Lossless coding for Still Pictures with HEVC

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Objectives of the presentation

- Show the positive points which make this scheme interesting
  - Use case oriented
- Explain the lossless coding which can be done with HEVC
  - Technology oriented

Use Case Part

WHY USING LAYERED LOSSLESS?

Targeted applications

- Storing format for data on PACS
  - This solution is to replace heavy and inconvenient pure raw files

- Lossless monochrome still pictures
  - CT images etc.

- Lossless 4:4:4 videos as series of still pictures
  - 2D rendering of 3D captures are saved in lossless
  - Also targeting endoscopic videos
  - Needs observed by Fujitsu in medical facilities

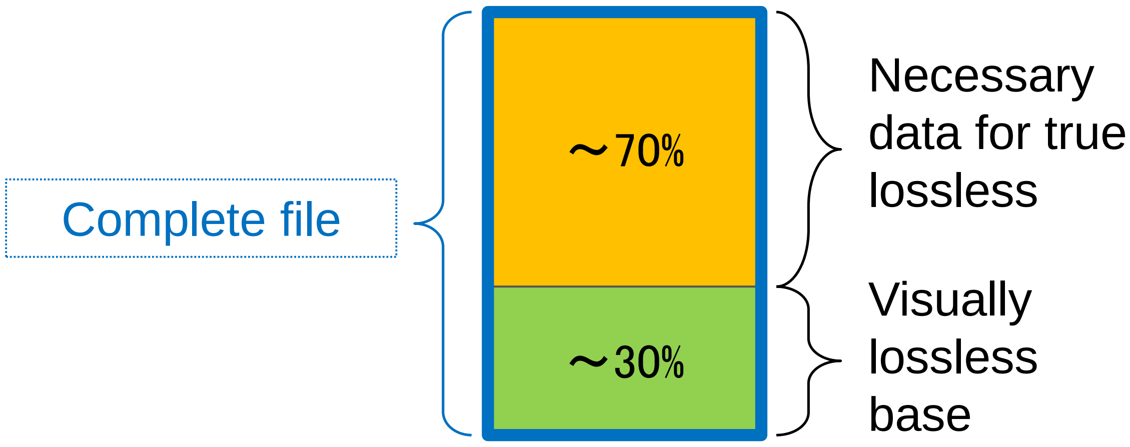
HEVC for still pictures?

- HEVC is very efficient for still picture coding too

- By industry demand, HEVC even has a dedicated profile
  - https://en.wikipedia.org/wiki/High_Efficiency_Video_Coding#Main_Still_Picture

Desirability of layered lossless

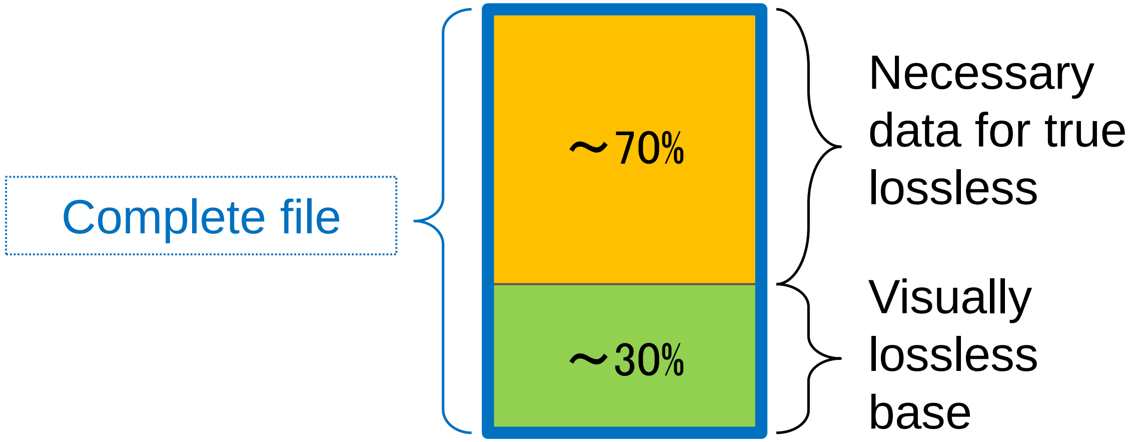
- Each picture is separated into two parts:
  - A light lossy part
    - Which can still be visually lossless
  - A heavy lossless part
    - Encoding remaining noise for full lossless reconstruction
- The two parts are complementary
- The lossy part can be processed without the other



