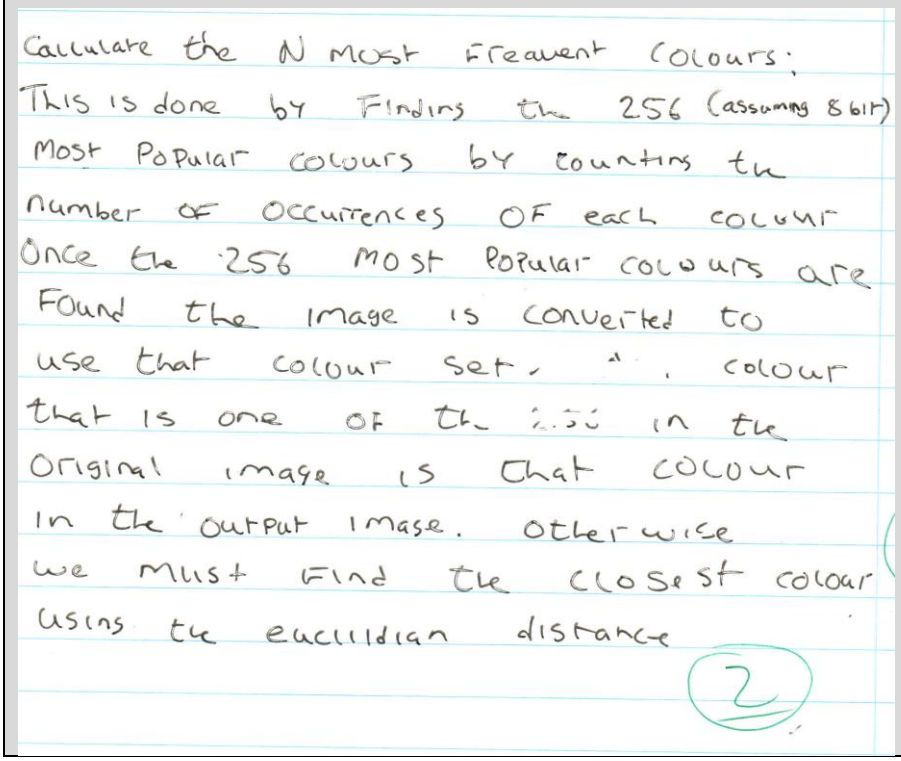
1. Topic: Image Coding (24 Marks)
    a. Colour quantisation reduces the number of distinct colours in an image, with the intention that the new image should be as visually similar as possible to the original image. The populosity algorithm selects the n most frequent colours in an image as the set of representative colours.
        i. List the main steps in this algorithm. (2 marks)

Answer

- Create a colour frequency histogram
- Sort histogram by count
- Keep the 256 colours with the largest counts
- Convert all other scene colours to the closest kept colour

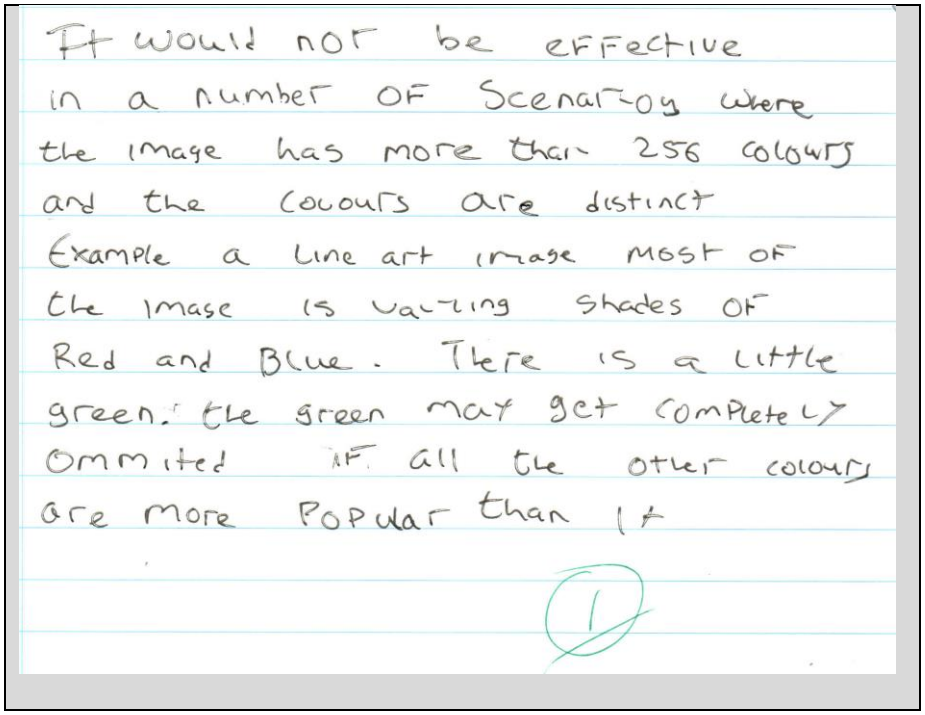

Calculate the N most freaent colours.
This is done by Finding the 256 (assuming 8 bit)
most popular colours by countins the
number of occurrences of each colour
Once the 256 most popular colours are
Found the image is converted to
use that colour set. A colour
that is one of the [illegible] in the
original image is that colour
in the output image. Otherwise
we must find the closest colour
using the euclidian distance
2

        ii. Describe where the algorithm would not be effective in yielding a visually similar image.

(2 marks)

Answer

- When the number of different colours in the original scene is much greater than the target number, the algorithm breaks down, especially where small scene objects are concerned.

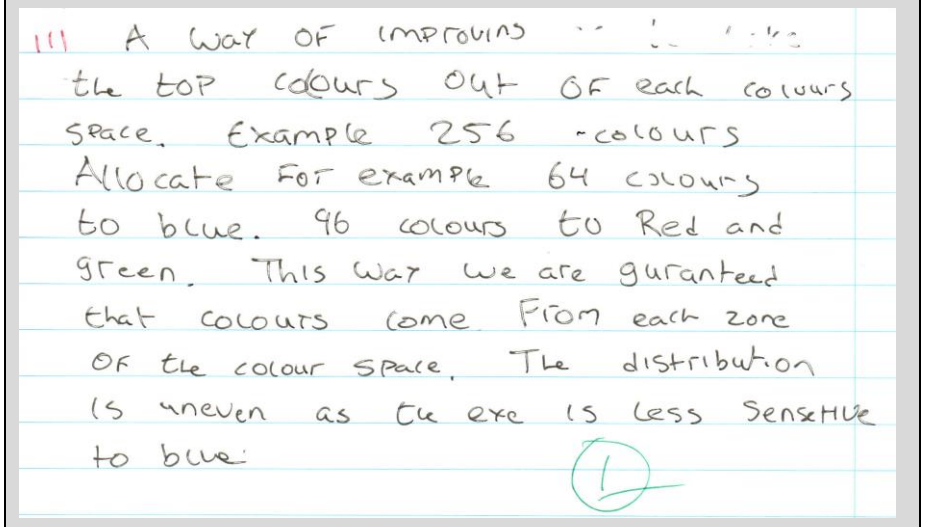


iii. Suggest a way of improving the algorithm to yield a more visually similar image.

