Data Compression
Lecture 4

Dr. Mona M.Soliman

Faculty of Computers and Artificial Intelligence

Cairo University

Feb 2020

Adaptive Huffman Coding Algorithm

(Unknown Symbols Probabilities)

Why adaptive Huffman

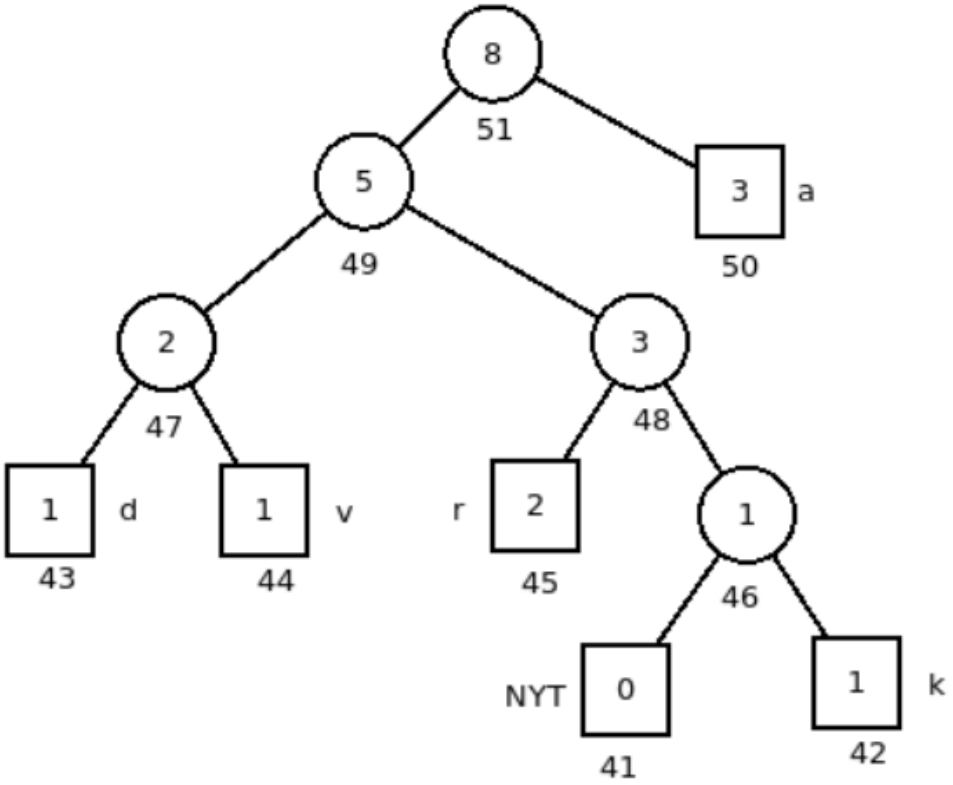
Adaptive coding technique based on Huffman coding. It permits building the code as the symbols are being transmitted, having no initial knowledge of source distribution (e.g. Compressing Real data over internet)

If a file (or block) has different letter frequencies in different regions, then **adaptive huffman can use shorter codes for frequent letters in each of those regions, whereas static huffman can only use the average for the whole file**

The key idea The key idea is to build a Huffman tree that is optimal for the part of the message already seen, and to reorganize it when needed, to maintain its optimality

Adaptive Huffman

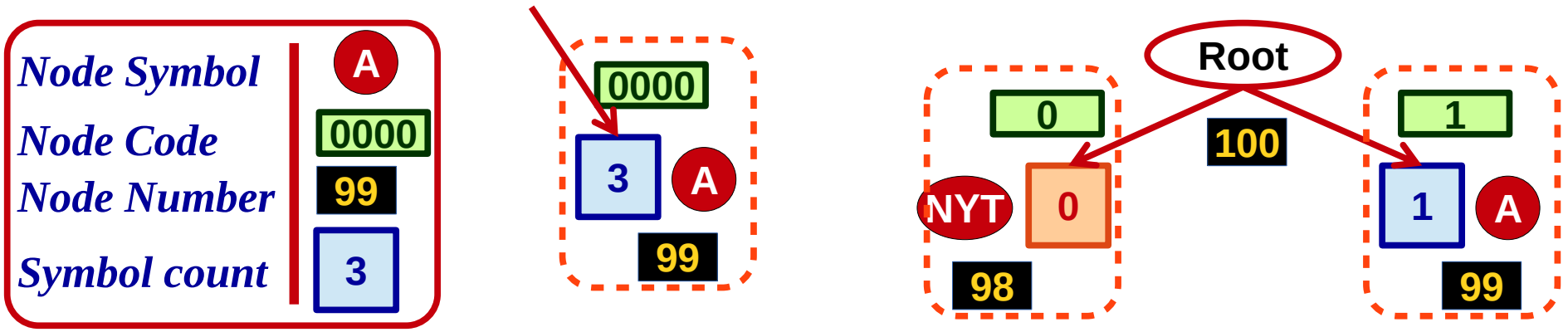
a	d	v	d	d	d	a
00	10	10	0	001	001	01



(aardvark) - swap 43, 46

We create a binary tree with two nodes for each parent

Single Node Structure



Node Symbol: *Each Node is associated with ONE Symbol. Also, Max ONE Node for each symbol*

Node Count: *is the Number of Occurrence of Node Symbol (e.g. Number of Occurrence of "A")*

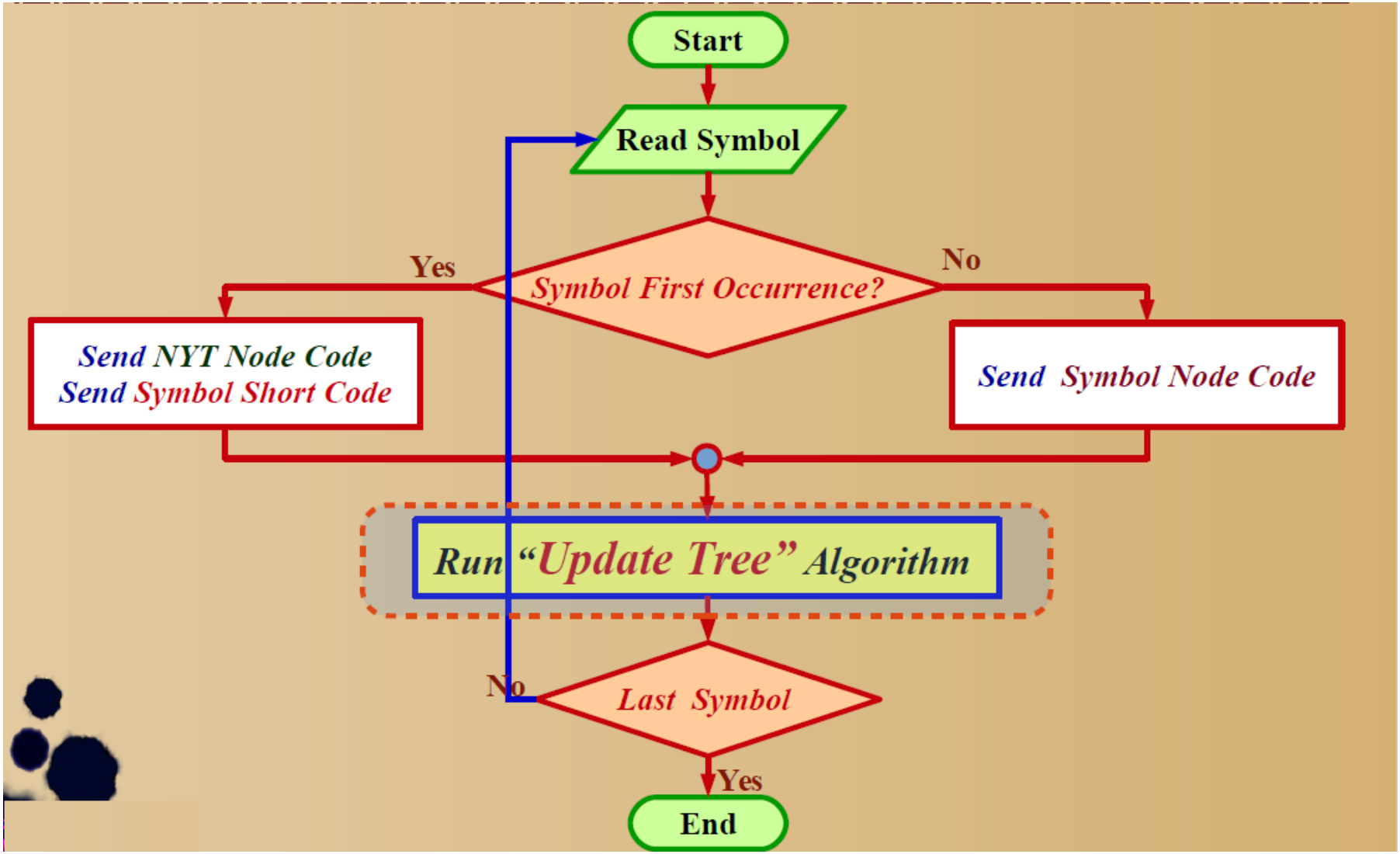
Node Code: *Code Nodes as Binary Tree. Use same Enumeration for*

Compression and Decompression (e.g. Always "0" for Right branch and "1" for left branch)

