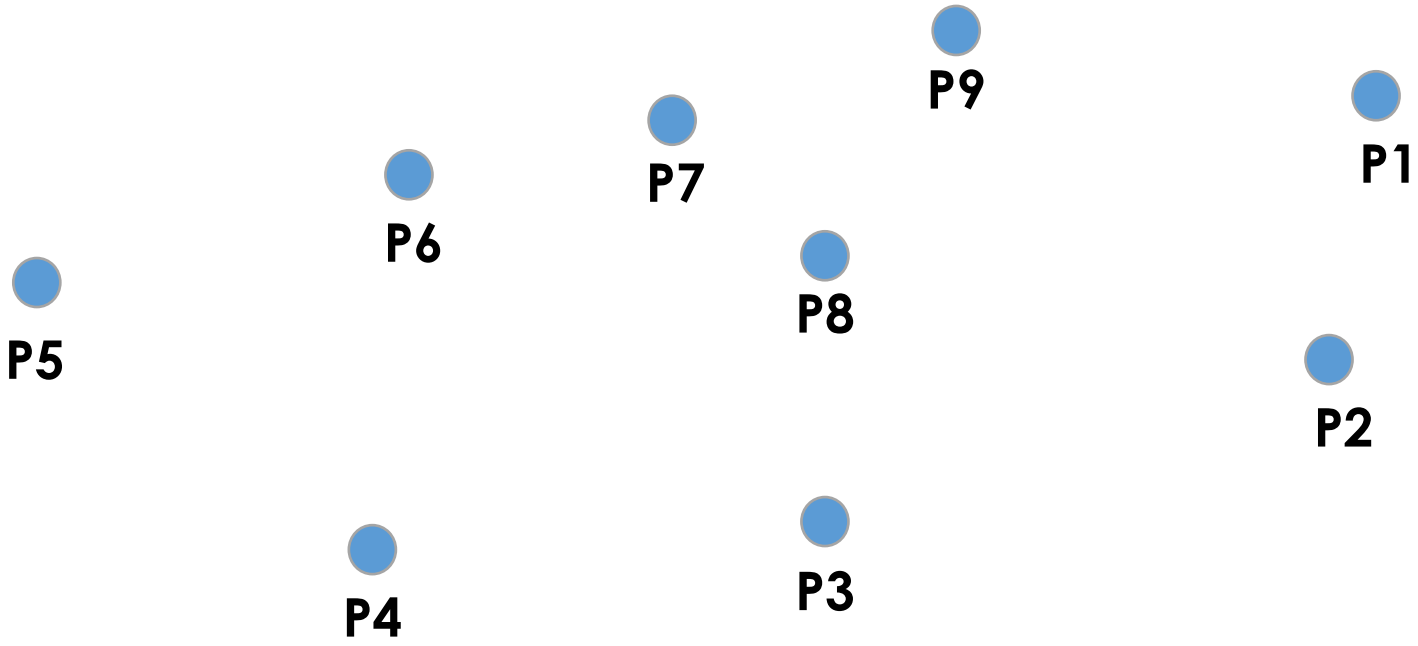
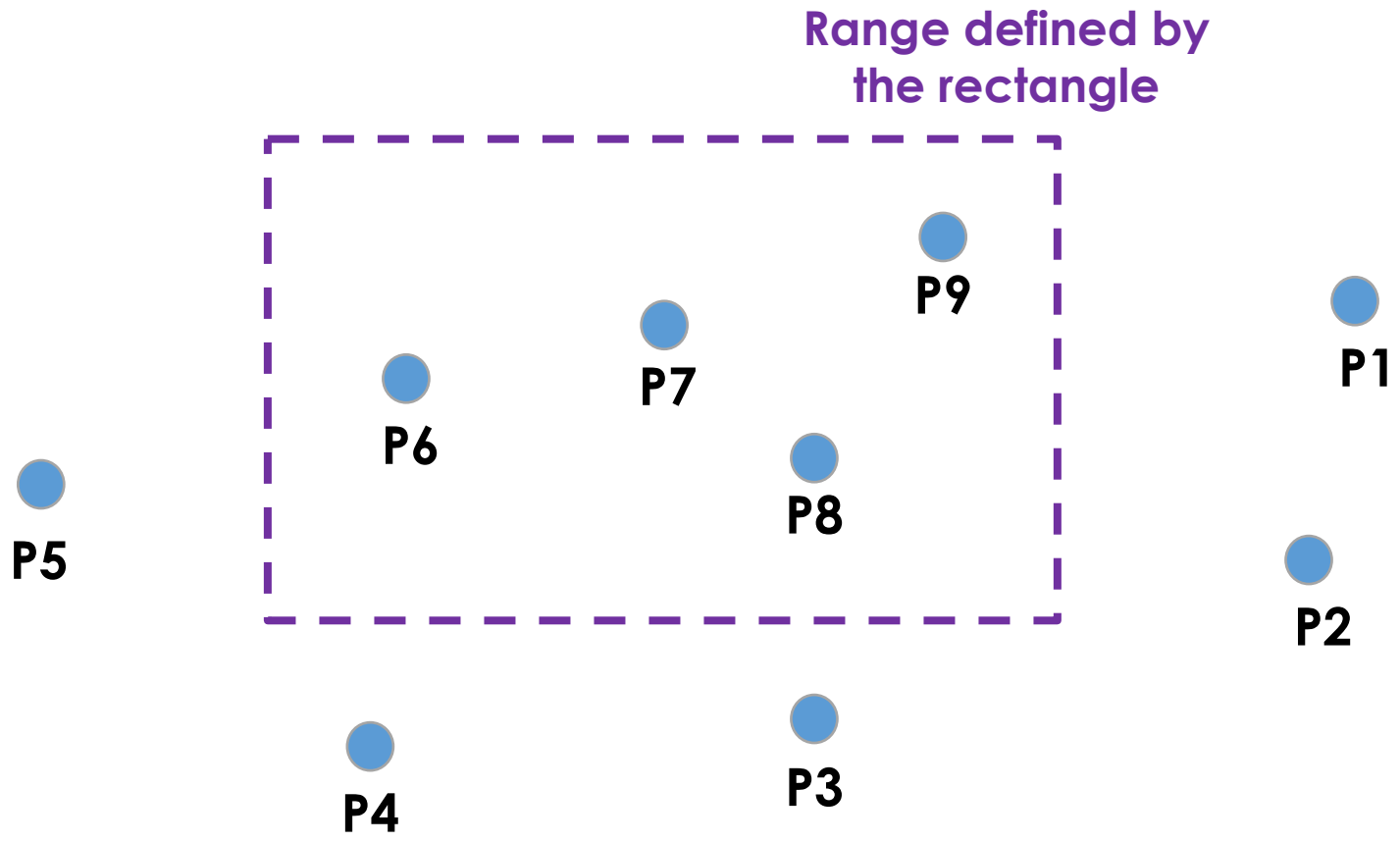
Spatial Data structures
For Point Data

J. Nievergelt and H. Hinterberger. The Grid File: An Adaptable, Symmetric Multikey File Structure. ACM Transactions on Database Systems, Vol. 9, No. 1, March 1994

Points in 2D space



Range Queries



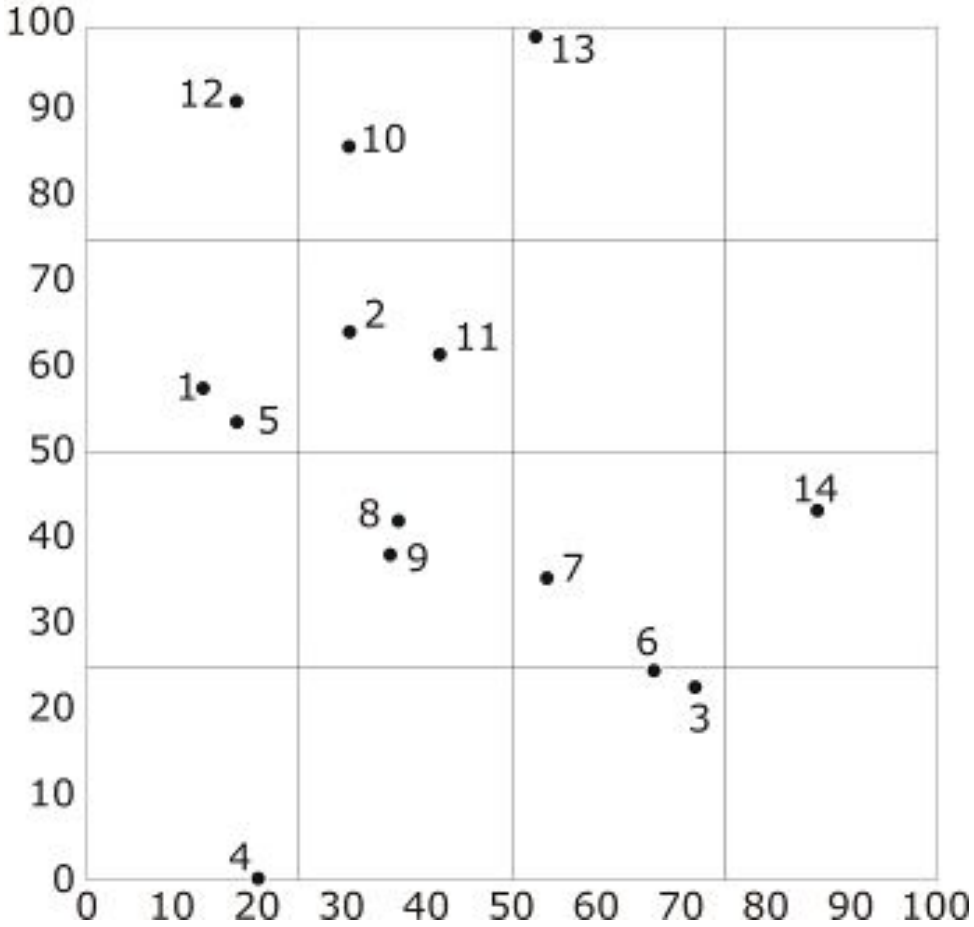
Retrieve all points inside the rectangle
E.g., return all restaurants in GK-1, New Delhi
Range can also be defined by a rectangle

How to store 2D points in a secondary memory ?

Data structure should support efficient query algorithms for range queries

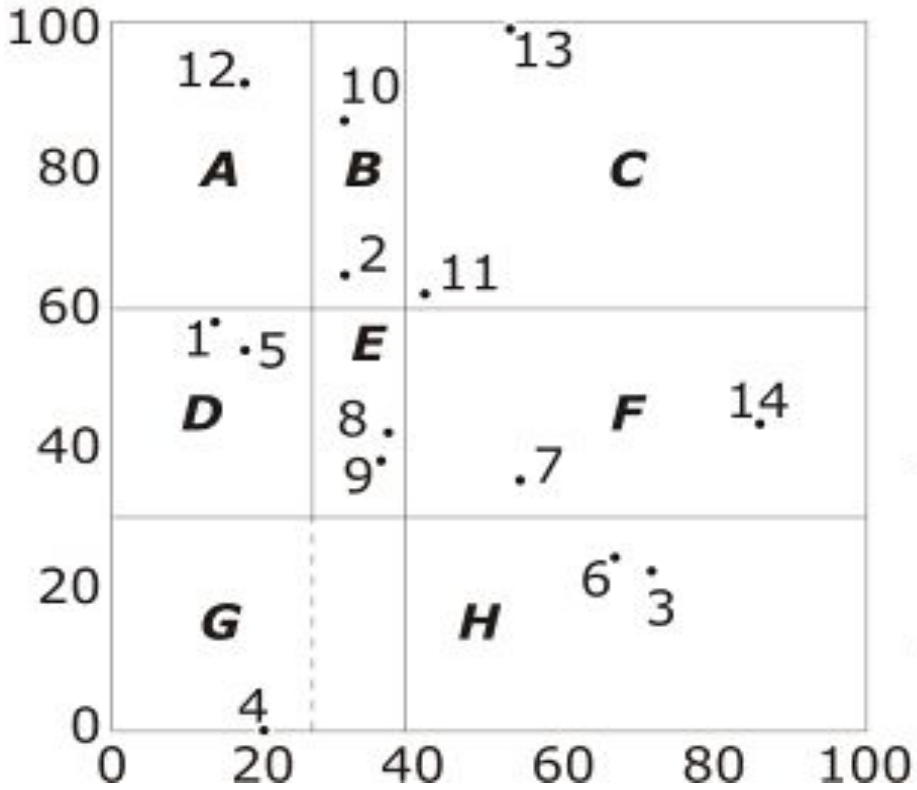
Uniform Grids over 2D space

- Divide space into cells by a grid
- Store data in each cell in distinct disk page
- A directory structure needed
- Efficient for find, insert, range and nearest neighbor
- **But wastes a lot of disk storage space**
- **Non-uniform data distribution over space ??**



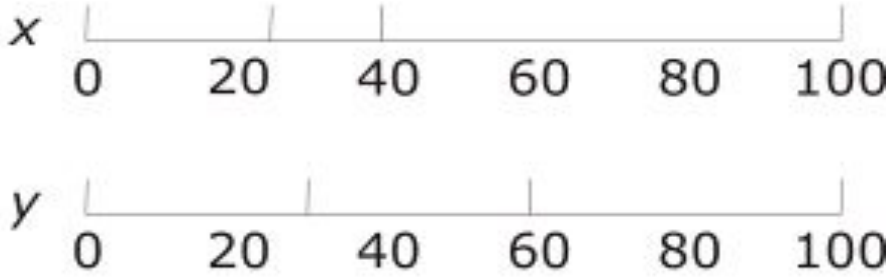
Refinement of basic idea into Grid Files

- Use non-uniform grids
- Linear scale store row and column boundaries
- Allow sharing of disk pages across grid cells



