

EECE5698

Networked XR Systems

Lecture Outline for Today

- Homework2
- Point Cloud Compression
 - MPEG GPCC
 - MPEG VPCC

Point Clouds

- A point cloud is a discrete set of data points in space.
- Or a set of 3D independent points
- Each Point (X, Y, Z) + Attributes
- Attributes: Color, Alpha, Reflectance



Point Cloud

- Representation
 - Each Point is a floating-point number – 32 bits
 - $\langle X, Y, Z \rangle$: 96 bits
 - RGB: 3 channels: 24 bits
 - Also, has other attributes sometimes (light related)
- Each point: 96 + 24 bits or 15 bytes
- Typically, a point cloud has thousands to millions of points – guess the data rate numbers

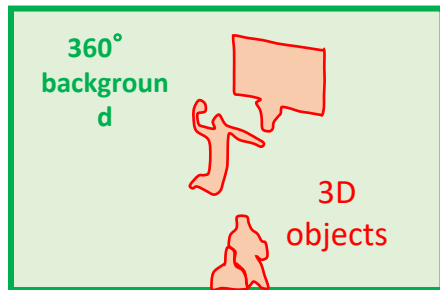
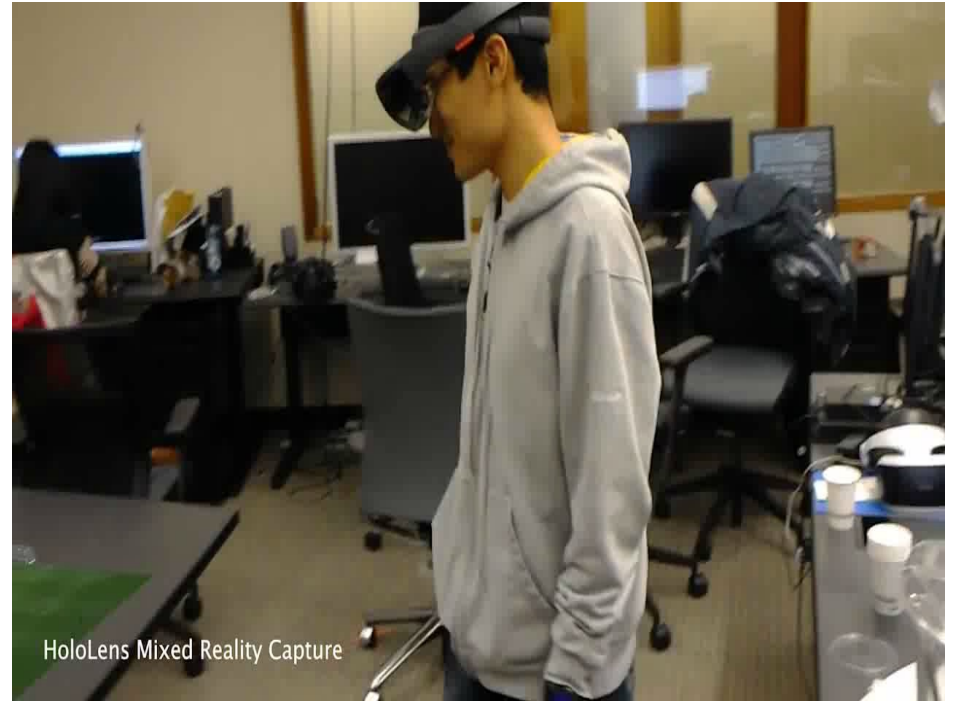
Point Cloud

Sample data numbers



	queen	longdress	loot	redandblack	soldier
Average number of points (in 300 frames)	1,005,000	834,000	794,000	727,000	1,076,000
Bitrates for transmitting uncompressed video (Mbytes/s)	514.47	542.22	490.61	448.21	681.96

Example Applications



1-3 Gbps per object

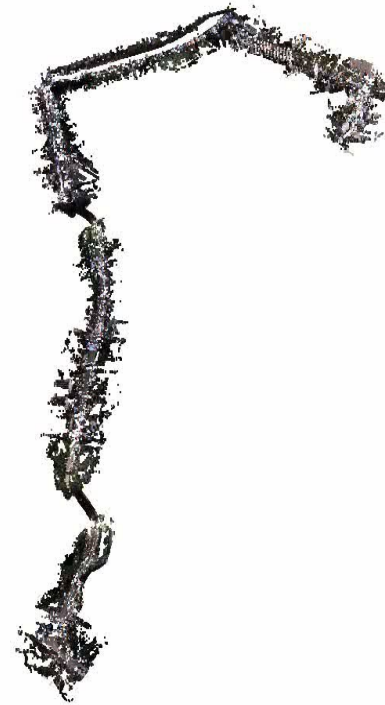
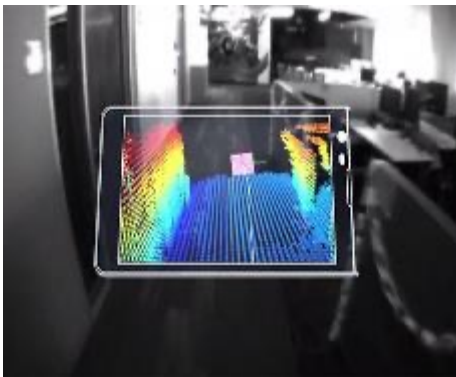
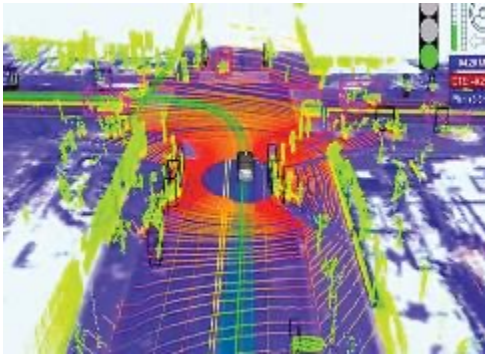


Example Applications



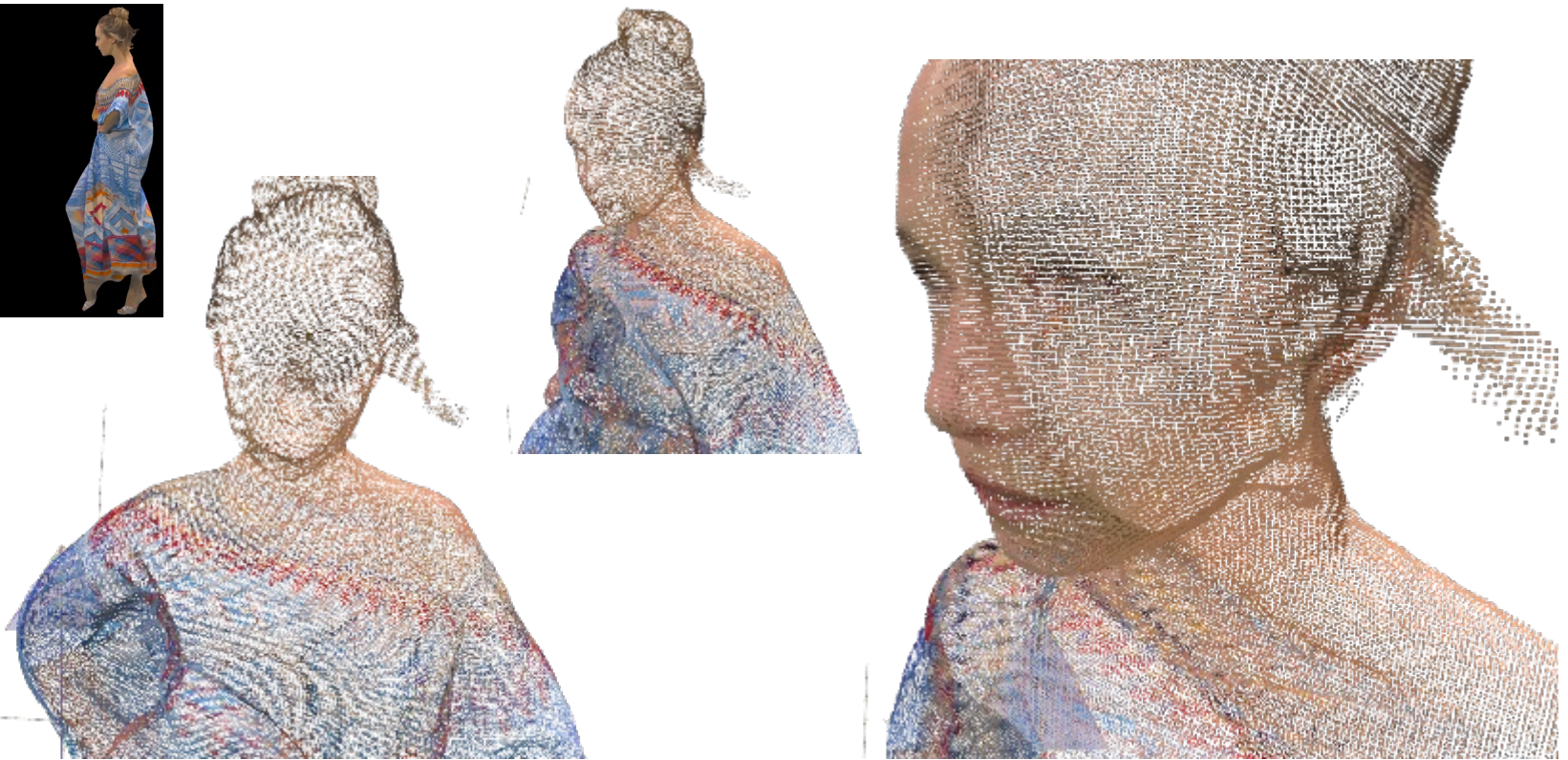
Example Applications

- ~20 million points
 - 2,020,734,515 bytes



Point Cloud Compression

800,000 points -> 1 000 Mbps (uncompressed)



