

Trace Stream OLAP Analysis



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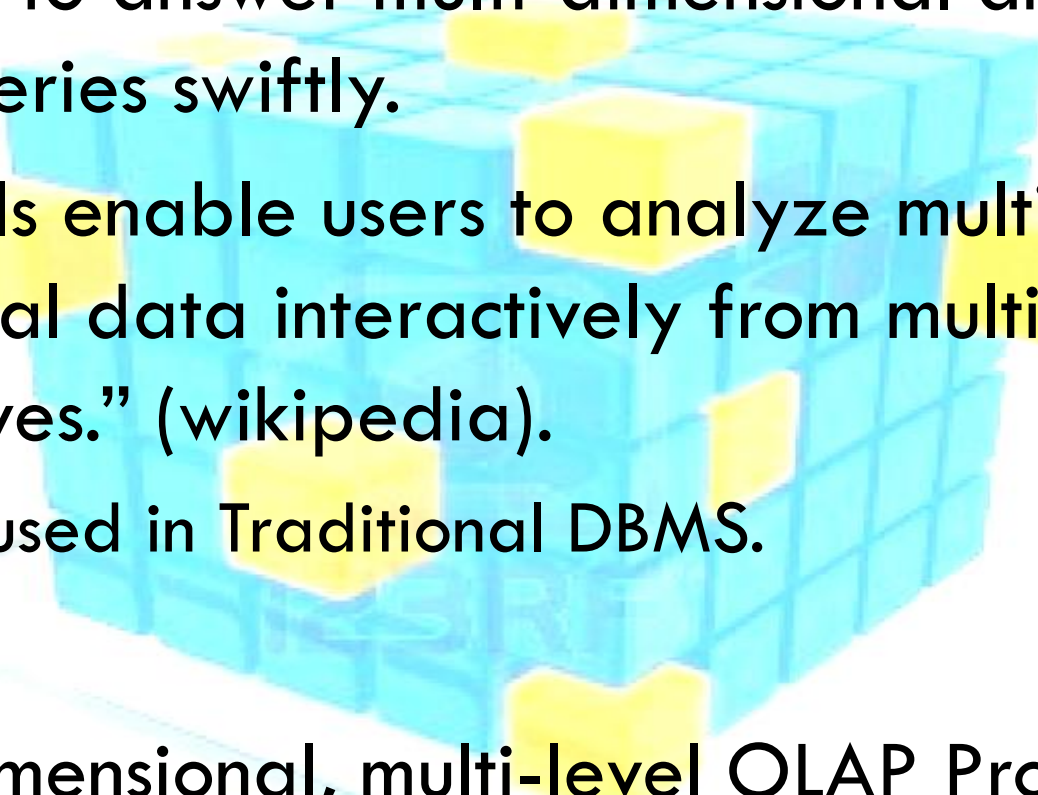
Trace Stream

- The importance of extending the existing tools and techniques to streaming mode, to capture today's needs.
 - ▣ Live performance monitoring
 - ▣ Live security monitoring
- Trace stream contains continuous high volumes (infinite) of events.
- Recording the whole trace or even a complete summary may not be possible.

Trace Stream

- Trace events usually represent low level behavior of the system.
 - Users might be interested in higher level analysis
- Trace events are multidimensional in nature.
 - A typical trace event represents interactions between different dimensions (i.e. system resources).
 - "file read" event contains information of:
 - a file, running process, the current CPU ,
 - processes or VMs use in the last 15 minutes, 30% more system resources than the last 24 hours average.
- Is multi-dimensional, multi-level OLAP Processing possible over trace stream?

OLAP?

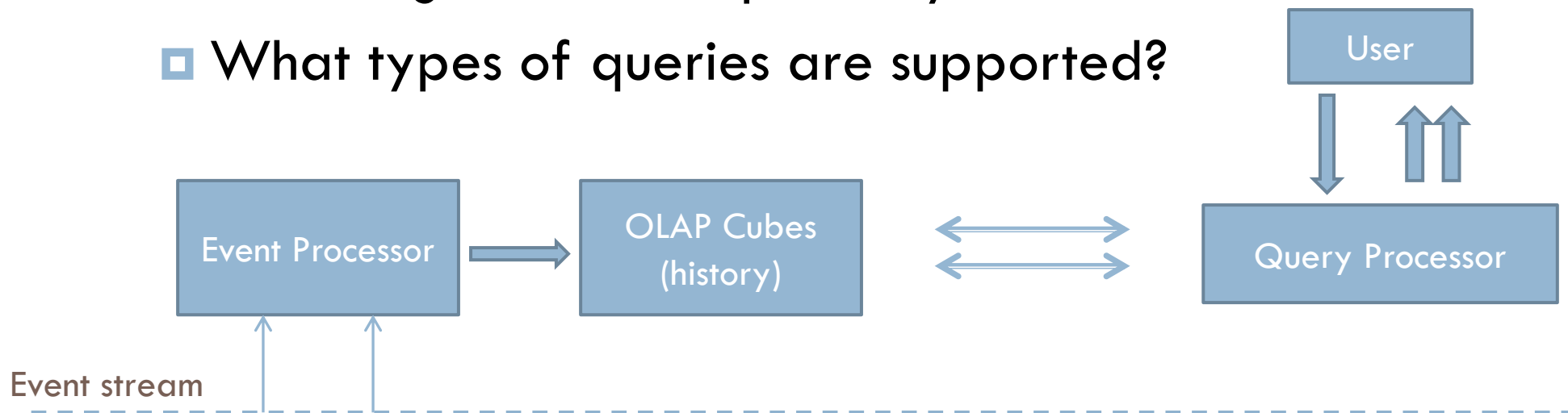
- “**Online analytical processing, or OLAP** is an approach to answer multi-dimensional analytical (MDA) queries swiftly.
 - OLAP tools enable users to analyze multi-dimensional data interactively from multiple perspectives.” (wikipedia).
 - ▣ Usually used in Traditional DBMS.
 - Is multi-dimensional, multi-level OLAP Processing possible over trace stream?
- 

Challenges

- Large (infinite) number of events.
 - ▣ Referring back to the events is not possible.
- Keeping track of a long history is not possible.
 - ▣ Main memory or disk size limitations.
- Continuous Queries
 - ▣ answers are updated over time.
- Different levels and dimensions.
 - ▣ Different data aggregations

