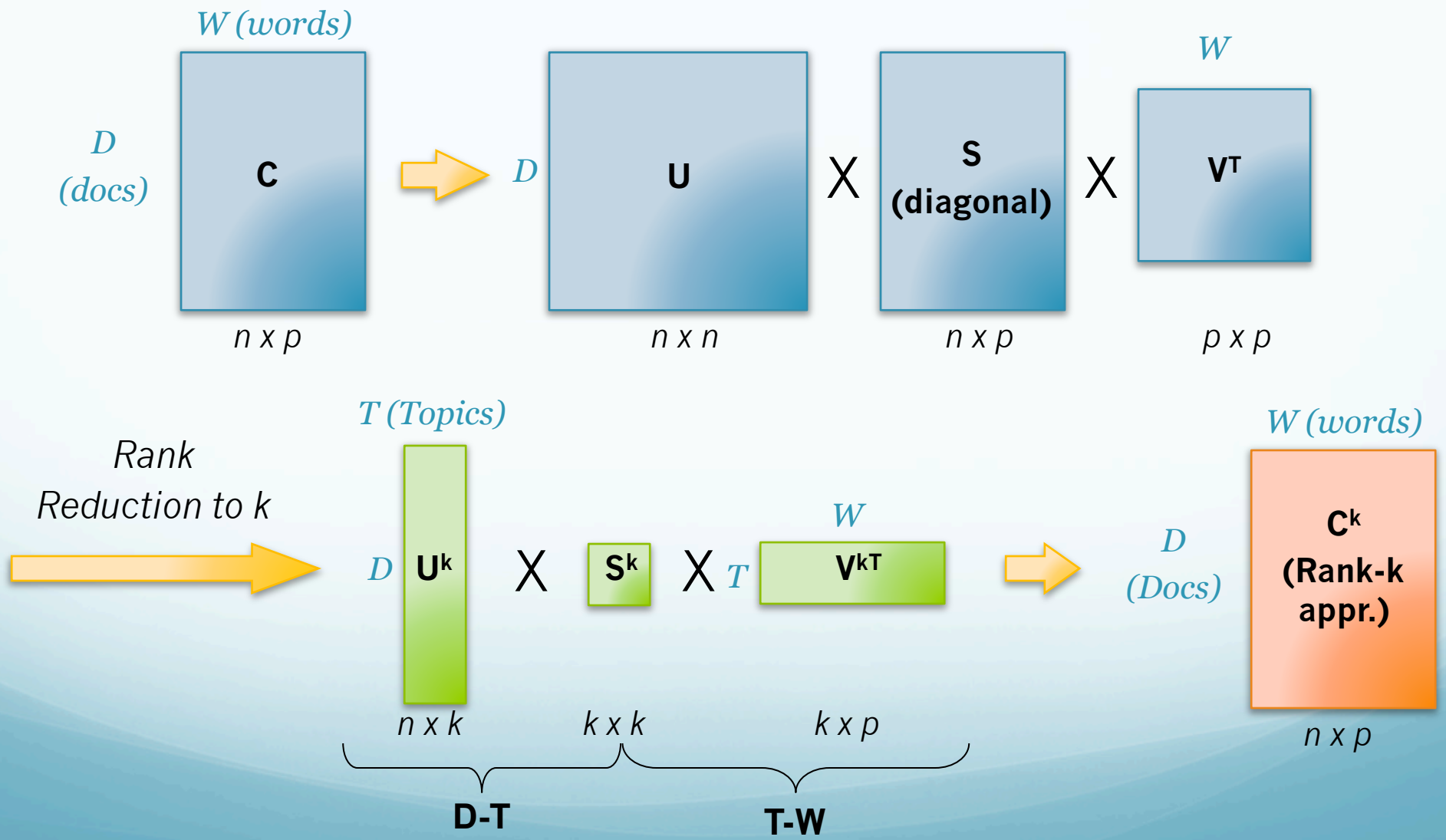
Spatial Indexing

Sessions 1A and 1B

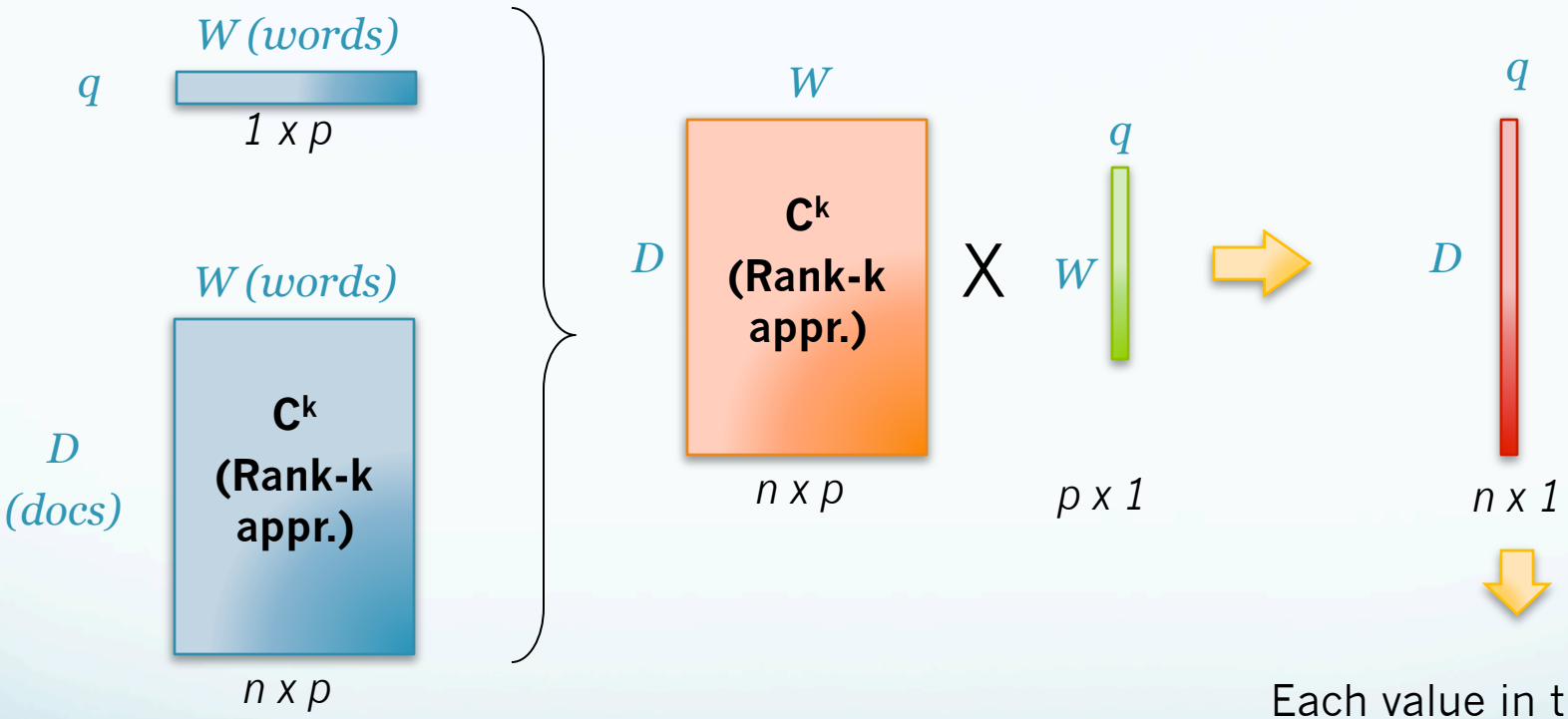
A Reminder…

- Project 3 is due next **Friday, 13th**!
- Please submit one only archive `project3.zip` containing:
  - `project3-indexer.zip`
  - `project3-searcher.zip`
  - `project2.zip`