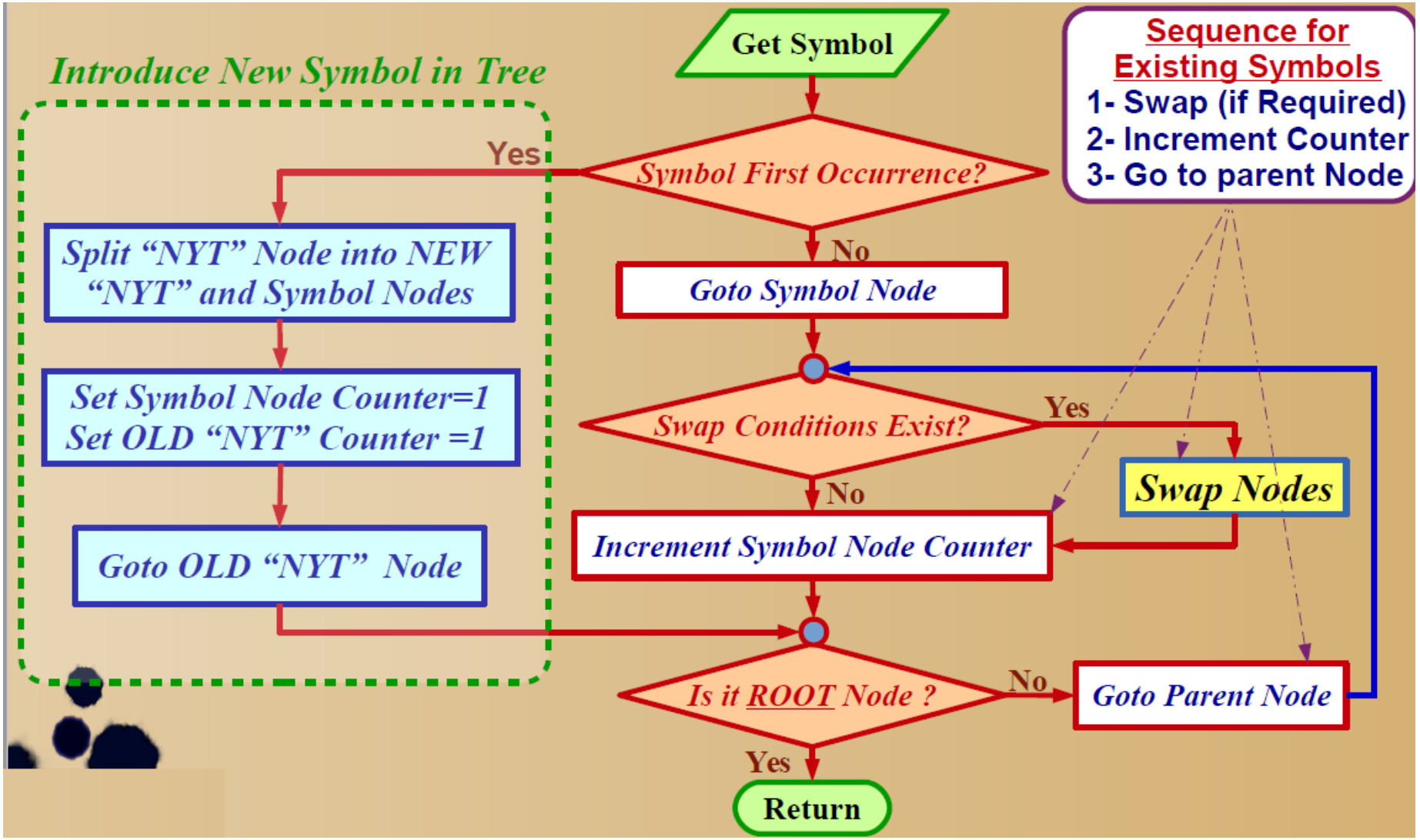
Node Number: *Enumerate Nodes in descending order (starting from Root,*

1st level Right branch, 1st level Left branch , then for 2nd level Right branch ,...etc)

Adaptive Huffman Algorithm



“Update Tree” Algorithm



Swap Conditions

If you are a Node of symbol "X"

You can Swap Node of Symbol "X" with Node of Symbol "Y" if

1- **Node Number** of Symbol "Y" is higher than Node Number of Symbol "X"

2- **Node counter** of Node "X" is higher than or equal to Node Counter of Node "Y"

3- **No Swap with Parent Node**

4- if "X" can Swap with more than one Node, **Swap with Node with higher Node Number**

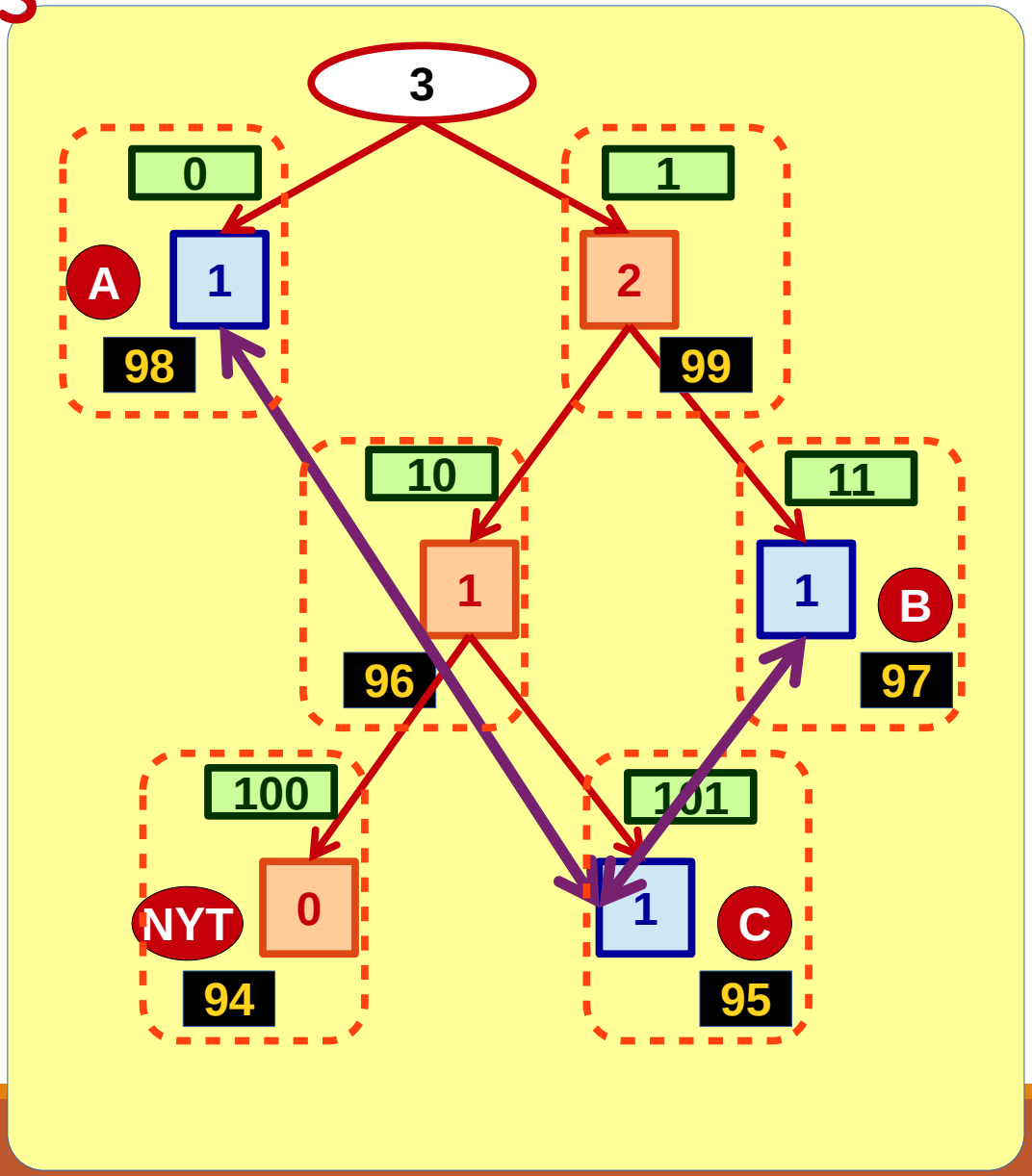
Swap Conditions

Example of Allowed Swaps:

Swap Node 95 with Node 98
Swap Node 95 with Node 97
(if both are applicable, swap with 98)

Example of NOT Allowed Swaps:

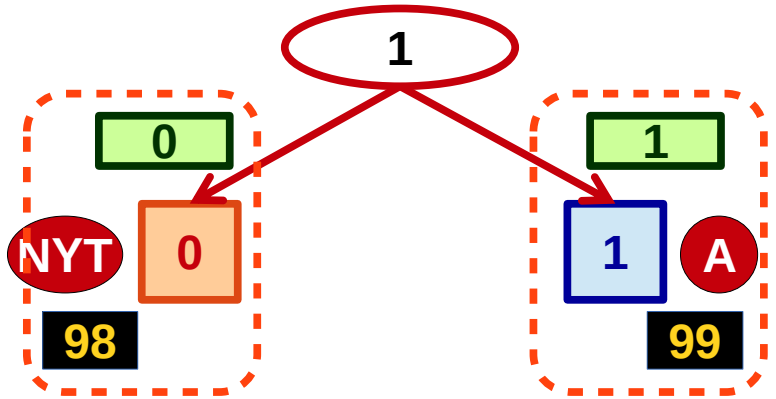
Node 95 with Node 96 **{Parent}**
Node 98 with Node 99 **{Counter}**



Example: Adaptive Huffman Compression

Symbol	"A"													
Code	00													

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Symbol Occurs for first time:

Code ="A" Short Code [00]

Update Tree

Go To Node: Root

Split: Yes

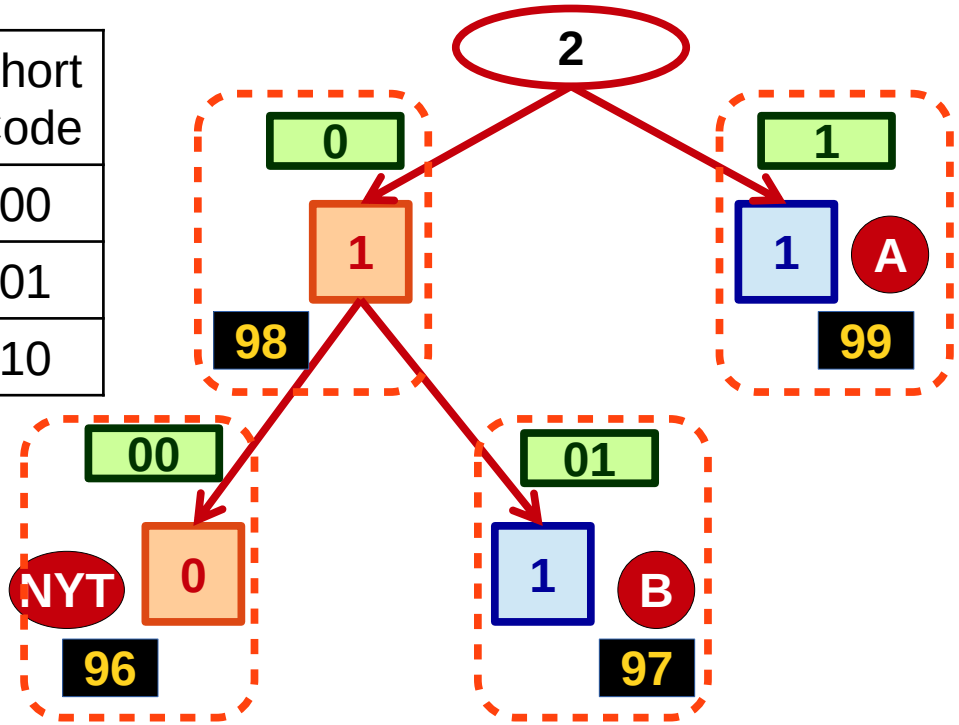
Inc Counter: Node 99,Root

Goto Parent: Root

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"											
Code	00	0	01											

Symbol	Short Code
A	00
B	01
C	10



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Code

Symbol Occurs for first time:

Code = NYT [0],

"B"Short Code [01]

Update Tree

Go To Node: NYT [98]

Split: Yes

Inc Counter: Node 97, 98

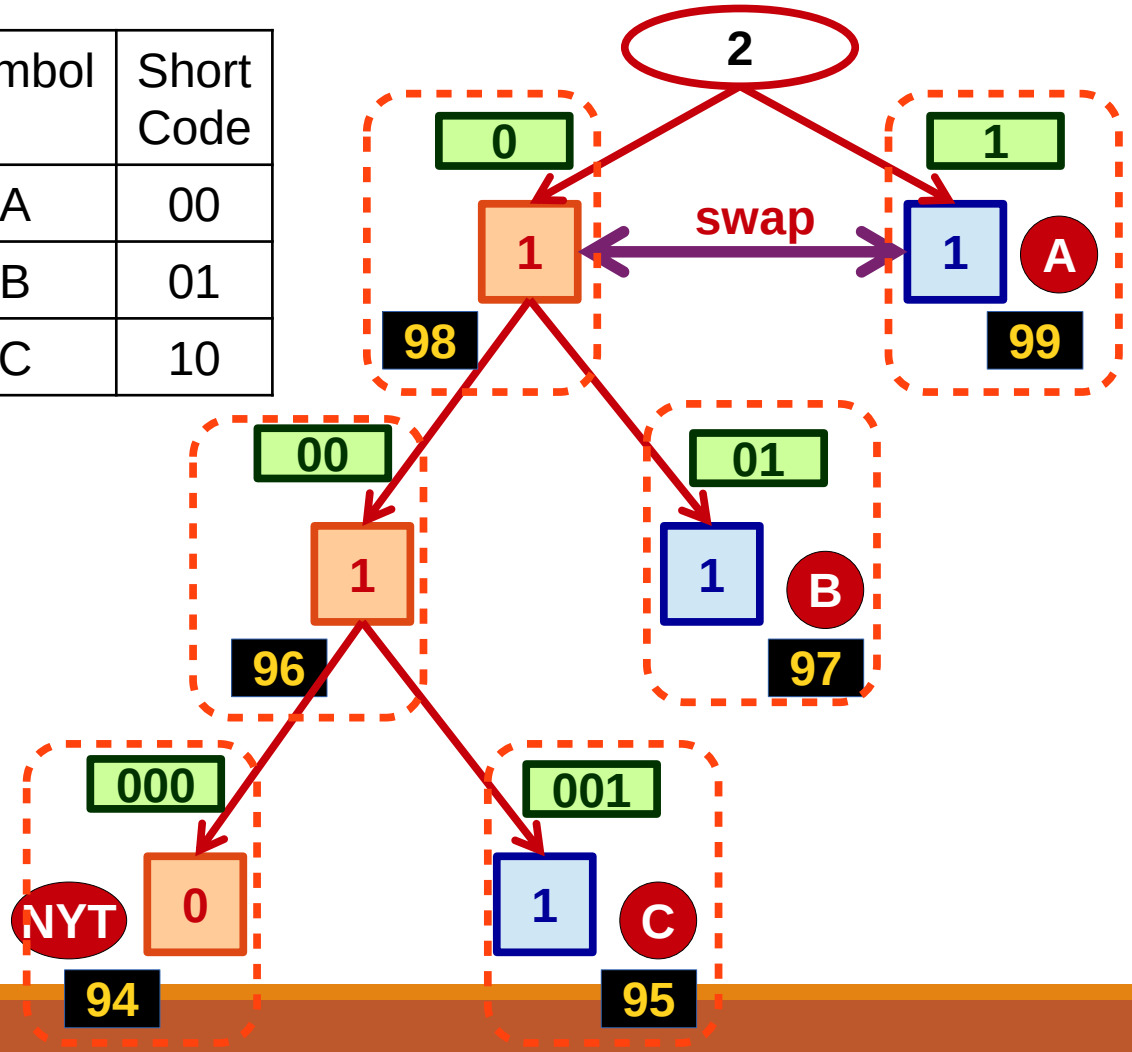
Goto Parent: Root,

Inc {1+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"										
Code	00	0	01	00	10										

Symbol	Short Code
A	00
B	01
C	10



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Code

Symbol Occurs for first time:

Code = NYT [00],

"C" Short Code [10]

Update Tree

Go To Node: NYT [96]

Split: Yes

Inc Counter: Node 95, 96

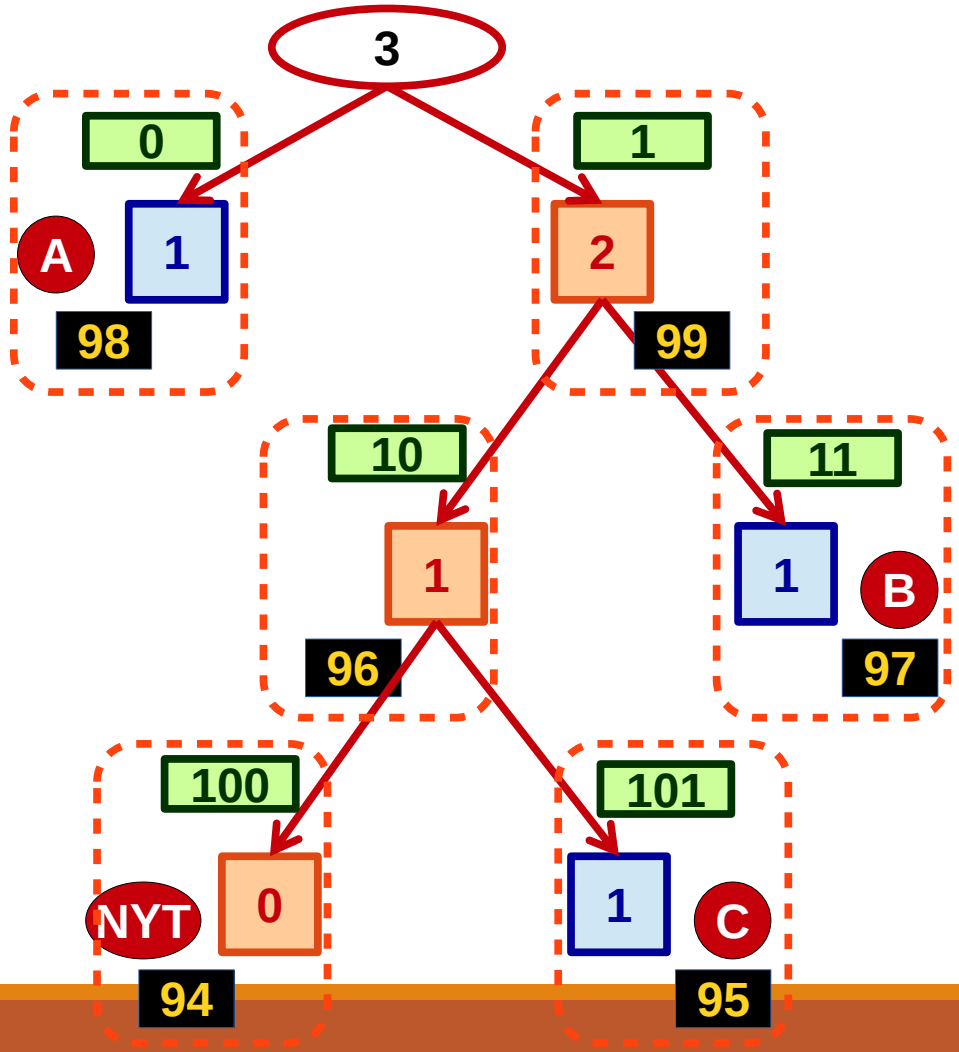
Goto Parent: 98

Need Swap: Yes [98], [99]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"										
Code	00	0	01	00	10										

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [98], [99]

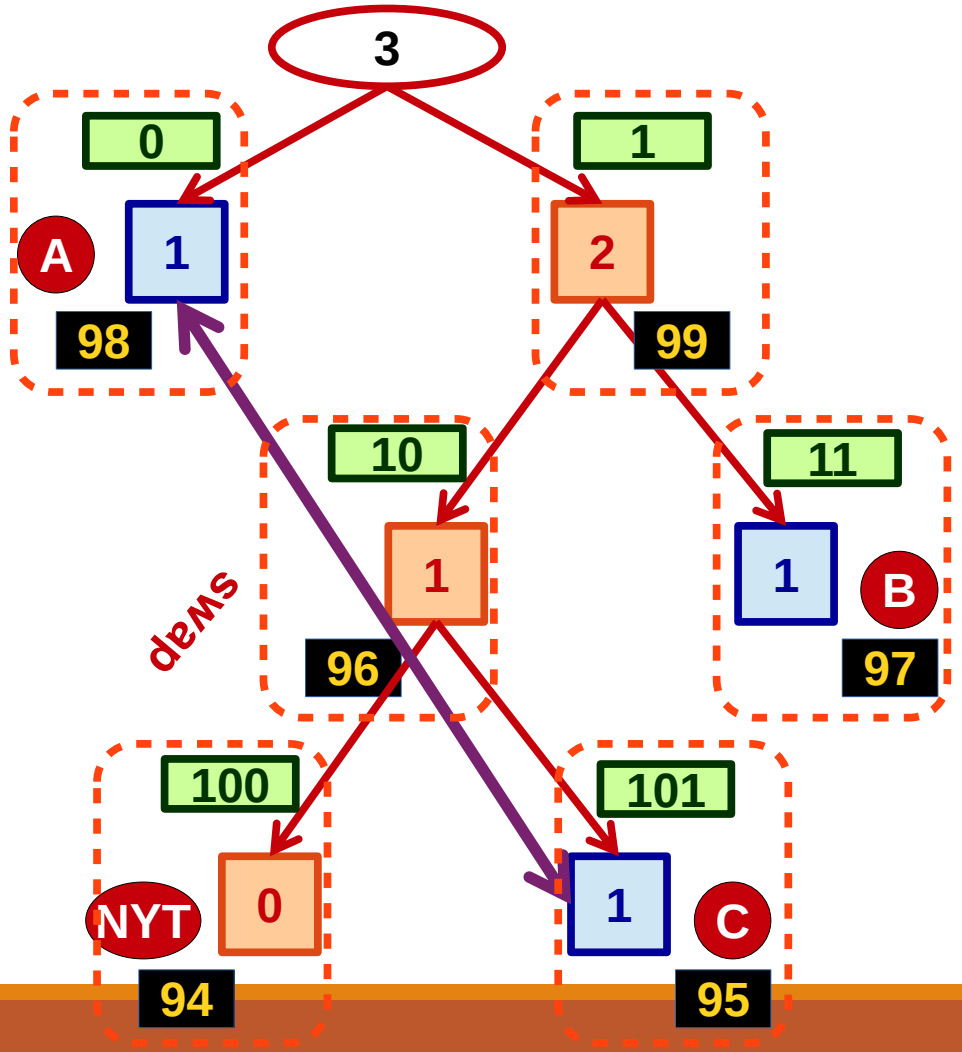
Inc Counter: Node 99 [1+]