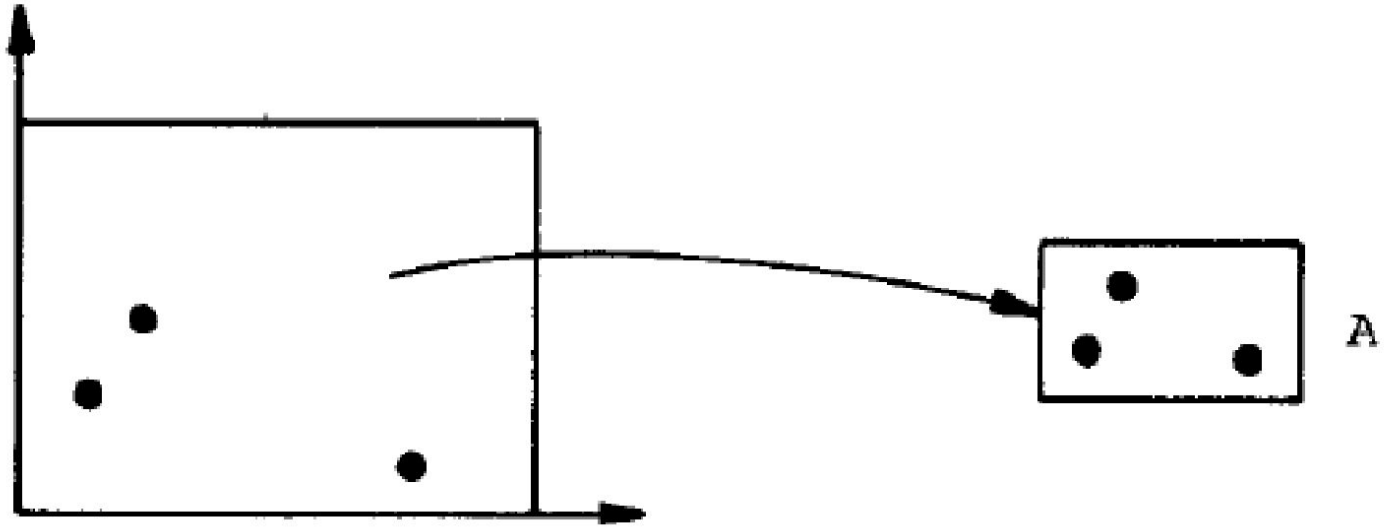
A	B	C
D	E	F
G	G	H

Grid directory



Grid Files (insertion example)

- Capacity of bucket = 3



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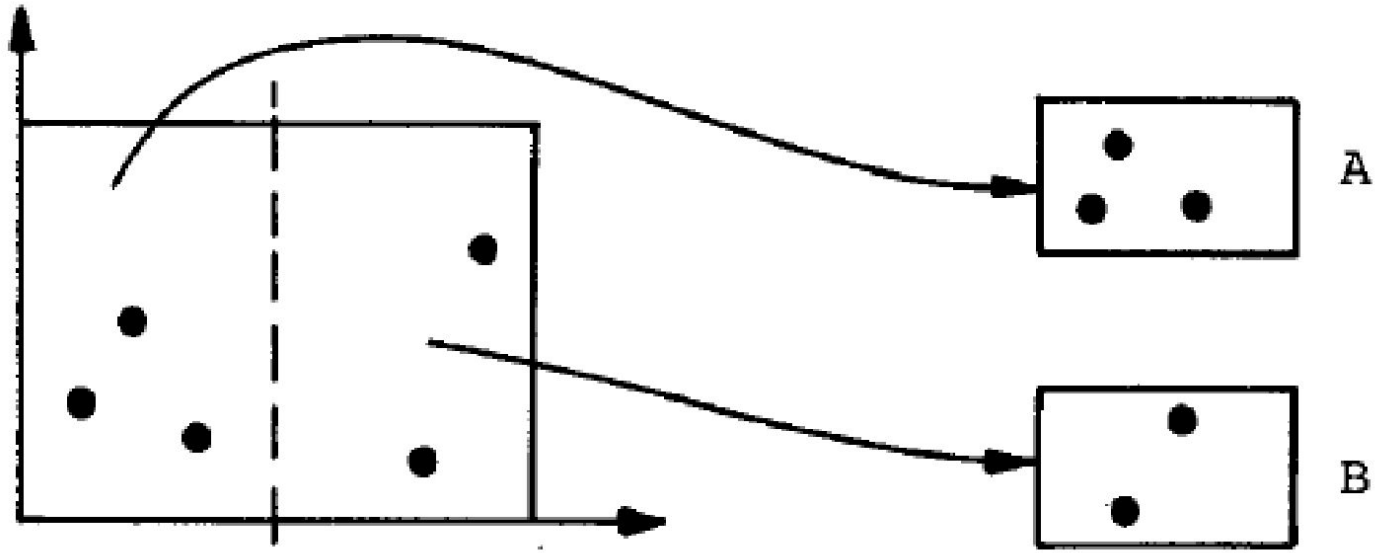
Grid Files (insertion example)

- When the bucket overflows we split it.
- A new bucket is made.
- Records that lie in one half of the space are moved to the new bucket.



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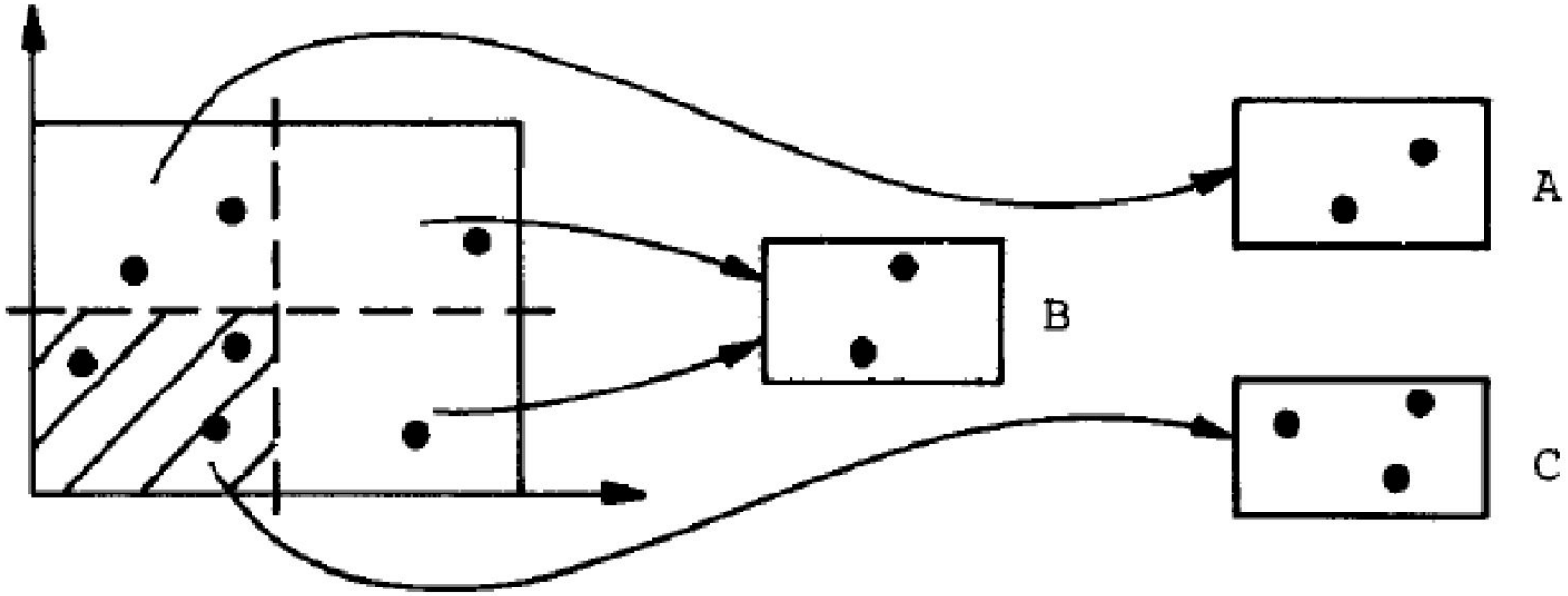
Grid Files (insertion example)

- Bucket A overflows again.



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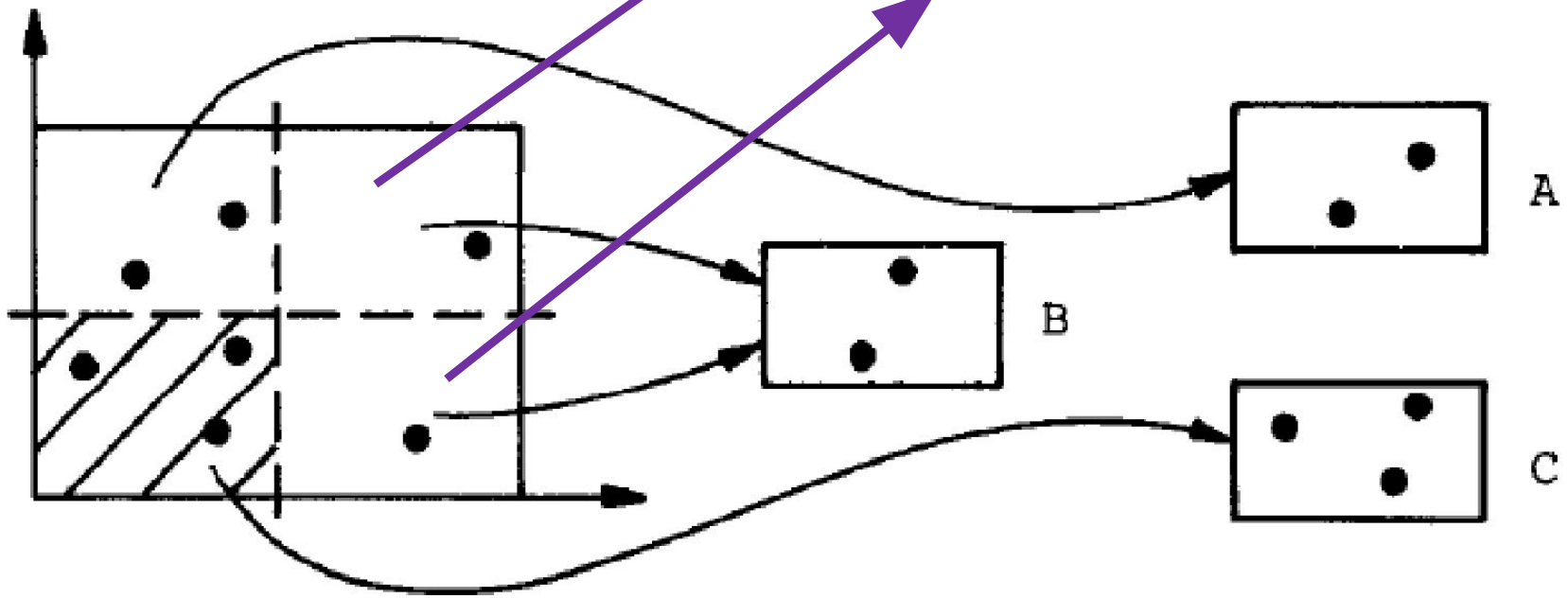
Grid Files (insertion example)

- Bucket A overflows again.

Very Imp: Splitting of A is full horizontal split, i.e., region of B is also split. But B was not overflowing, so both buckets still point to B only



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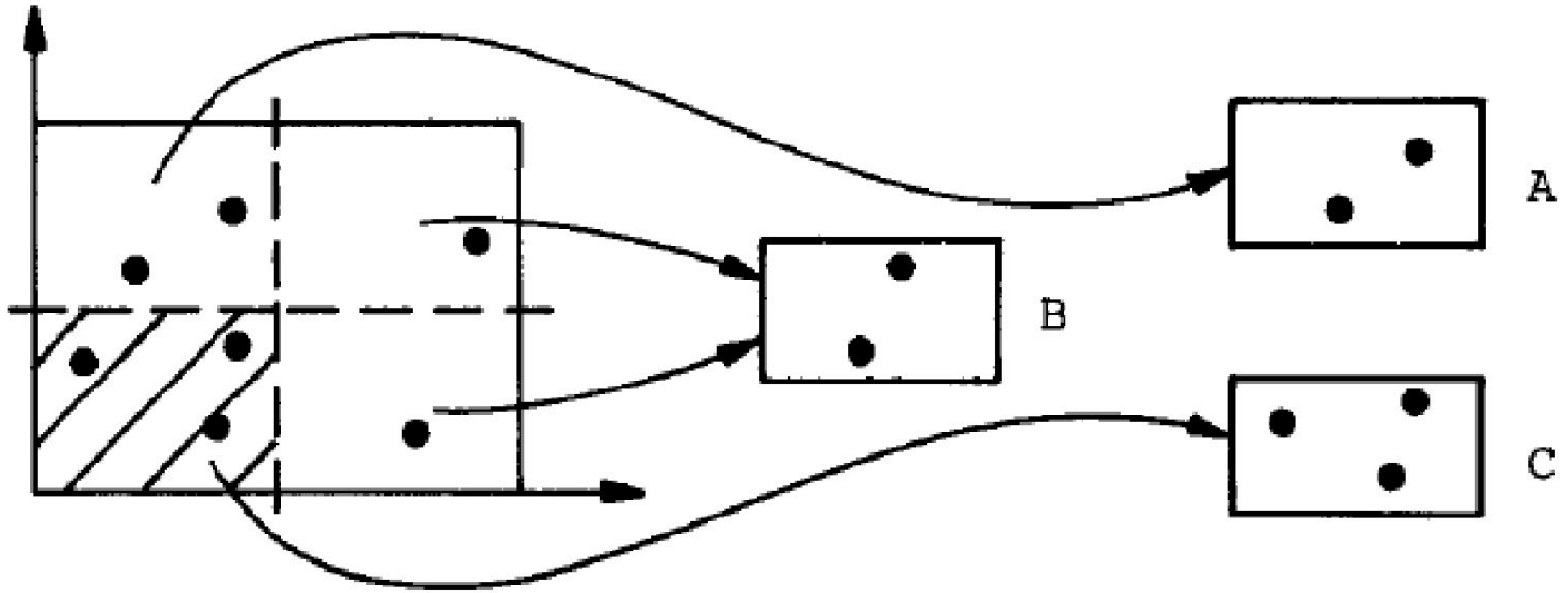
Grid Files (insertion example)

- Bucket A overflows again.

In Grid files, data space which are the buckets is different from the geographic spread of the data.



