6.034 Quiz 2
October 25, 2006

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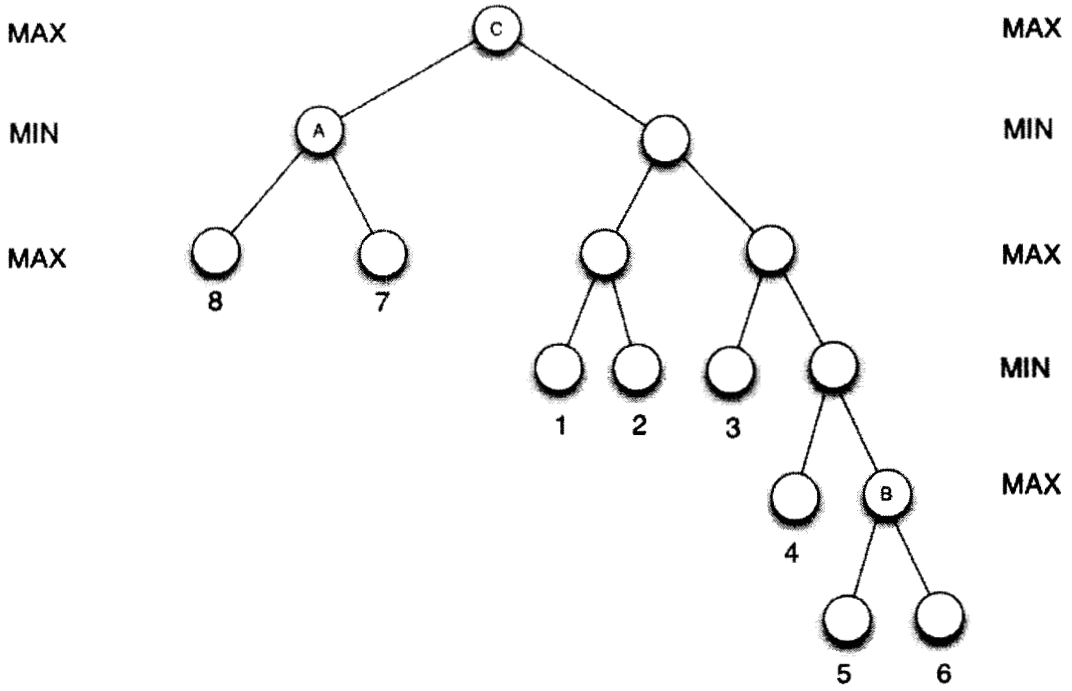
Problem number	Maximum	Score	Grader
1	50	50	PAC
2	50	50	PAC
Total	100	100	

There are 10 pages in this quiz, including this one. Tear-off sheets are provided at the end with duplicate drawings and data.

Problem 1: Search in Games (50 points)

Part A: Minimax (6 points)



Compute the **minimax value** of

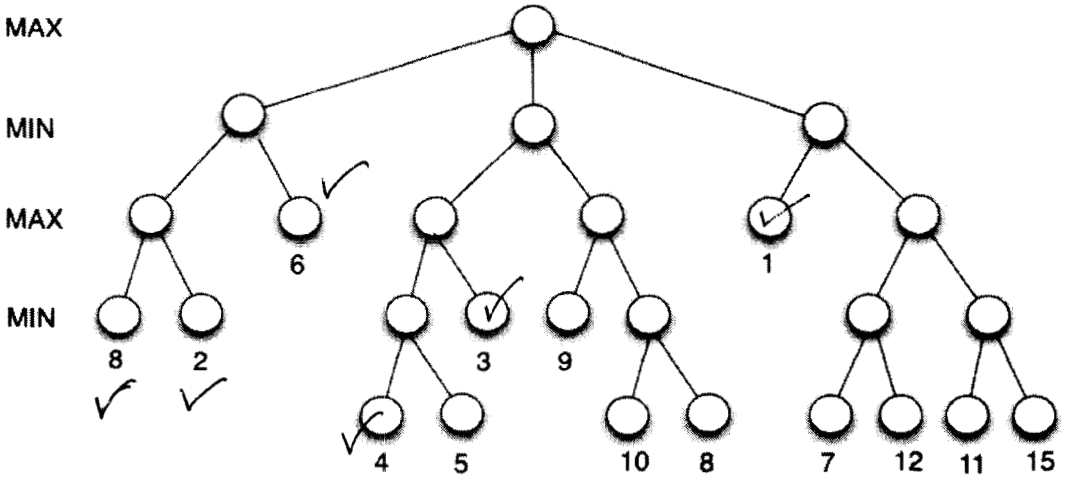
A = 7

B = 6

C = 7

Part B: Minimax with Alpha-Beta Pruning (20 points)

In the game tree below, clearly indicate with a checkmark the nodes/states that are statically evaluated during minimax with alpha-beta pruning.

