CSCI 241

Lecture N-1
Review

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Goals

- Fill out course evaluations.
- Work on some review problems.

Announcements

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- A3 grades are out
  - You can resubmit for half unit test credit back.
  - Push updates to grading branch, send me email.
- Deadline: **10pm Thursday, 3/21**

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- Final study guide is up on Canvas

What now?

- 241 prepares you for:
  - internships (and the interviews to get them)
  - research
- I’m always looking for highly motivated research students. Get in touch!

Course Evaluations

- Your feedback is helpful and I will read it carefully (after I submit grades).
- I will make changes based on what you say.
- The most helpful feedback is **specific** and **actionable**

Course evaluations

Practice Problems

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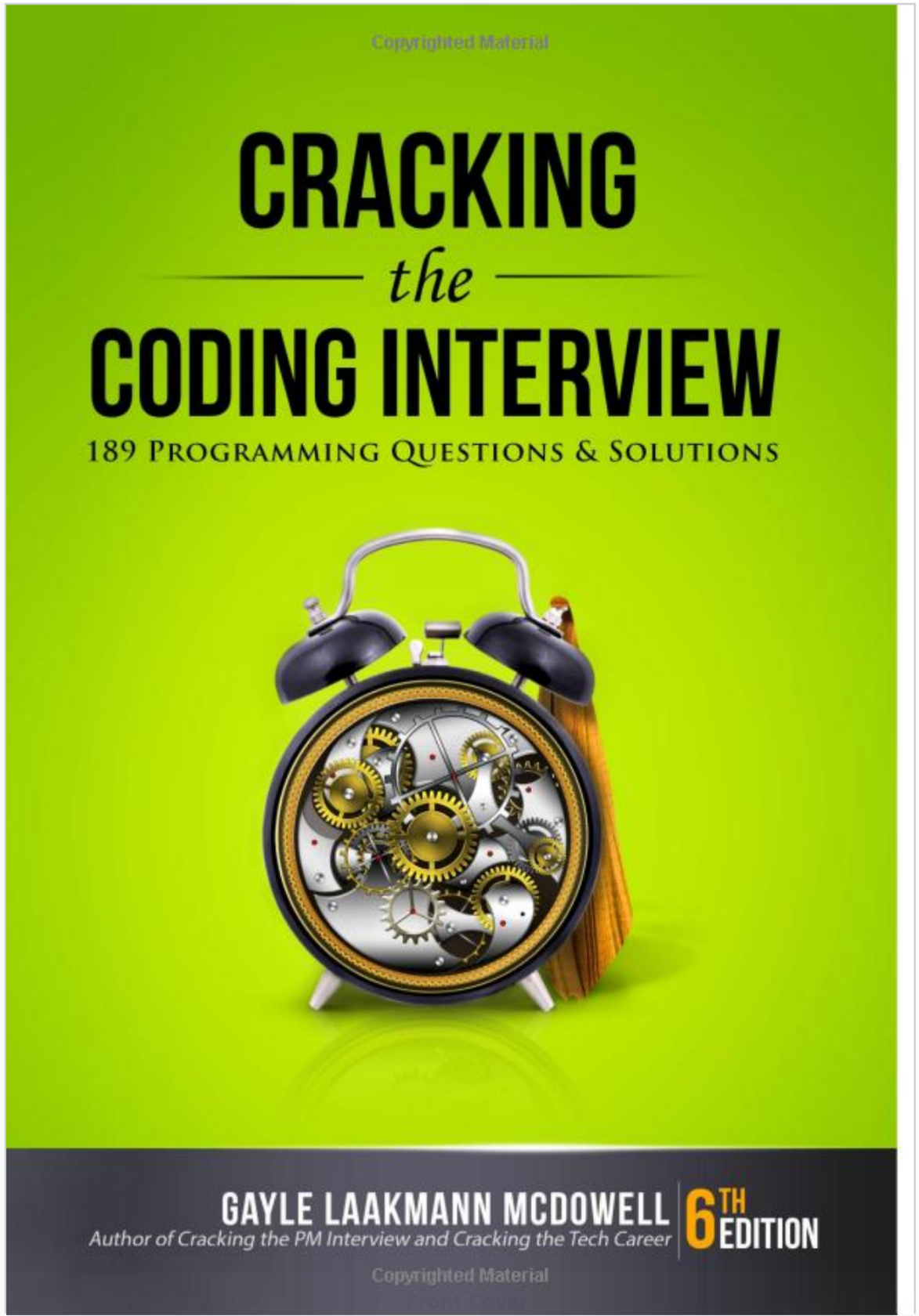
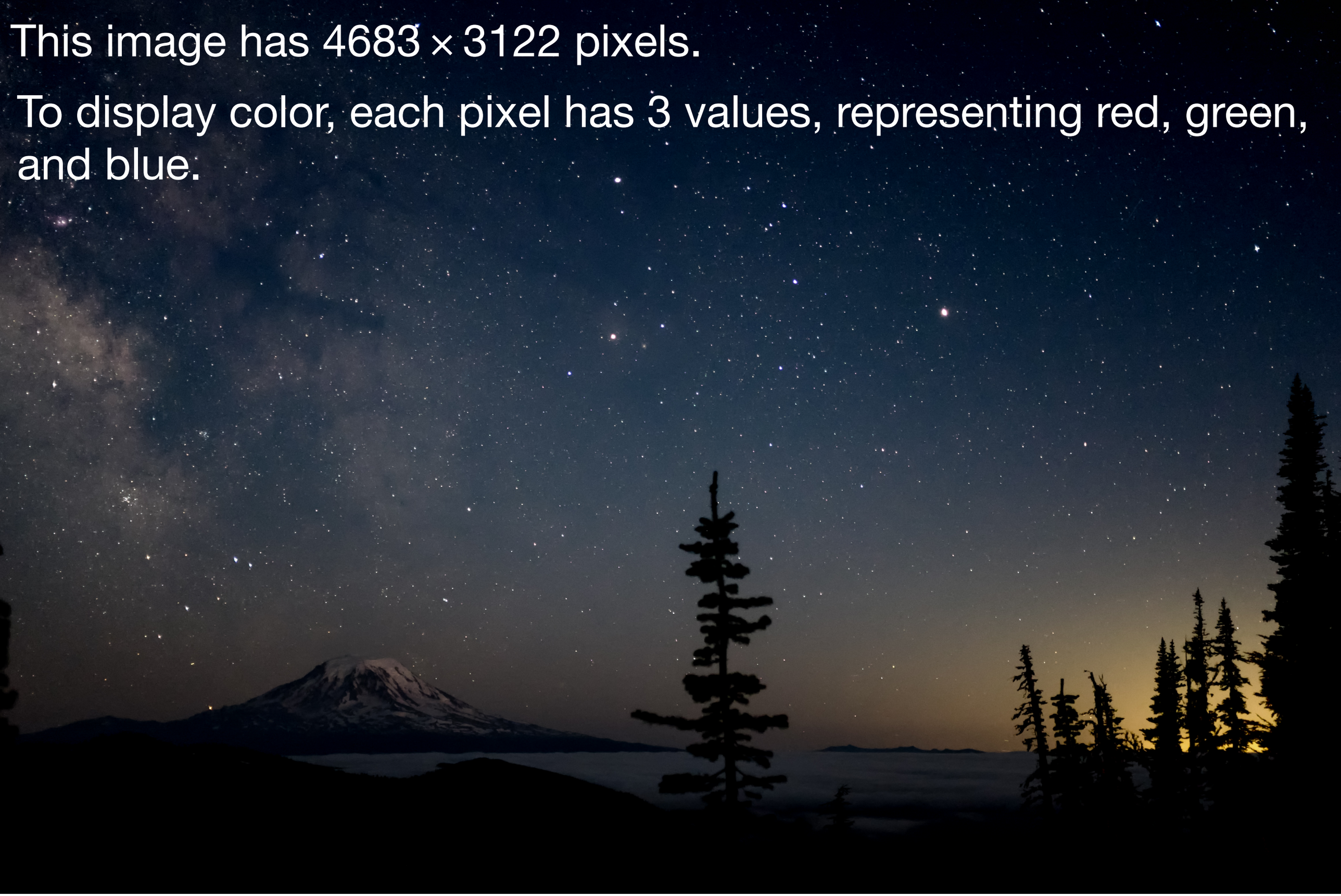
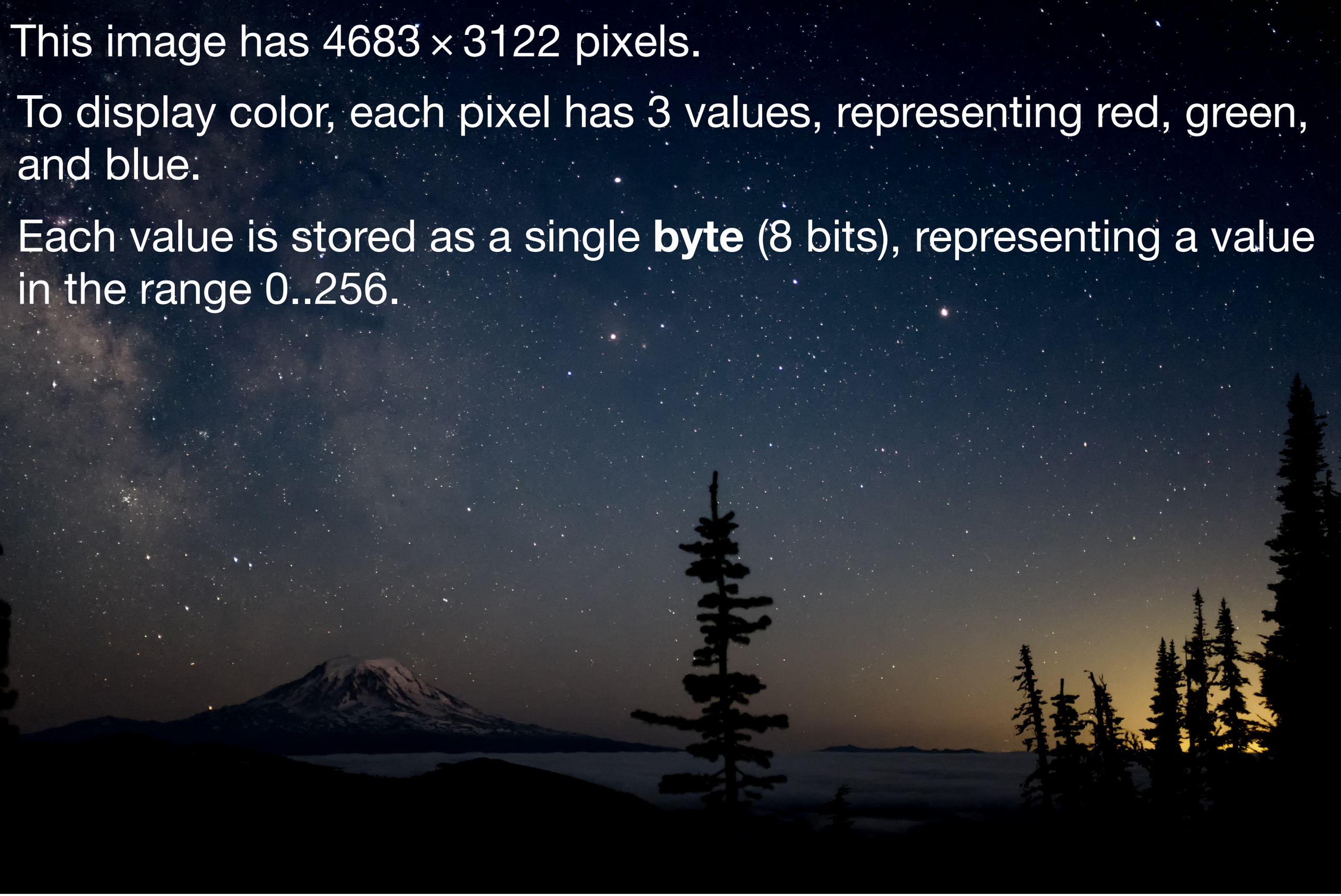