Goto Parent: Root,
Inc {2+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"									
Code	00	0	01	00	10	101									

Symbol	Short Code
A	00
B	01
C	10



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Code

Symbol Occurred before:

Node: [95]

Code =[101]

Update Tree

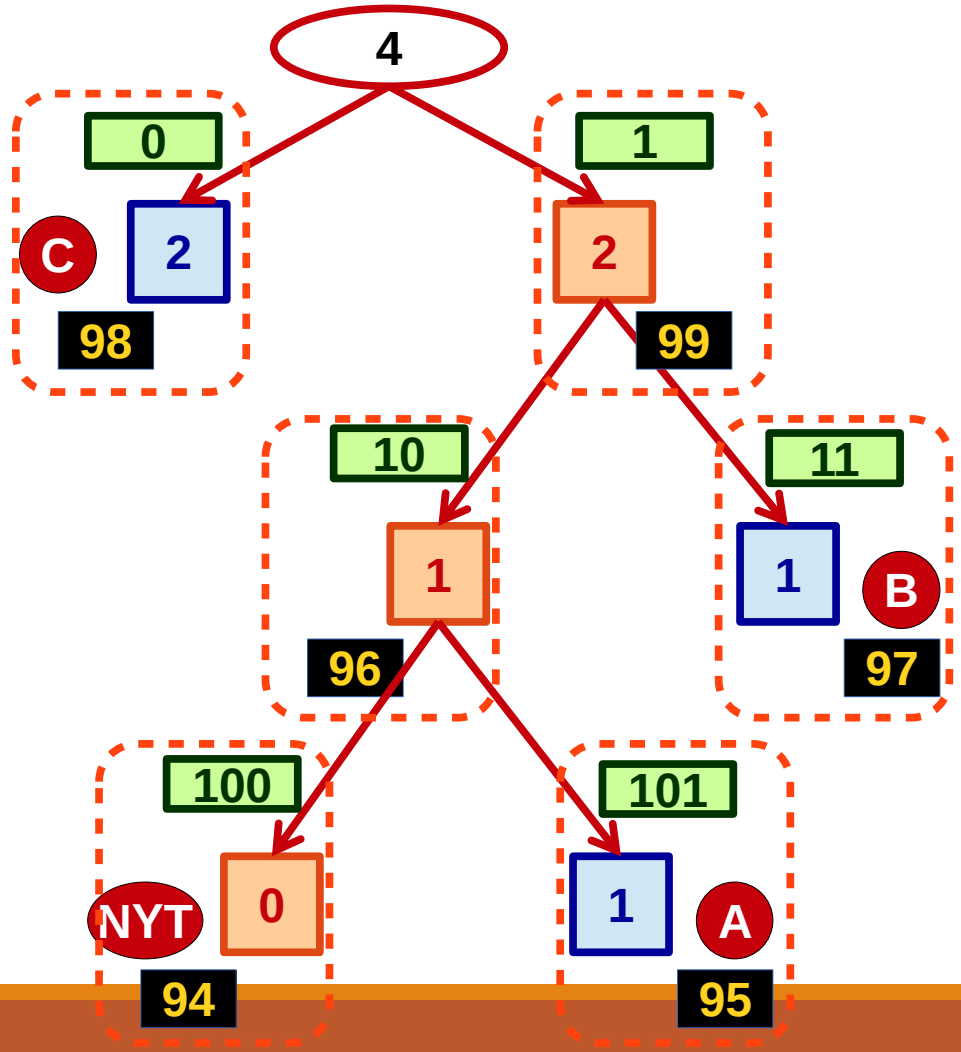
Go To Node: 95

Need Swap: YES [95], [98]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"									
Code	00	0	01	00	10	101									

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [95], [98]

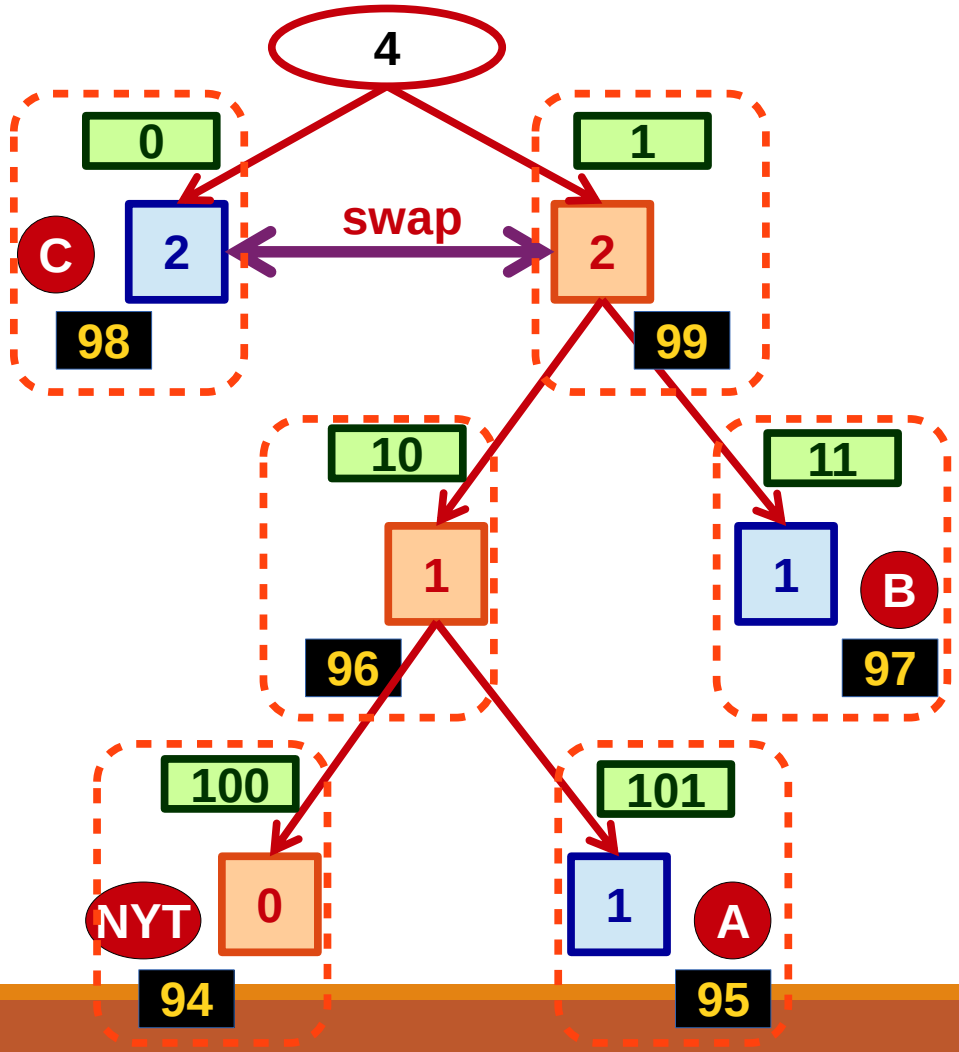
Inc Counter: Node 98 {1+}

Goto Parent: Root,
Inc {3+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"								
Code	00	0	01	00	10	101	0								

Symbol	Short Code
A	00
B	01
C	10



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Code

Symbol Occurred before:

Node: [98]

Code =[0]