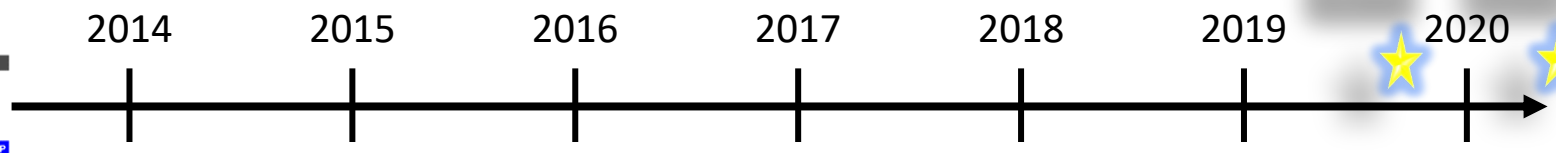
Compression is required in order to make PC useful

Point Cloud Compression

- Can we use similar block based intra and inter frame prediction and transform coding for point clouds?
 - E.g., is it possible to divide the point cloud into 3D blocks and apply similar techniques that we used in case of 2D videos (block matching algorithms etc.)

MPEG Point Cloud Compression

V-PCC 01/2020
G-PCC 4/2020

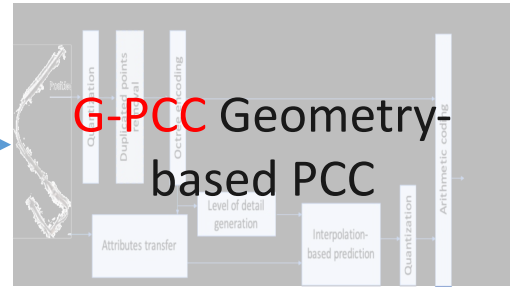
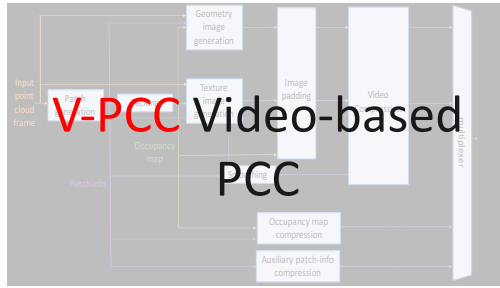
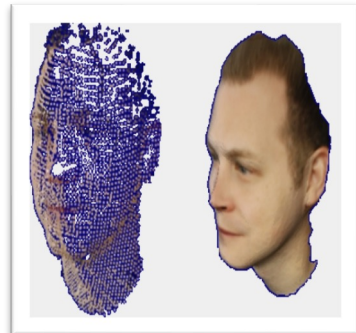
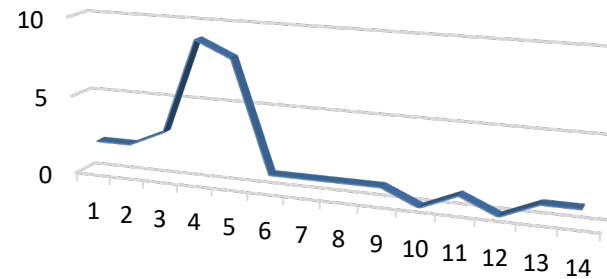


MPEG initiated the work on PCC

In April 2017 MPEG issued a Call for Proposals

First Committee Draft issued in October 2018

9 technology leading companies responded and MPEG evaluated them in October 2017

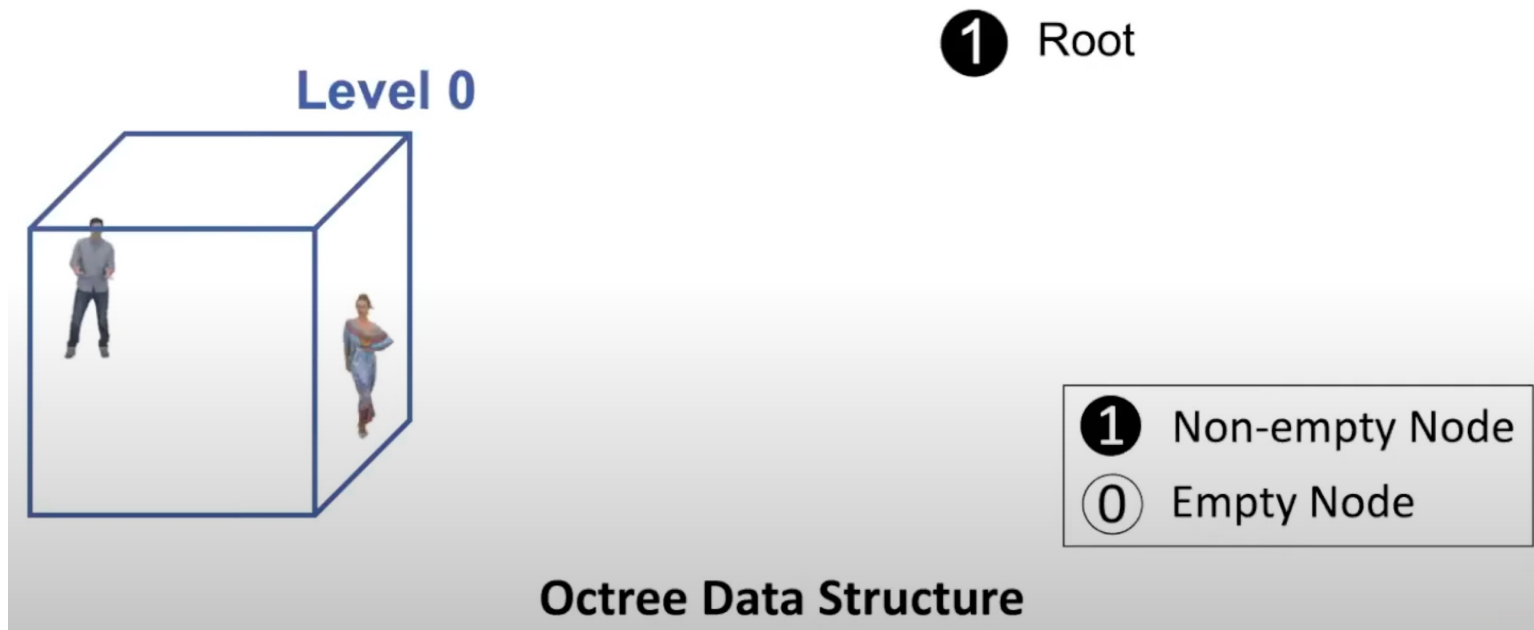


MPEG GPCC

- Geometry based point cloud compression
 - 3D tree data structures (Octree or KD-tree)

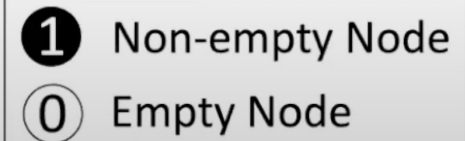
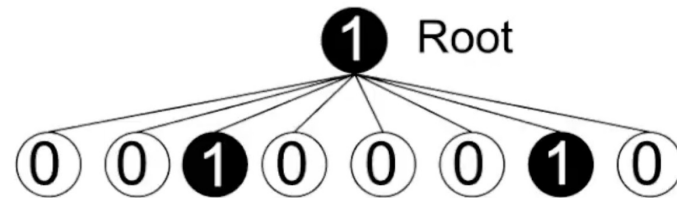
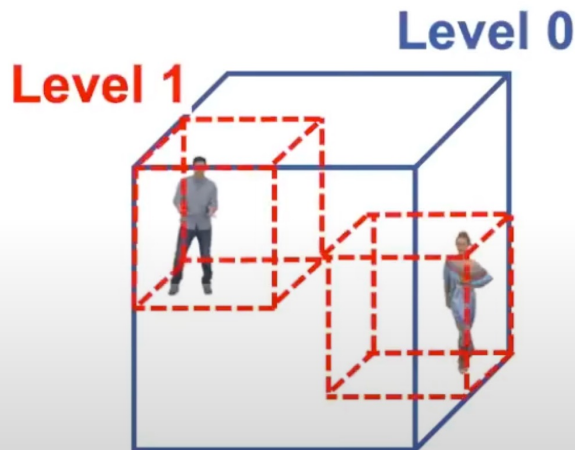
MPEG GPCC

