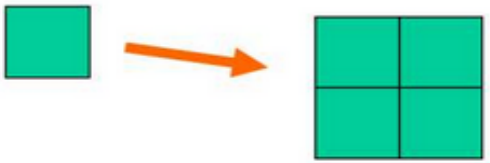
QUAD TREES
REGION SPLITTING

- Region splitting is the opposite approach of region growing
- Top-down approach
- Starts with the assumption that the entire image is homogeneous
- If this is not true, the image is split into four sub images
- Splitting procedure is repeated recursively until we split the image into homogeneous regions

- If the original image is square N x N, having dimensions that are powers of 2(N = 2n):
  - All regions produced by the splitting algorithm are squares having dimensions M x M , where M is a power of 2 as well.
- Since the procedure is recursive, it produces an image representation that can be described by a tree whose nodes have four children each.
- This tree is called a Quadtree.



1 partitioned to $2^2 = 4$

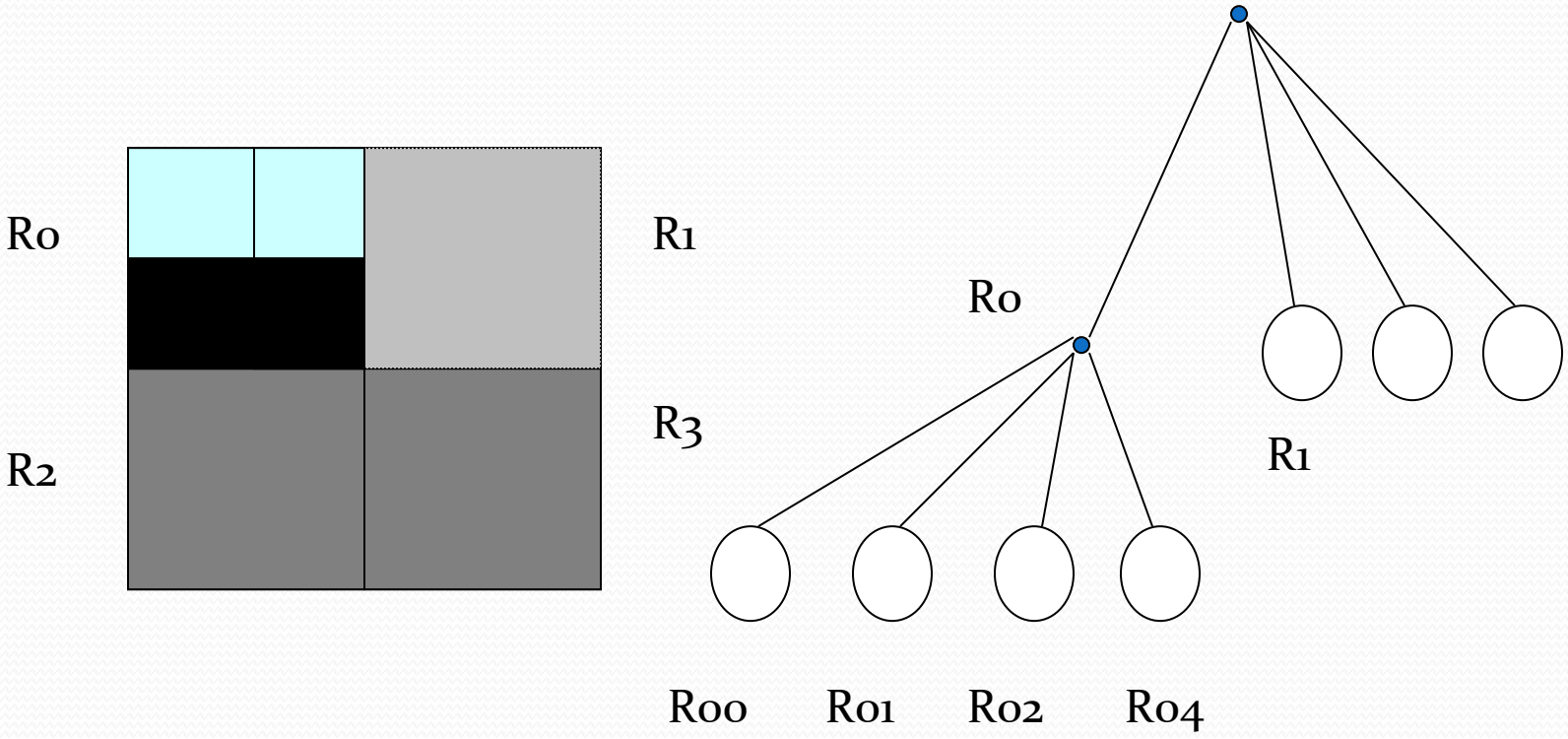
QUADTREE DEFINITION

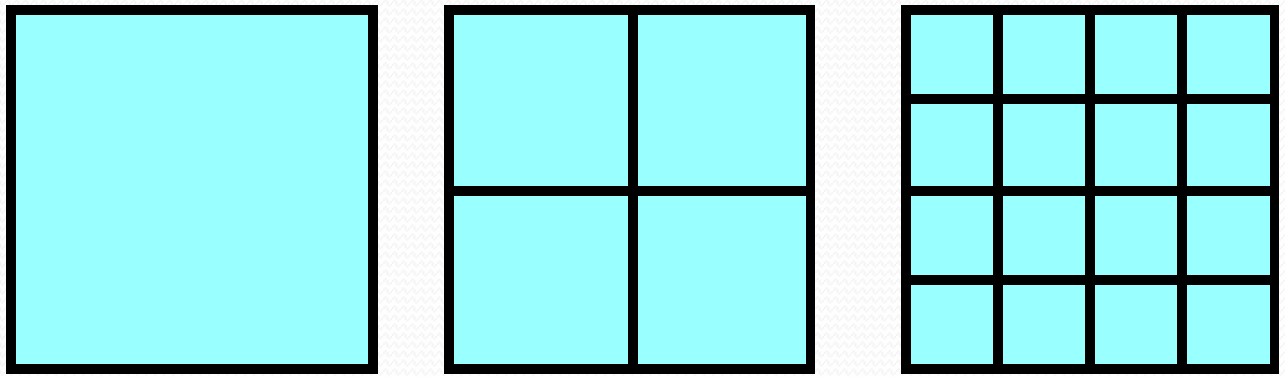
- A **Quadtree** is a tree data structure in which each internal node has exactly four children.
- Quadtrees are most often used to partition a two-dimensional space by recursively subdividing it into four quadrants or regions.
- The regions may be square or rectangular, or may have arbitrary shapes.

Quad Tree

- A *quad tree* is a tree whose nodes either are leaves or have 4 children. The children are ordered 1, 2, 3, 4.
- Here we will outline the strategy behind using quad trees as a data structure for pictures. The key is to "Divide and Conquer".
- One way to efficiently store the quad tree in binary format is to use the following scheme.
- Let's say we divide the picture area into 4 sections. Those 4 sections are then further divided into 4 subsections. We continue this process, repeatedly dividing a square region by 4. We must impose a limit to the levels of division otherwise we could go on dividing the picture forever. Generally, this limit is imposed due to storage considerations or to limit processing time or due to the resolution of the output device. A *pixel* is the smallest subsection of the quad tree.