Use case 1

- Across medical facilities

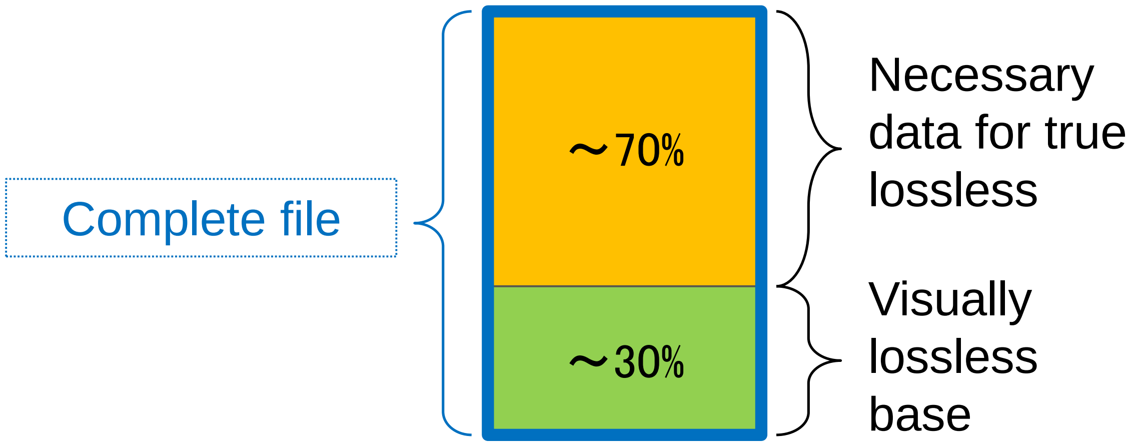
- Physician can
  - 1) Request files from another facility
  - 2) Receive the visually lossless files quickly
  - 3a) Start working on the visually lossless files
  - 3b) Meanwhile, the full lossless versions are downloaded
  - 4) The physician's facility gets full lossless data for legal purposes



Use case 2

- Within the medical facility

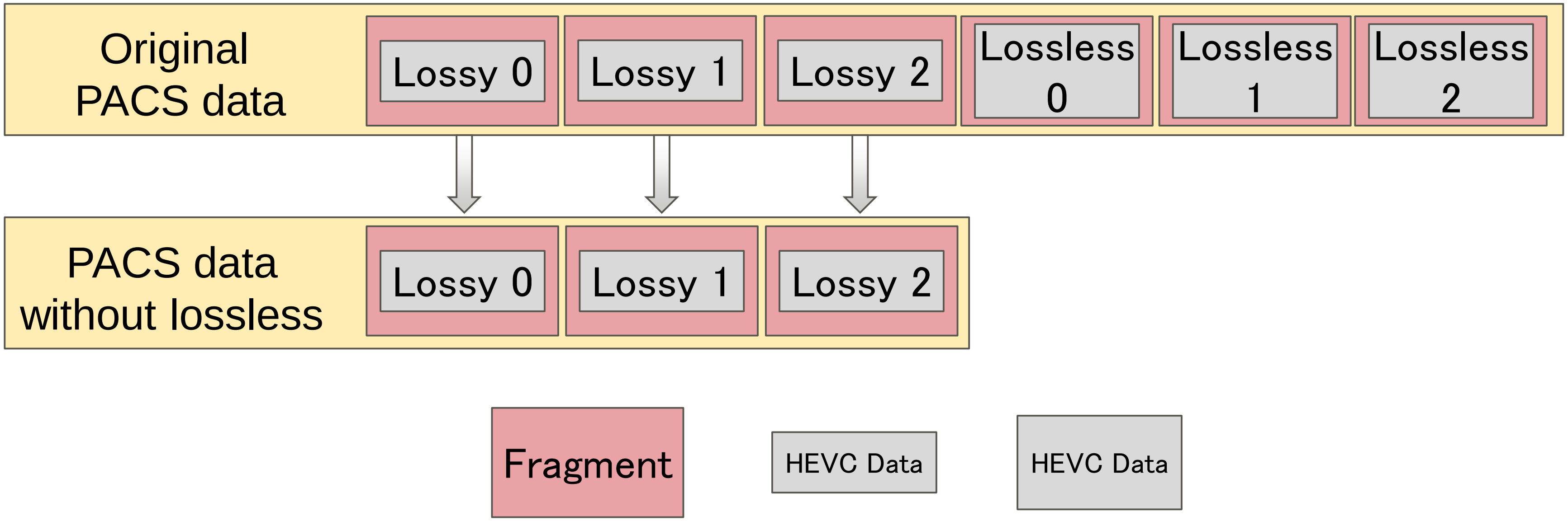
- Physician can
  - 1) Request for lossy files from PACS
  - 2) Receive the visually lossless files quickly on his tablet
  - 3) Work on the visually lossless files
  - The whole transfer requires no big complexity from PACS
    - No encoding/decoding – only re-encapsulating
  - The whole transfer is light for the internal network