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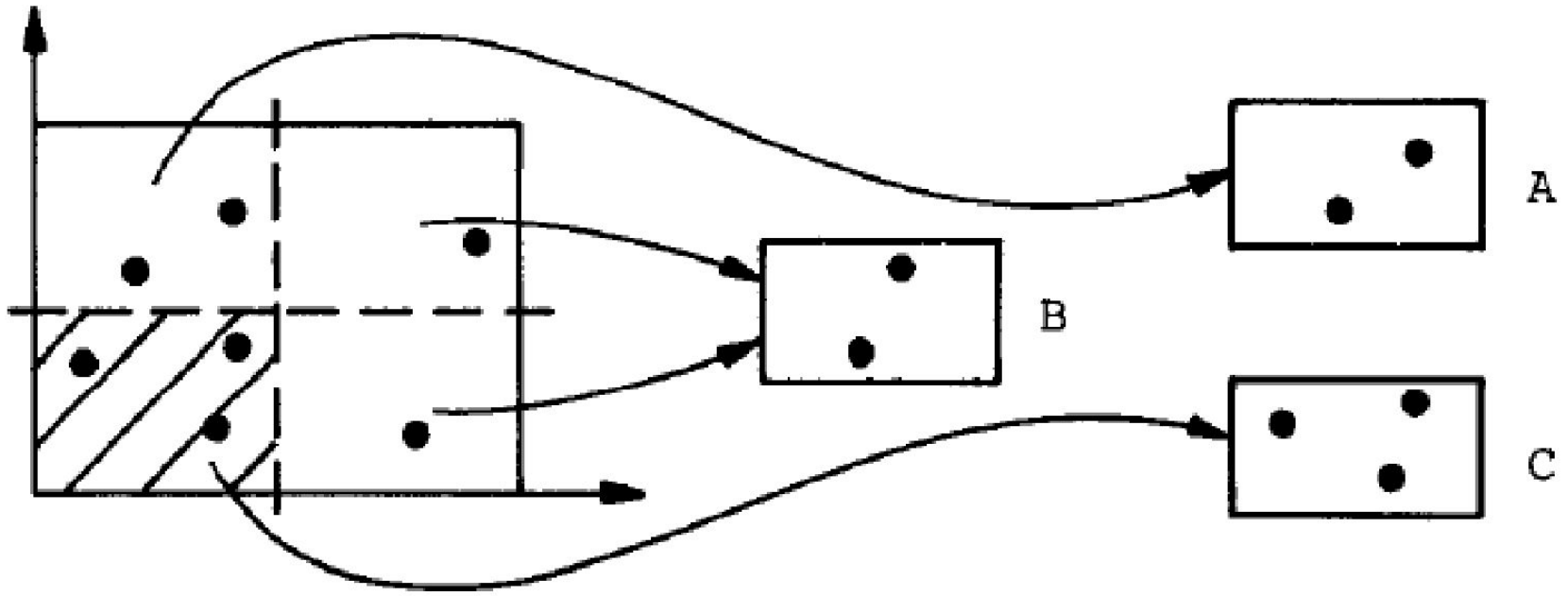
Grid Files (insertion example)

- Bucket A overflows again.

Splits in any dimension are made through and trough out. This makes the task of maintain linear scales easy



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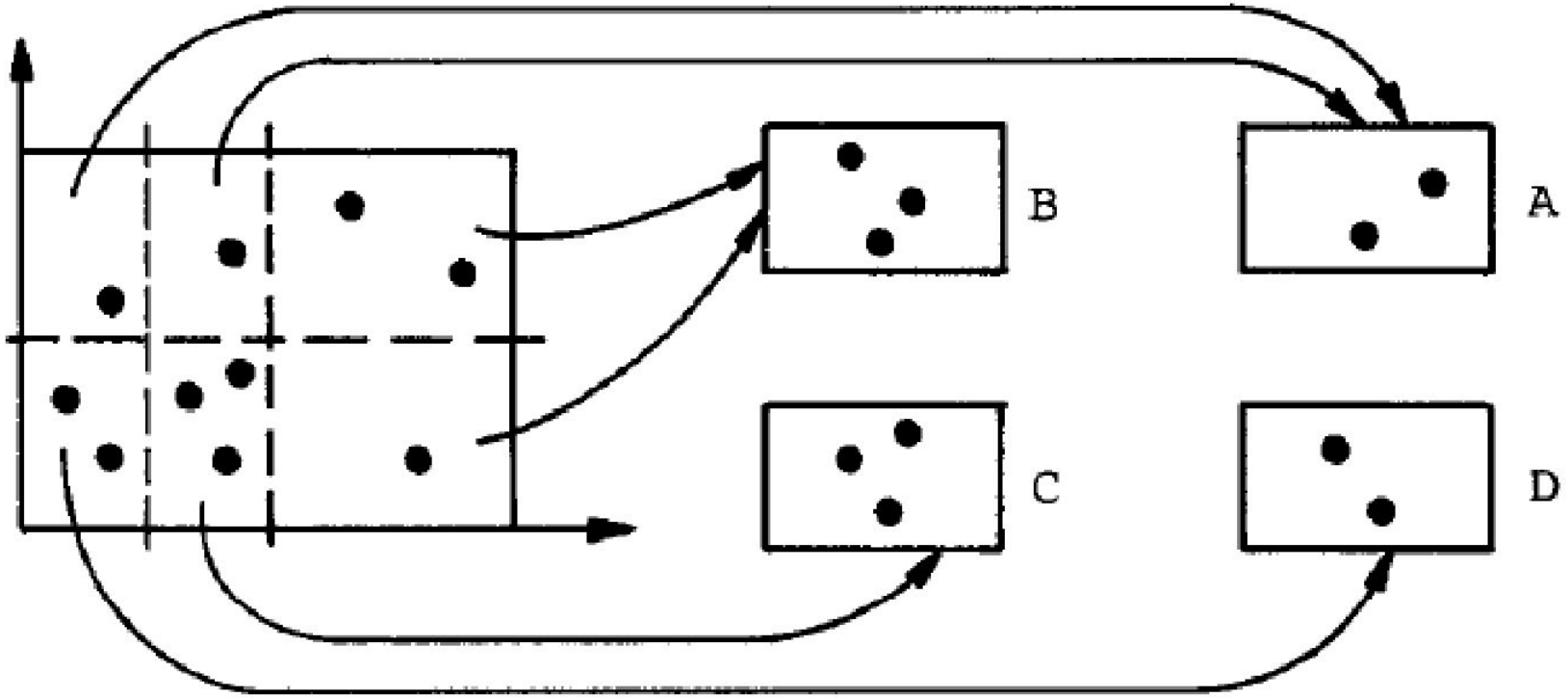
Grid Files (insertion example)

- One more split.



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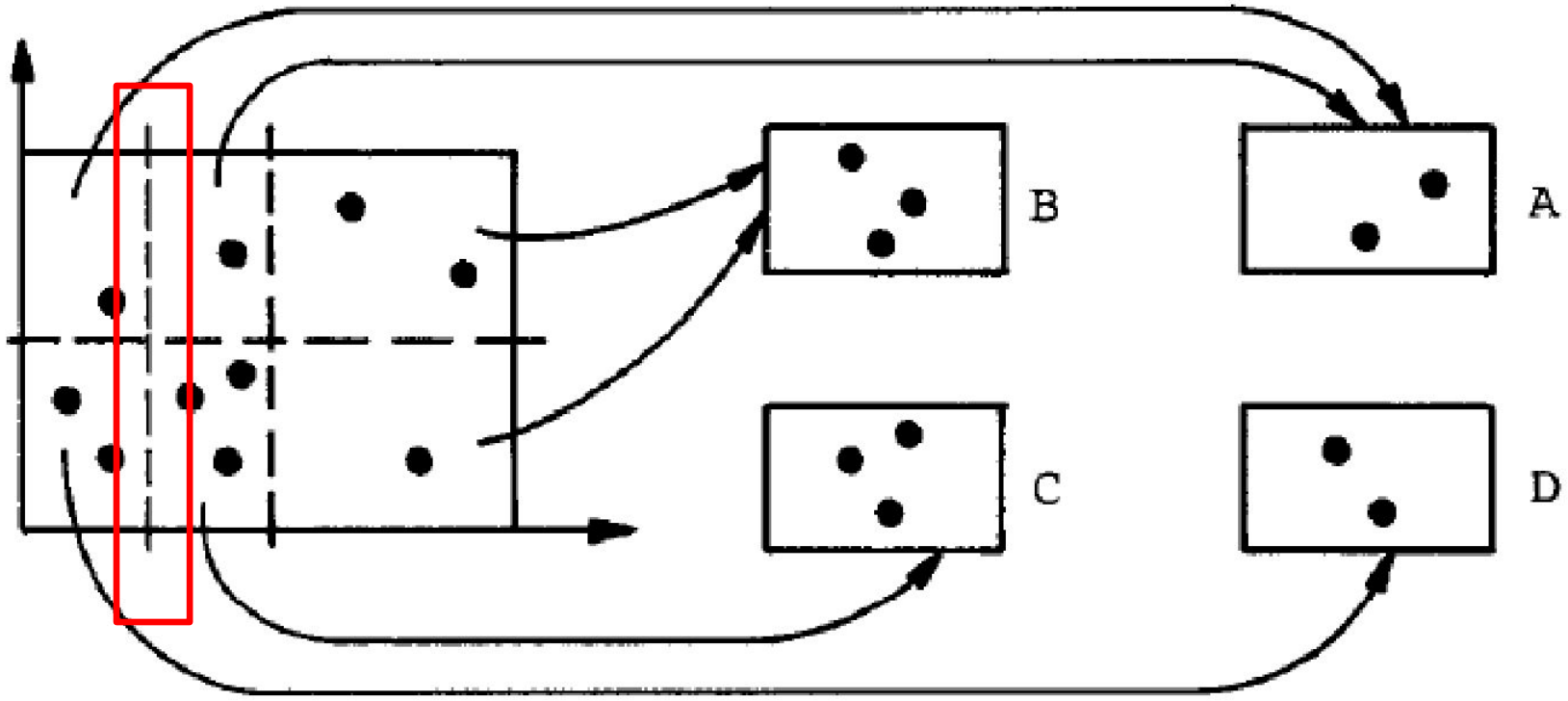
Grid Files (insertion example)

- One more split.
- Note that splits in any dimension are made through and trough.



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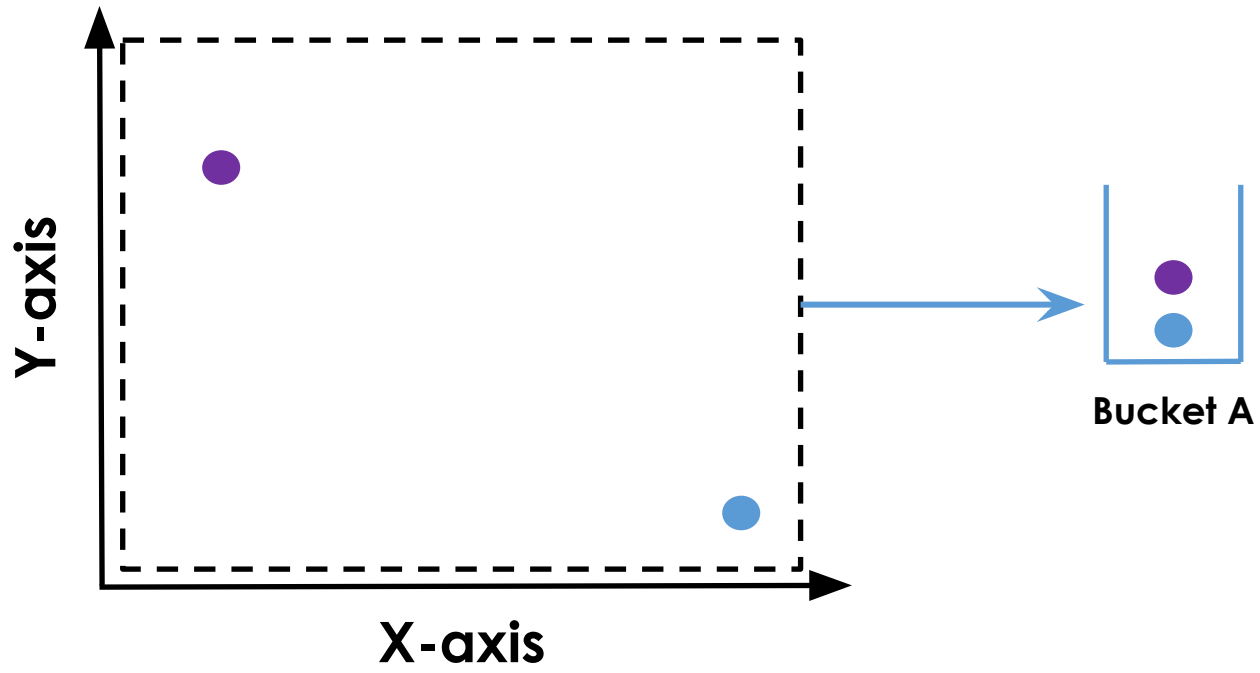
Grid Files Inserting Points (Another example)

- Assume Bucket size = 3



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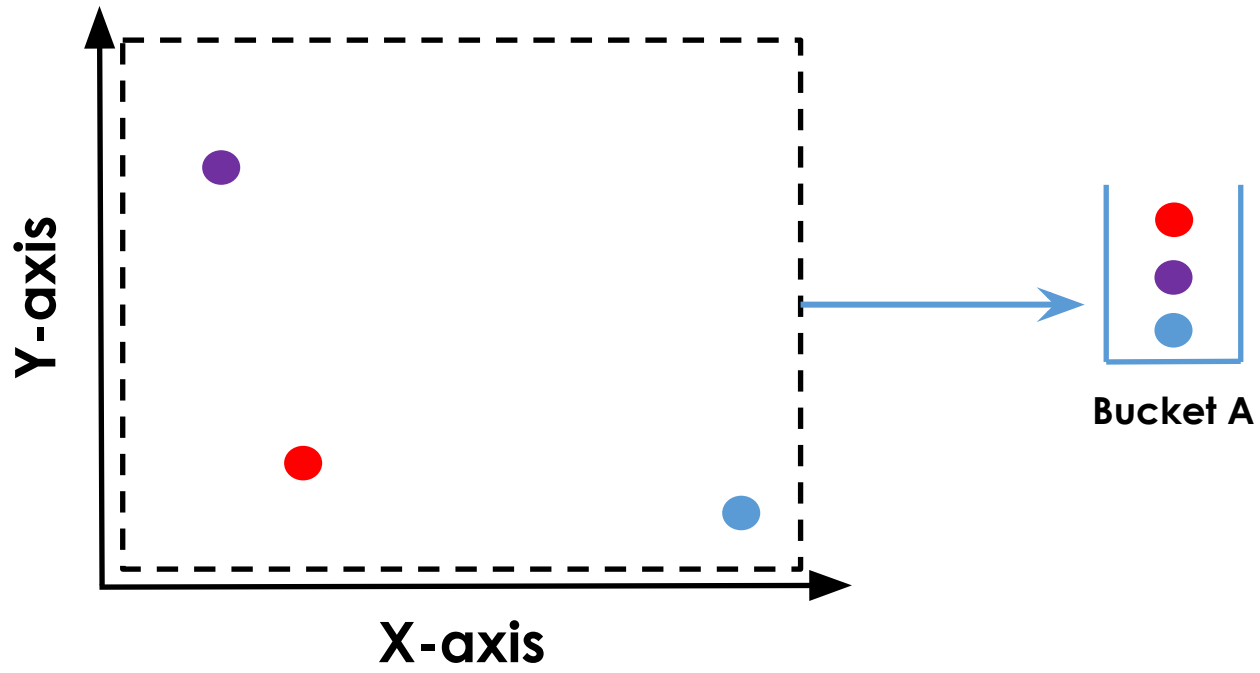

