# Overview of SciDB: Large Scale Array Storage, Processing and Analysis

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10/30/2013

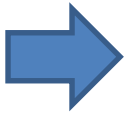
# Executive Summary

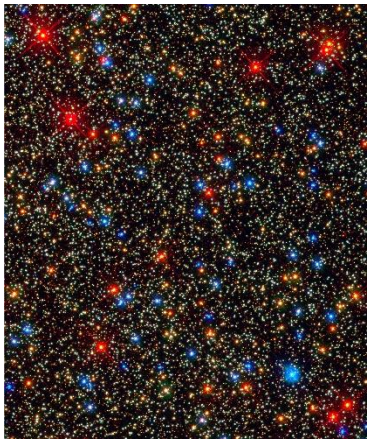
- **Problem**:
  - Modern databases are primarily built for **business** applications
  - **Scientific data** have different characteristics and are becoming more data-intensive

- **Solution**: SciDB
  - A new open-source DBMS to support VERY large (PB) **ARRAY** data

# Background and Motivation

- Scientific data differ from business data in 3 ways
- **1. Science makes use of *sensor arrays***
  - Rectangular array of individual sensors
  - Example: Hubble Space Telescope's camera





  - A block of collocated pixels
  - Implicit ordering

# Background and Motivation

- **2. Require sophisticated data processing methods**
  - Sensor data needs filtering
  - Clean data are fed into complex analytic processing

- **3. Extremely LARGE data**
  - Produced at large scale and reused frequently
  - Example: LHC -> 15PB data annually

# SciDB Features

- **Goal**: provide scalability to store, process and analyze data

- **Array data model**:
  - Implicit ordering
  - Organized as collections of n-dimensional arrays
  - Each cell contains a **tuple of values** with attribute names

**(A::INTEGER, B::FLOAT) -> (2, 0.7)**

# Array Definition

**CREATE ARRAY EXAMPLE**
**(A::INTEGER, B::FLOAT) [ I=0:2, J=0:2];**

I = 0 : 2

J = 0 : 2

| | | |
|---|---|---|
| (2, 0.7) | (1, 0.5) | (3, 0.1) |
| (6, 0.3) | (7, 0.1) | (0, 0.1) |
| (1, 0.4) | (4, 0.6) | (8, 0.1) |

I = 0 : 2

J = 0 : 2

| | | |
|---|---|---|
| (2, 0.7) | (1, 0.5) | (3, 0.1) |
| | (7, 0.1) | (0, 0.1) |
| (1, 0.4) | (4, 0.6) | |

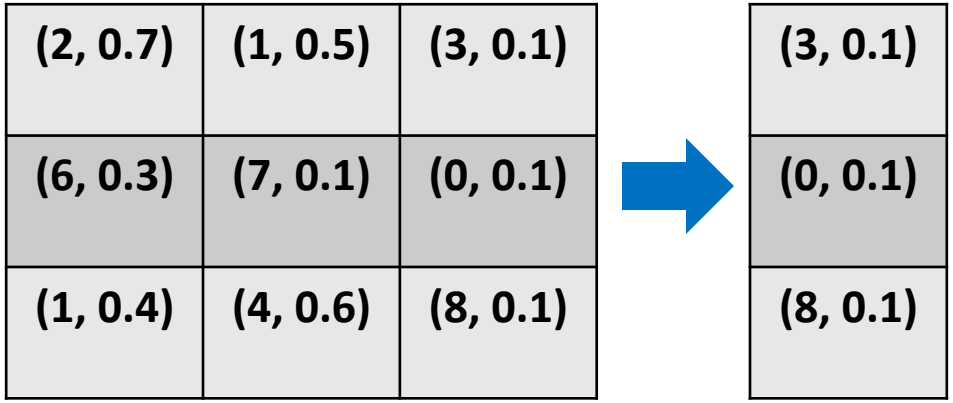
Empty cells

- SciDB will support extensible type system (PDF)
- Nested model (an array within an array)

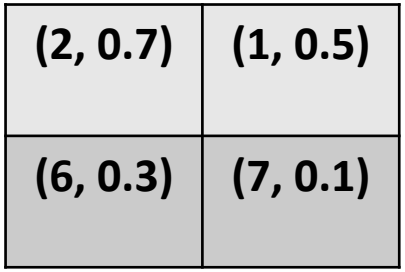
# Data Manipulation

- Declarative query language

**Slice (Example, I=2);**




**Subsample (Example, I BETWEEN 0 AND 1 AND J BETWEEN 0 AND 1);**

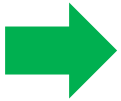


# Data Manipulation

```
Sjoin (Slice (Example, I=2),
Subsample (Example,
I BETWEEN 0 AND 1 AND
J BETWEEN 0 AND 1)
);
```

| | |
|---|---|
| (2, 0.7) | (1, 0.5) |
| (6, 0.3) | (7, 0.1) |

| |
|---|
| (3, 0.1) |
| (0, 0.1) |
| (8, 0.1) |



| | | |
|---|---|---|
| (2, 0.7) | (1, 0.5) | (3, 0.1) |
| (6, 0.3) | (7, 0.1) | (0, 0.1) |
| | | (8, 0.1) |

# Data Manipulation

- Manipulate data content

**Filter (Example, A > 2);**

- Operations are ***composable***

**Apply (Slice (Example, I = 2), A * B);**

# Extensibility

- User-defined data type (UDT)
- User-defined function (UDF)
  - Highly specific algorithm
  - C/C++
  - Example: **Gaussian smoothing**

```
Smooth (Subsample (Example,
I BETWEEN 0 AND 1 AND
J BETWEEN 0 AND 1));
```