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MPEG GPCC

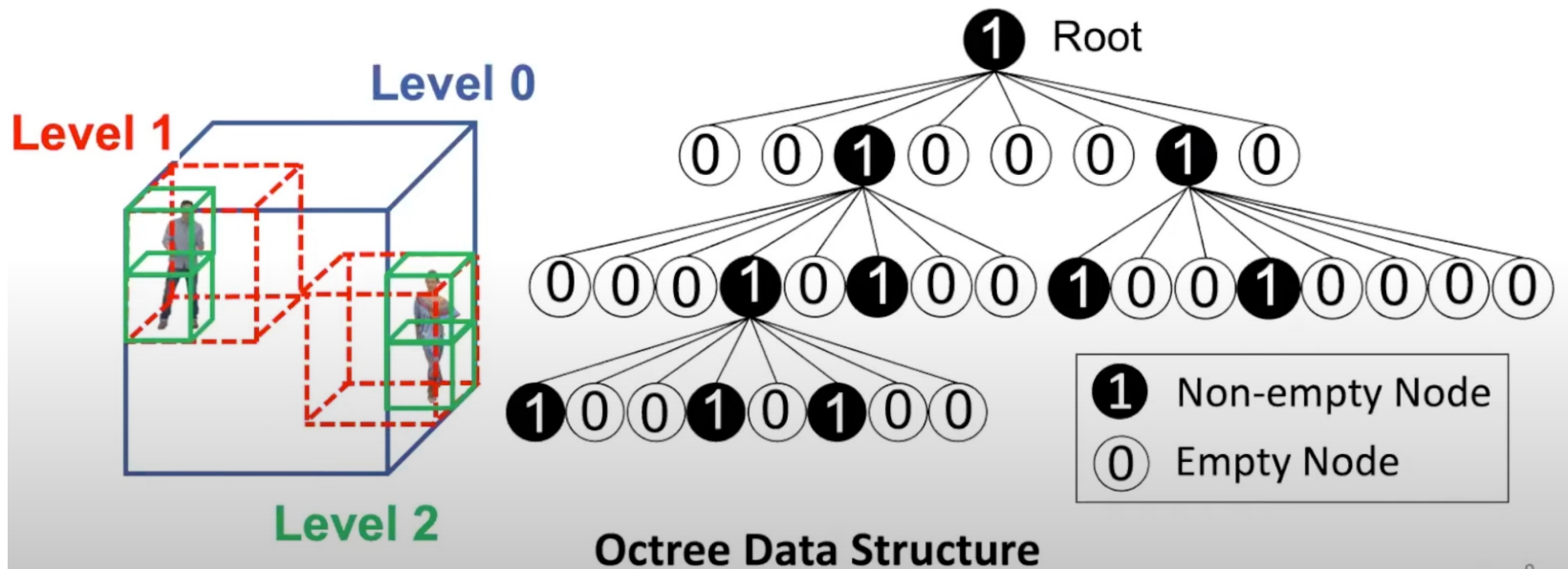
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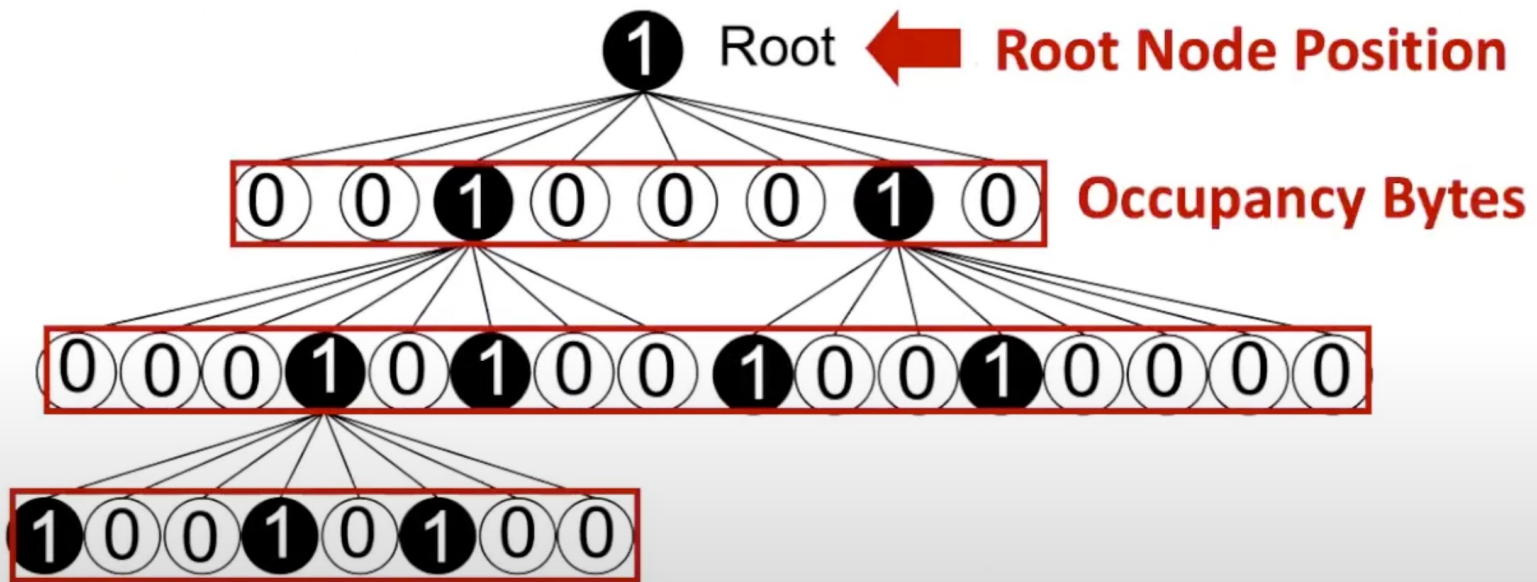
Octree Data Structure