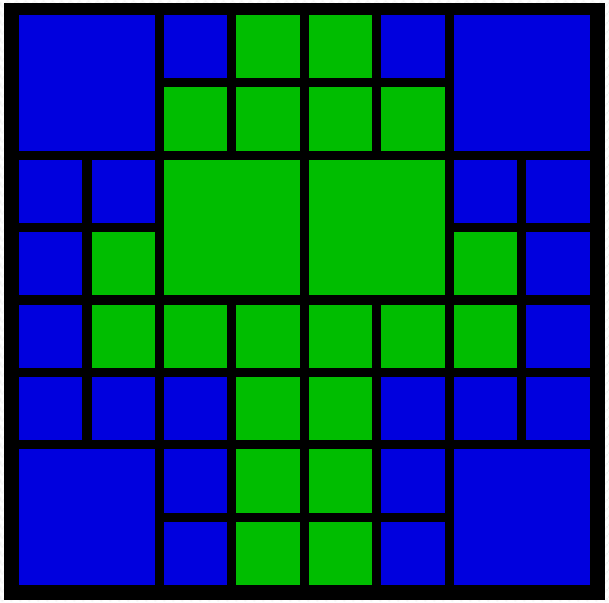
QUADTREE REPRESENTATION

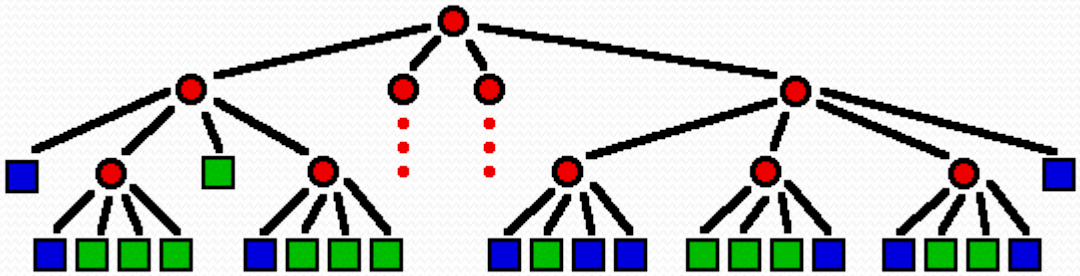




First three levels of a quad tree

image stored in a quad tree.

