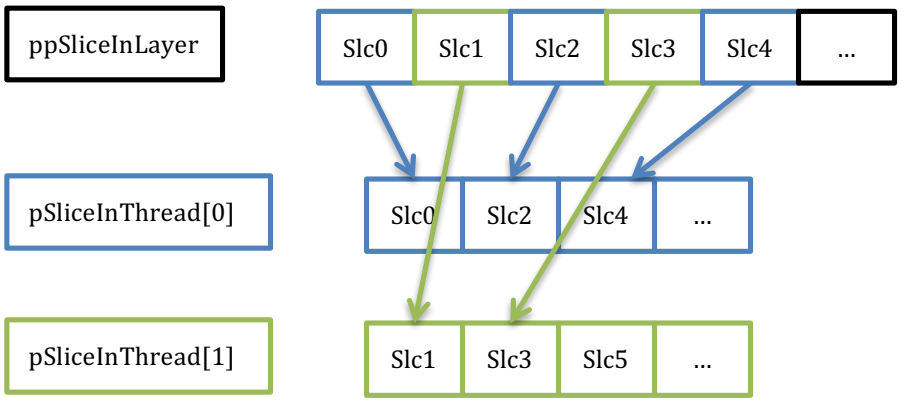
1.2.1 Single thread



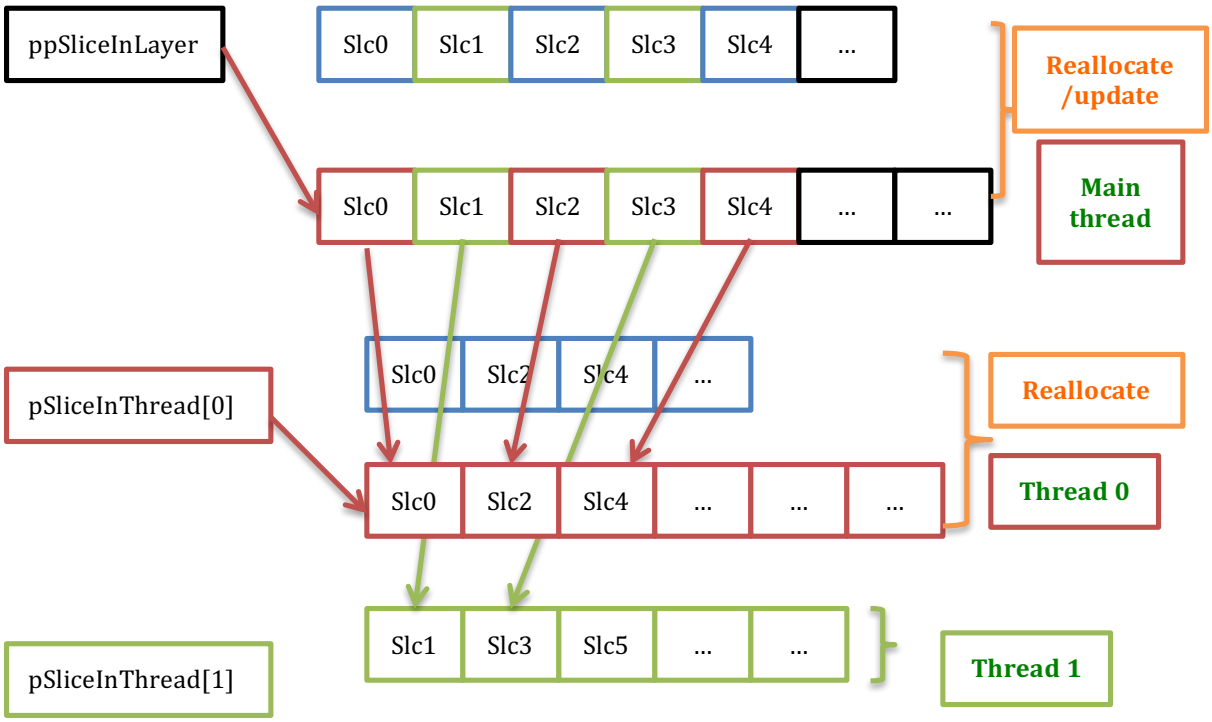
reallocate when current slice index larger than max slice num



1.2.2. Multi-thread



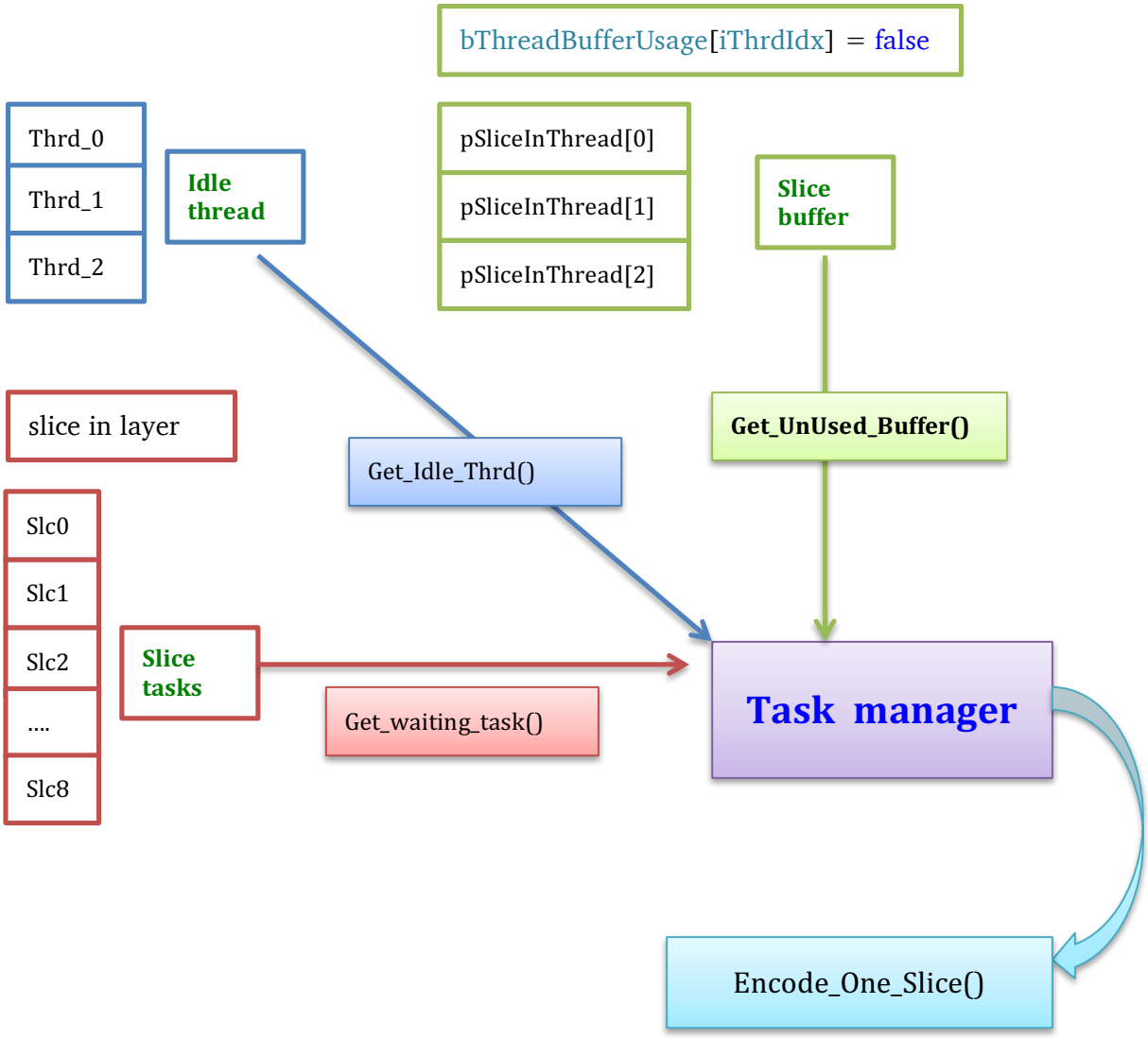
for reallocate, each thread will do it independently, and will update ppSliceInLayer by ***main thread*** when all slices in layer are encoded.



