61A Extra Lecture 4

Thursday, February 19

01000101011011100110001101101111011001000110100101101110011001111

(Encoding)

What’s the point?

- Why do we encode things?
  - You don’t speak binary
  - Computers don’t speak English

http://pixshark.com/confused-face-clip-art.htm

A First Attempt

- Let’s use an encoding

Letter	Binary	Letter	Binary
a	0	n	1
b	1	o	0
c	0	p	1
d	1	q	1
e	1	r	0
f	0	s	1
g	0	t	0
h	1	u	0
i	1	v	1
j	1	w	1
k	0	x	1
l	1	y	0
m	1	z	0

Analysis

Pros

- Encoding was easy
- Took a very small amount of space

Cons

- Decoding it was impossible

Decoding

- Encoding by itself is **useless**
- **Decoding** is also necessary
- So… we need more bits
- How many bits do we need?
  - lowercase alphabet
  - 5 bits

A Second Attempt

- Let’s try another encoding

Letter	Binary	Letter	Binary
a	00000	n	01101
b	00001	o	01110
c	00010	p	01111
d	00011	q	10000
e	00100	r	10001
f	00101	s	10010
g	00110	t	10011
h	00111	u	10100
i	01000	v	10101
j	01001	w	10110
k	01010	x	10111
l	01011	y	11000
m	01100	z	11001

Analysis

Pros

- Encoding was easy
- Decoding was possible

Cons

- Takes more space…

- What restriction did we place that’s unnecessary?
  - Fixed length

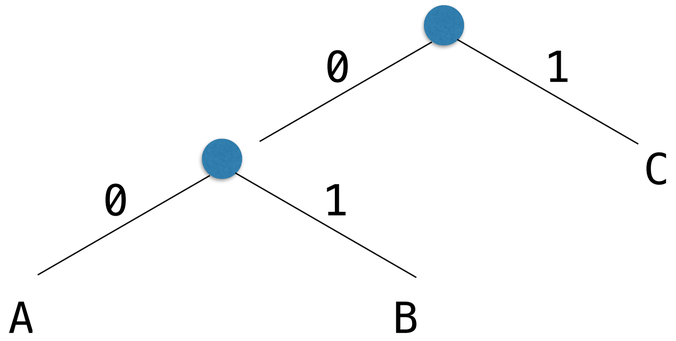
Variable Length Encoding

- Problems?
  - When do we start and stop?
    - String of As and Bs: ABA
    - A – 00, B – 0
    - Encode ABA: 00000
    - Decode 00000:
      - ABA, AAB, BAA?
  - What lengths do we use?

A Second Look at Fixed Length

Letter	Binary	Letter	Binary
a	00000	n	01101
b	00001	o	01110
c	00010	p	01111
d	00011	q	10000
e	00100	r	10001
f	00101	s	10010
g	00110	t	10011
h	00111	u	10100
i	01000	v	10101
j	01001	w	10110
k	01010	x	10111
l	01011	y	11000
m	01100	z	11001

Trees!



Letter	Binary
A	00
B	01
C	1

What happens when…?

- Rule 1: Each leaf only has 1 label

Letter	Binary	Letter	Binary
a	0	n	1
b	1	o	0
c	0	p	1
d	1	q	1
e	1	r	0
f	0	s	1
g	0	t	0
h	1	u	0
i	1	v	1
j	1	w	1
k	0	x	1
l	1	y	0
m	1	z	0

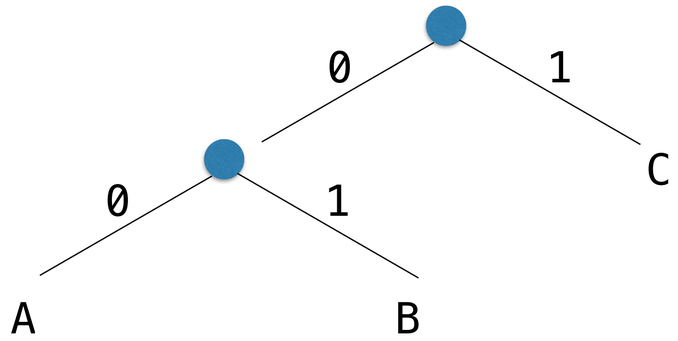
What happens when…?