Update Tree

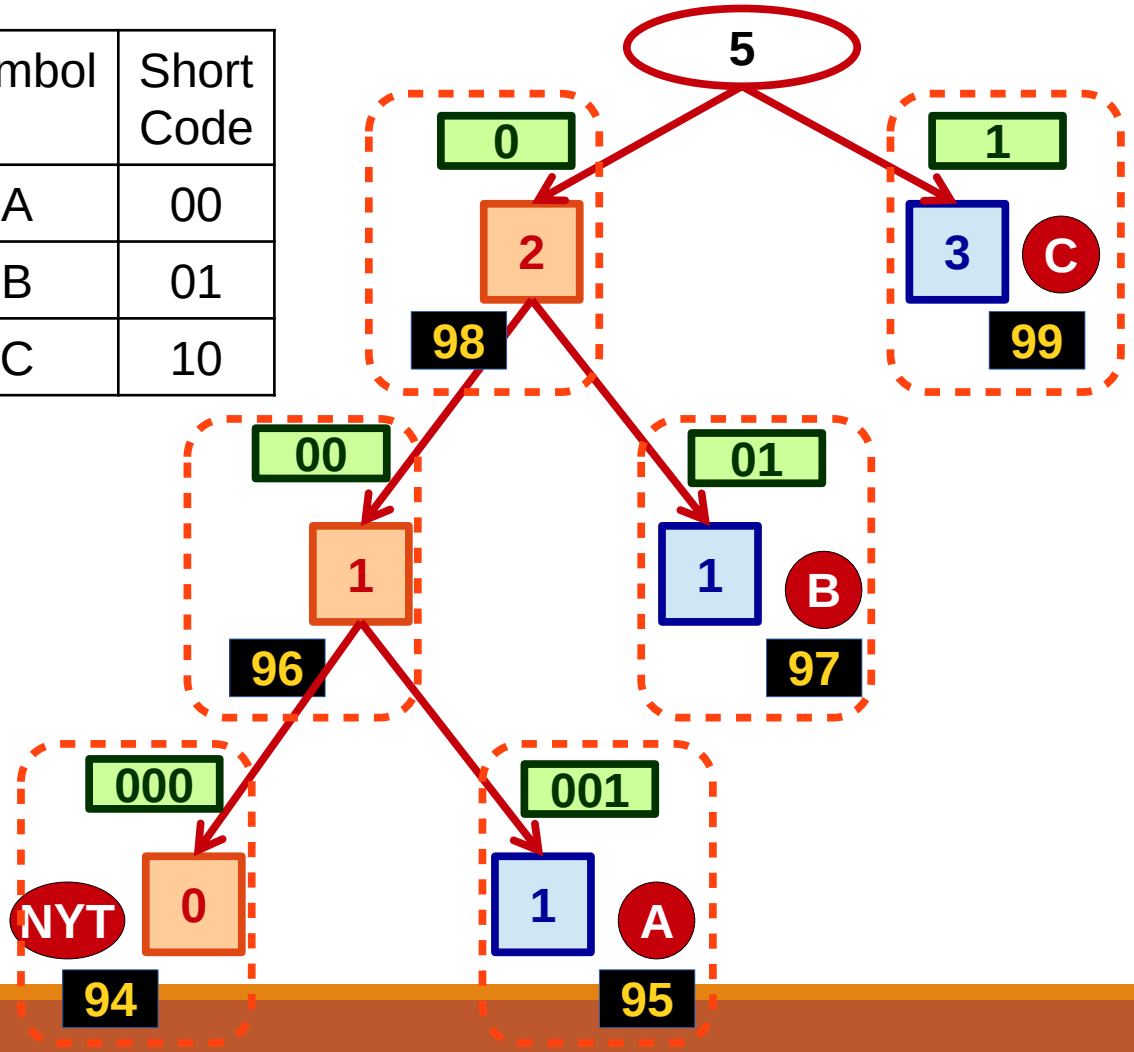
Go To Node: 98

Need Swap: YES [98] , [99]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"								
Code	00	0	01	00	10	101	0								

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [99, [98]

Inc Counter: Node 99 {2+}

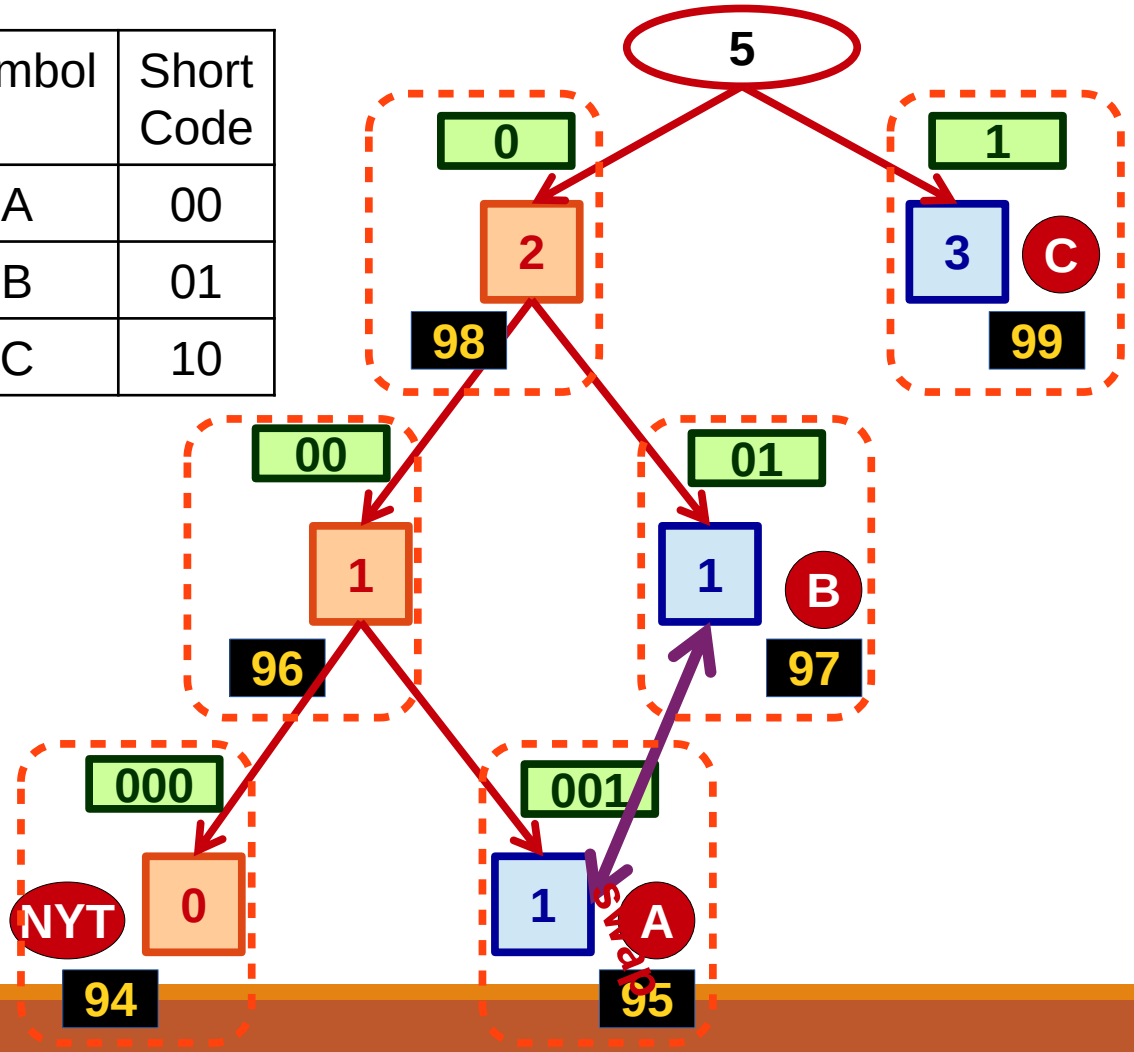
Goto Parent: Root,

Inc {4+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"							
Code	00	0	01	00	10	101	0	001							

Symbol	Short Code
A	00
B	01
C	10



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Code

Symbol Occurred before:

Node: [95]

Code =[001]

Update Tree

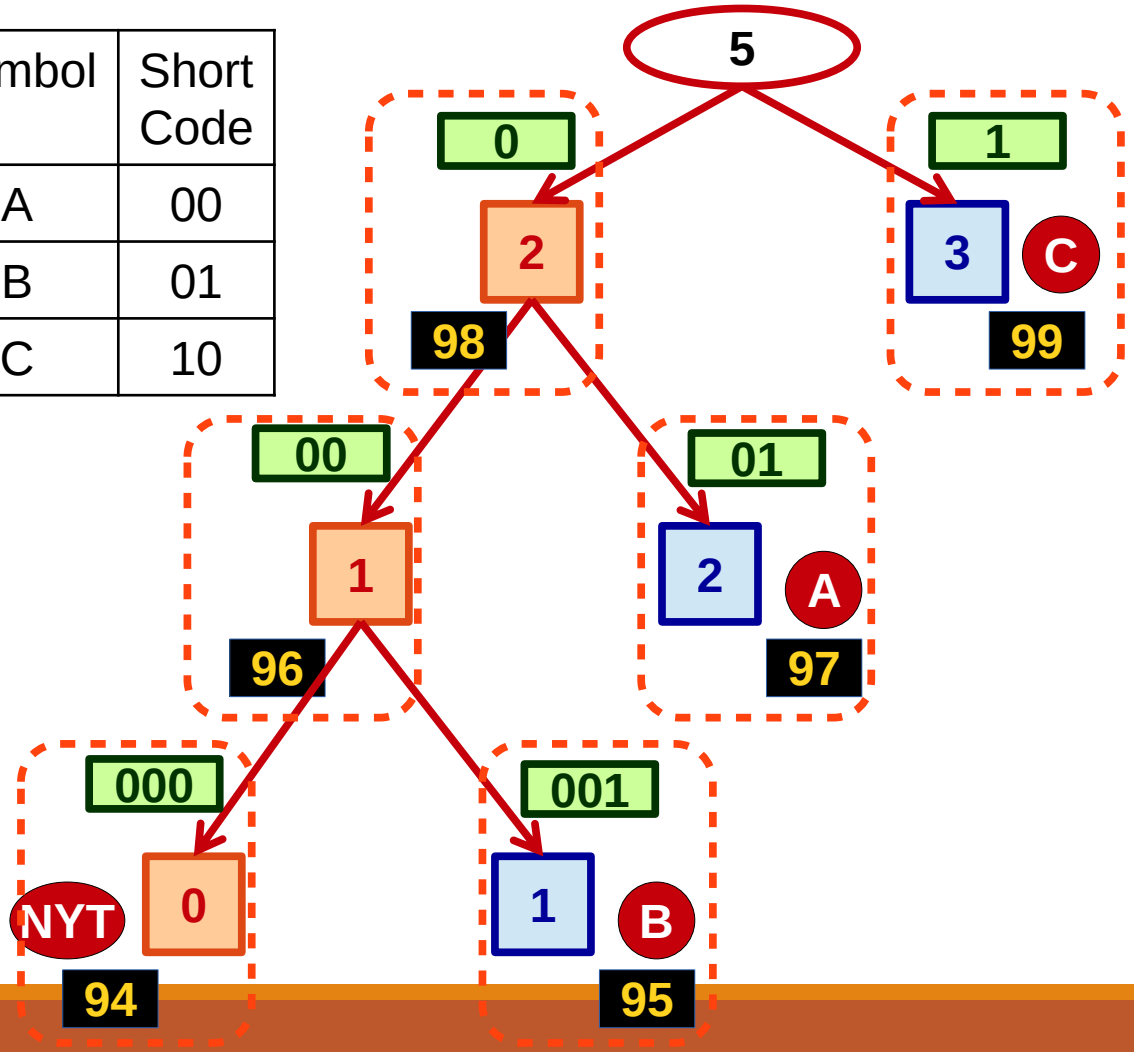
Go To Node: 95

Need Swap: YES [95] , [97]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"							
Code	00	0	01	00	10	101	0	001							

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [95] , [97]

