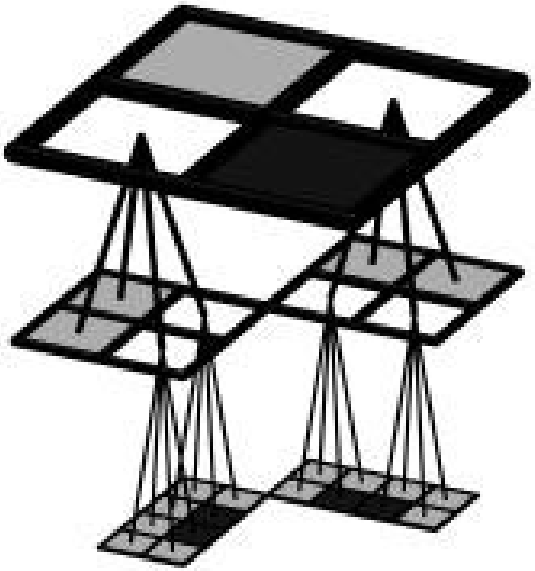


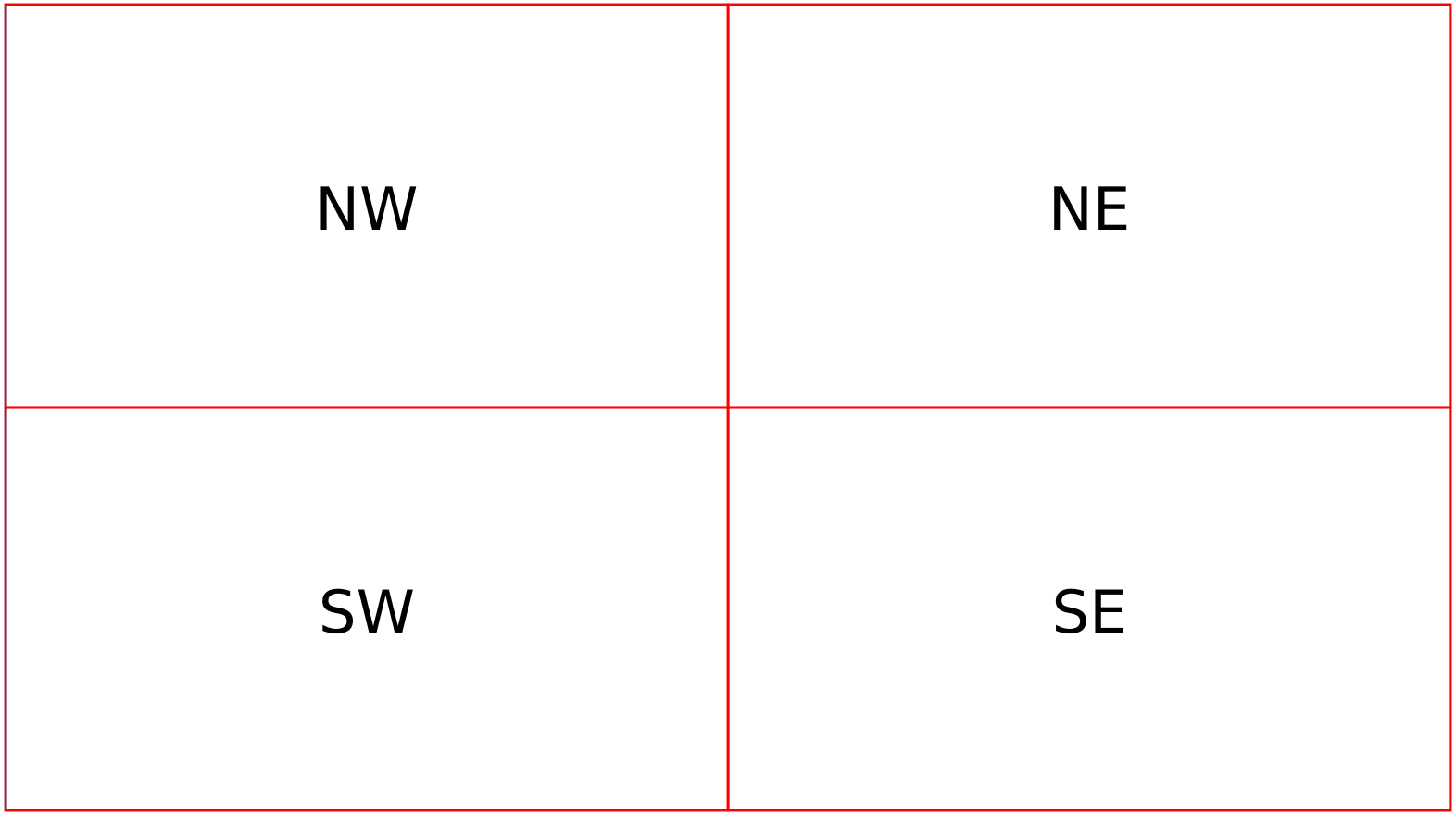
Dados espaciais
QuadTree para Pontos

Estruturas de Dados II

Jairo Francisco de Souza

Quadtree

- Espaço dividido em quadrantes (direções)

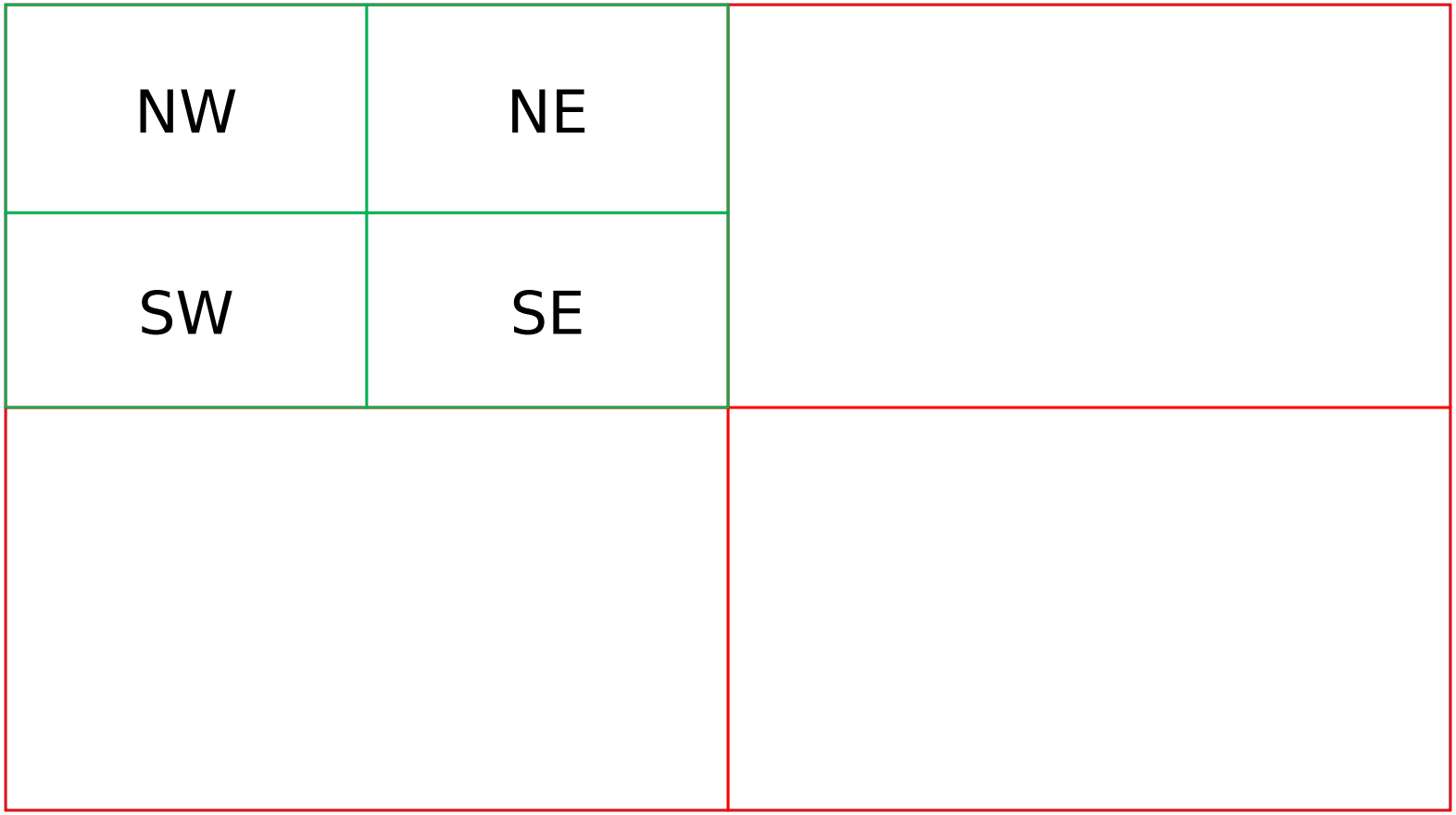


Quadtree

- Espaço dividido em quadrantes (direções)

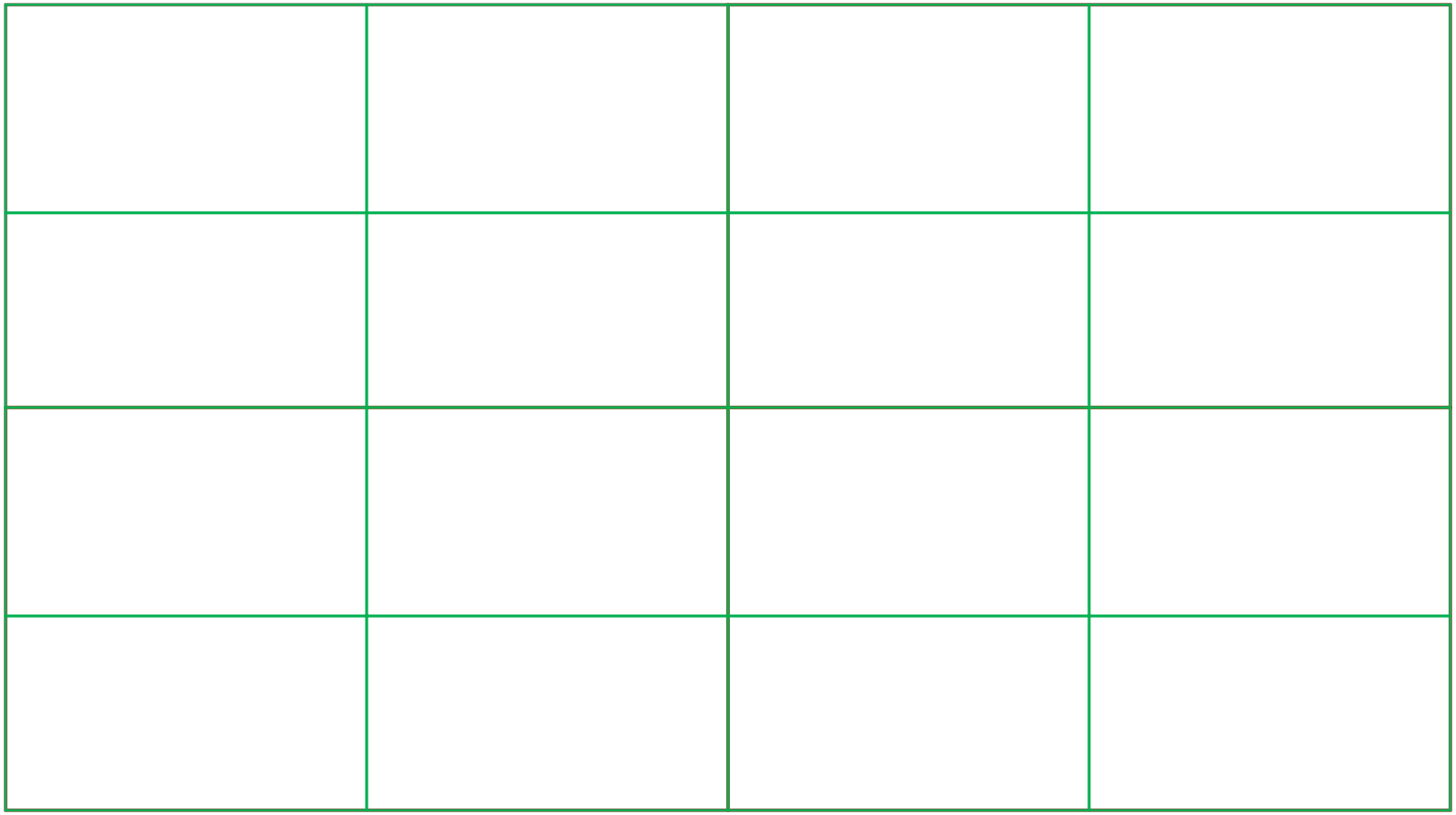
Quadtree

- Espaço dividido em quadrantes (direções)



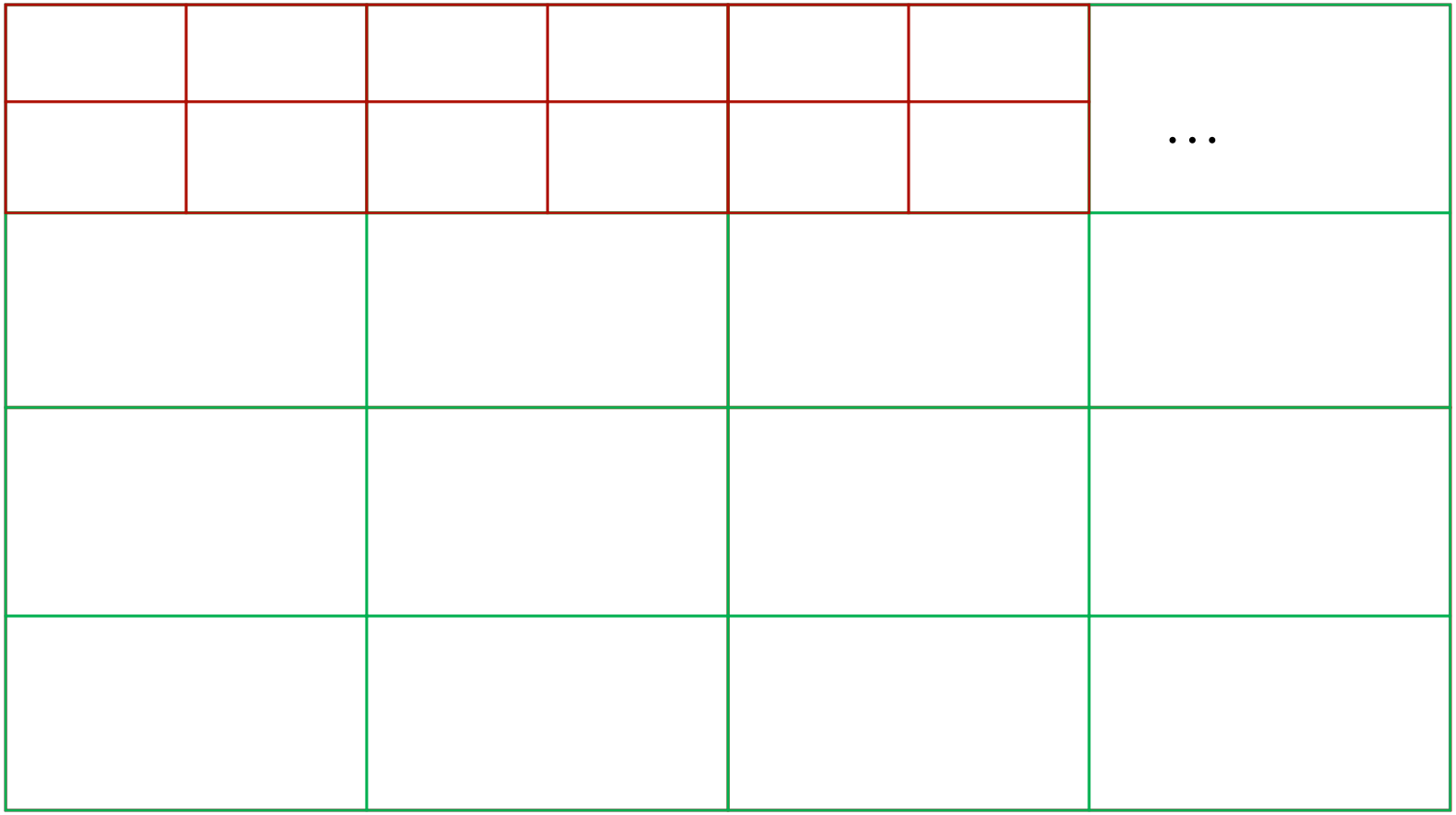
Quadtree

- Espaço dividido em quadrantes (direções)



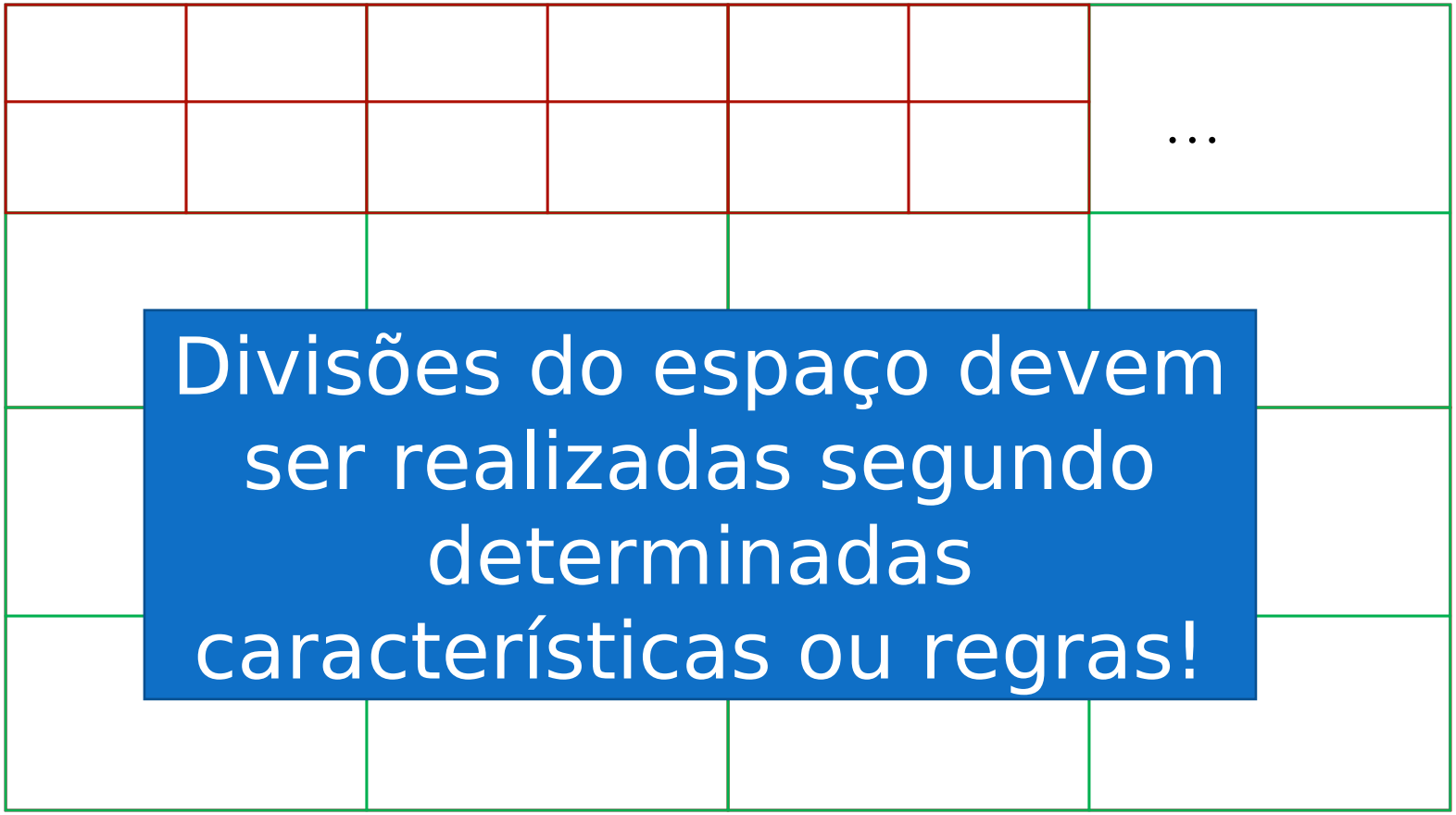
Quadtree

- Espaço dividido em quadrantes (direções)