- Rule 2: Only leaves get labels

Letter	Binary
A	00
B	0

An Optimal Encoding

- Start with a tree
- What kinds of things do we want to encode with this?
- What letter do we want to appear the most?
- How about the least?
- This is called a **Huffman Encoding**

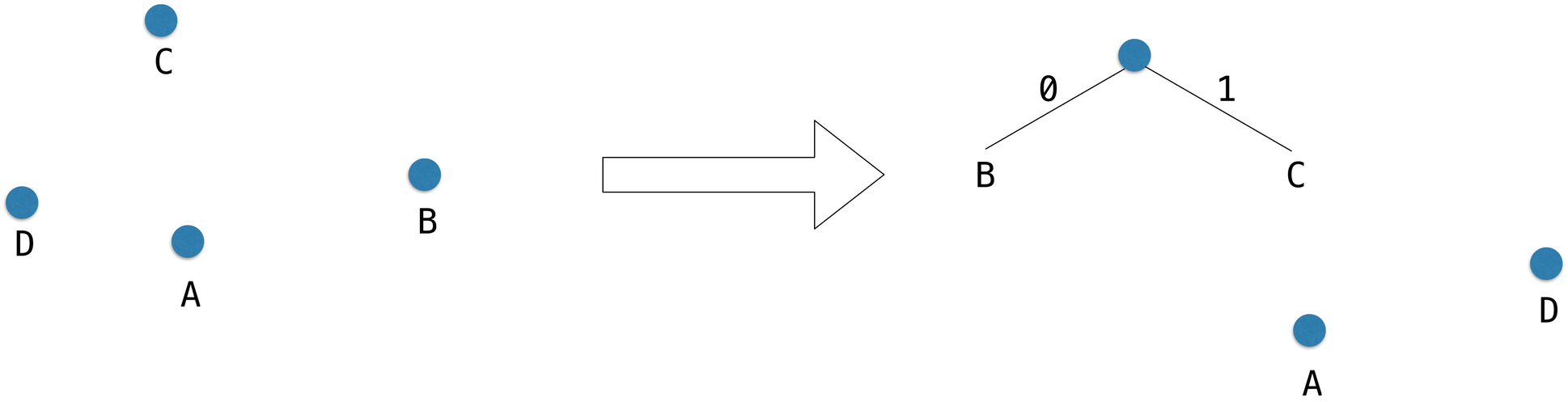


Huffman Encoding

- Let’s pretend we want to come up with the optimal encoding:
  - AAAAAAAAAABBBBBCCCCCCCDDDDDDDDD
  - A appears 10 times
  - B appears 5 times
  - C appears 7 times
  - D appears 9 times