Solution: Cube Data Model

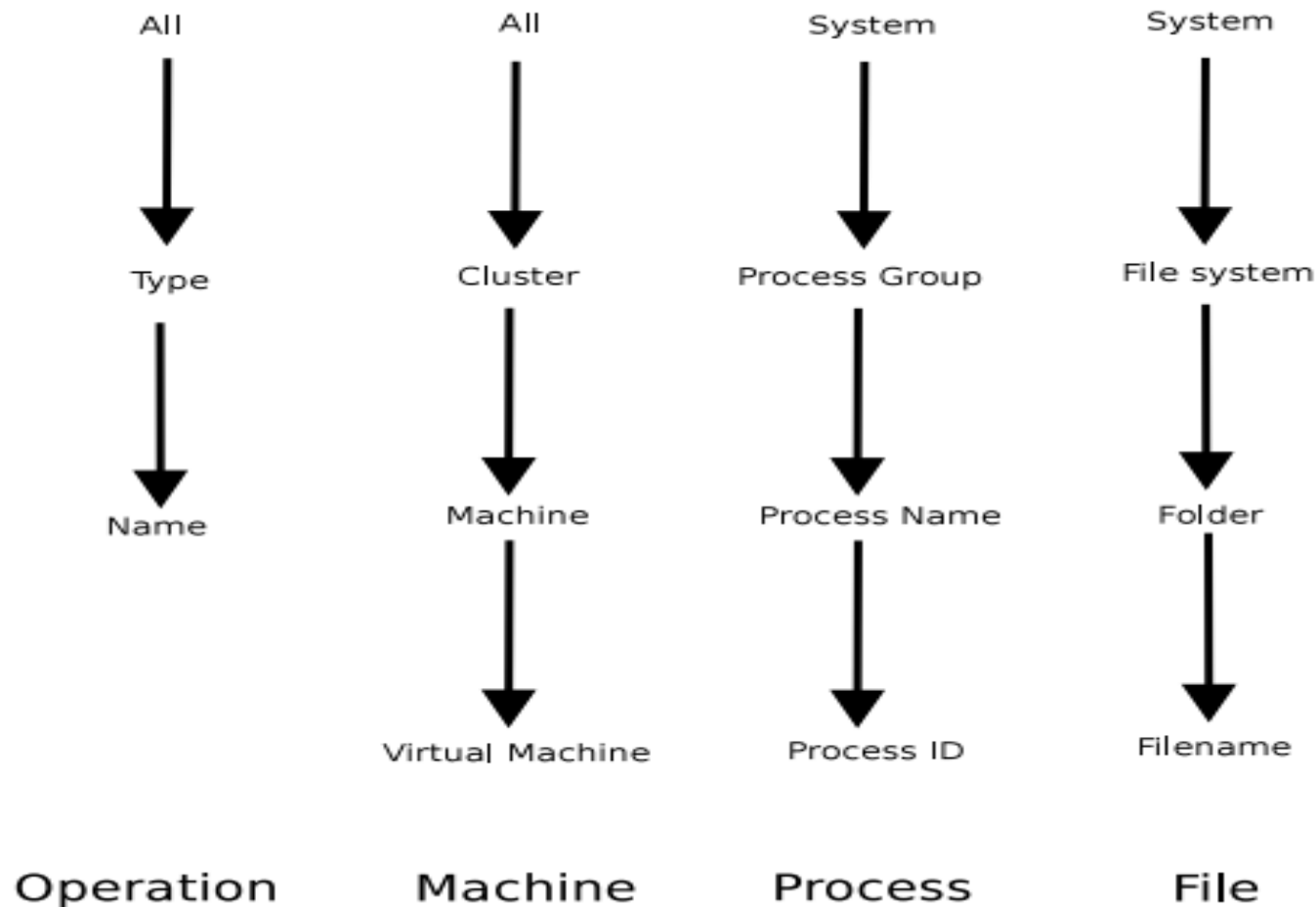
- Extending the state system to support multi-level multi-dimensional stream based queries.
 - ▣ How to model the cubes (dimensions and measures)?
 - ▣ How to materialize the cubes along the time axis?
 - ▣ How long we can keep history?
 - ▣ What types of queries are supported?



How to model the cubes?

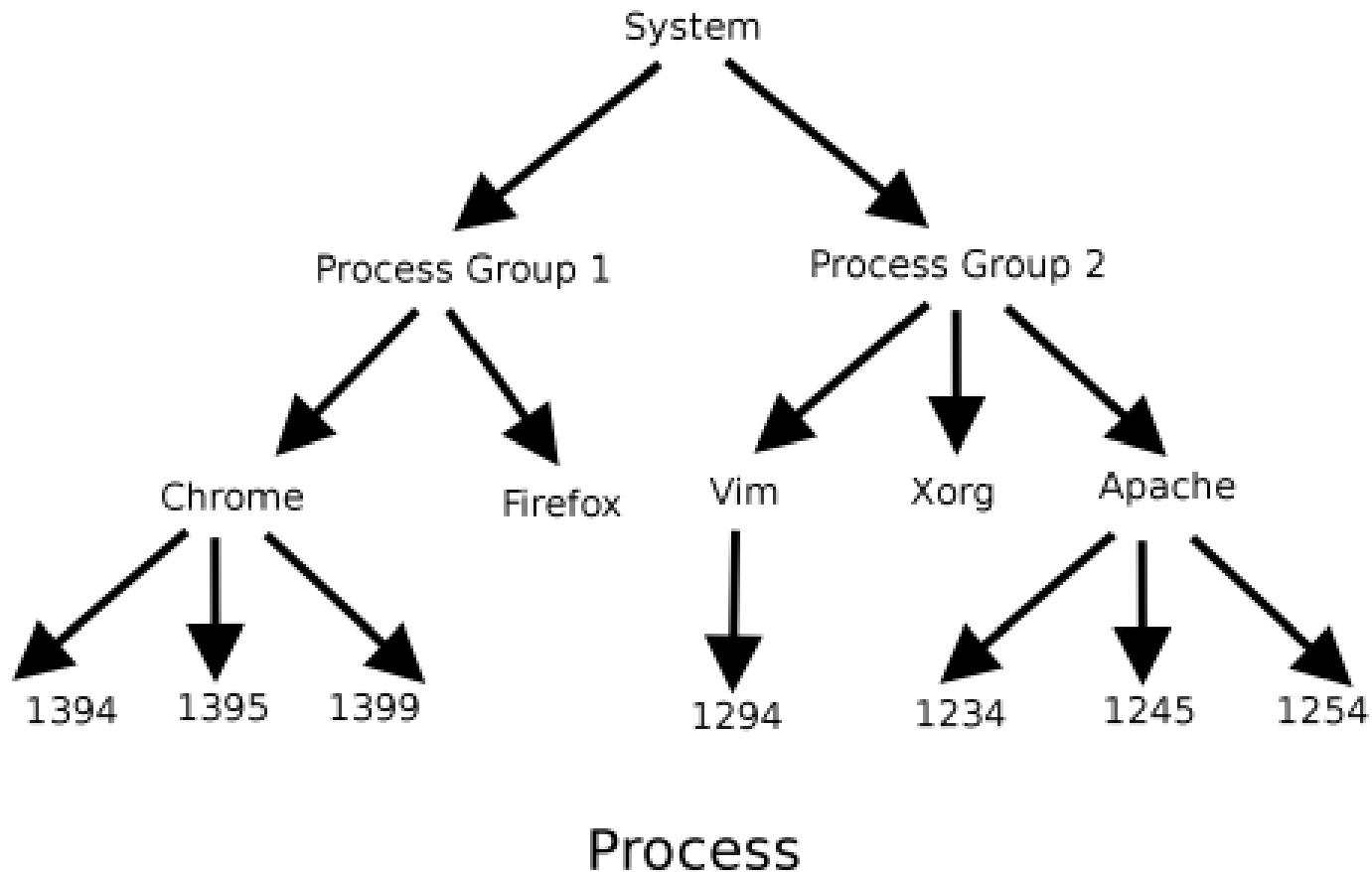
(Dimensions and Measures)