(4 marks)

Answer

- By using the median-cut algorithm technique, rather than just histogram and keep the most popular colours, the median-cut algorithm attempts to find colours that represent equal numbers of colours in the original scene.



b. Baseline JPEG is a lossy compression technique that achieves a high compression ratio by exploiting the weaknesses in the human visual system.

i. List the steps a baseline JPEG codec would use to encode RGB image data. (2 marks)

Answer

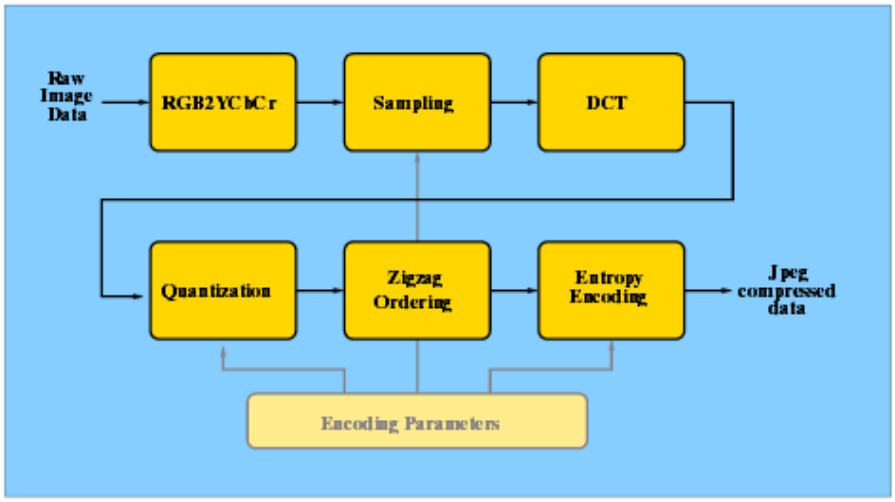
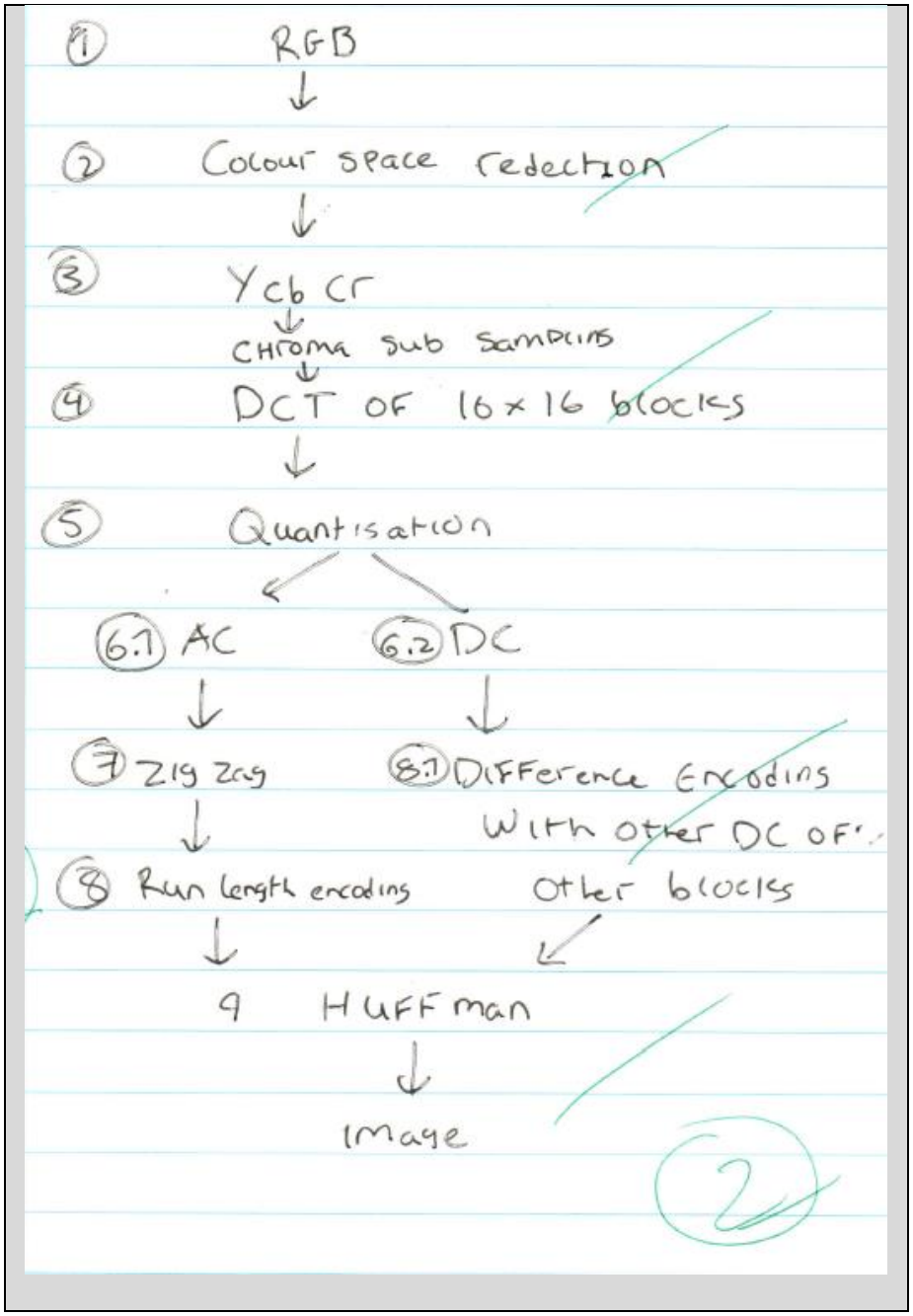