Quadtree

- Espaço dividido em quadrantes (direções)

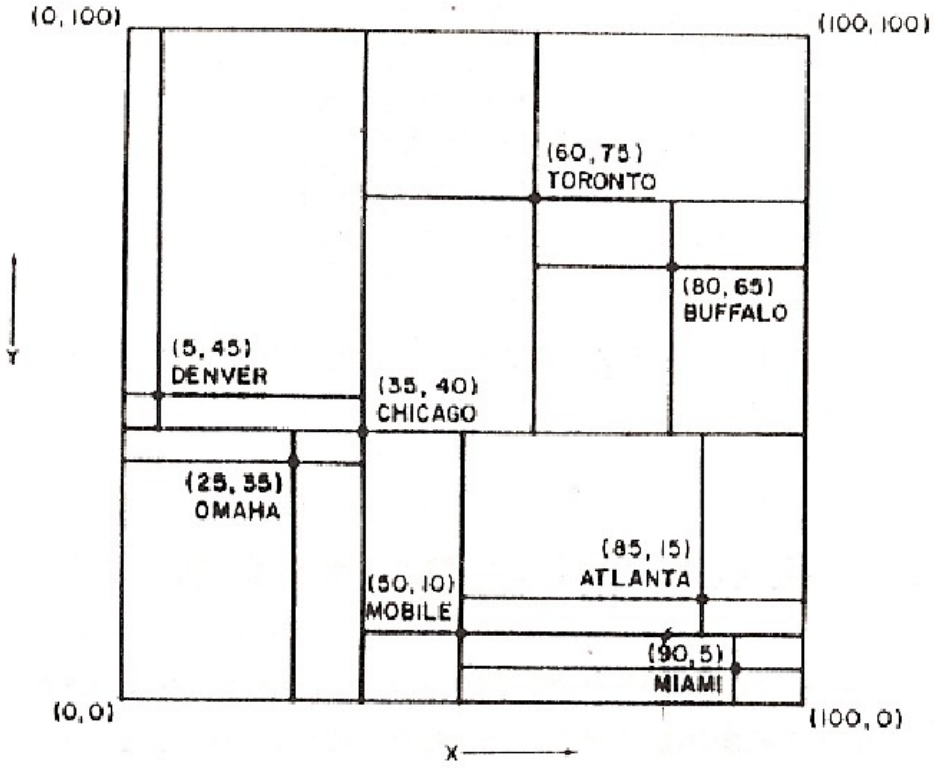


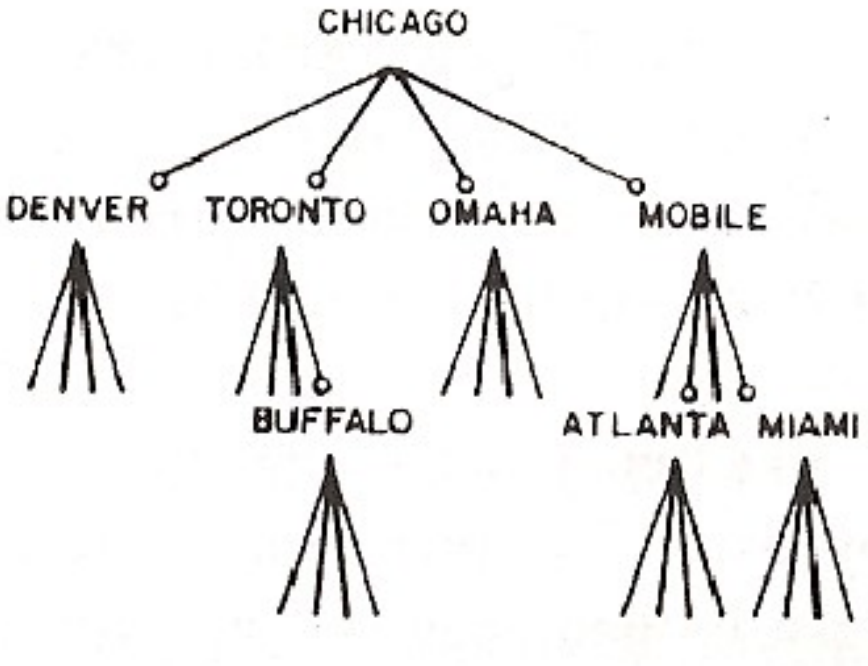
Point Quadtrees

- Finkel e Benkley [1974]
- É implementada como uma generalização multidimensional de uma árvore binária de busca.
- Em duas dimensões cada ponto de dados é representado por um nó da quadtree:Tipo de dados com 7 campos:
  - Primeiros 4 campos representam os 4 quadrantes (ou direções)
    - NW (noroeste)
    - NE (nordeste)
    - SW (sudoeste)
    - SE (sudeste)
  - Coordenada X do ponto
  - Coordenada Y do ponto
  - Campo nome: contém informações descritivas sobre o nó, por exemplo, nome da cidade.

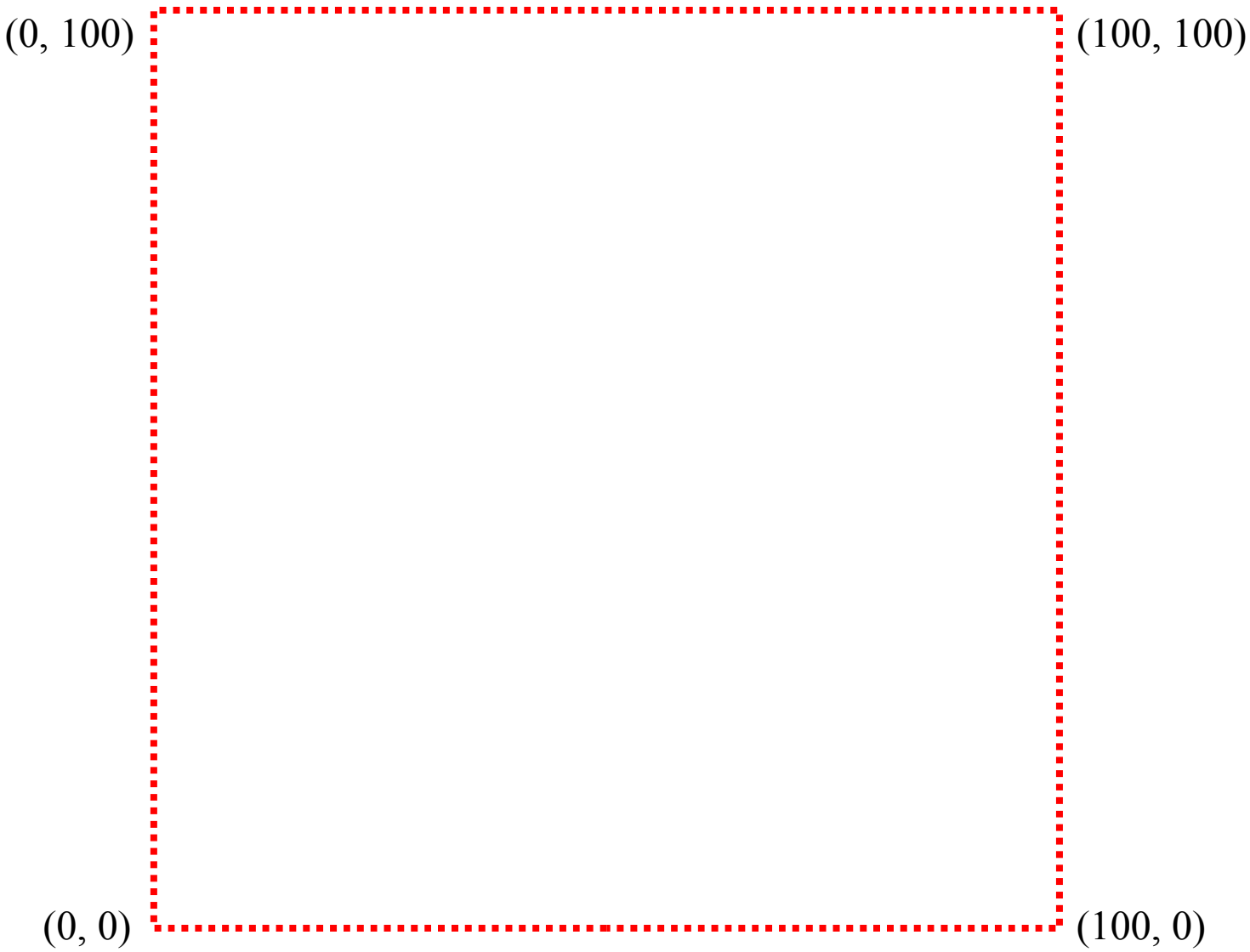
Se P é um ponteiro para um nó e I é um quadrante, então estes campos são referenciados SON(P, I)

Point QuadTrees - Exemplo

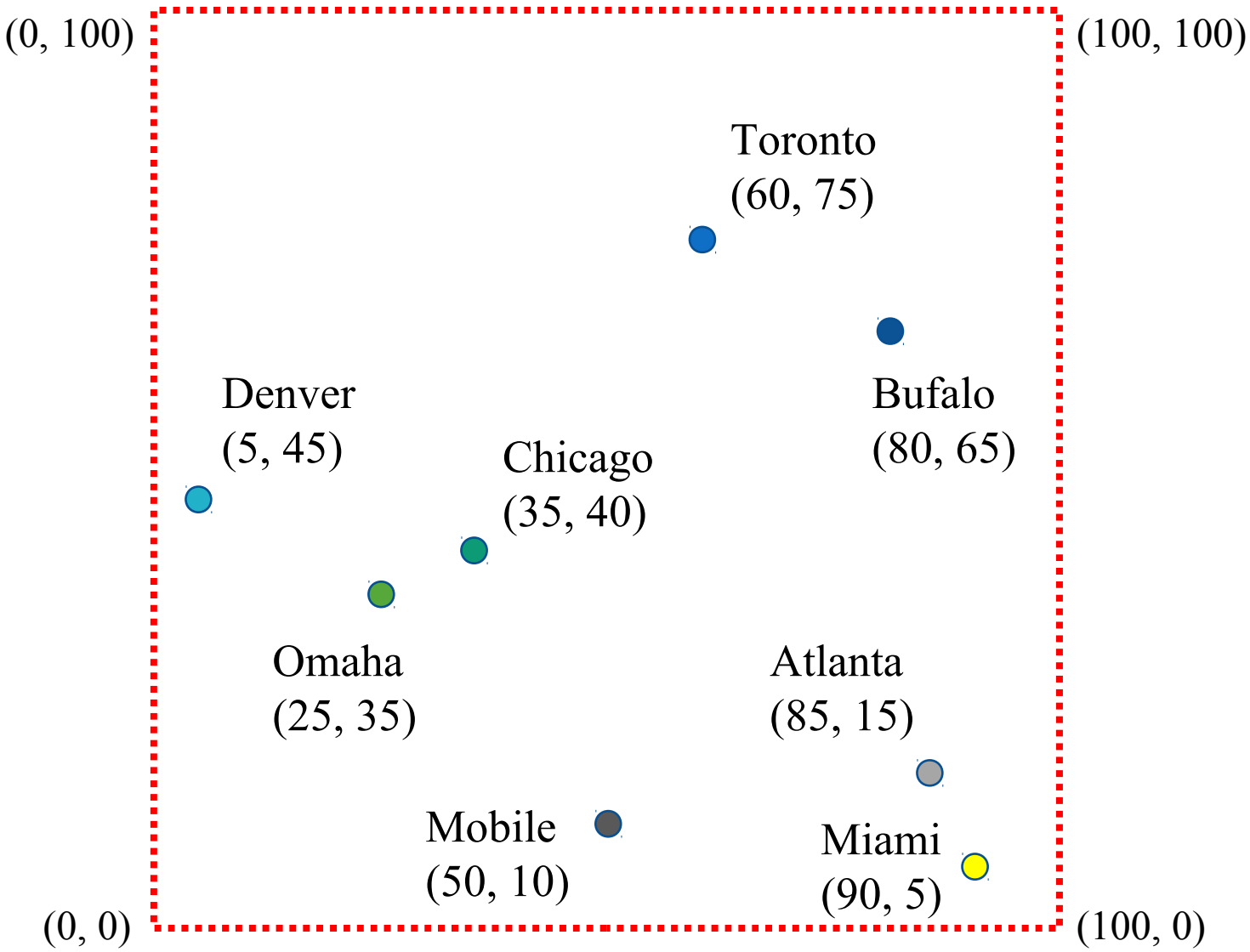




Point QuadTrees – Exemplo (Quadrante)

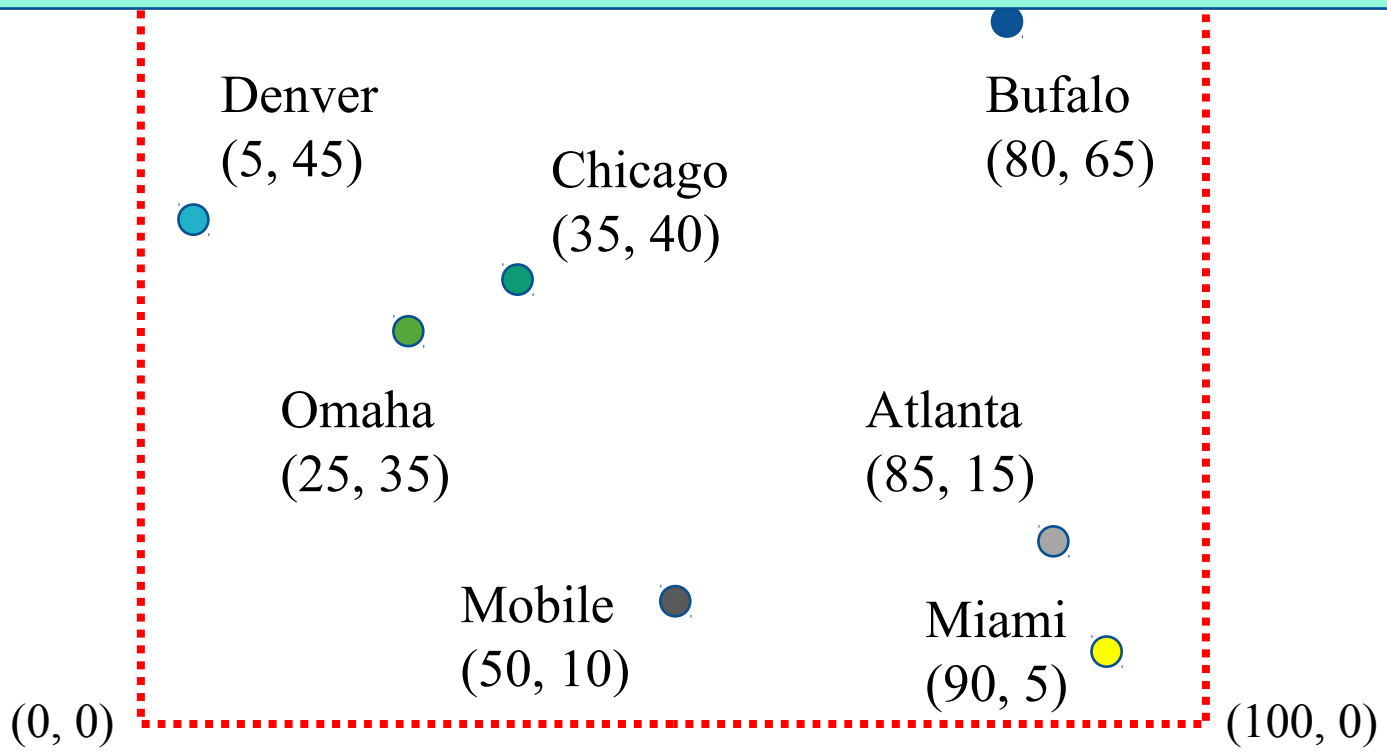


Point QuadTrees – Cidades (pontos)



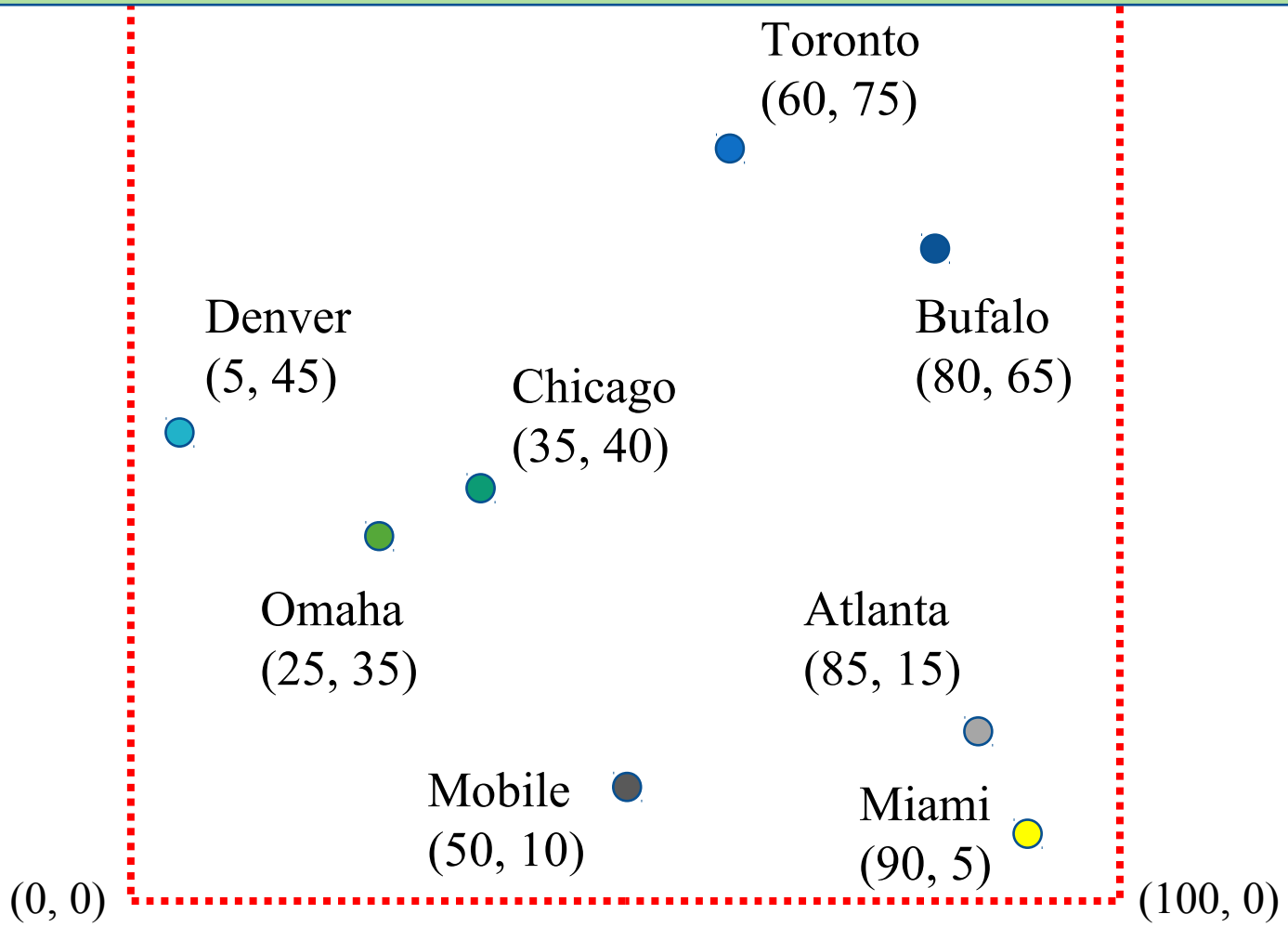
Point QuadTrees - Inserção

Registros são inseridos de forma semelhante à árvore binária de busca.
A posição desejada é buscada de acordo com as coordenadas X e Y.
Em cada nó uma comparação é feita e a subárvore apropriada (NE, NW, SW ou SE) é escolhida.
Quando chega-se na base da árvore (filho nulo), foi encontrada a posição desejada para inserir o registro.