□ Dimension Schema

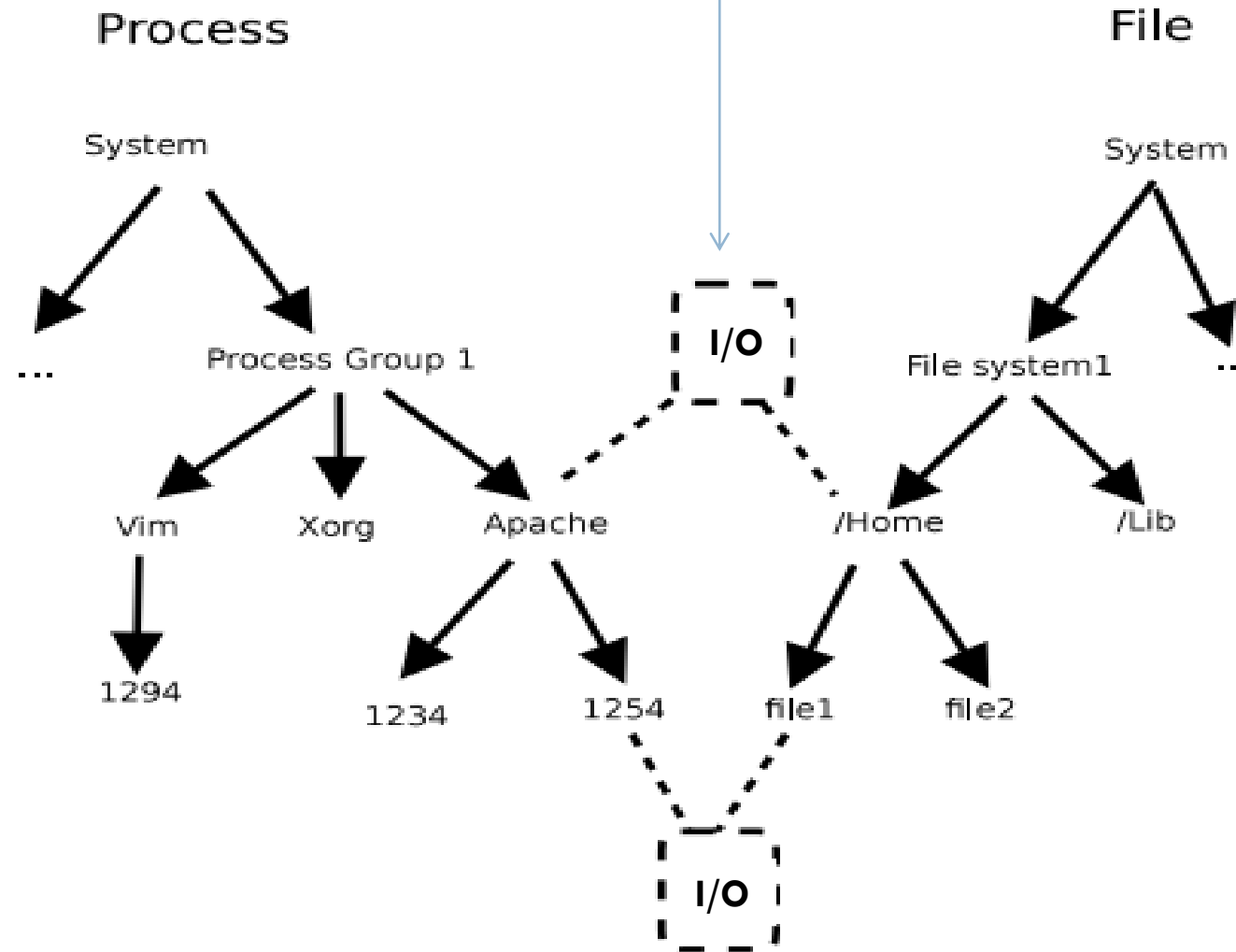


How to model dimensions?

- Dimension instance: a set of members from all levels.