- If you **plan to change your team status**, please let me know ASAP, so that you can submit your project 3 on CCLE.
- We have set up project 3 submission with the same teams as project 2.

Latent Semantic Indexing



- Similarity between a query vector and the corpus



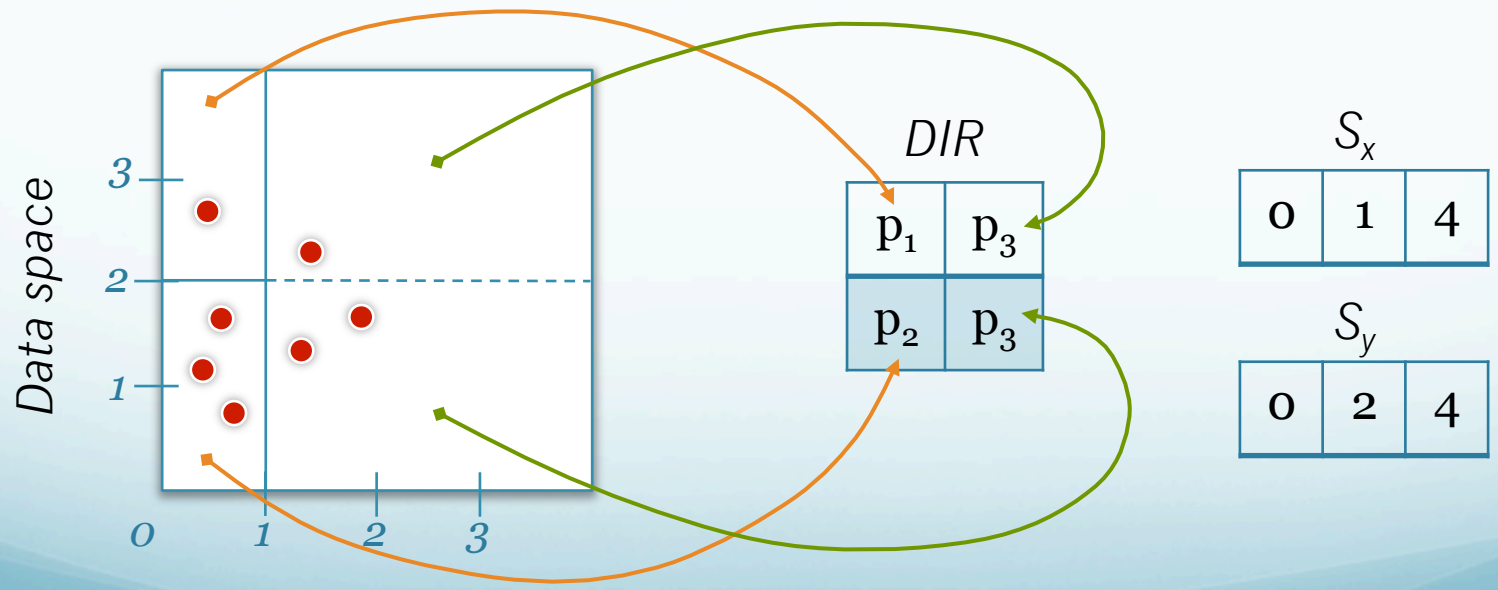
Each value in the vector represents the similarity between q and d_i

