#### DayiddedHuffman

David Huffmar straight st known for the invention of **State** an code, a highly important compression scheme for lossless variable length encoding. It was the result of a term paper he wrote while a graduate student at the Massachusetts Institute of Teehitelete (MIT)...

https://tutorcs.com

From: Wikipedia

#### Huffman, coding algorithm

- 1. Take the two transfer to the alphabeter to th
  - (longest code words, equal length, differing in last digit)

Assignment Project Exam Help

- 2. Combine these two symbols into a single symbol QQ: 749389476
- 3. Repeat https://tutorcs.com

#### Example: Huffman fooding



## 程序X字体的PS编程辅导

S Freq Hu  a 30  b 30  WeChat: cstutorcs  c 20  Assignment Project Exam Help  d 10  Email: tutorcs@163.com				
b 30 WeChat: cstutorcs  c 20 Assignment Project Exam Help  d 10 Email: tutorcs@163.com	S	Freq	Hu	
c 20 Assignment Project Exam Help d 10 Email: tutorcs@163.com	а	30	<ul><li>■ \$2,550</li><li>■ \$2,500</li><li>■ \$2,500</li>&lt;</ul>	រាំ ទ
c 20 Assignment Project Exam Help d 10 Email: tutorcs@163.com	b	30	WeChat	: cstutorcs
d 10 Email: tutorcs@163.com	С	20		
e 10	d	10		
	е	10	Email: t	utores@163.com

QQ: 749389476

https://tutorcs.com



b

<sup>(30)</sup>



(10)



# 程序X字和BPS编程辅导

_		
Freq	Hu : Tulor CS	
30		:វិ ទ
30	WeChat	: cstutorcs
20	Accionn	nent Project Exam Help
10		
10	Email: t	utorcs@163.com
	30 30 20 10	30 WeChat 20 Assignn 10 Email: t

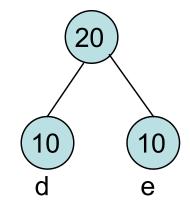
QQ: 749389476

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30





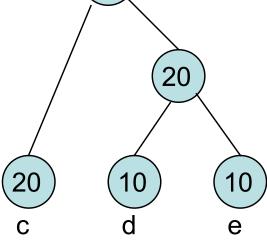
## 程序X字体的PS编程辅导

S	Freq	Hu
а	30	
b	30	WeChat: cstutorcs
С	20	Assignment Project Exam Help
d	10	
е	10	Email: tutorcs@163.com
		<u>00.749</u> 389476