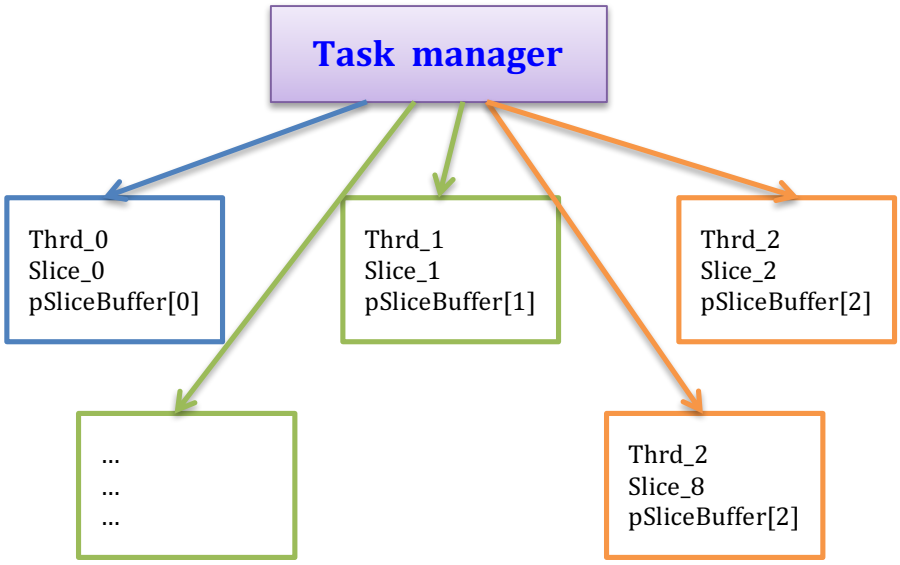
2. SLICE BUFFER AND THREAD

2.1 Before encoding one layer

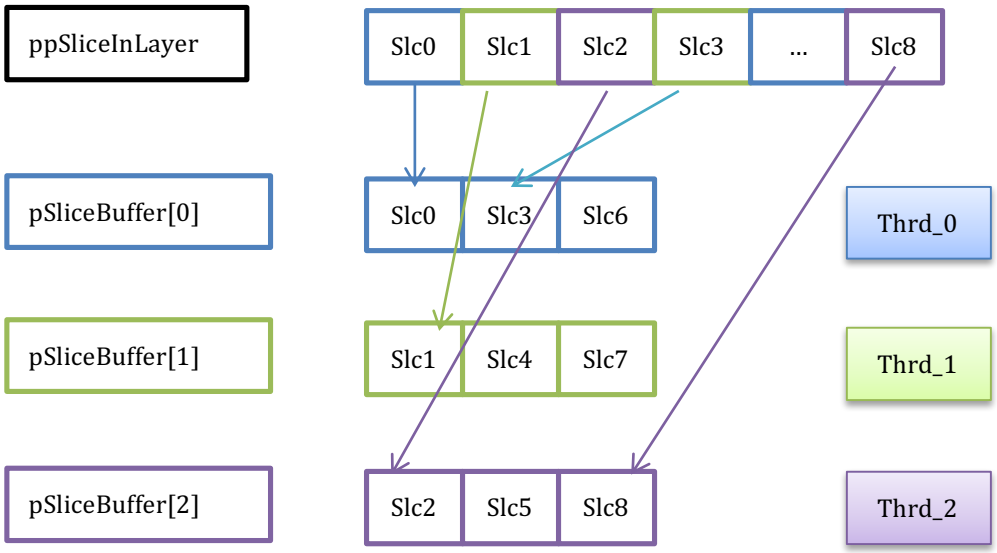
the status of slice buffer and thread :
example:
thread: 3 threads
slices: 9 slices in layer



2.2. Normal case for thread index and slice buffer index



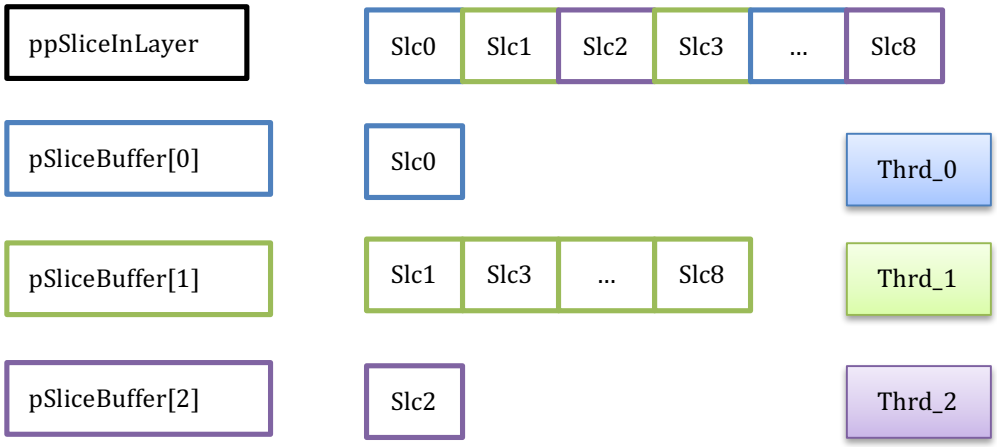
Final map for thread index and slice buffer index, slice index



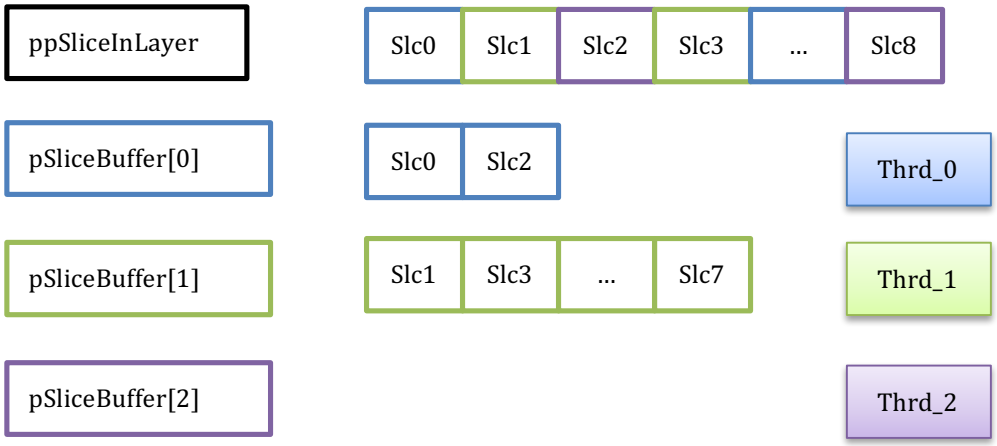
2.3. Slice num not the same among threads

case 1:

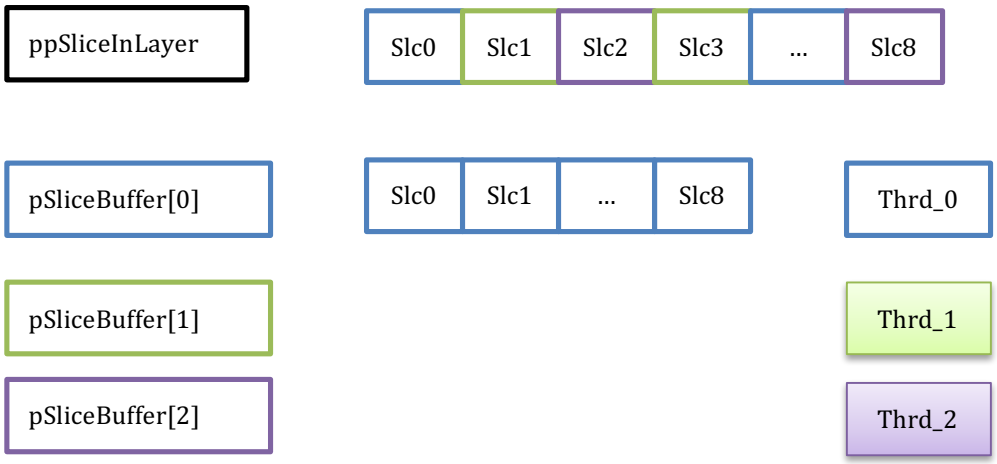
case 2:



