Multimedia
Lecture 8

Dr. Mona M.Soliman

Faculty of Computers and Artificial Intelligence

Cairo University

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Scalar Quantization

Quantization

Quantization:

- a process of representing a large – possibly infinite – set of values with a much smaller set.

Scalar quantization:

- a mapping of an input value ***x*** into a finite number of output values ***(Reconstruction values)***

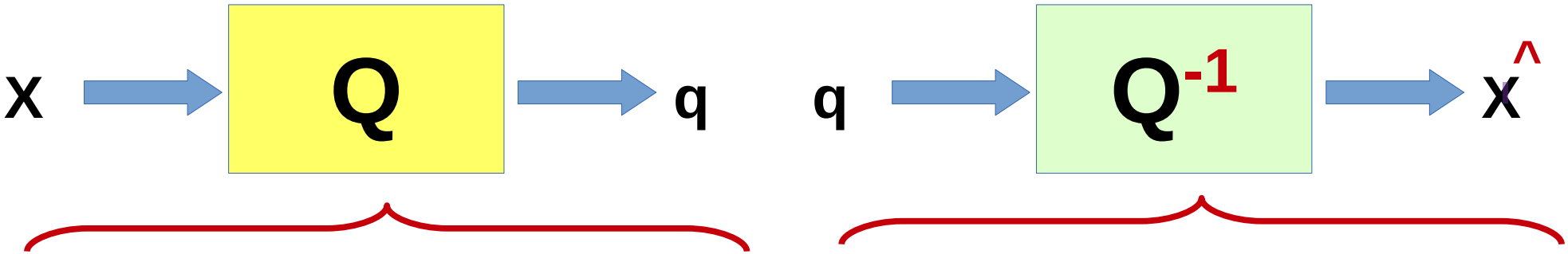
Quantization is one of the simplest and most general idea in **lossy compression.**

Image Quantization

Uniform Scalar Quantizer

- A **uniform** scalar quantizer partitions the domain of input values into **equally spaced intervals.** Each Interval is defined by its **decision boundaries**
- Each **interval** is represented by a distinct **codeword** (**Q**).
- The output or **reconstruction value** ($\mathbf{Q^{-1}}$) corresponding to each interval is taken to be the **midpoint** of the interval.
- The **length** of each interval is referred to as the ***step size***.

Quantization and De-Quantization



Quantization (Encoding)

De-Quantization (Decoding)

X: Input Value

q: Codeword for X (Encoded value of X)

$\hat{X}$: Output Value (Reconstructed Values of X)

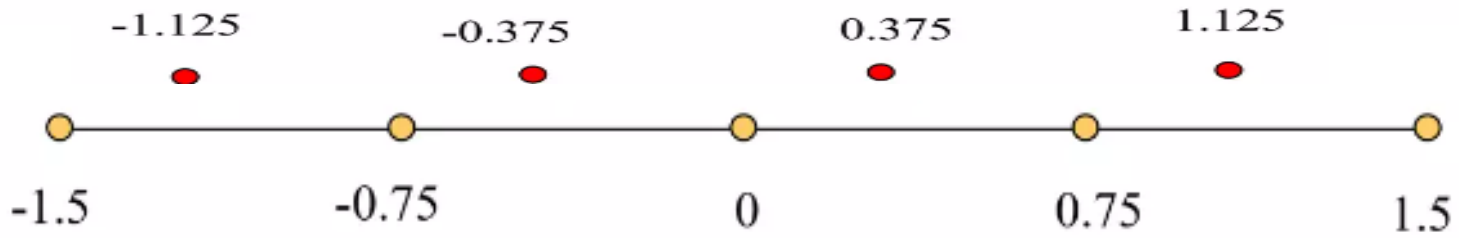
MAX Error=1/2 STEP

For the following sequence {1.2,-0.2,-0.5,0.4,0.89,1.3…}, Quantize it using a uniform quantizer in the range of (-1.5,1.5) with 4 levels, and write the quantized sequence.

Q_Step=(MAX-MIN)/# of levels

Q^{-1}=(Lower_R+Upper_R)/2

Solution: Q=3/4=0.75. Quantizer is illustrated below.