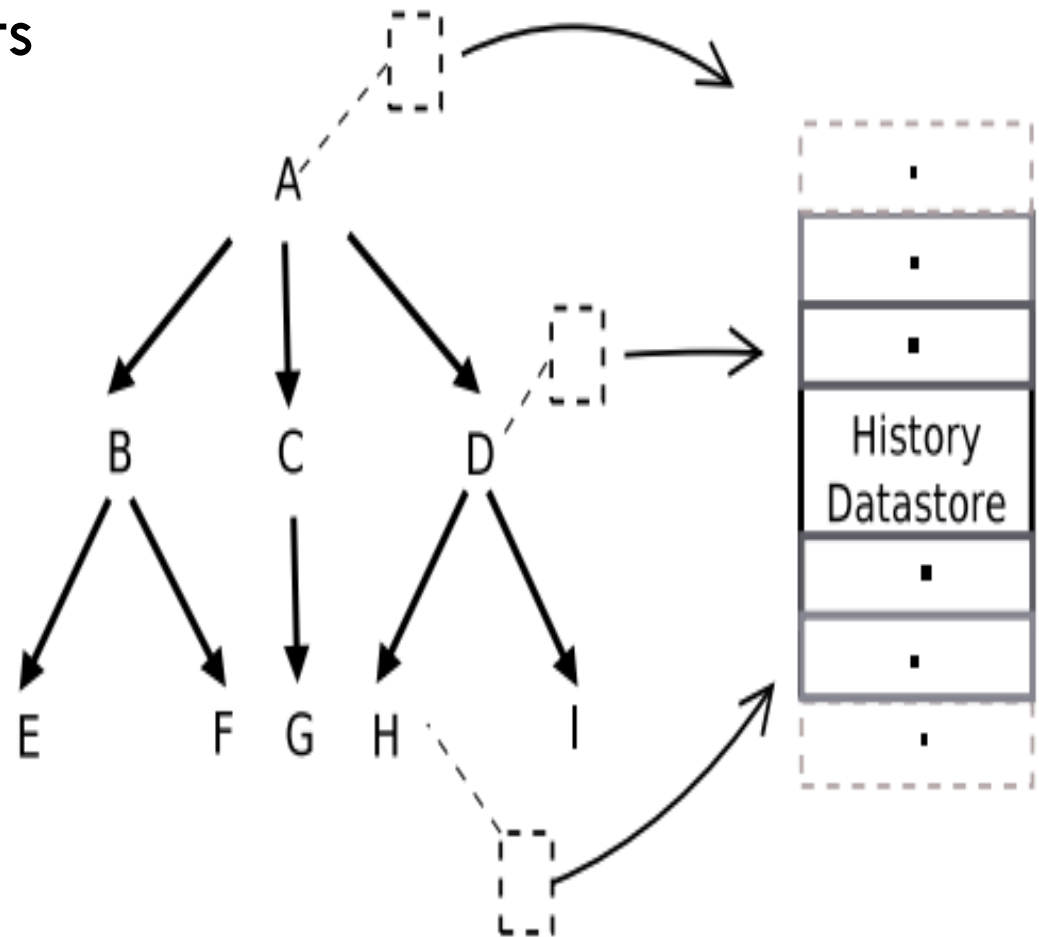


Measures



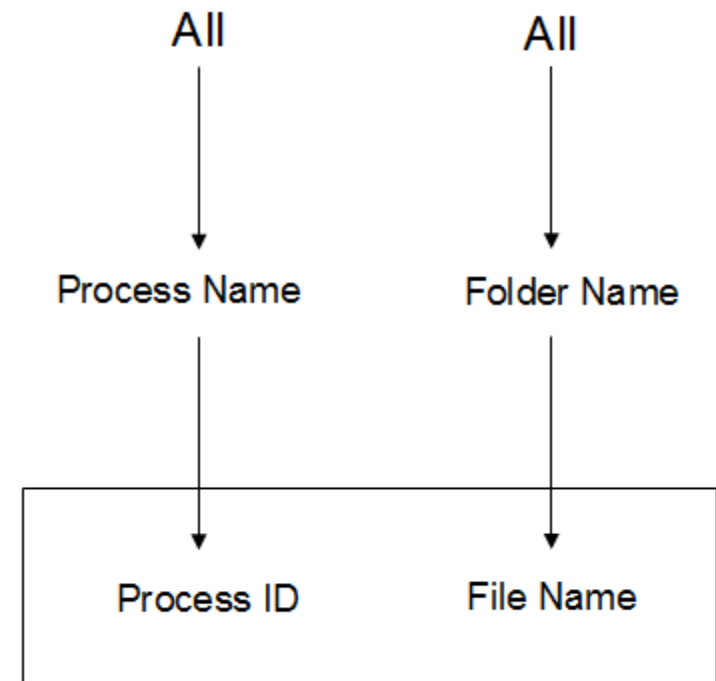
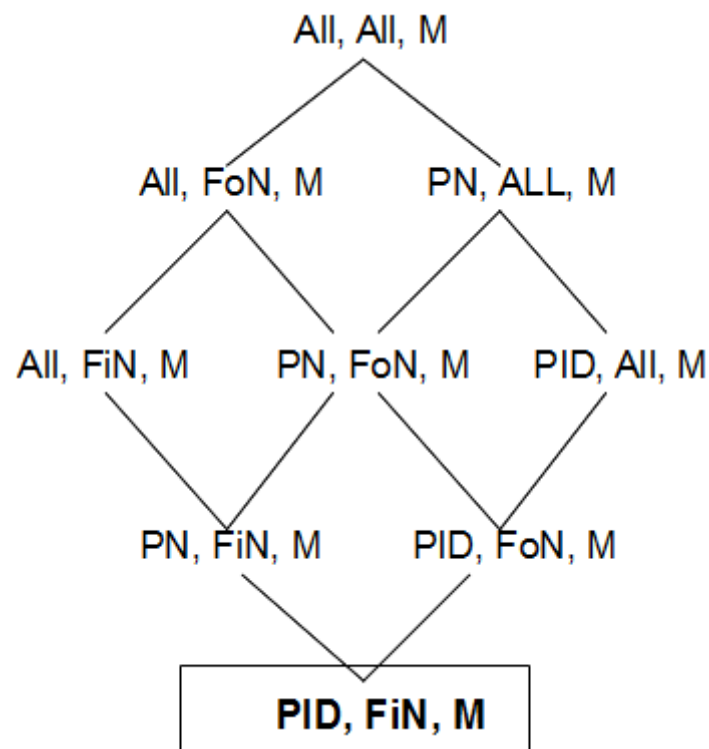
Measures at Different Levels

- Selection is based on:
 - ▣ User/App requirements
 - ▣ Available resources
 - Storage,
 - time ,
 - ...
 - ▣ Static / Dynamic