MPEG GPCC

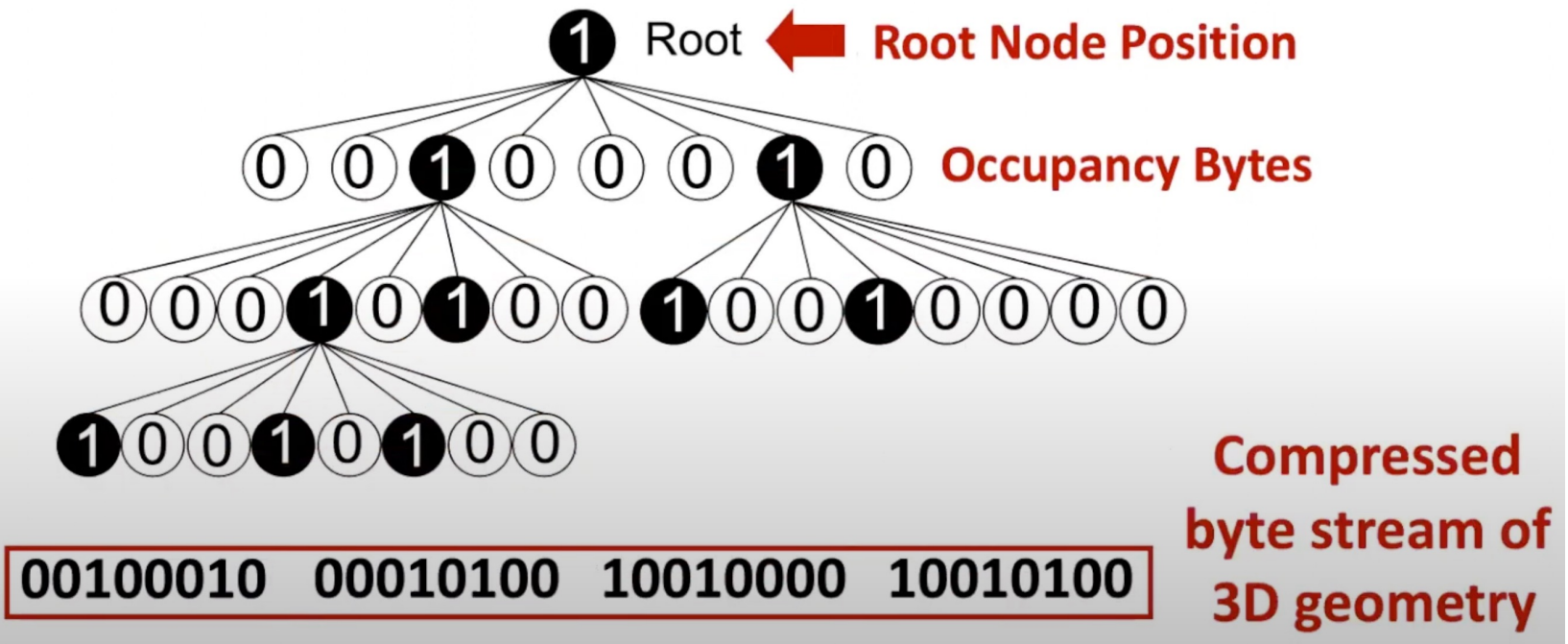
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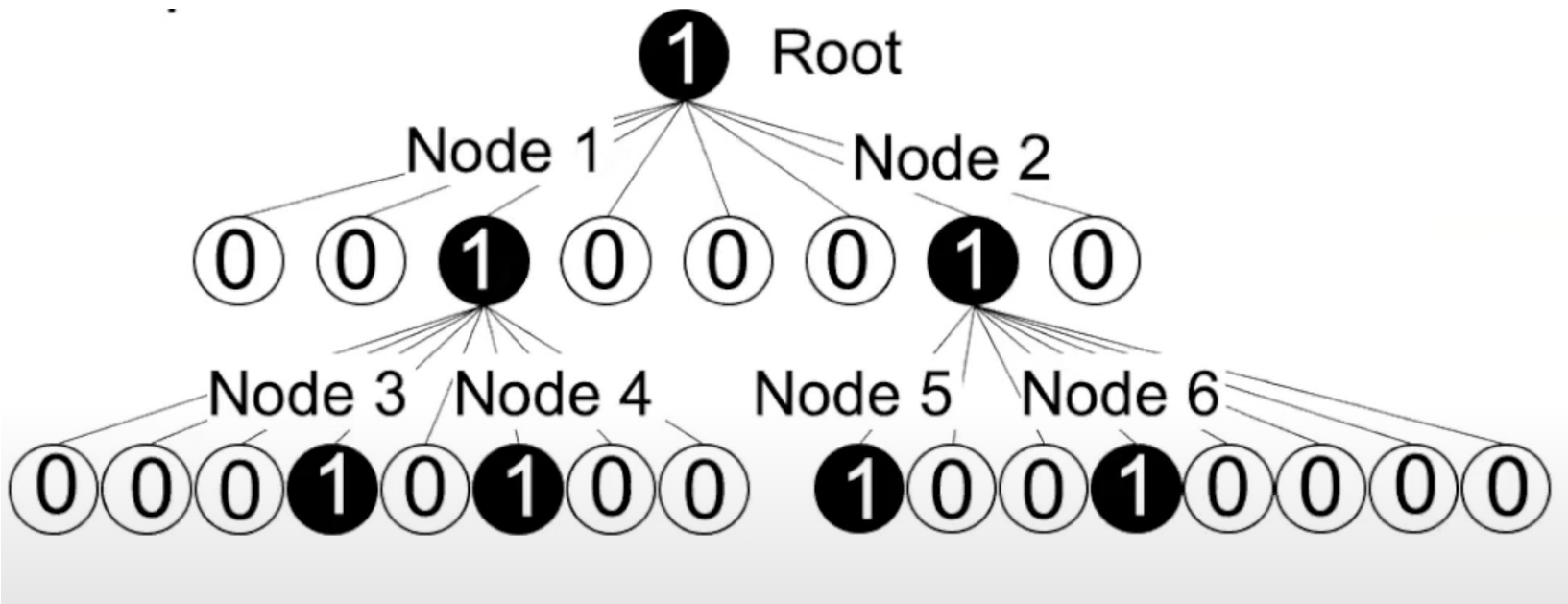
MPEG GPCC



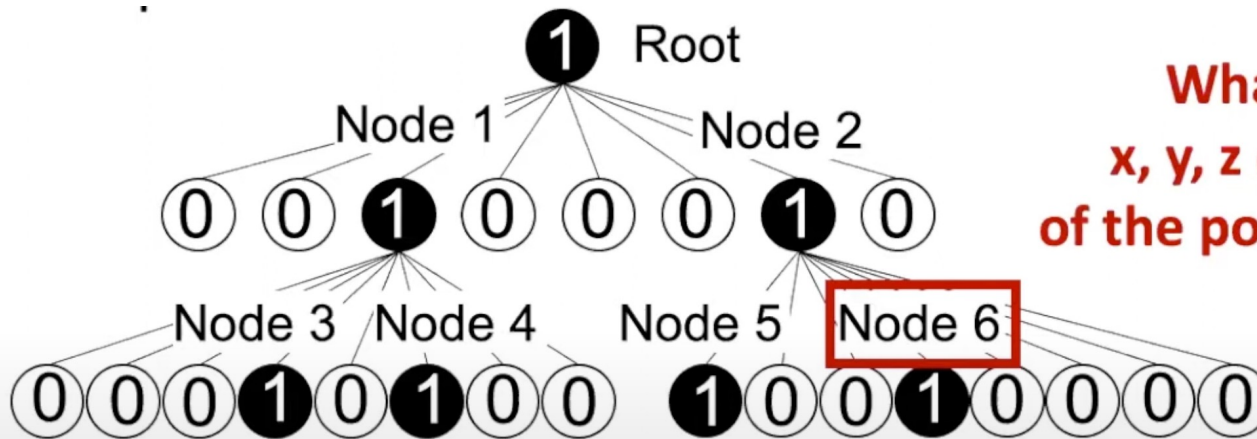
MPEG GPCC



MPEG GPCC



MPEG GPCC

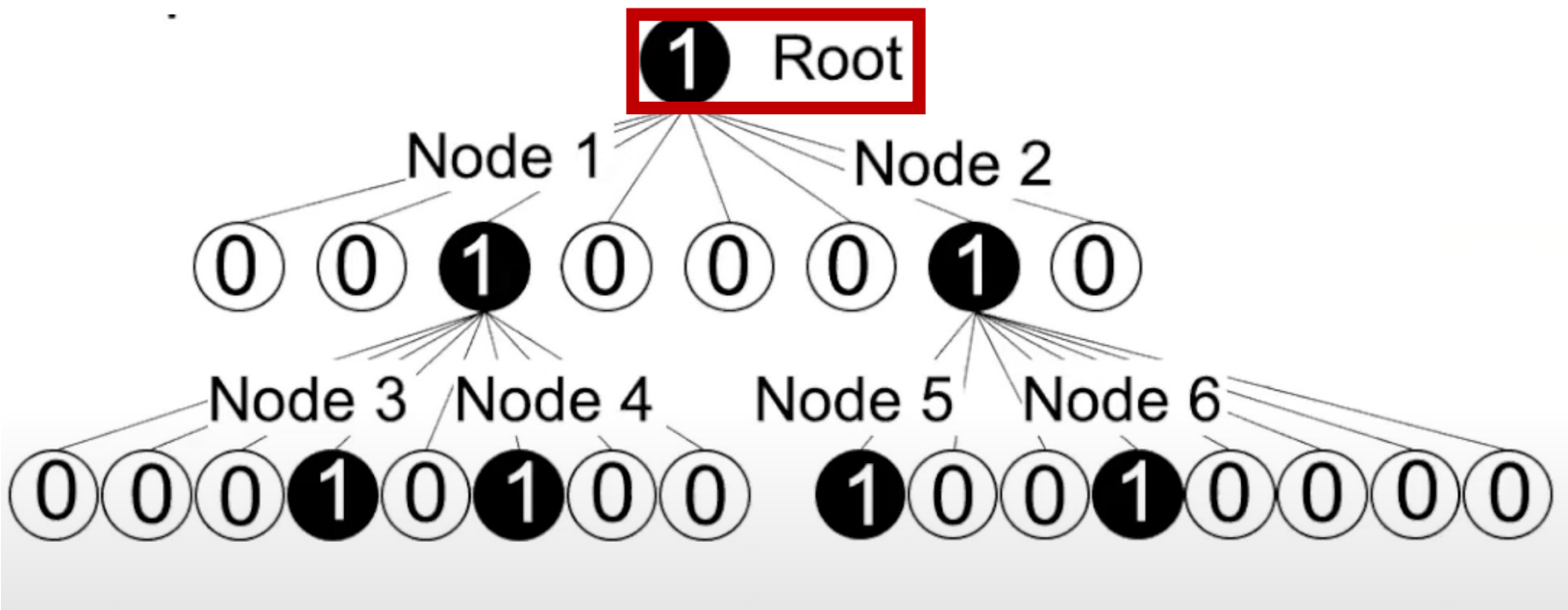


**What are the
x, y, z coordinates
of the points in Node 6?**

00100010	00100010	10010000	00010100	0001110	10000100	01110100
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Compressed Byte Stream

