Fast Window Aggregate on Array Database by Recursive Incremental Computation

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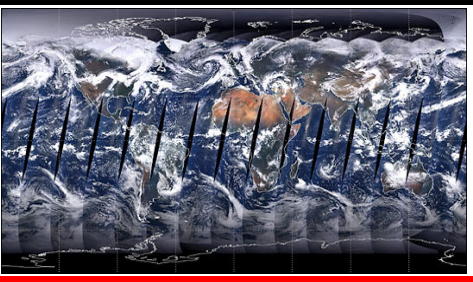
Window Aggregate over Array Database



NASA Earth Science Data Product: MODIS Satellite Sensing Data

- ✓ Huge multi-dimensional data is generated rapidly in many sciences
- ✓ Require efficient tools to manage and analyze such data, since multi-dimensional schema doesn't fit in relationship database very well

Query: select max(v) from *arr* grouping by window (2,3)

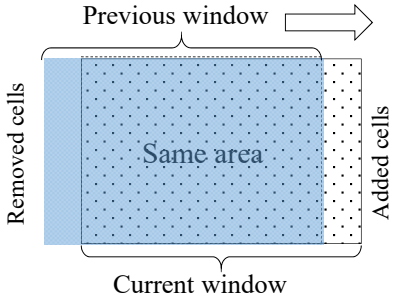
4	7	3	1	8
5	2	6	2	2
3	9	3	2	4
7	7	8	2	6

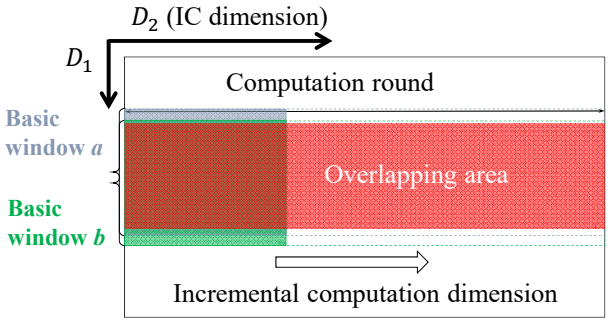
→

7	7	8	8	8
9	9	6	4	4
9	9	8	6	6
7	7	8	6	6

[Insight] 1-D Incremental Computation and its Defect

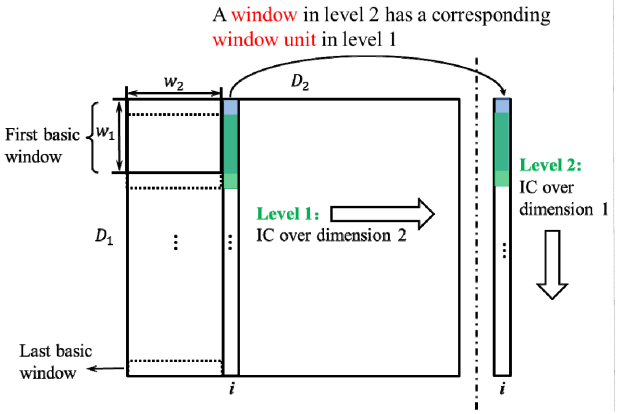
- ✓ Naive method
  - ➢ For each window, scan all the elements inside it, accumulate and compute the aggregate results
- ✓ Problem: redundant calculation exists
- ✓ Considering adjacent windows
  - ➢ Large overlapping area
  - ➢ Few cells are different
- ✓ Incremental Computation works as stream processing

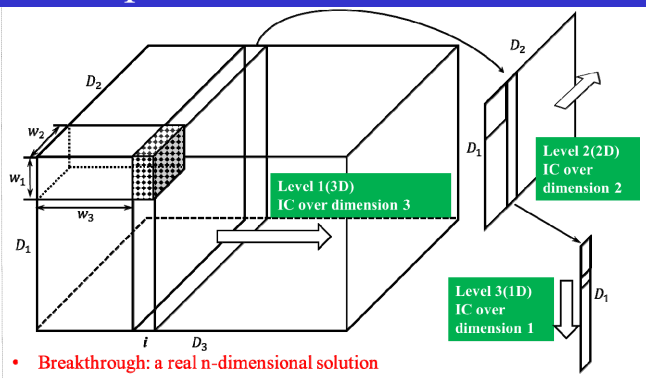




[Proposal] Recursive Incremental Computation

- ✓ Recursive Dimensionality Reduction
  - ➢ Keeping breaking a n-D window aggregate down to multiple smaller window aggregates.
- ✓ Each level has its unique IC dimension.
  - ➢ Level 1: n-D task (the original window aggregate)
  - ➢ Level 2 (n-1)-D tasks
  - ➢ ……
  - ➢ Level n: 1-D tasks



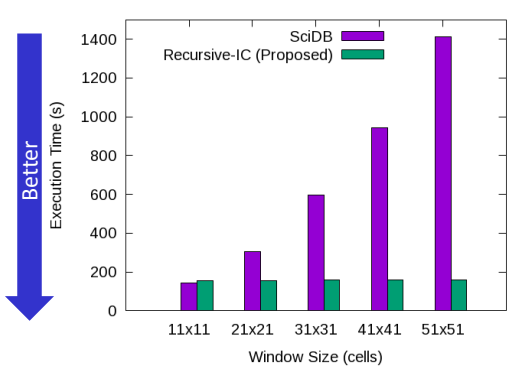


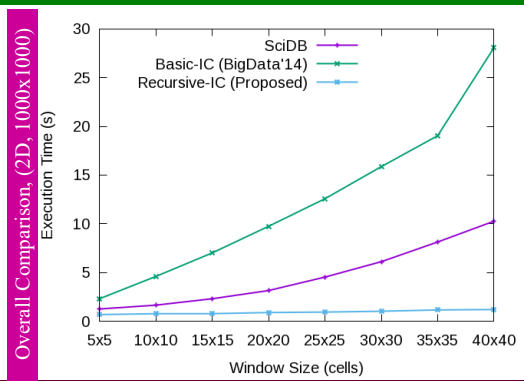
- Breakthrough: a real n-dimensional solution
  - No redundant calculation during the whole process at all
- Tradeoff: more extra space cost, one buffer tool maintained for each computation round

[Result] Experiment on Earth Science Benchmark

- ✓ A real application of earth scientific data analysis [1]
  - ➢ Earth Science benchmark [2]
  - ➢ Window aggregate operator used to reduce resolution of other analyzing tasks' results on purpose of visualizing, comparison and further analysis.
- ✓ Data: NASA MODIS product
  - ➢ 45 MODIS files downloaded
  - ➢ Preprocessed, loaded into SciDB cluster
- ✓ Task: NDVI (Normalized Difference Vegetation Index)
  - ➢ Result: huge 2-D array
  - ➢ Average window aggregate to down-sample

[1] Gary Lee Planthaber Jr. Modbase: A scidb-powered system for large-scale distributed storage and analysis of modis earth remote sensing data. PhD thesis MIT,, 2012.
[2] Earth science benchmark over modis data.
http://people.csail.mit.edu/jennie/elasticity_benchmarks.html.





[Conclusions]

1. Proposed a method for efficient calculating window aggregates in array databases.
2. Improvement is proportional to total window size W
   A) For a real earth application, recursive method achieved 10 times faster against SciDB method
   B) For a big window case in synthetic test, proposed method achieved 64 times faster

Code is on GitHib
https://github.com/ljiangjl/Recursive-IC-Window