# Architecture

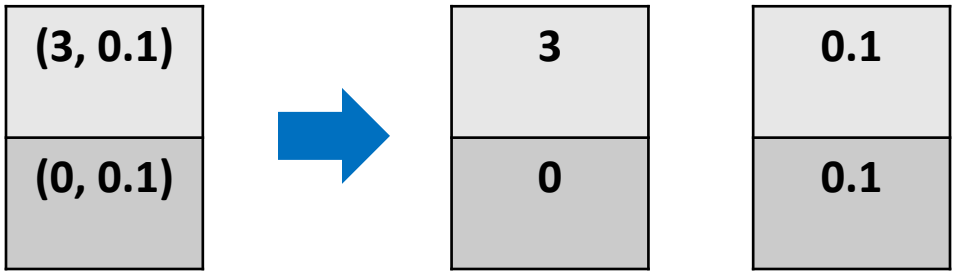
- Shared nothing over a network of computers
- One centralized system catalog database
  - Stores info about data distribution, UDF, etc

- **Storage manager**:
  - Distributed and **no-overwrite** storage manager
    - Data can only be appended
  - ACID: **Atomicity** and **durability**
    - Does not talk about its implementation

# Data storage

- Mapping of logical array data into physical storage

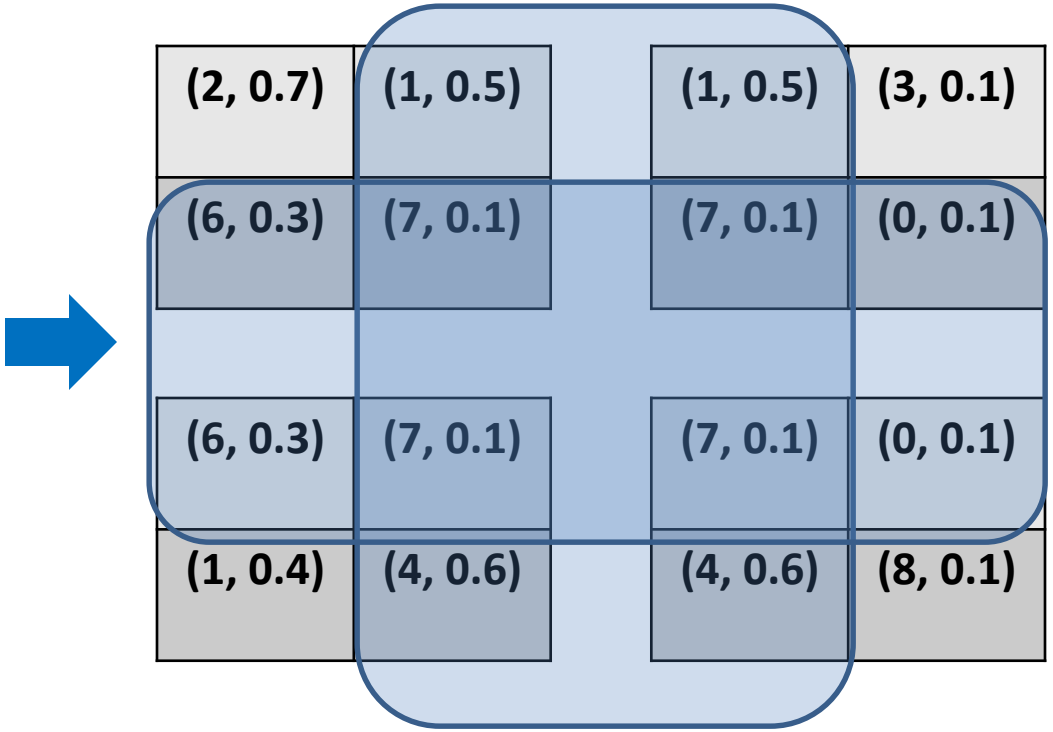
- **1. Vertical partitioning like column store**:
  - Users tend to focus on a single attribute
  - Each cell only stores a single value



# Data Storage

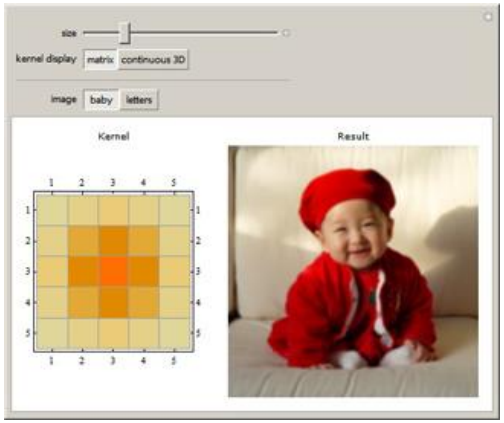
- **2. Chunking**:
  - Operate on a small area
  - Split into equal-sized (and overlapping) chunks

| | | |
|---|---|---|
| (2, 0.7) | (1, 0.5) | (3, 0.1) |
| (6, 0.3) | (7, 0.1) | (0, 0.1) |
| (1, 0.4) | (4, 0.6) | (8, 0.1) |



# Data Storage

- **Overlapping chunks**:
  - Some methods require computation on neighboring cells
  - Example: Gaussian smoothing




  - Advantage: enables parallel computation
  - Storage overhead **Apply (Slice (Example, I = 2), A * B);**
  - Pipelined operators

# Other Features

- **Data distribution**: Some chunks are collocated on the same node for ***locality***

- **Compression**: Reduce bandwidth consumption
  - Sparse matrix compression?

# Query Processing

- Complicate parsing due to user-defined operators
- Optimization: Tries to parallelize queries
- Scatter/Gather operations to dynamically redistribute data across nodes

# Conclusion

- A new **ARRAY** DBMS
  - Data management
  - Math operations
- Open source
- SciDB outperforms Postgres by 2 orders of magnitude
  - Astronomy-style workloads

***THE END***