Cube Materialization

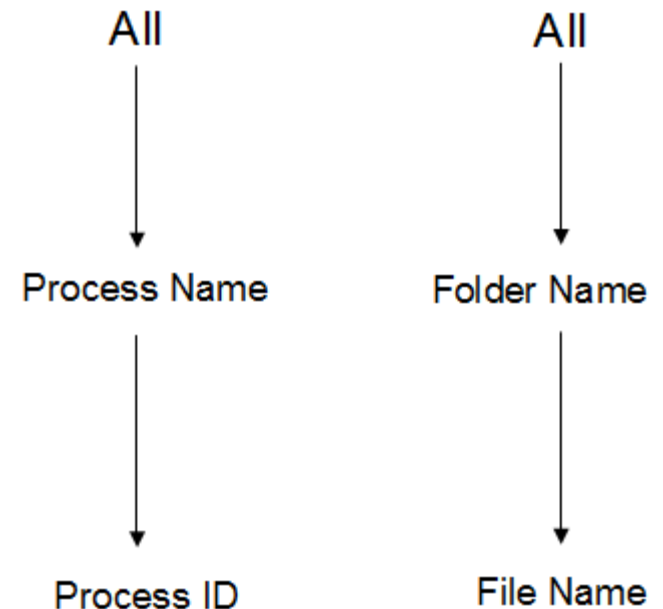
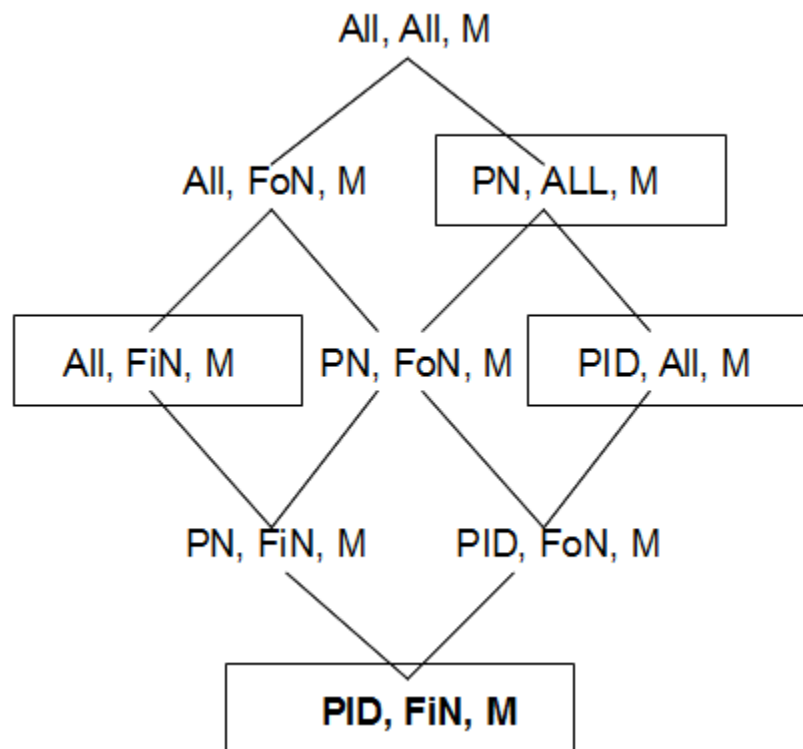
- **Minimal** materialization
 - ▣ Only the finer level nodes are materialized.



Cube Materialization

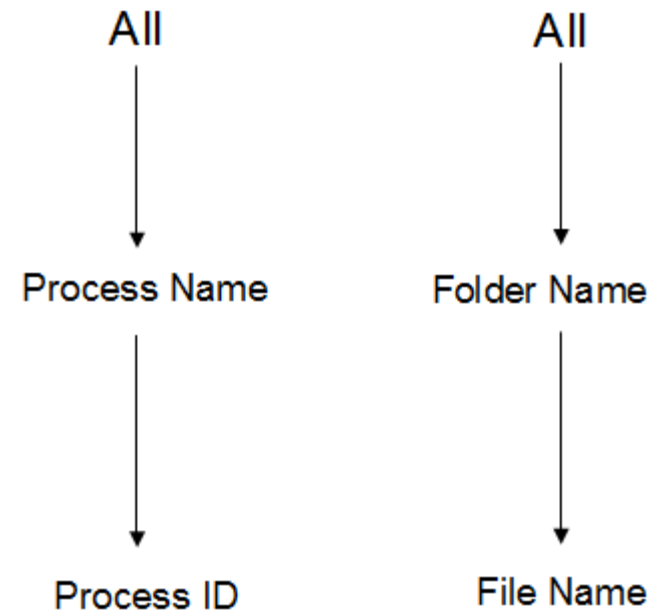
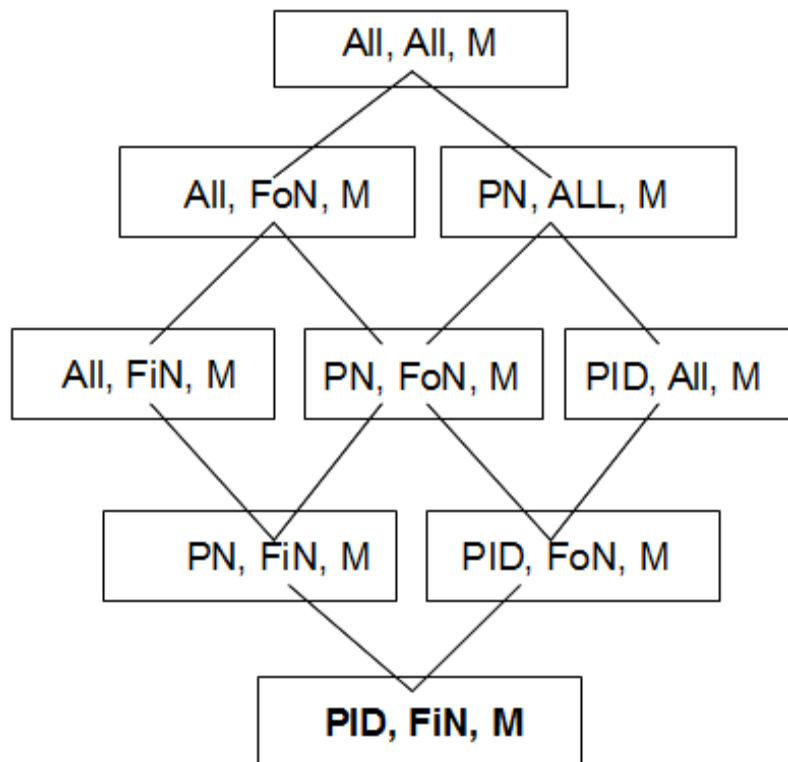
□ Partial materialization

- ▣ The finer level and some high level nodes are materialized.