Additional Source of Fun

- Easier: https://codingbat.com/java
  - good for recursion
- Easy -> Hard https://adventofcode.com/
  - see how far into December you can get before giving up
  - A couple years ago I got to ~Dec 21
- Easy -> Nuts https://projecteuler.net/
  - first 50 are pretty manageable
-

This image has 4683 × 3122 pixels.


This image has 4683 × 3122 pixels.
To display color, each pixel has 3 values, representing red, green, and blue.



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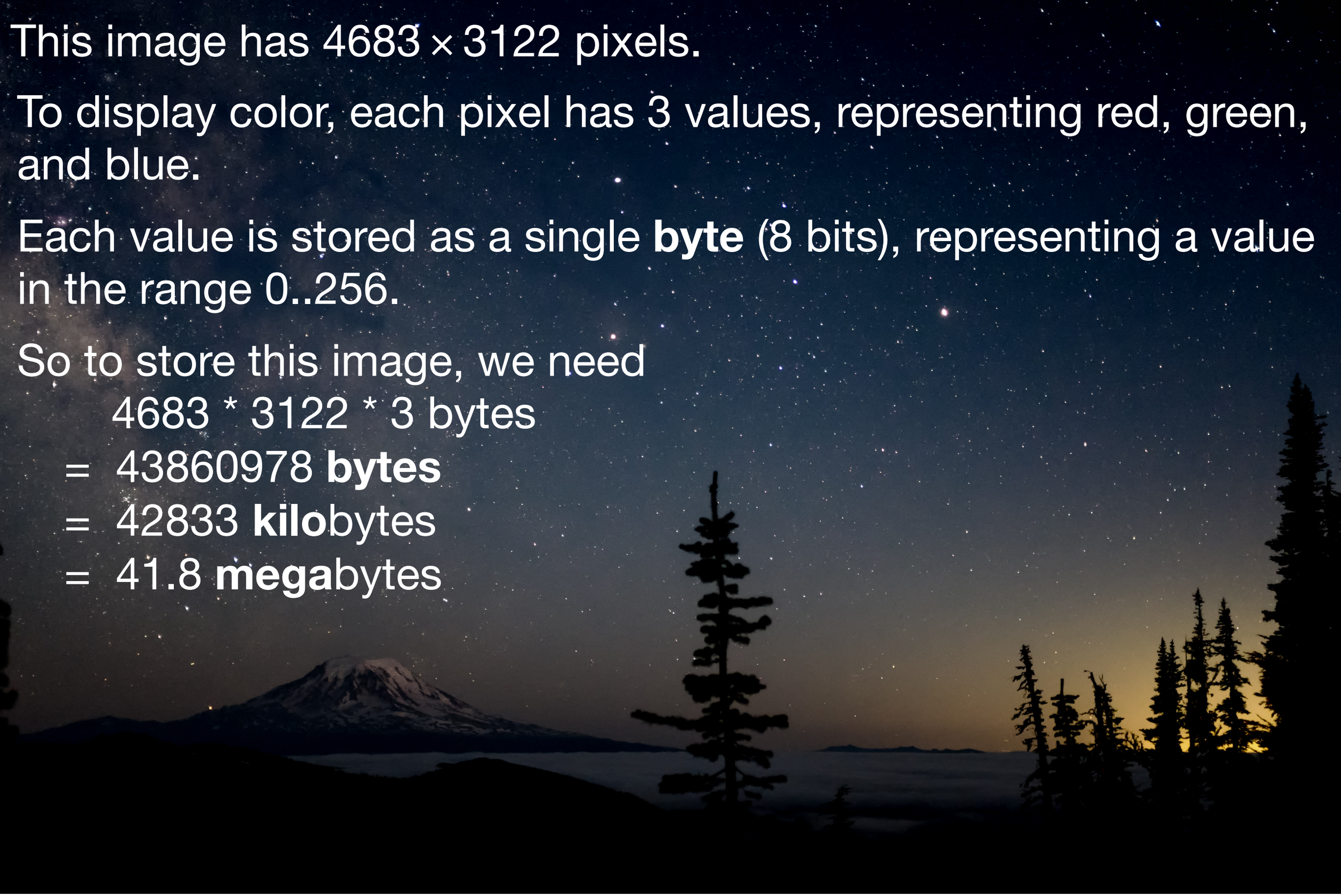
Each value is stored as a single **byte** (8 bits), representing a value in the range 0..256.



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So to store this image, we need

4683 * 3122 * 3 bytes

= 43860978 **bytes**

= 42833 **kilo**bytes

= 41.8 **mega**bytes

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What gives?

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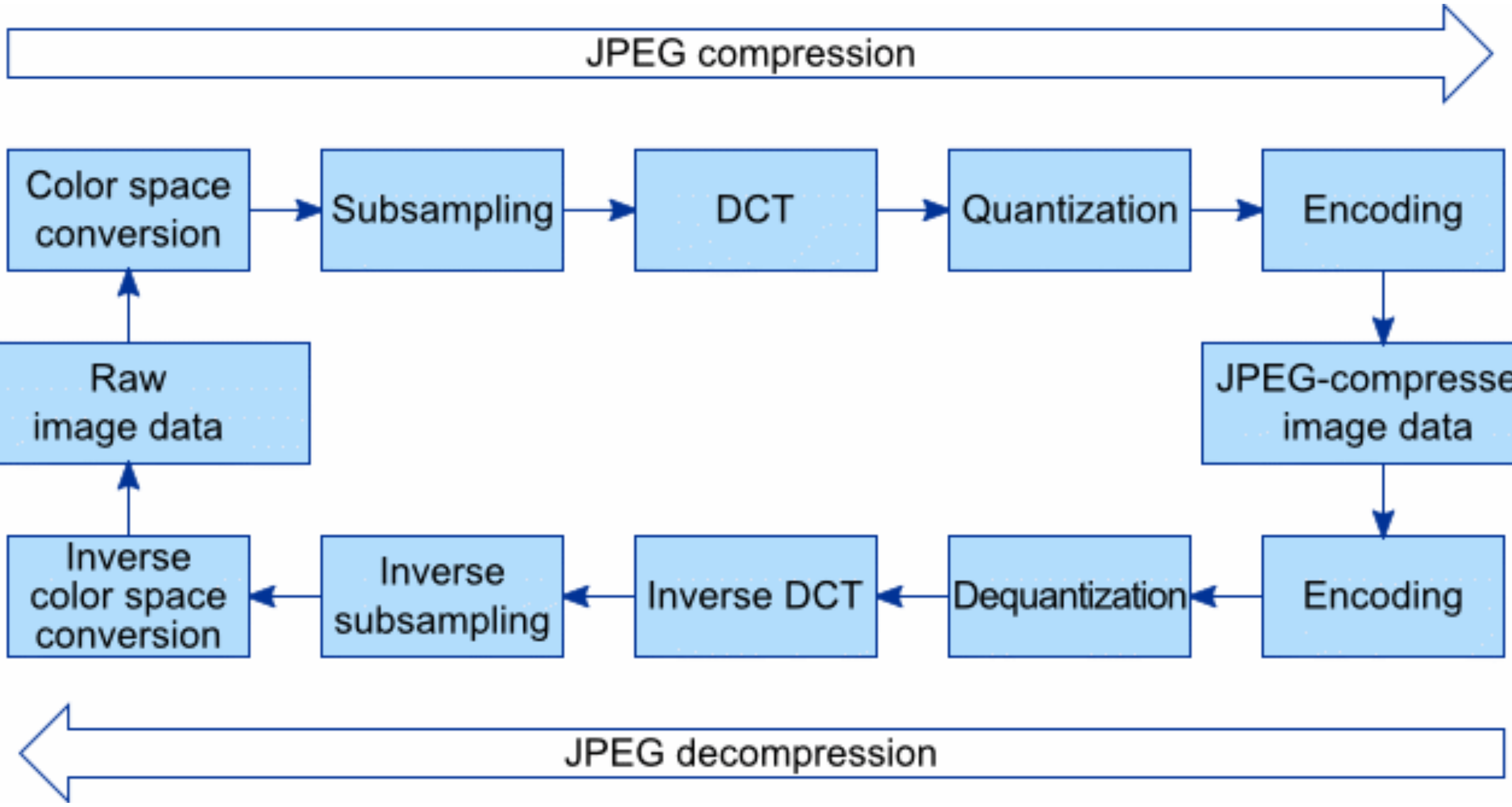
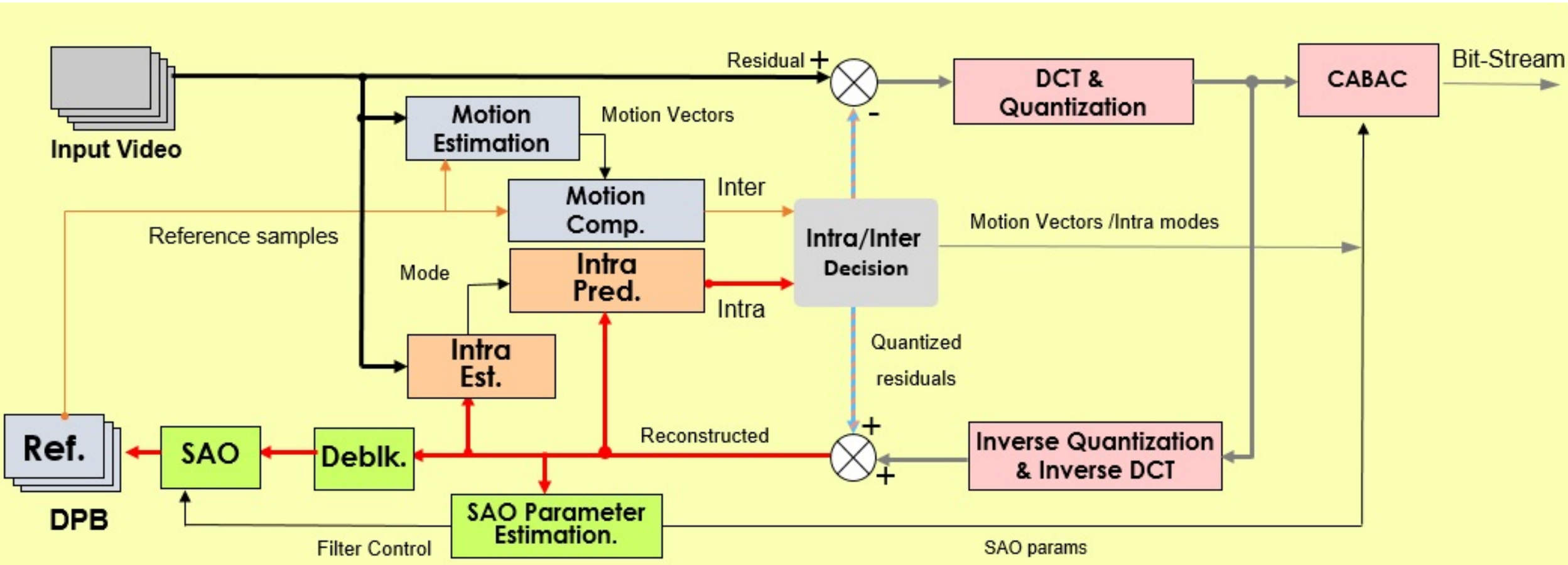
Image Compression: JPEG