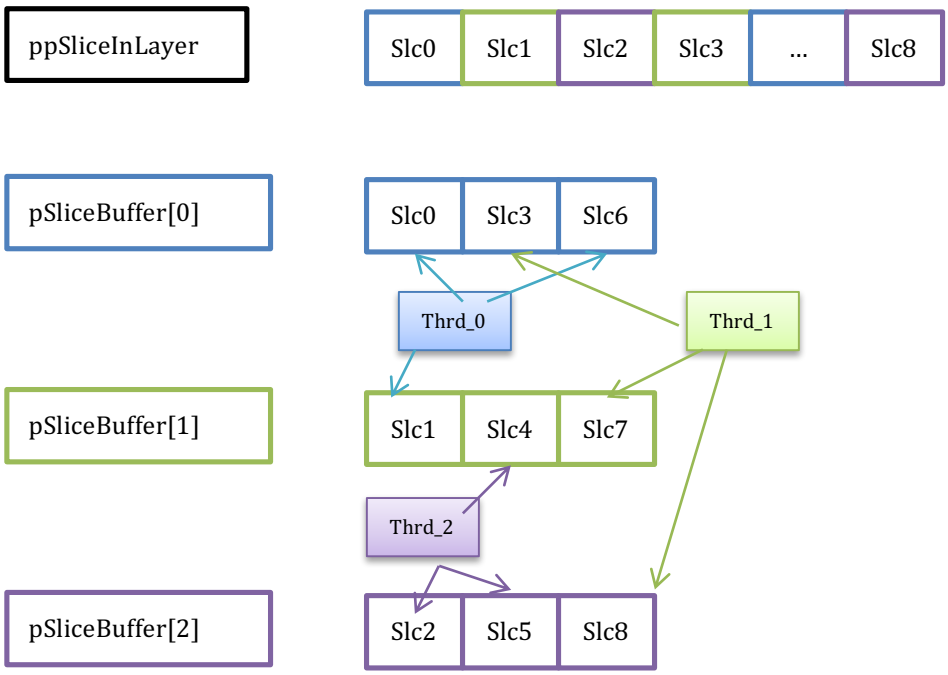
Corner case 1, no encoded slice for one thread:



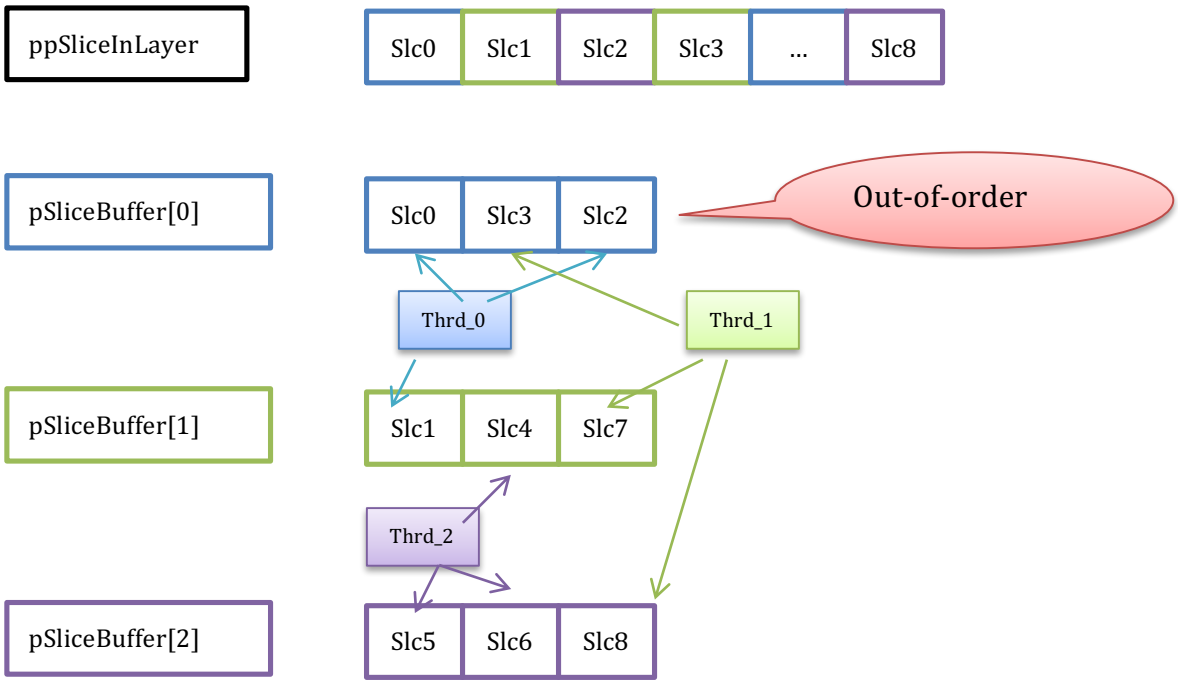
Corner case 2, all slices encoded by one thread :



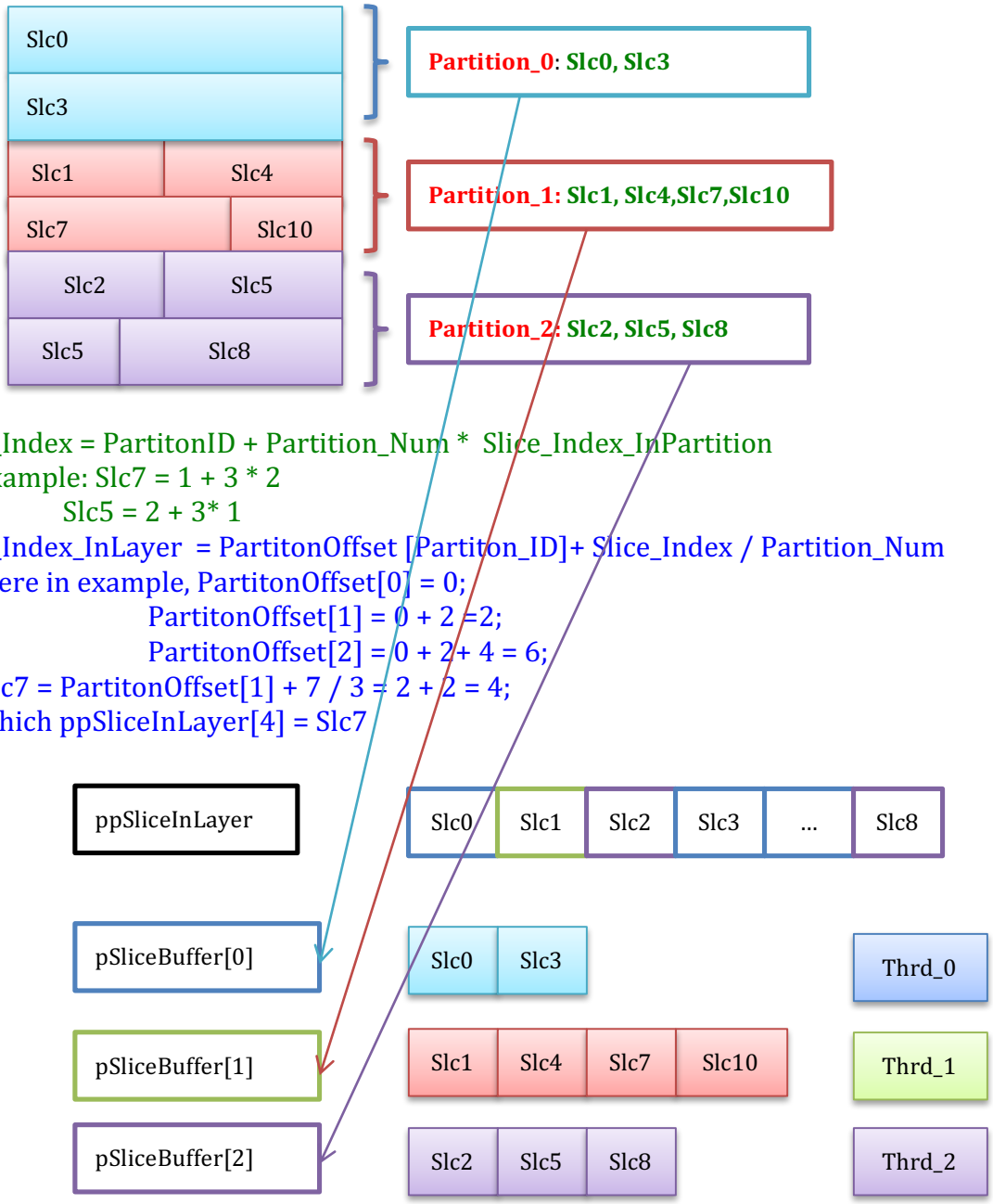
2.4. Different thread index in the same slice buffer