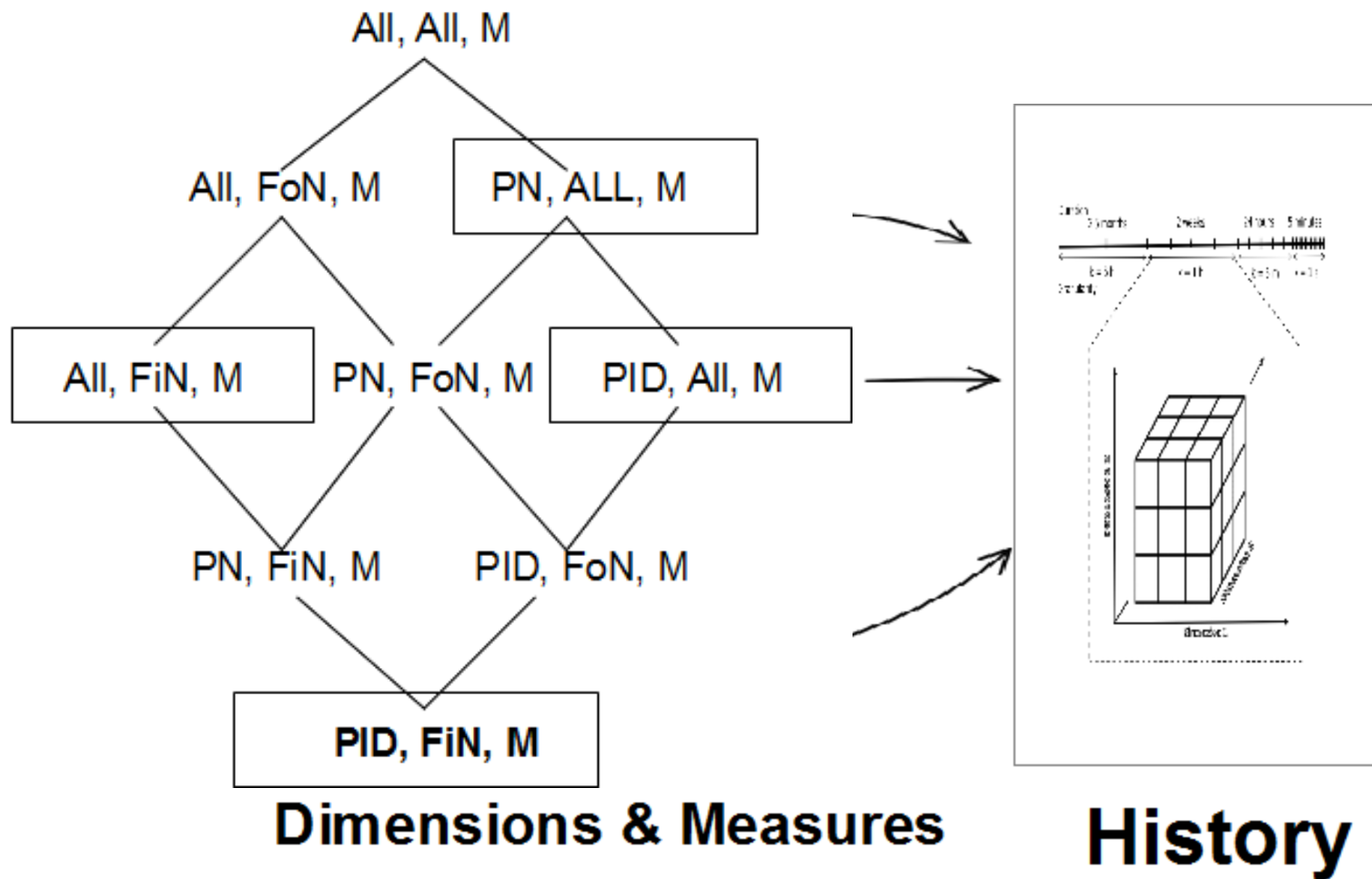


Cube Materialization

- **Maximal** materialization
 - ▣ All levels are materialized.

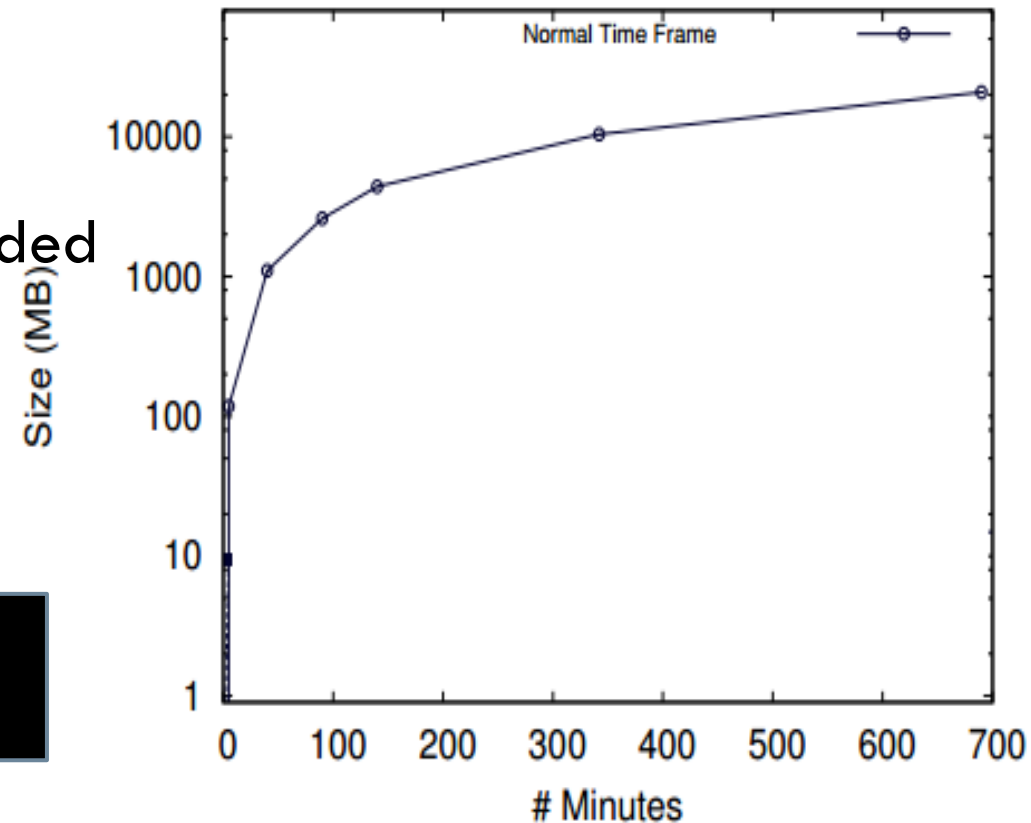
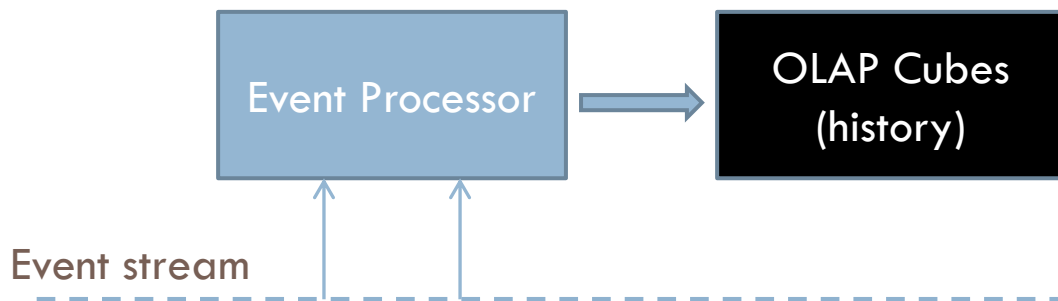