https://tutorcs.com

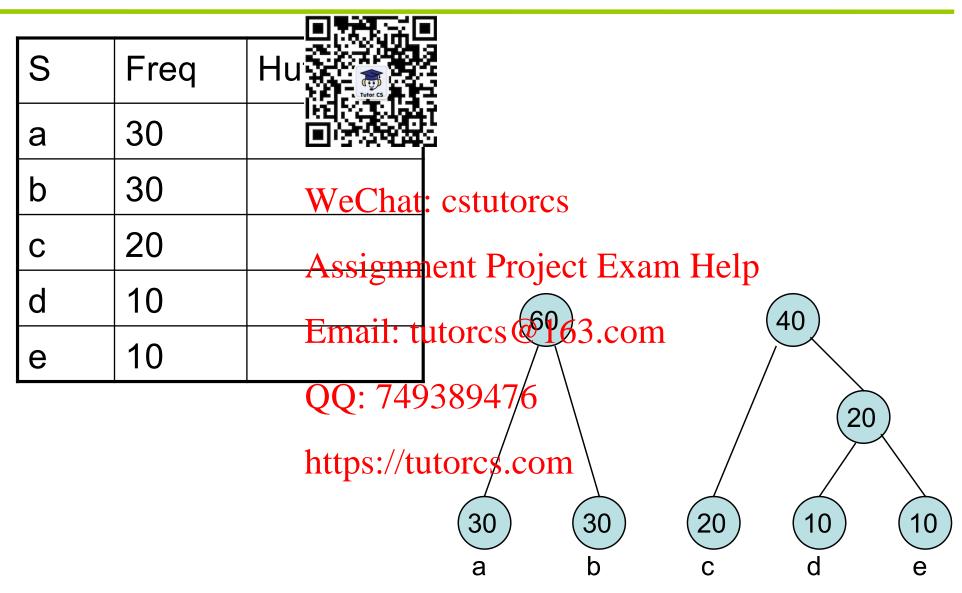




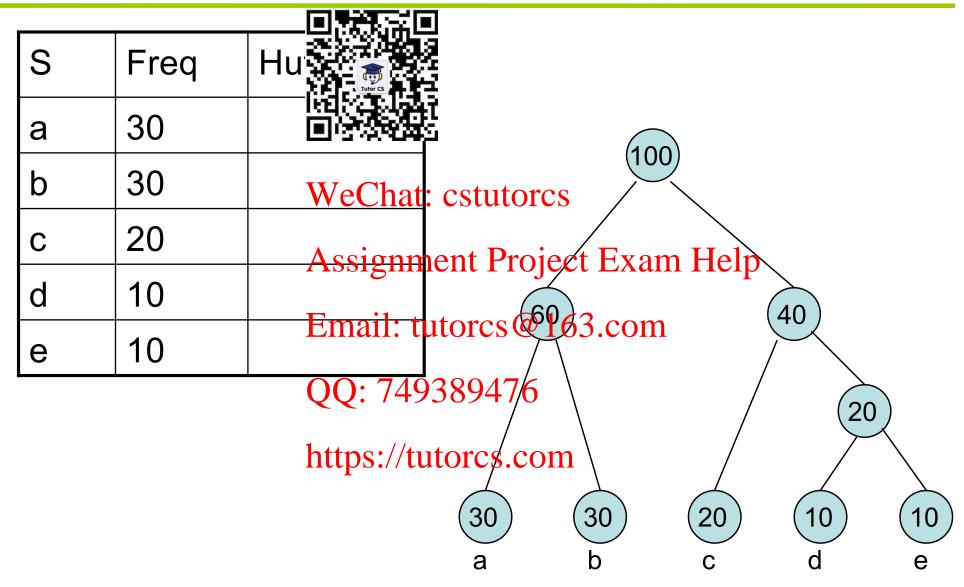


40

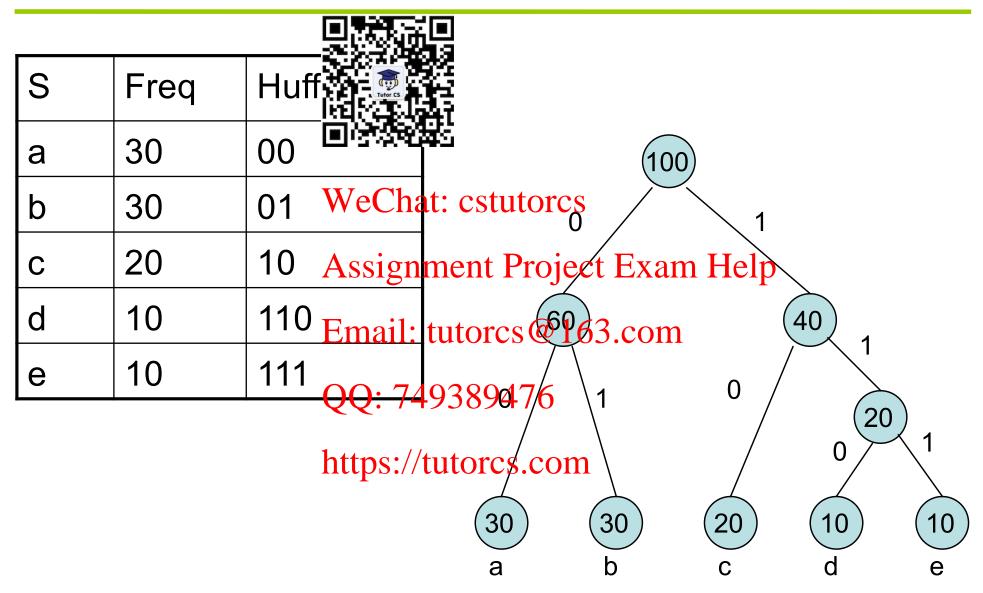
## 程序X字体的S编程辅导



### 程序X多种PS编程辅导



#### 程序XQQQQ5编程辅导



### Average length.

$$= (30*2 + 30*)$$

= 220 / 100



\*2 + 10\*3 + 10\*3 ) / 100

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Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

### Average length !

$$= (30*2 + 30*)$$

= 220 / 100



<u>\*</u>2 + 10\*3 + 10\*3 ) / 100

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Email: tutorcs@163.com

QQ: 749389476
Better than using fixed length 3 bits

## 程序代写代的PS编程辅导

H = 
$$-0.3 * \log 3 * 3 * \log 0.3 + -0.2 * \log 0.2 + -0.1 * \log 3 * 3 * \log 0.1 = -0.3*(-1.737) + -0.3*(-1.737) + -0.2 * (-2.322) + -0.10*(h3t:322) otcs 0.1 * (-3.322)$$