2.5. Slice index out-of-order case

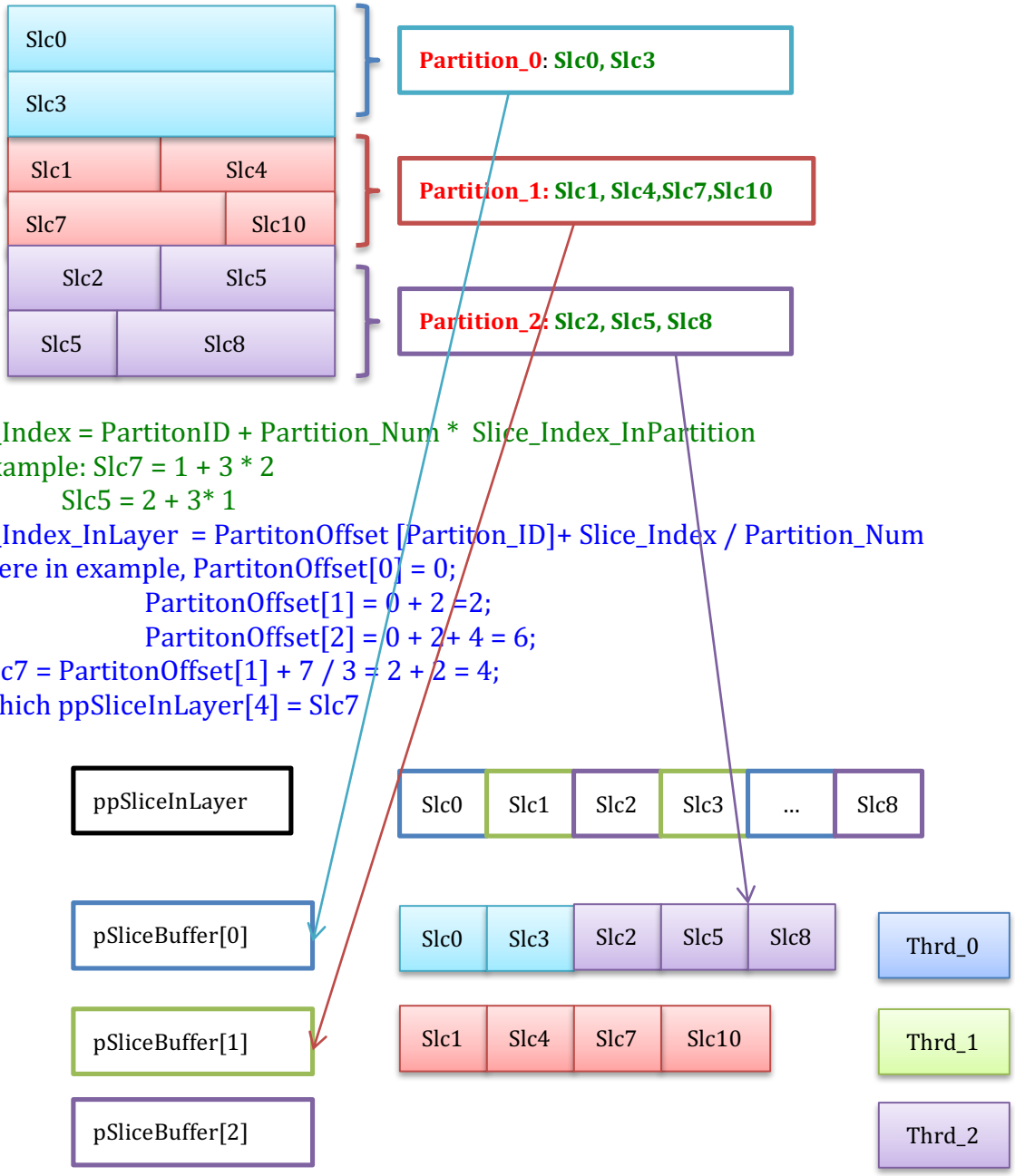


2.6. Dynamic slice mode case1



2.7. Dynamic slice mode case2

Thread_0 encoded two partitions
while no partition for Thread_2



Slice_Index = PartitonID + Partition_Num * Slice_Index_InPartition

Example: Slc7 = 1 + 3 * 2

Slc5 = 2 + 3* 1

Slice_Index_InLayer = PartitonOffset [Partiton_ID]+ Slice_Index / Partition_Num

Here in example, PartitonOffset[0] = 0;

PartitonOffset[1] = 0 + 2 =2;

PartitonOffset[2] = 0 + 2+ 4 = 6;

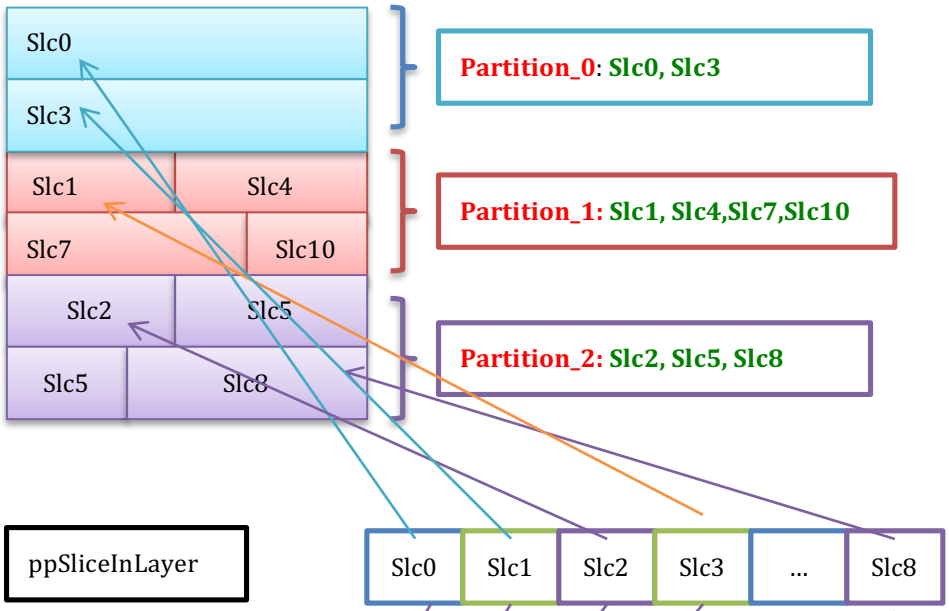
Slc7 = PartitonOffset[1] + 7 / 3 = 2 + 2 = 4;