Spatial Indexing: Motivation

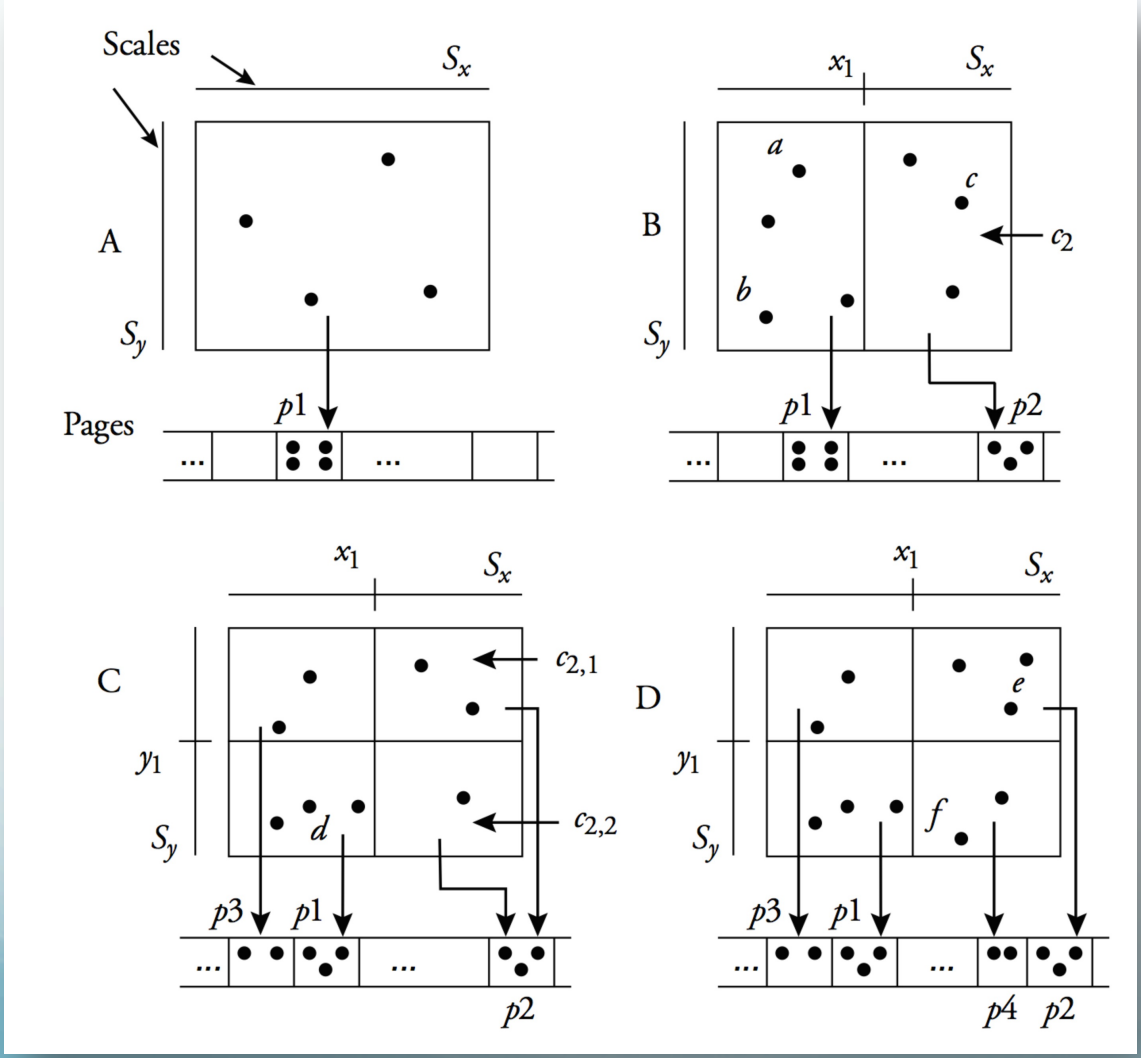
- DB Querying: **nearest neighbor**, **range**, **where-am-I?**, **partial match**.
- Efficient collision detection in 2 or 3D – **Videogames**!
- Computational **fluid dynamics**.

Grid Files

- Requires three data structures:
  - One directory DIR – 2D array that references pages associated with cells.
  - Two scales, S_x and S_y – 1D arrays to store axes' intervals.