#### Assignment Project Exam Help

```
= 0.3 log 10/3 + 0.3 log 10/3 + 0.2 log 5 + 0.1 log 10 + 0.1 log 10
= 0.3*1.737 \frac{QQ}{0.3} + 0.2*2.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1*3.322 + 0.1
```

#### Anothertexample

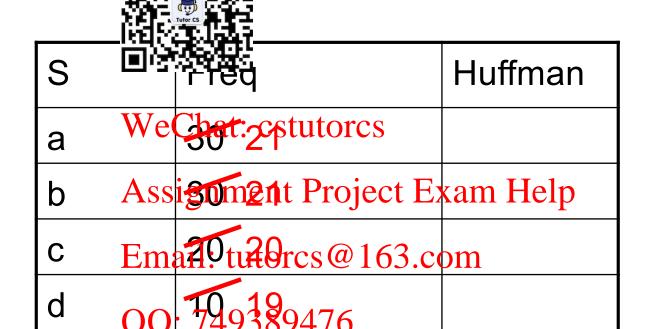
- S={a, b, c, d} wit
- 2, 1, 1}
- $H = 4/8*log_2 + 2P = 29 + 1/8*log_2 +$

#### WeChat: cstutorcs

- H = 1/2 + 1/2 + 3/8 + 3/8 = 1.75 Assignment Project Exam Help
- a => 0  $b => 16 \frac{\text{Email: tutores@163.com}}{\text{c}} = \frac{163 \text{ com}}{\text{c}} = \frac{163 \text{ c$
- Message: {abcda@a749389476110 111 0 10 0 0}

- Average length L = 14 bits / 8 chars = 1.75
- If equal probability, i.e. fixed length, need  $log_24 = 2$  bits

