

Complexity Analysis of *updateMaterialQuantities()*

1. *updateMaterialQuantities*

- Input Processing:
 - *scanner.nextLine()* for reading input: $O(1)$.
 - Material Search (*tree.searchNode*): Map lookups are $O(1)$ (worst case $O(N)$).
- Material Quantity Update:
 - Displaying and validating quantities: $O(1)$.
 - Updating material quantity: $O(1)$.
- Propagation (*materialNode.propagateUpdate*): Worst-case $O(N)$ for full tree traversal.
- Overall Time Complexity: Worst case $O(N)$.

2. *Tree.updateMaterialQuantities*

- Updating material quantity and propagation factor: $O(1)$.
- Propagation: Worst-case $O(N)$ if the entire tree is affected.
- Overall Time Complexity: Worst case $O(N)$.

3. *TreeNode.propagateUpdate*

- Iterating over children and updating their quantities: $O(1)$ per node.
- Recursive propagation: Worst-case $O(N)$ for full tree traversal.
- Overall Time Complexity: Worst case $O(N)$.

Summary

Method	Time Complexity (Best Case)	Time Complexity (Worst Case)	Space Complexity
updateMaterialQuantities	$O(1)$	$O(N)$	$O(N)$
Tree.updateMaterialQuantities	$O(1)$	$O(N)$	$O(N)$
TreeNode.propagateUpdate	$O(1)$	$O(N)$	$O(N)$
searchNode	$O(1)$	$O(N)$	$O(N)$