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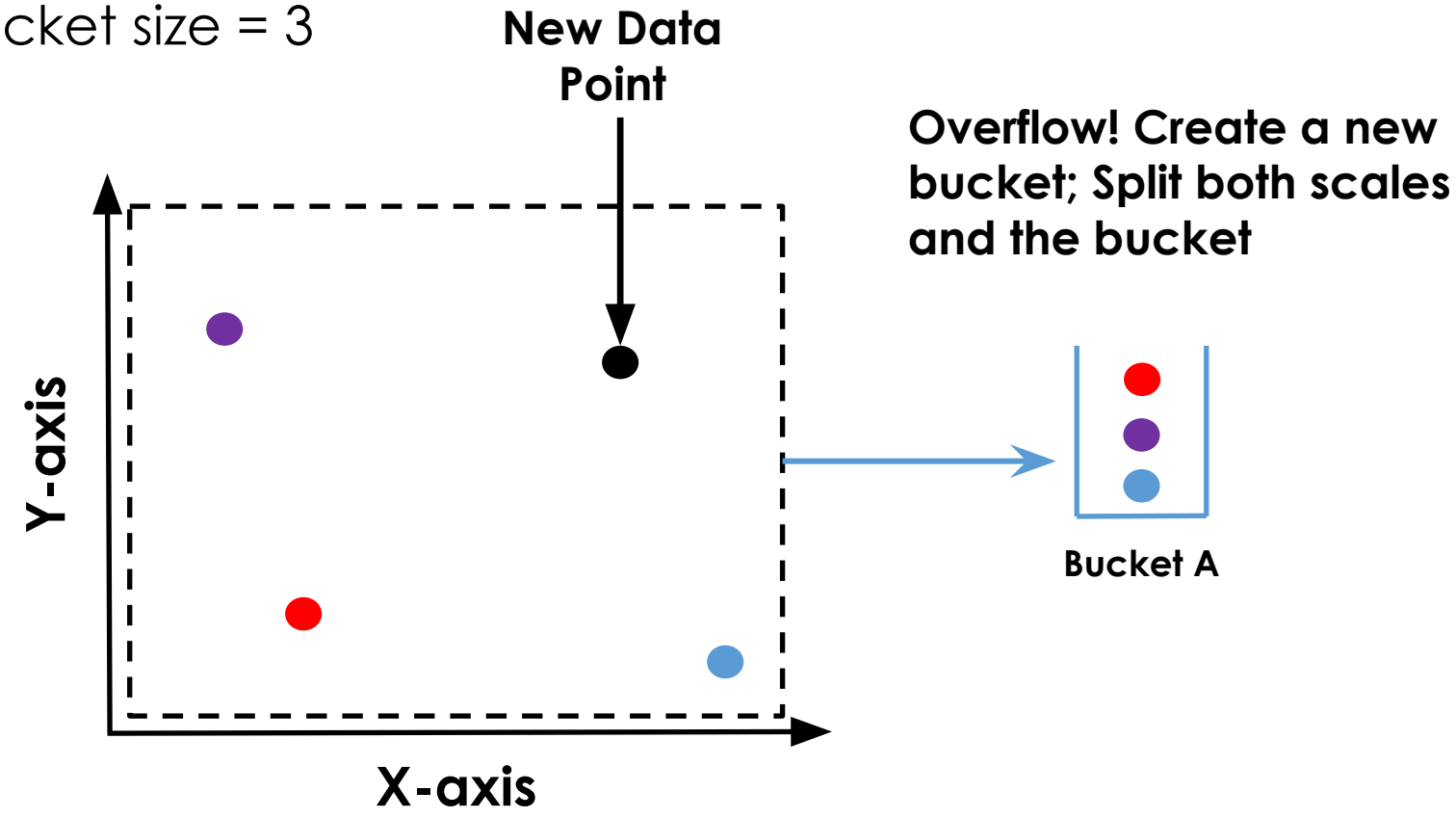
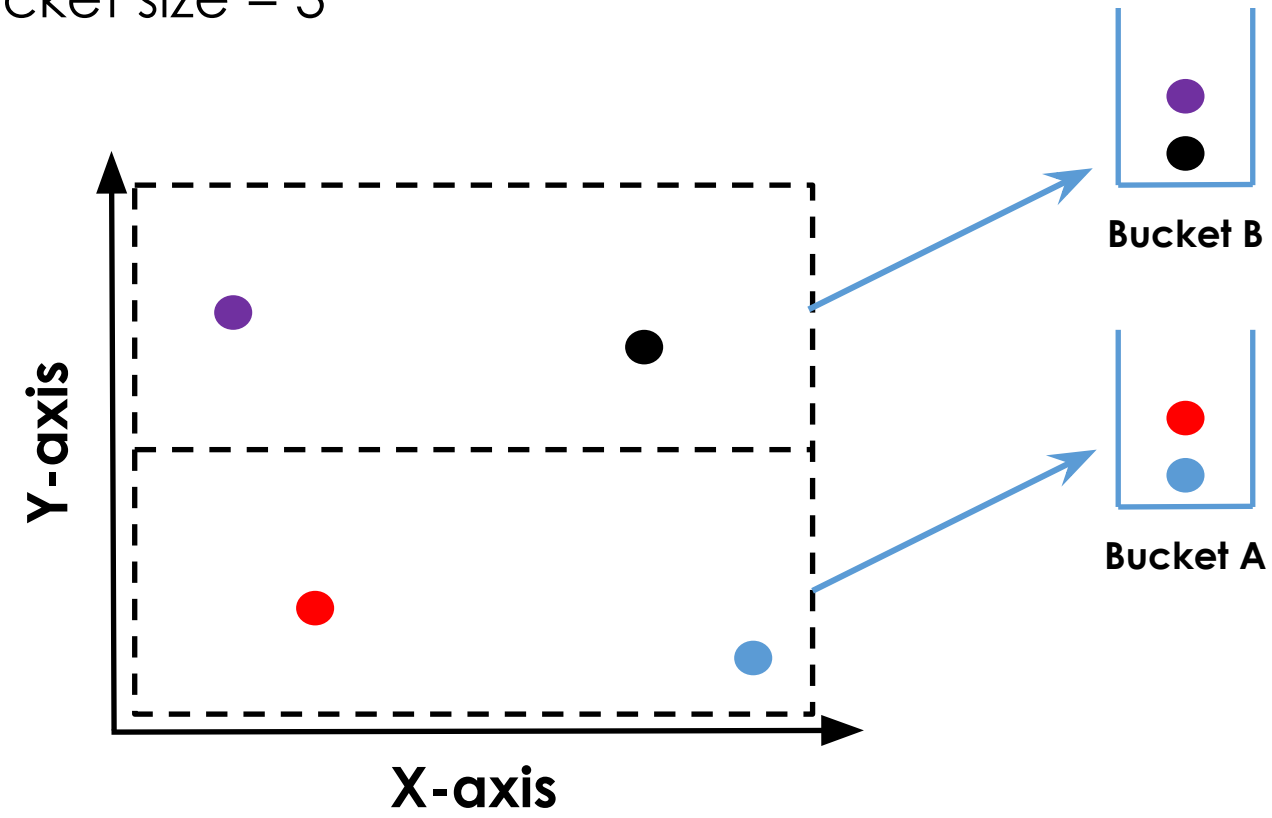


Resulting Grid File

- Assume Bucket size = 3



Both Directory (x & y scales) and the Bucket are split

Grid Files Inserting Points (Another example)

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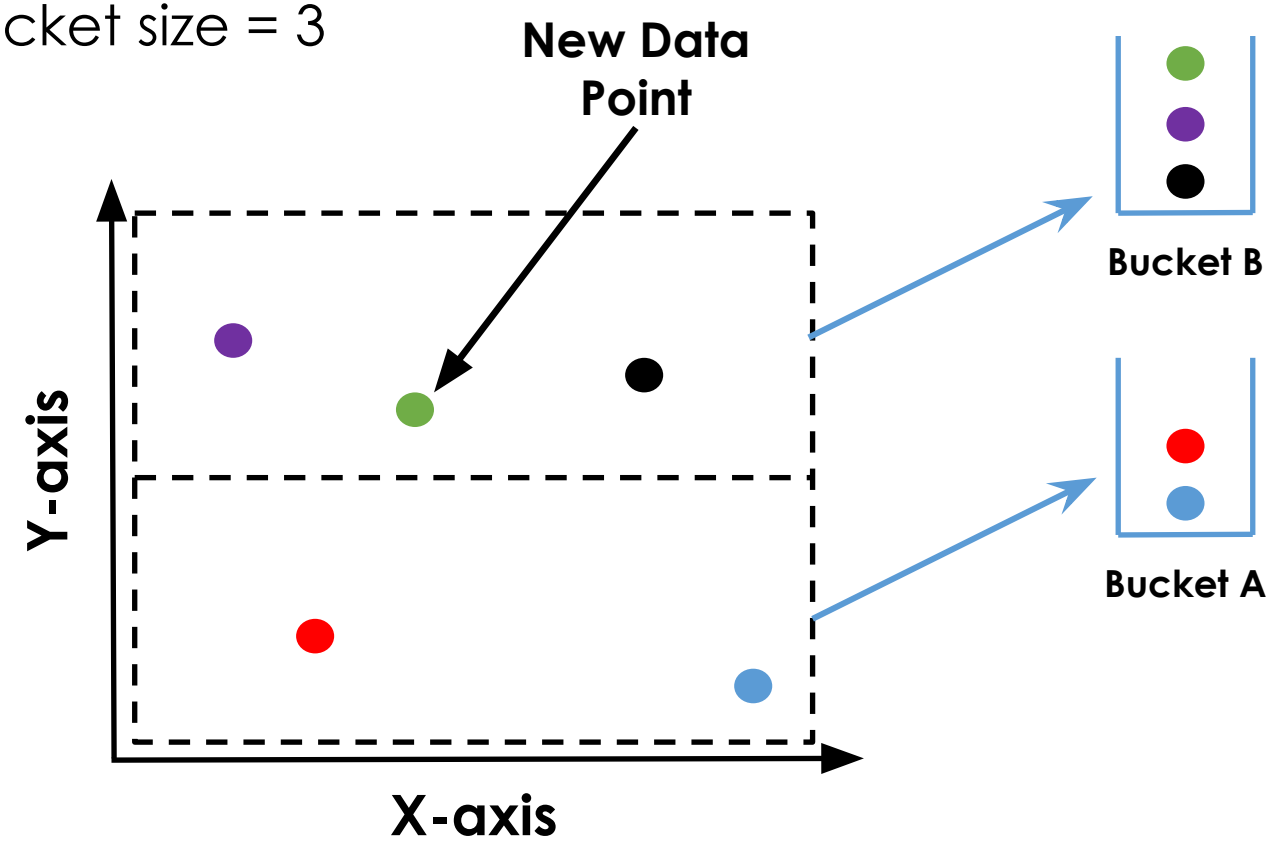

Grid Files Inserting Points (Another example)

