

Q1)

A) Formula for number of total depths at each level is:

$$= 2^{(\text{depth}-1)} * (\text{depth}) \quad (\text{until } h-1)$$

The lowest level may contain empty spaces in complete binary tree. So, we have to calculate this level with this formula below:

$$= (\text{depth}) * (\text{number of nodes})$$

We can obtain the following formula, with combining these two formulas:

$$\sum_{n=1}^{h-1} 2^{n-1} * n + h * (\text{number of nodes at the lowest level})$$

B) Since the number of searched items is halved at each step of search operation, the result is $\theta(\log n)$ for worst case and $\theta(1)$ for best case.

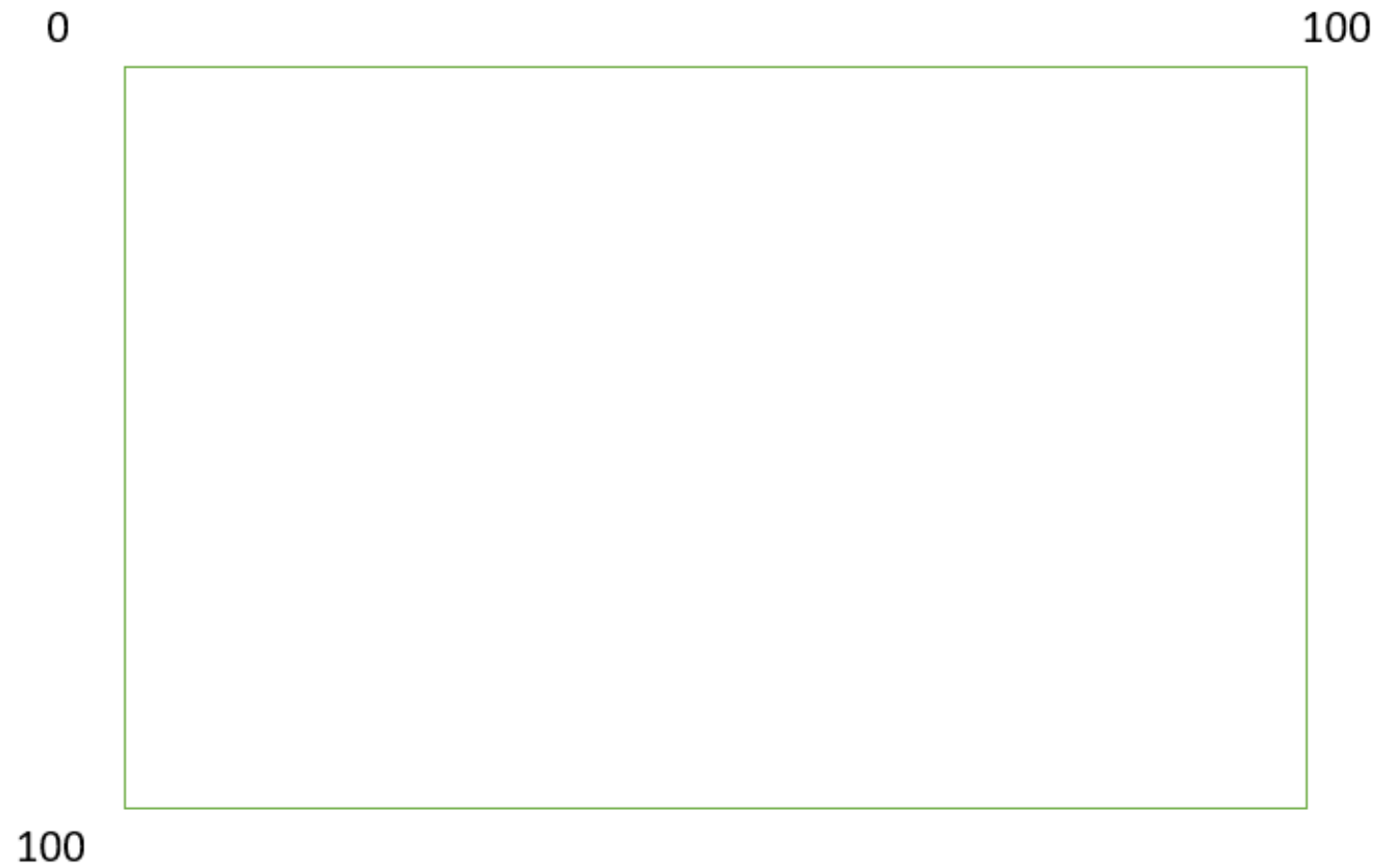
C) There is no restriction on number of nodes for full binary tree. But there is a relation between number of non-leaf nodes and number of total nodes in this structure. According to this relation, a full binary tree with n non-leaf nodes contains $2n+1$ nodes.