Use case 3

- Within the medical facility

- Facility can delete all lossless complementary data
  - No reading of the stream necessary
  - Simply re-encapsulate the lossy fragments into a new DICOM item
    - Without the lossless complementary parts
  - Reduce memory burden on systems without complexity



Availability on market

- Decoders:
  - Software decoding is fast enough for most use cases
  - Proposed simplifications allow for cheaper dedicated hardware
  - Decoding Lossless complement requires very low complexity:
    - Copy the lossy image
    - Decode extra noise
      - Using DPCM: Difference between values sent instead of raw values

- For encoders
  - Any 4:0:0 / 4:4:4 scalable encoder with the specified constraints
      - It only simplifies their processing
      - No required additional functionality
  - Using specific codecs is advantageous but not required
    - Lowers the complexity of implementing and operating

Advantages over JPEG2000 (1/2)

Lower complexity when processing images:

When sending 1 lossy part:	
JPEG streams	HEVC streams
1) Find Image in DICOM object 2) Open JPEG stream 3) Find necessary where to truncate stream to get required lossy quality 4) Re-encapsulate lossy trunk selected 5) Send new object	1) Find lossy image in DICOM object 2) Re-encapsulate lossy fragment selected 3) Send new object

When sending 1 lossless image:	
JPEG streams	HEVC streams
1) Find Image in DICOM object 2) Re-encapsulate Image fragment selected 3) Send new object	1) Find lossy image in DICOM object 2) Find Lossless image in DICOM object 3) Re-encapsulate lossy and lossless fragments selected 4) Send new object

Note: in HEVC case, finding lossy or lossless fragments means reading the DICOM object header index data

Advantages over JPEG2000 (2/2)

- No patent issue, can be used now
- Similar complexity for decoding
- Can similarly use 1 object for multi frame
  - (with all frames independent from one another)

OR

- Can use 1 object for 1 frame
- Big lossy compression improvement
  - 6dB at the same bit-rate
- Small lossless gain
  - 4% extra compression efficiency

Is this needed by users?

- Let us talk about what we know: Japan

- Medical facilities have to keep lossless images for X years
  - Then they want to painlessly transform them into lossy archives
  - DICOM can address this problem with the proposed scheme

- Remote facilities need to be connected to each others
  - Sending lossless files as a bulk and on the fly is not an option
  - Their internal network is often not strong
  - DICOM can address this problem with the proposed scheme

- The needs exists → there is value in supporting the syntax

- This scheme comes from medical facilities requirements
  - This is not a lab pet project we want to see taking off

Technical Part

LOSSLESS CODING WITH HEVC

Lossless in HEVC

- HEVC is most famous for its lossy compression
  - Its “main” frequency transform (DCT) is lossy
- HEVC has DPCM for lossless coding
  - Less efficient than frequency transforms
- How to get both efficiency + lossless?
  - → Use both DCT and DPCM