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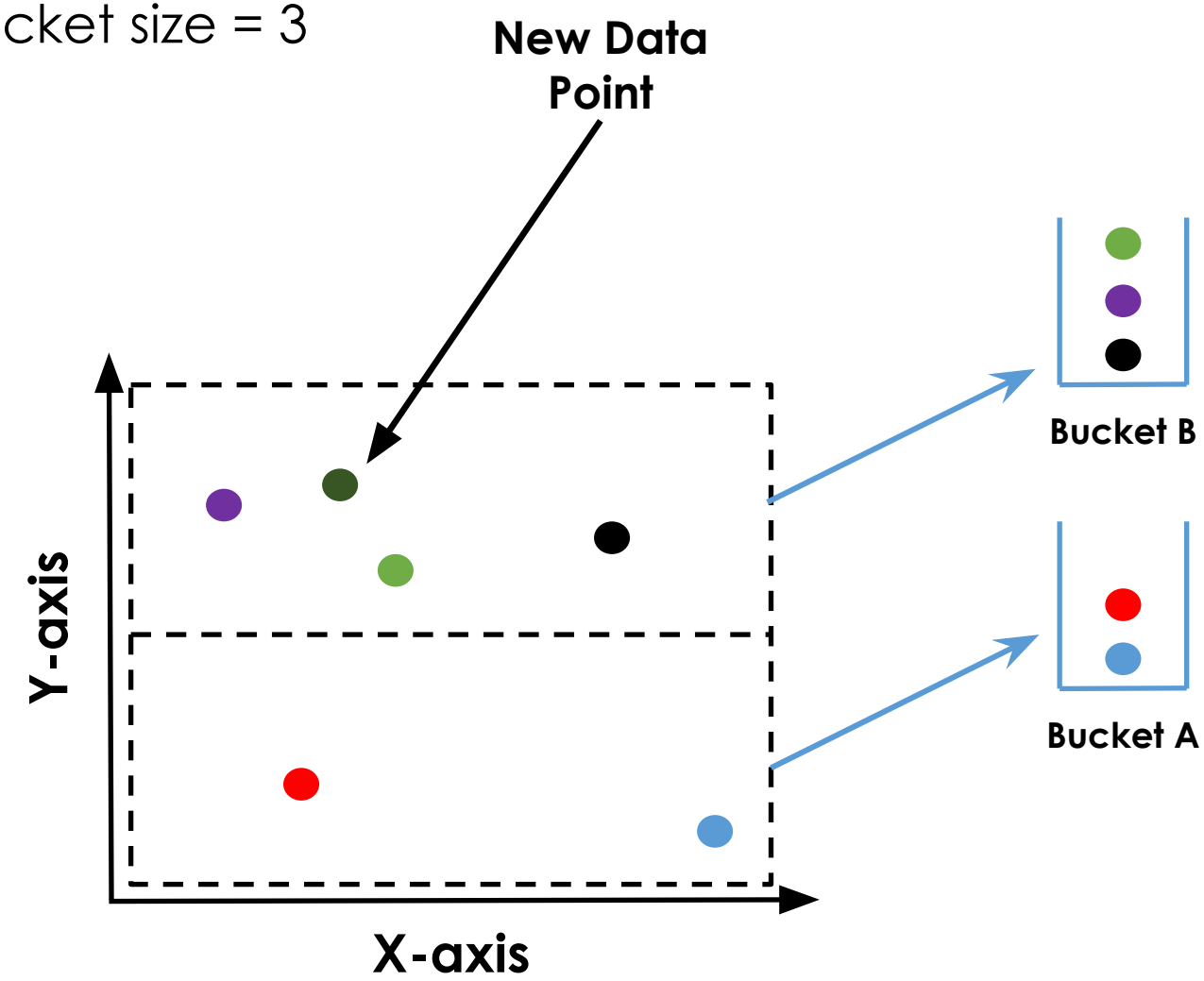
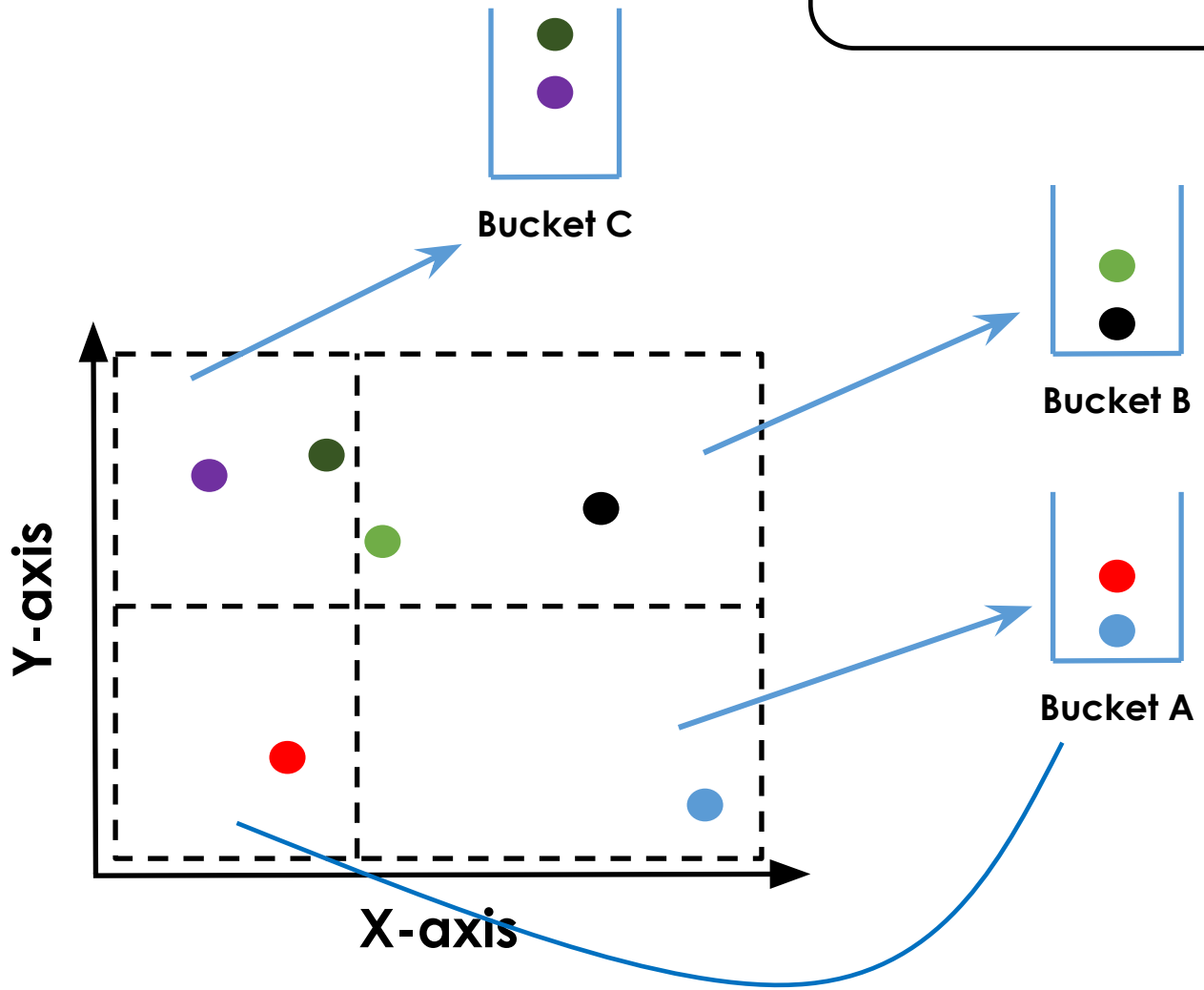


Overflow! Create a new bucket; Split both scales and the bucket.

Resulting Grid File

- Assume Bucket size = 3

Both Directory (x & y scales) and the Bucket are split



Grid Files Inserting Points (Another example)

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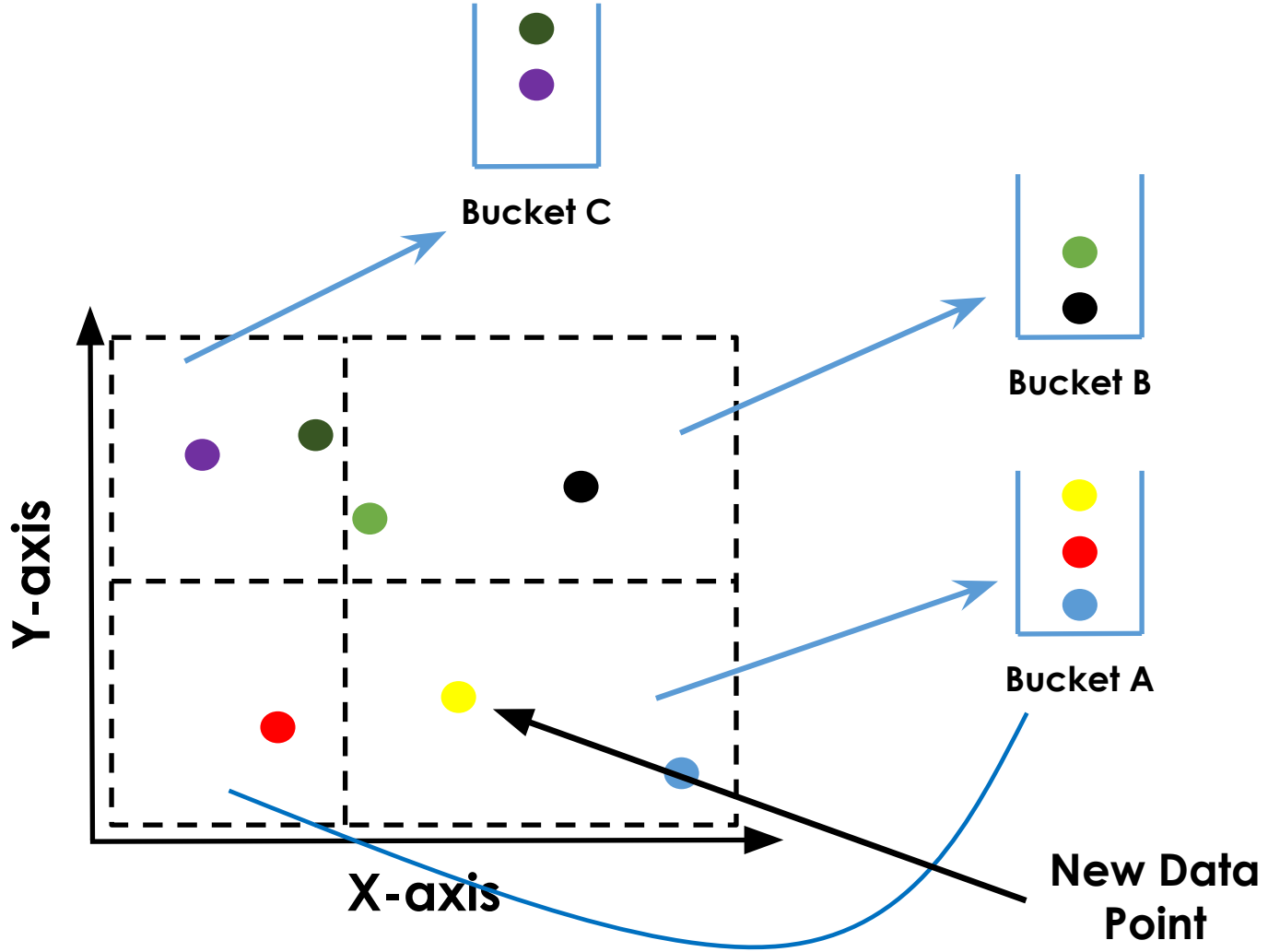

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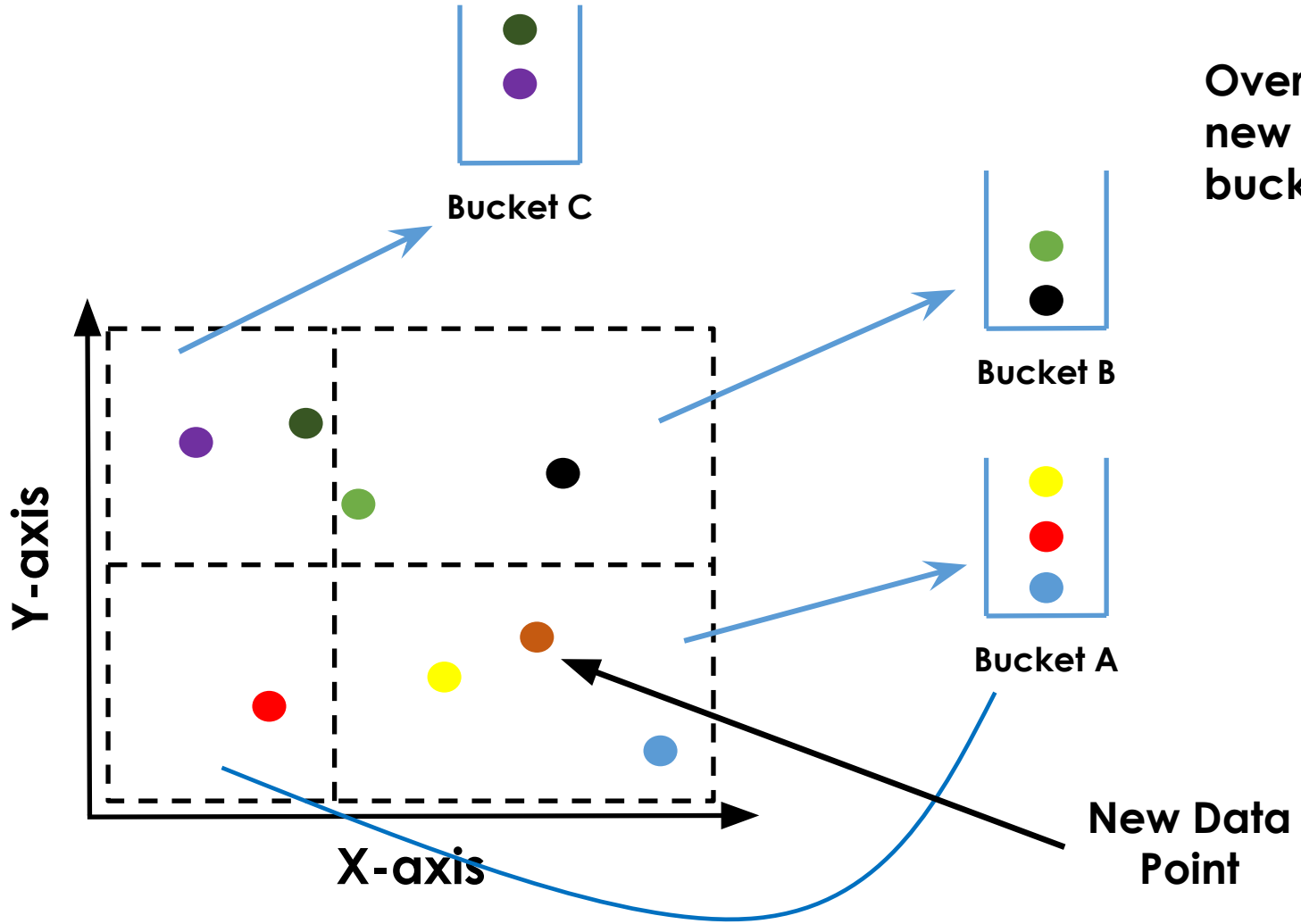
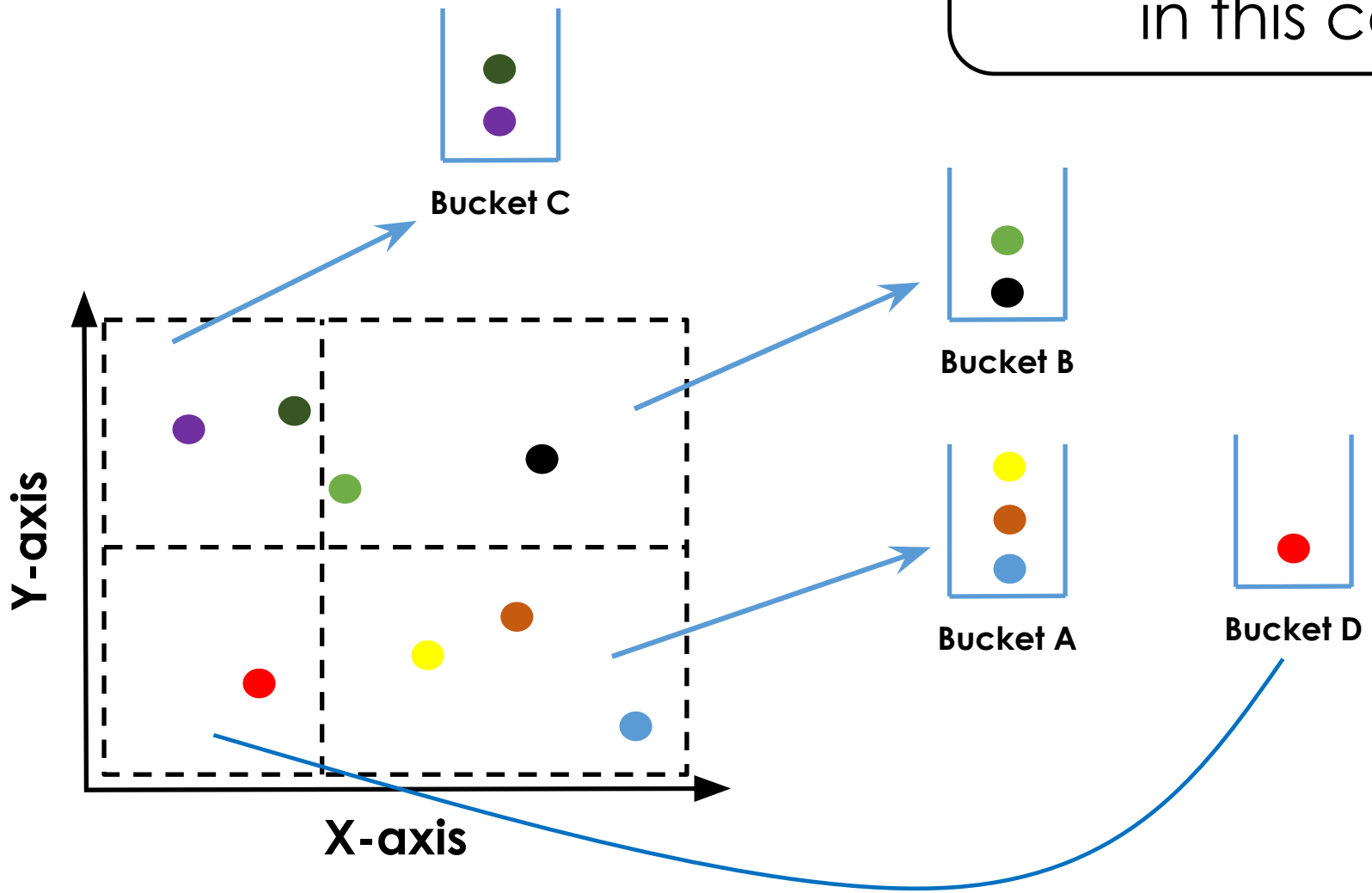