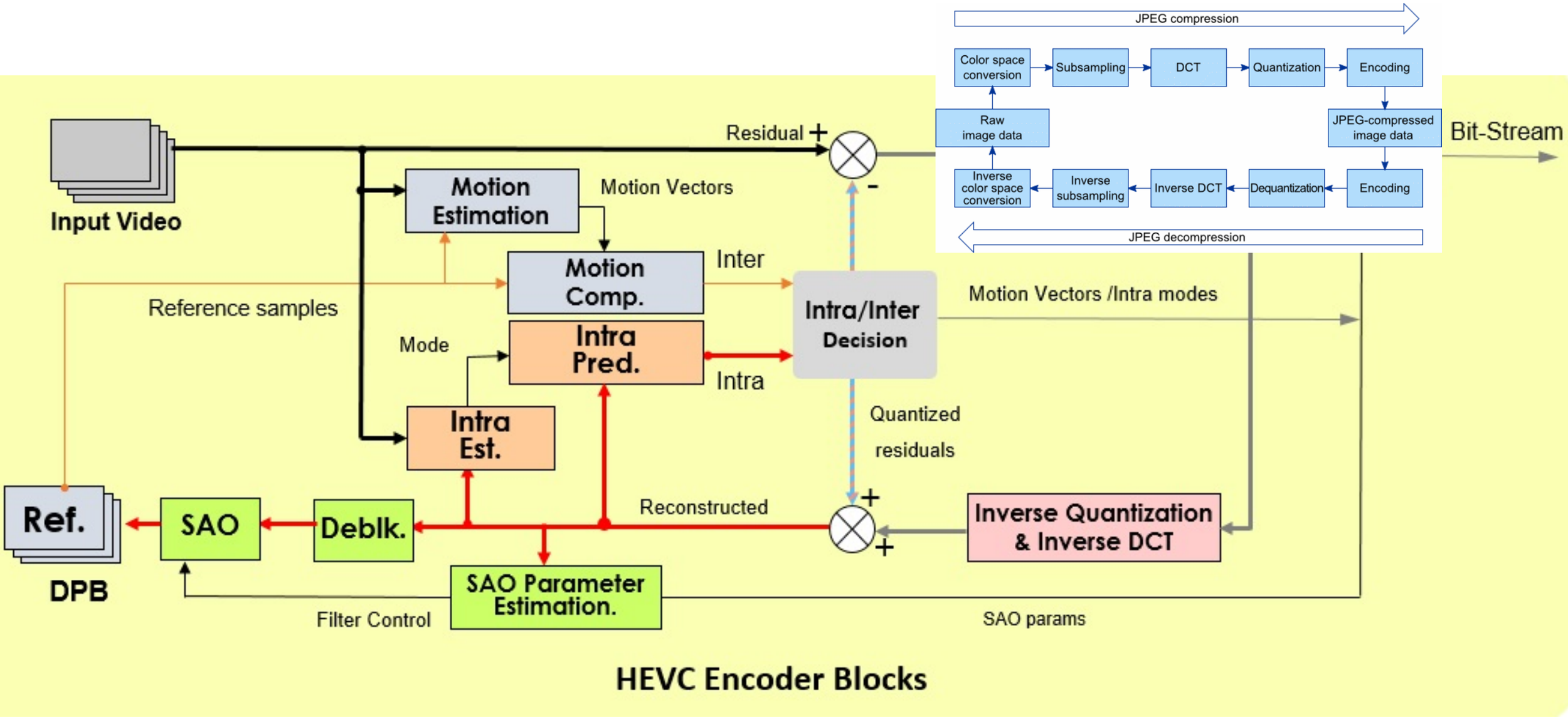


Video Compression: H.265



HEVC Encoder Blocks

Video Compression: H.265



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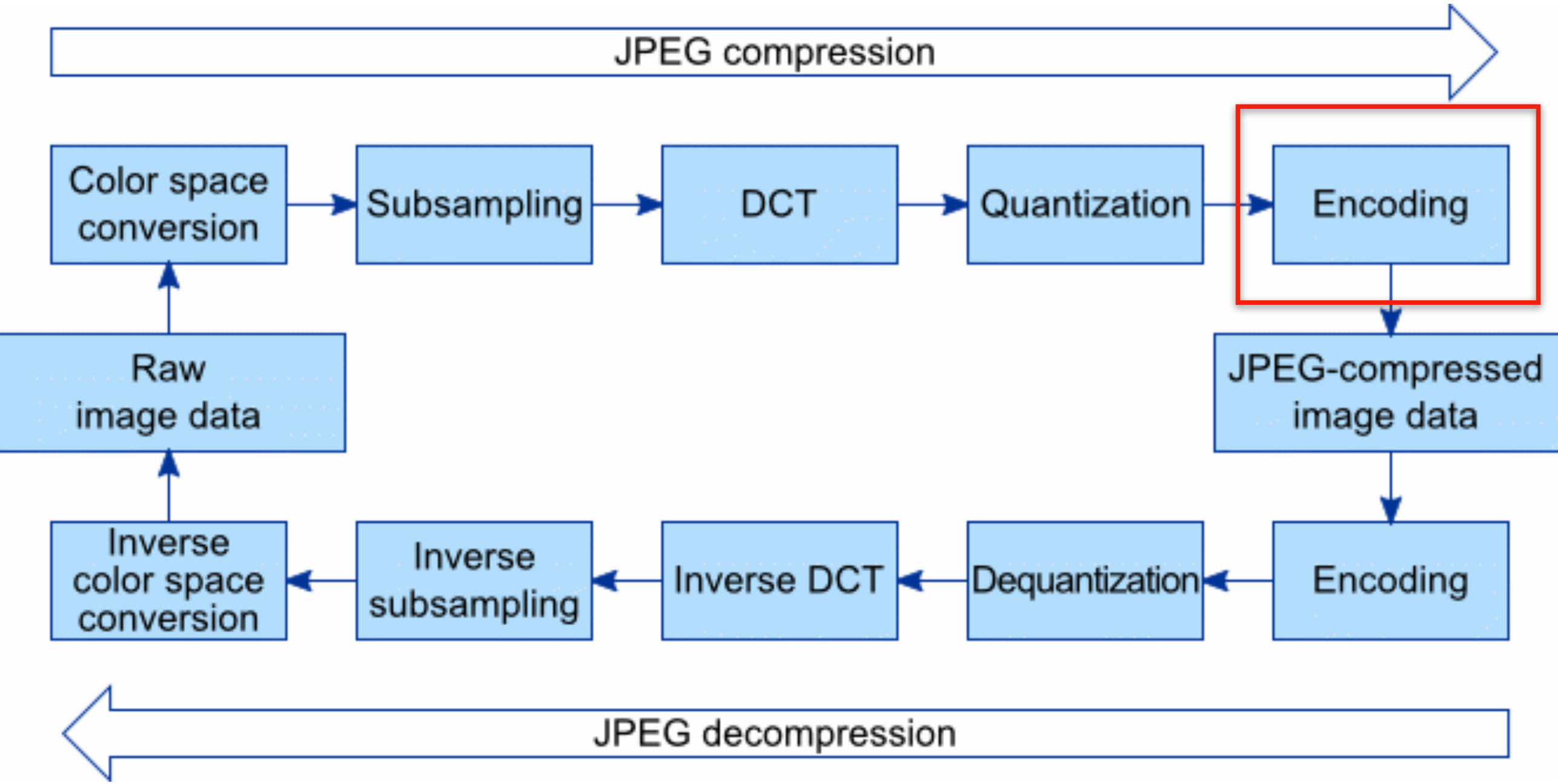


A Method for the Construction of Minimum-Redundancy Codes*

DAVID A. HUFFMAN+, ASSOCIATE, IRE

Summary—An optimum method of coding an ensemble of messages consisting of a finite number of members is developed. A minimum-redundancy code is one constructed in such a way that the average number of coding digits per message is minimized.