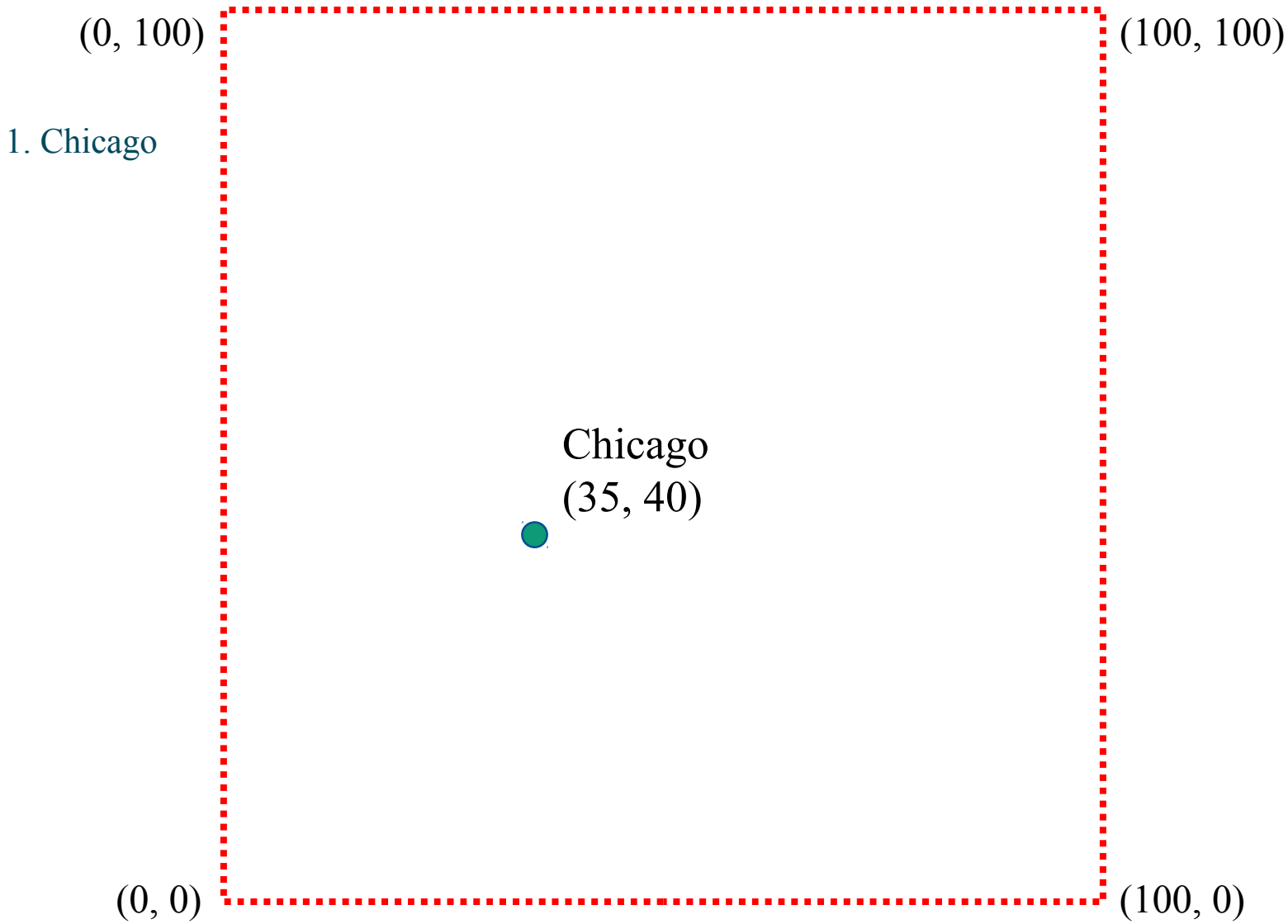


Point QuadTrees - Inserção

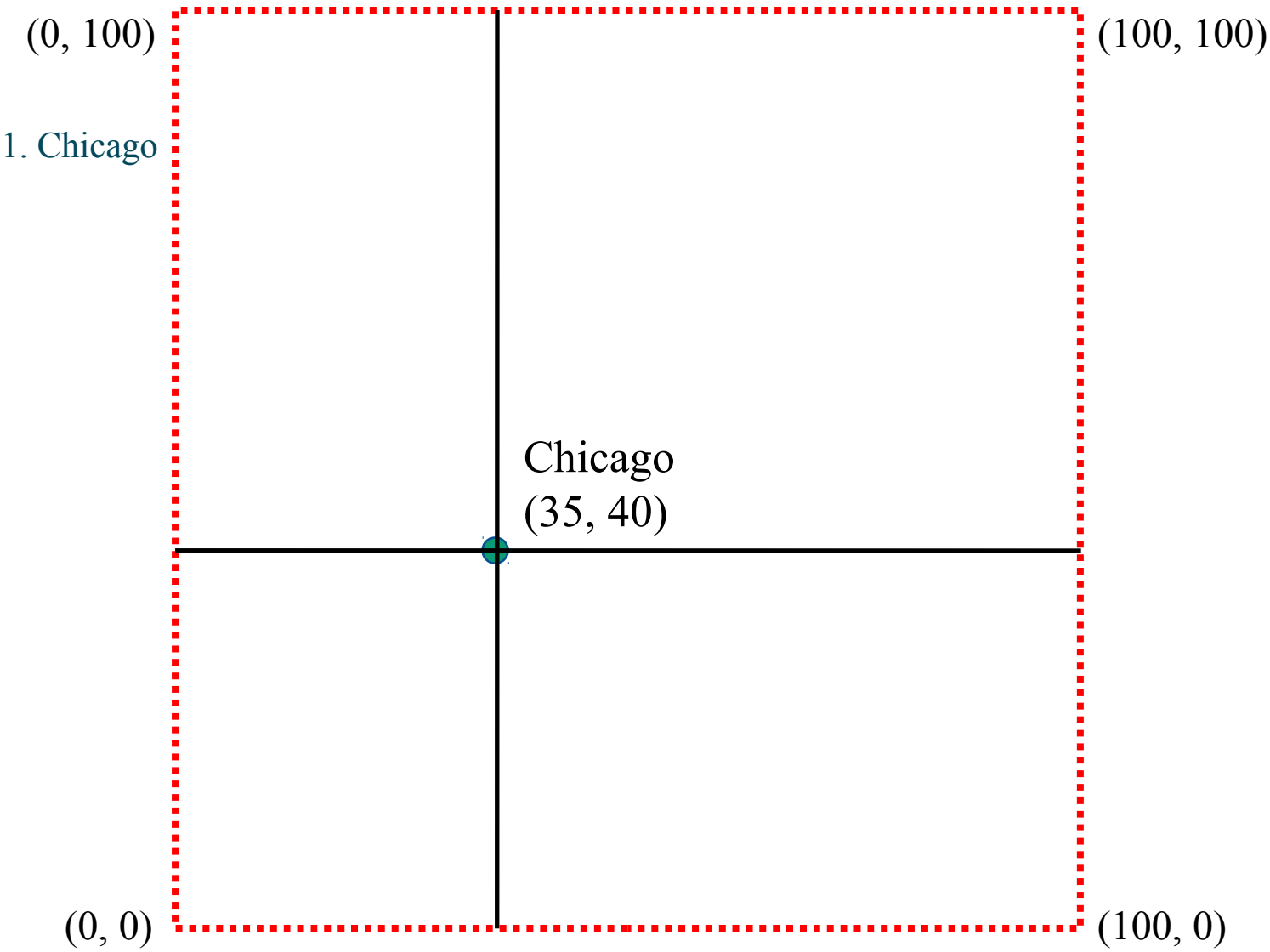
Inserção na ordem: Chicago, Mobile, Toronto, Buffalo, Denver, Omaha, Atlanta e Miami.