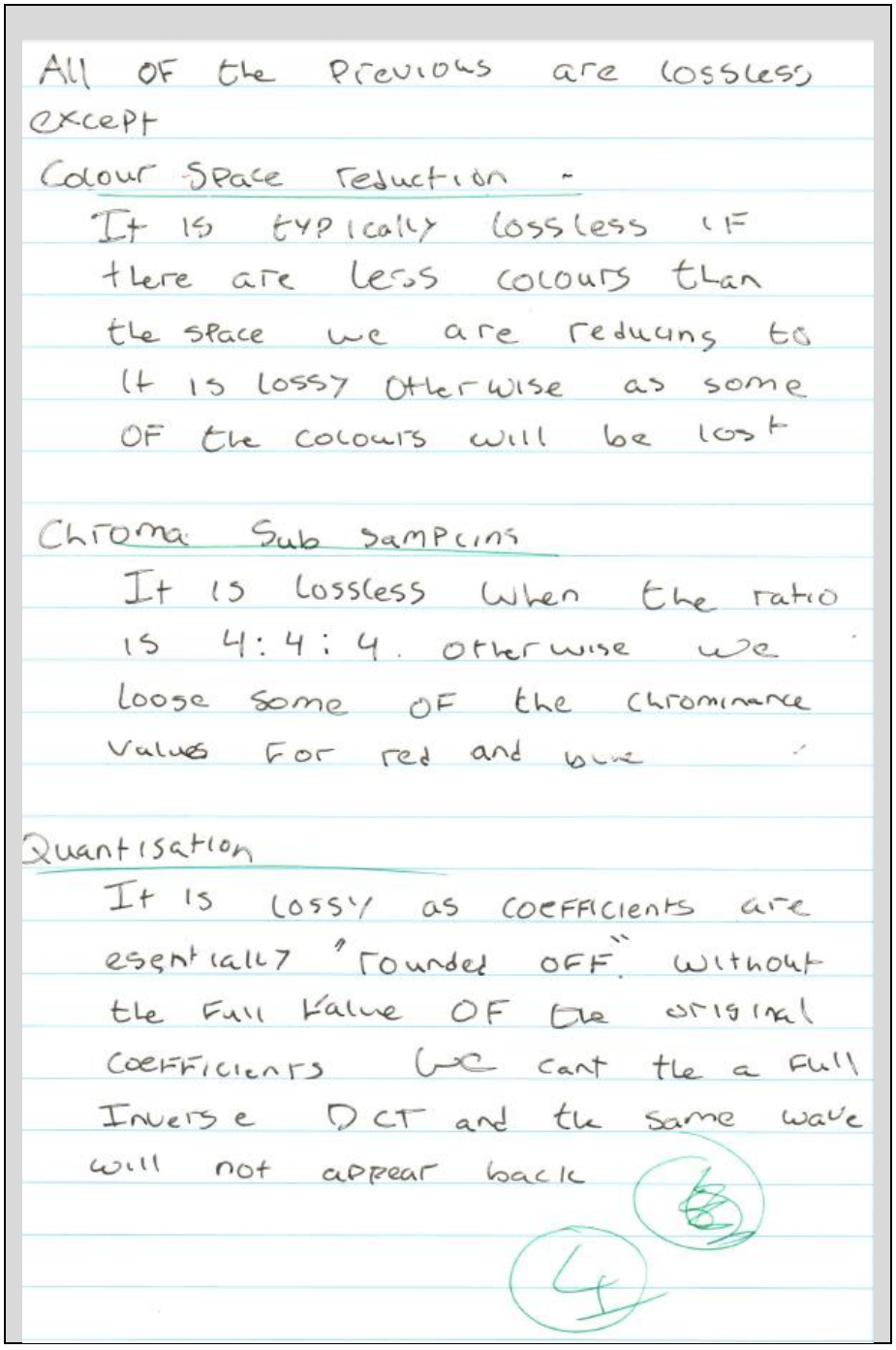
Figure 1.1: The essential steps in *JPEG* encoding (*baseline process*). First the image is transformed to the YCbCr color mode separating luma (Y) from chroma (Cb/Cr) information `[RGB2YCbCr]`. Then the color components are reduced in spatial resolution `[Sampling]`. Applying the *Discrete Cosine Transformation (DCT)* the blocks are mapped to frequency space `[DCT]` where the higher frequencies can now be removed `[Quantization]`. After reordering the remaining coefficients `[Zigzag-Ordering]` the resulting bitstream is then very well prepared for entropy encoding using run length encoding and an Huffman algorithm `[Entropy Encoding]`.



ii. For each step, state whether the technique used is lossy or lossless. If the step is lossy justify why losses are allowed. (6 marks)

Answer

- RGB2YCbCr – Lossy
- Sampling – Lossy ???
- DCT - Lossy
- Quantisation - Lossy
- Zig-Zag – Ordering - Lossless
- Entropy Encoding - Lossless



All OF the Previous are lossless except

Colour Space reduction -

It is typically lossless IF there are less colours than the space we are reducing to it is lossy otherwise as some OF the colours will be lost

Chroma Sub sampling

It is lossless when the ratio is 4:4:4. otherwise we loose some OF the chrominance values For red and blue

Quantisation

It is lossy as coefficients are esentially "rounded OFF" without the Full Value OF the original coefficients we cant the a Full Inverse DCT and the same wave will not appear back

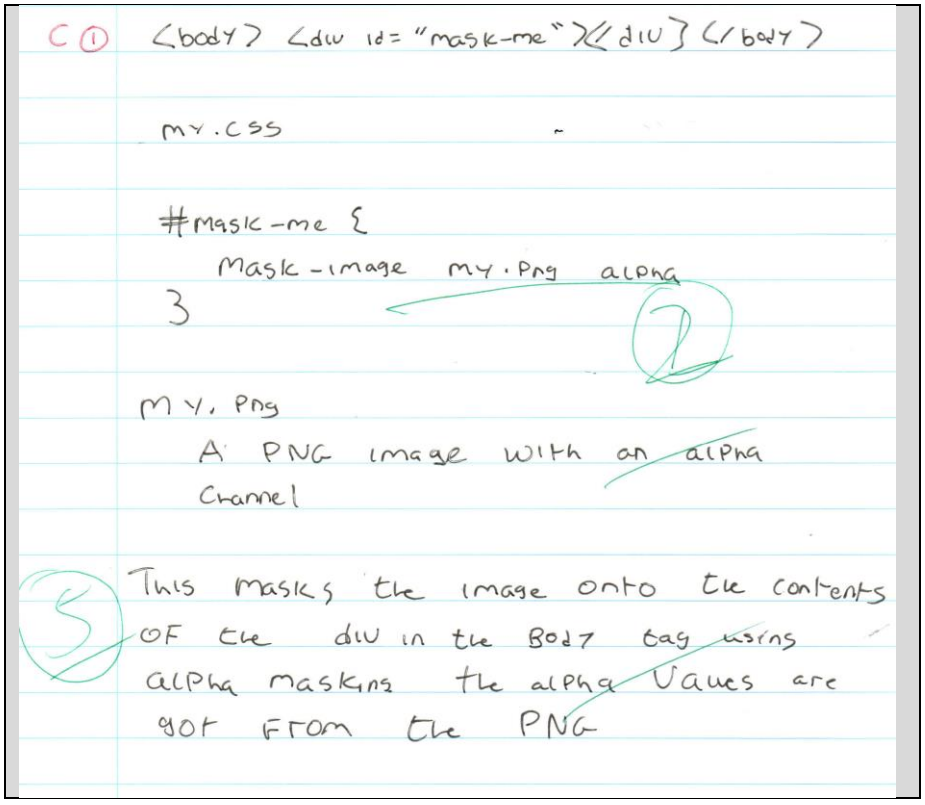
4

c. Masking provides a means for hiding portions of visual elements.

i. Describe using code, how to mask a JPEG image using CSS masking.