Cube Materialization & Time Dimension



How long we can keep history?

- Memory or disk size limit.
- Solutions:
 - Cut off after a while
 - Decent data might be needed
 - **A New Time Frame !**

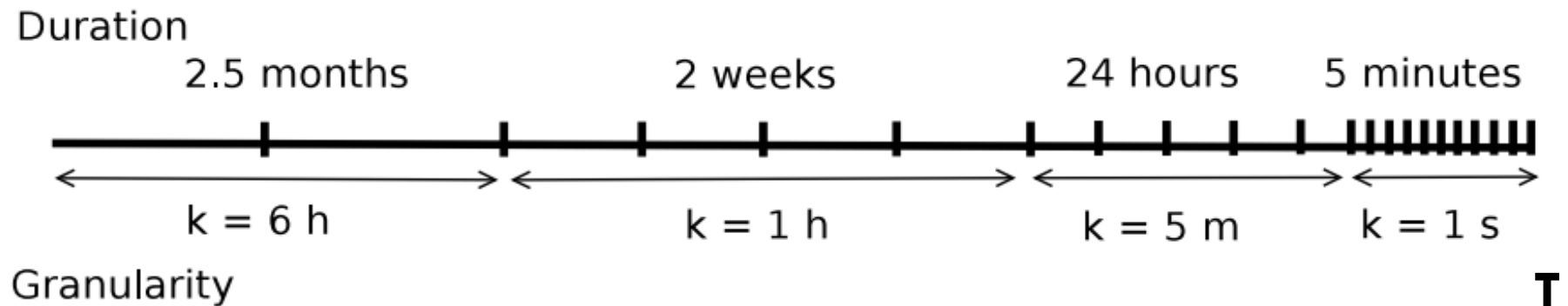


Comparison

Normal Time Frame

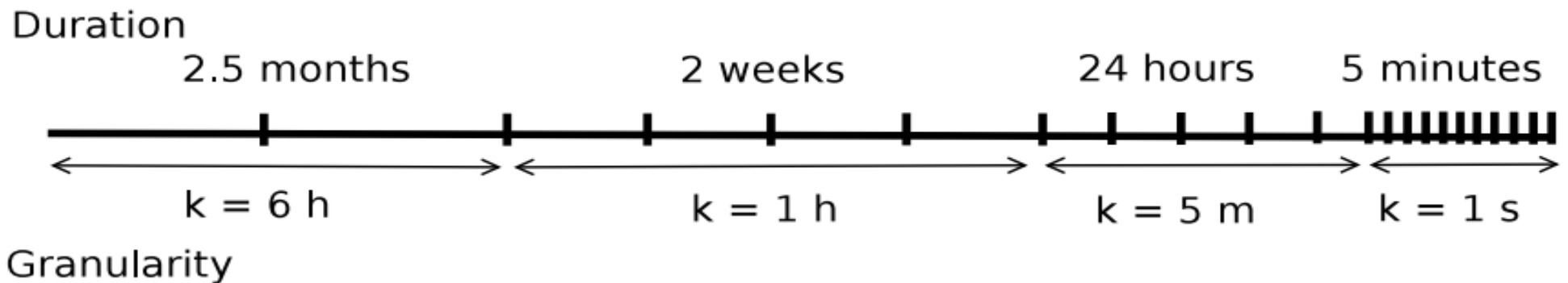


Tilted Time Frame