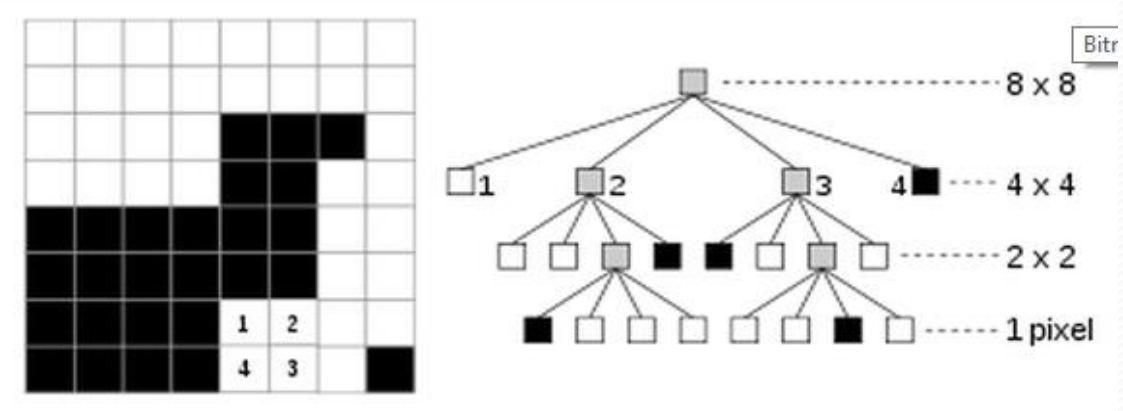




8 x 8 pixel picture represented in a quad tree

USES OF QUADTREES

- Image representation

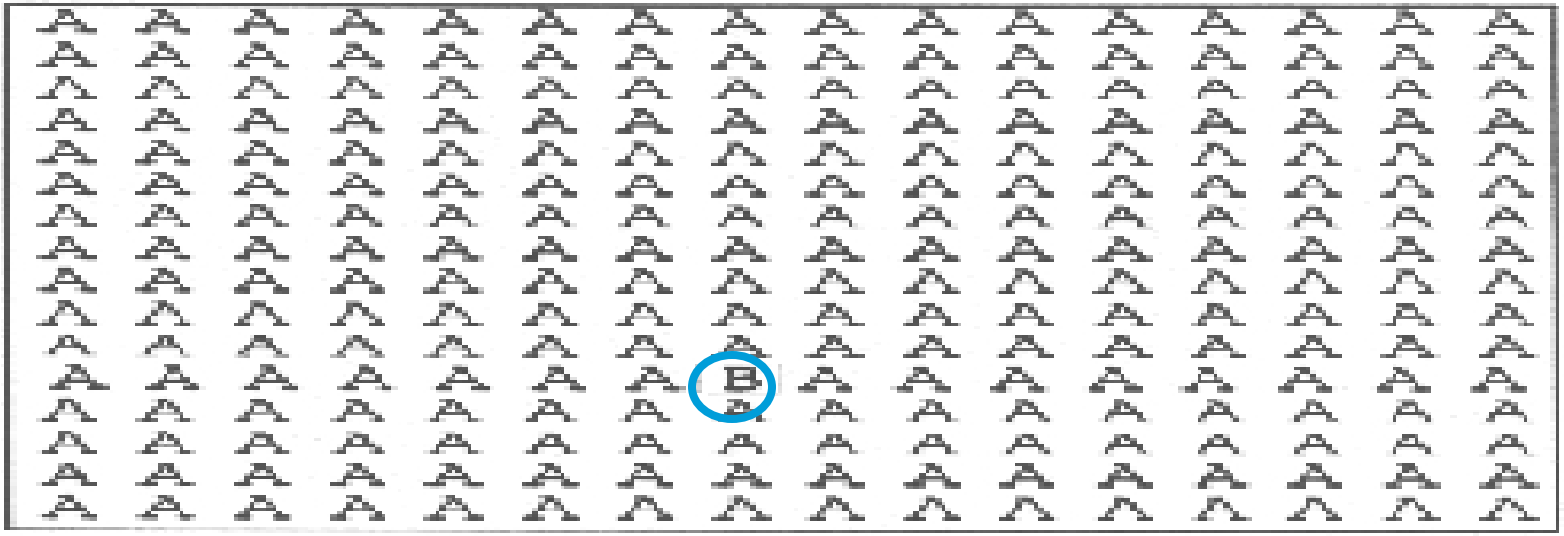


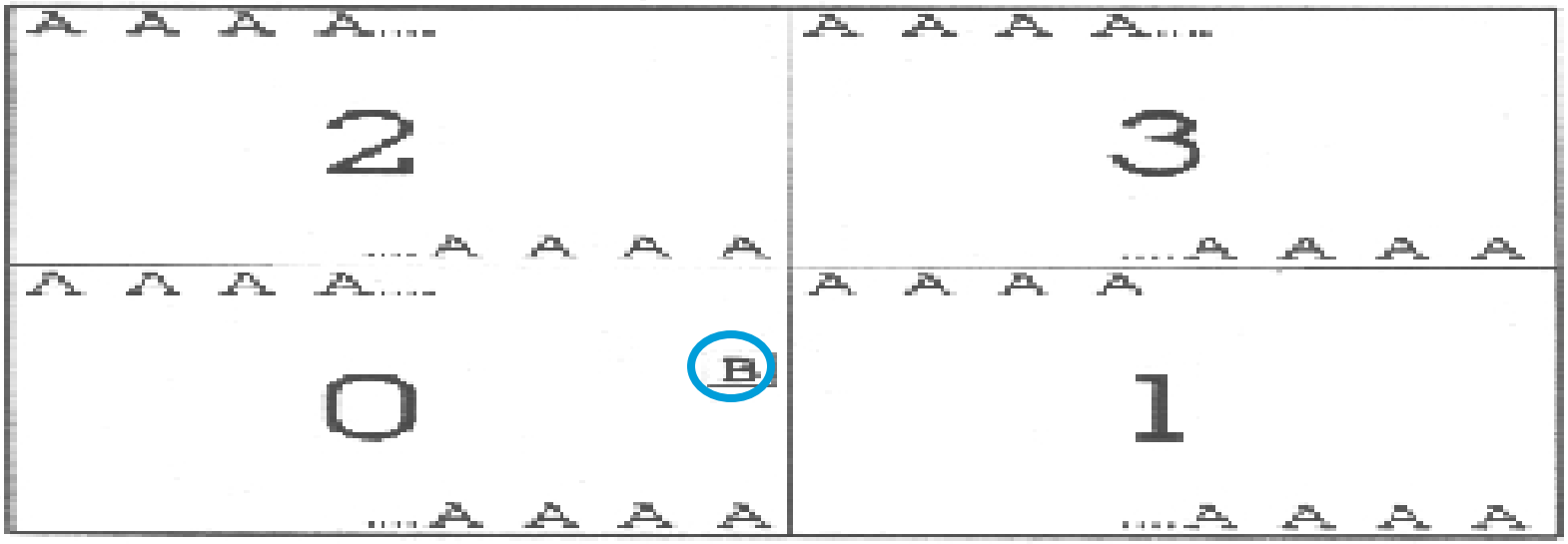
- Spatial indexing
- Storing sparse data, such as a formatting information for a spreadsheet or for some matrix calculations
- Solution of multidimensional fields (computational fluid dynamics, electromagnetism)