MPEG GPCC



Root

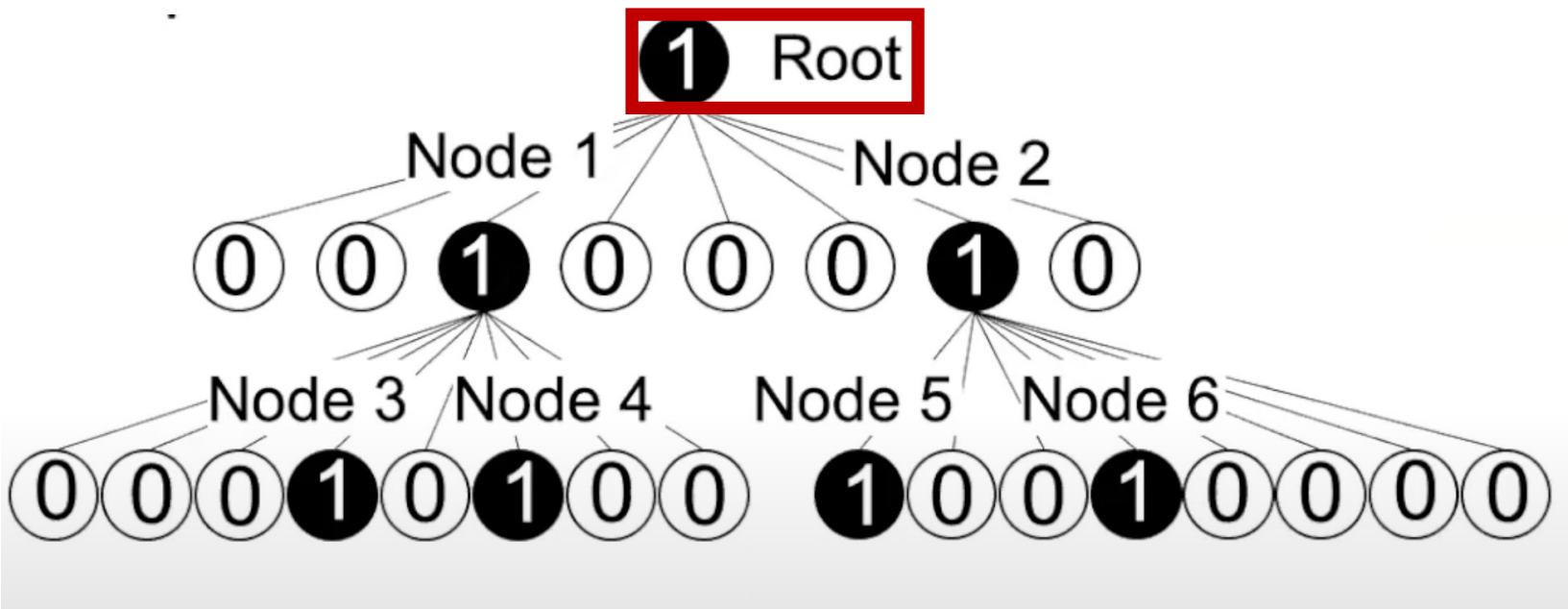
Node1

Node2

00100010	00100010	10010000	00010100	0001110	10000100	01110100
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Compressed Byte Stream

MPEG GPCC

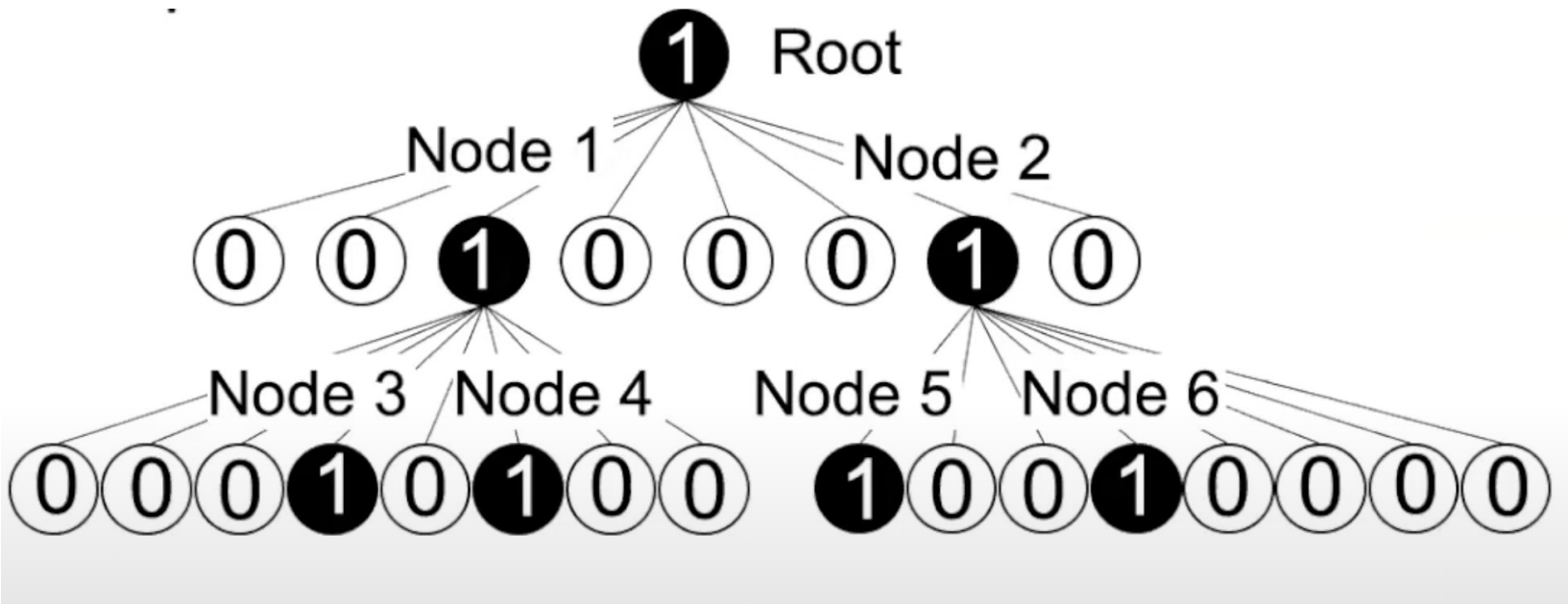


Which one is Node6?

Root	Node1	Node2				
00100010	00100010	10010000	00010100	0001110	10000100	01110100

Compressed Byte Stream

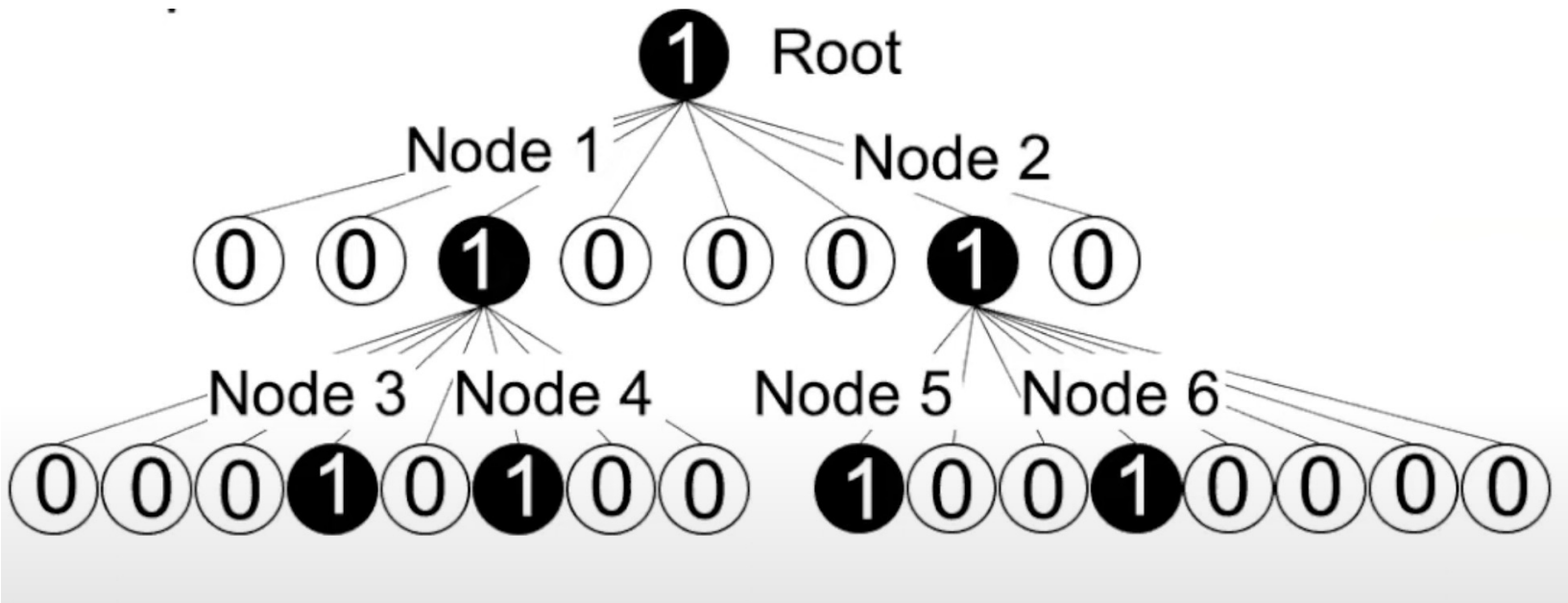
MPEG GPCC



Root	Node1	Node2	Node3	Node4	Node5	Node6
00100010	00100010	10010000	00010100	0001110	10000100	01110100