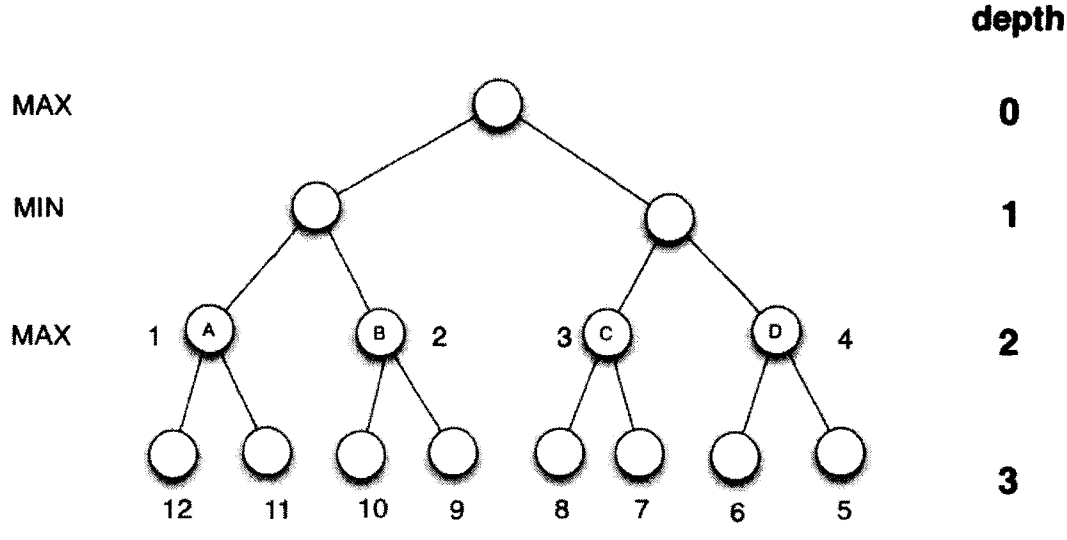


Part C: Minimax with Alpha-Beta Pruning and Progressive Deepening (10 points)

When answering the question in Parts C.1 and C.2 below, assume you have already applied minimax with alpha-beta pruning and progressive deepening on the corresponding game tree up to **depth 2**. The value shown next to each node of the tree at depth 2 is the respective node's static-evaluation value. Assume the procedure uses the information it has acquired up to a given depth to try to improve the order of evaluations later. In particular, the procedure reorders the nodes based on the evaluations found up to depth 2 in an attempt to improve the effectiveness of alpha-beta pruning when running up to depth 3.

We want to know in which order the nodes/states A, B, C, and D in the game tree are evaluated when the procedure runs up to depth 3, after running up to depth 2 and reordering.