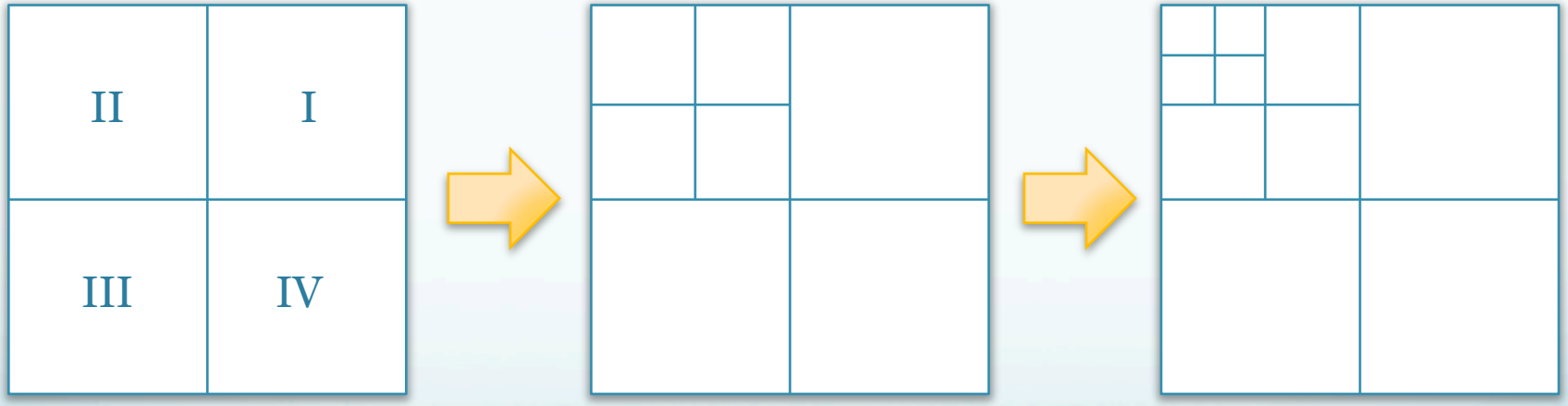
- Insertions in a File Grid, for $M = 4$



Any problem with this method?

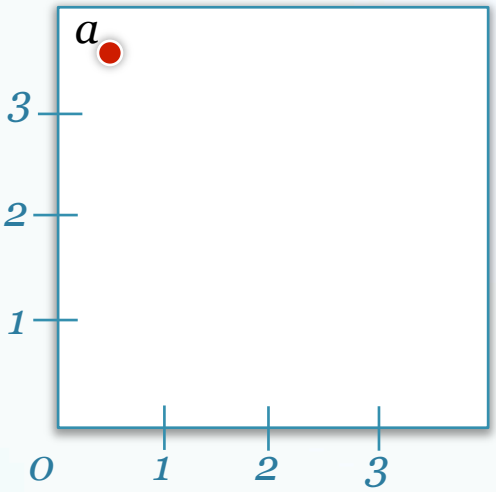
Quadtree

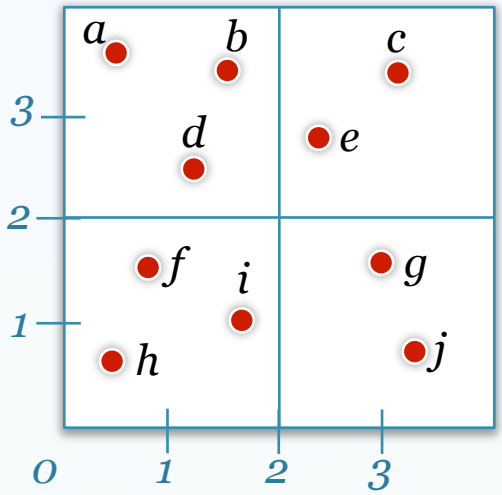
- An extended version of a Binary tree, but with (usually) four children.
- We can have at most M objects per quadrant – otherwise, split into four children.