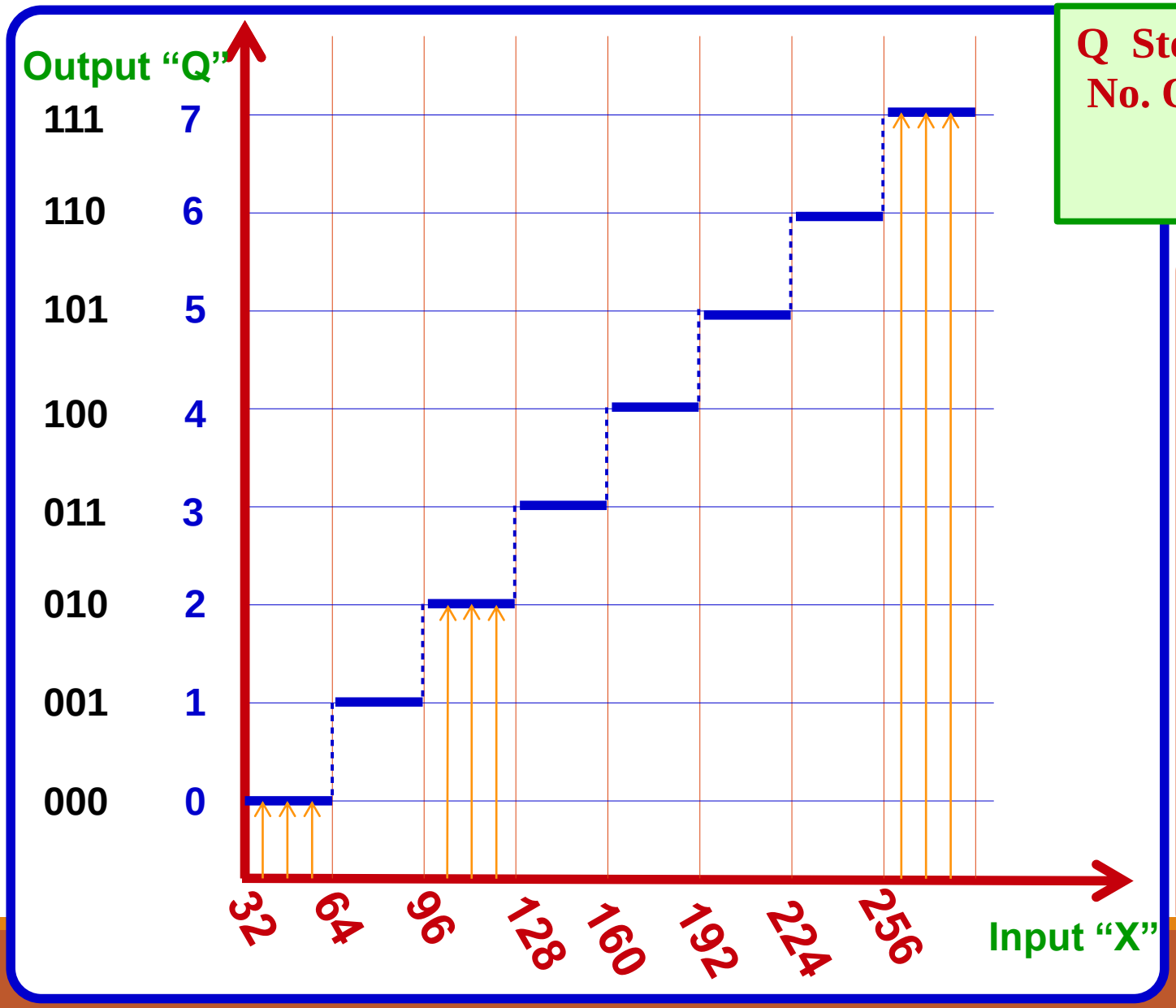
Coded_Sequence "Q" : 3,1,1,2,2)

Quantized sequence:

{1.125,-0.375,-0.375,0.375,1.125,1.125}

Yellow dots indicate the partition levels (boundaries between separate quantization intervals)
Red dots indicate the reconstruction levels (middle of each interval)

Scalar Quantization - Encoder
(Input Output Mapping)