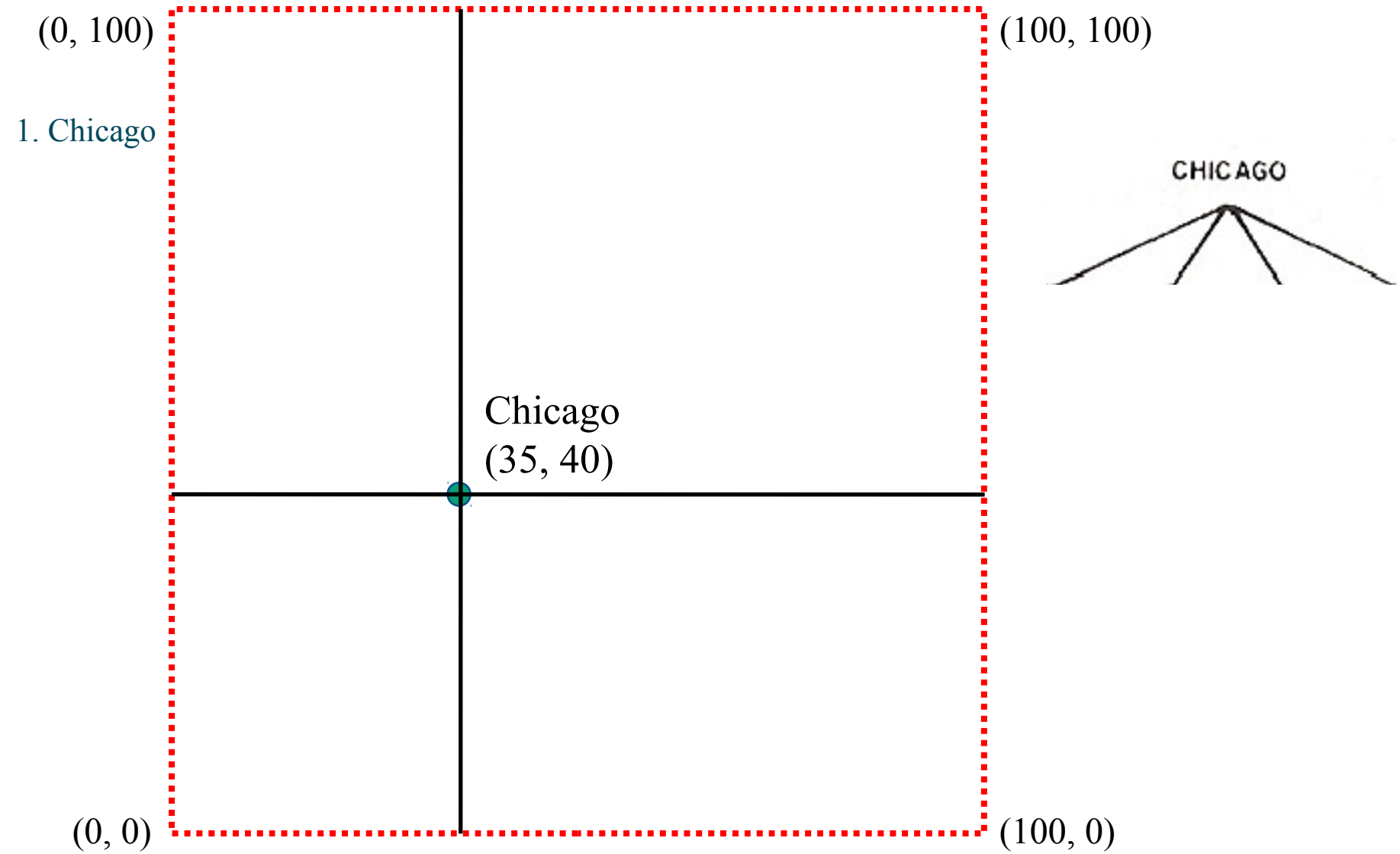
Point QuadTrees - Inserção



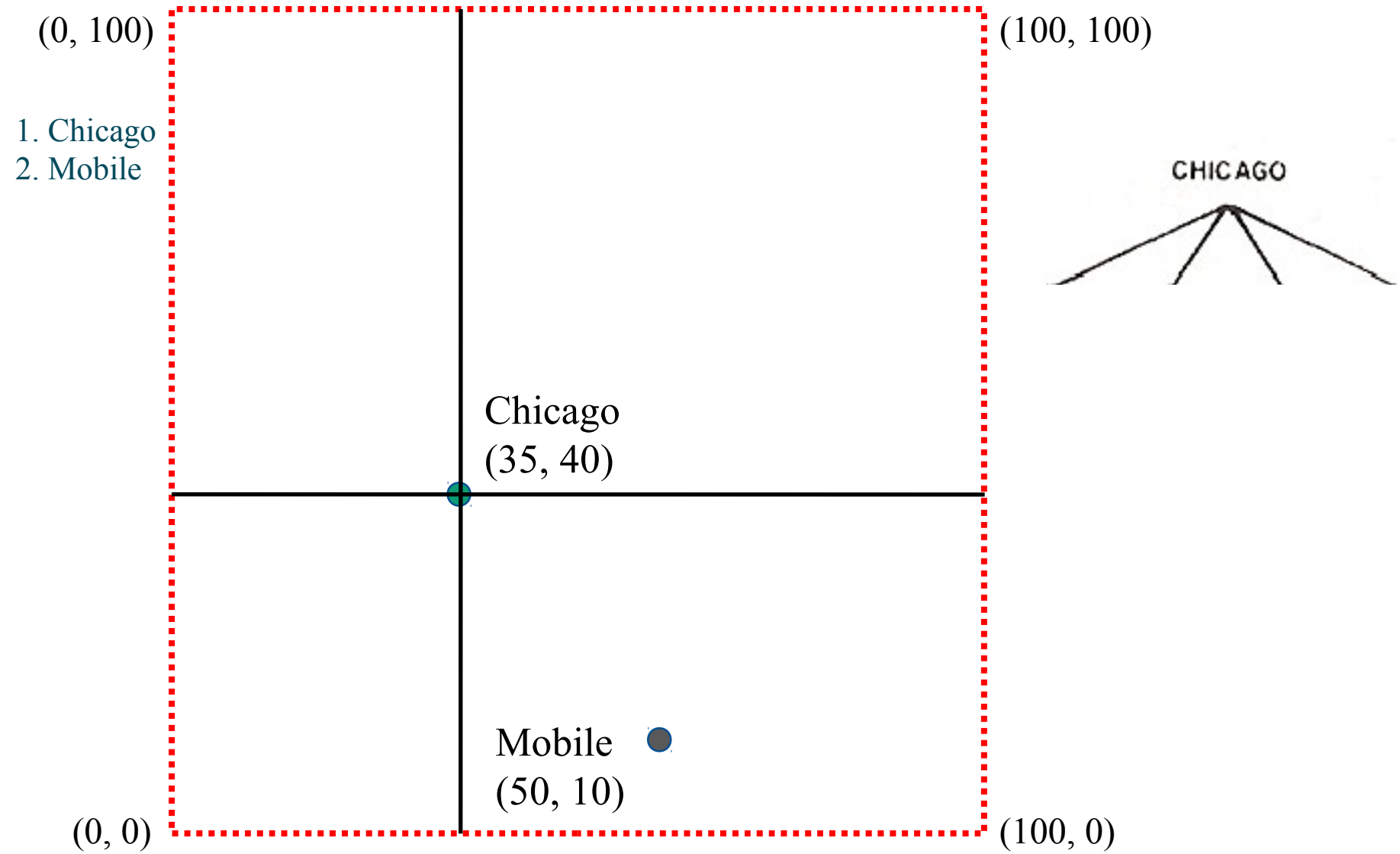
Point QuadTrees - Inserção



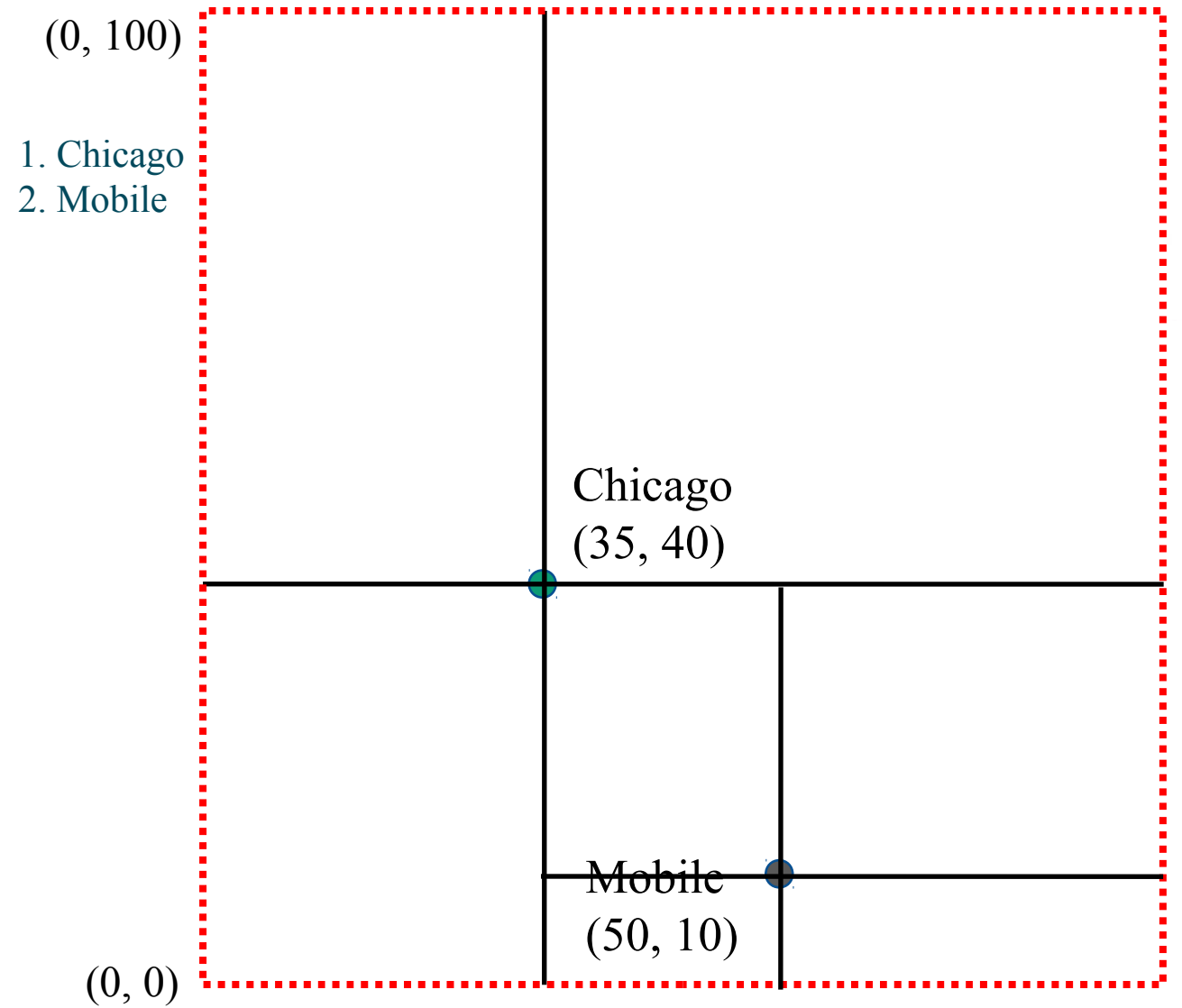
Point QuadTrees - Inserção

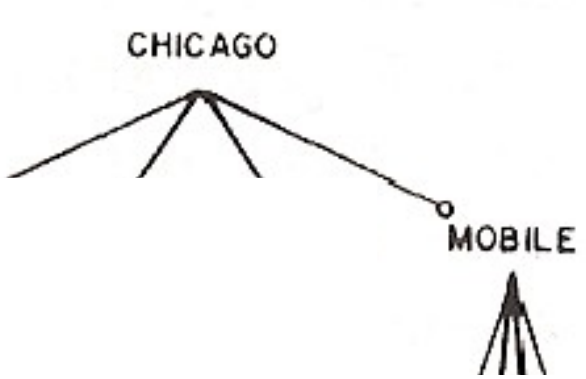


Point QuadTrees - Inserção

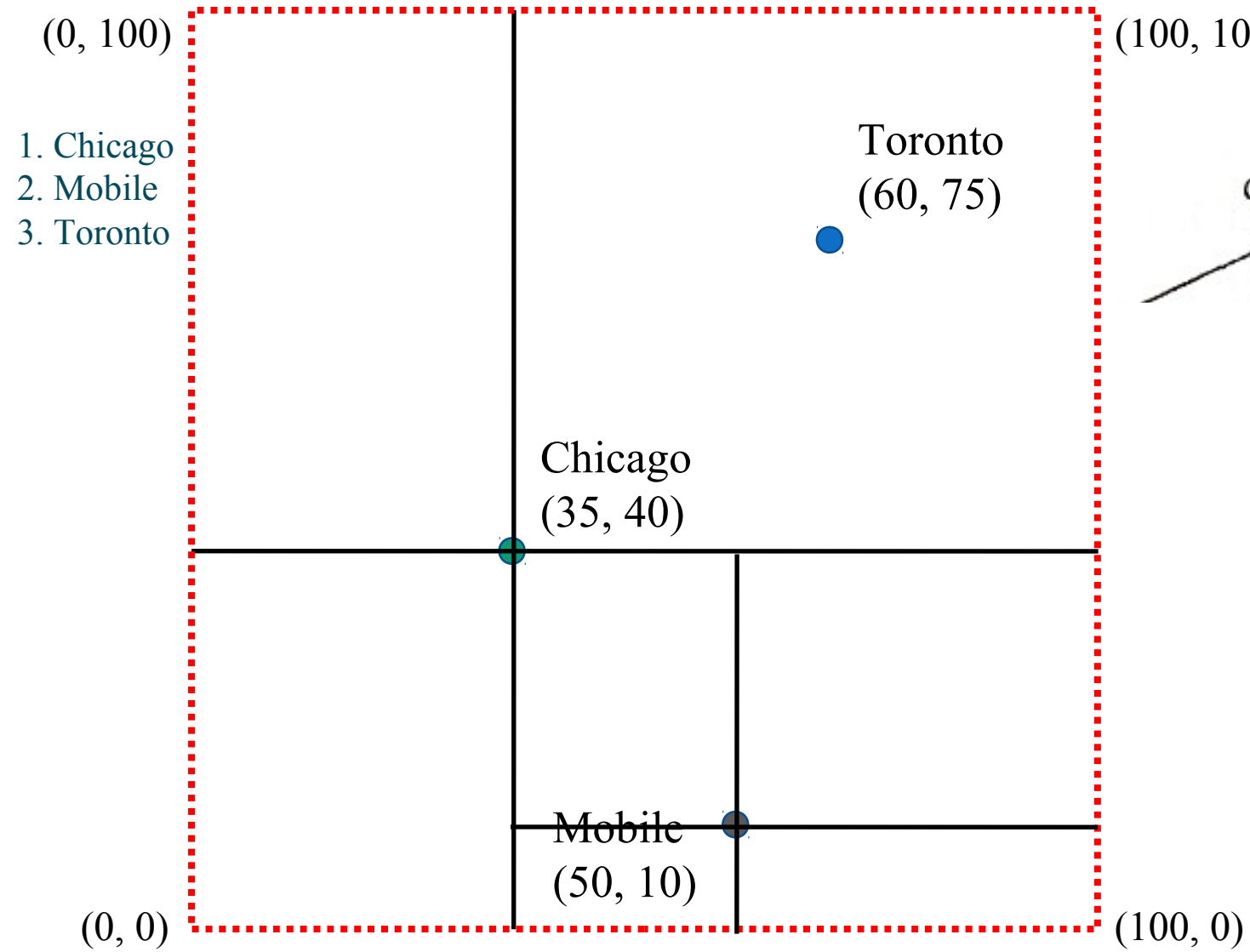


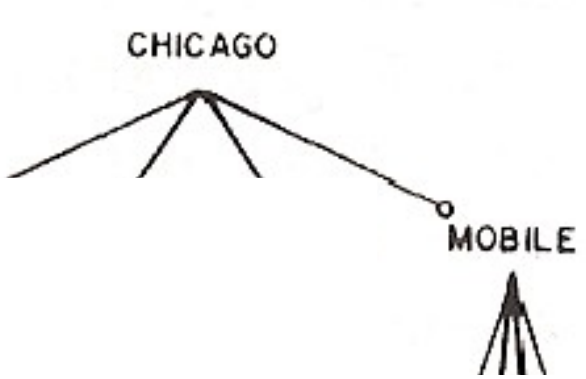
Point QuadTrees - Inserção



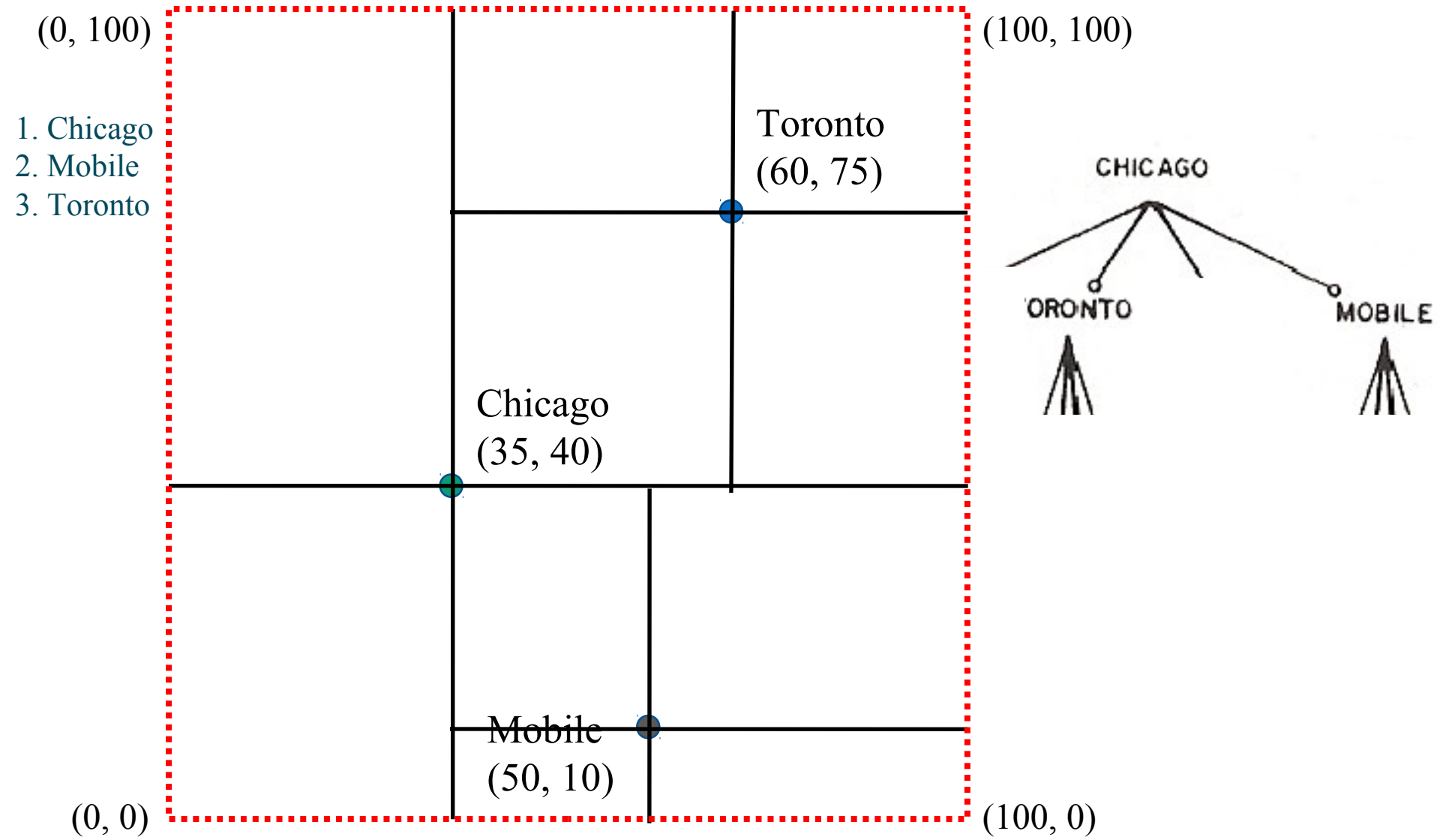


Point QuadTrees - Inserção

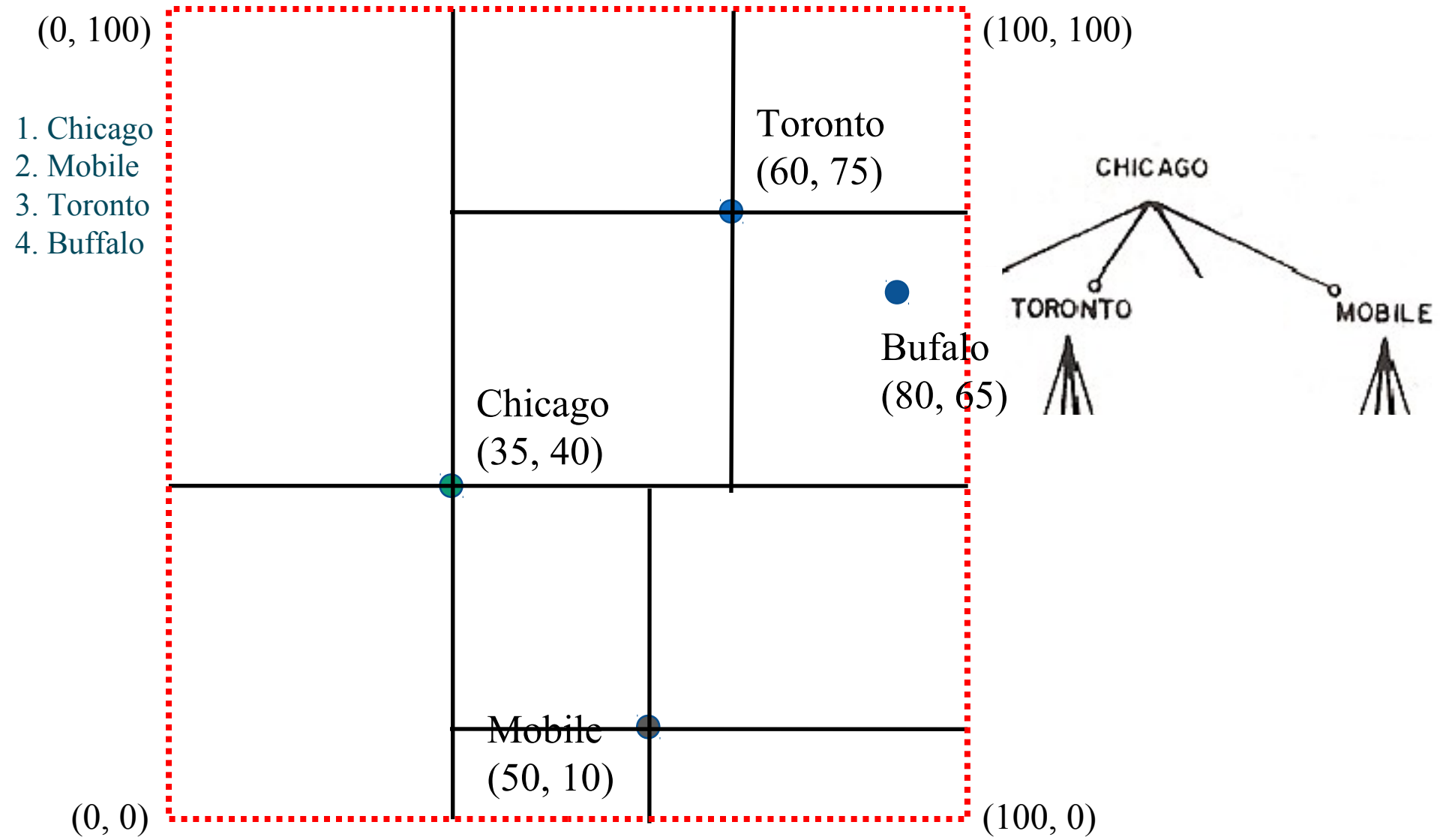




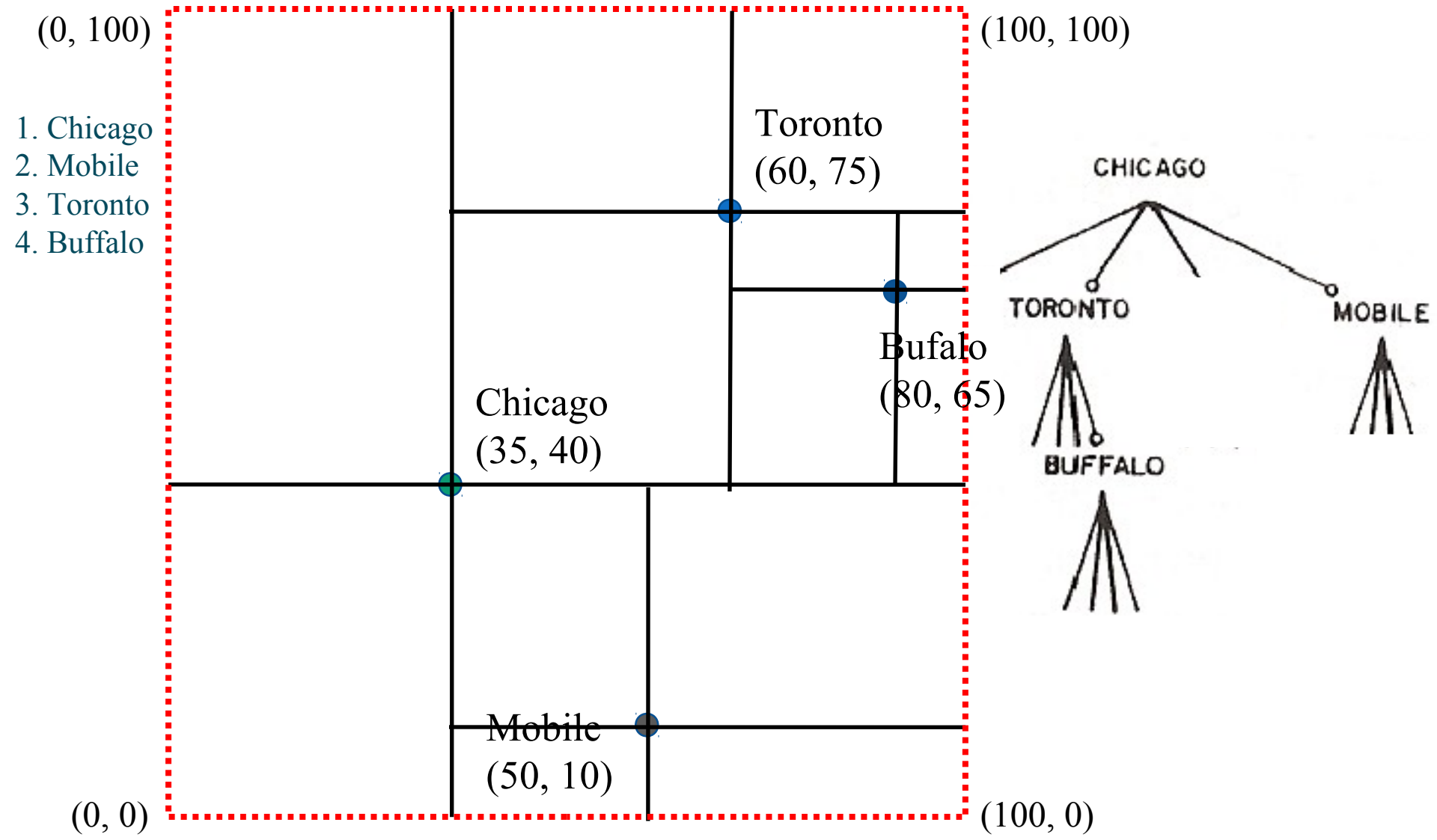