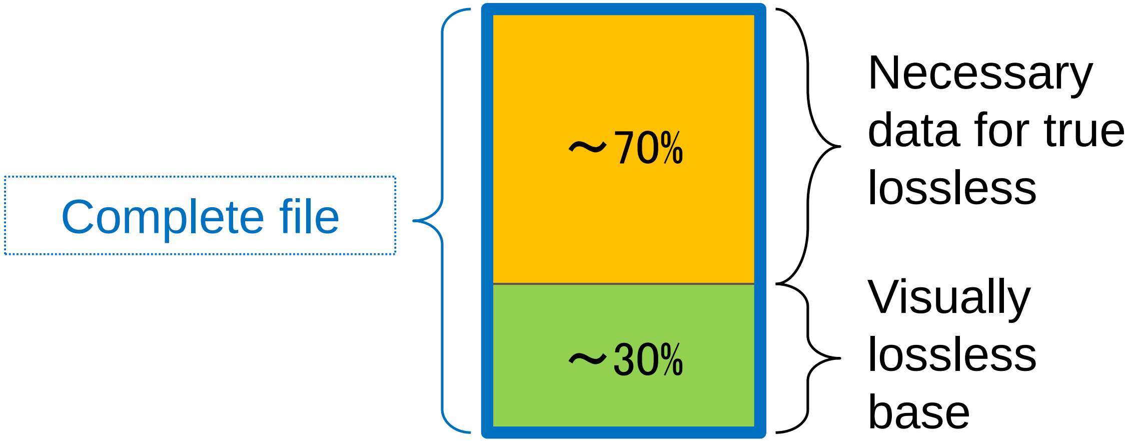
Layered coding in HEVC

- Encode a picture in lossy mode
  - Good compression ratio with DCT
- Encode the remaining noise in the enhancement layer
  - Guaranteed Lossless results
- What does a scalable stream look like?
  - Different layers can be sent together or separately
  - Adapt shape of stream to defined needs
    - In our case, separating layers is more interesting

Layered Lossless Compression

- Key point: Divide images into two parts
  - 1 light layer with good quality but lossy data
  - 1 heavier layer with information necessary for lossless reconstruction

- The ratio quality/weight of lossy base is adjustable
  - Encoder decides
  - Optimal compression when lossy is at around 30% of bitrate



Scalability: What can you fear?

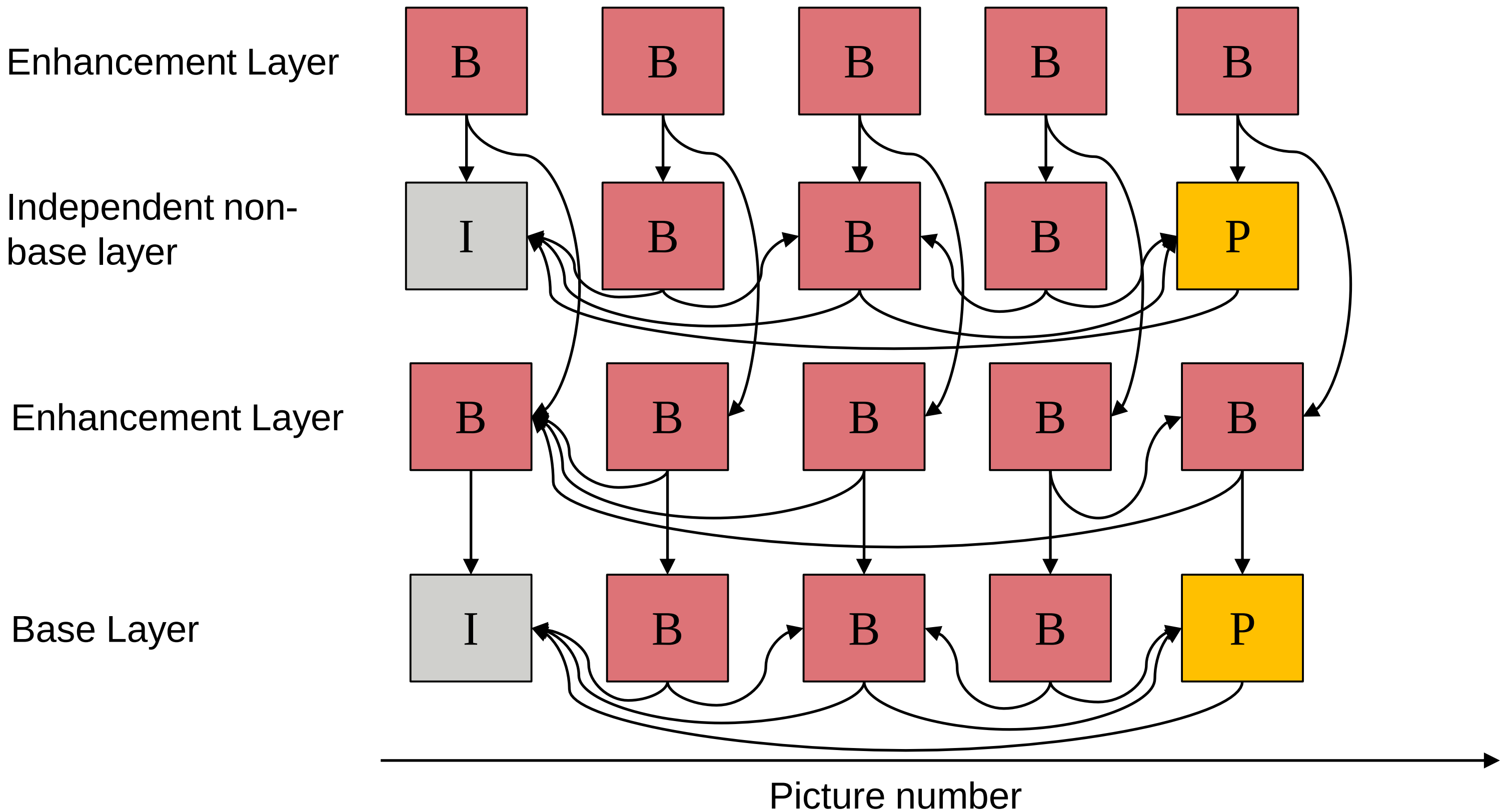
- HEVC's scalability can have up to 63 layers
  - Some that can be decoded without others
  - Some that need other streams to be decoded
- Diverse types of scalability
  - Temporal scalability
    - Higher frequency when decoding more layers
  - Quality scalability
    - Higher quality when decoding more layers
  - Color Gamut scalability
    - Changing color gamut depending on the decoded layer
  - Spatial scalability
    - Change the frame size depending on the layer decoded