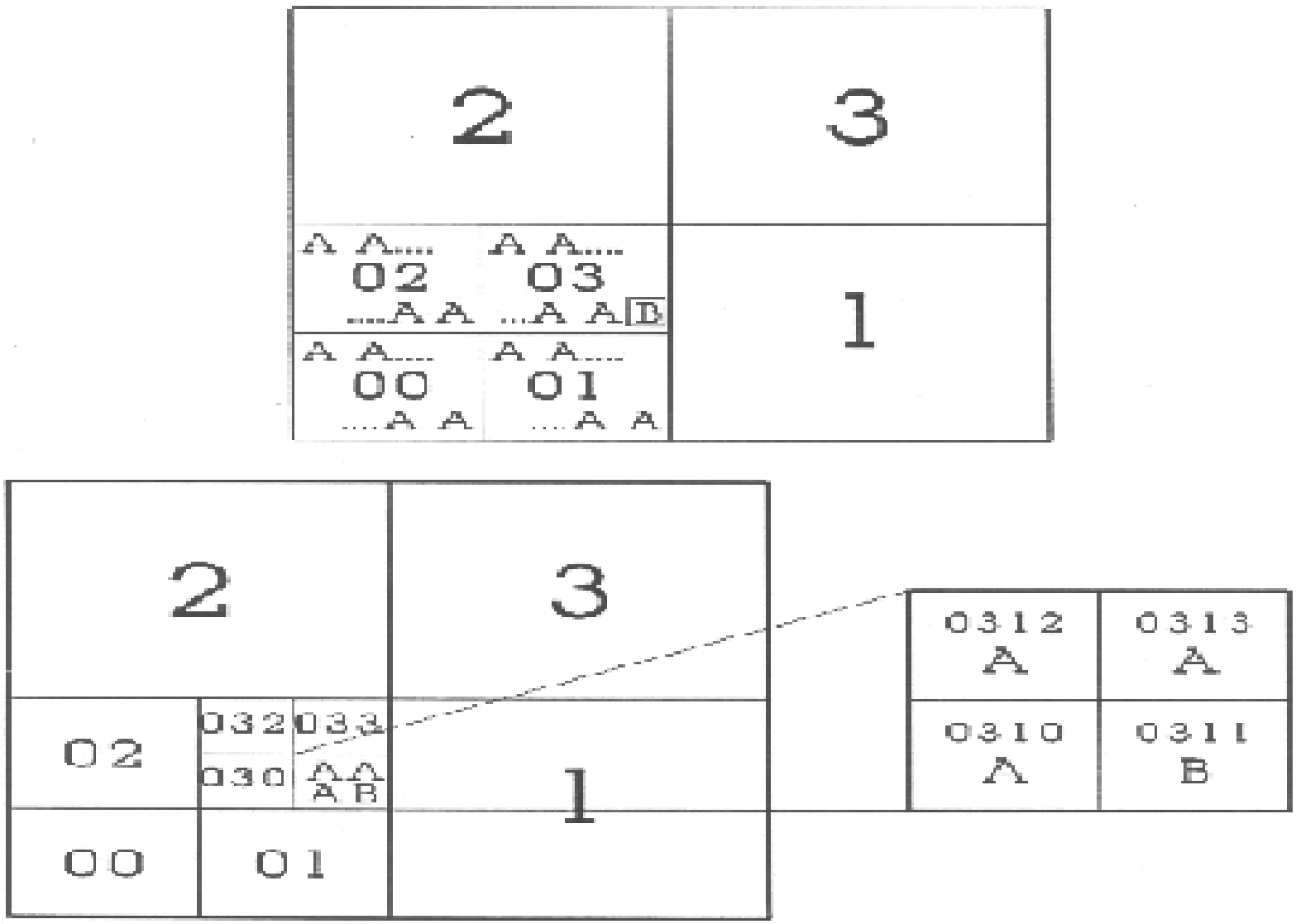
Split / Merge

- If a region R is not homogeneous
  - P(R)= False
  - then is split into four sub regions
- If two adjacent regions Ri,Rj are homogeneous
  - $P(R_i \cup R_j)$ = TRUE
  - they are merged
- The algorithm stops when no further splitting or merging is possible
- The split and merge algorithm produces more compact regions than the pure splitting algorithm

We want to know where is B located structurally in our image



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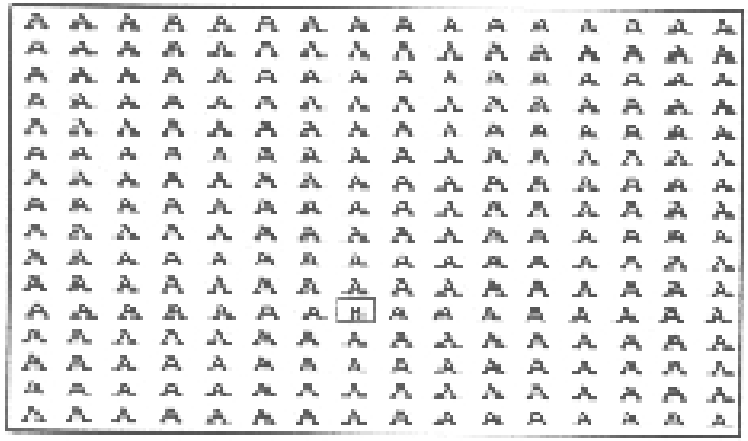