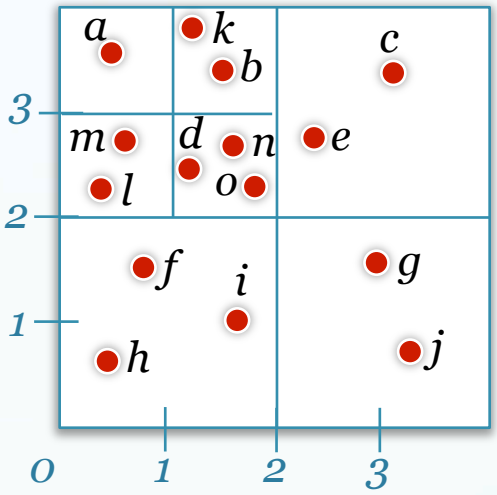


Increasing granularity

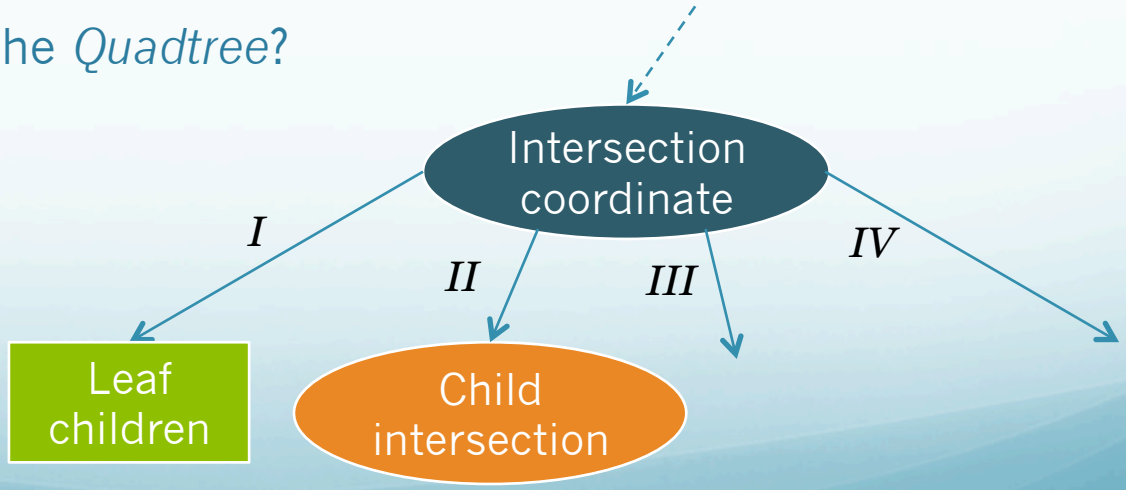
For $M = 3$



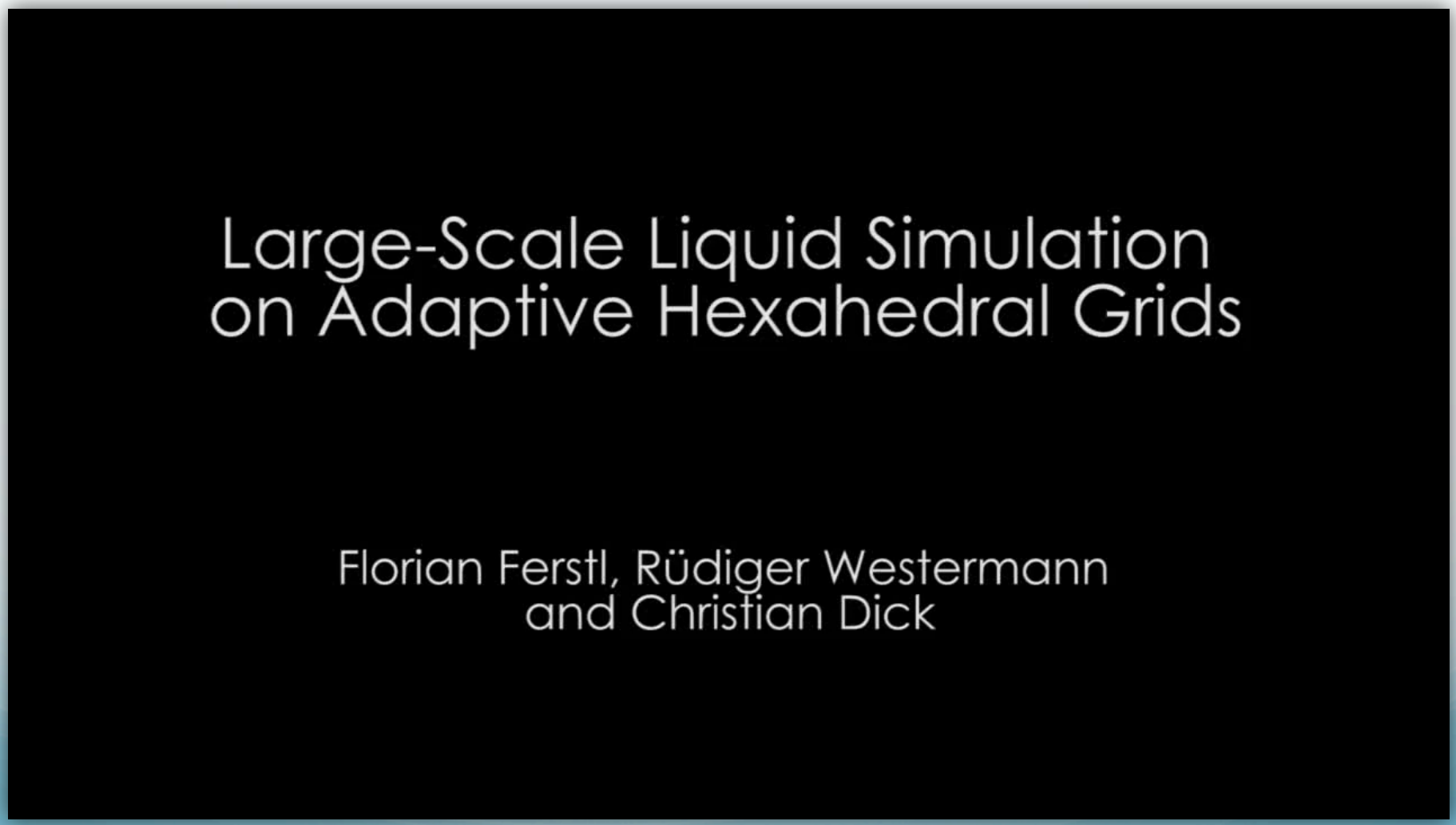




How do we build the *Quadtree*?