(2 marks)

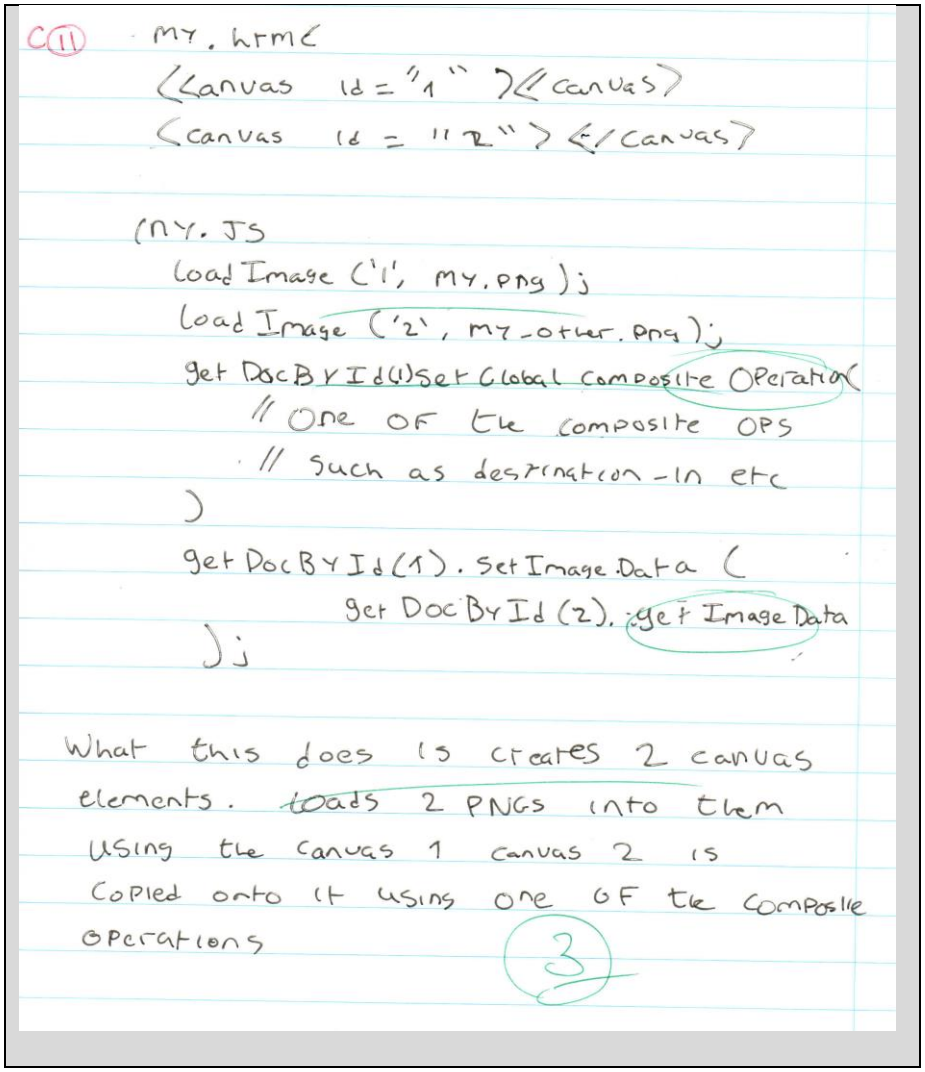
Answer



ii. Describe an alternative HTML5-based solution.

(6 marks)

Answer



c (ii)

my.html

<canvas id="1"></canvas>

<canvas id="2"></canvas>

my.js

loadImage('1', my.png);

loadImage('2', my-other.png);

getDocById(1).setGlobalCompositeOperation(

// one of the composite ops

// such as destination-in etc

)

getDocById(1).setImageData(

getDocById(2).getImageData

);

What this does is creates 2 canvas elements. loads 2 PNGs into them using the canvas 1 canvas 2 is copied onto it using one of the composite operations

3

2. Topic: Audio and Video Coding (28 Marks)
   a. List the steps in digitising and coding audio signals. (2 marks)

Answer

- Sampling Rate
  The more samples taken per second, the higher the accuracy
  If you use the wrong one, important frequencies may be removed
  8KHz -> Telephone
  22.05KHz -> Radio
  44.1KHz -> CD
  48KKz -> Professional Audio
  96KHz -> DVD Audio or Audio Recording
- Bit Depth
  Increasing the number of bits increases quality
  8-bit -> Telephone
  16-bit -> CD
  20-bit -> DVD
- Channels

Current formats can support 1 to 6 channels

- Mono (1) -> Telephone
- Stereo (2) -> CD
- 5.1 Surround (6) -> DVD

- Bit Rate

  Digital audio files / streams are measured in terms of bit rate

b. Explain why differential pulse code modulation encoding is used for representing digital audio. (2 marks)

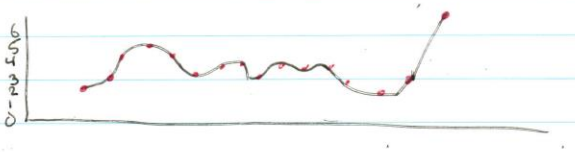
Answer

- The DPCM Encoder and DPCM Decoder blocks can help you implement a DPCM predictive quantizer.
- Differential pulse code modulation (DPCM) is a procedure of converting an analogue into a digital signal in which an analogue signal is sampled and then the difference between the actual sample value and its predicted value (predicted value is based on previous sample or samples) is quantized and then encoded forming a digital value.