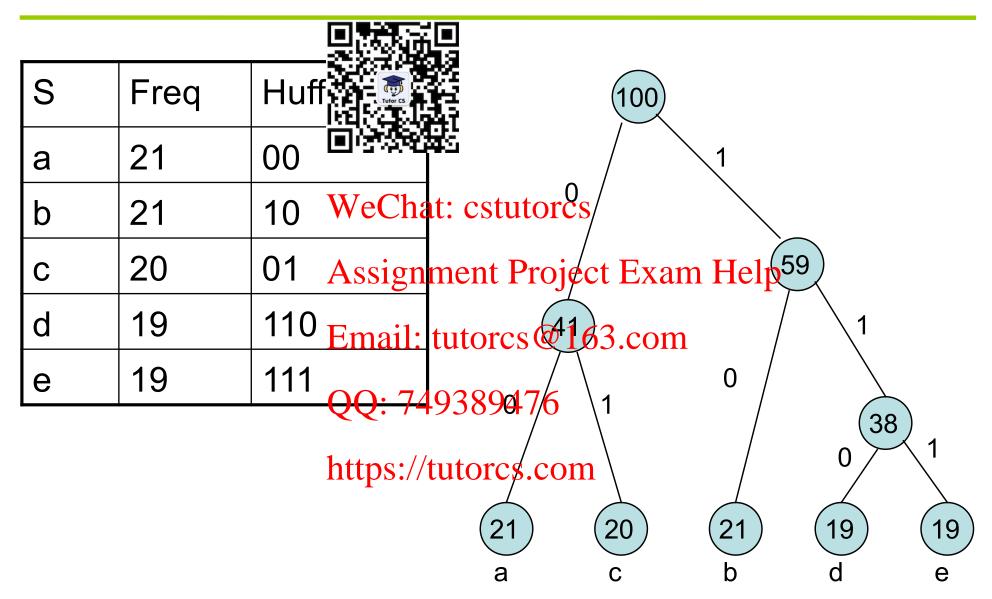
### Huffmand Coaling



Total: 100

е

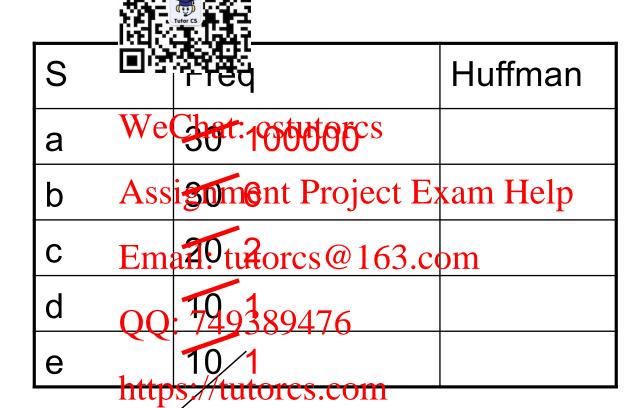
#### Huffmank Cosking



#### Huffmant optimal?

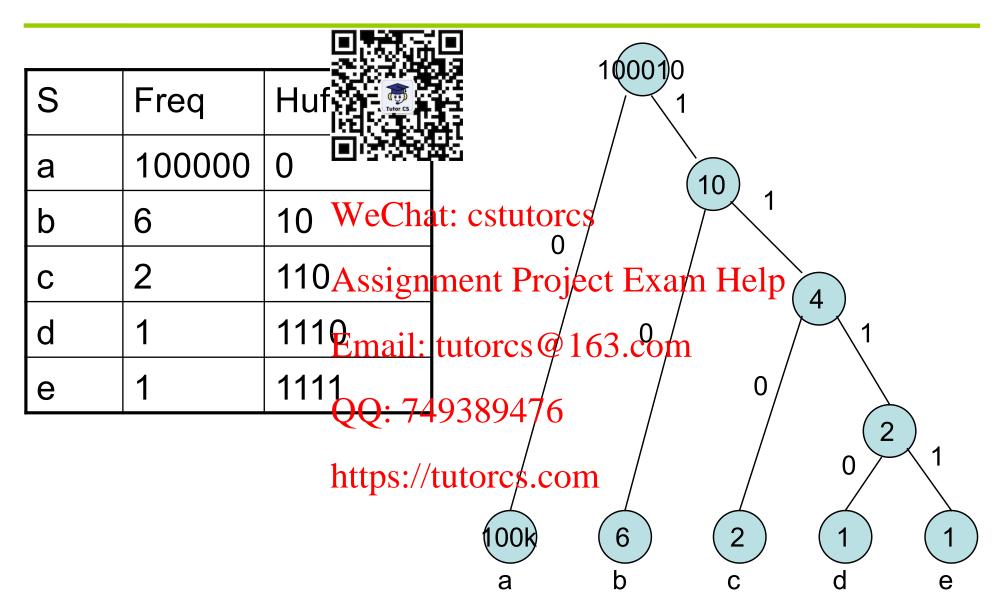
```
H = 0.21 \log 3
                                                                                                                                                                                                + 0.21 log 100/21 + 0.2 log
                                        5 + 0.19 log (100/19)
                                        = 0.21*2.25  + 0.2*2.322 + 0.2*2.322 + 0.2*2.25 + 0.2*2.322 + 0.2*2.25 + 0.2*2.25 + 0.2*2.322 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 + 0.2*2.25 +
                                        0.19*2.396 WOCh9t*2sB96rcs
                                        = 2.32
                                                                                                                                                  Assignment Project Exam Help
                   = (21*2 + 21*2 + 20*2 + 19*3 + 19*3)/100
Email: futores@163 com
                                         = 2.38
                                                                                                                                                   QQ: 749389476
```