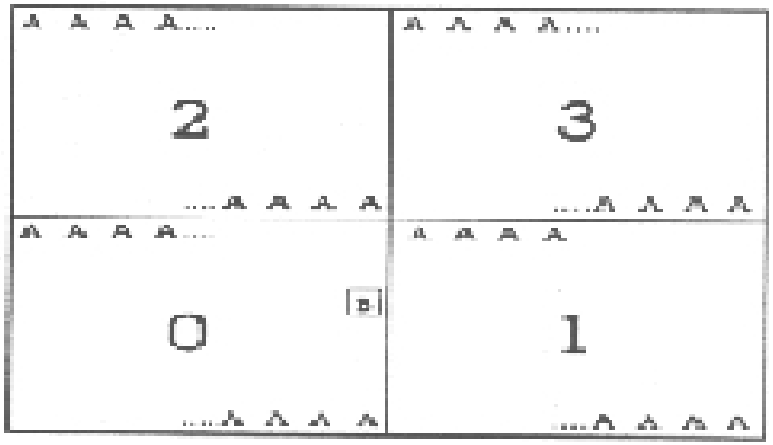
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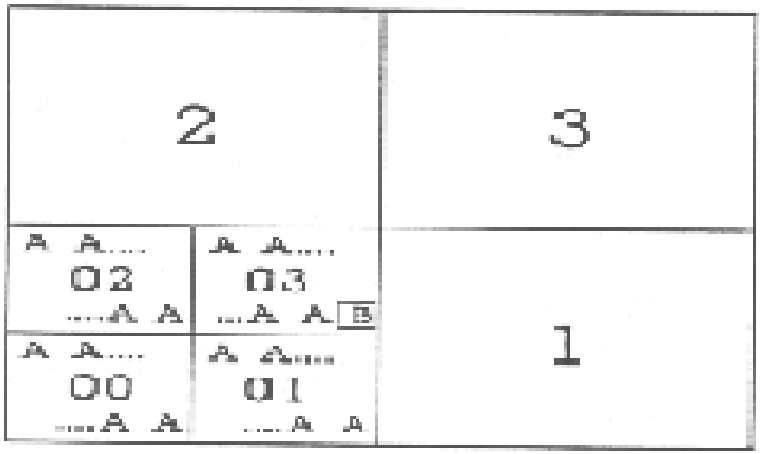
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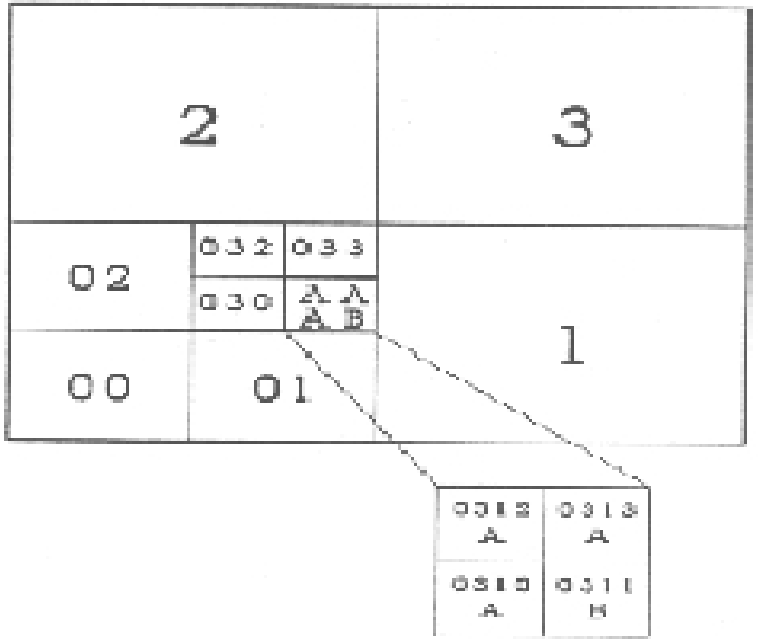
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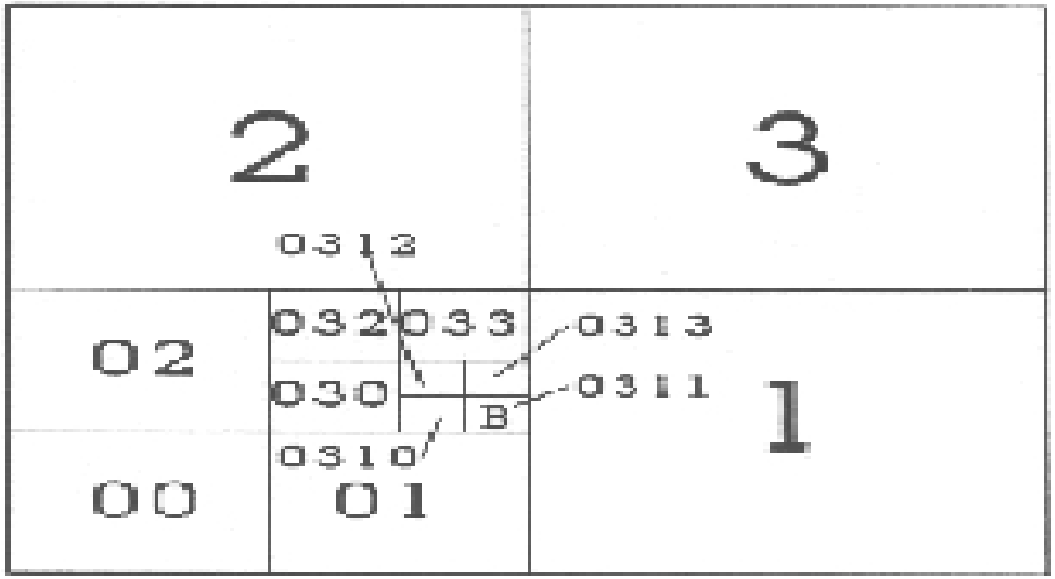