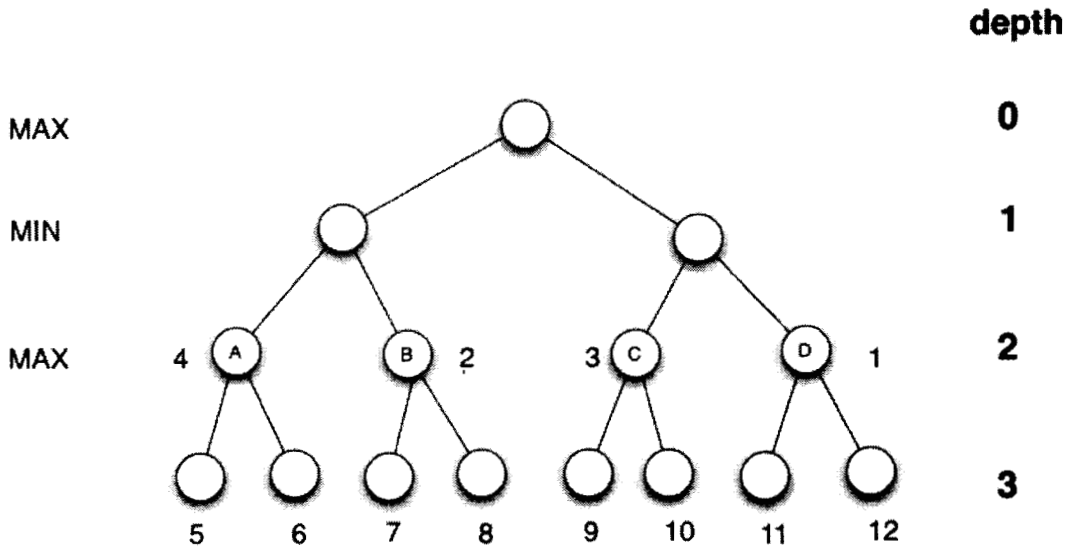
Part C.1: Game Tree I (5 points)



Choose the order in which the nodes/states A, B, C and D in game tree I above are evaluated when running minimax with alpha-beta pruning and progressive deepening after running up to depth 2 and reordering. (Circle your answer)

a. A B C D
b. D A B C
c. B A D C
(d.) C D A B
e. D C B A

Part C.2: Game Tree II (5 points)

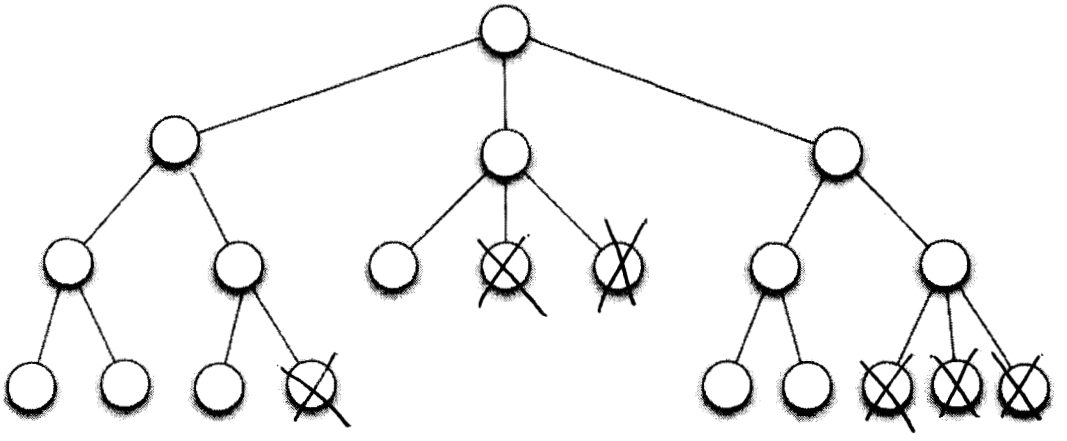


Choose the order in which the nodes/states A, B, C and D in game tree II above are evaluated when running minimax with alpha-beta pruning and progressive deepening after running up to depth 2 and reordering (Circle your answer)

f. A B C D
g. D A B C
(h.) B A D C
i. C D A B
j. D C B A

Part D: Optimal Minimax with Alpha-Beta Pruning (14 points)

In the game tree below, cross out the nodes/states that are **not** statically evaluated in the best case for minimax with alpha-beta pruning (when the procedure performs the smallest number of static evaluations ever possible for the given game tree).



Problem 2: Constraints (50 points)