Q2

B Differential PCM is used to represent Audio data as an audio signal is a fairly consistent wave

For example this wave



After the wave is sampled each sample has the previous sample value taken away from it

example above:

2, 3, 4, 5, 4, 3, 3, 3, 2, 3, 2, 3, 2 1, 6

Taking each of the previous values away from the next leaves us with

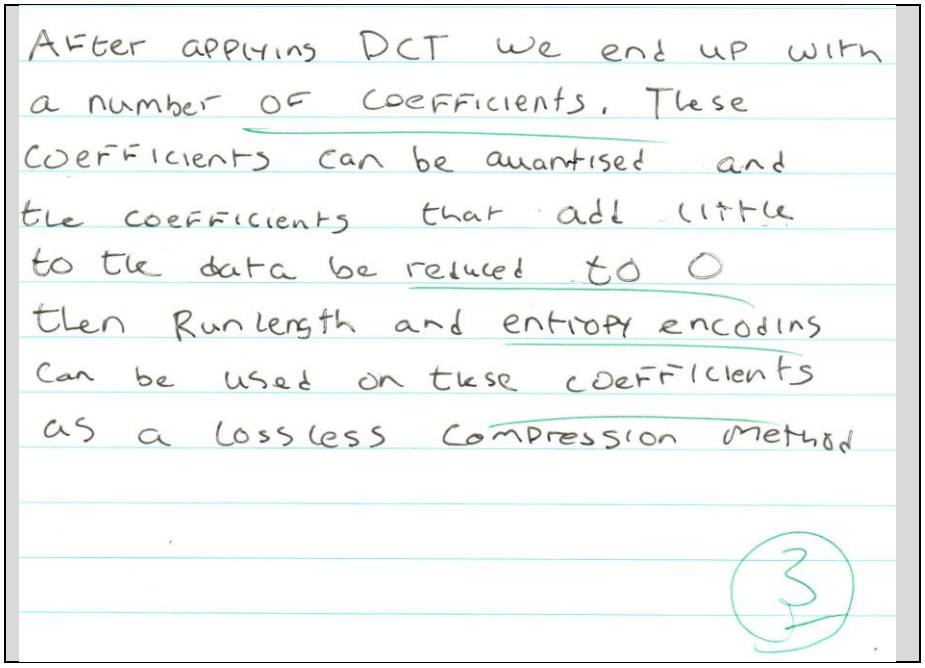
2, +1, +1, −1, −1, −1, 0, 0, 0, −1, +1, −1, +1, +1 −1
+ 5

We can then compress these much better using run length encoding

c. One approach for compressing digital audio data is to apply a discrete cosine transform to a list of audio samples.

   i. Describe how this compression scheme could be implemented. (6 marks)

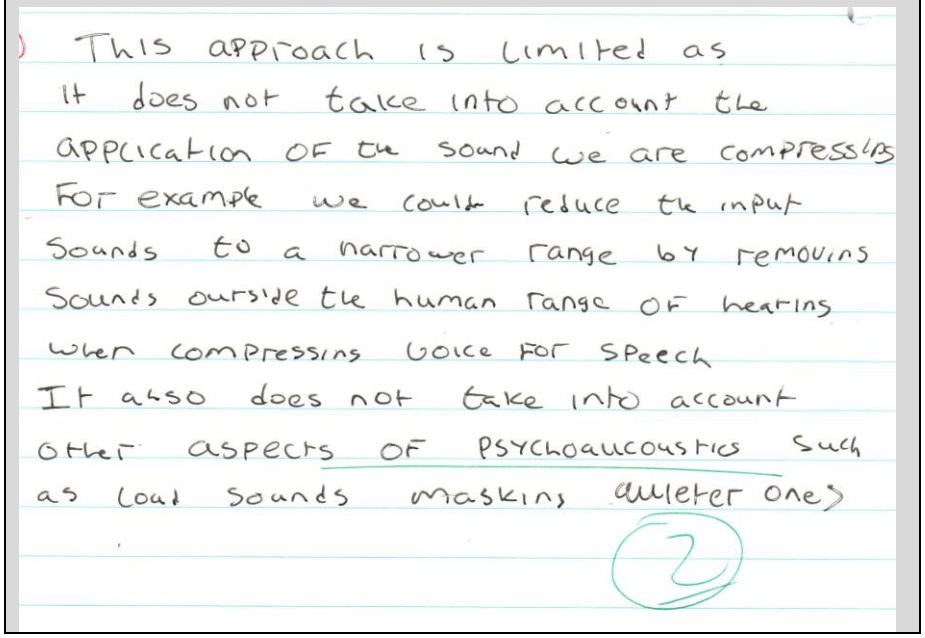
Answer


After applying DCT we end up with a number of coefficients. These coefficients can be quantised and the coefficients that add little to the data be reduced to 0 then Run length and entropy encoding can be used on these coefficients as a lossless compression method

3

ii. What are the limitations of this approach? (4 marks)

Answer


This approach is limited as it does not take into account the application of the sound we are compressing For example we could reduce the input sounds to a narrower range by removing sounds outside the human range of hearing when compressing voice for speech It also does not take into account other aspects of psychoacoustics such as loud sounds masking quieter ones

2

d. Video encoding in MPEG-1 consists of five steps (motion estimation, coding-block preparation, discrete cosine transform, quantisation and entropy encoding). Describe each of these five steps. Be sure to include the choices (if any) an encoding application can make at each step. (8 marks)

Answer

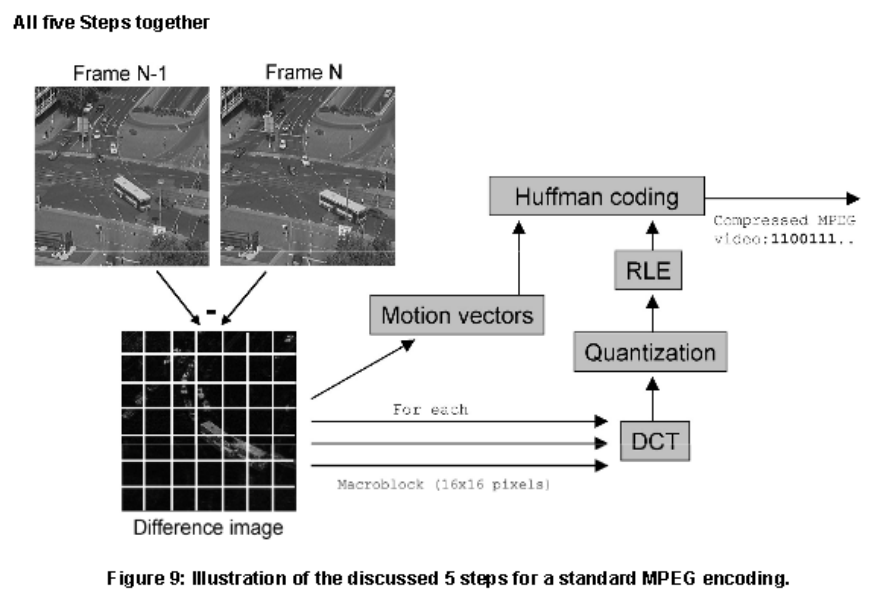


Figure 9: Illustration of the discussed 5 steps for a standard MPEG encoding.

- Motion Estimation
  - *Talk about I-frames (intra), P-frames (predicted) and B-frames (bidirectional).*
  - The references between the different types of frames are realised by a process called motion estimation or motion compensation. The correlation between two frames in terms of motion is represented by a motion vector.
  - The resulting frame correlation, and therefore the pixel arithmetic difference, strongly depends on how good the motion estimation algorithm is implemented.
  - Good estimation results in higher compression ratios and better quality of the coded video sequence. However, motion estimation is a computational intensive operation, which is often not well suited for real time applications.