Which ppSliceInLayer[4] = Slc7

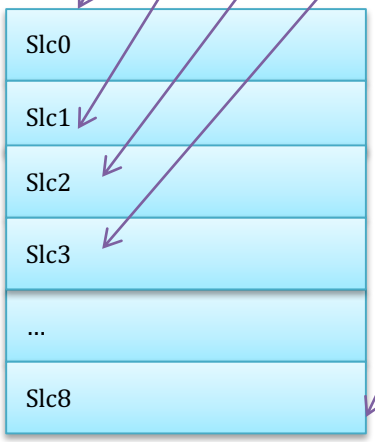
3. Slice Buffer Update/Reorder

3.1. Slice index in different slice mode.

Dynamic slice mode

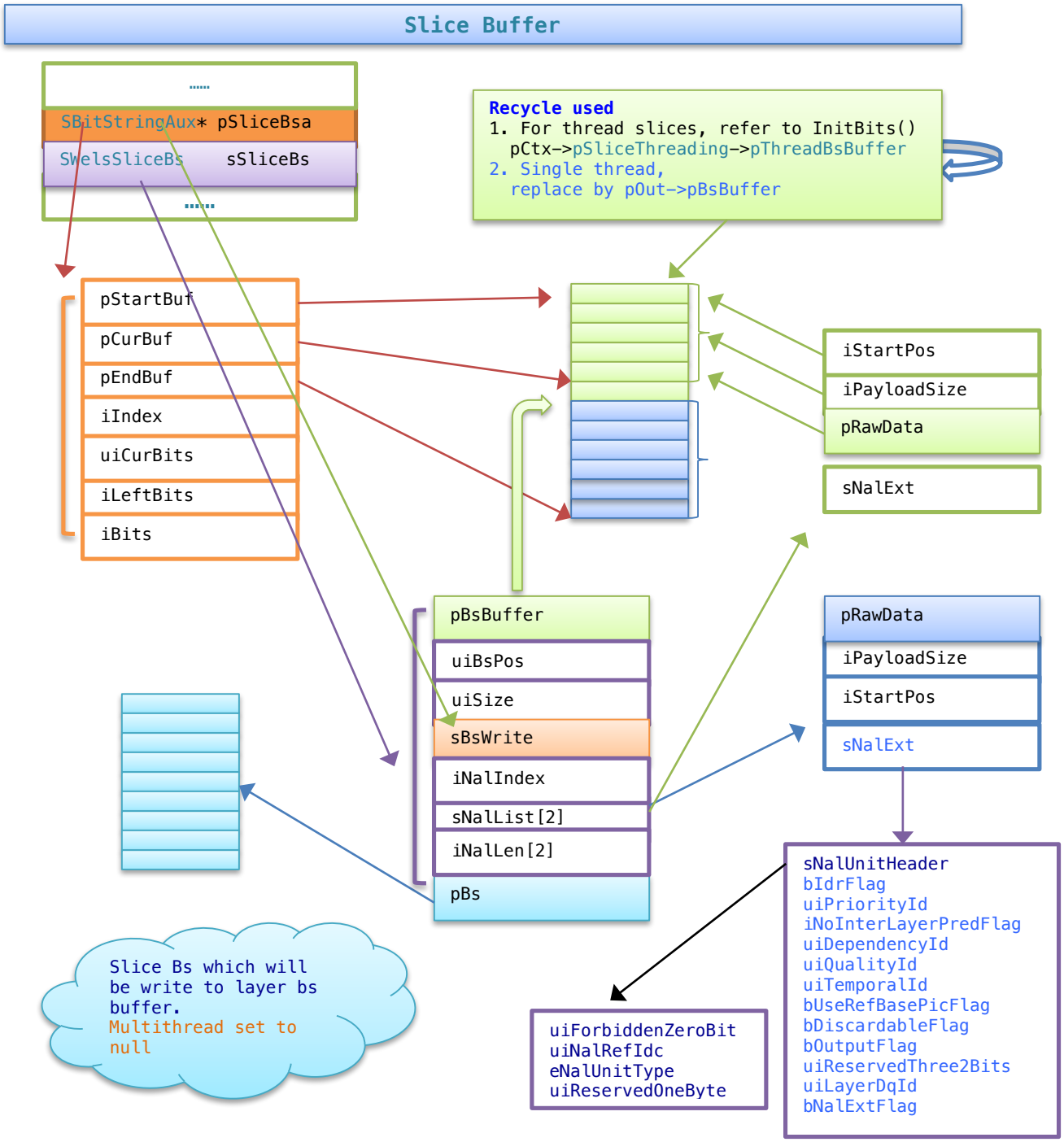


Non-dynamic slice mode



4. Bs buffer design

4.1. Slice Bs buffer



4.1.1. init

```
InitSliceBsBuffer()
   pSlice->sSliceBs.uiSize  = iMaxSliceBufferSize;
   (pCtx)->iSliceBufferSize[kiDlayerIndex];
   (*ppCtx)->pOut->uiSize   = iCountBsLen;

InitBits (&m_pSliceBs->sBsWrite,
           m_pSliceBs->pBsBuffer,
           m_pSliceBs->uiSize);



if (bIndependenceBsBuffer) {
    pSlice->pSliceBsa      = &pSlice->sSliceBs.sBsWrite;
    pSlice->sSliceBs.pBs   =
      (uint8_t*)pMa->WelsMalloc (iMaxSliceBufferSize, "SliceBs");

  } else {
    pSlice->pSliceBsa      = pCtx->pOut->sBsWrite;
    pSlice->sSliceBs.pBs   = NULL;
  }
```

4.1.2 encode one slice

```
//set recycle bs buffer to m_pSliceBs->pBsBuffer
SetOneSliceBsBufferUnderMultithread (m_pCtx,
                                     m_iThreadIdx, m_iSliceIdx);
//init m_pSliceBs->sBsWrite, and set its start buffer to recycle buffer
InitBits (&m_pSliceBs->sBsWrite,
           m_pSliceBs->pBsBuffer,
           m_pSliceBs->uiSize);


WelsLoadNalForSlice (m_pSliceBs,
                     m_eNalType,
                     m_eNalRefIdc);
WelsCodeOneSlice (m_pCtx, m_iSliceIdx,
                  m_eNalType);

WelsUnloadNalForSlice (m_pSliceBs);

WriteSliceBs (m_pCtx,
              m_pSliceBs,
              m_iSliceIdx,
              m_iSliceSize)

iLayerSize = AppendSliceToFrameBs (pCtx, pLayerBsInfo, iSliceCount);
```

4.2. Frame bs buffer

4.2.1 init

```
  iVclLayersBsSizeCount += iLayerBsSize;
  iCountBsLen   = iNonVclLayersBsSizeCount + iVclLayersBsSizeCount;
  (*ppCtx)->pOut->uiSize = iCountBsLen;

  (*ppCtx)->pOut->pBsBuffer =
         (uint8_t*)pMa->WelsMallocz (iCountBsLen, "pOut->pBsBuffer");
  (*ppCtx)->pFrameBs = (uint8_t*)pMa->WelsMalloc (iTotalLength,
"pFrameBs");
  (*ppCtx)->iFrameBsSize = iTotalLength;

  InitBits (&pEncCtx->pOut->sBsWrite, pEncCtx->pOut->pBsBuffer,
pEncCtx->pOut->uiSize)


if (bIndependenceBsBuffer) {
    pSlice->pSliceBsa      = &pSlice->sSliceBs.sBsWrite;
    pSlice->sSliceBs.pBs   =
      (uint8_t*)pMa->WelsMalloc (iMaxSliceBufferSize, "SliceBs");

  } else {
    pSlice->pSliceBsa      = pCtx->pOut->sBsWrite;
    pSlice->sSliceBs.pBs   = NULL;
  }
```

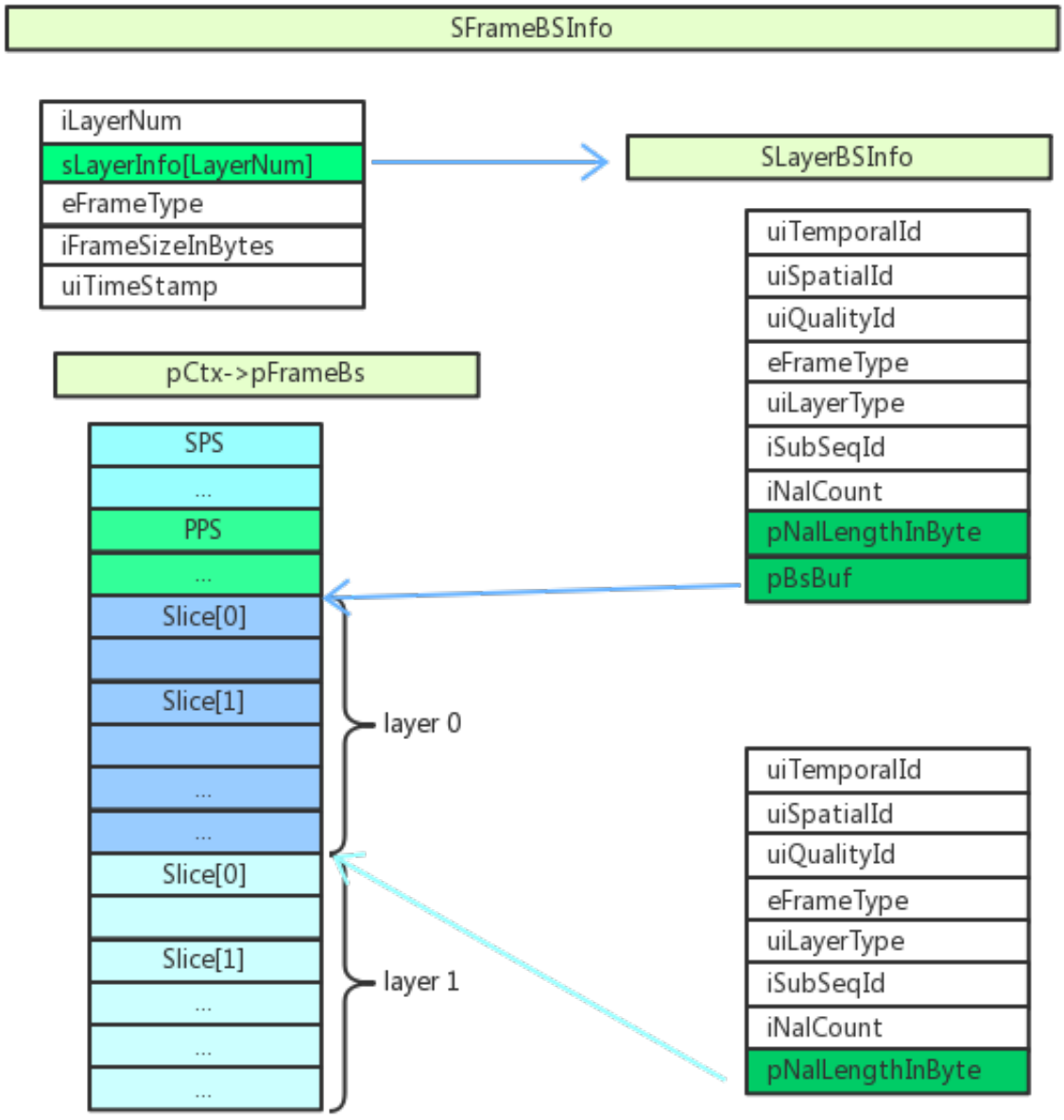
4.2.2. WelsWriteOneSPS()

```
WelsLoadNal (pCtx->pOut,
             NAL_UNIT_SPS,
             NRI_PRI_HIGHEST);

WelsWriteSpsNal (&pCtx->pSpsArray[kiSpsIdx],
                 &pCtx->pOut->sBsWrite,
                 …);
WelsUnloadNal (pCtx->pOut);

WelsEncodeNal (&pCtx->pOut->sNalList[iNal],
               NULL,
               pCtx->iFrameBsSize - pCtx->iPosBsBuffer,
               pCtx->pFrameBs + pCtx->iPosBsBuffer,
               &iNalSize);
```