Compressed Byte Stream

MPEG GPCC



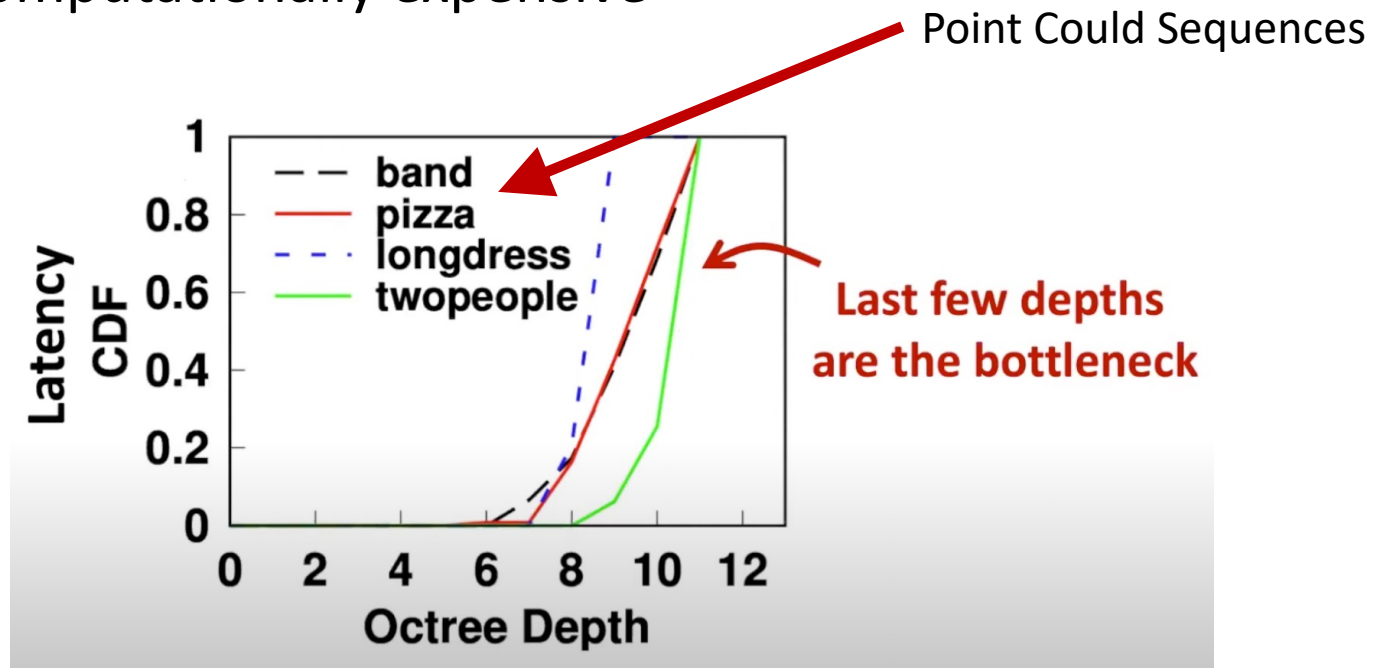
Root	Node1	Node2	Node3	Node4	Node5	Node6
00100010	00100010	10010000	00010100	0001110	10000100	01110100

Compressed Byte Stream

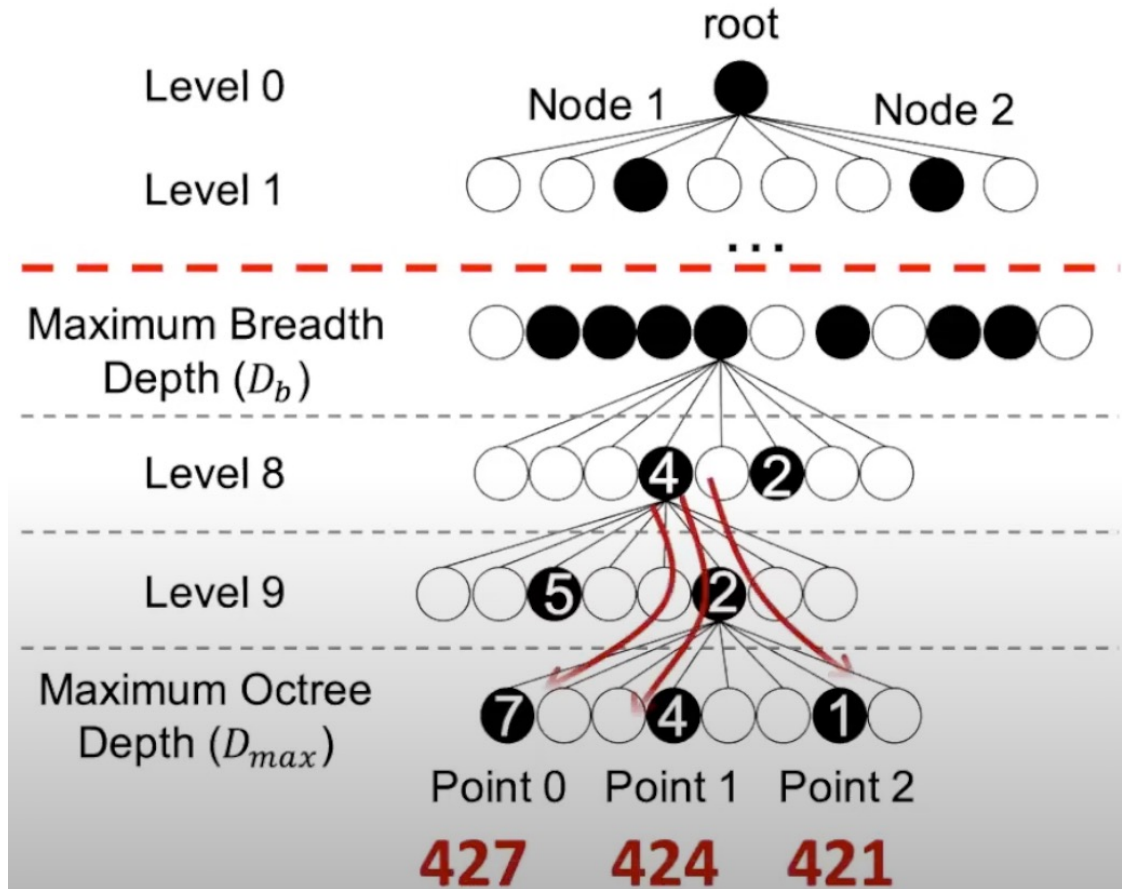
MPEG GPCC

- Problem

- Generates a dependency between the points – makes parallel processing difficult
- Computationally expensive