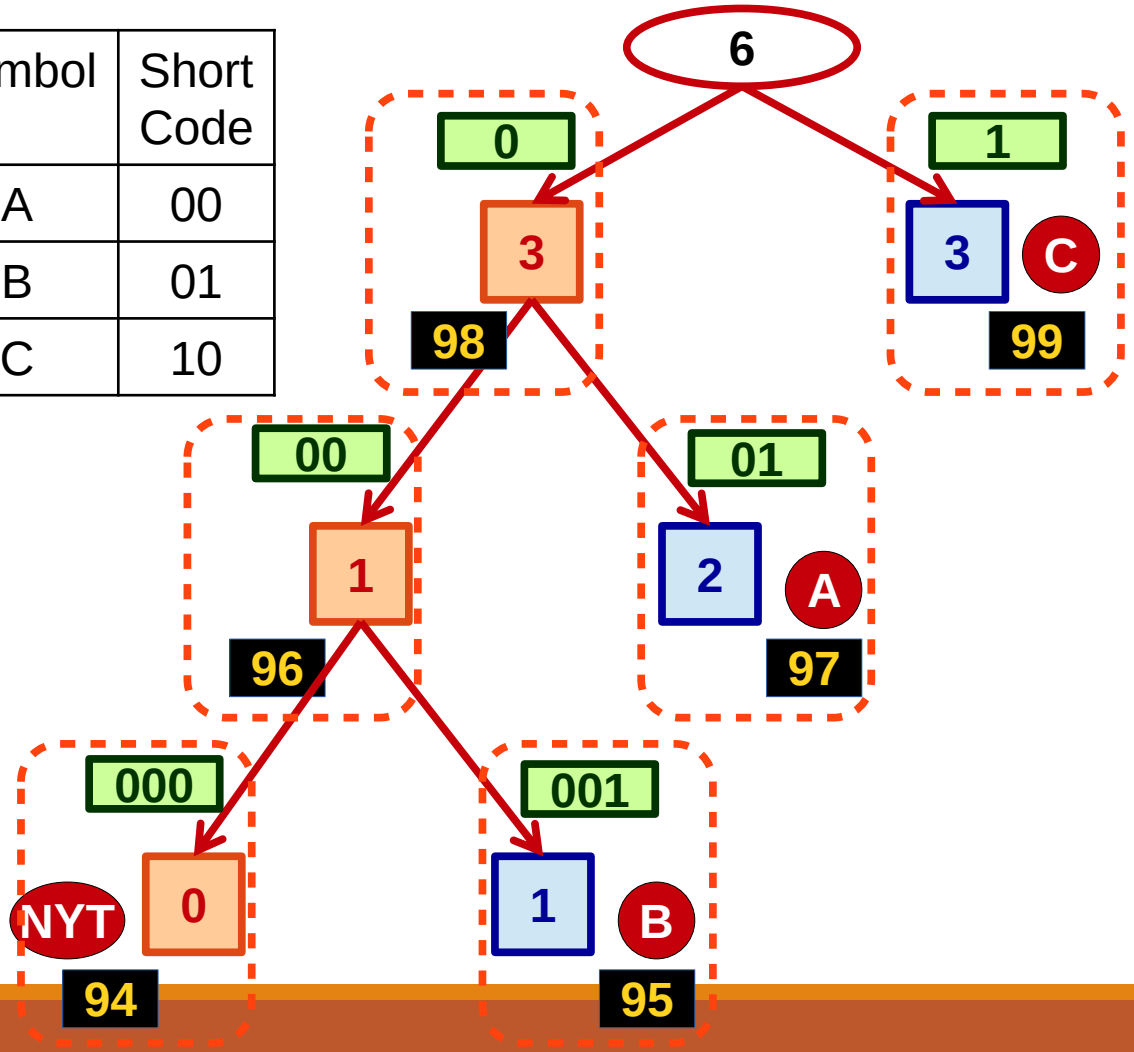
Inc Counter: Node 97 {1+}

Goto Parent: Node [98]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"							
Code	00	0	01	00	10	101	0	001							

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Need Swap:No

Inc Counter: Node 98 {2+}

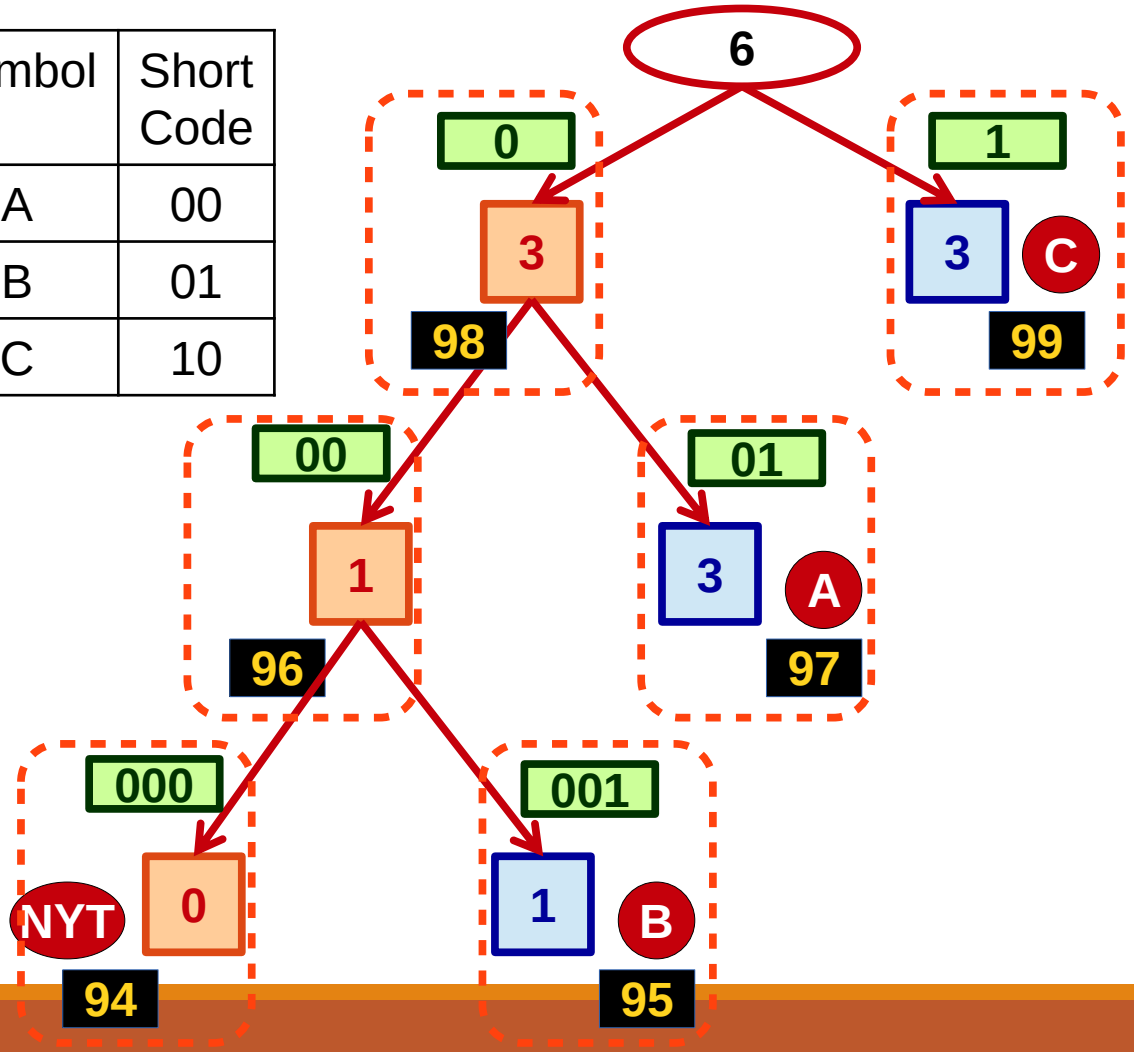
Goto Parent: Root,

Inc {5+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"						
Code	00	0	01	00	10	101	0	001	01						

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Symbol Occurred before:

Node: [97]

Code =[01]

Update Tree

Need Swap: No

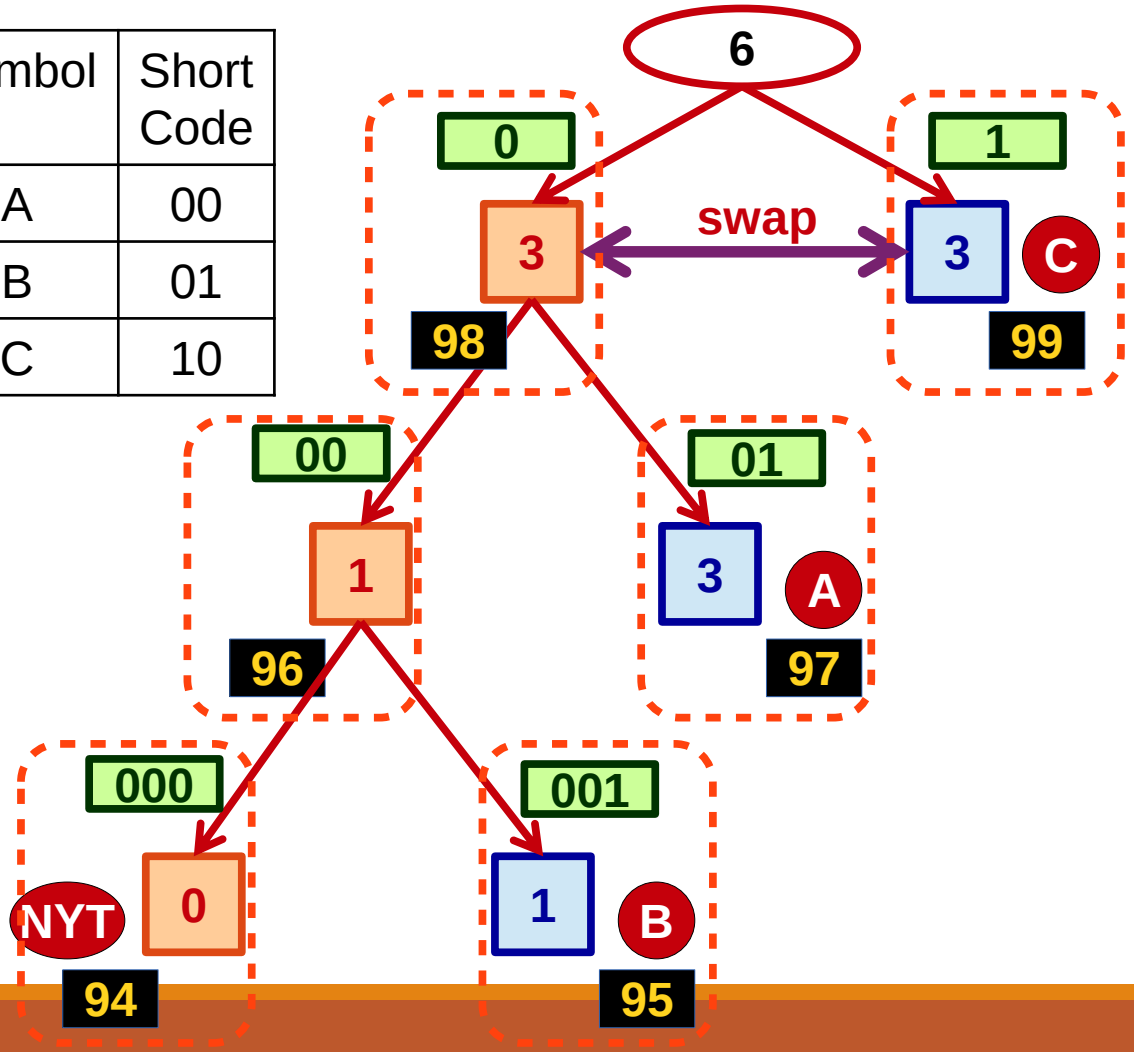
Inc Counter: Node 97 {2+}

Goto Parent: Node [98]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"						
Code	00	0	01	00	10	101	0	001	01						