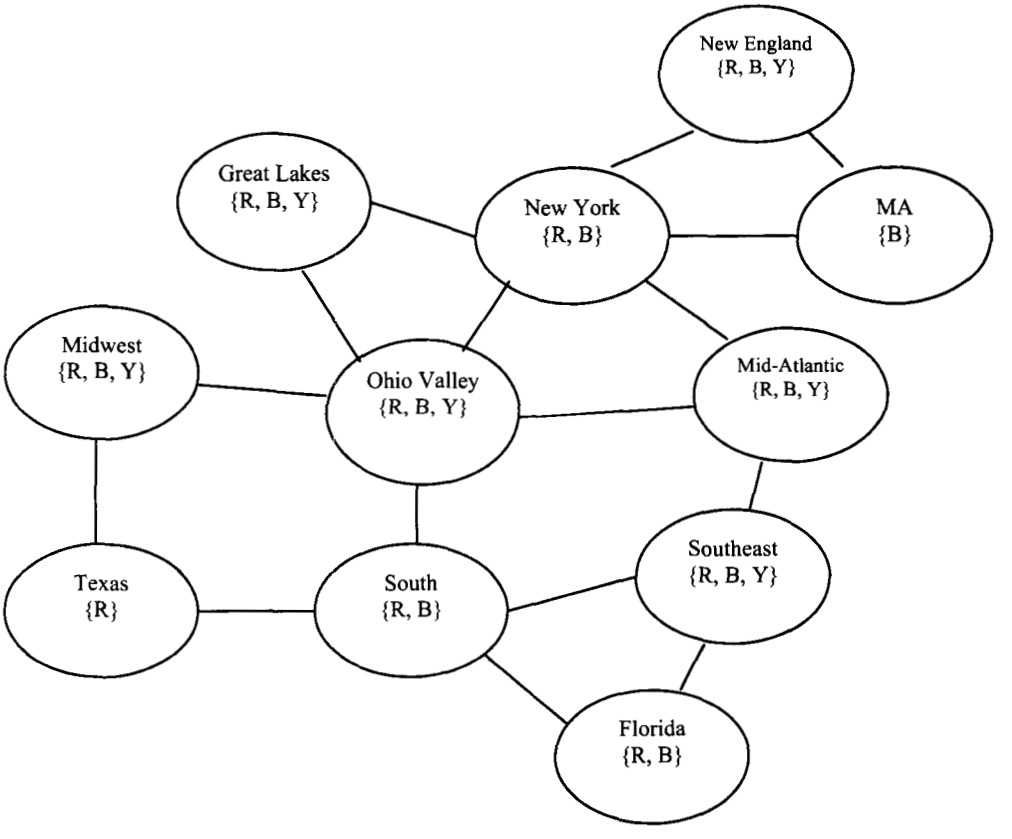
In the following questions, you will be asked to color in a map of some states and regions of the United States according to how you think they will vote in this years' election. You created the following constraint network, which contains:

- Nodes (which are the variables representing states that you will color)
- Edges (which represent the constraints between variables)
- Domains (the possible colors for each state or region, also listed in each node)

You also know that Massachusetts will vote Blue, and that Texas will vote Red. For this reason, you have restricted the value of those domains to just B and R, respectively. If you've determined the vote of a particular state, no surrounding state may be the opposite color. Whenever possible, you want to color surrounding states the same color, but if that is not possible, you decide to color them yellow, which acts as a buffer between the blue and red states. However, yellow states cannot share a border.

The constraint used is **NOT THE SAME AS IN THE MAP COLORING PROBLEM.** Instead, the edge between states (or regions) indicates:

- R-B, B-R, and **Y-Y** pairs <u>are not</u> allowed
- R-R, B-B, R-Y, B-Y <u>are</u> allowed by the constraint



Part A: Backtracking Search with Forward Checking (20 points)