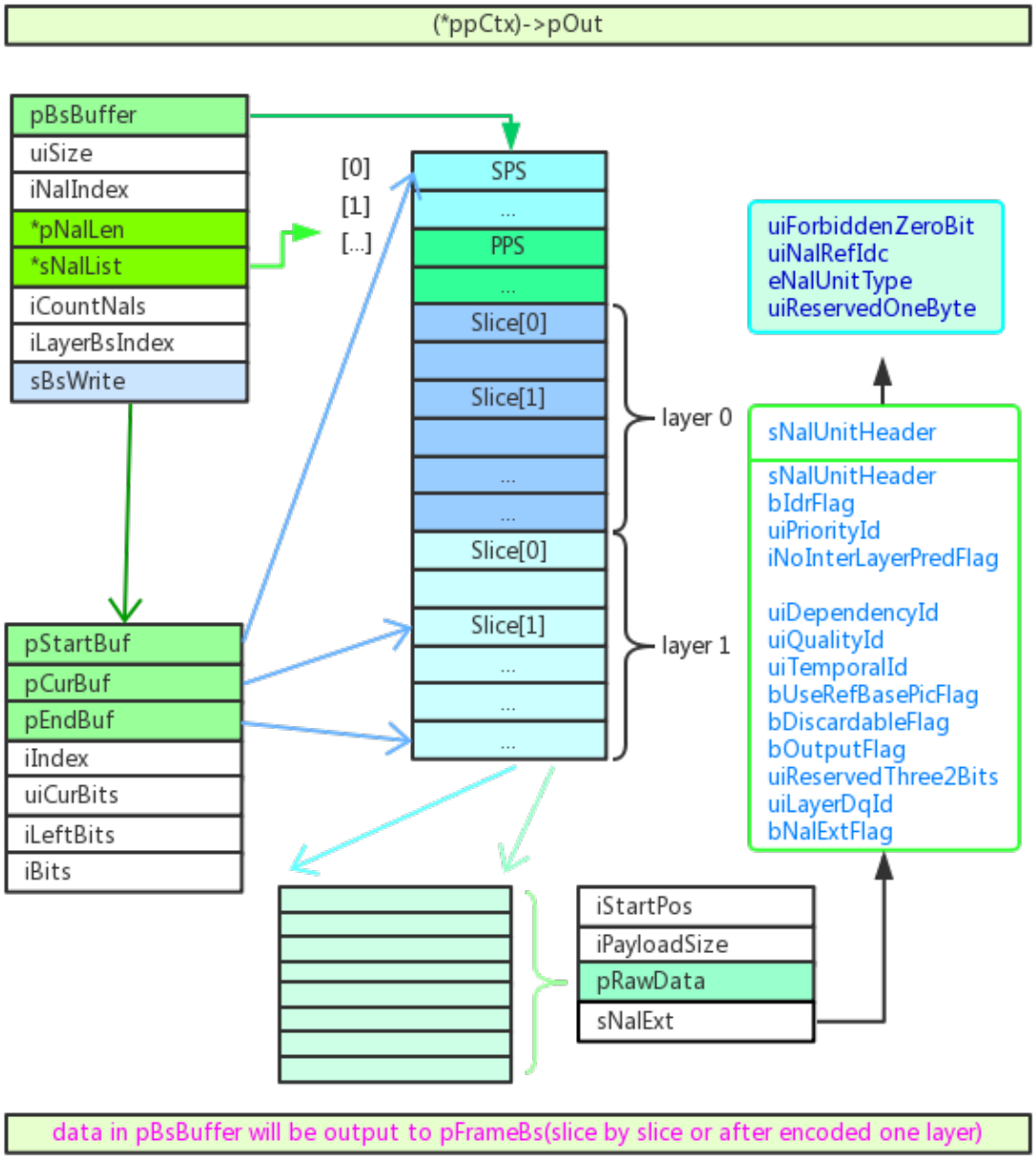
4.2.3. Single thread, encode one slice

```
WelsLoadNal (pCtx->pOut,
             eNalType,
             eNalRefIdc);
WelsCodeOneSlice (pCtx,
                  iSliceIdx,
                  eNalType);

WelsUnloadNal (pCtx->pOut);

WelsEncodeNal (&pCtx->pOut->sNalList[pCtx->pOut->iNalIndex - 1],
               &pCtx->pCurDqLayer->sLayerInfo.sNalHeaderExt,
               pCtx->iFrameBsSize - pCtx->iPosBsBuffer,
               pCtx->pFrameBs + pCtx->iPosBsBuffer,
               &pLayerBsInfo->pNalLengthInByte[iNalIdxInLayer]);
```

4.2.4. frame bs and layer bs



4.2.5. pCtx-pOut



4.3. Slice layer buffer reallocate

4.3.1. origin design

?? max slice num limitation in JM?? Standard??

```
int32_t FrameBsRealloc (sWelsEncCtx* pCtx,
                        SFrameBSInfo* pFrameBsInfo,
                        SLayerBSInfo* pLayerBsInfo)

int32_t ReallocSliceBuffer (sWelsEncCtx* pCtx){

       ReallocateSliceList()
       for (iSliceIdx = 0; iSliceIdx < iMaxSliceNumNew; iSliceIdx++) {
           pCurLayer->ppSliceInLayer[iSliceIdx] =
           pCurLayer->sSliceThreadInfo.pSliceInThread[0] + iSliceIdx;
       }
   }

int32_t DynSliceRealloc (sWelsEncCtx* pCtx,
                         SFrameBSInfo* pFrameBsInfo,
                         SLayerBSInfo* pLayerBsInfo) {

            iRet = FrameBsRealloc (pCtx, pFrameBsInfo, pLayerBsInfo);
            iRet = ReallocSliceBuffer (pCtx);
      }

int32_t ReallocateSliceList (sWelsEncCtx* pCtx,
                             SSliceArgument* pSliceArgument,
                             SSlice*& pSliceList,
                             const int32_t kiMaxSliceNumOld,
                             const int32_t kiMaxSliceNumNew){
          for(){
            iRet = InitSliceBsBuffer (pSlice,
                              & pCtx->pOut->sBsWrite,
                              bIndependenceBsBuffer,
                              iMaxSliceBufferSize, pMA);
            iRet = AllocateSliceMBBuffer (pSlice, pMA);
            iRet = InitSliceMBInfo (pSliceArgument,
                            pSlice,
                            pCurLayer->iMbWidth,
                            pCurLayer->iMbHeight);

            InitSliceHeadWithBase (pSlice, pBaseSlice);
            InitSliceRefInfoWithBase (pSlice, pBaseSlice,
                              pCtx->iNumRef0);

            iRet = InitSliceRC (pSlice,
                                pCtx->iGlobalQp, iBitsPerMb);
         }
}

int32_t ReallocateSliceInThread (sWelsEncCtx* pCtx,
                                 SDqLayer* pDqLayer,
                                 const int32_t kiDlayerIdx,
                                 const int32_t kiThreadIndex);
```