Point QuadTrees - Inserção



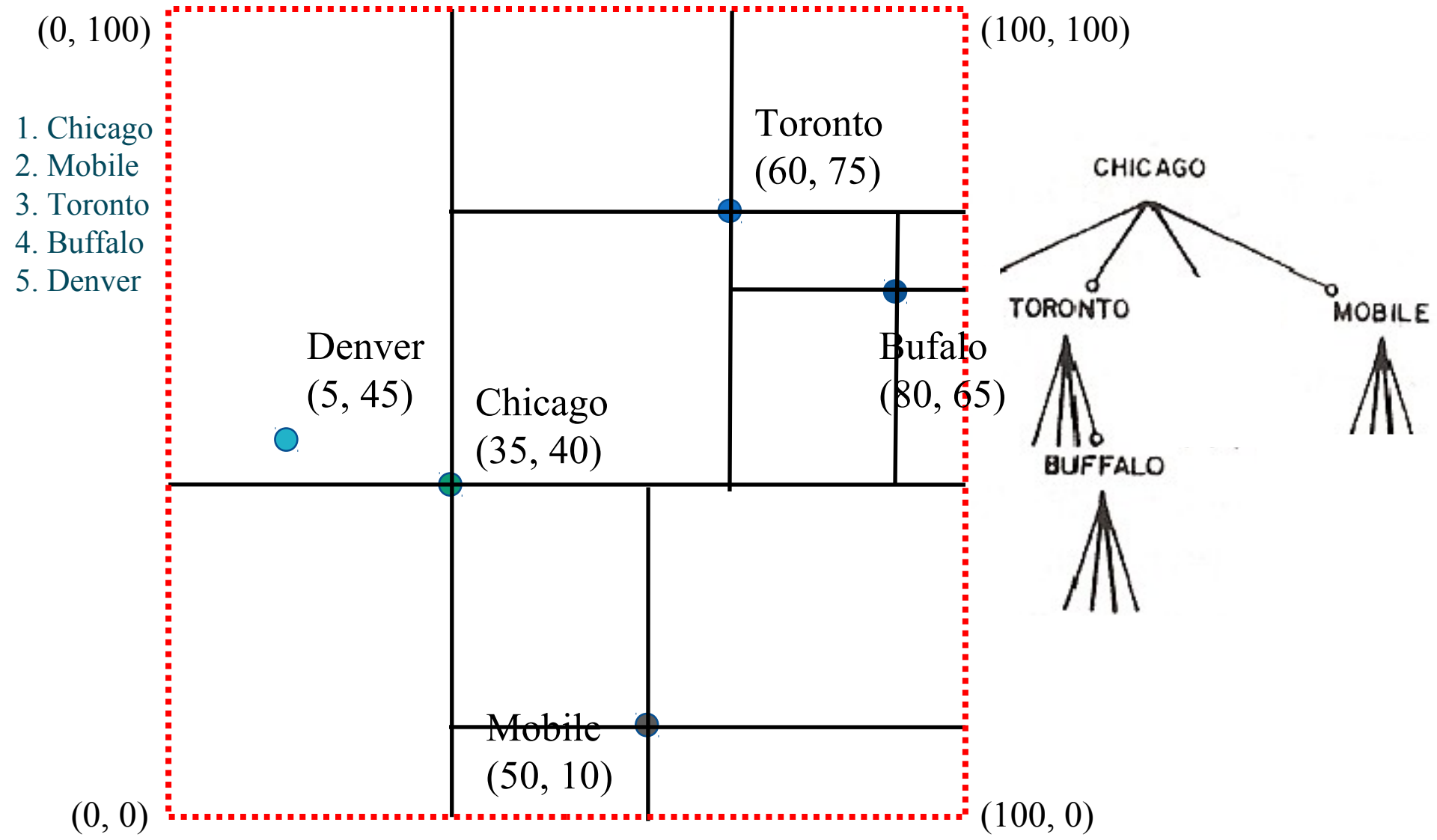
Point QuadTrees - Inserção



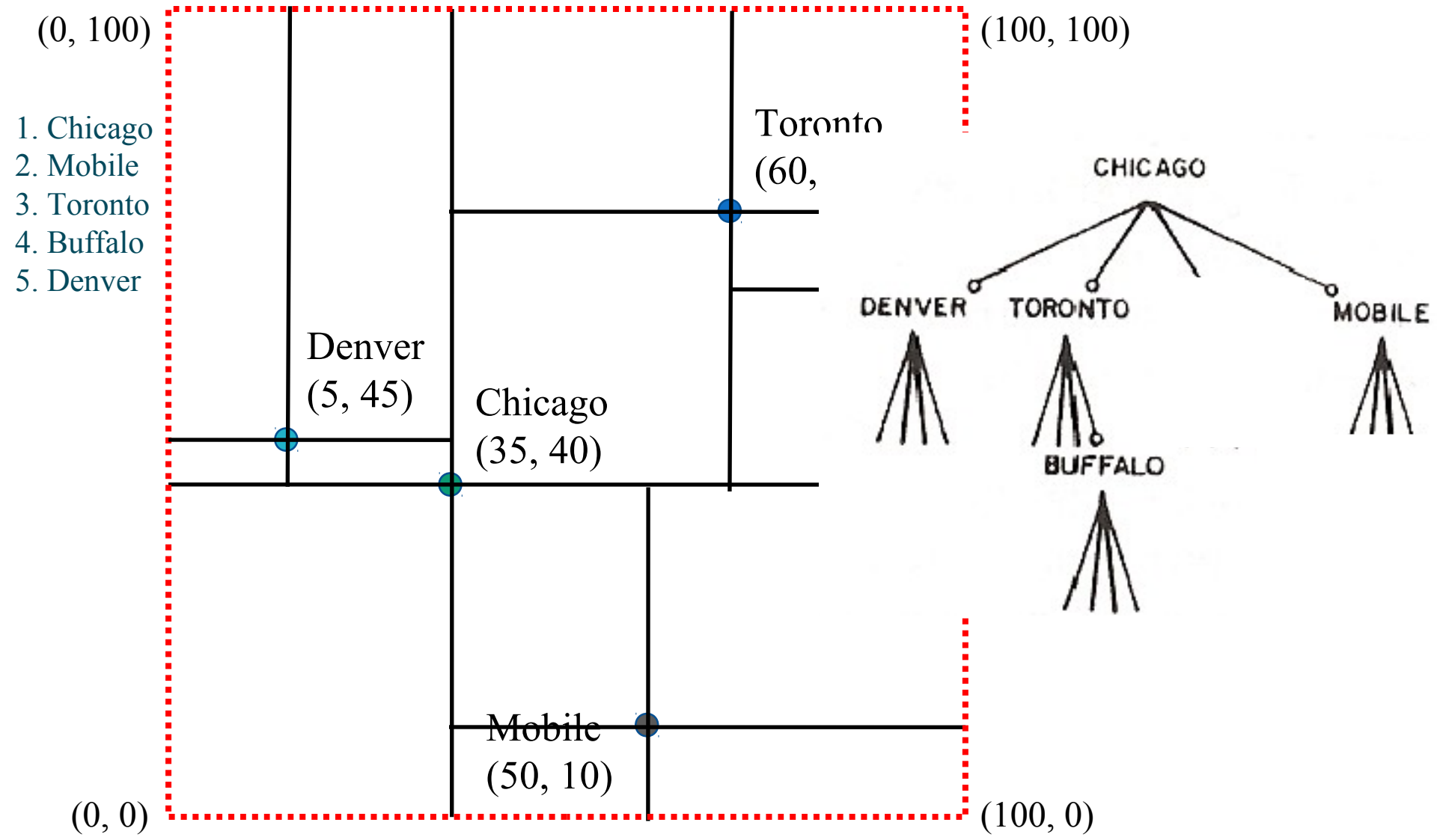
Point QuadTrees - Inserção



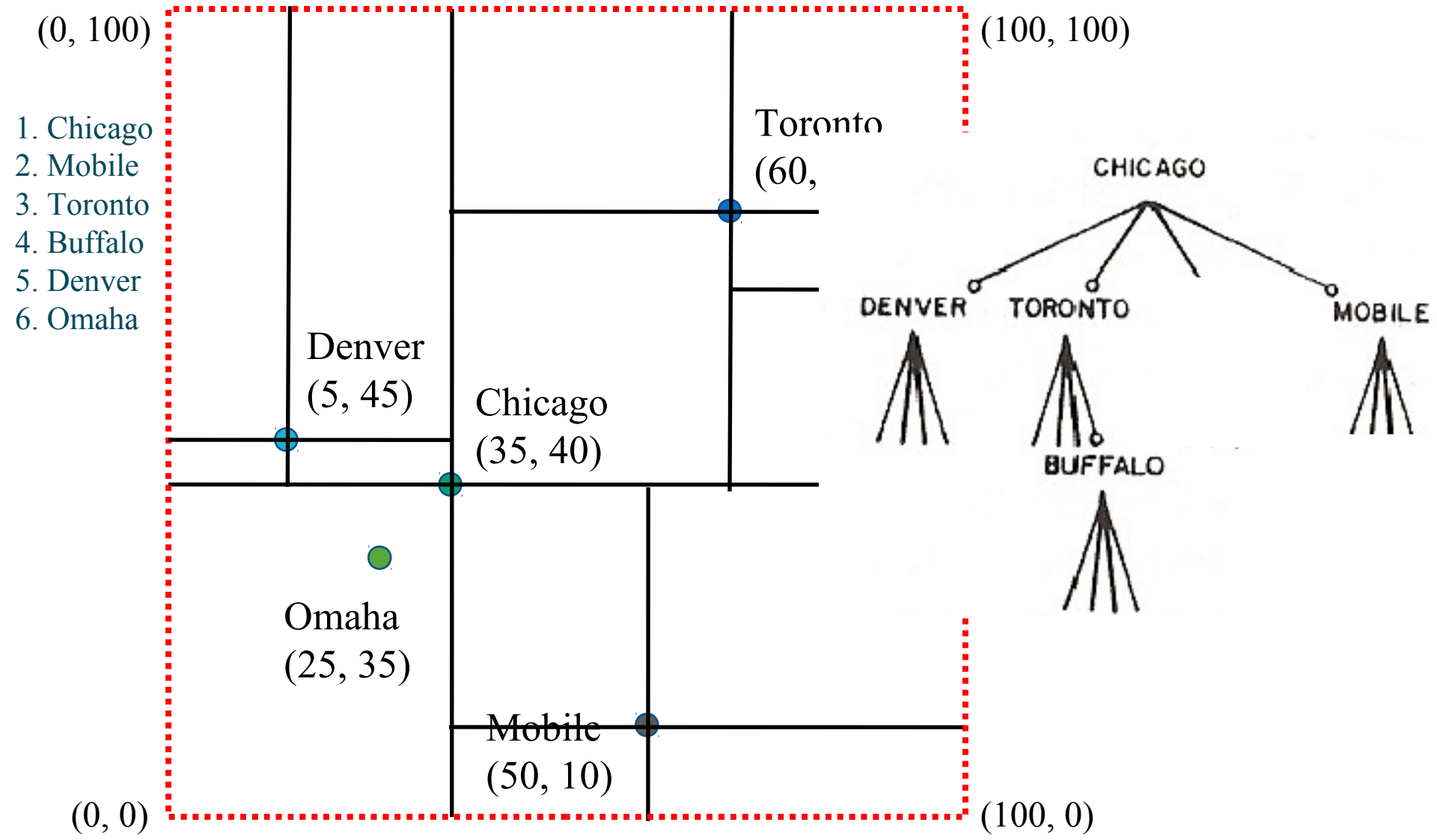
Point QuadTrees - Inserção



Point QuadTrees - Inserção

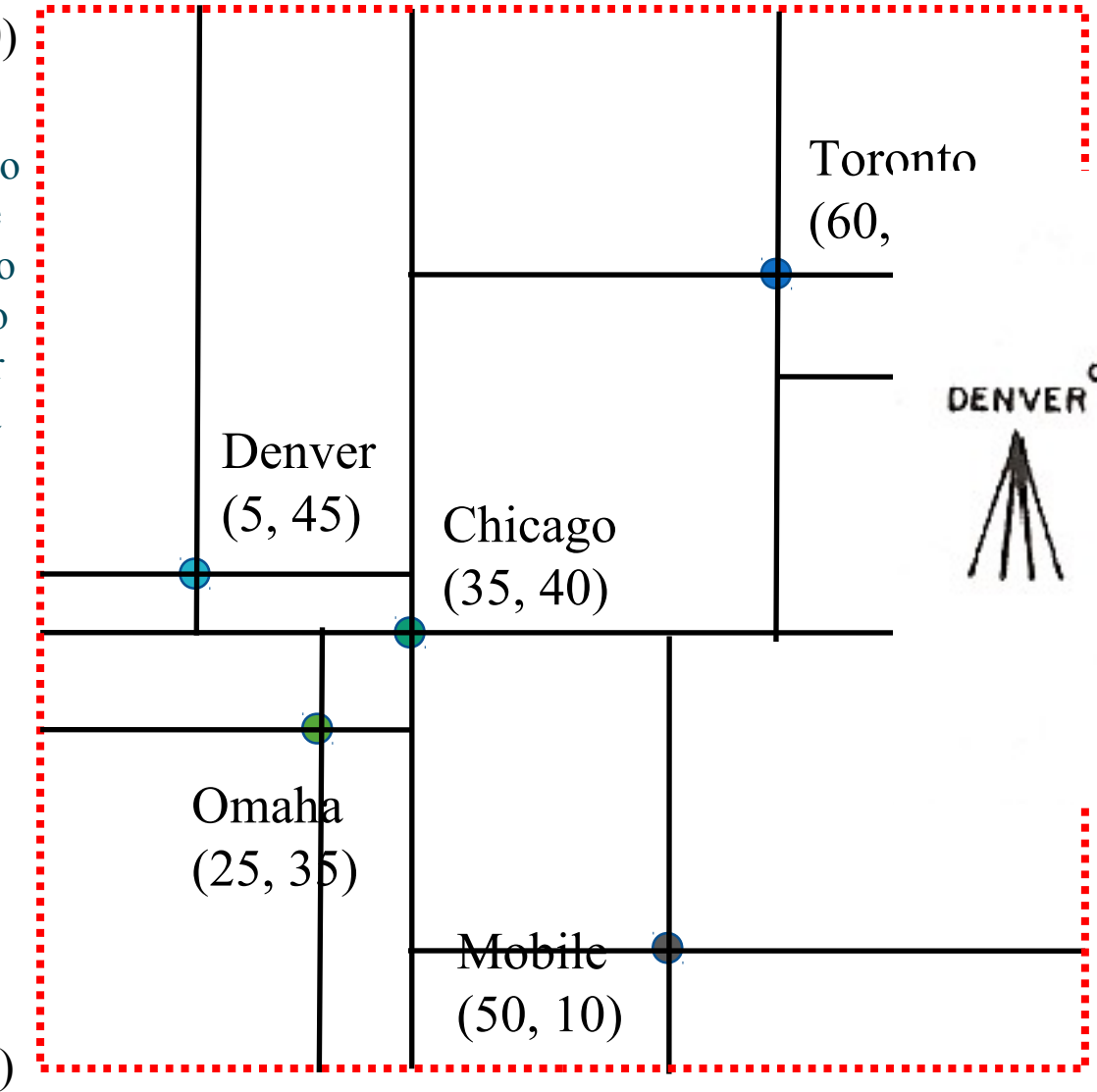


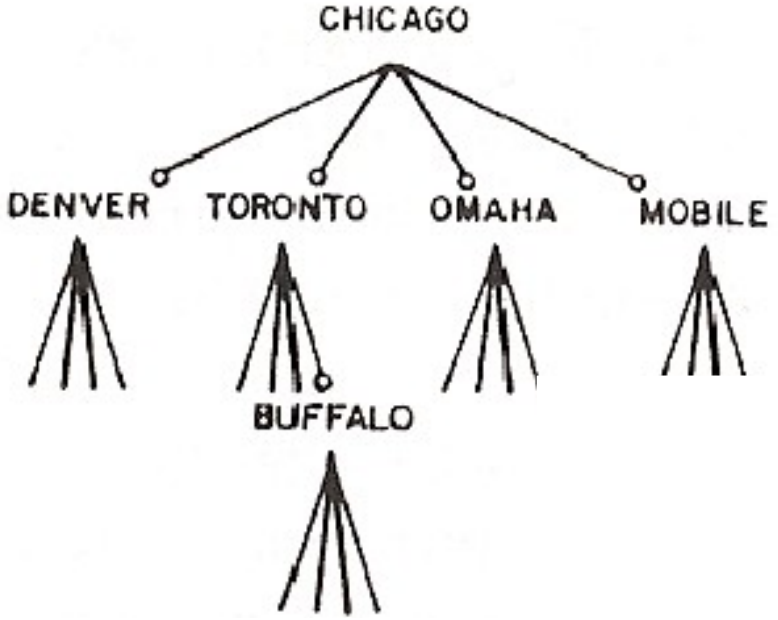
Point QuadTrees - Inserção



Point QuadTrees - Inserção

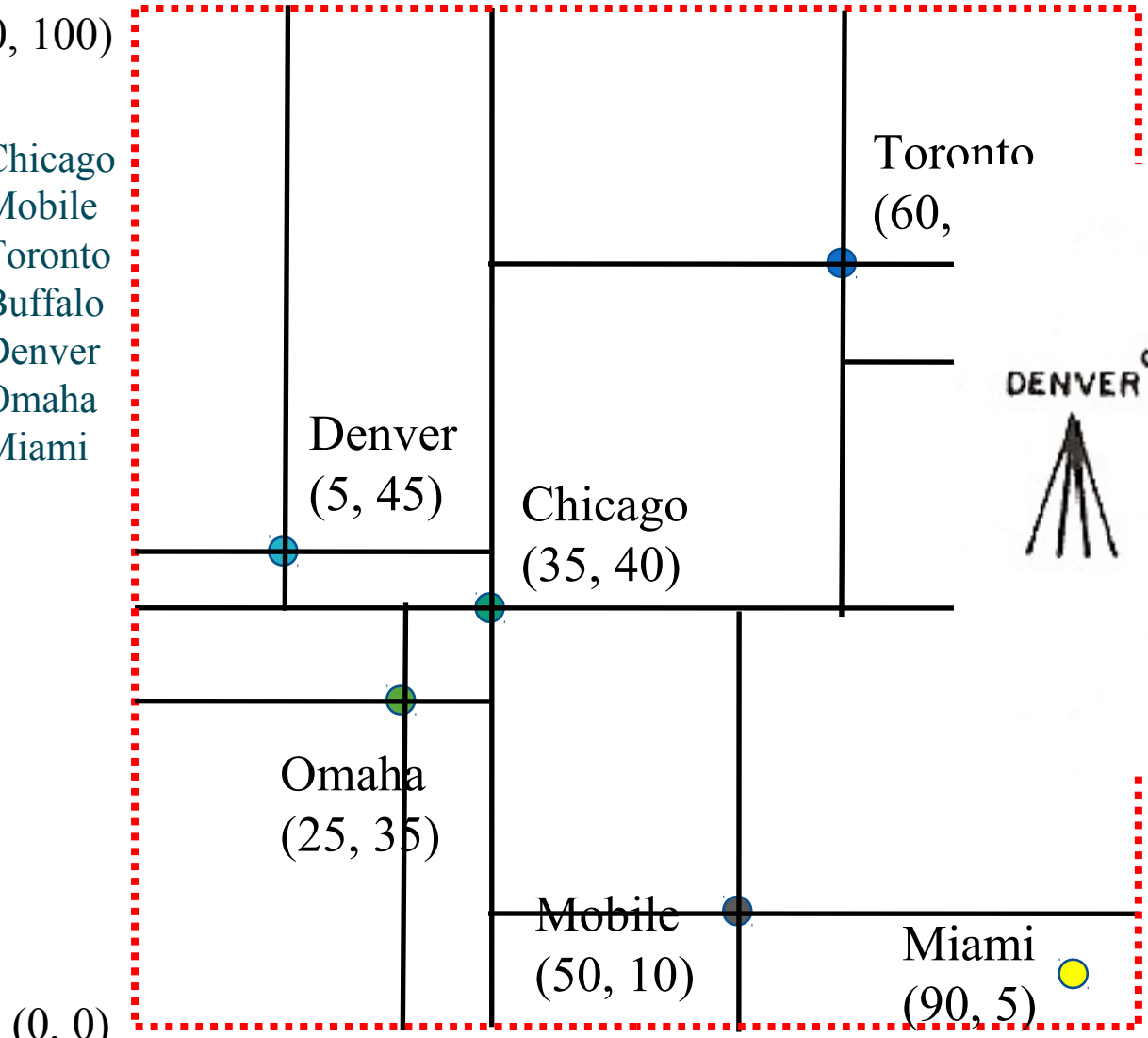
1. Chicago
2. Mobile
3. Toronto
4. Buffalo
5. Denver
6. Omaha