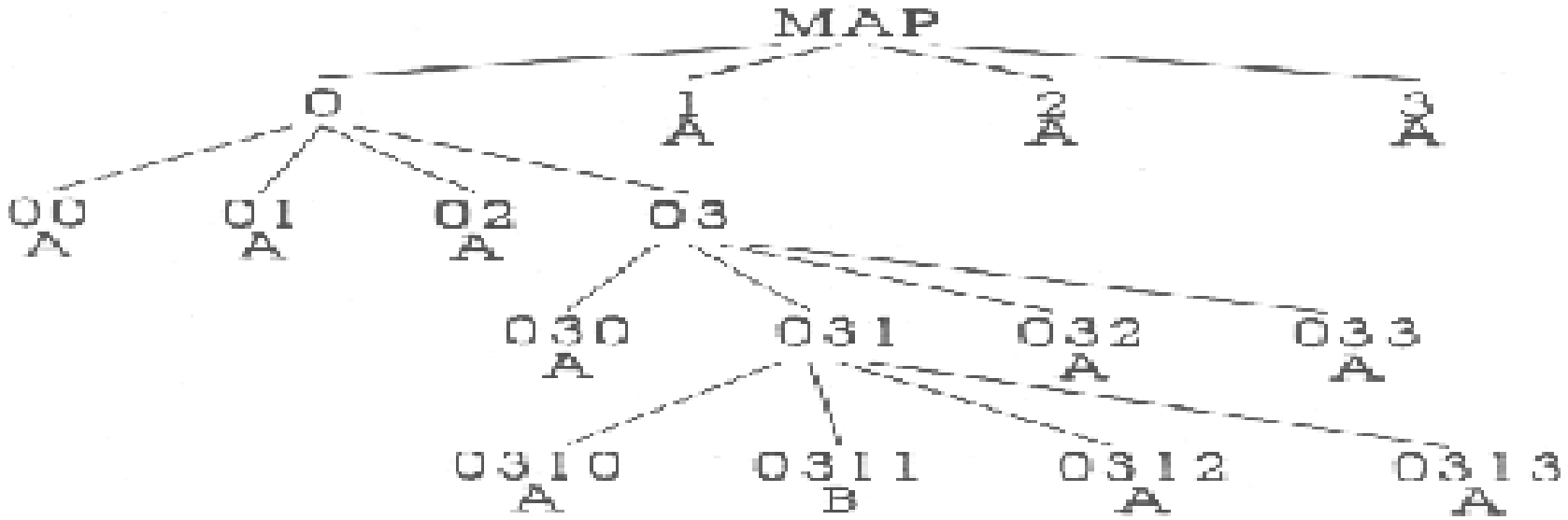

We got here the structure of our environment