Parallel Decodable Tree

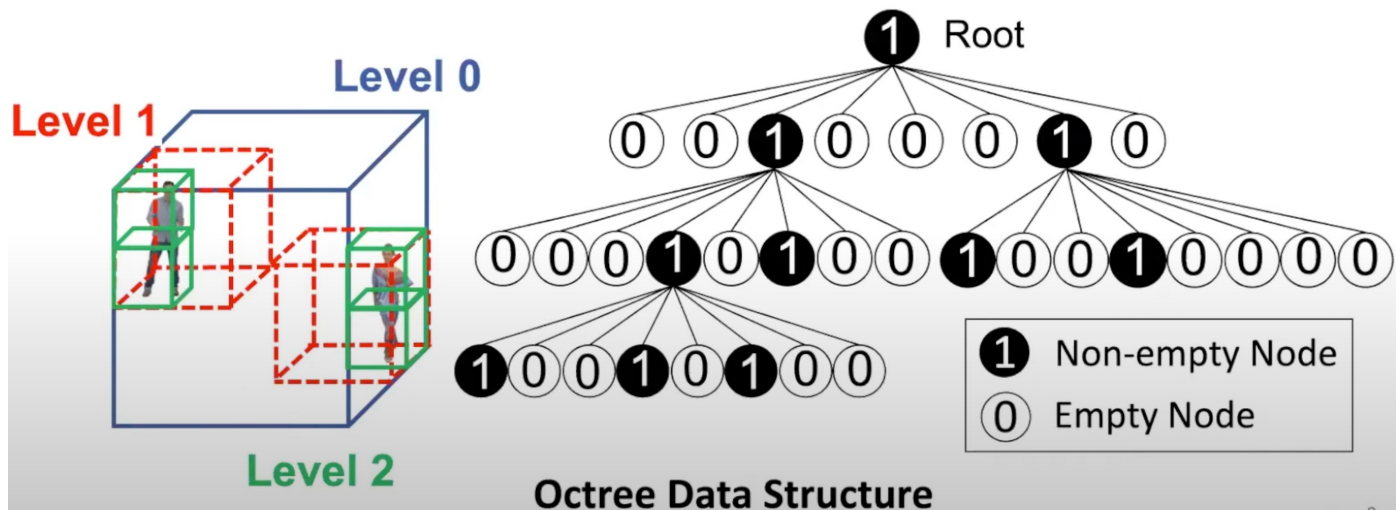


Break the dependency between points for parallel decoding

MPEG GPCC

- Problem

- Points jump from one branch of the tree to another even with small motion or due to sensor noise
- Great for static point cloud frames, but problematic temporally



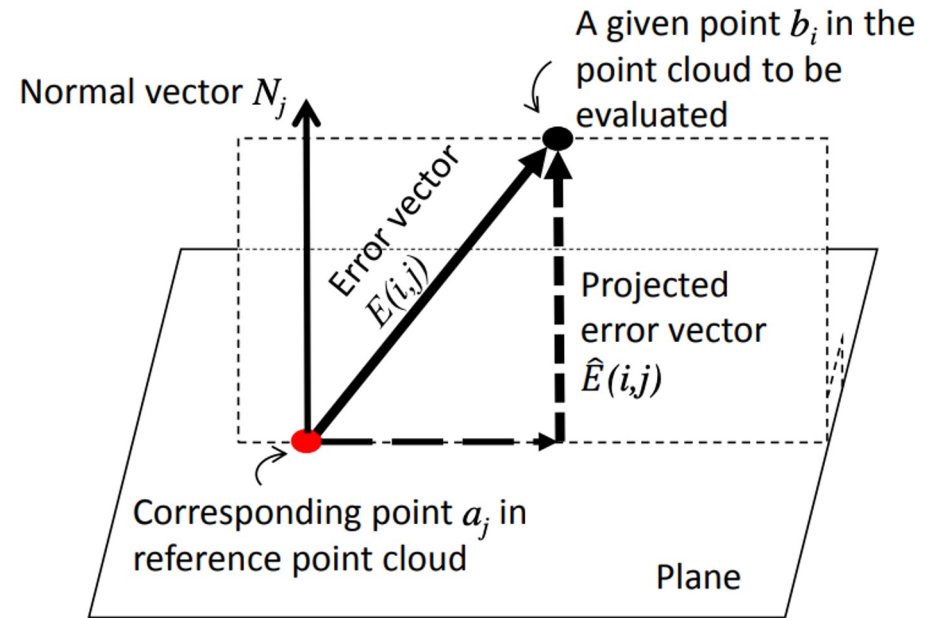
Point Cloud Error Metrics

- Point-to-Point
 - Error between nearest neighbor points

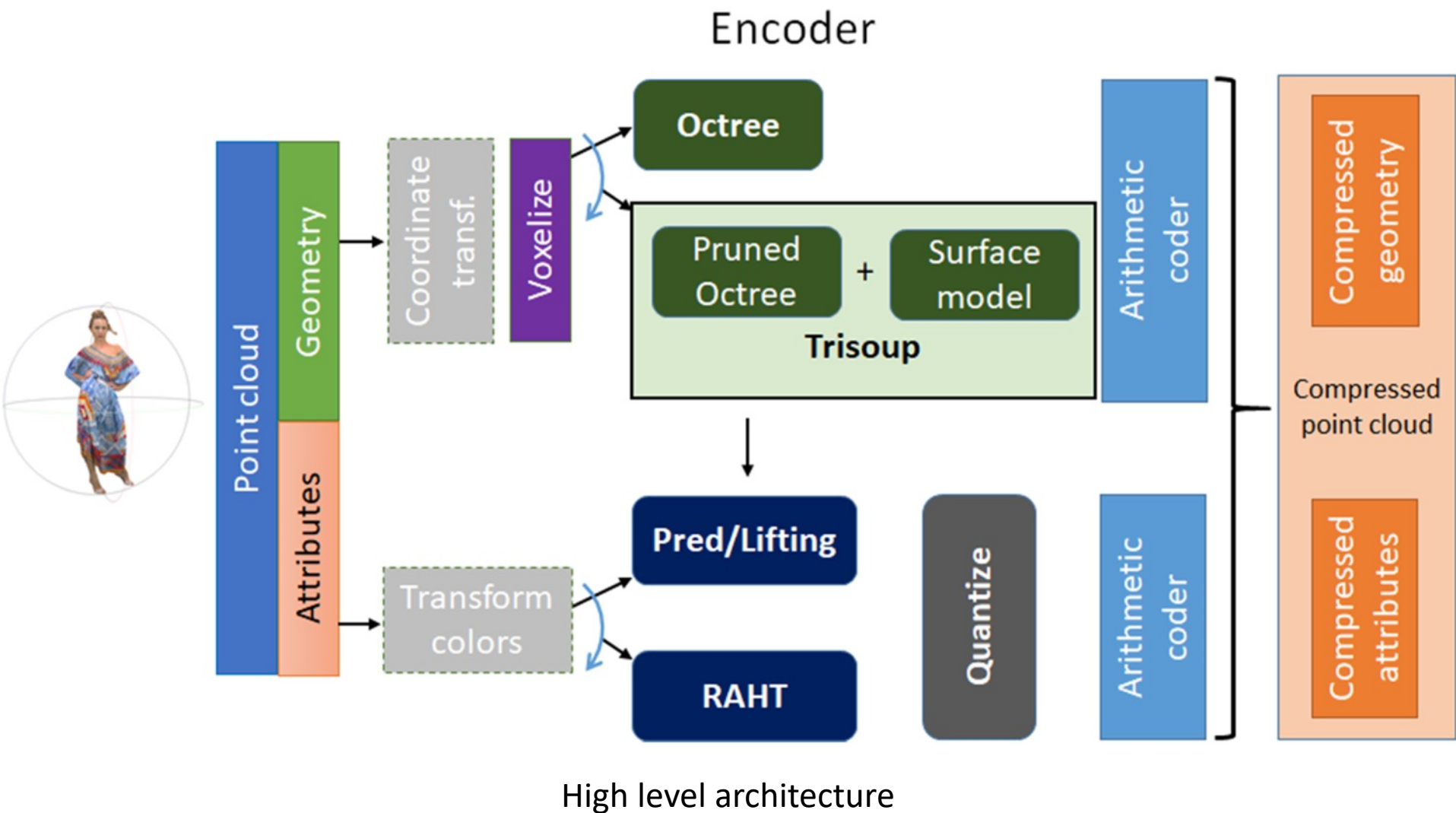
$$\frac{1}{N_A} \sum_{\forall a_j \in \mathbf{A}} \|E(i, j)\|_2^2$$

Point Cloud Error Metrics

- Point-to-Plane
 - Measures error along normal directions
 - More penalty on error that are away from surface



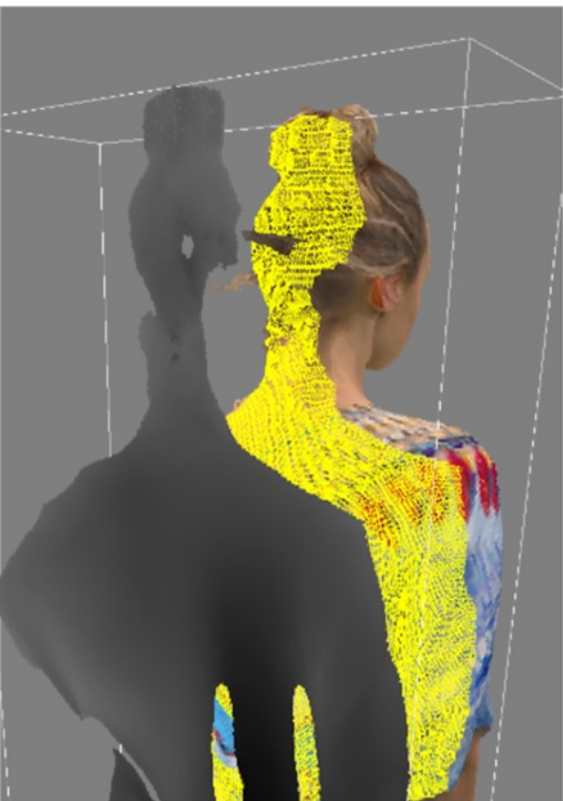
MPEG GPCC



MPEG VPCC

- Video based point cloud compression
 - Projection based coding – from 3D to 2D
 - Idea: Take advantage of existing video codecs to compress 2D projections