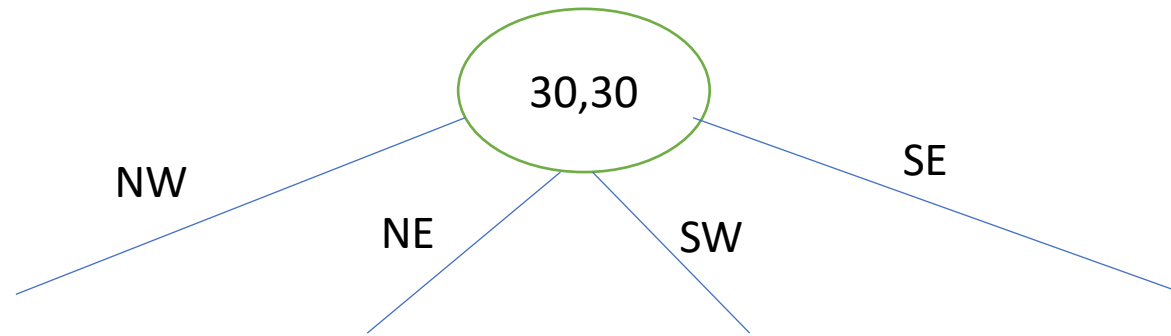
As a result, If we have n nodes for total, it means we have $(n+1)/2$ leaf nodes and $(n-1)/2$ internal nodes.

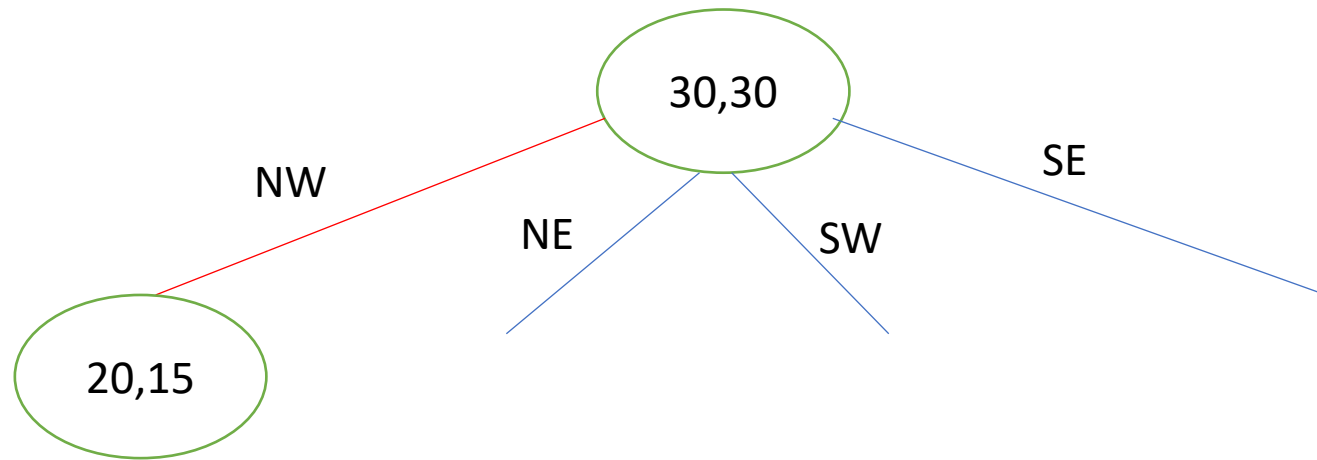
Q2) QuadTree Structure

Thanks to quadtree structure, we can store data of points on a two dimensional space. In this structure type, each node has at most four children. We may think each children represents one of these four directions: NorthEast, NorthWest, SouthEast, SouthWest