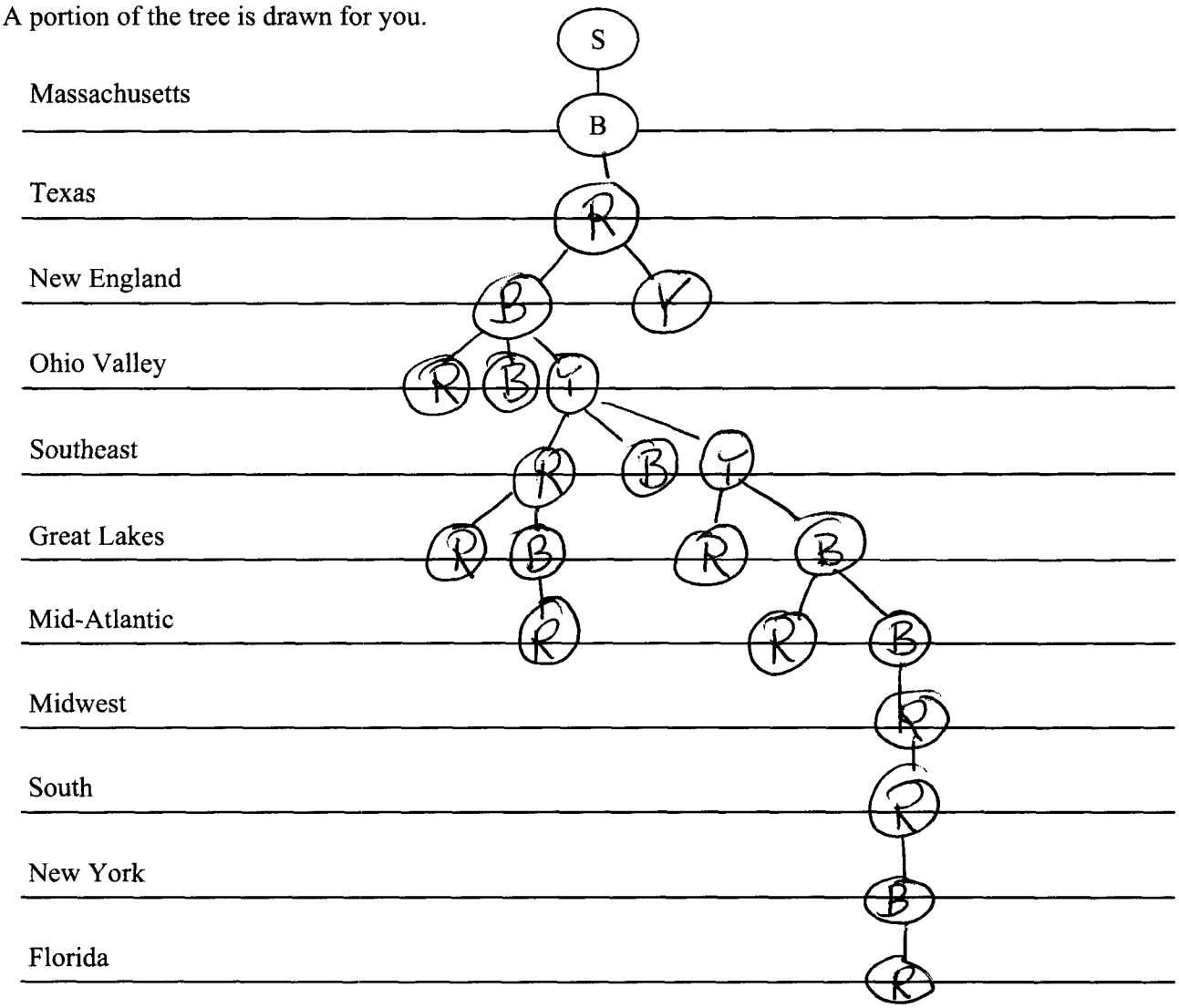
Draw a search tree using **backtracking with forward checking** (no propagation beyond neighbors of just-assigned variable). For every node in your tree, draw only all its **valid** descendants.

The constraint you should use is repeated below:
The edge between states (or regions) indicates:

- R-B, B-R, and **Y-Y** pairs <u>are not</u> allowed
- R-R, B-B, R-Y, B-Y <u>are</u> allowed by the constraint

For each node that was just assigned, order the descendents of the node in the order R, B, Y.

A portion of the tree is drawn for you.



Part B: Backtracking Search with Forward Checking and Constraint Propagation (20 points)