- Coding-Block Preparation

- Discrete Cosine Transform

  - DCT allows a representation of image data in terms of frequency components. So the frame-blocks (8x8 or 16x16 pixels) can be represented as frequency components.
  - The DCT is unfortunately computational very expensive and its complexity increases disproportionately ($O(N^2)$). That is the reason why images compressed using DCT are divided into blocks.
  - Another disadvantage of DCT is its inability to decompose a broad signal into high and low frequencies at the same time. Therefore the use of small blocks allows a description of high frequencies with less cosine-terms.

- Quantisation

- During quantization, which is the primary source of data loss, the DCT terms are divided by a quantization matrix, which takes into account human visual perception.
- The human eyes are more reactive to low frequencies than to high ones.
- Higher frequencies end up with a zero entry after quantization and the domain was reduced significantly.

- Entropy Encoding

- The entropy coding takes two steps:
- Run Length Encoding (RLE) [2] and
- Huffman coding [1].
- These are well known lossless compression methods, which can compress data, depending on its redundancy, by an additional factor of 3 to 4.

Motion Estimation
The motion of 1 MB from 1 frame to another need be estimated.
There are many options available here such as what is the range of our search space. what is the shape of our search space. When can we declare 2 macro blocks as a good enough match. These all need to be decided upon

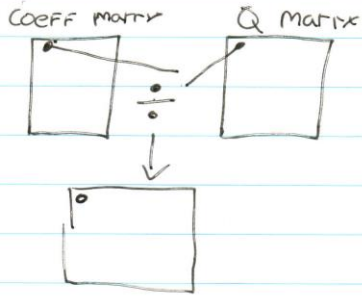
Coding block preparation
Now that we've found the correct MB match what do we need to do to it before its an exact match ie what pixels do we need to change This is dependent on 2 thresholds 1) is if the mean squared error is below a certain threshold we declare it as an exact match and make no changes, just send the Motion Vector. Another is if it is below a different threshold we determine the difference in the pixels and send that too

Discrete Cosine Transform

After applying the DCT we get a DC coefficients and a number of AC coefficients. There are no real options here

Quantisation

Using the AC coefficents acreated in the DCT step we quantise them using a quantisation matrix this quantisation matrix describes FOR each coefficient in an 8 x 8 image block how to quantise that coefficient the quantisation process aims to reduce the entropy of the coefficients such that it is better suited to entropy encoding



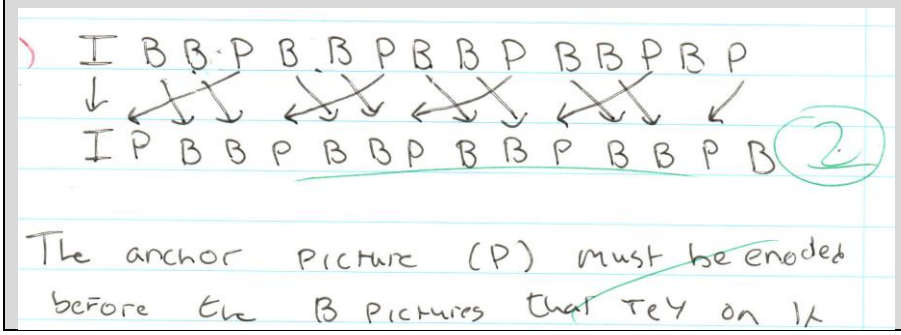
Entropy encoding is a loss less compression OF the coefficients as they have been mapped into a less random range we can use something like huffman encoding to encode the coefficients, We can use a predefined huffman table or generate our own

e. An MPEG-1 closed group of pictures (GOP) consists of the following pictures shown in playback order.

I B B P B B P B B P B B P B P

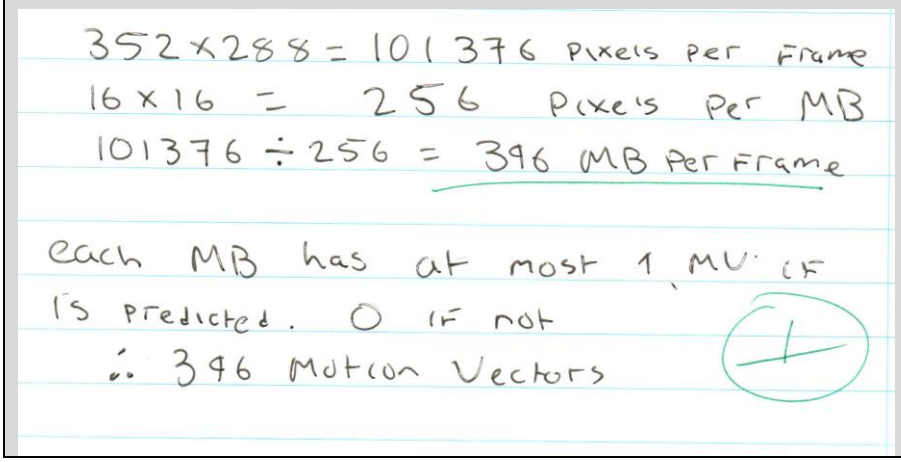
i. Write out the encoding order of the above GOP. (2 marks)

Answer



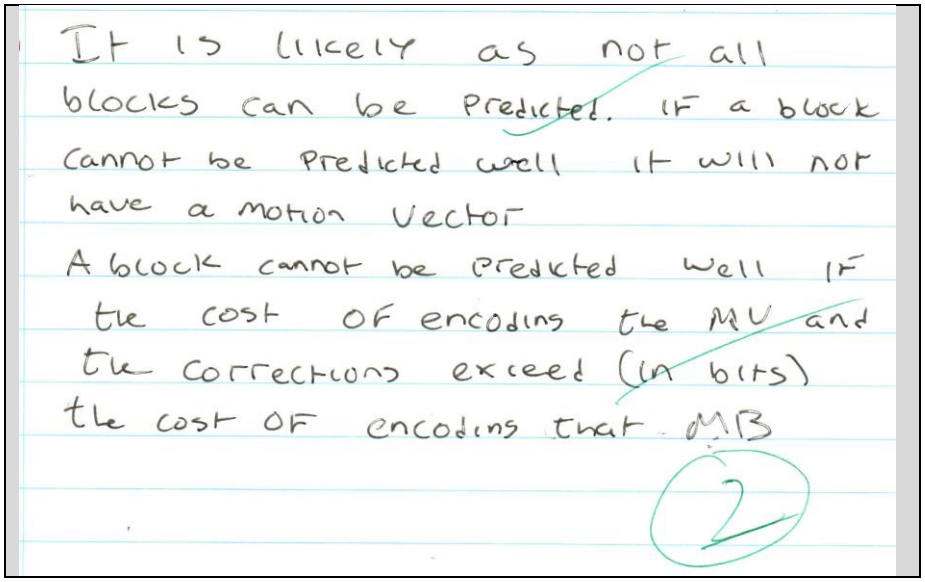
ii. If the frame size is 352 x 288 pixels, calculate the maximum number of motion vectors that could result when encoding the GOP. (2 marks)