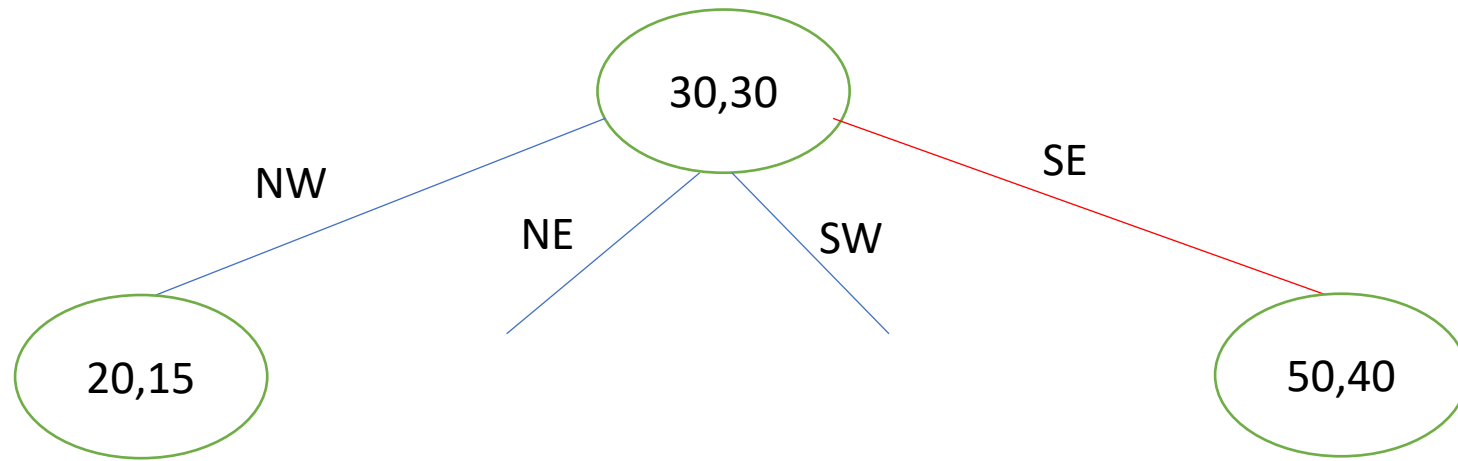
Nodes will be added to this two dimensional space according to the our quadtree