Q Step = 32, Full Scale =256

No. Of Steps

=Full Scale / Step

=256 / 32 = 8 Steps (3 bits)

Range			Q
0	→	31	0
32	→	63	1
64	→	95	2
96	→	127	3
128	→	159	4
160	→	191	5
192	→	223	6
224	→	255	7

Scalar Quantization - Decoder (Input Output Mapping)

Example

Quantize the following:

5 , 100, 200 , 85

5	0
100	3
200	6
85	2

0	16
3	112
6	208
2	8

Original	Q(compressed)	Q-1(Uncompressed)	Error
5	0	16	11
100	3	112	12
200	6	208	8
85	2	80	5

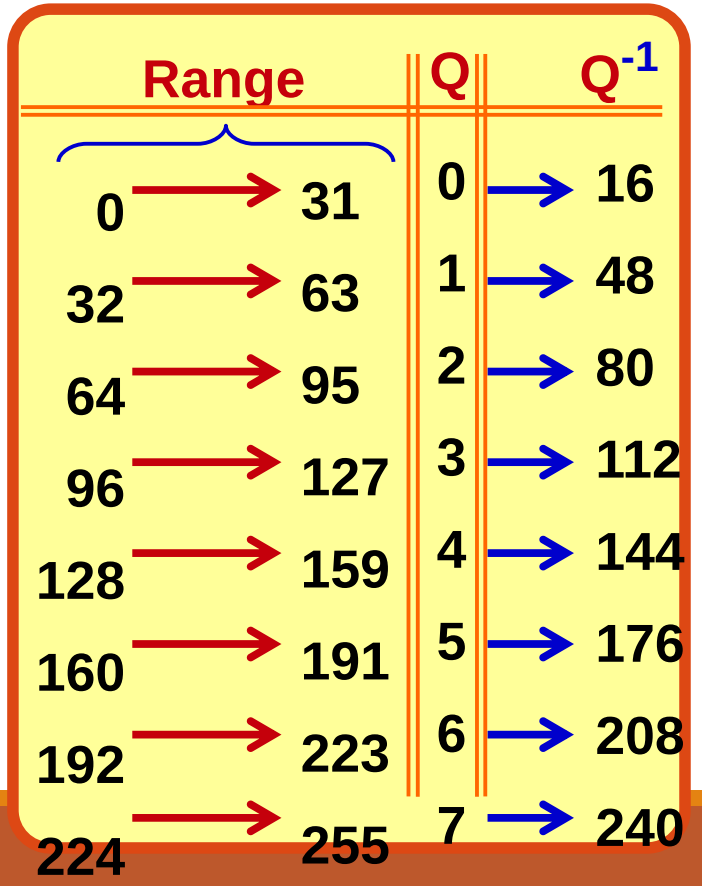
Q Step = 32, Full Scale =256

No. Of Steps

=Full Scale / Step

=256 / 32 = 8 Steps (3 Bits)

Max Error = 1/2 Step = 16



Example of Output Quality of Uniform and Non Uniform Quantizers

Example:

Compress the following Data using 2 bits uniform quantizer with step= 32, Full Scale=128

6, 15, 17, 60, 100, 90, 66, 59, 18, 3, 5, 16, 14, 67, 63, 2, 98, 92.

Calculate MSE (as Distortion Measure)

Range	Q	Q^{-1}
0... 31	0	16
32...63	1	48
64...95	2	80
96....127	3	112

Original	6	15	17	60	100	90	66	59	18	3	5	16	14	67	63	2	98	92
Q	0	0	0	1	3	2	2	1	0	0	0	0	0	2	1	0	3	2
Q^{-1}	16	16	16	48	112	80	80	48	16	16	16	16	16	80	48	16	112	80
Error	10	1	1	12	12	10	14	11	2	13	11	0	2	13	15	14	14	12
$Error^2$	100	1	1	144	144	100	196	121	4	169	121	0	4	169	225	196	196	144

Mean Square Error (MSE)= 1/18[100+1+1+144+144+100+196+....]= 2035 /18=113

Max Error = 15 (< ½ Step)

Example of Output Quality of Uniform and Non Uniform Quantizers

Example:

Compress the following Data using the following 2 bits

Non uniform quantizer

6, 15, 17, 60, 100, 90, 66, 59, 18, 3, 5, 16, 14, 67, 63, 2, 98, 92.