4.3.2. new design

```
in layer level, reallocate thread by thread;
ReallocSliceBuffer() will be removed later
int32_t ReallocateSliceInThread (sWelsEncCtx* pCtx,
                                 SDqLayer* pDqLayer,
                                 const int32_t kiDlayerIdx,
                                 const int32_t kiThreadIndex);

after encoded one layer, reallocate layer level buffer if need.
if (iSliceIdx >= (pSliceCtx->iMaxSliceNumConstraint - kiSliceIdxStep)){}

 int32_t FrameBsRealloc (sWelsEncCtx* pCtx,
                         SFrameBSInfo* pFrameBsInfo,
                         SLayerBSInfo* pLayerBsInfo);


AppendSliceToFrameBs (pCtx, pLayerBsInfo, iSliceCount);
```

TODO:

```
//will update slice  by slice after encoded one slice
sSliceThreadInfo.iEncodedSliceNumInThread[iThreadIdx]
```

//will update layer maxsliceNum

```
pCurLayer->sSliceEncCtx.iMaxSliceNumConstraint
// ++ pSliceCtx->iSliceNumInFrame
```

//will remove below check, no need to check in MB level but slice level

```
const bool    kbSliceNumNotExceedConstraint =
                pSliceCtx->iSliceNumInFrame <
                pSliceCtx->iMaxSliceNumConstraint;
const bool    kbSliceIdxNotExceedConstraint =
                ((int) pCurSlice->uiSliceIdx + kiActiveThreadsNum) <
        pSliceCtx->iMaxSliceNumConstraint;
const bool    kbSliceNumReachConstraint =
       (pSliceCtx->iSliceNumInFrame ==
        pSliceCtx->iMaxSliceNumConstraint);
```

4.4. Slice buffer update

```
int32_t ReOrderSliceInLayer (SDqLayer* pCurLayer,
                             const int32_t kiThreadNum,
                             const int32_t kiPartitionNum);

int32_t CheckAllSliceBuffer(SDqLayer* pCurLayer,
                            const int32_t kiCodedSliceNum);

int32_t SliceLayerInfoUpdate (sWelsEncCtx* pCtx,
                              const int32_t kiDlayerIndex);
```

4.5 slice encode and MB info update

```
int32_t WelsISliceMdEncDynamic (sWelsEncCtx* pEncCtx,
                                SSlice* pSlice) {
      pCurLayer->pLastCodedMbIdxOfPartition[kiPartitionId] =
                                                    iCurMbIdx -1;
      ++ pCurLayer->pNumSliceCodedOfPartition[kiPartitionId];
}

pCurLayer->sSliceEncCtx.iMaxSliceNumConstraint
// ++ pSliceCtx->iSliceNumInFrame
```

//MB—Slice—partition map

```
pSliceCtx->pOverallMbMap[iCurMbIdx]
pEncCtx->iActiveThreadsNum;
pEncCtx->pCurDqLayer->pLastMbIdxOfPartition[kiPartitaionId];

const int32_t  kiPartitaionId = pCurSlice->uiSliceIdx %
                                kiActiveThreadsNum;
const int32_t  kiLastMbIdxInPartition =
           pEncCtx->pCurDqLayer->pLastMbIdxOfPartition[kiPartitaionId];
const bool    kbCurMbNotFirstMbOfCurSlic  = ((iCurMbIdx > 0) &&
              (pSliceCtx->pOverallMbMap[iCurMbIdx] ==
               pSliceCtx->pOverallMbMap[iCurMbIdx - 1]));
const bool    kbCurMbNotLastMbOfCurPartition = iCurMbIdx <
kiLastMbIdxInPartition;
```

4.6. dynamic slice, slice boundary strategy

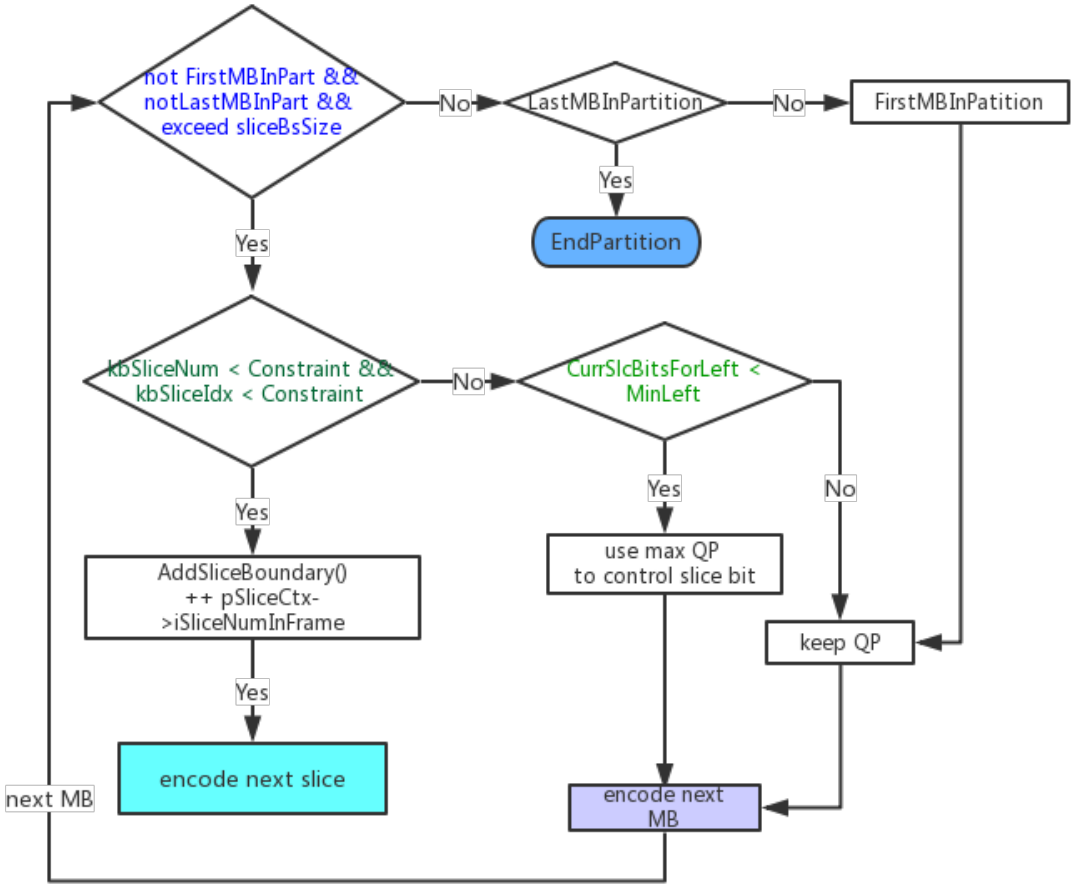
4.6.1. relate function

```
int32_t WelsISliceMdEncDynamic (sWelsEncCtx* pEncCtx, SSlice* pSlice)

int32_t WelsMdInterMbLoopOverDynamicSlice (sWelsEncCtx* pEncCtx,
                                           SSlice* pSlice,
                                           void* pWelsMd,
                                          const int32_t kiSliceFirstMbXY)


void AddSliceBoundary (sWelsEncCtx* pEncCtx,
                       SSlice* pCurSlice, SSliceCtx* pSliceCtx,
                       SMB* pCurMb,
                       int32_t iFirstMbIdxOfNextSlice,
                       const int32_t kiLastMbIdxInPartition) {

  const int32_t kiSliceIdxStep  = pEncCtx->iActiveThreadsNum;
  uint16_t      iNextSliceIdc   = iCurSliceIdc + kiSliceIdxStep;

  //update cur pSlice info
  pCurSlice->sSliceHeaderExt.uiNumMbsInSlice = 1 +
           iCurMbIdx - pCurSlice->sSliceHeaderExt.sSliceHeader.iFirstMbInSlice;

  //pNextSlice pointer/initialization
  pNextSlice = pCurLayer->ppSliceInLayer[ iNextSliceIdc ];

  ppSliceInLayer[iNextSliceIdc]->sSliceHeaderExt.sSliceHeader.iFirstMbInSlice =
                                                          iFirstMbIdxOfNextSlice;

  WelsSetMemMultiplebytes_c (pSliceCtx->pOverallMbMap + iFirstMbIdxOfNextSlice,
                             iNextSliceIdc,
                             (kiLastMbIdxInPartition -iFirstMbIdxOfNextSlice +1),
                             sizeof (uint16_t));

 // update left/right/up ect available info, one row only
  UpdateMbNeighbor(pCurDq, &pMbList[iIdx], kiMbWidth, uiSliceIdc);


#
}
```