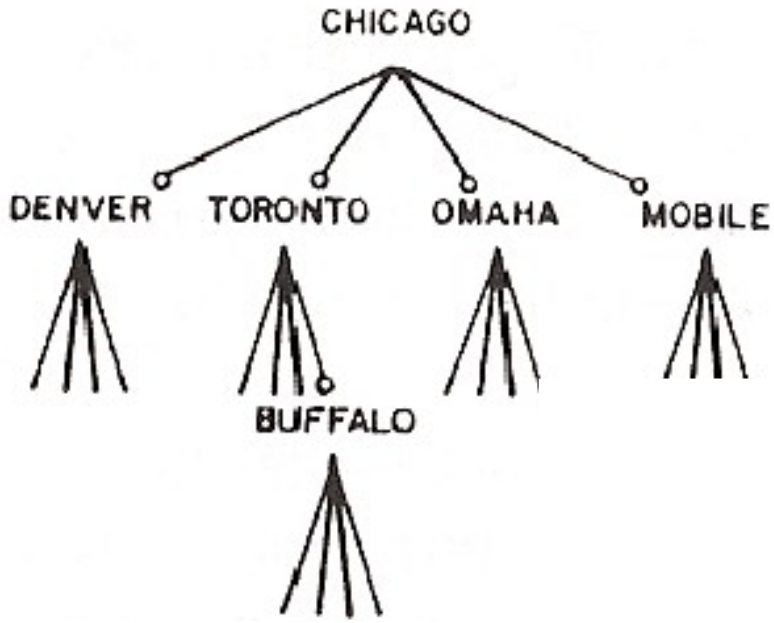




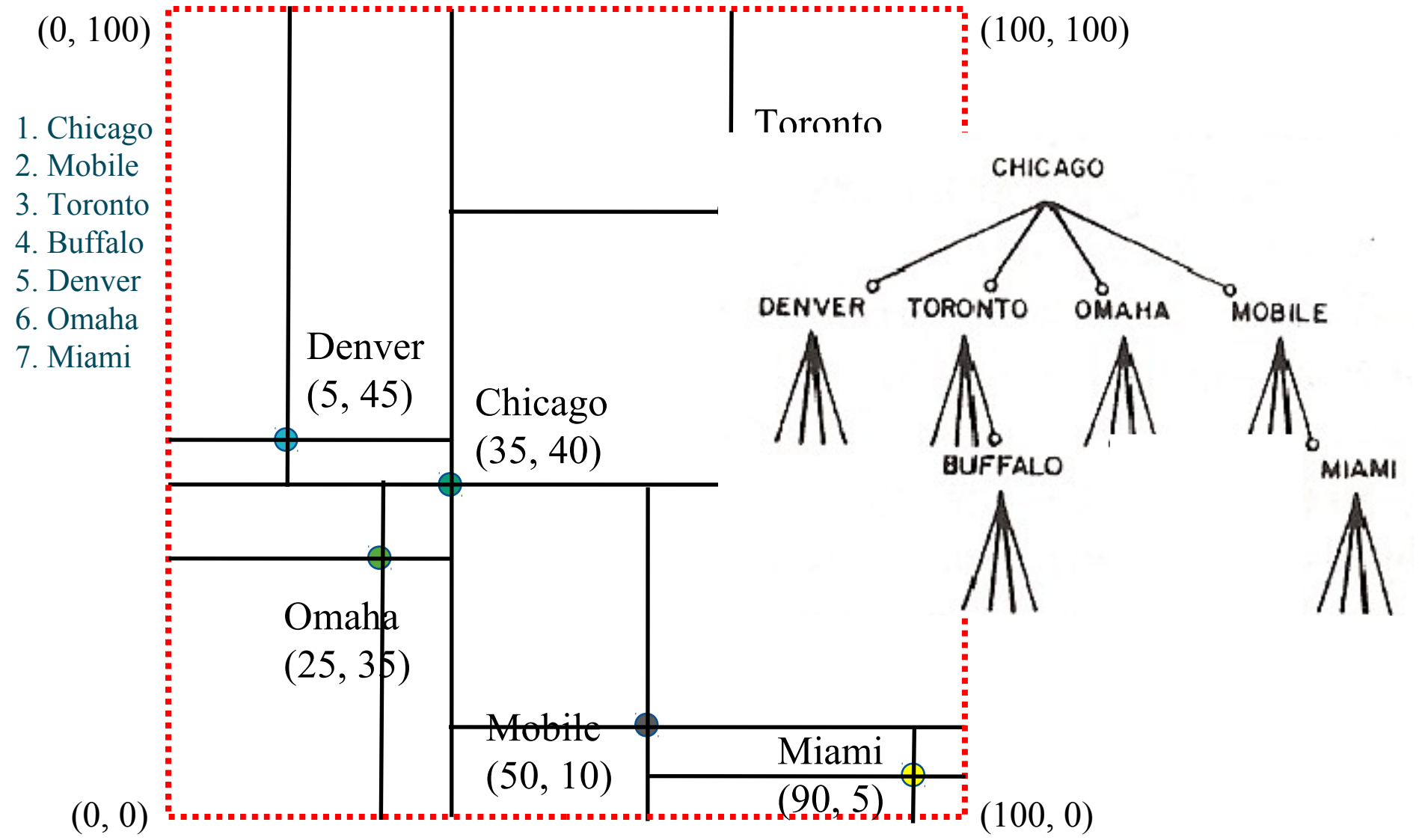
Point QuadTrees - Inserção

1. Chicago
2. Mobile
3. Toronto
4. Buffalo
5. Denver
6. Omaha
7. Miami

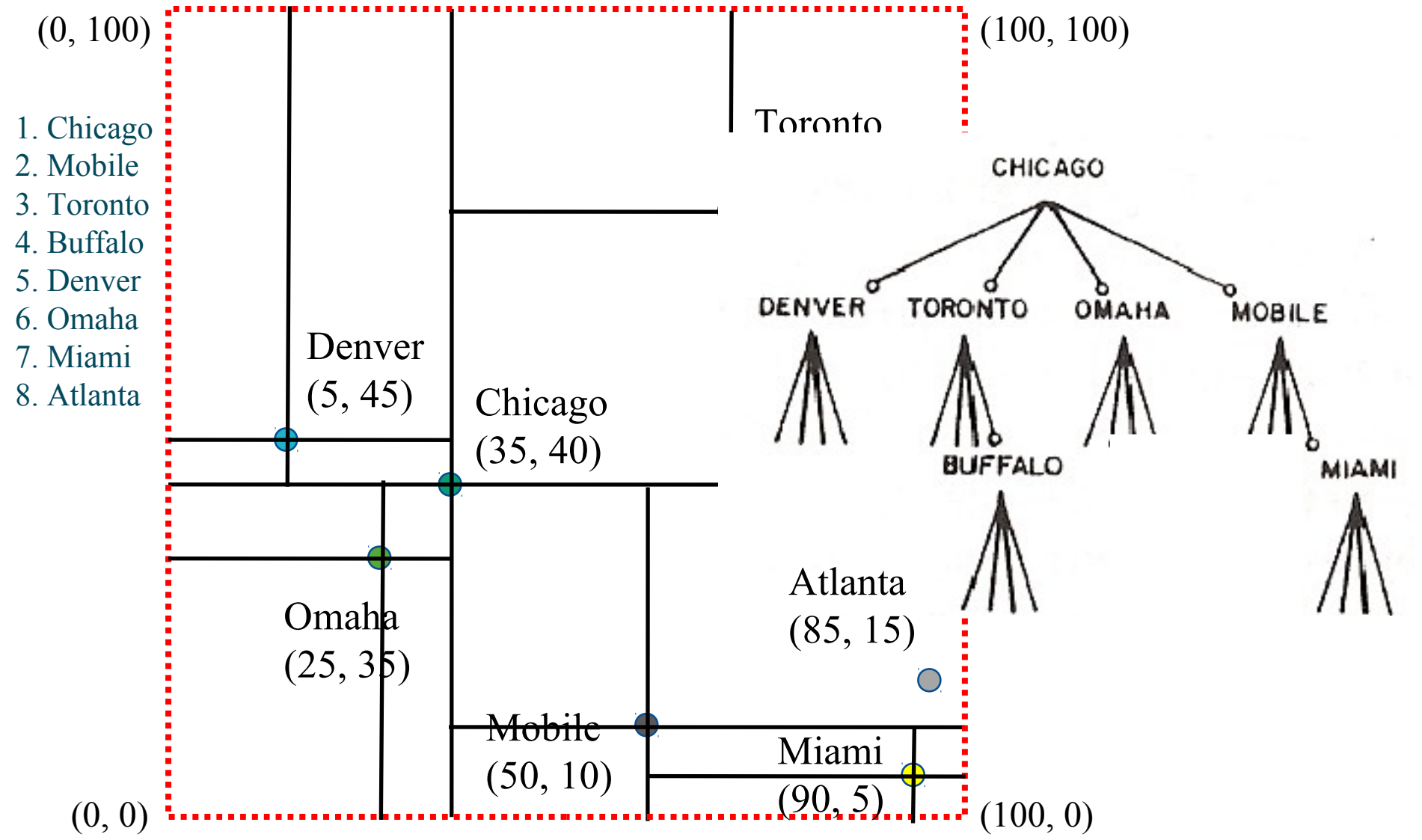




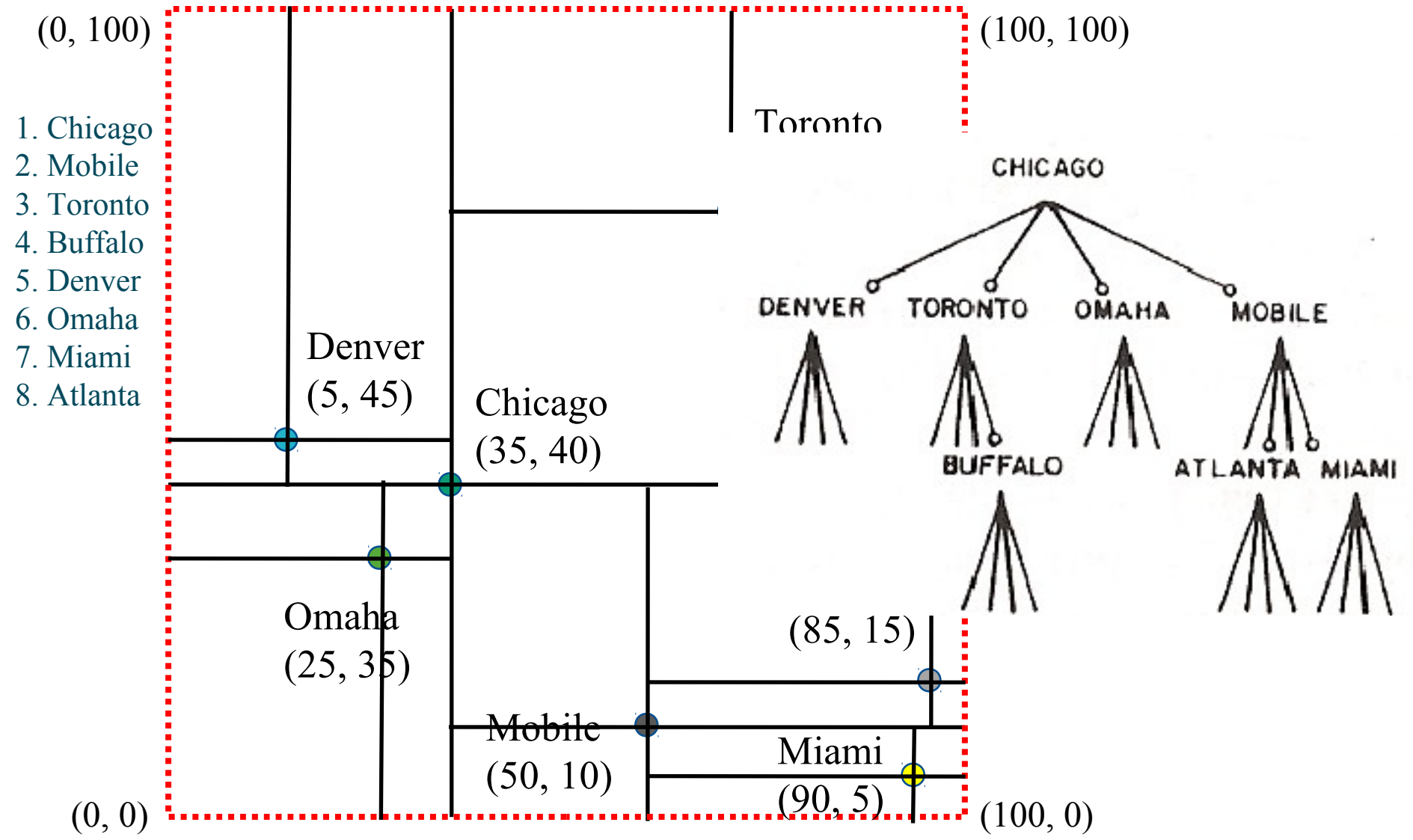
Point QuadTrees - Inserção



Point QuadTrees - Inserção



Point QuadTrees - Inserção



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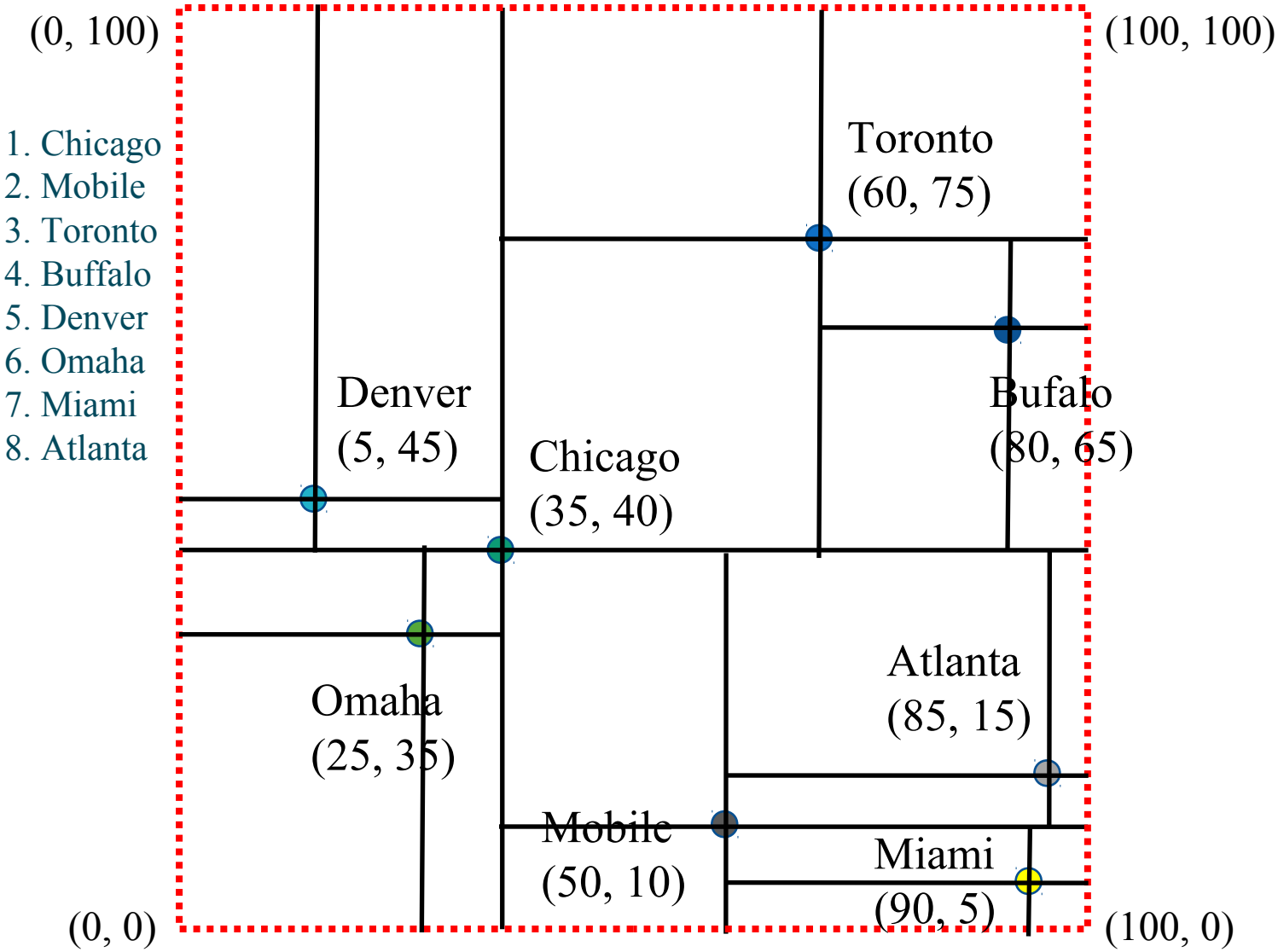
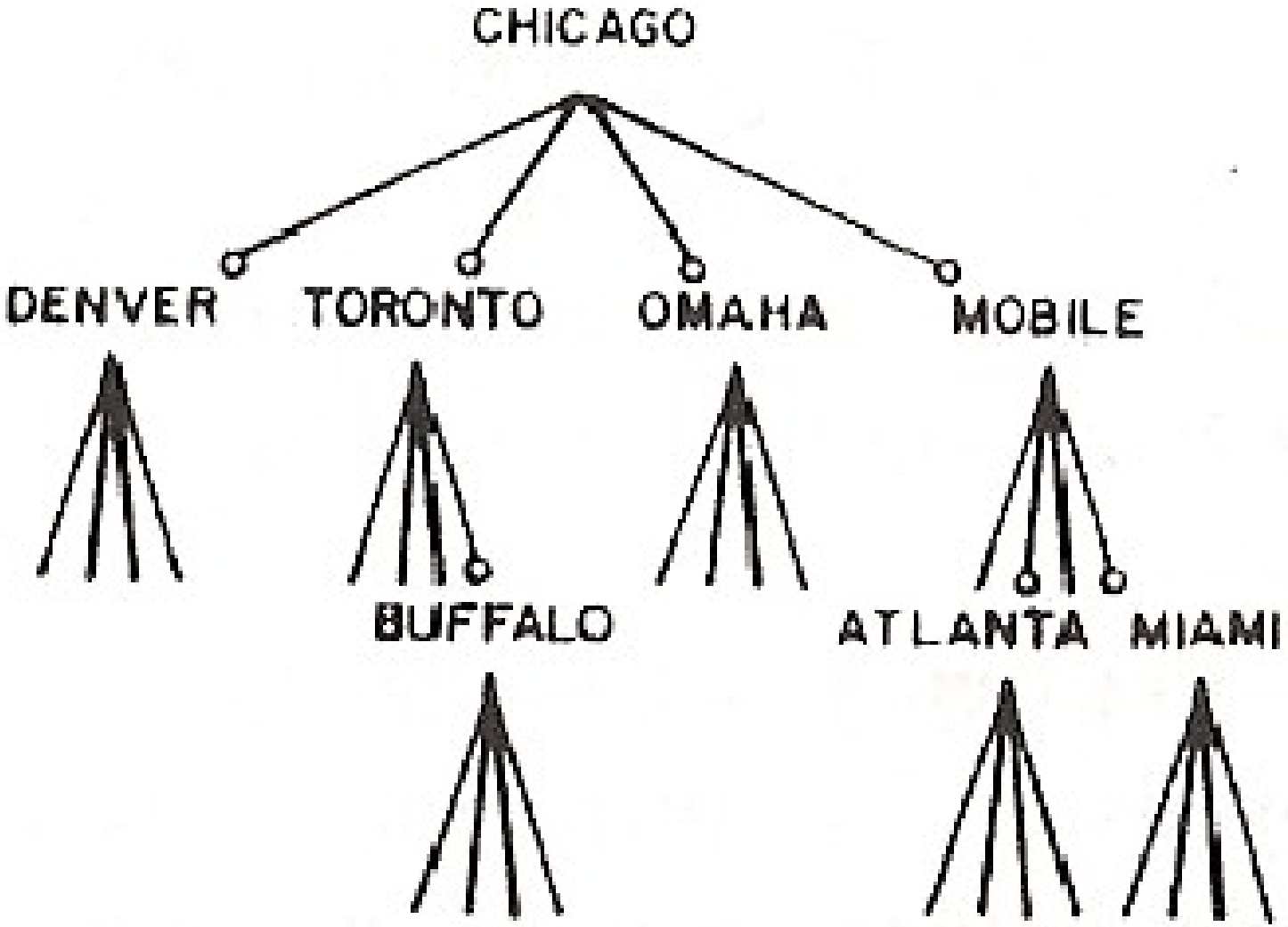
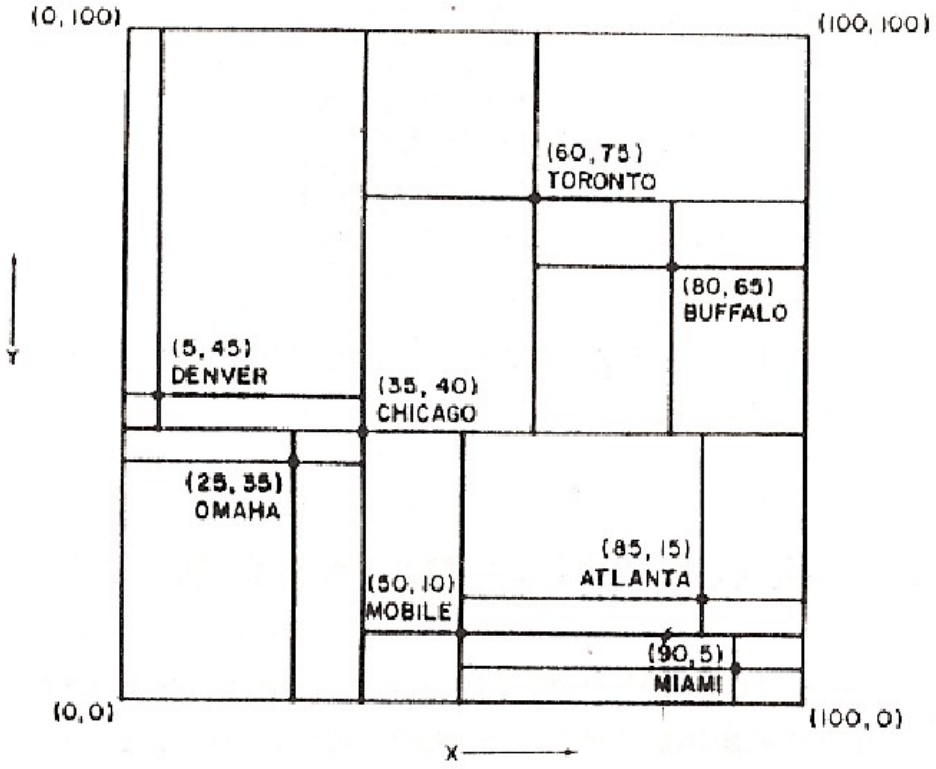
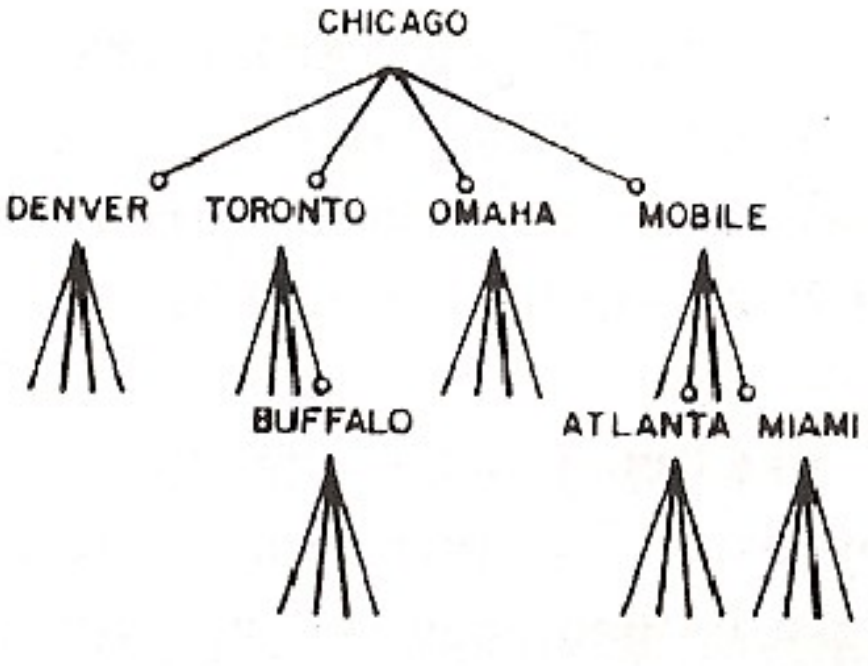