Introduction

ONE IMPORTANT METHOD of transmitting messages is to transmit in their place sequences of symbols. If there are more messages which might be sent than there are kinds of symbols available, then some of the messages must use more than one symbol. If it is assumed that each symbol requires the same time for transmission, then the time for transmission (length) of a message is directly proportional to the number of symbols associated with it. In this paper, the symbol or sequence of symbols associated with a given message will be called the "message code." The entire number of messages which might be transmitted will be

will be defined here as an ensemble code which, for a message ensemble consisting of a finite number of members, N, and for a given number of coding digits, D, yields the lowest possible average message length. In order to avoid the use of the lengthy term "minimum-redundancy," this term will be replaced here by "optimum." It will be understood then that, in this paper, "optimum code" means "minimum-redundancy code."

The following basic restrictions will be imposed on an ensemble code:

(a) No two messages will consist of identical arrangements of coding digits.

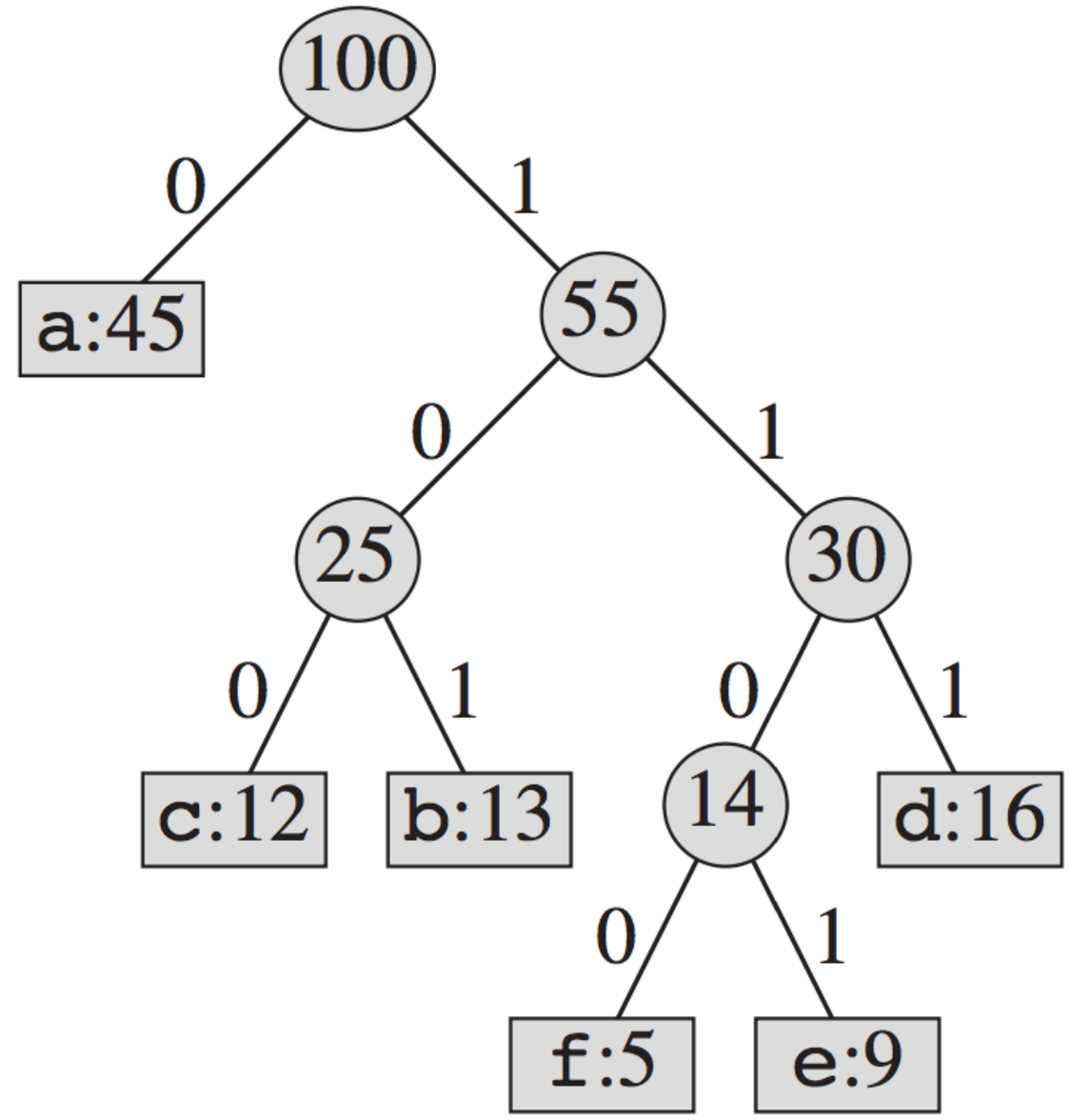
(b) The message codes will be constructed in such a way that no additional indication is necessary to specify where a message code begins and ends once the starting point of a sequence of messages is known.

This is a coding tree.

Encodes a **map**ping from bit strings to words:

0 means go left

1 means go right

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0: a

111: d

101: b
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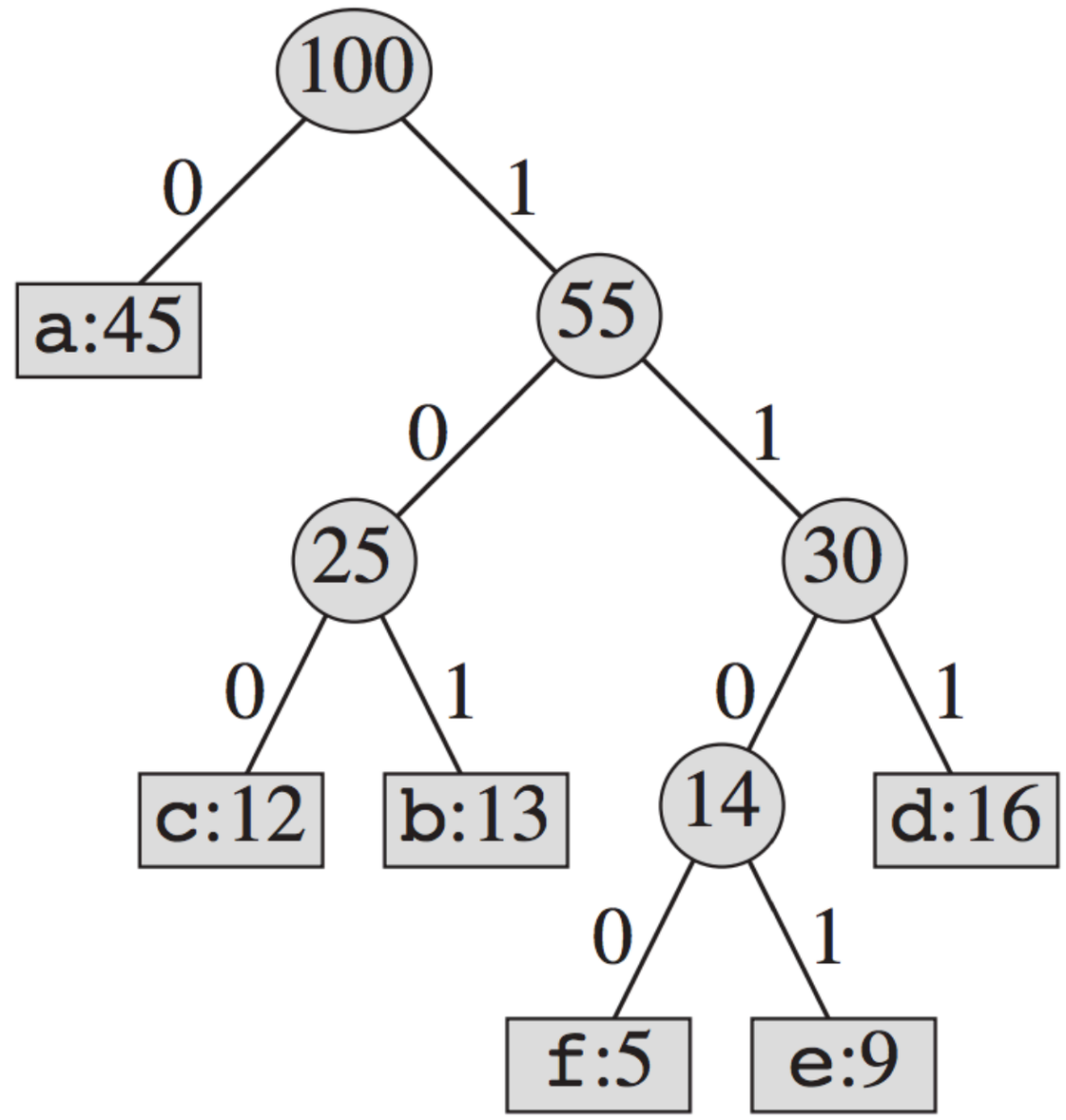


