

## 1

$$C' = RTSC$$

## 2

$$M_1 M_2$$

## 3

blue square:  $M_1 M_3 M_6$

black square:  $M_1 M_4 M_9 M_{12}$

blue triangle:  $M_1 M_3 M_7$

blue rectangle:  $M_1 M_4 M_{10}$

white circle:  $M_1 M_4 M_8 M_{11}$

## 4

We can save in each node the corresponding transformation matrix. To do this, we can apply DFS and the complexity would be  $O(n)$  where  $n$  is the number of nodes.

```
class Node {
private:
    mat4 transformMat;
    int numChildren;
    Node[] children;
    mat4[] edgeTransforms;
    // other attributes
};

void dfs(Node node, mat4 nodeMat, mat4 edgeMat) {
    node.transformMat = nodeMat * edgeMat

    if (0 == node.numChildren) render(node); // leaf

    for (int i = 0; i < node.numChildren; i++) {
        dfs(node.children[i], node.transformMat, node.edgeTransforms[i]);
    }
}
```