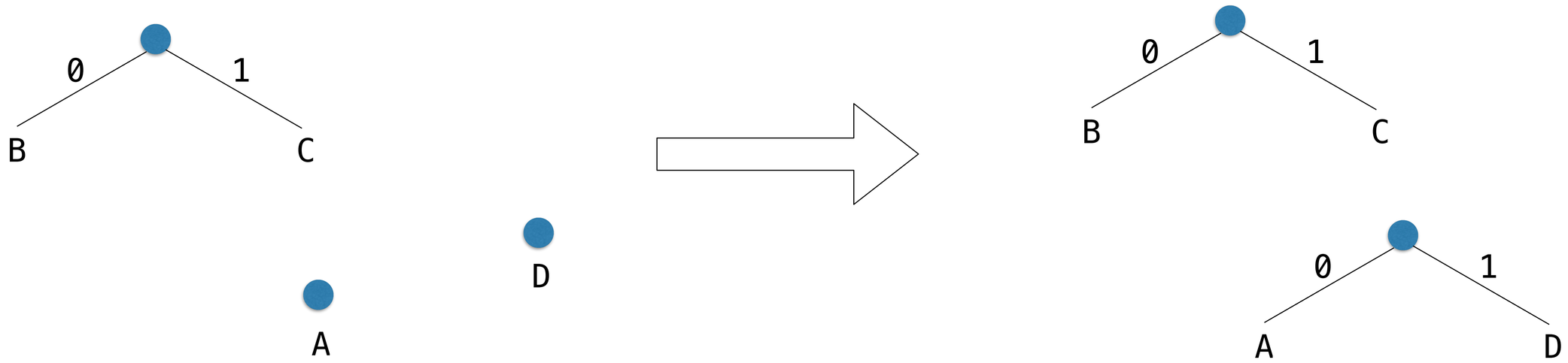
Huffman Encoding

- Start with the two smallest frequencies
  - A appears 10 times, B appears 5 times, C appears 7 times, D appears 9 times



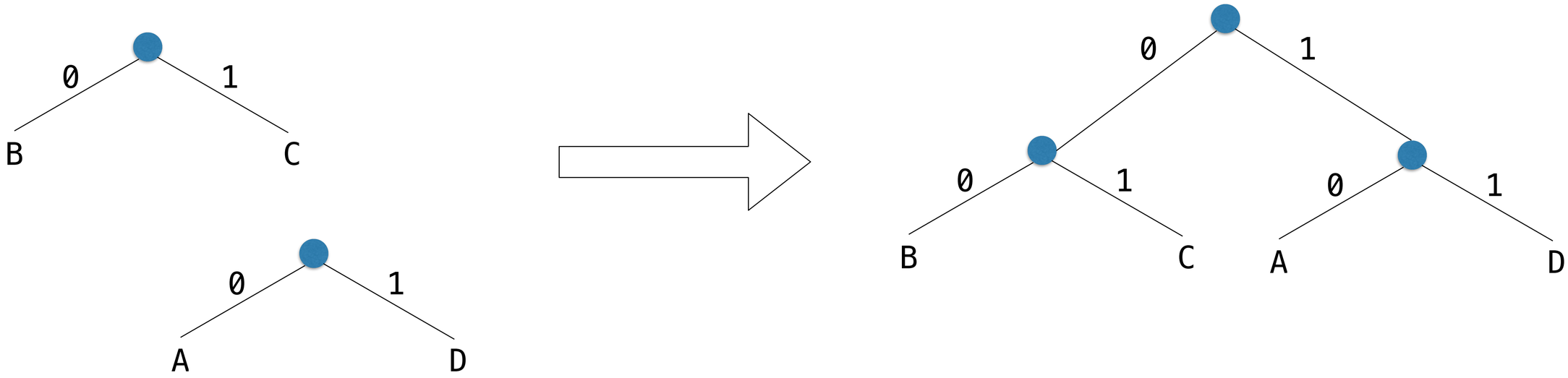
Huffman Encoding

- Continue…
  - A appears 10 times, B & C appear a combined 12 times, D appears 9 times