### Huffmand Coaling



Total: 100010

#### Huffman Cosking



### Huffmant optimal?

H = 0.9999 lo 1 + 0.00006 log 16668.333 + ... + 1/10(11) 100010 ≈ 0.00

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L = (100000\*1Assign) 100000 1000 Exam Help

≈ 1

Email: tutorcs@163.com

QQ: 749389476

#### Problems of Huffman coding

- Huffman cod
   we an integral # of bits.
  - E.g., log (3) while Huffman may need 2 bits

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• Noticeable non-optimality when prob of a Assignment Project Exam Help symbol is high.

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=> Arithmetic coding

Message to encode:

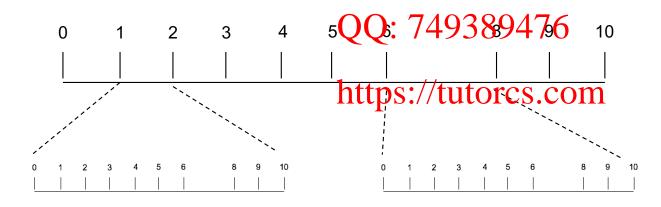
**BILL GATES** 

naracter National Space	Probability  1/10
WeChat: cstutorcs	1/10
Assignment Project Exa	$\frac{1}{10}$ m $\frac{1}{10}$
Email: tutofes@163.com	n 1/10
QQ: 749389476	1/10
QQ. 749303470	2/10
https://tutores.com	1/10
Τ	1/10

Characte	ry bability	Range
SPACE	WeChat: cstutorcs	0.00 - 0.10
A	weChat: cstutores	0.10 - 0.20
В	Assignment Project Ex	kam Help 0.30
E	Email: tutores@163.cd	0.30 - 0.40
G	Eman. tutoles @ 105.co	0.40 - 0.50
I	QQ: 749389476	0.50 - 0.60
L	https://tutorcs.com	0.60 - 0.80
S	1/10	0.80 - 0.90
Τ	1/10	0.90 - 1.00

Character	Probabilit	
SPACE	1/10	Tutor CS
А	1/10	
В	1/10	mi,żi%, <del>artáj</del> 0
E	1/10	0.30 - 0.40
G	1/10	Wechat 5 cstutores
I	1/10	vv <sub>0.50</sub> hat cstatores
L	2/10	0.60 - 0.80
S	1/10	Assignment Project Exam Help
T	1/10	7 15515 IIII 1 10 1000 LAUIT 1101p

Email: tutorcs@163.com



#### Arithmetic coding algorithm

```
Set low to 0.0
Set high to 1.0
While there are still input symbols do
  get an input symbol cstutorcs
  code range = Assignment Project Exam Help
  high = low + range*highs cange (symbol)
  low = low + range*lowsorange(symbol)
End of While
output low or a number within the range
```

New Charac	termina value	High Value
		1.0
В	0.2	0.3
I	WeChat: cstutorcs	0.26
L	Assignment Project Exam	Help <sup>58</sup>
L	0.2572	0.2576
SPACE	Emailotutores@163.com	0.25724
G	00.790257216	0.257220
А	QQ: 749389476 <sub>4</sub>	0.2572168
T	https://tutorcs.com	0.2572168
E	0.257216772	0.257216776
S	0.2572167752	0.2572167756