Resulting Grid File

- Assume Bucket size = 3

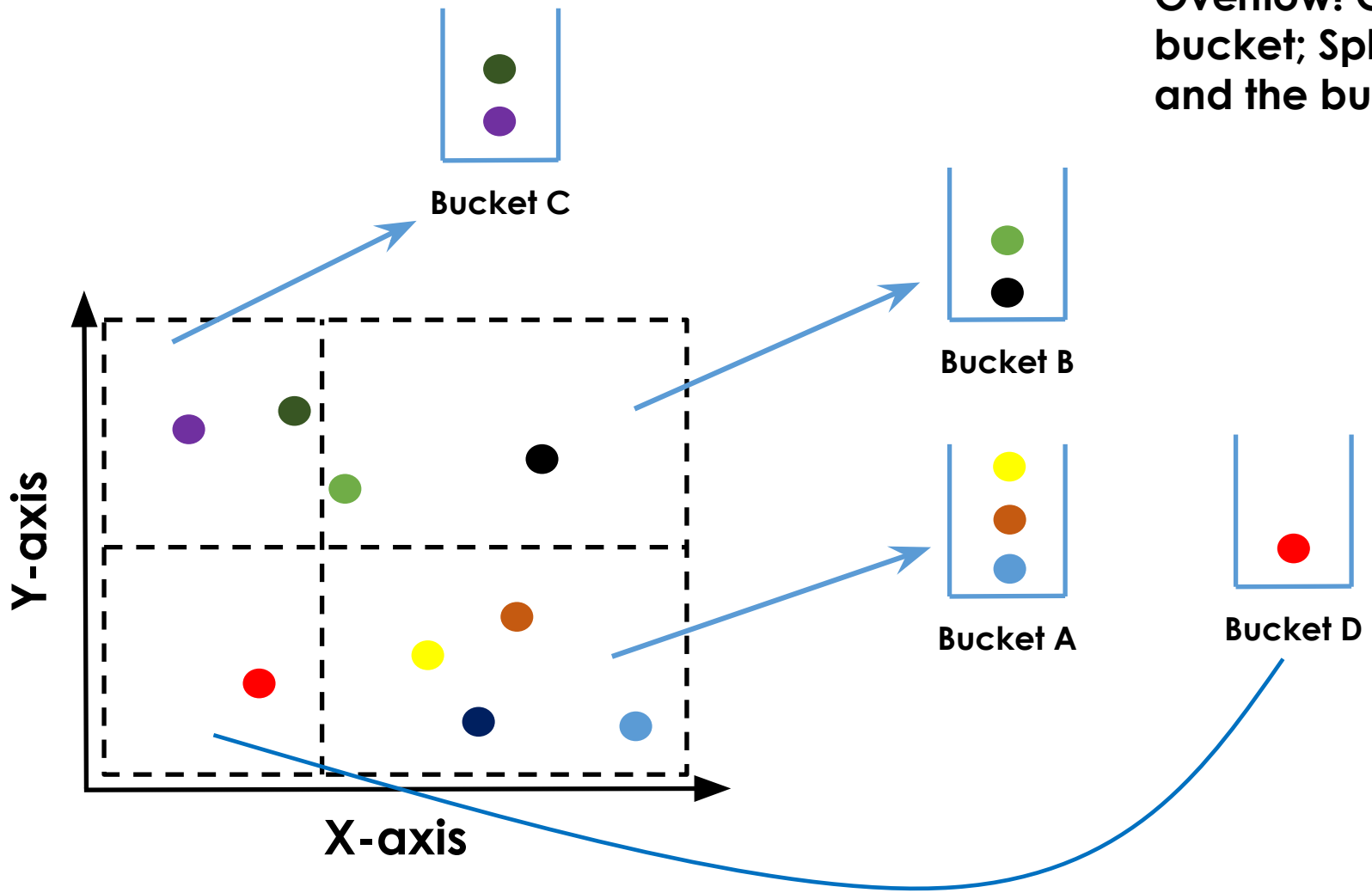
Only Bucket was split. Directory was not split in this case.



Grid Files Inserting Points (Another example)

- Assume Bucket size = 3

Overflow! Create a new bucket; Split both scales and the bucket.



Grid Files (Another example)

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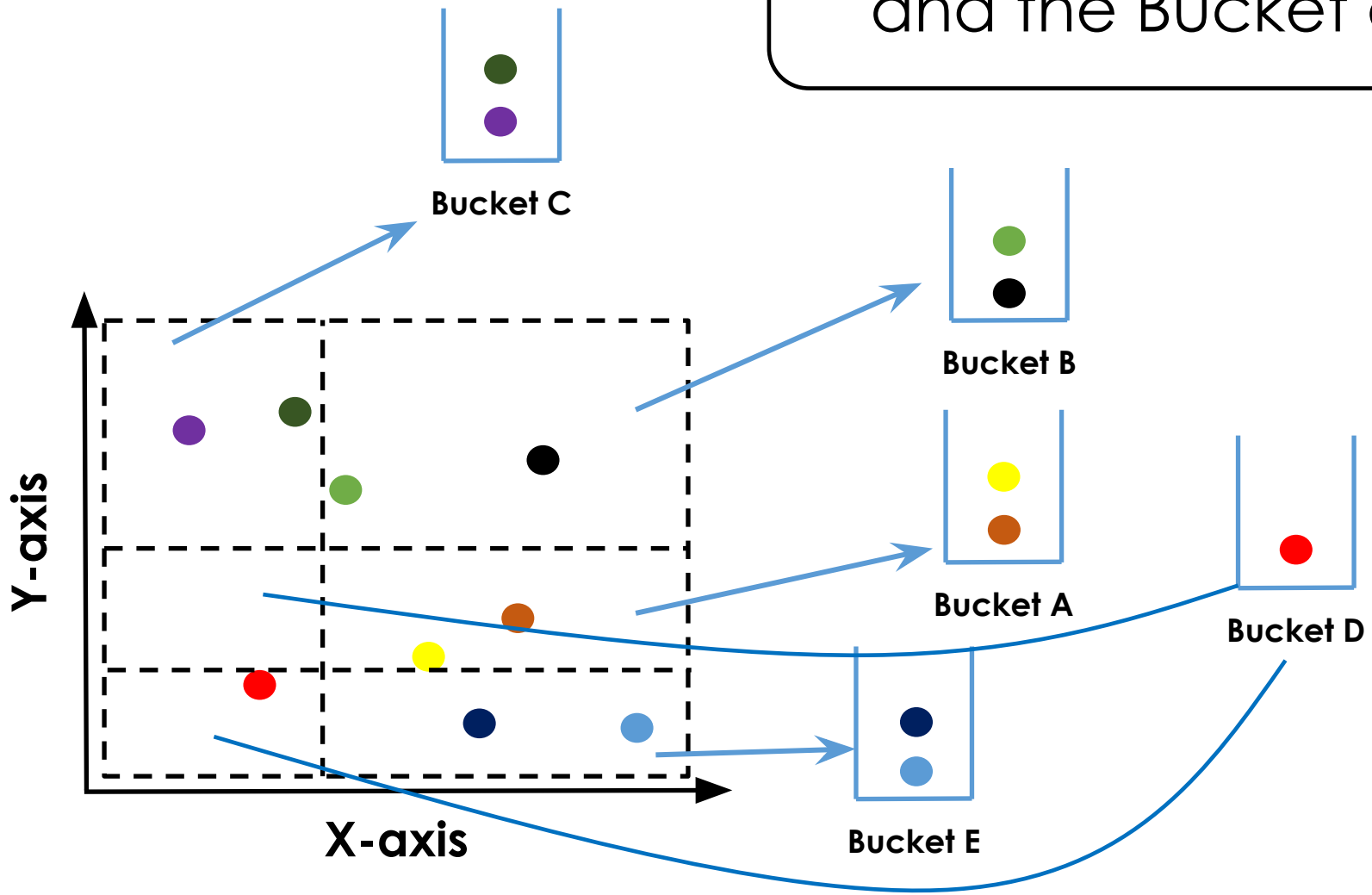
Both Directory (x & y scales) and the Bucket are split



Grid Files (Splitting Policies)

- **Splits:**
  - Can happen during insertion.
  - Overflow of a bucket corresponding to a grid partition leads to a split.
  - Can also happen if bucket containing records from several grid partition fills up.
  - Splitting dimension can be changed alternatively.
  - Splitting point may not always be the middle point, other algorithms are also possible.

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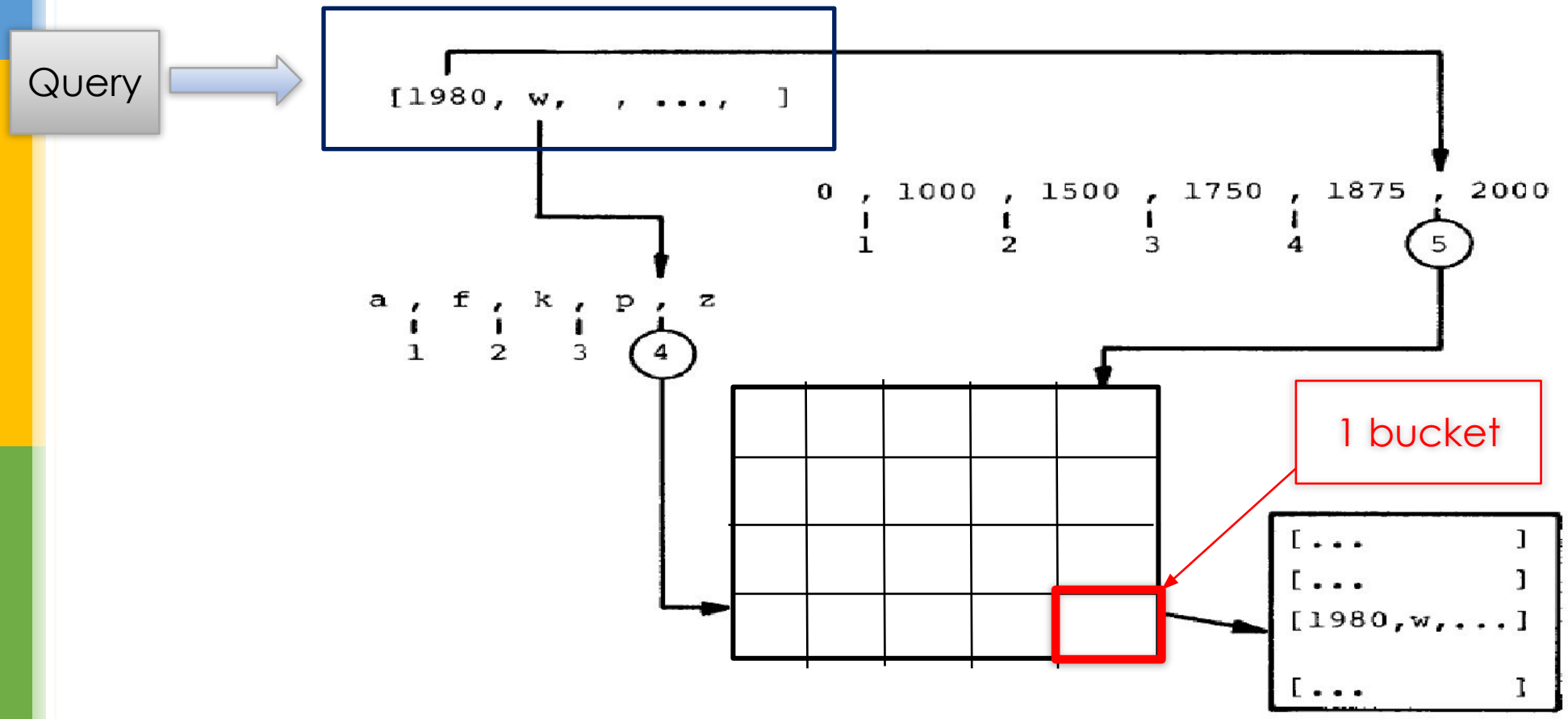
Grid Files (Querying example)

- X-partitions (0,1000,1500,1750,1875,2000)
- Y-partitions (a, f, k, p, z).