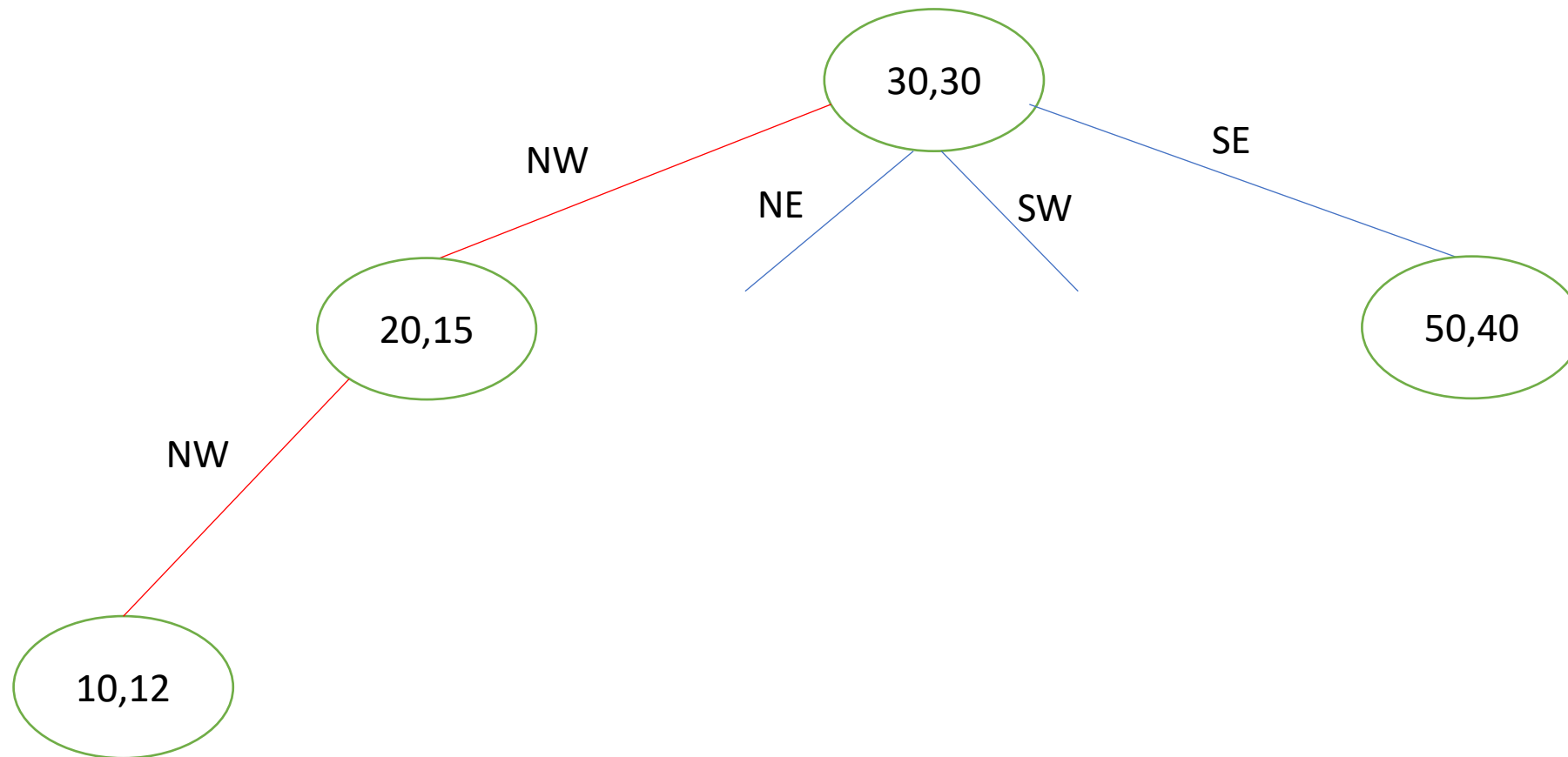




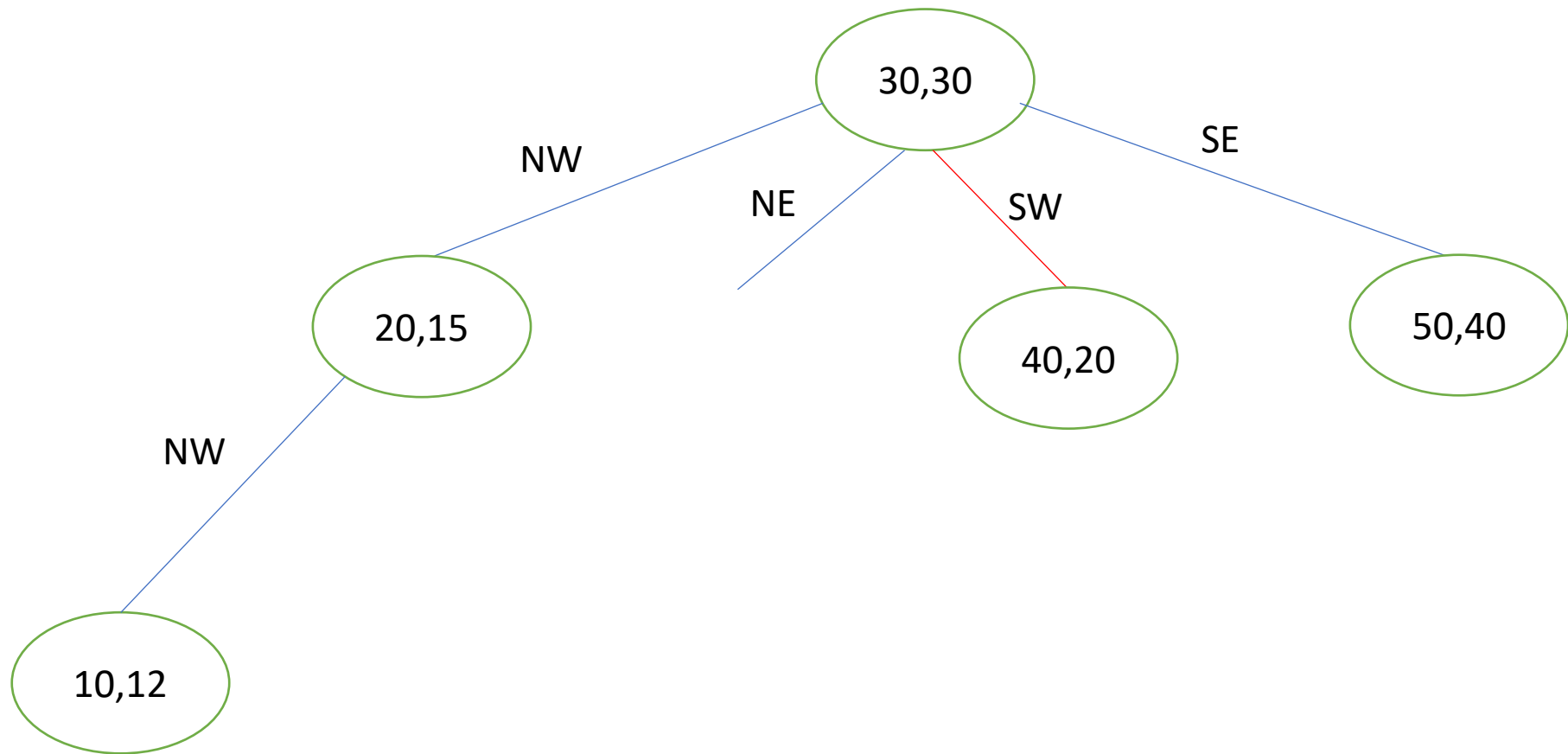
P.S: Red colored lines are path