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

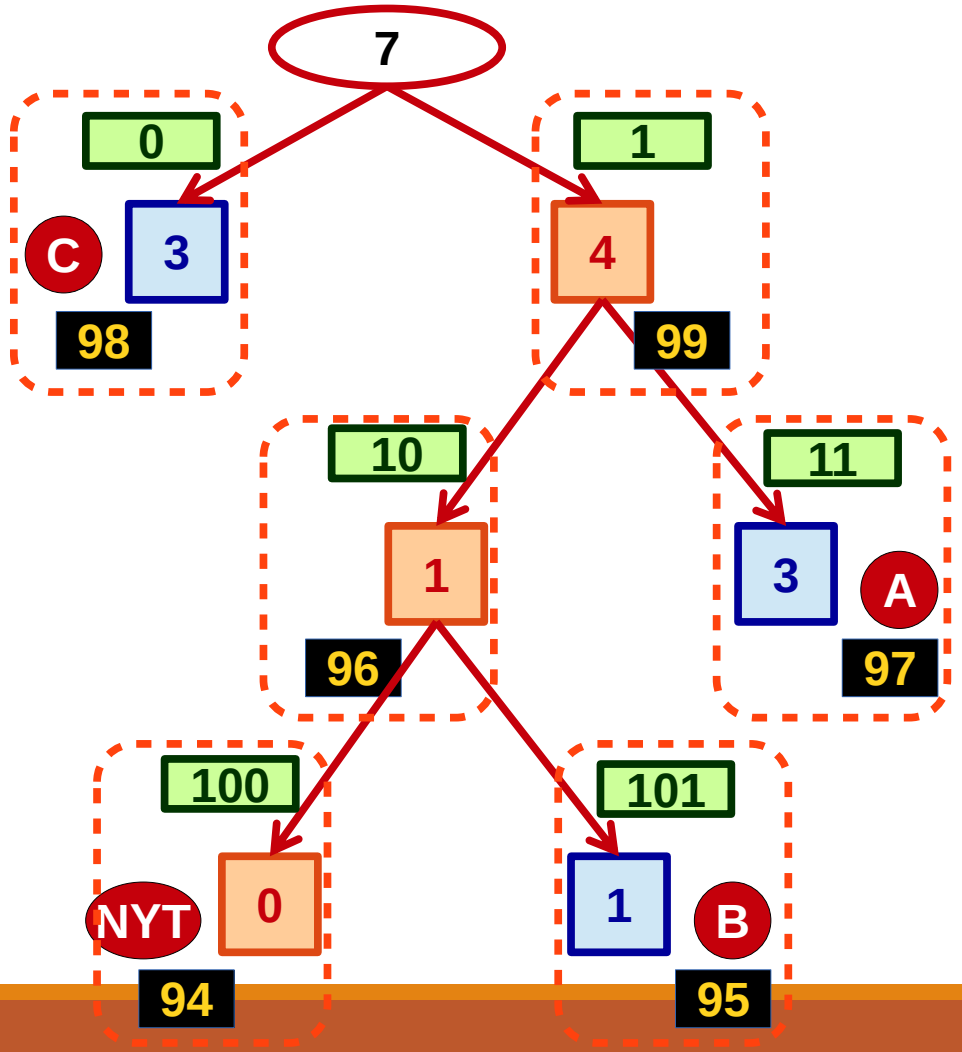
Update Tree

Need Swap: Yes [98] , [99]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"						
Code	00	0	01	00	10	101	0	001	01						

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [98] , [99]

Inc Counter: Node 99 {3+}

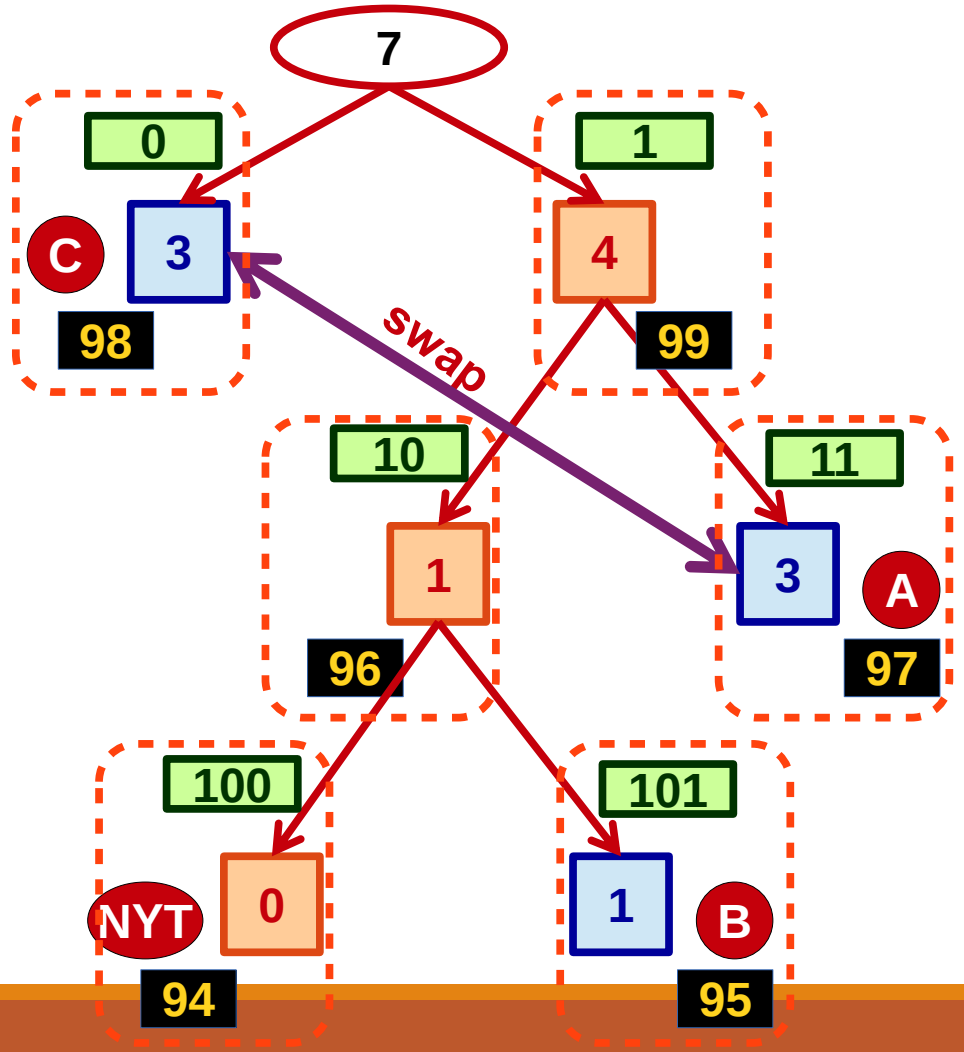
Goto Parent: Root,

Inc {6+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"	"A"					
Code	00	0	01	00	10	101	0	001	01	11					

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Symbol Occurred before:

Node: [97]

Code =[11]

Update Tree

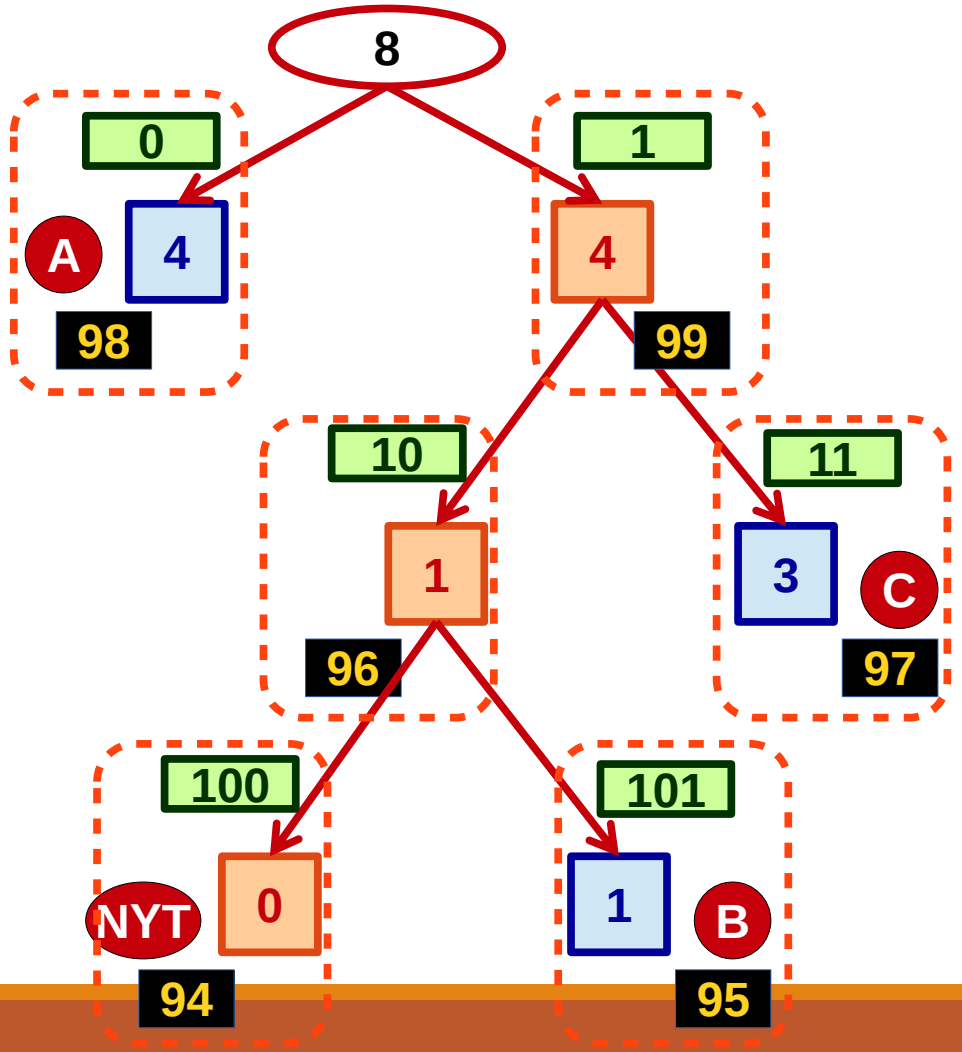
Go To Node: 97

Need Swap: YES [97] , [98]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"	"A"					
Code	00	0	01	00	10	101	0	001	01	11					