Point QuadTrees - Inserção



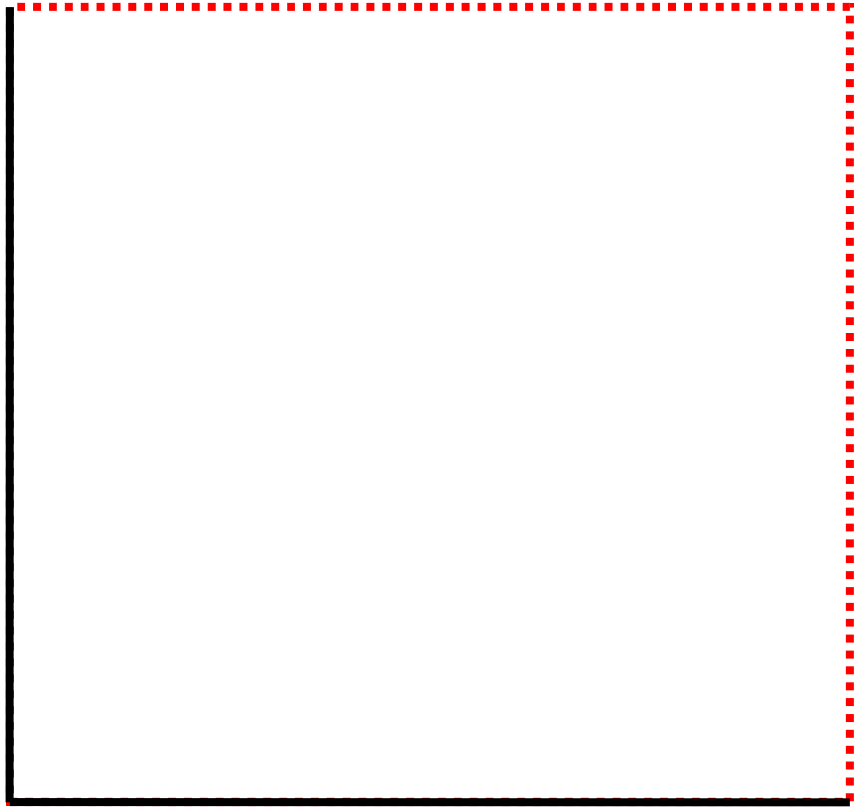
Point QuadTrees - Exemplo





Ponto sobre a linha de um quadrante

- Regra adotada
  - Limites inferior e esquerdo de cada bloco são fechados
  - Limites superior e direito são abertos



Ponto sobre a linha de um quadrante

- Regra adotada
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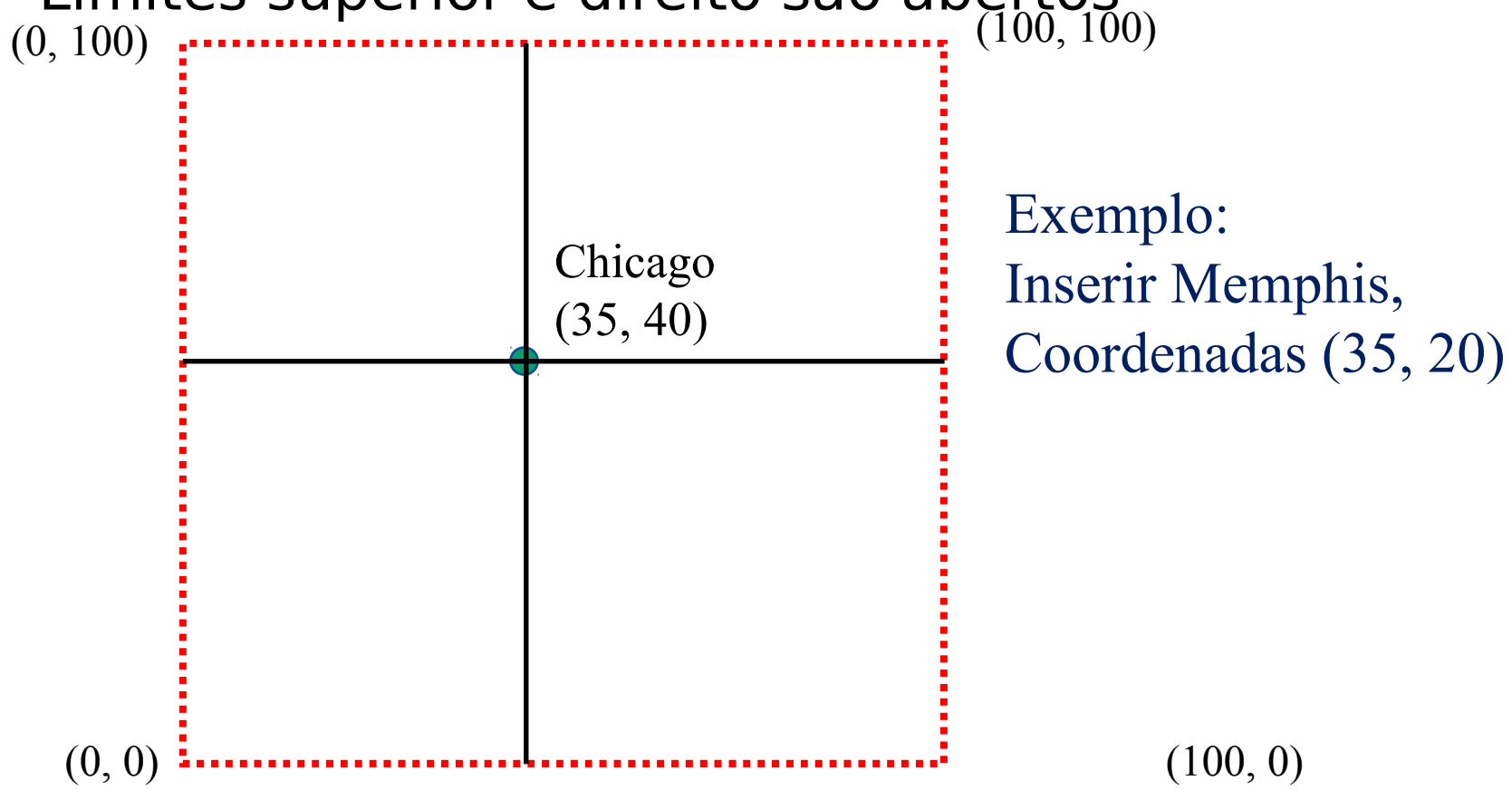
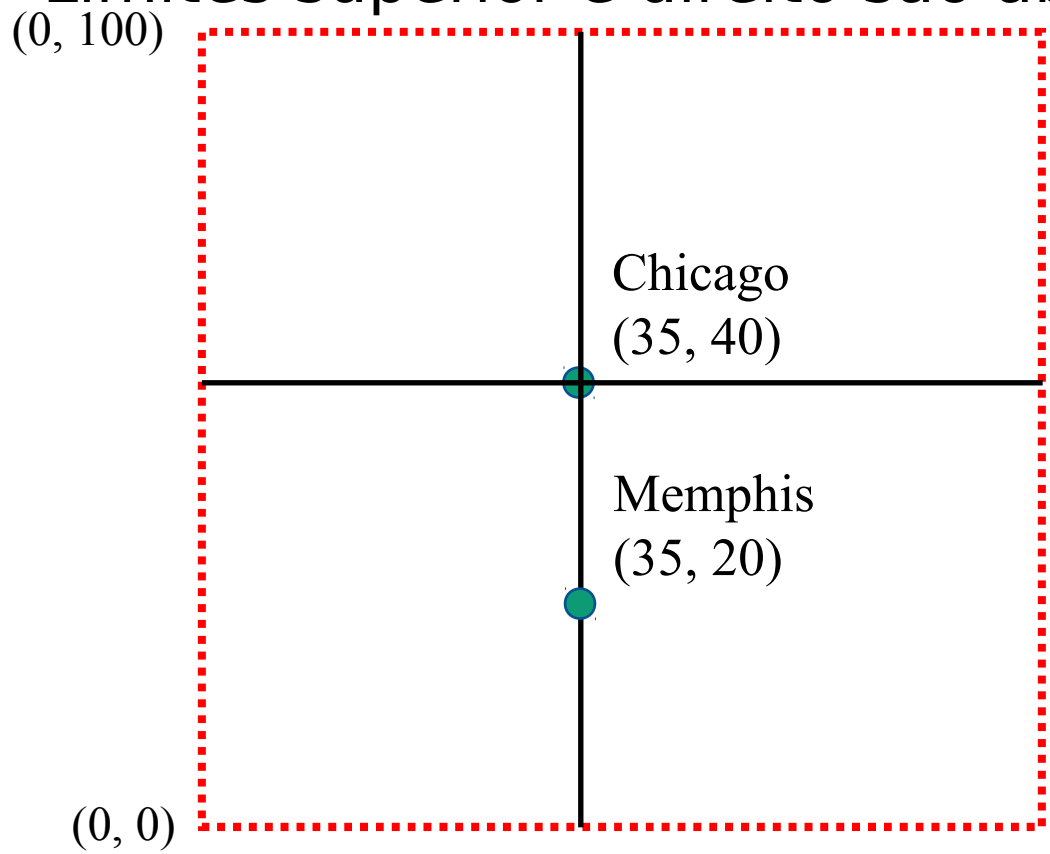


Exemplo:
Inserir Memphis,
Coordenadas (35, 20)

Ponto sobre a linha de um quadrante

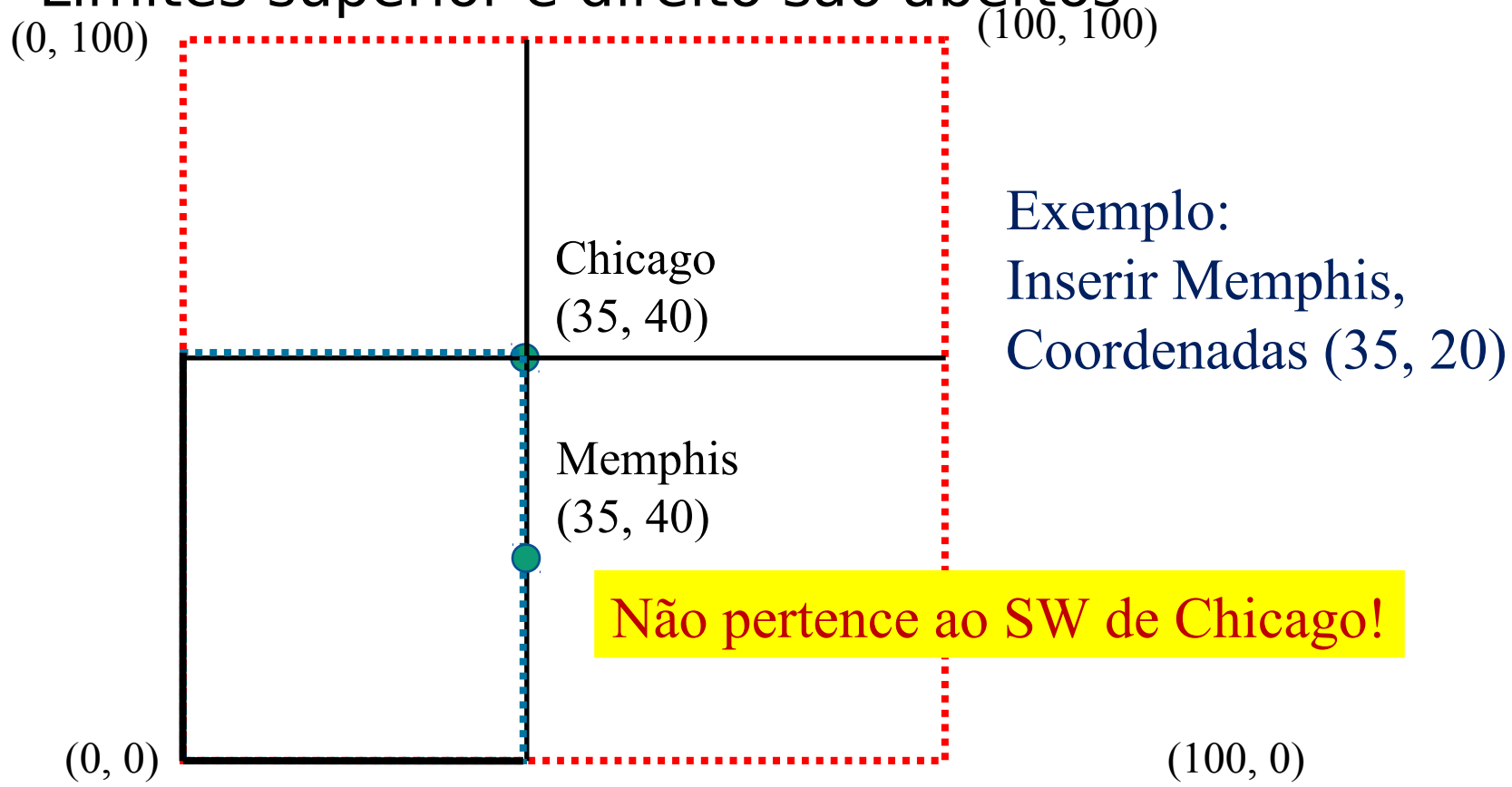
- Regra adotada
  - Limites inferior e esquerdo de cada bloco são fechados
  - Limites superior e direito são abertos



Exemplo:
Inserir Memphis,
Coordenadas (35, 20)