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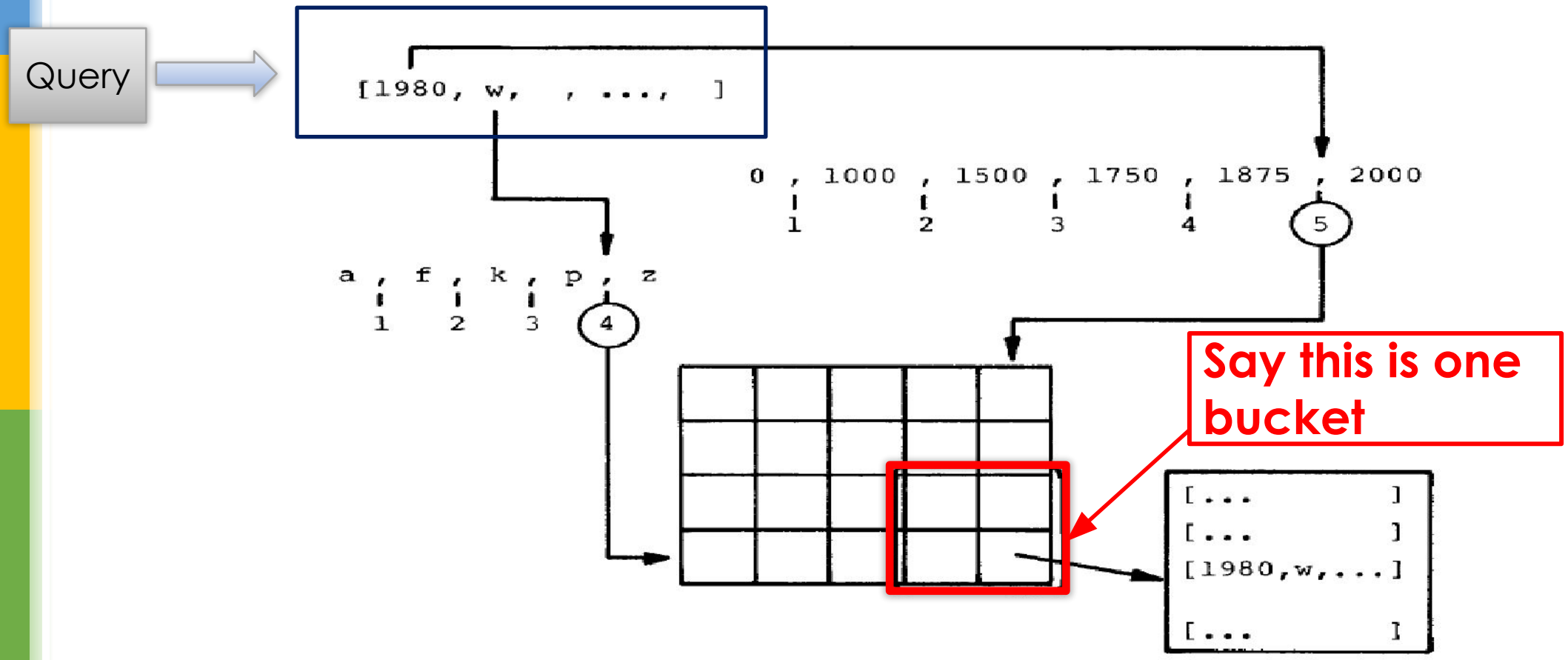

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More Examples on Grid Files (Inserting Points)

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Grid Files (Another example)

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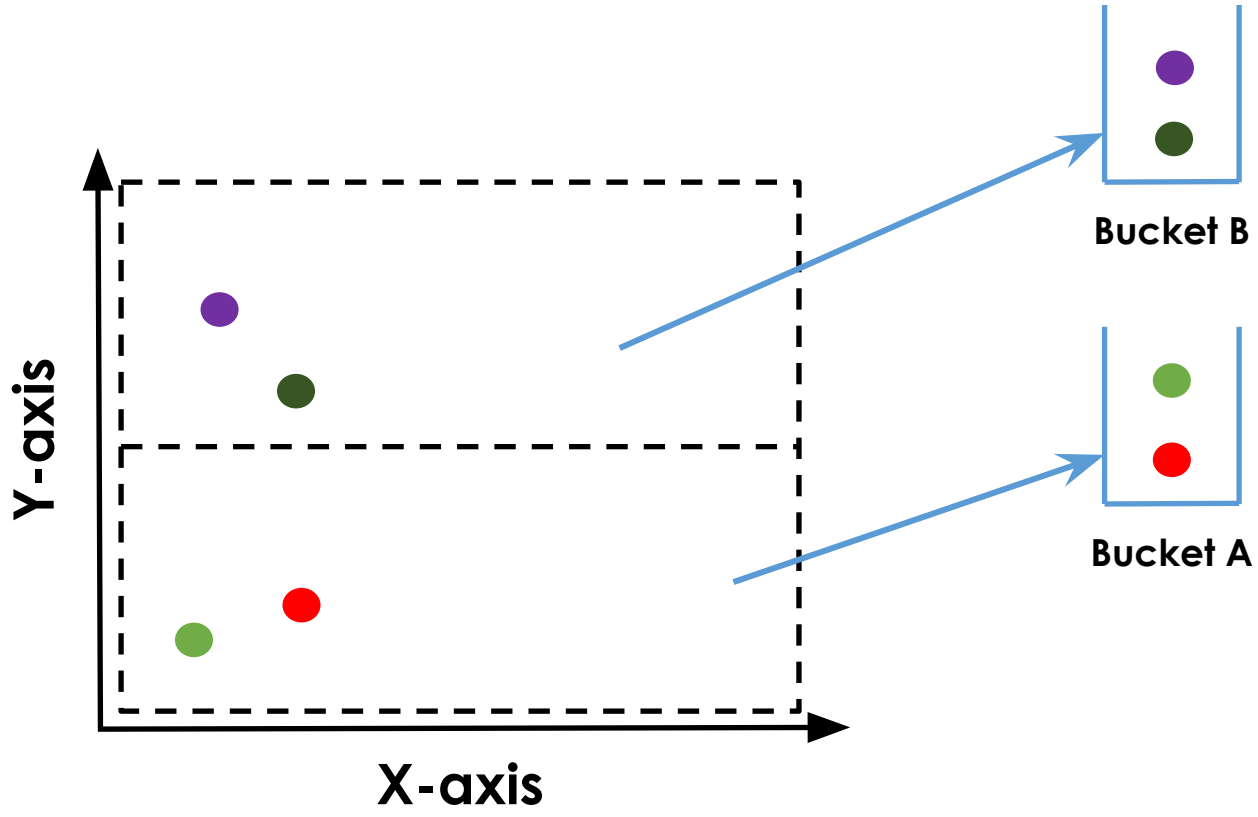

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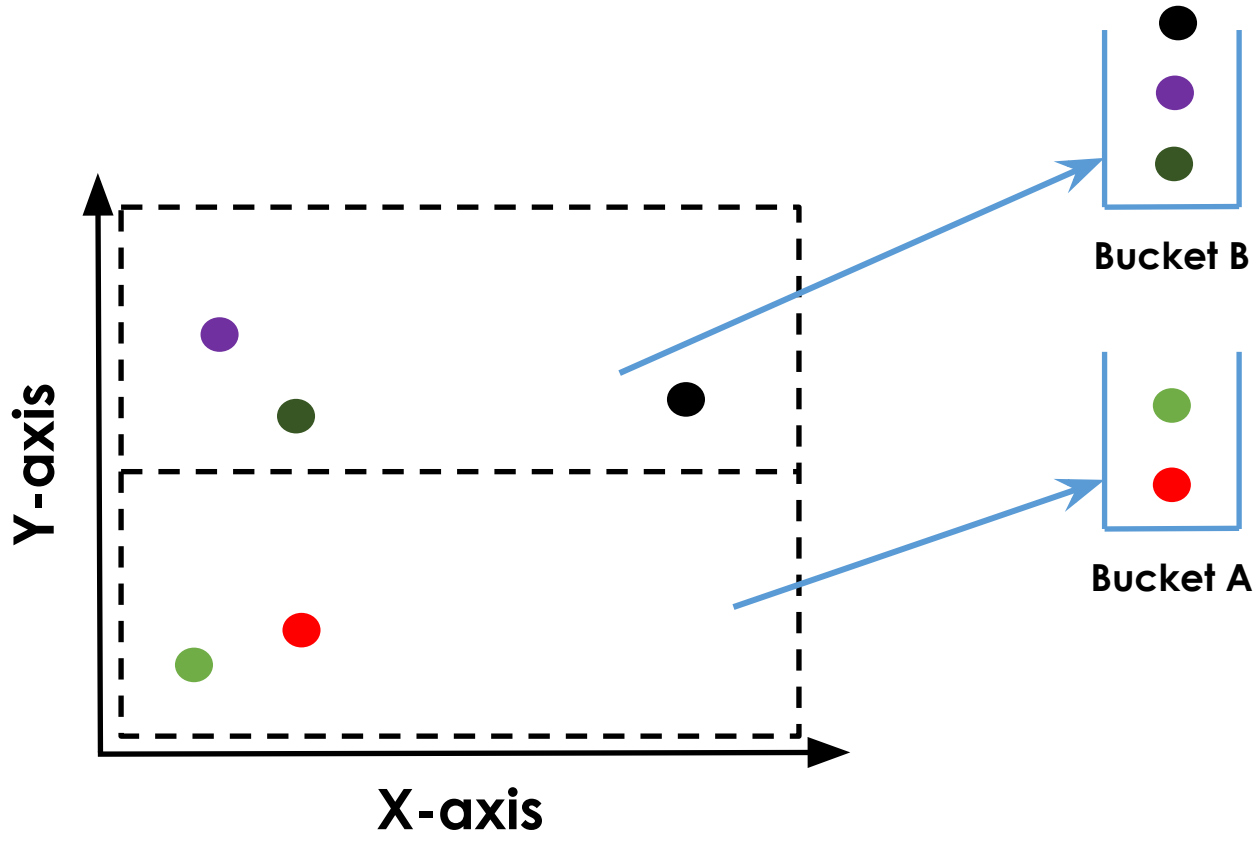

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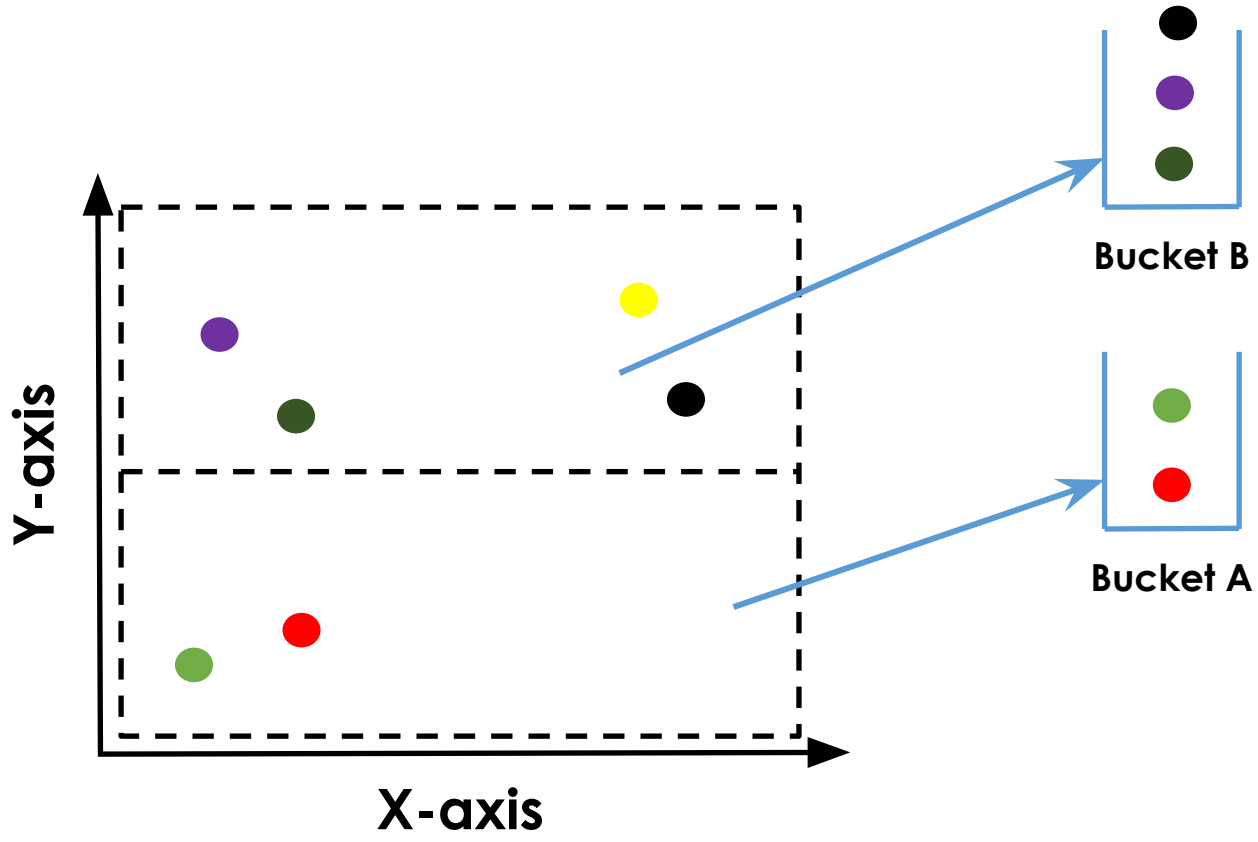
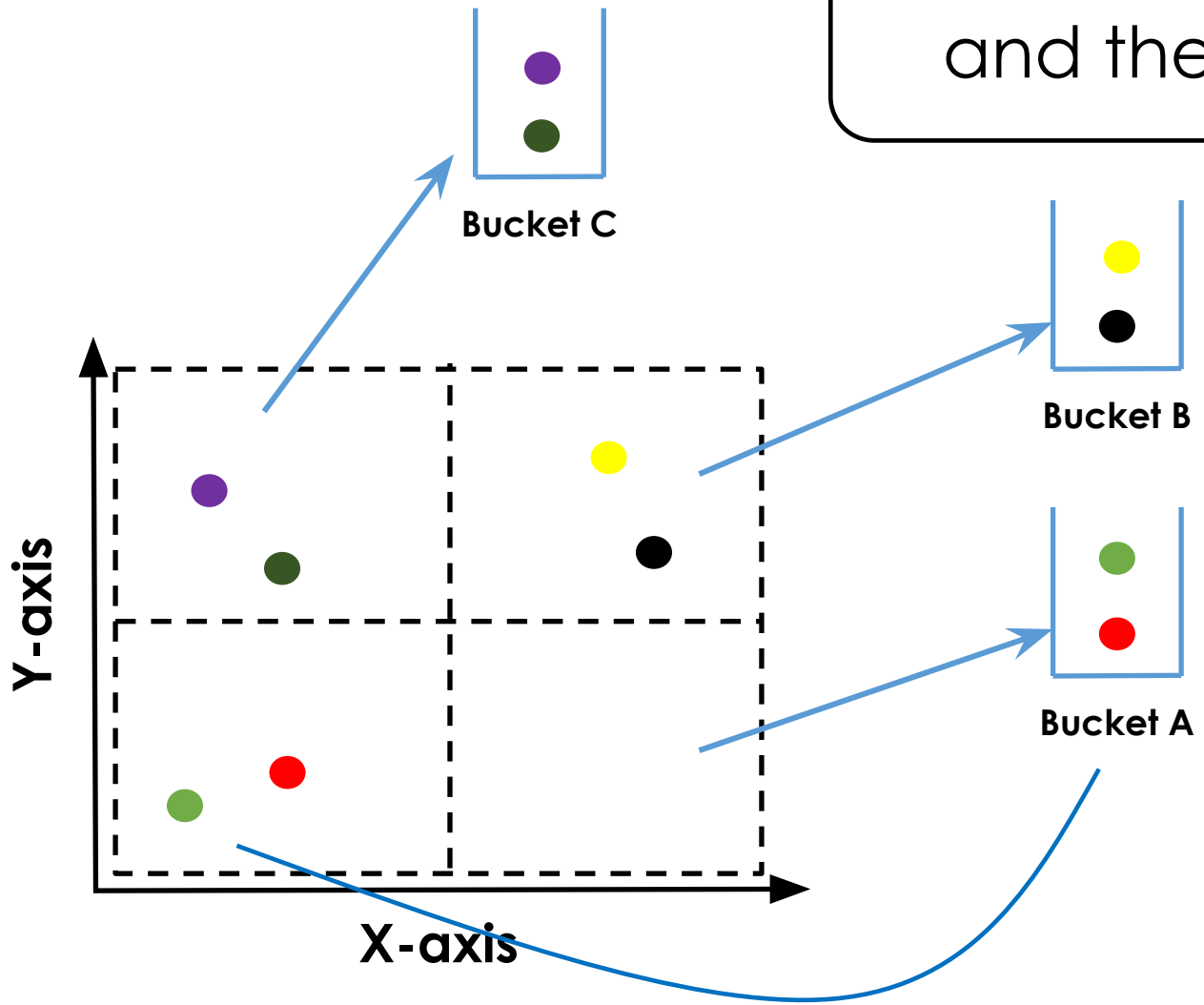