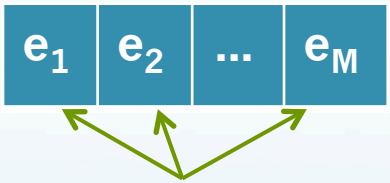
- Watch a JavaScript demo at: http://www.mikechambers.com/blog/2011/03/21/javascript-quadtree-implementation/



R-Tree

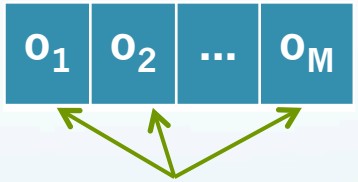
- A data-driven approach – it is a **depth-balanced tree**.
- Organize points according to a containment relationship.
- Each node has **directory rectangle** (dr) which is **minimal bounding box** (mbb) of its children.
- Each node is mapped onto a disk page:

Non-leaf node

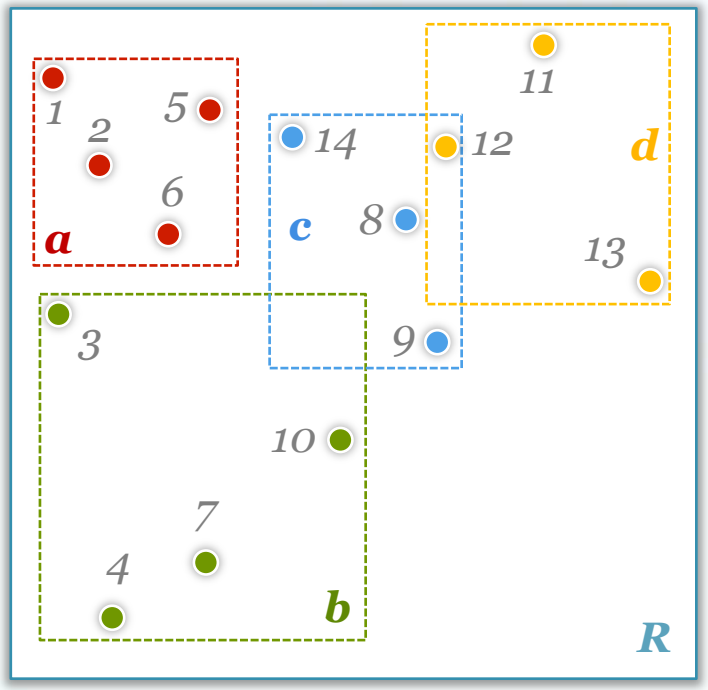


Non-leaf entries (dr_i, $addr_i$)
where $[0, M/2] \leq i \leq M$

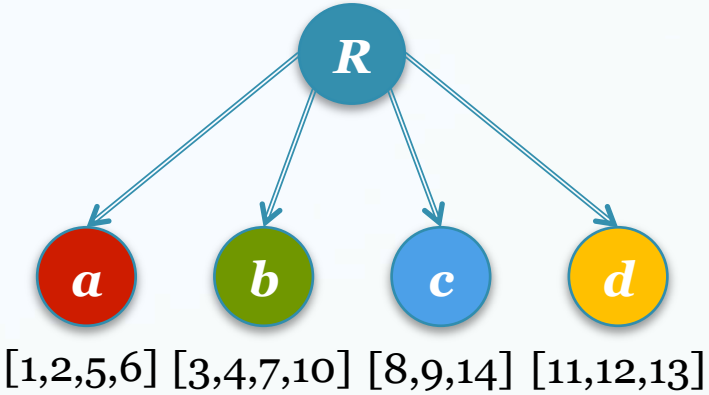
Leaf node



Leaf entries (x_i, y_i)
where $[0, M/2] \leq i \leq M$,
all leaf nodes are at the same level