Answer



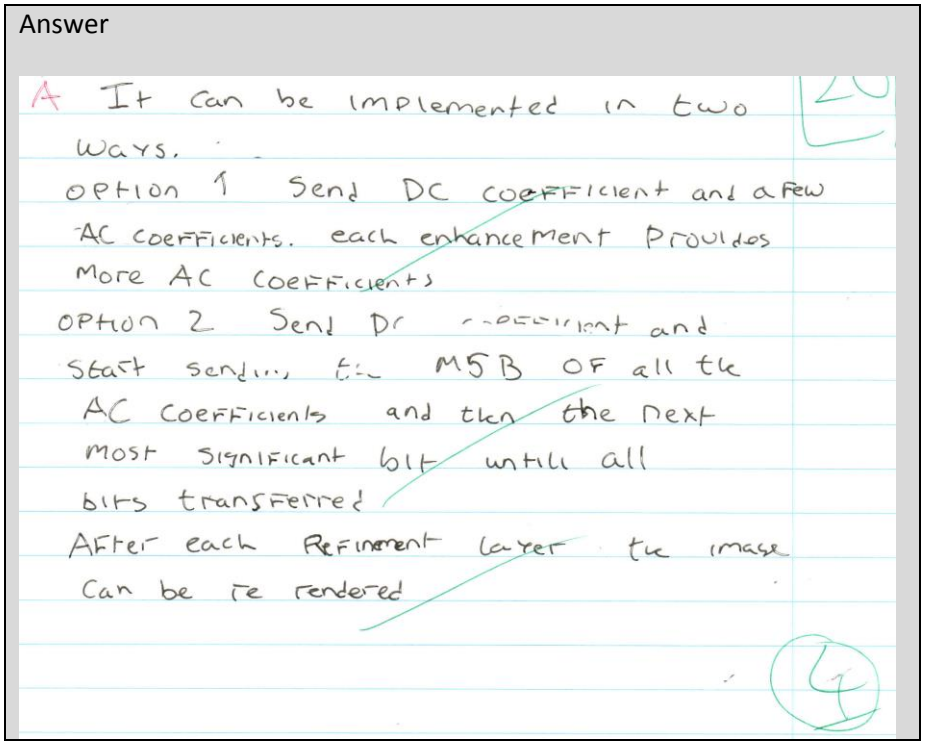
iii. Why is it likely that an encoding application will use fewer motion vectors? (2 marks)

Answer


It is likely as not all blocks can be predicted. If a block cannot be predicted well it will not have a motion vector
A block cannot be predicted well if the cost of encoding the MV and the corrections exceed (in bits) the cost of encoding that MB
2

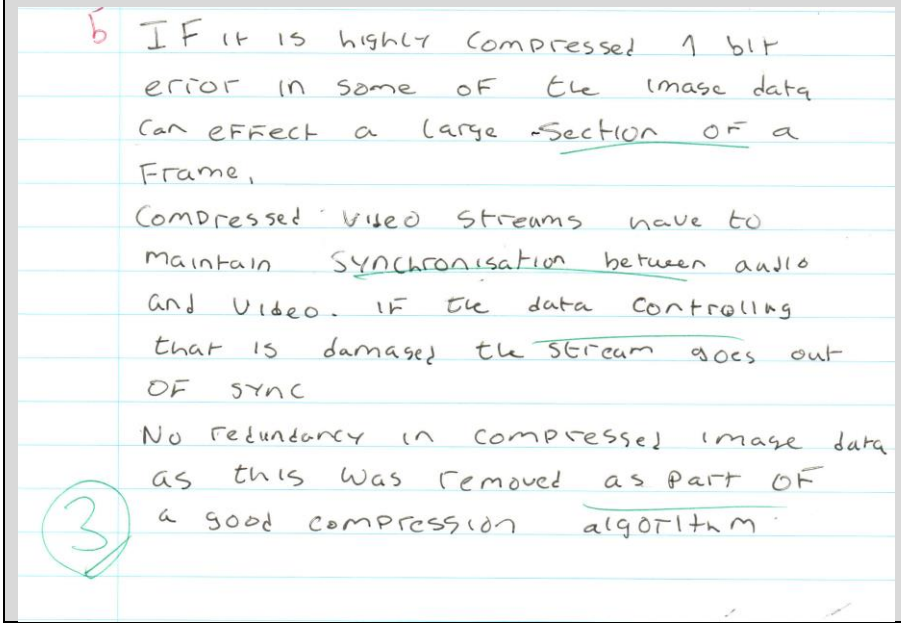
3. Topic: Media Delivery and Presentation (28 Marks)
   a. Progressive JPEG mode delivers an initial low-quality version of an image, followed by ahigher-quality refinements. Assuming the main steps of the JPEG algorithm are the same as sequential JPEG mode, suggest how this mode could be implemented. (4 marks)

Answer


A It can be implemented in two ways.
option 1 Send DC coefficient and a few AC coefficients. each enhancement provides more AC coefficients
option 2 Send DC coefficient and start sending the MSB of all the AC coefficients and then the next most significant bit until all bits transferred
After each Refinement layer the image can be re rendered
4

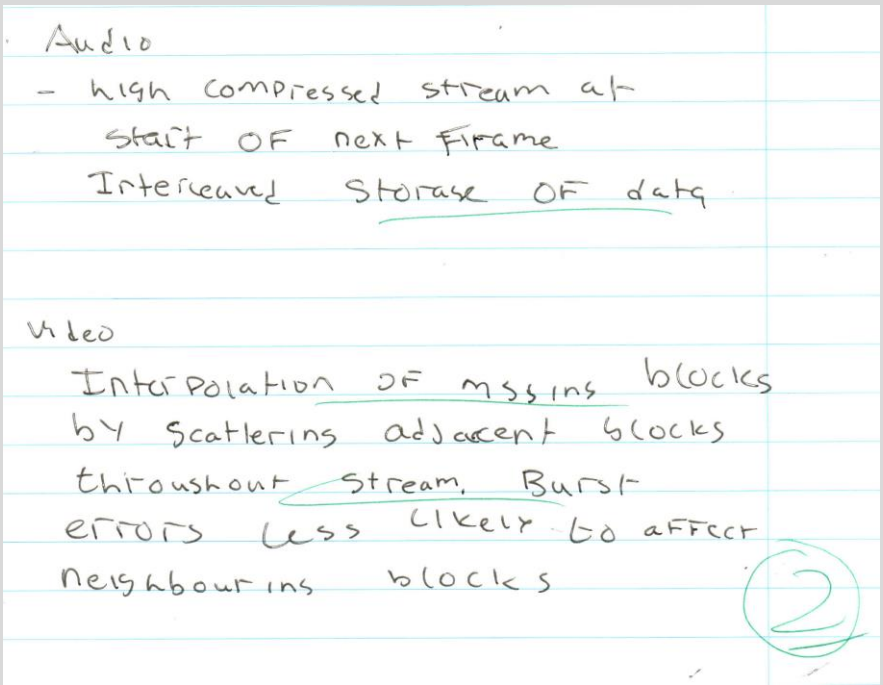
   b. What features of a typical video codec make the compressed bitstream sensitive to transmission errors? (3 marks)