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [98] , [97]

Inc Counter: Node 98 {3+}

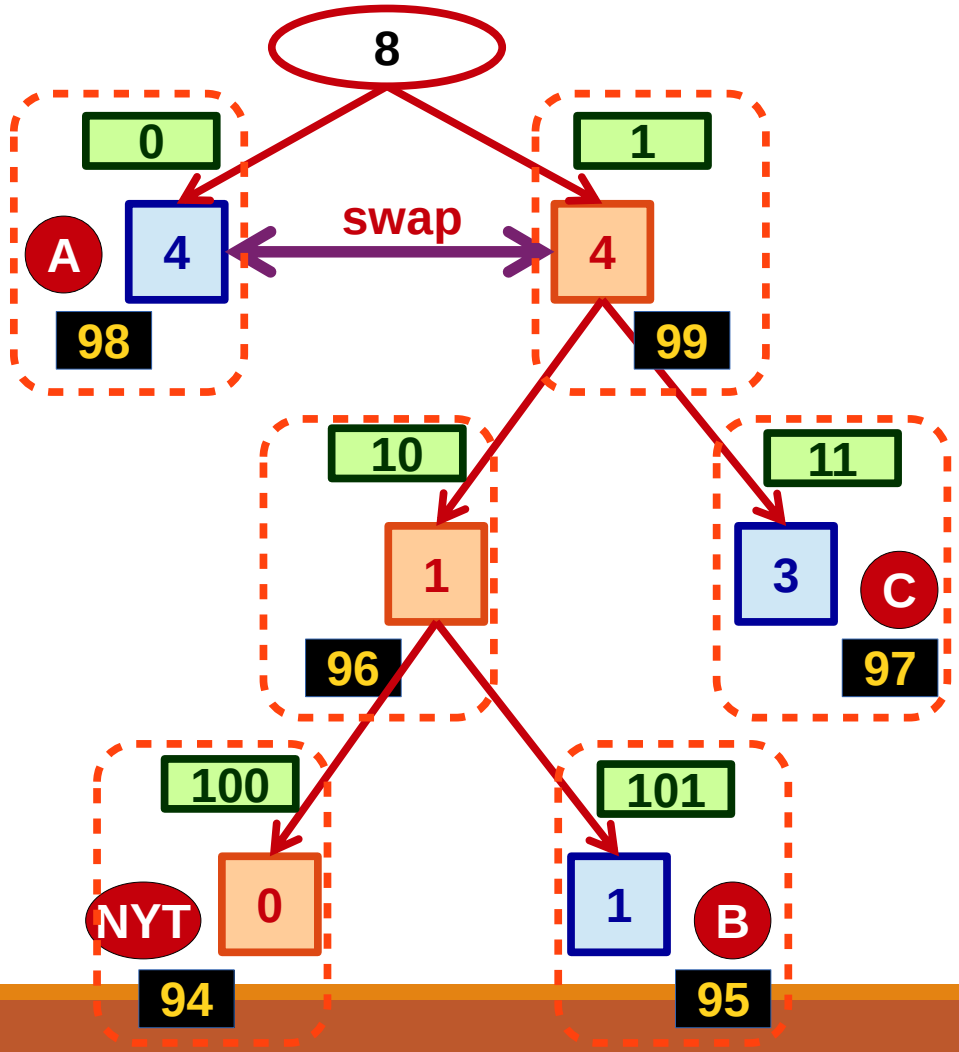
Goto Parent: Root,

Inc {7+}

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"	"A"	"A"				
Code	00	0	01	00	10	101	0	001	01	11	0				

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Symbol Occurred before:

Node: [98]

Code =[0]

Update Tree

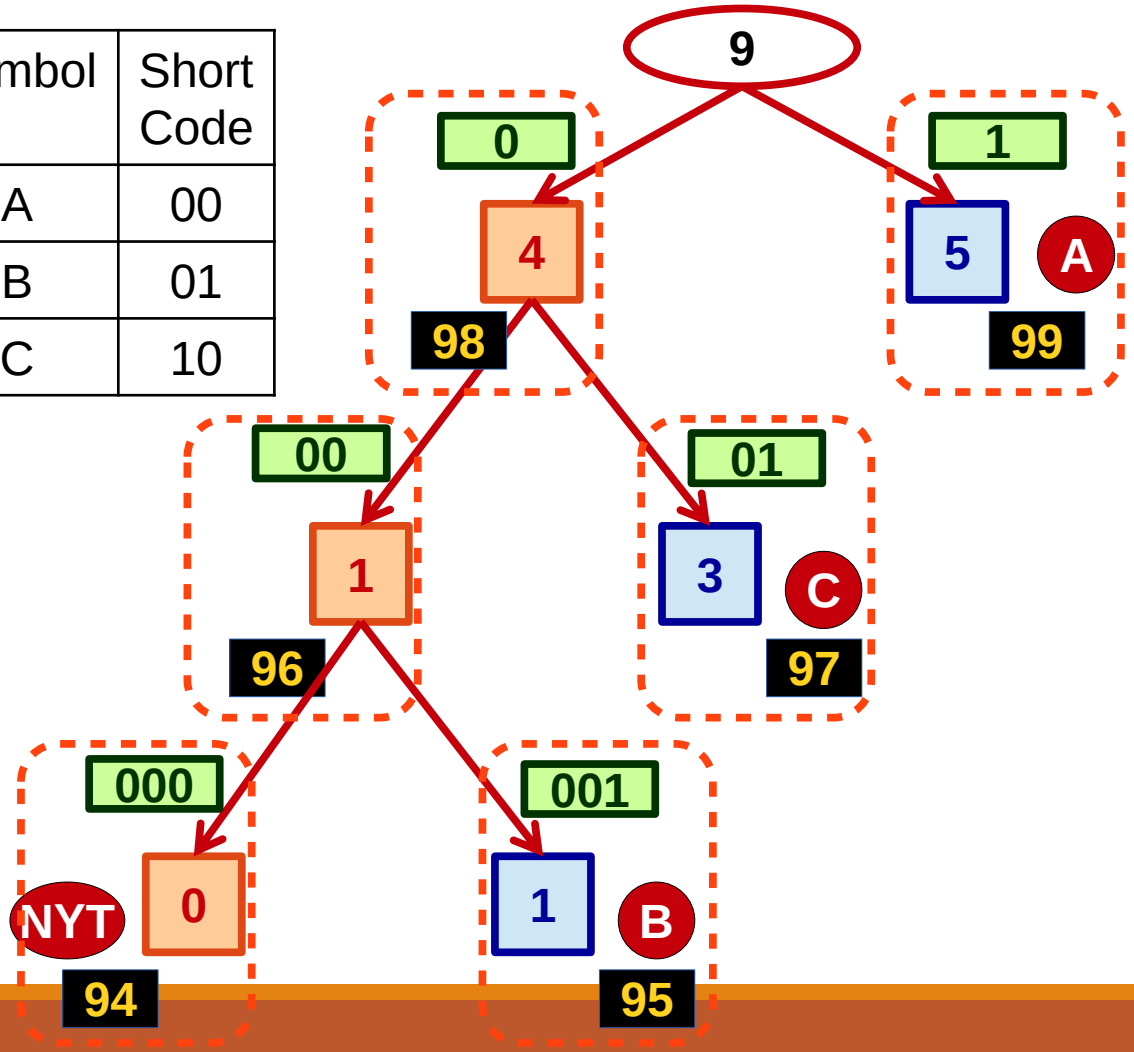
Go To Node: 98

Need Swap: YES [98] , [99]

Example: Adaptive Huffman Compression

Symbol	"A"	NYT	"B"	NYT	"C"	"C"	"C"	"A"	"A"	"A"	"A"				
Code	00	0	01	00	10	101	0	001	01	11	0				

Symbol	Short Code
A	00
B	01
C	10



ABCCCAAAA

Code

Update Tree

Swap: Done [98] , [99]

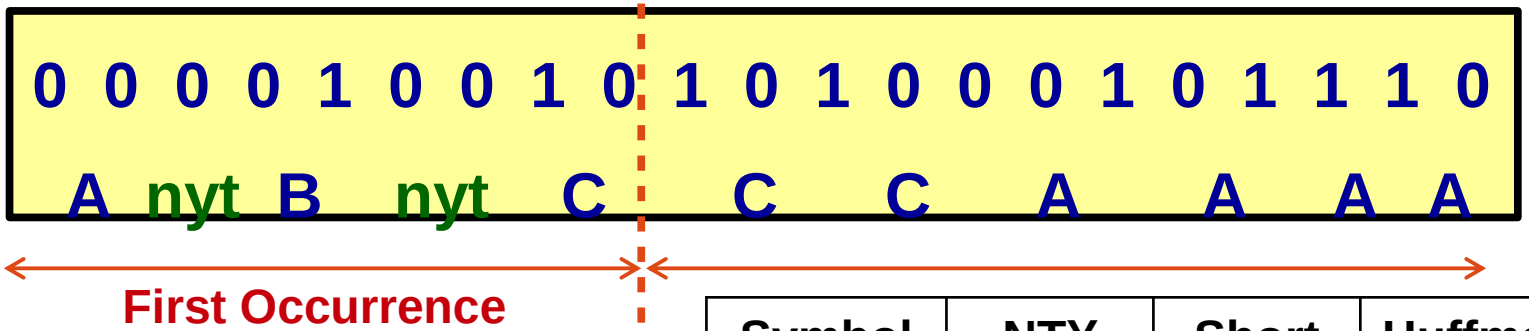
Inc Counter: Node 99 {5+}

Goto Parent: Root,

Inc {8+}

Example: Adaptive Huffman Compression

Compressed Code



Symbol	NTY Code	Short Code	Huffman Code	Number of Bits
A	–--	00	–---	2
B	0	01	–---	3
C	00	10	–---	4
C			101	3
C			0	1
A			001	3
A			01	2
A			11	2
A			0	1