//ToDo:

```
pNextSlice = pCurLayer->ppSliceInLayer[ iNextSliceIdc ];
will be replace by pSliceInThread[]
```

4.6.2. flow chart



4.7. ppSliceInLayer init/update functions

4.7.1 ppSliceInLayer info init/update befor encode all slice in one layer

before encode one sequence

```
  ---->pPtrEnc->SetOption()
      ---->WelsRcInitFuncPointers()
          ----> pRcf->pfWelsRcPictureInit = WelsRcPictureInitGom()
              ---->RcInitGomParameters() //ppSlice, init function pointer only
          ---->pRcf->pfWelsRcPictureInit = WelRcPictureInitScc;                 // no ppSlice
          ----> pRcf->pfWelsRcPictureInit = WelRcPictureInitBufferBasedQp // no ppSlice
          ----> pRcf->pfWelsRcPictureInit = WelsRcPictureInitDisable;         // no ppSlice

          ----> pRcf->pfWelsRcPictureInfoUpdate = WelsRcPictureInfoUpdateGom;
              ---->  RcUpdatePictureQpBits (pEncCtx, iCodedBits);   //ppSlice, init function only
             ---->RcInitSliceInformation (pEncCtx);  //ppSlice

          ---->pRcf->pfWelsRcPictureInfoUpdate = WelsRcPictureInfoUpdateGomTimeStamp;
              ---->  RcUpdatePictureQpBits (pEncCtx, iCodedBits);   //ppSlice, init function only
          ---->pRcf->pfWelsRcPictureInfoUpdate = WelsRcPictureInfoUpdateScc;  // no ppSlice

          ---->pRcf->pfWelsRcMbInit = WelsRcMbInitGom;
               ---->WelsRcMbInitGom()   //ppSlice
          ---->pRcf->pfWelsRcMbInit = WelsRcMbInitScc;  // no ppSlice

          ----> pRcf->pfWelsRcMbInfoUpdate = WelsRcMbInfoUpdateGom;
              ---->WelsRcMbInfoUpdateGom()   //ppSlice

  ---->WelsInitEncoderExt()
       ----> RequestMemorySvc (&pCtx, pExistingParasetList) //multi thread
           ---->InitDqLayers (ppCtx, pExistingParasetList);
               ---->InitSliceInLayer()   //ppSlice
```

Before encode one frame

```
EncodeFrameInternal()
 -->WelsEncoderEncodeExt()
     before encode all slice in layer
     ---->WelsUpdateRefSyntax (pCtx,  pParamInternal->iPOC,  eFrameType) // ppSlice
     ----> PreprocessSliceCoding (pCtx);
          ---->DeblockingFilterSliceAvcbase()  // function pointer only, no processing
          ---->pFuncList->pfUpdateFMESwitch = UpdateFMESwitch;  //function pointer
              ---->CountFMECostDown()  //ppSlice

     ---->WelsInitCurrentDlayerMltslc (pCtx, iPicIPartitionNum) //Dynamic slice mode only
         ---->UpdateSlicepEncCtxWithPartition() // ppSlice Dynamic slice mode only

     ---->WelsInitCurrentLayer()  // ppSlice
     ---->PrefetchReferencePicture (pCtx, eFrameType); // ppSlice update reference picture
     ---->pCtx->pFuncList->pfRc.pfWelsRcPictureInit (pCtx, pFbi->uiTimeStamp)
         ---->RcInitGomParameters() //ppSlice
         ---->RcInitSliceInformation (pEncCtx);  //ppSlice

     ---->pCtx->pReferenceStrategy->MarkPic();
         ---->WelsMarkPic (m_pEncoderCtx)   //ppSlice
         ---->WelsMarkPicScreen (m_pEncoderCtx);  //ppSlice

     ---->AdjustEnhanceLayer (pCtx, iCurDid); //ppSlice FixedSlice Mode only
        ---->NeedDynamicAdjust()  //ppSlice
        ---->DynamicAdjustSlicing() //ppSlice
```

```
---->int32_t FiredSliceThreads (sWelsEncCtx* pCtx, ...) // ppSlice for Partition first MB info
    ---->SetOneSliceBsBufferUnderMultithread()  //ppSlice
---->WelsErrorType CWelsSliceEncodingTask::InitTask()  //ppSlice
```

4.7.2. ppSliceInLayer buffer update functions during encode all slice in layer

during encoding one slice

```
EncodeFrameInternal()
 -->WelsEncoderEncodeExt()
   ---->WelsCodeOnePicPartition
   ---->CWelsConstrainedSizeSlicingEncodingTask::ExecuteTask()  //ppSlice
        ---->int32_t ReallocSliceBuffer (sWelsEncCtx* pCtx)

   ---->int32_t WelsCodeOneSlice ()   // ppSlice
      ---->WelsSliceHeaderExtInit (pEncCtx, pCurLayer, pCurSlice); //ppSlice
           ---->WelsGetFirstMbOfSlice() //ppSlice

      ---->WelsCodePSlice()
      ----> WelsCodePOverDynamicSlice()
          ---->AddSliceBoundary() //ppSlice
      ---->WelsISliceMdEnc()
      ----> WelsISliceMdEncDynamic()
          ---->pEncCtx->pFuncList->pfRc.pfWelsRcMbInit (pEncCtx, pCurMb, pSlice)
               ---->WelsRcMbInitGom()   //ppSlice
          ----> pEncCtx->pFuncList->pfRc.pfWelsRcMbInfoUpdate( );
              ---->WelsRcMbInfoUpdateGom()  //ppSlice

   ---->void UpdateMbListNeighborParallel (SDqLayer* pCurDq,..)  //ppSlice, seem no call this funtion

   ---->void CWelsLoadBalancingSlicingEncodingTask::FinishTask() //ppSlice
```

4.7.3. ppSliceInLayer buffer update functions after encode all slice in layer

```
EncodeFrameInternal()
  -->WelsEncoderEncodeExt()
       after encode all slice in layer
     ---->int32_t SliceLayerInfoUpdate()
          ---->int32_t ReOrderSliceInLayer (SDqLayer* pCurLayer..)
          ---->static inline int32_t CheckAllSliceBuffer...)()

     ---->AppendSliceToFrameBs (pCtx, pLayerBsInfo, iSliceCount);  //ppSlice, MT only
      ---->PerformDeblockingFilter()
           ----> DeblockingFilterFrameAvcbase (pCurLayer, pEnc->pFuncList); //ppSlice
           ---->DeblockingFilterSliceAvcbase()  //ppSlice
     ---->pCtx->pFuncList->pfRc.pfWelsRcPictureInfoUpdate (pCtx, iLayerSize);
           ---->WelsRcPictureInfoUpdateGomTimeStamp
                 ---->RcUpdatePictureQpBits()   //ppSlice
           ---->WelsRcPictureInfoUpdateGom()
                 ---->RcUpdatePictureQpBits()   //ppSlice
     ---->pCtx->pFuncList->pfUpdateFMESwitch (pCtx->pCurDqLayer);
           ---->CountFMECostDown()  //ppSlice


     ---->TrackSliceComplexities()
     ----> CalcSliceComplexRatio (pCtx->pCurDqLayer);

      after encode all slice in all layer
      ---->TrackSliceConsumeTime (pCtx, iDidList, iSpatialNum);  //ppSlice
      ----> AdjustBaseLayer (pCtx) //ppSlice,  FixedSlice Mode && multiLayer && MultiThread only
          ---->NeedDynamicAdjust()   //ppSlice
          ---->DynamicAdjustSlicing() //ppSlice
```