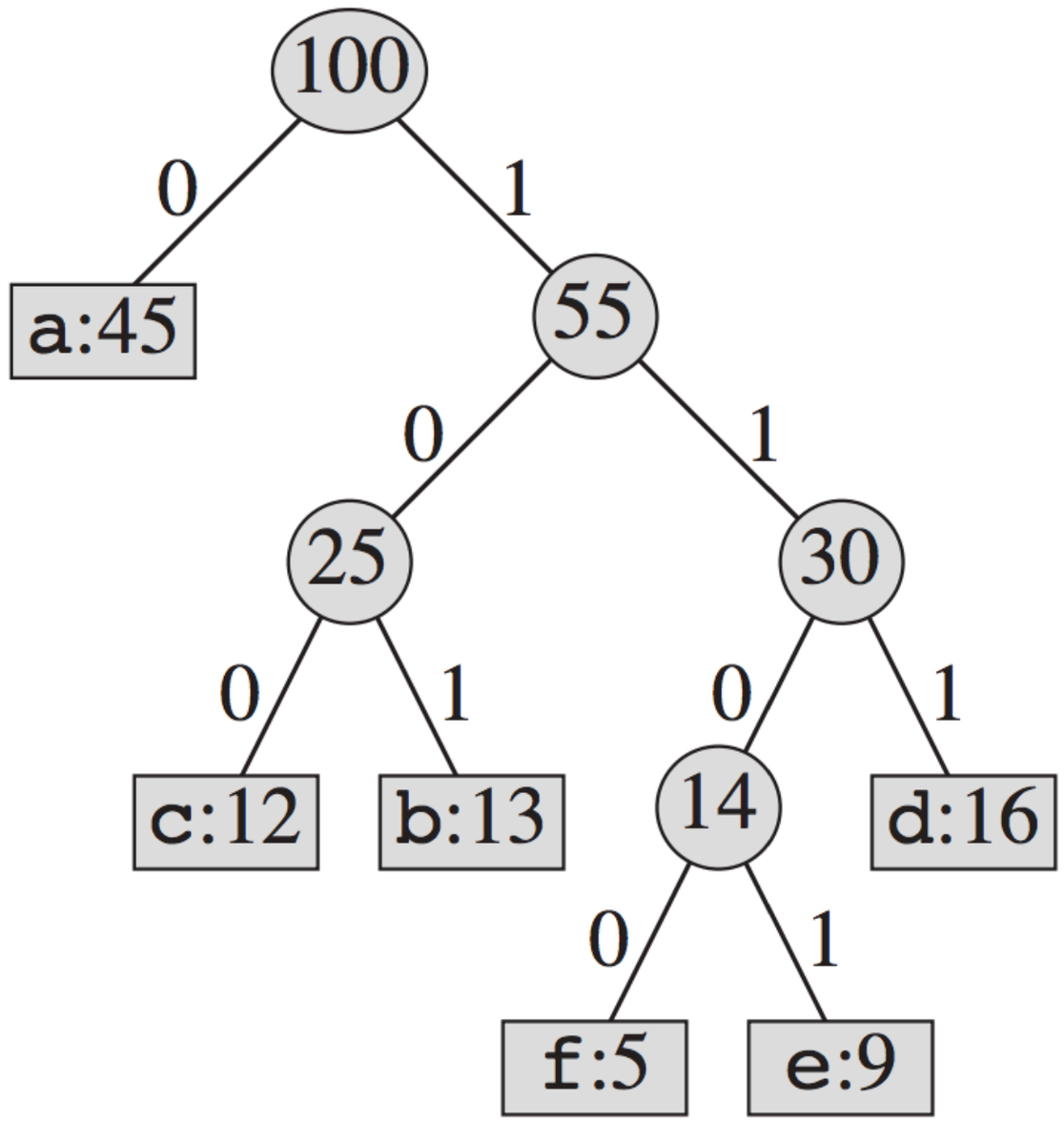

```
0: a

111: d

101: b
```

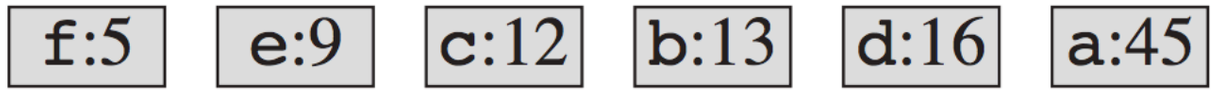
Key intuition: put common words near the root.

	a	b	c	d	e	f
Frequency (in thousands)	45	13	12	16	9	5

```
HUFFMAN(C)
1  n = |C|
2  Q = C
3  for i = 1 to n − 1
4      allocate a new node z
5      z.left = x = EXTRACT-MIN(Q)
6      z.right = y = EXTRACT-MIN(Q)
7      z.freq = x.freq + y.freq
8      INSERT(Q, z)
9  return EXTRACT-MIN(Q)      // return the root of the tree
```

	a	b	c	d	e	f
Frequency (in thousands)	45	13	12	16	9	5
Variable-length codeword	0	101	100	111	1101	1100




f:5
e:9
c:12
b:13
d:16
a:45

Smallest two: 5, 9

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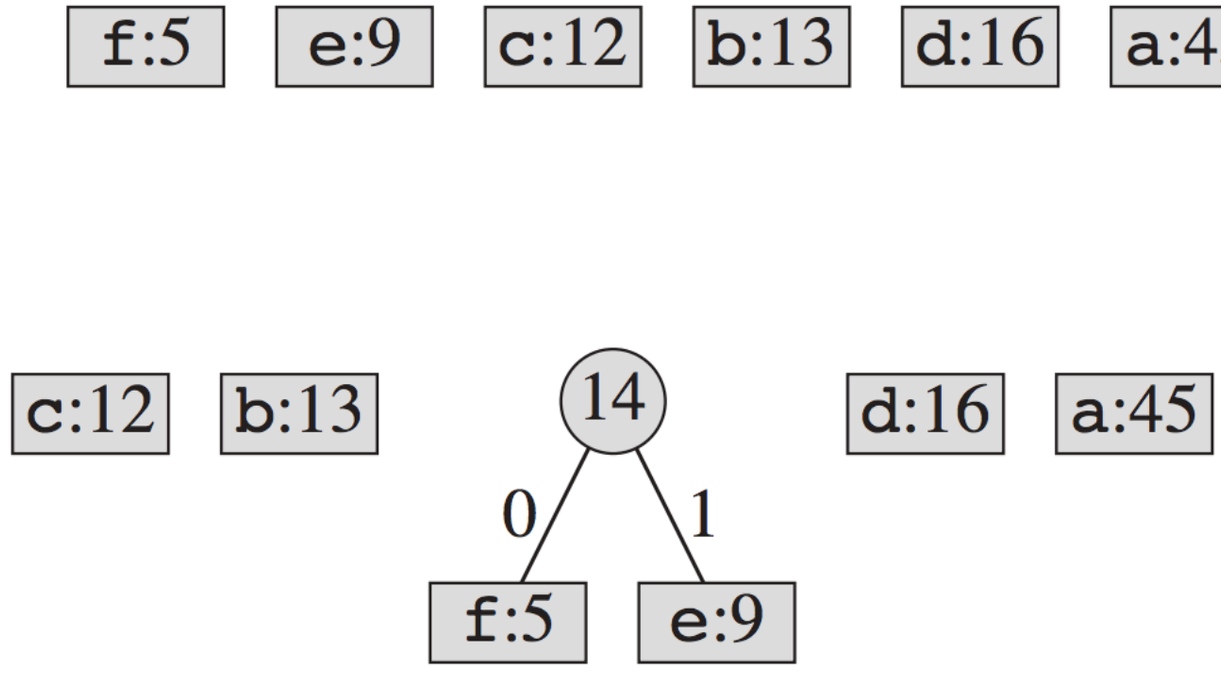

Smallest two: 5, 9

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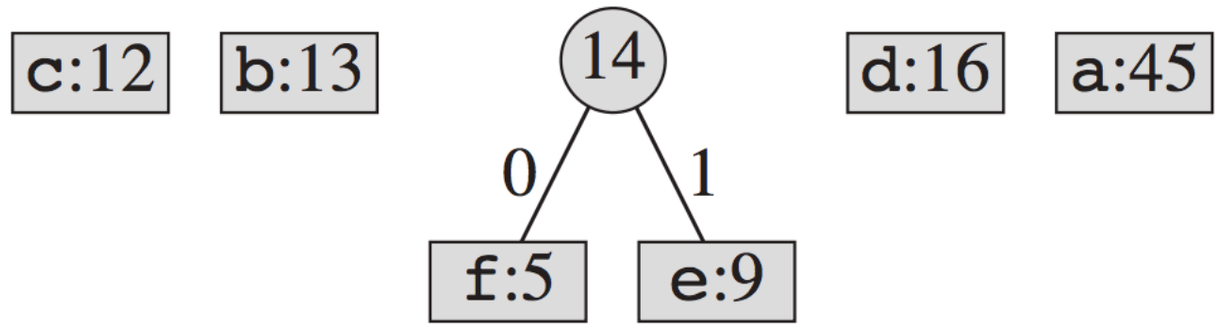

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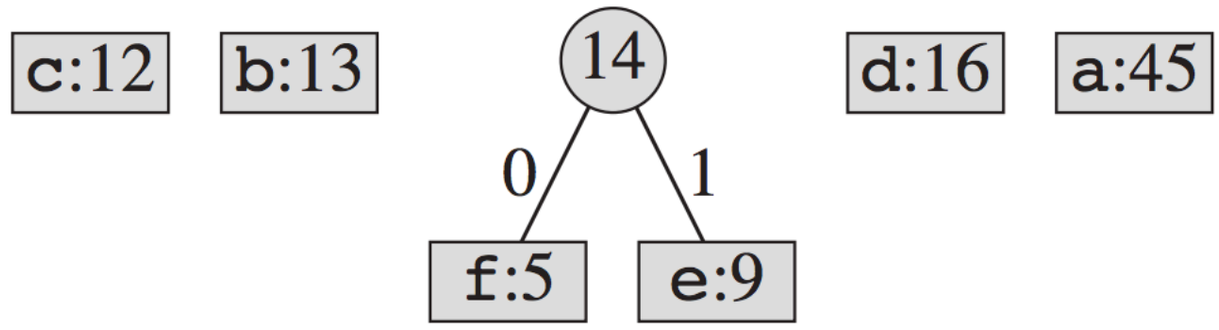

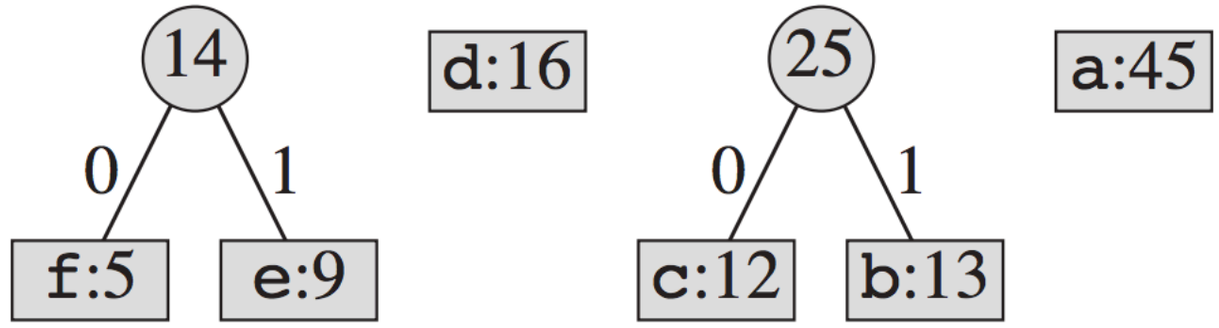

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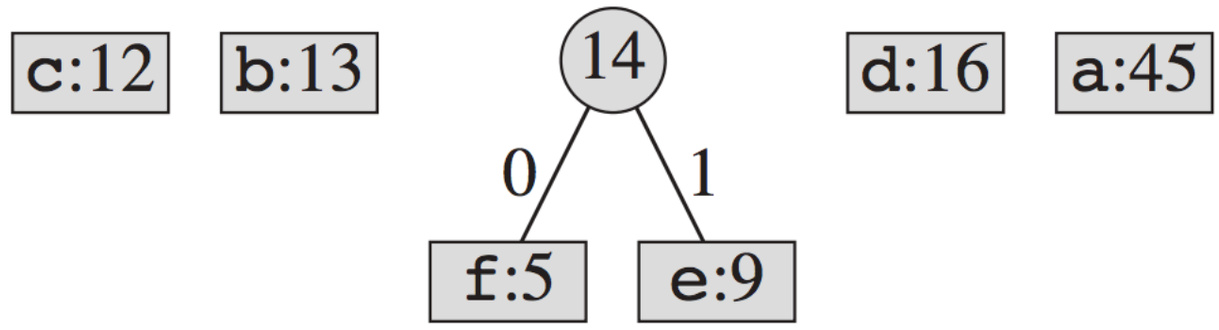