Calculate MSE (as Distortion Measure)

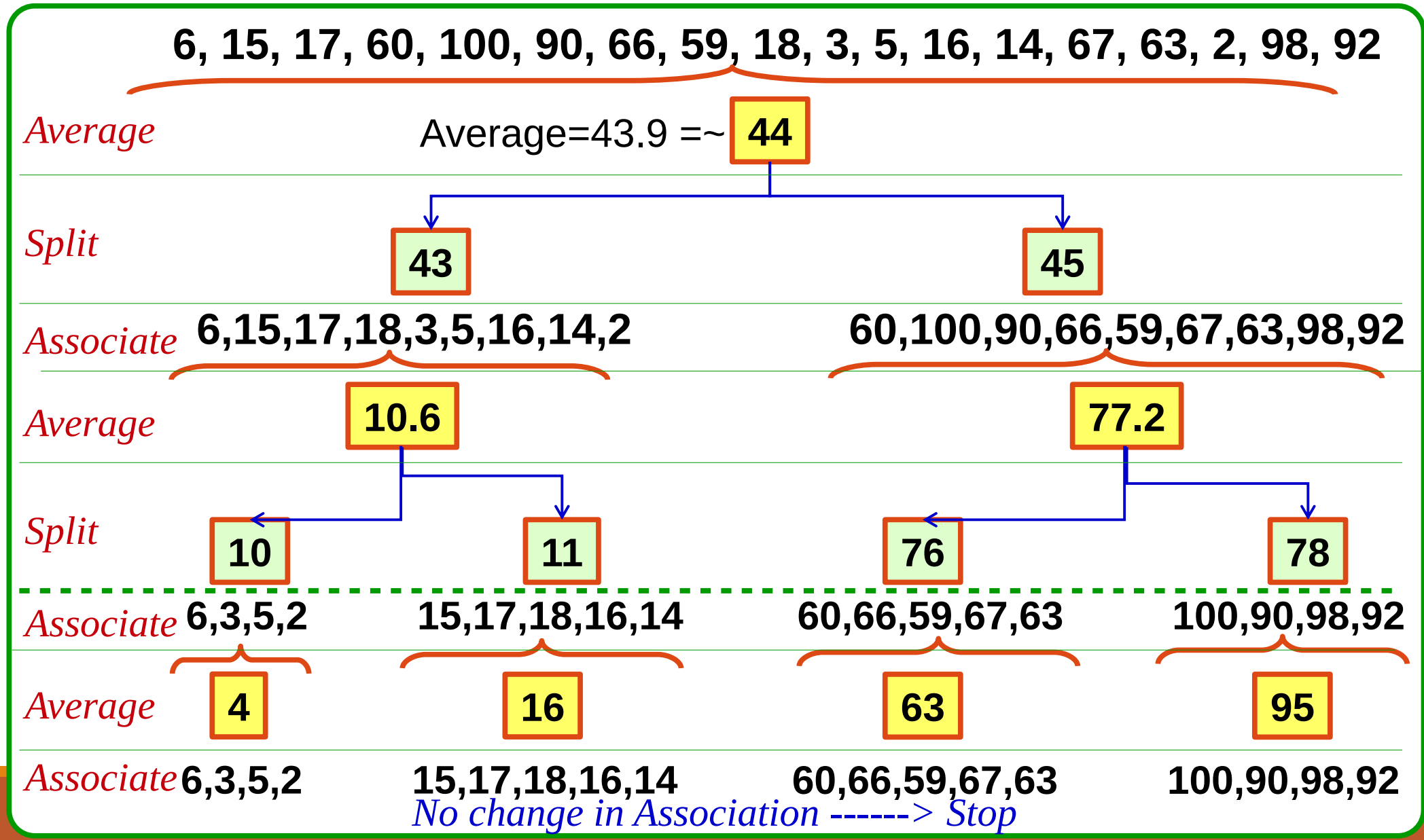
Range	Q	Q^{-1}
0...10	0	4
11....39	1	16
40...79	2	63
80...127	3	95