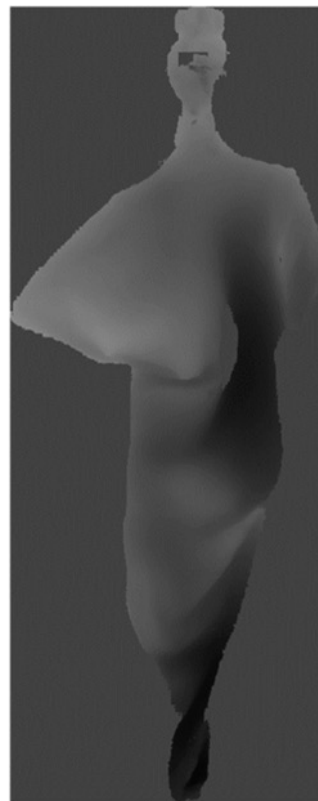
MPEG VPCC



(a)



(b)



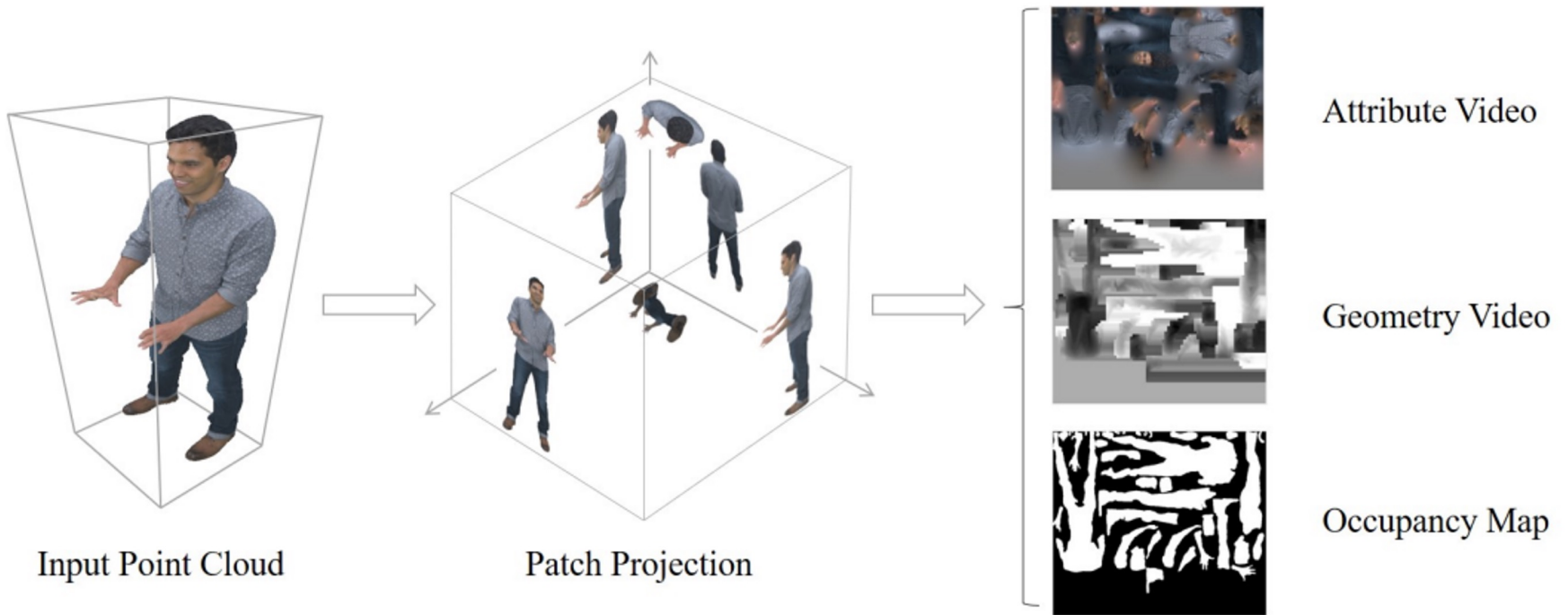
(c)



(d)

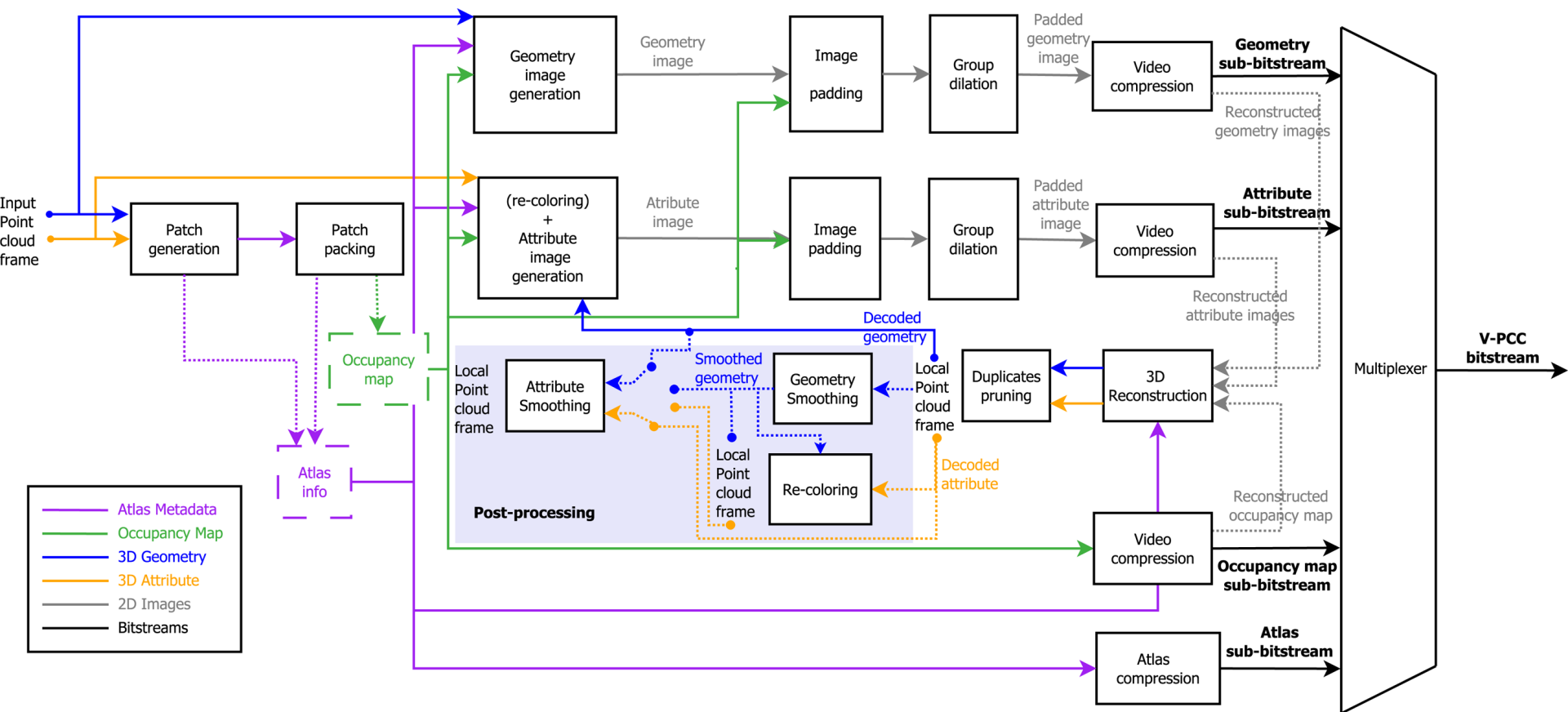
3D Patch projection and respective occupancy map, geometry, and attribute 2D images, (a) 3D patch, (b) 3D Patch Occupancy Map, (c) 3D Patch Geometry Image, (d) 3D Patch Texture Image.

MPEG VPCC



3 Video streams + 1 additional meta data stream

MPEG VPCC



High level architecture

MPEG VPCC

- Problem
 - Computationally expensive – Patch generation, packing, video generation, compression (4 streams)

Compressing Large Scale Point Clouds

- Both GPCC and VPCC suffer
 - Need to rely on the other forms of data structures for efficiency

Summary of the Lecture

- MPEG GPCC
- MPEG VPCC

- Both are computationally expensive – unusable at this point for practical purpose