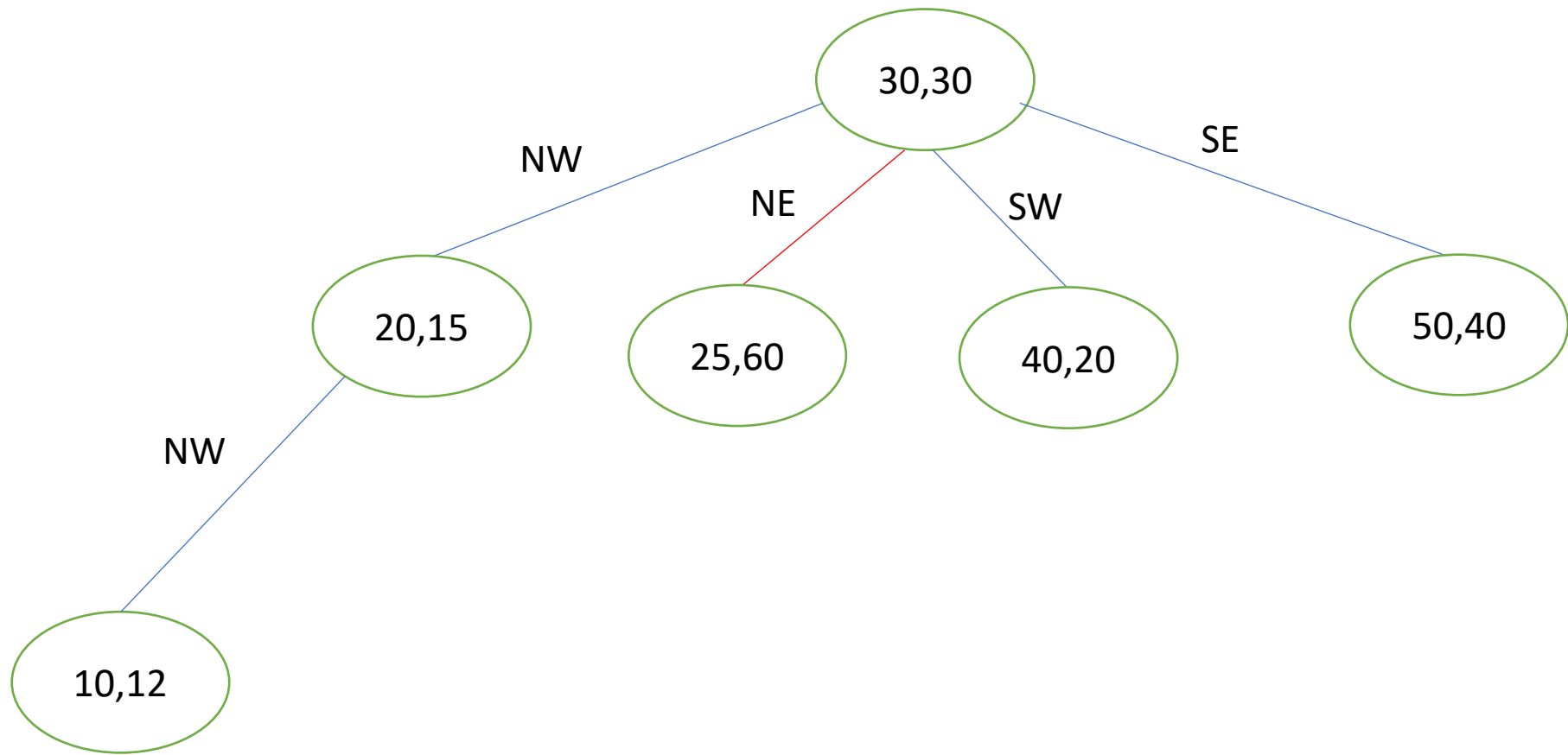
P.S: Red colored lines are path



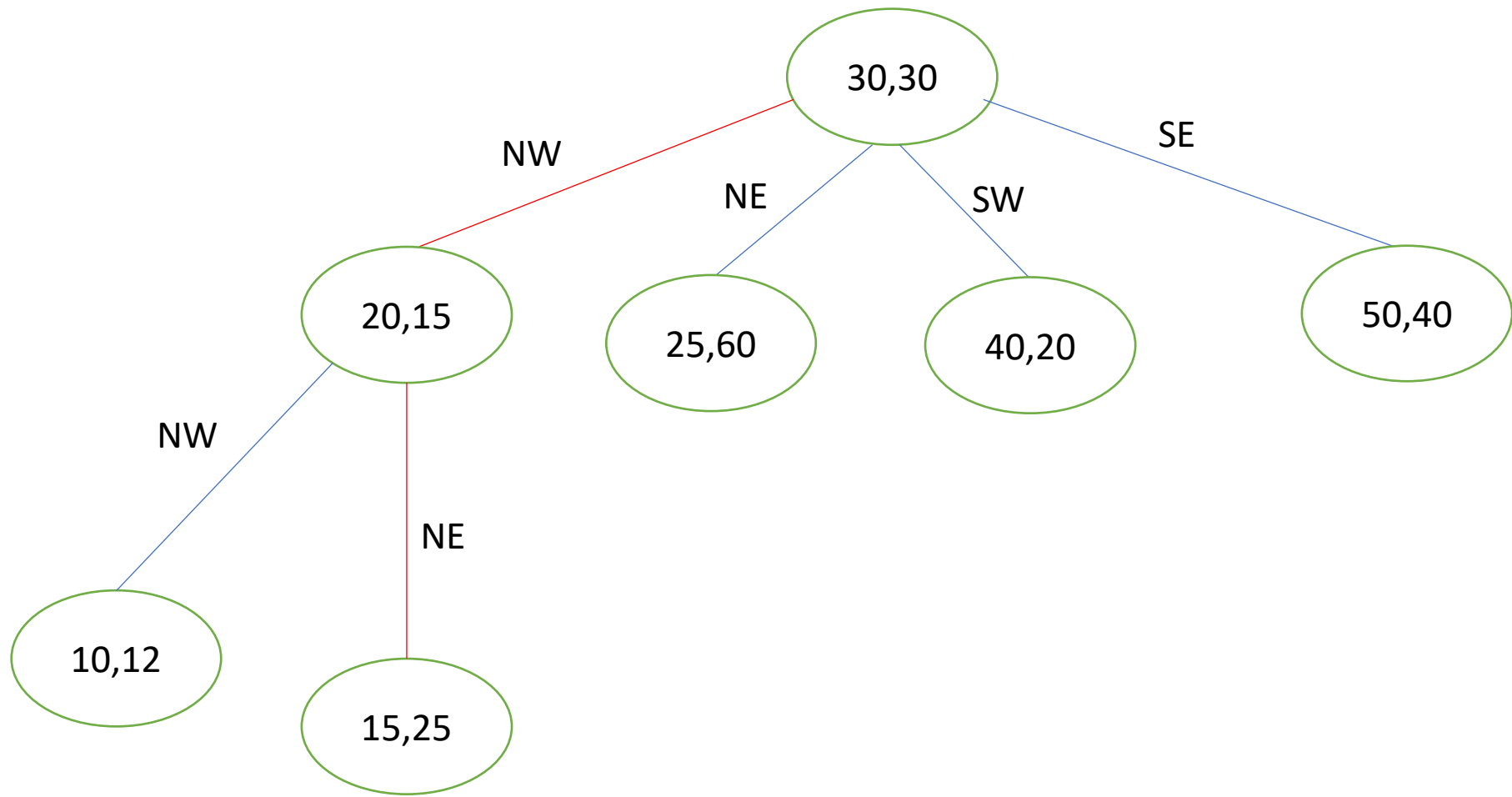
P.S: Red colored lines are path



P.S: Red colored lines are path



P.S: Red colored lines are path



P.S: Red colored lines are path