Original	6	15	17	60	100	90	66	59	18	3	5	16	14	67	63	2	98	92
Q	0	1	1	2	3	3	2	2	1	0	0	1	1	2	2	0	3	3
Q^{-1}	4	16	16	63	95	95	63	63	16	4	4	16	16	63	63	4	95	95
Error	2	1	1	3	5	5	3	4	2	1	1	0	2	4	0	2	3	3
$Error^2$	4	1	1	9	25	25	9	16	4	1	1	0	4	16	0	4	9	9

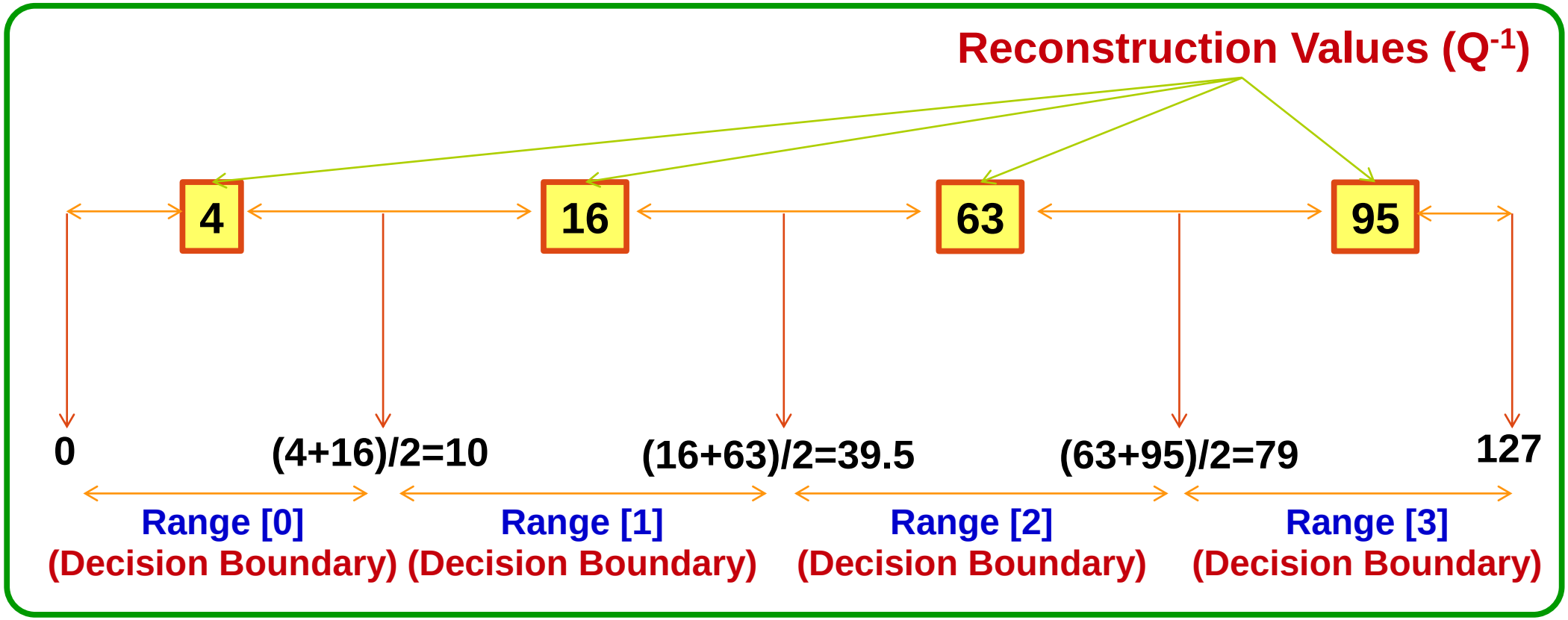
Mean Square Error (MSE)= 1/18[4+1+1+9+25+25+9+16+....] = 138 /18=7.66

Max Error = 5

Design of Non Uniform Quantizer
(using LBG Algorithm with Splitting)



Design of Non Uniform Quantizer
(using LBG Algorithm with Splitting)



Range	Q	Q^{-1}
0...10	0	4
11....39	1	16
40...79	2	63
80...127	3	95