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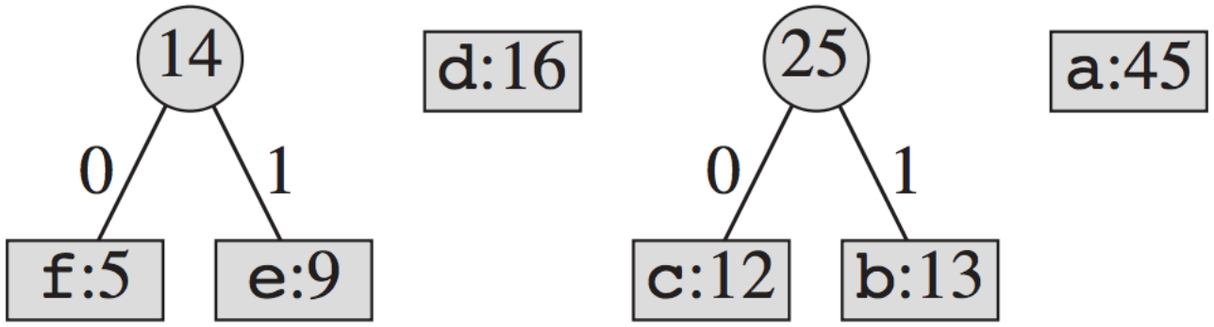

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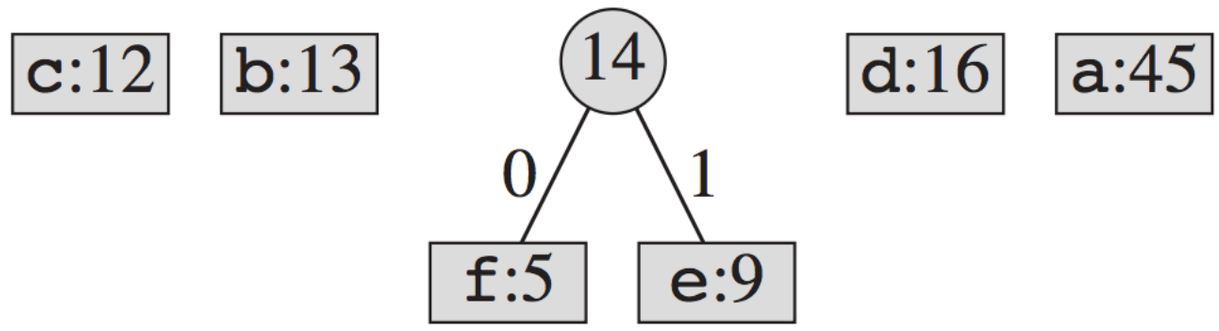

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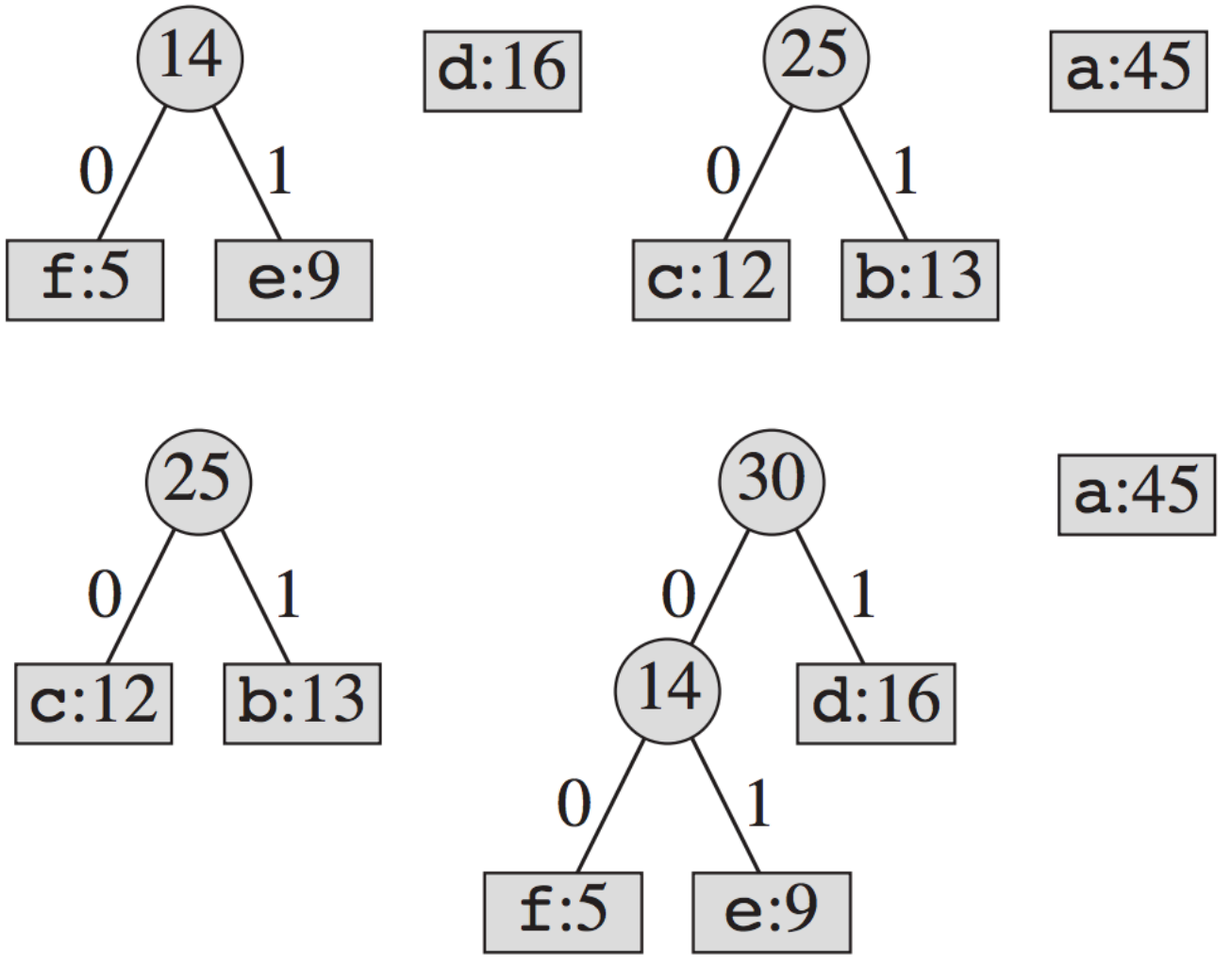

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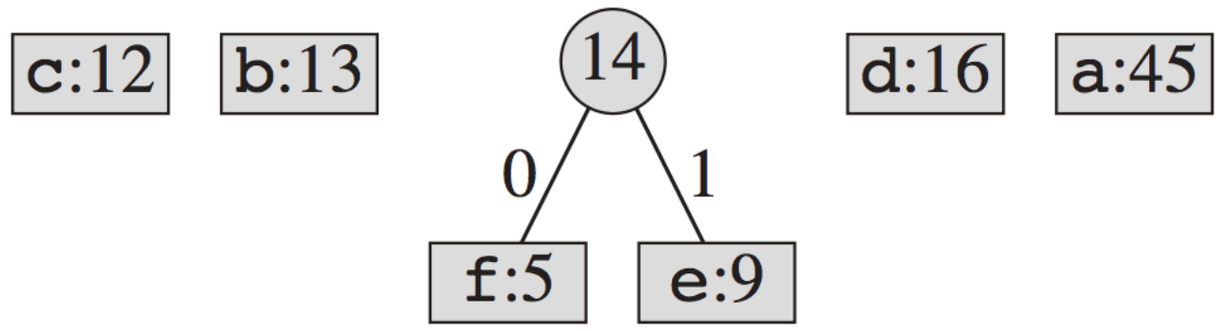

