Red-Black Tree

1. Every node is red or black
2. Root is black
3. If a node is red, its children are black
4. Every “empty” subtree (leaf) is black
5. The number of black nodes on a path from a node to a leaf, not including the node, is the same on every such path. (This number is called the black-height.)

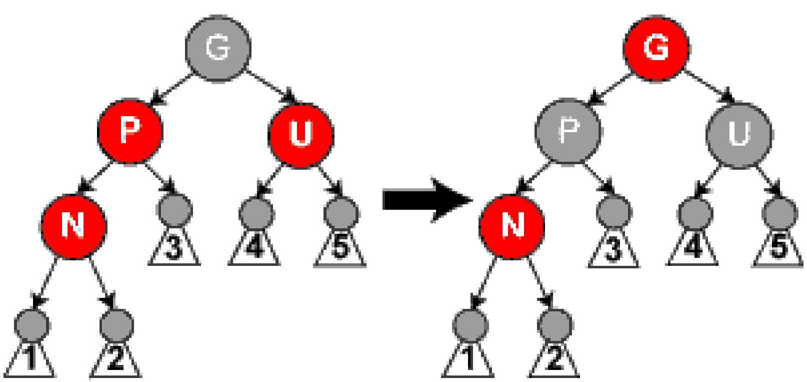
Insertion:

Insert a node and color it red. Notice this does not effect the black-height. If this is the root, immediately color it black.

Case 1: parent[N] is black. If the inserted node N is red and its parent is black then we can stop the insertion process.

Case 2: parent[N] is red and uncle[N] is red.

N, parent[N] and uncle[N] are all red, then we can recolor u[N] and p[N] to black and recur on the grandparent (toward the root of the tree) to recheck. There are four symmetric cases to case 2, and the picture below shows only one of the cases. Note that this transformation decreases the number of red nodes. Also note that it may cause another red parent/red child situation.



Case 3: parent[N] is red and uncle[N] is black.

N and parent[N] are red and uncle[N] is black. This is a reference rearrangement. Notice that the number of red nodes remains the same.