Huffman Encoding

- And finally…

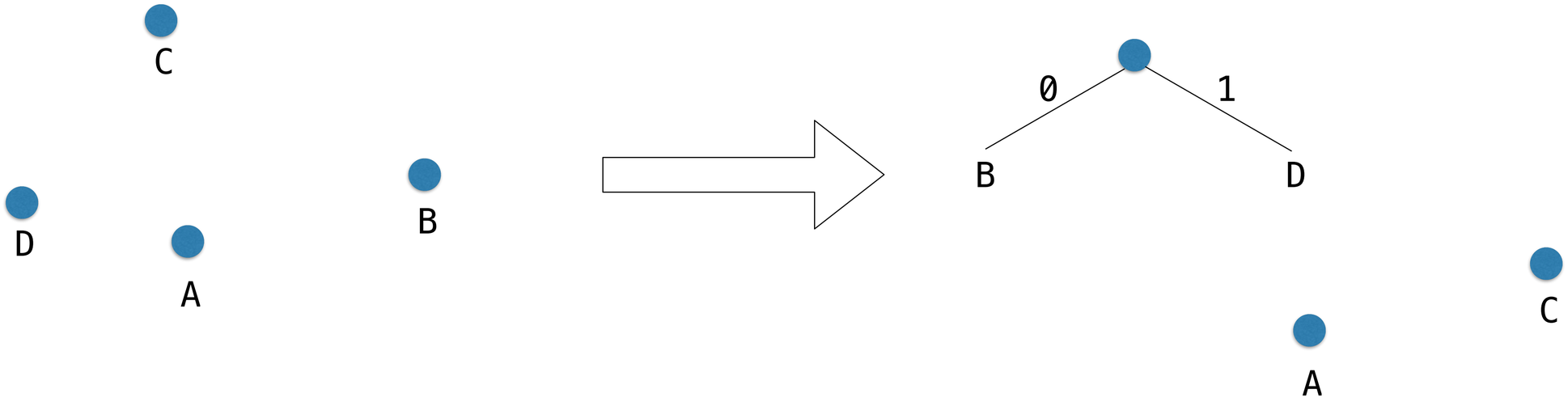


Huffman Encoding

- Another example…
  - AAAAAAAAAABCCD
  - A appears 10 times
  - B appears 1 time
  - C appears 2 times
  - D appears 1 time

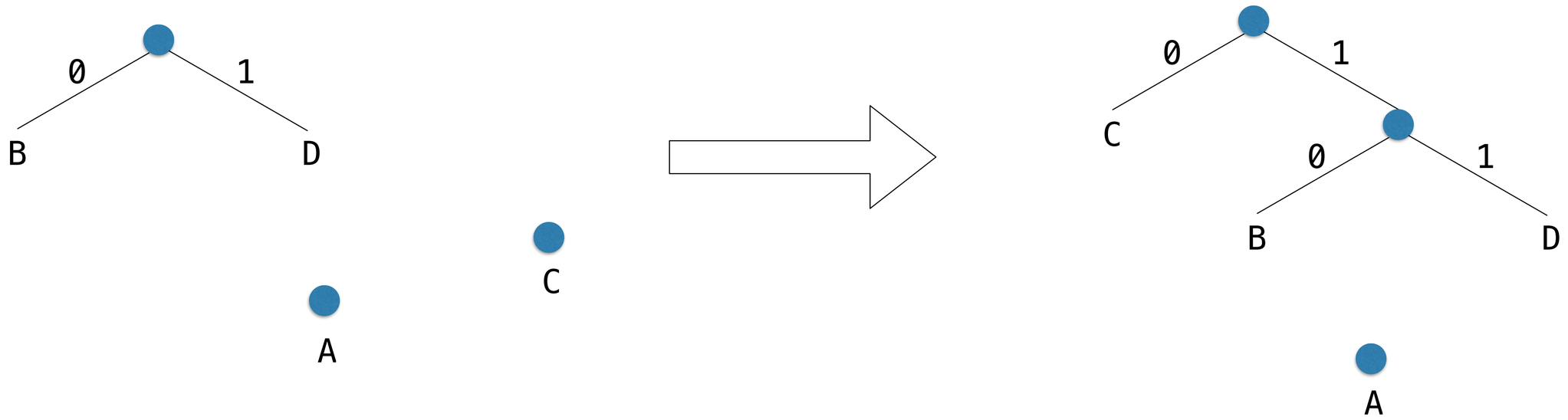
Huffman Encoding

- Start with the two smallest frequencies
  - A appears 10 times, B appears 1 time, C appears 2 times, D appears 1 time



Huffman Encoding

- Start with the two smallest frequencies
  - A appears 10 times, B & D appear a combined 2 times, C appears 2 times



Huffman Encoding

- And finally…