Usually, decoders need to be ready for all these cases

Scalability: What can you fear?

FUJITSU

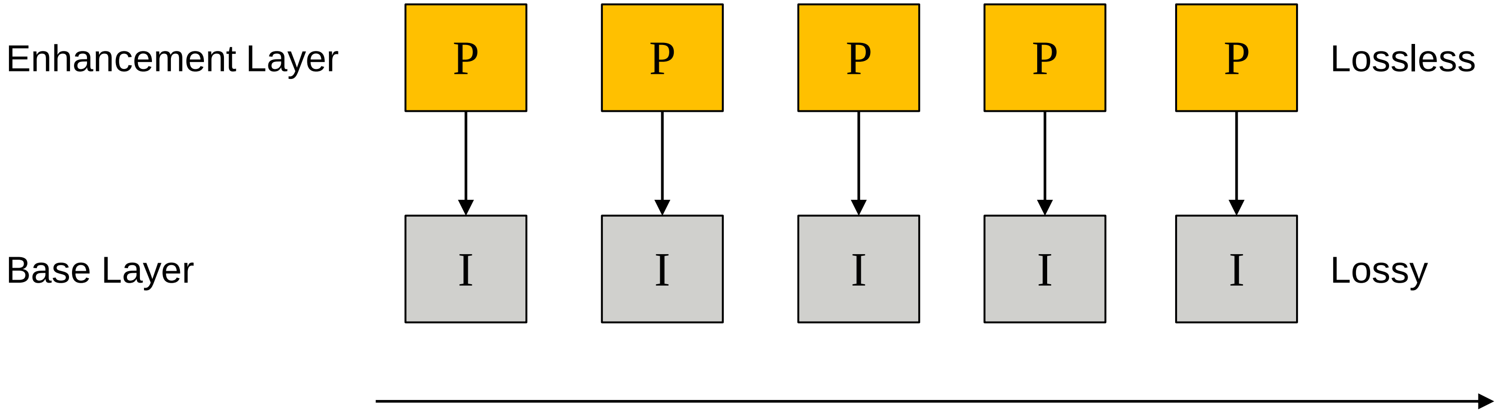
- Example of a possible scalable stream:



I — I pictures Do not require other pictures	B — B pictures Make reference to 2 other pictures	P — P pictures Make reference to 1 other picture	One reference

Fujitsu's proposed scalability

- Only 2 layers
- Only quality scalability
- First layer only has I pictures
  - Each picture is independently coded
- Second layer only has P pictures
  - Only need to encode remaining noise (by "DPCM")
  - Second layer carries the information for lossless reconstruction
- Decoder will **never** have to handle more complexity than that:



Where is the motion compression?

- Each frame is encoded independently from others
- No motion compression
- Every frame is essentially a <u>still picture</u>

What is the expected complexity?

- Fujitsu estimates performances can be:
- Software decoding of 4:0:0 12 bits 510*510 frames at 30fps
- Software encoding of 4:0:0 12 bits 510*510 frames at 4fps
- Deployable on existing platforms without extra-hardware

FORWARD

Can we help?

- Do you need additional details? Explanations?
  - Please reach Guillaume Barroux at guillaume.b@jp.fujitsu.com
  - Also available for discussions over phone or Skype calls

- We are also available to help with:
  - Showing Fujitsu encoded tests
  - Help you set your own test using the official HEVC reference software
    - https://hevc.hhi.fraunhofer.de/shvc

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