### 程序X多种PS编程辅导

#### Consider the s



L as new char:

 $code_range = \sqrt{625\%} est \sqrt{0.256} = 0.002$ 

high = 0.256 + Alsign 2eth Projec (E256716elp

QQ: 749389476

#### Deceding algarithm

get encoded nur



find symbol whose range straddles the encoded number WeChat: cstutorcs

output the symboundent Project Exam Help

range = symbol high value resymbol low value subtract symbol low value from encoded number divide encoded number by range until no more symbols

Encoded Number	Symbol	Low	High	Range
0.2572167752		0.2	0.3	0.1
0.572167752	I	0.5	0.6	0.1
0.72167752	WeChat cstutores	0.6	0.8	0.2
0.6083876	Assignment Project	Exam I	Help 8	0.2
0.041938	SPACE	0.0	0.1	0.1
0.41938	Email: tutorcs@163	.com	0.5	0.1
0.1938	00. 740290476	0.2	0.3	0.1
0.938	QQ: 749389476	0.9	1.0	0.1
0.38	https://tutorcs.com	0.3	0.4	0.1
0.8	S	0.8	0.9	0.1
0.0				

### 程序X字(做PS编程辅导

At the first Line number is 0.72167752. output the first Line 1.

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range = 0.8 - 0.6 = 0.2Assignment Project Exam Help

encoded number = (0.72167752 - 0.6) / 0.2 = 0.6083876

# Advantage of arithmetic coding

Assume: A	4 90% END 1					
To encode	To encode: AAAAAAA					
	New Char	acter Low value	High Value			
		WeChat: cstutorcs	1.0			
	А	Assignment Project Exam 1	<b>Help.</b> 9			
	А	0.0	0.81			
	А	Email: tutores@163.com	0.729			
	А	QQ: 749389476	0.6561			
	А	0.0	0.59049			
	А	https://tutores.com	0.531441			
	А	0.0	0.4782969			
	END	0.43046721	0.4782969			

## Advantage of arithmetic coding

Assume: A 90% END 1						
To encode: AAAAAAA	To encode: AAAAAAA					
New Char	Tacter Low value	High Value				
	WeChat: cstutorcs	1.0				
A	Assignment Project Exam	Help 9				
A	Email: tutorcs@163.com	0.81				
A	Email: tutores@163.com	0.729				
A	QQ: 749389476	0.6561				
A	0.0	0.59049				
A	https://tutores.com	0.531441				
A	0.0	0.4782969				
END	0.43046721	0.4782969				

e.g., 0.45

### Patentsion编程编号

- Bzip2 and e Huffman as AC protected below ints
- PackJPG using ACtshows 25% of size saving

Assignment Project Exam Help

Email: tutorcs@163.com

QQ: 749389476

### Some A Capatents (expiring)

```
U.S. Patent 4,122,440 — (IB arch 77, Granted 24 October 78 (Now expired)
<u>U.S. Patent 4,286,256</u> — (IB 11 25 August 81 (Now expired) 
<u>U.S. Patent 4,467,317</u> — (IB 11 21 August 84 (Now expired)
U.S. Patent 4,652,856 — (IBM) Granted 4 February 86 (Now expired)
U.S. Patent 4,891,643 — (IBM) Electratics September 86, granted 2 January 90 (Now
     expired)
U.S. Patent 4,905,297 — (IBM) SSignmonter Project to Latent 7 Feb pary 90 (Now
     expired)
U.S. Patent 4,933,883 — (IBM) Mited 31M4988, Spent 63120 Me 90 (Now expired)
<u>U.S. Patent 4,935,882</u> — (IBM) Filed 20 July 88, granted 19 June 90 (Now expired)
U.S. Patent 4,989,000 — Filed 19 June 89, granted 29 January 91 (Now expired)
U.S. Patent 5,099,440 — (IBM) Filed 5 January 90 granted 24 March 92 (Now expired)
U.S. Patent 5,272,478 — (Ricoh) Filed 17 August 92, granted 21 December 93 (Now
     expired)
```