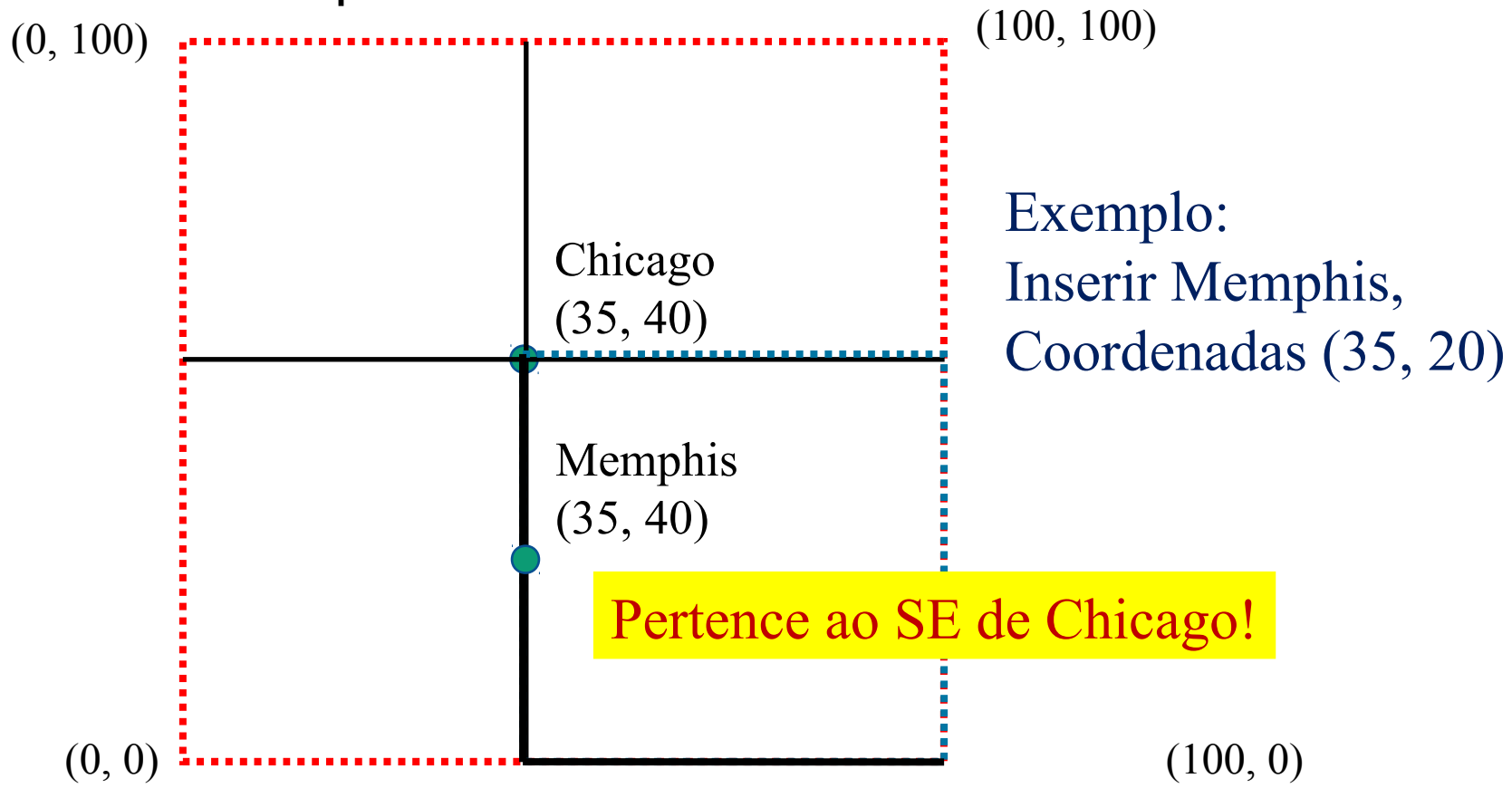
Ponto sobre a linha de um quadrante

- Regra adotada
  - Limites inferior e esquerdo de cada bloco são fechados
  - Limites superior e direito são abertos



Ponto sobre a linha de um quadrante

- Regra adotada
  - Limites inferior e esquerdo de cada bloco são fechados
  - Limites superior e direito são abertos



Algoritmo de comparação

```
quadrant procedure PT_COMPARE(P,R);
/* Return the quadrant of the point quadtree rooted at node R in which node P belongs. */
begin
  value pointer node P,R;
  return(if XCOORD(P) < XCOORD(R) then
            if YCOORD(P) < YCOORD(R) then 'SW'
            else 'NW'
          else if YCOORD(P) < YCOORD(R) then 'SE'
          else 'NE');
end;
```

Algoritmo de inserção

```
procedure PT_INSERT(P,R);
/* Attempt to insert node P in the point quadtree rooted at node R. */
begin
  value pointer node P;
  reference pointer node R;
  pointer node F;
  quadrant Q;
  if null(R) then R ← P /* The tree at R is initially empty */
  else
    begin
      while not(null(R)) and not(EQUAL_COORD(P,R)) do
        begin
          F ← R; /* Remember the father */
          Q ← PT_COMPARE(P,R);
          R ← SON(R,Q);
        end;
      if null(R) then SON(F,Q) ← P; /* P is not already in the tree */
    end;
end;
```

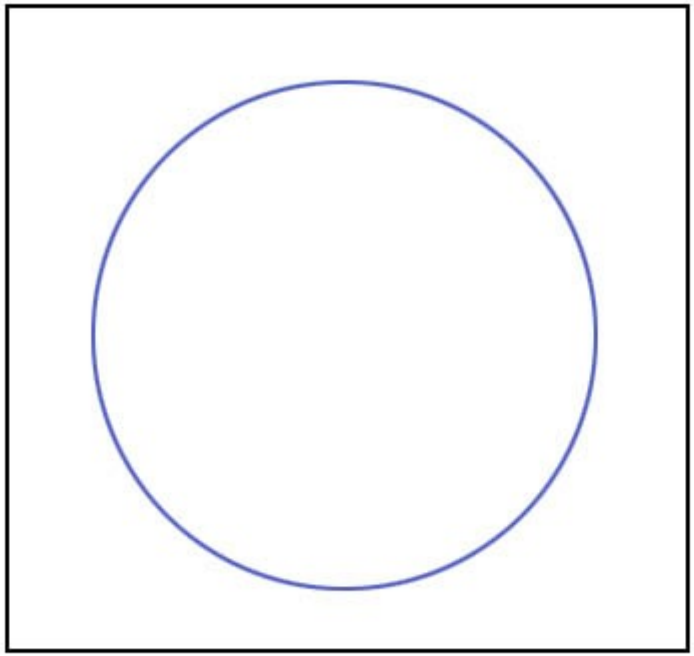
Exercício

- Mostre a QuadTree resultante após a inserção dos pontos:
  - (A, 51,30)
  - (B, 13,70)
  - (C, 81,40)
  - (D, 81,70)
  - (E, 02,25)
  - (F, 01,01)
  - (G, 99,99)
  - (H, 63,30)
  - (I, 70,67)
  - (J, 50,50)

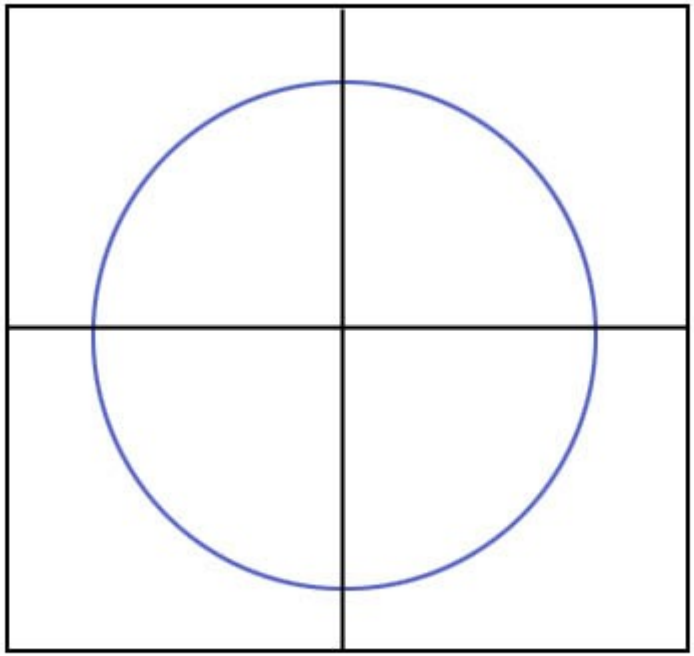
QuadTree para polígonos

- Uma QuadTree pode também ser utilizada para preencher polígonos
- Subdividir o espaço
  - Se o quadrante for homogêneo ou se o nível de detalhe foi alcançado, pára a divisão
  - Caso contrário, continue dividindo

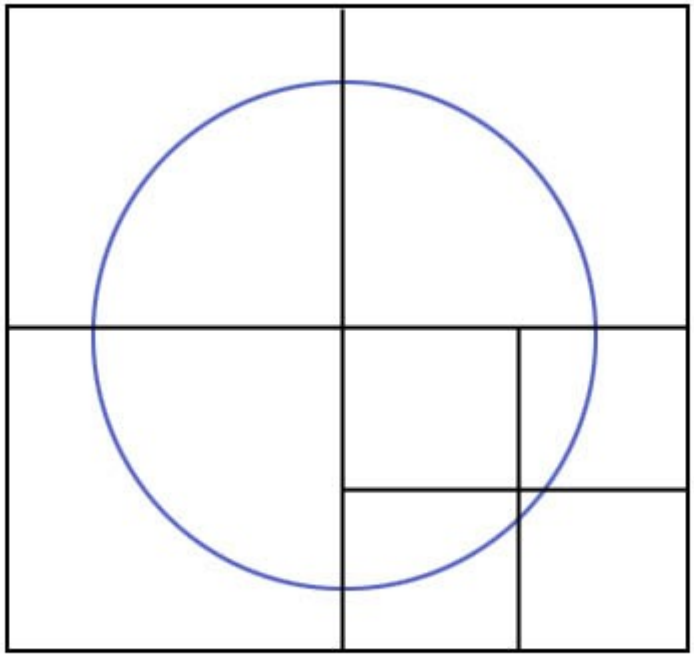
QuadTree para polígonos



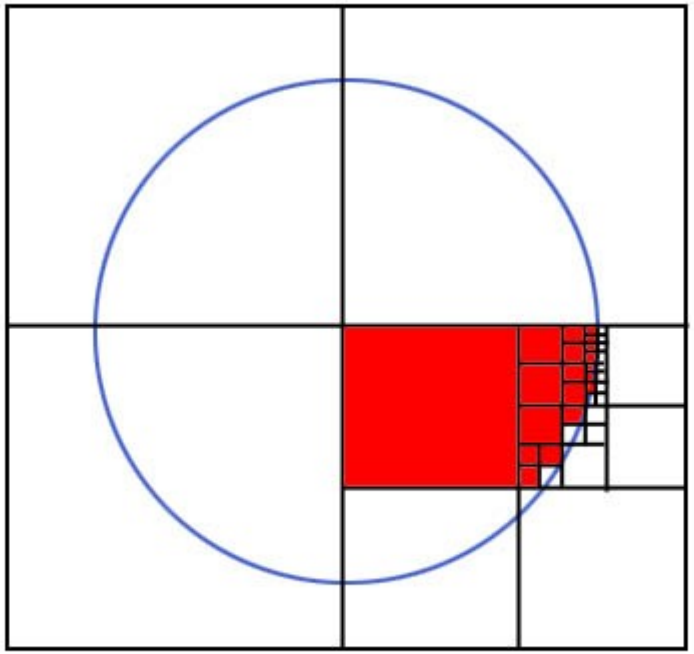
QuadTree para polígonos



QuadTree para polígonos

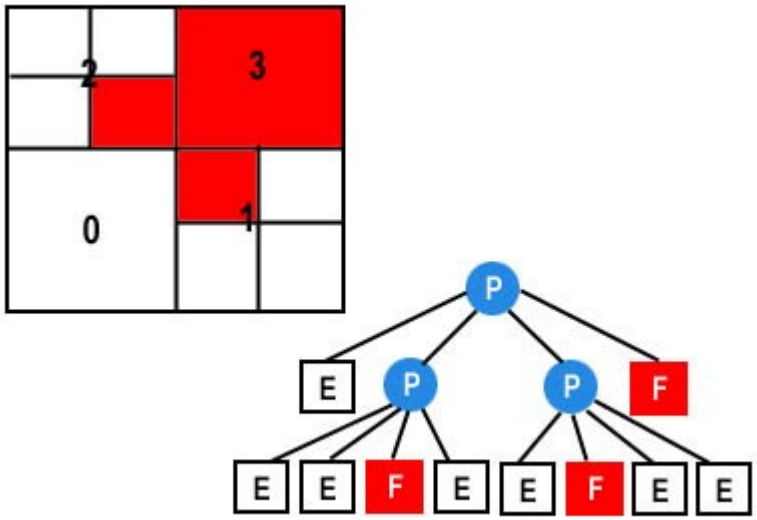


QuadTree para polígonos



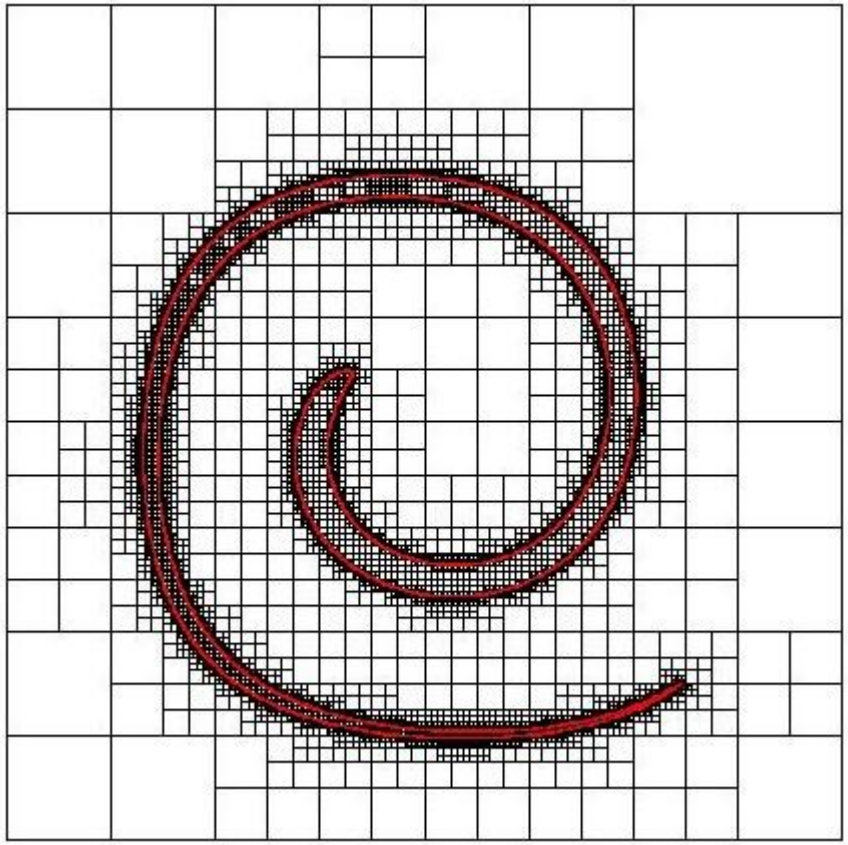
QuadTree para polígonos

- As divisões são representadas na árvore como nós caso sejam quadrantes heterogêneos e como folhas caso sejam quadrantes homogêneos.

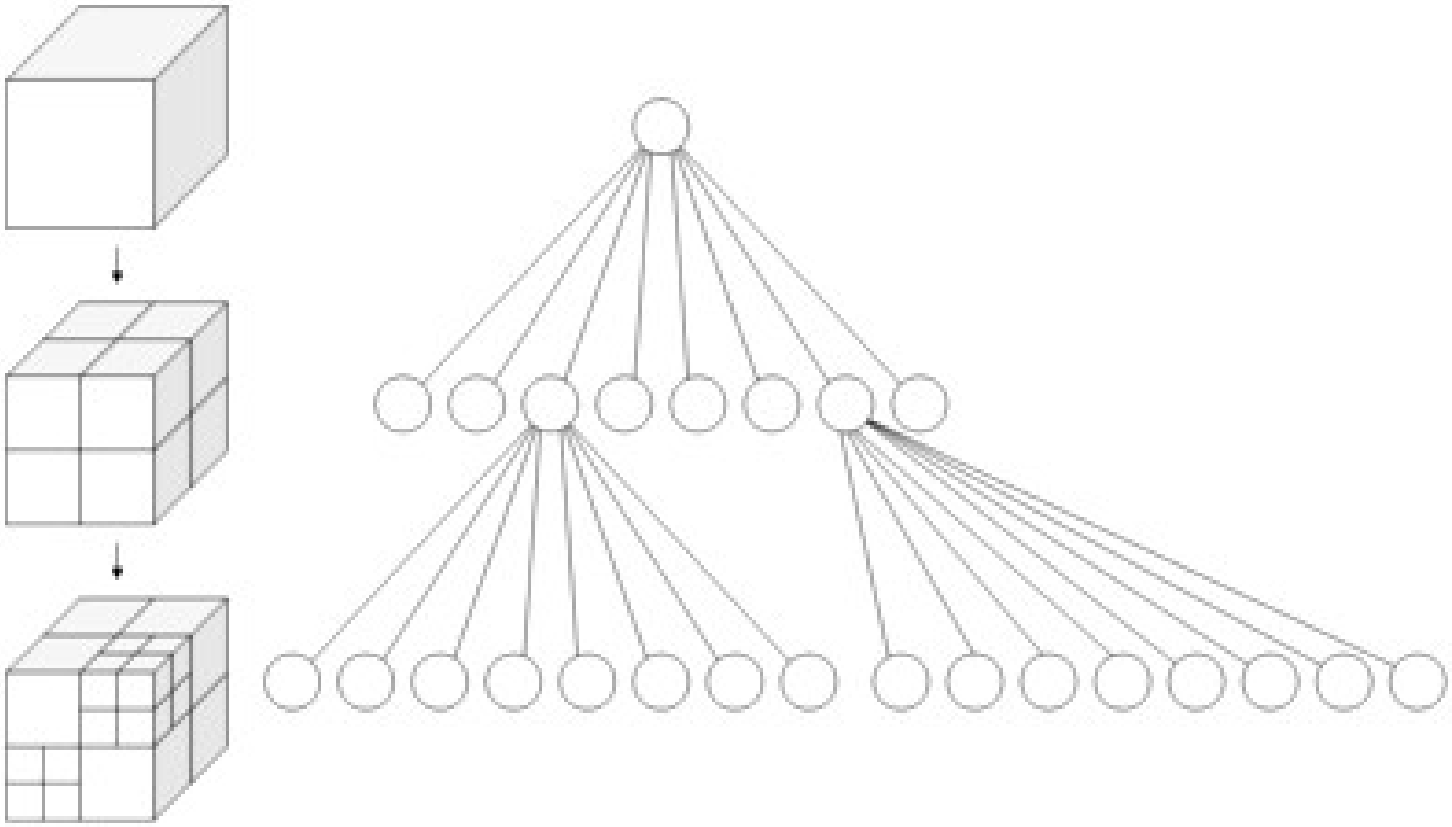


E = Empty
F = Full
P = Partially full

QuadTree para polígonos

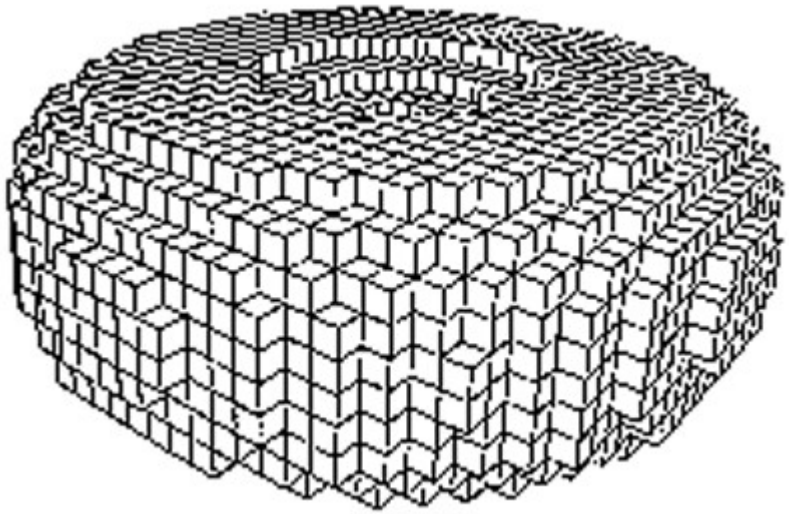


OctTree



OctTree para polígonos

- A mesma ideia da QuadTree para polígonos



OctTree