Grid Files (Another example)

- Assume Bucket size = 3

Both Directory (x & y scales) and the Bucket are split



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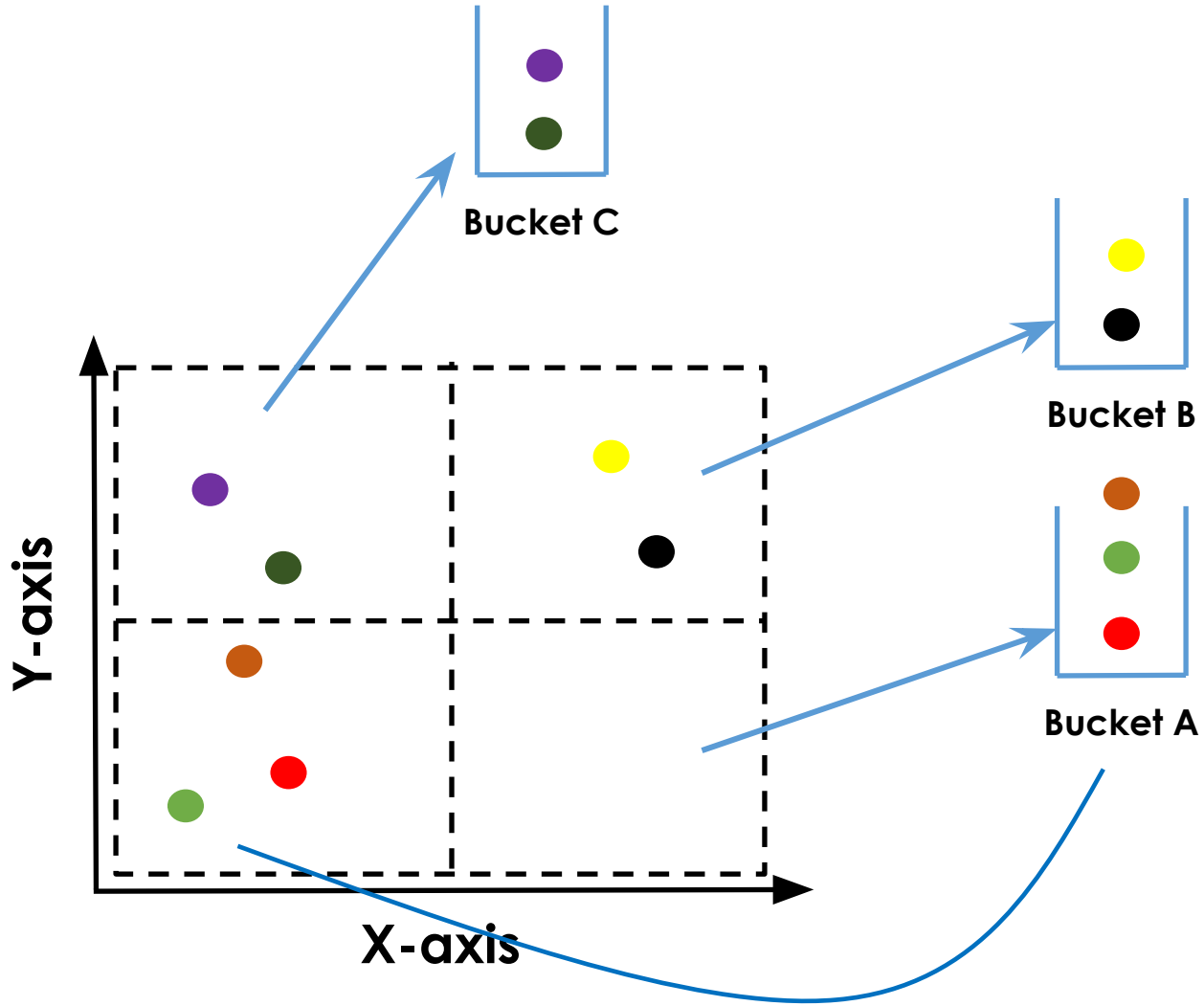

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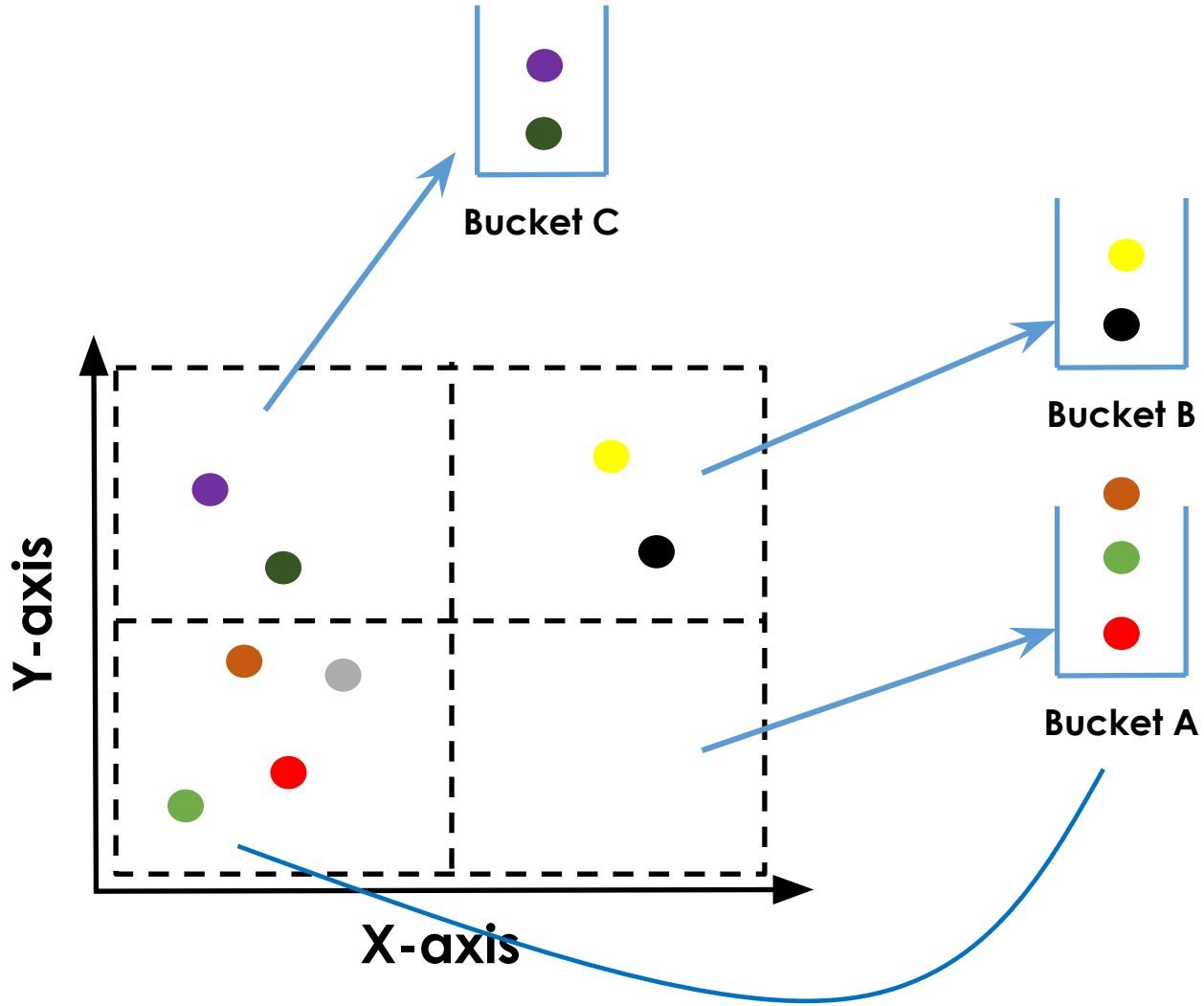

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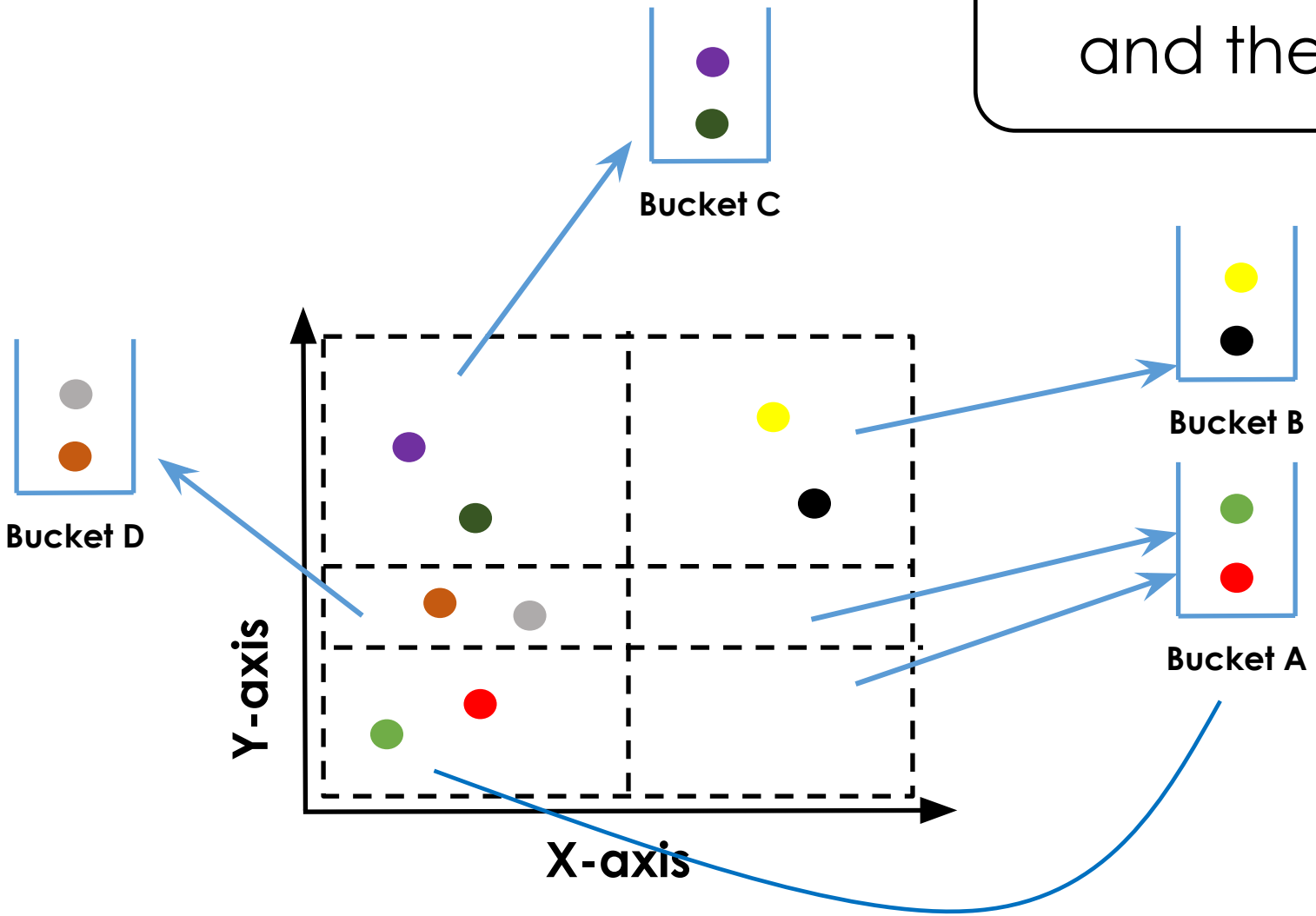

- Assume Bucket size = 3

In general, there can be multiple options while splitting. For e.g., cell C1 could be pointing to bucket D as well. Also it is ok for multiple cells to point to the same bucket.