Answer



c. Describe two techniques that can suppress error propagation after a transmission loss? (4 marks)

Answer



d. ISO/IEC developed the MPEG-DASH standard allowing for dynamic adaptive streaming of media content over HTTP.

   i. What caused the need for delivery platforms such as MPEG-DASH? (3 marks)

Answer

Mobile devices with limited processing power and slow / varying connections caused a need for MPEG Dash varying means connection speed can change during stream

2

ii. Describe the general architecture of an MPEG-DASH client could use to control the delivery of content from a server. (4 marks)

Answer

An MPEG Dash S...
An Itermediary CDN (optional)
An Client implementing - DASH standards

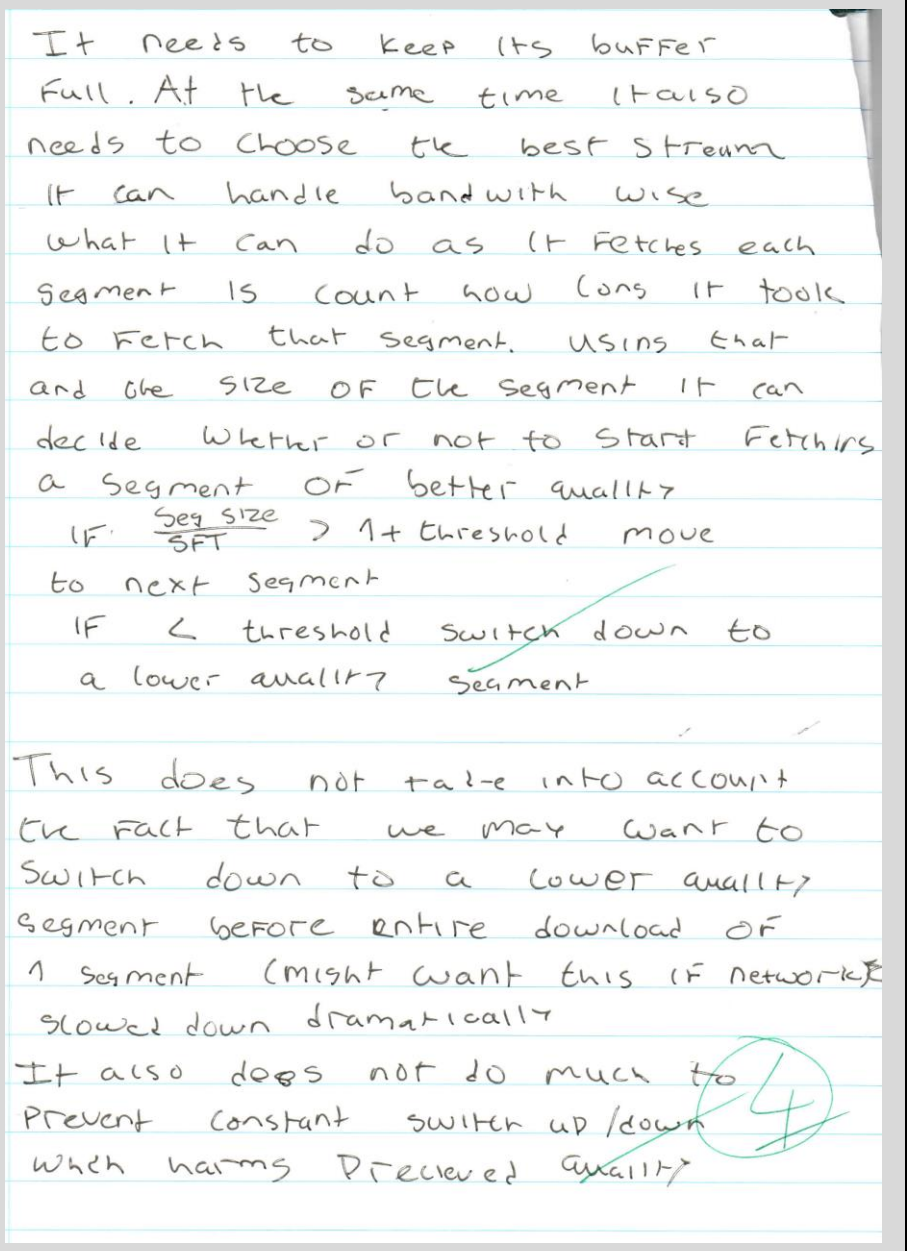
Dash server Publishes an MPD and makes streams OF varying bitrate available

Dash client (using HTTP) reads the MPD and chooses the correct stream. Then using partial HTTP get requests, requests the correct stream FOR its bandwith / processing power

2

iii. Outline an algorithm that an MPEG-DASH delivery system could use to control the delivery of content from a server. List the limitations of your solution. (6 marks)

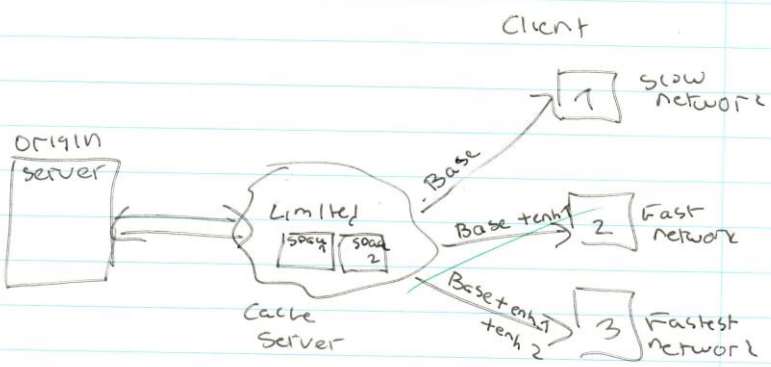
Answer



iv. Usually MPEG-DASH systems offer multiple representations of each video as separate files. It is also possible to offer all representations embedded in one file using Scalable Video Coding (SVC). Explain the potential advantages of the SVC approach. (4 marks)

Answer

Q
3D
iv



Potential advantage is that it increases cache efficiency. IA the above example the cache server may only store 2 files.
It will store the Base + enhancement 1 as they are most reuested
Everone but Client 3 will have 100% cache hit

3