Data space

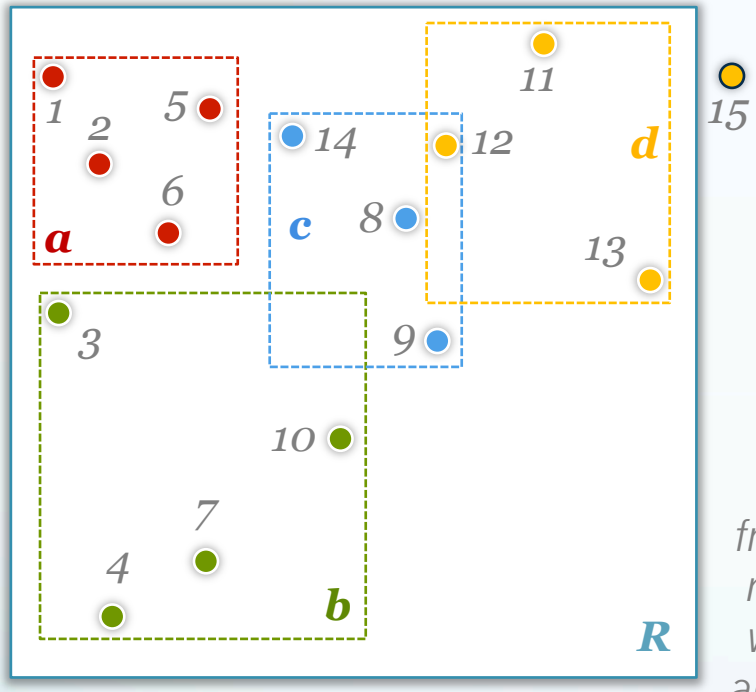


$M = 4, m = 2$

R-Tree

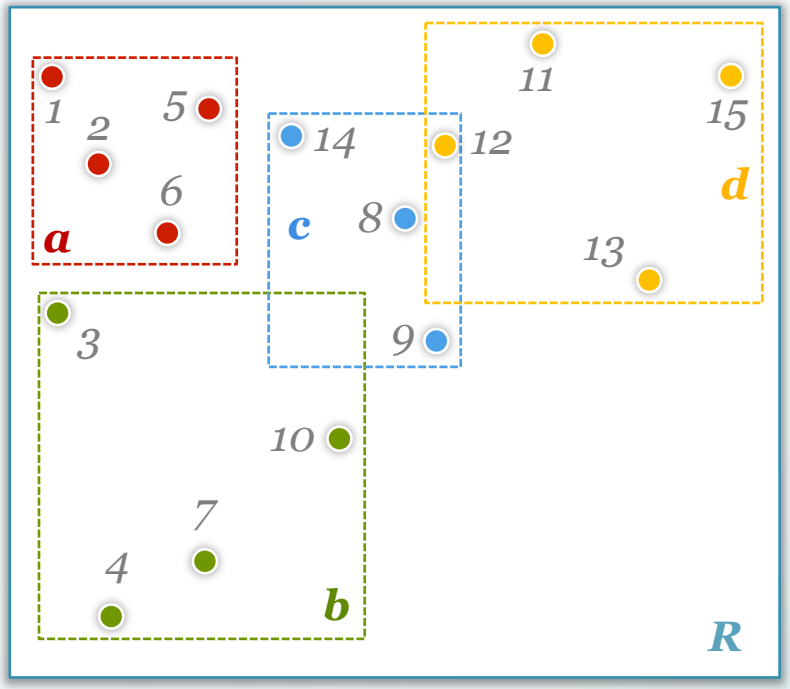
- How do you search for a point? Like, point 12…

- How do we insert points in the R-Tree?
  - Let's try with the **15th** point…



Data space

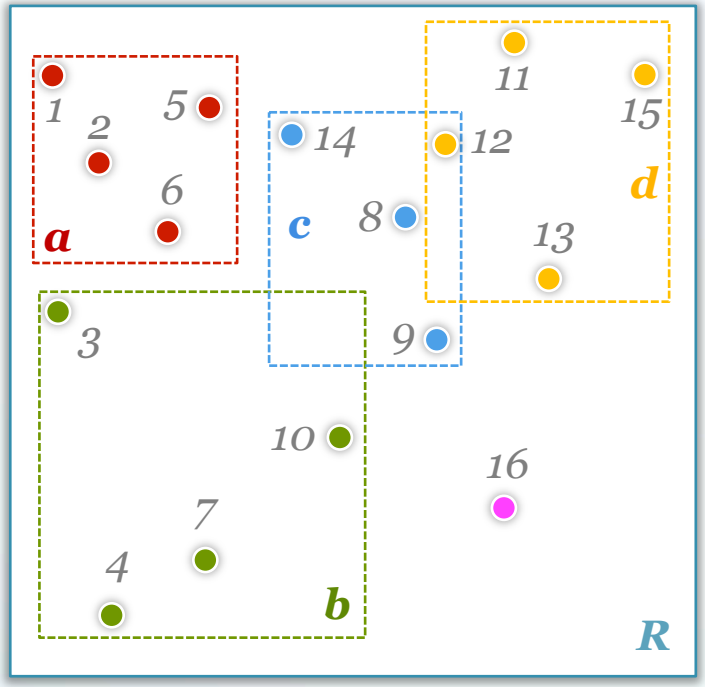
*Traverse tree from root to leaf node where **15** will live. Then, adjust the **dr** up to the root.*