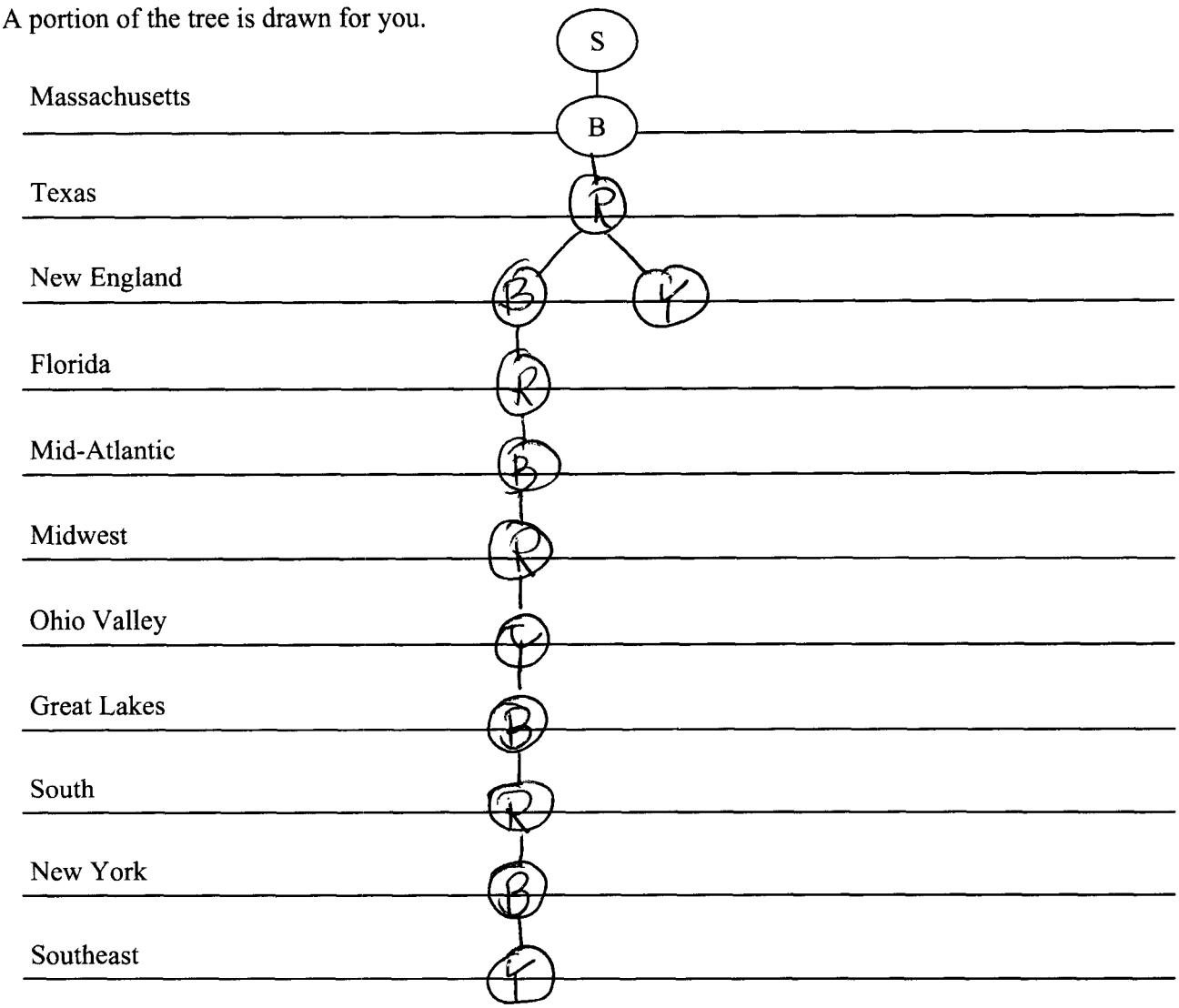
Draw the search tree that results from using **backtracking with forward checking AND propagating through domains that are reduced to size 1 [singleton domains].** For every node in your tree, draw only all its **valid** descendants.

The constraint you should use is repeated below:
The edge between states (or regions) indicates:

- R-B, B-R, and **Y-Y** pairs are not allowed
- R-R, B-B, R-Y, B-Y are allowed by the constraint

For each node that was just assigned, order the descendents of the node in the order R, B, Y.

A portion of the tree is drawn for you.



Part C: Ordering Variable Assignments (10 points)

Bill really wants to color states with his favorite color, and he has asked your help in order to do so. Instead of assigning colors randomly, you decide to assign colors to states/regions using the same algorithm that you would use to speed up map coloring. Using this algorithm for regular map coloring, after assigning values to Massachusetts and Texas, which state(s) would you color next?
(If you think more than one state should be colored next, circle more than one answer.)

Florida Great Lakes Mid-Atlantic Midwest New England

New York Ohio Valley Southeast South

Using the map coloring algorithm for ordering variable assignments, why did you choose your answer from above? (Please answer in one sentence or less).

MOST CONSTRAINED

A copy of the graph is repeated below for your convenience.