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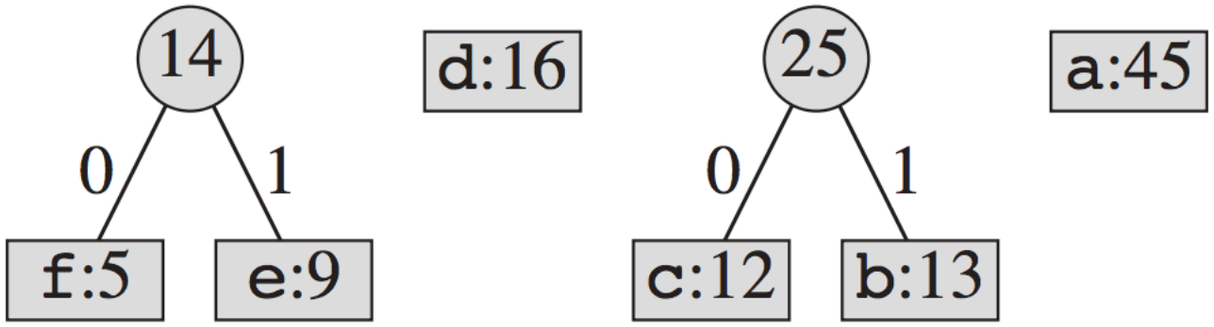
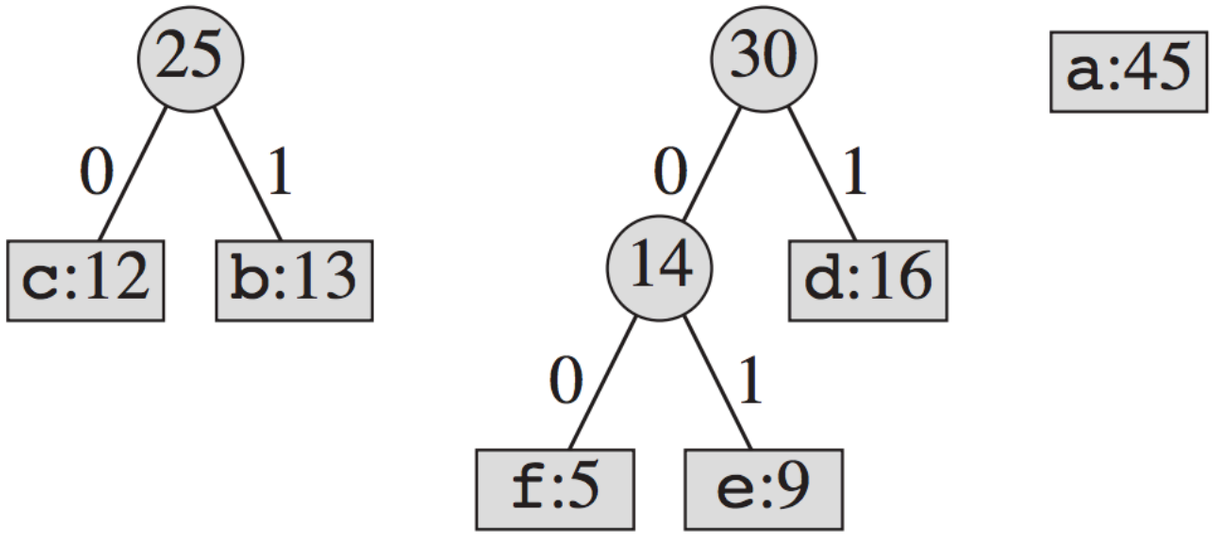
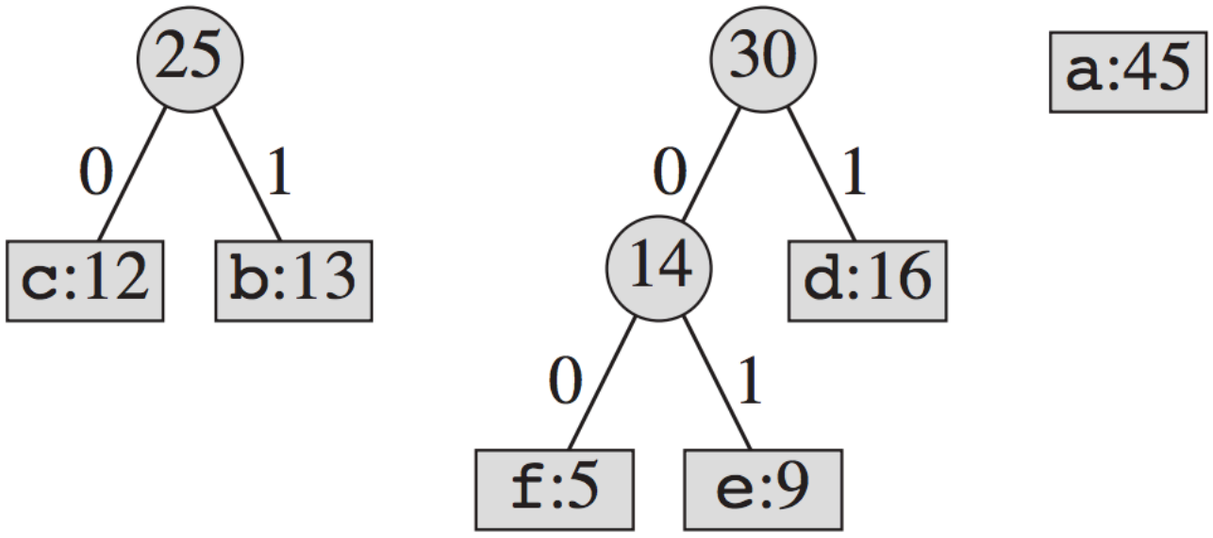


Smallest two: 25, 30




25
0
1
c:12
b:13
30
0
1
14
d:16
0
1
f:5
e:9
a:45

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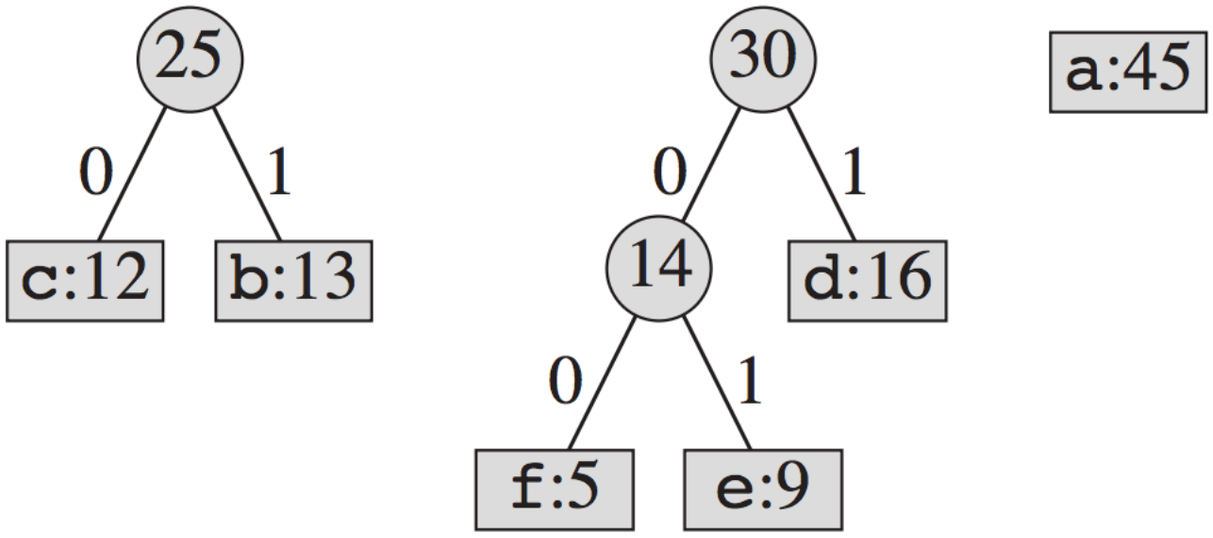

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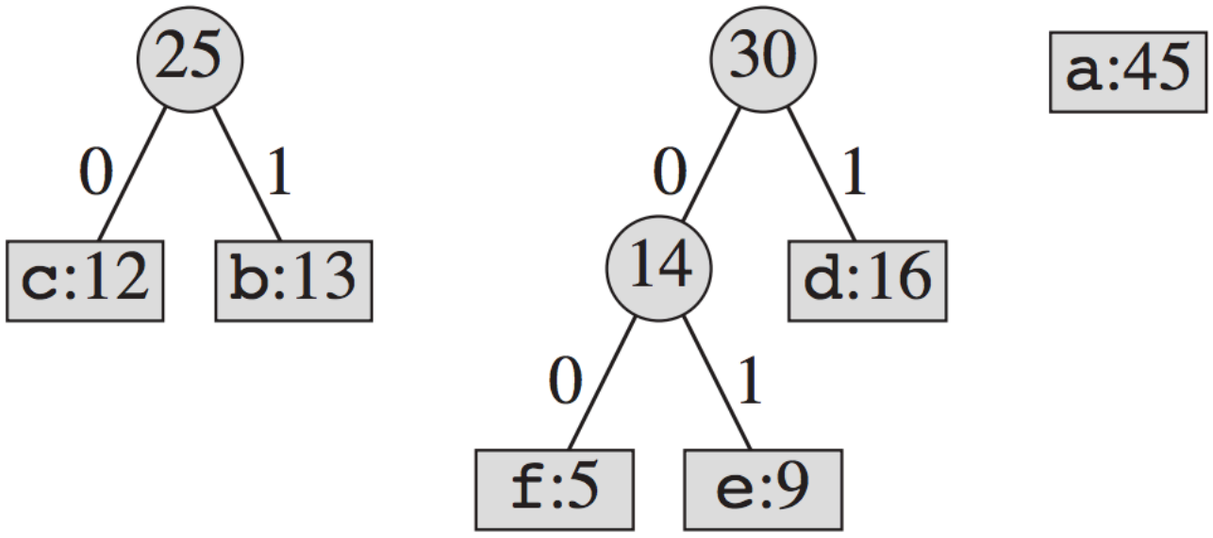
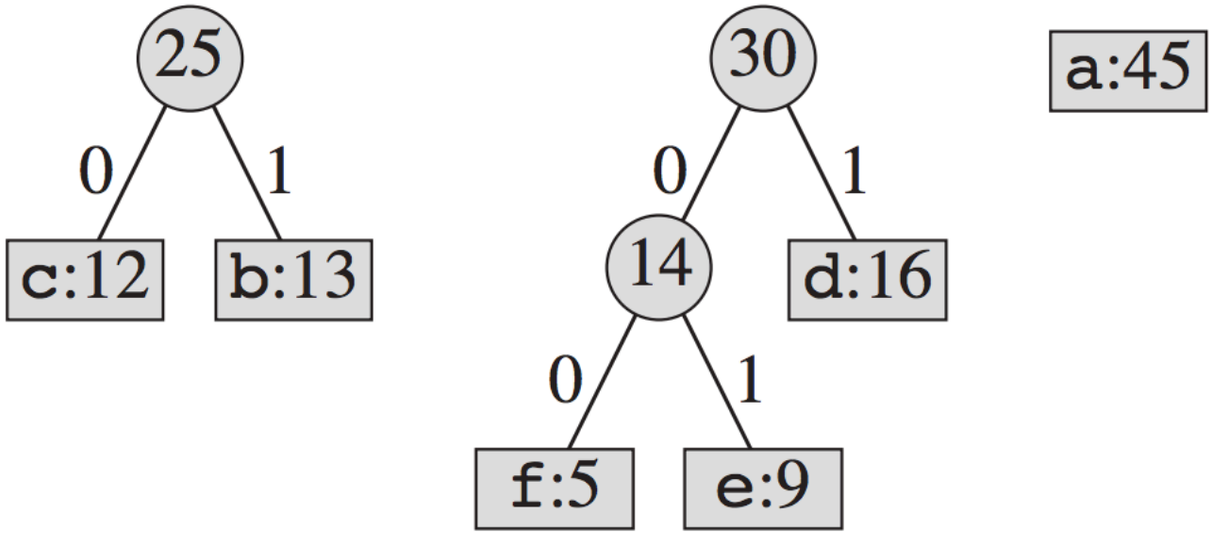


Huffman Tree:

Smallest two: 25, 30



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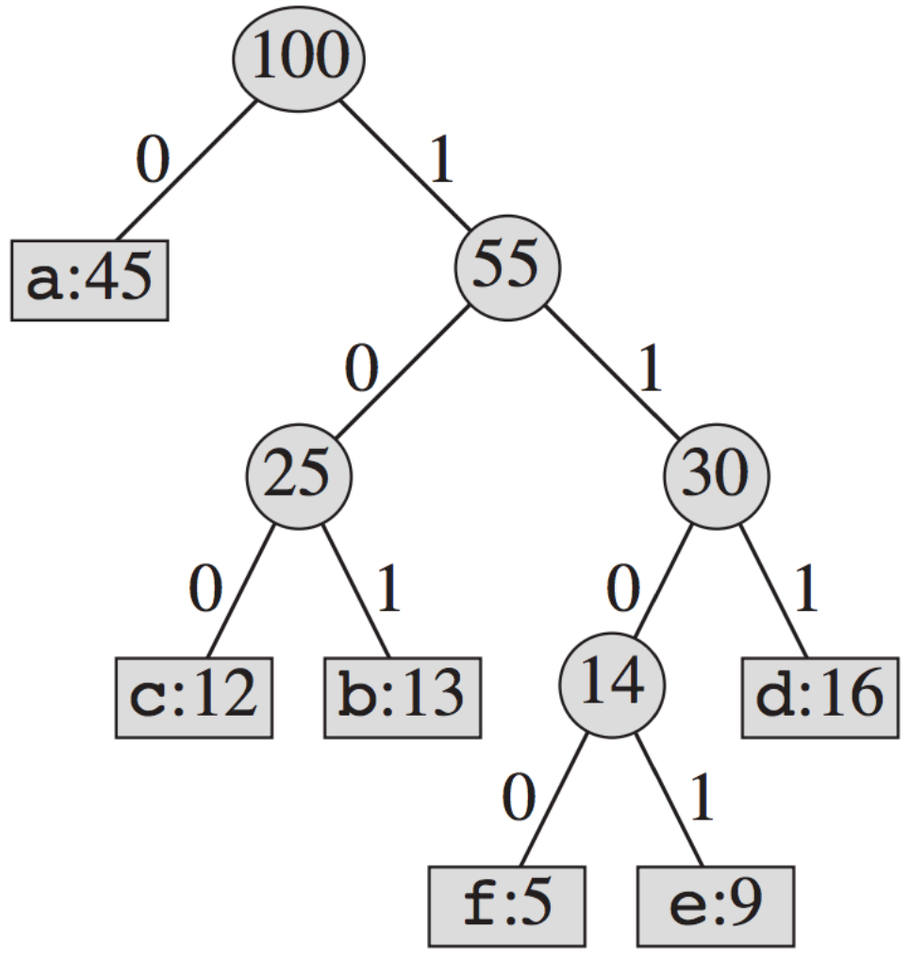

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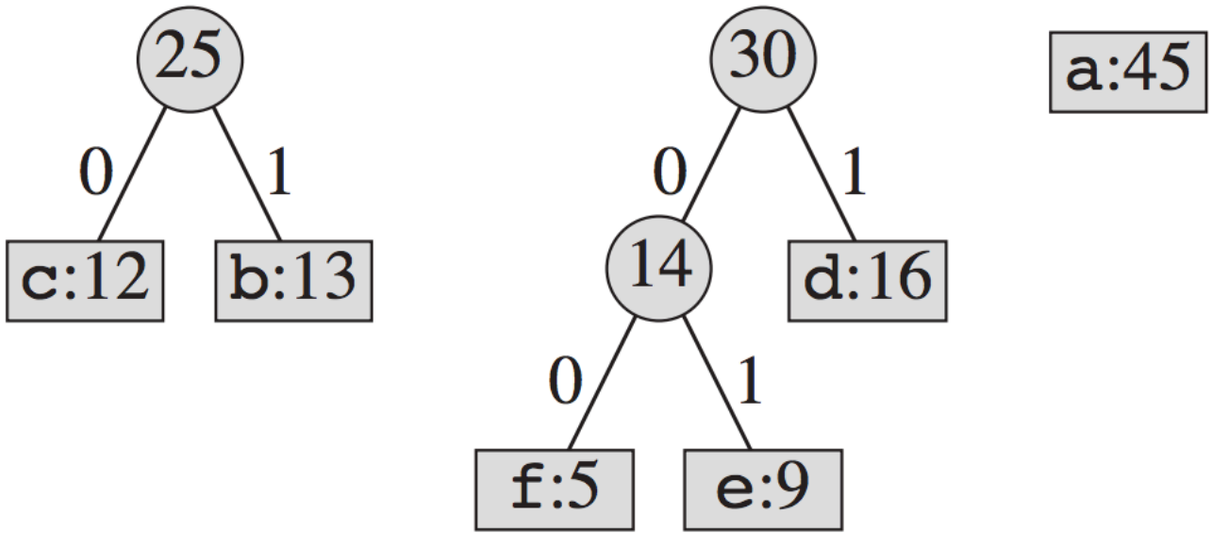

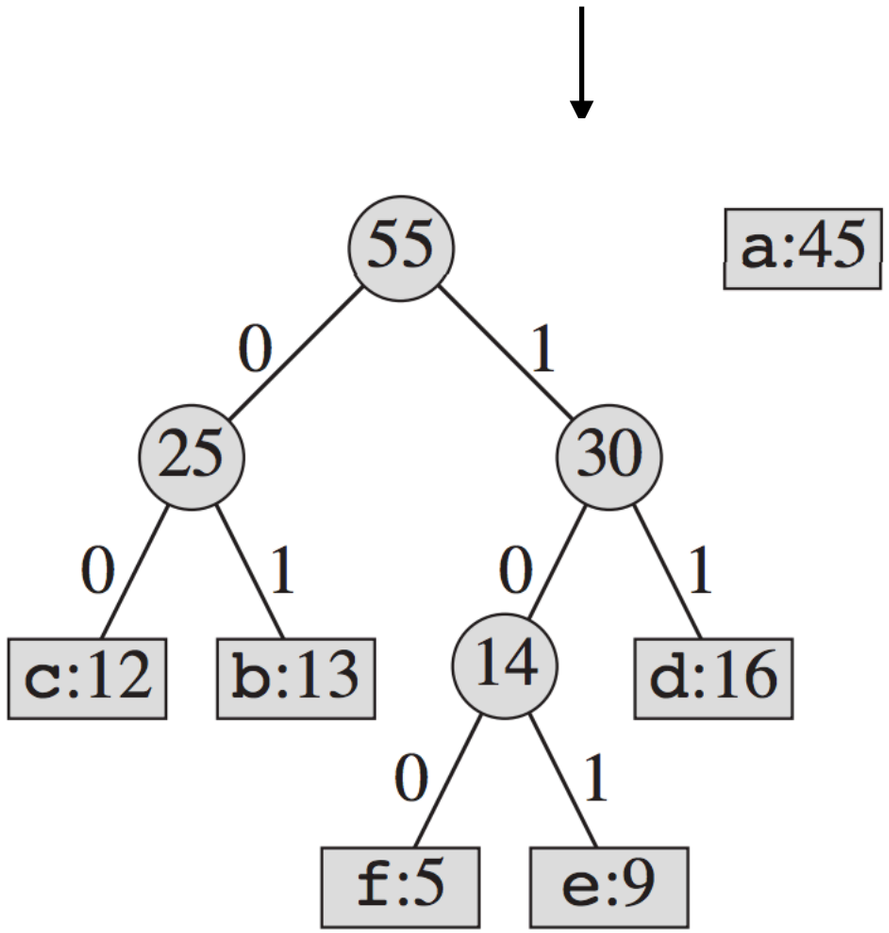

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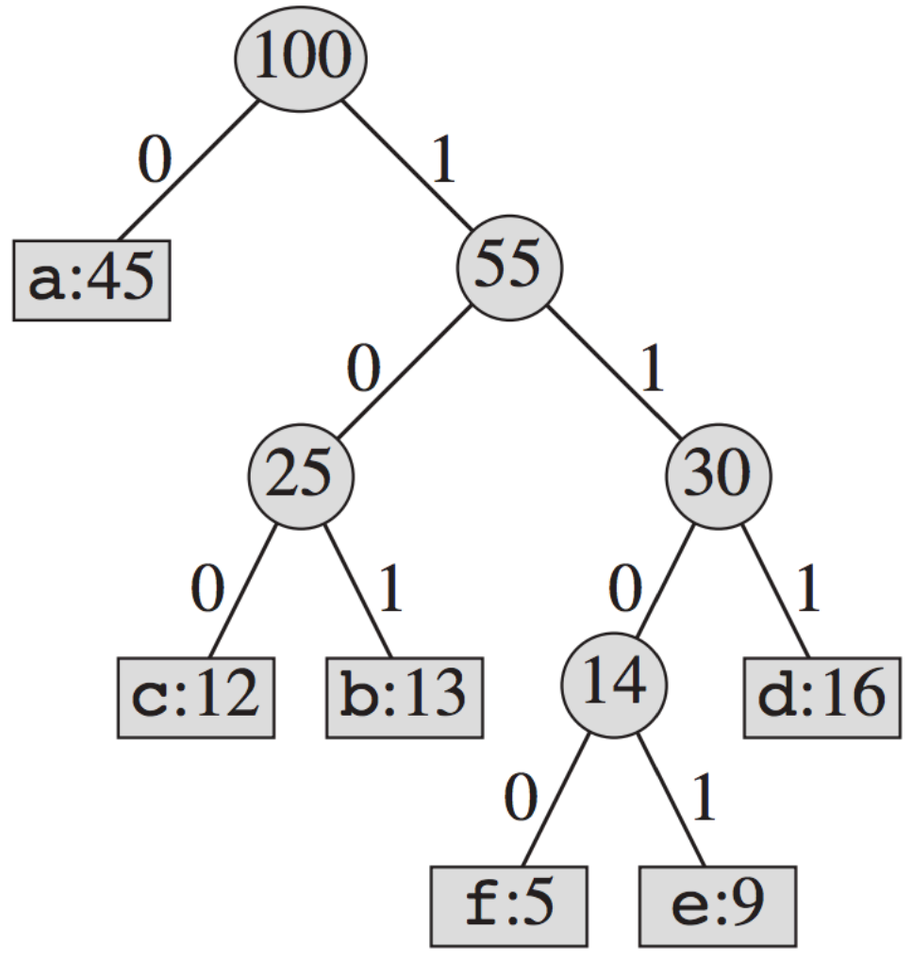

Coding Huffman Coding