Adjusted data space

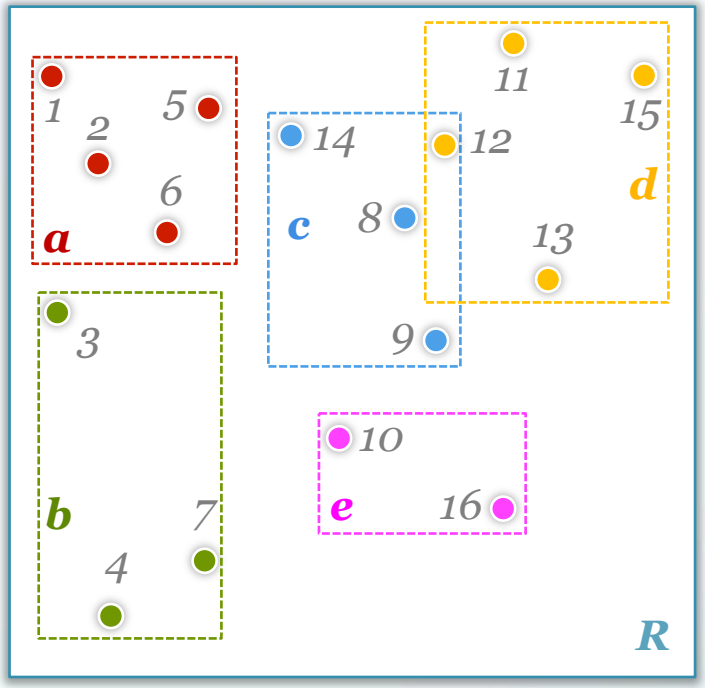
- How does the adjusted R-Tree look like?

- What about inserting the **16th** point?



Data space (0)

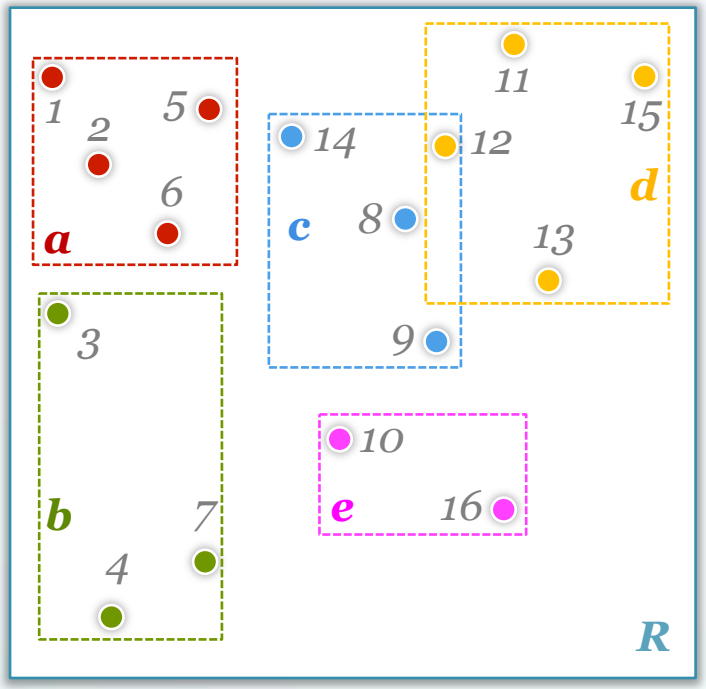
*Split **b**, since it overflowed. Create leaf **e** with points **10** and **16**.*



Data space (1)

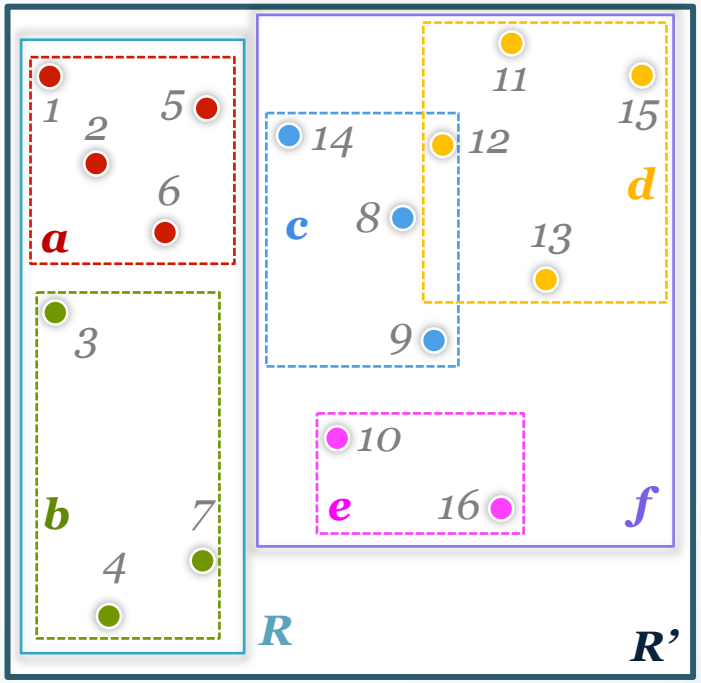
- **Are we done adjusting the data space?**

- ***R*** has overflowed too! We need to split it…



Data space (1)

*We will create one internal node, **f**, adjust node **R**, and create a new root, **R'**, for the data space.*



Data space (2)

- **How does the new R-Tree look like?**

Spatial Indexing in MySQL

- First, make sure your table has a **NOT NULL** column of type geometry, **g**

```
CREATE TABLE particles (g GEOMETRY NOT NULL) ENGINE=MyISAM;
```

- Given a string, in ***WKT*** (*Well Known Text*) format, representing a point: **(1.5, -2.6)**, populate your table as follows:

```
INSERT INTO particles VALUES (GeomFromText('POINT(1.5 -2.6)'));
```

- With the column **g** ready, create an *R-Tree* – MySQL will do it for you!!

```
CREATE SPATIAL INDEX sp_index ON particles (g);
```