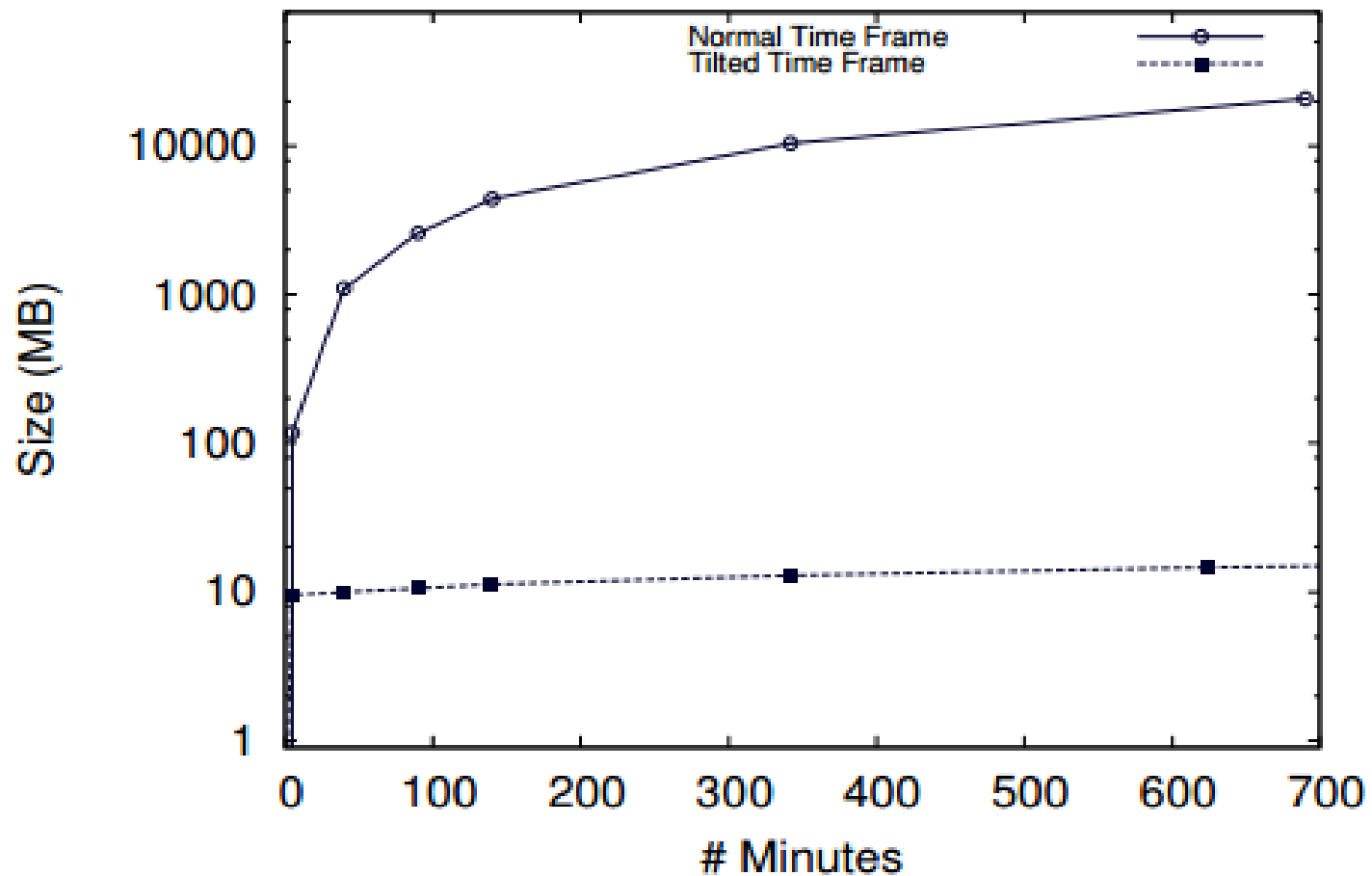


Tilted Time Frame

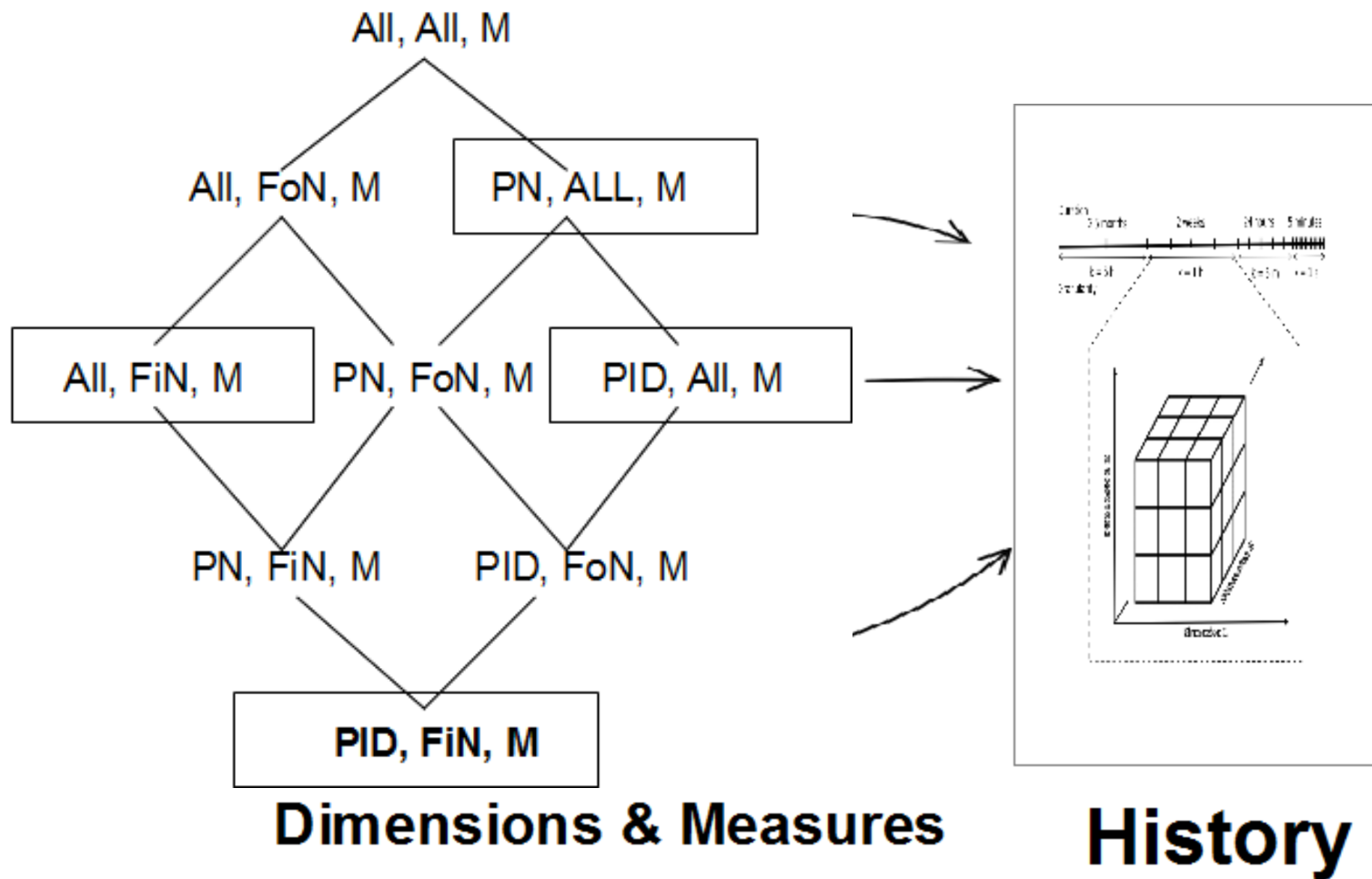
- Different time granularities for recent and decent information.
 - ▣ Coarser granularity for the too old history, but a finer granularity for the most recent history.
 - ▣ Compress the data over the time dimension.



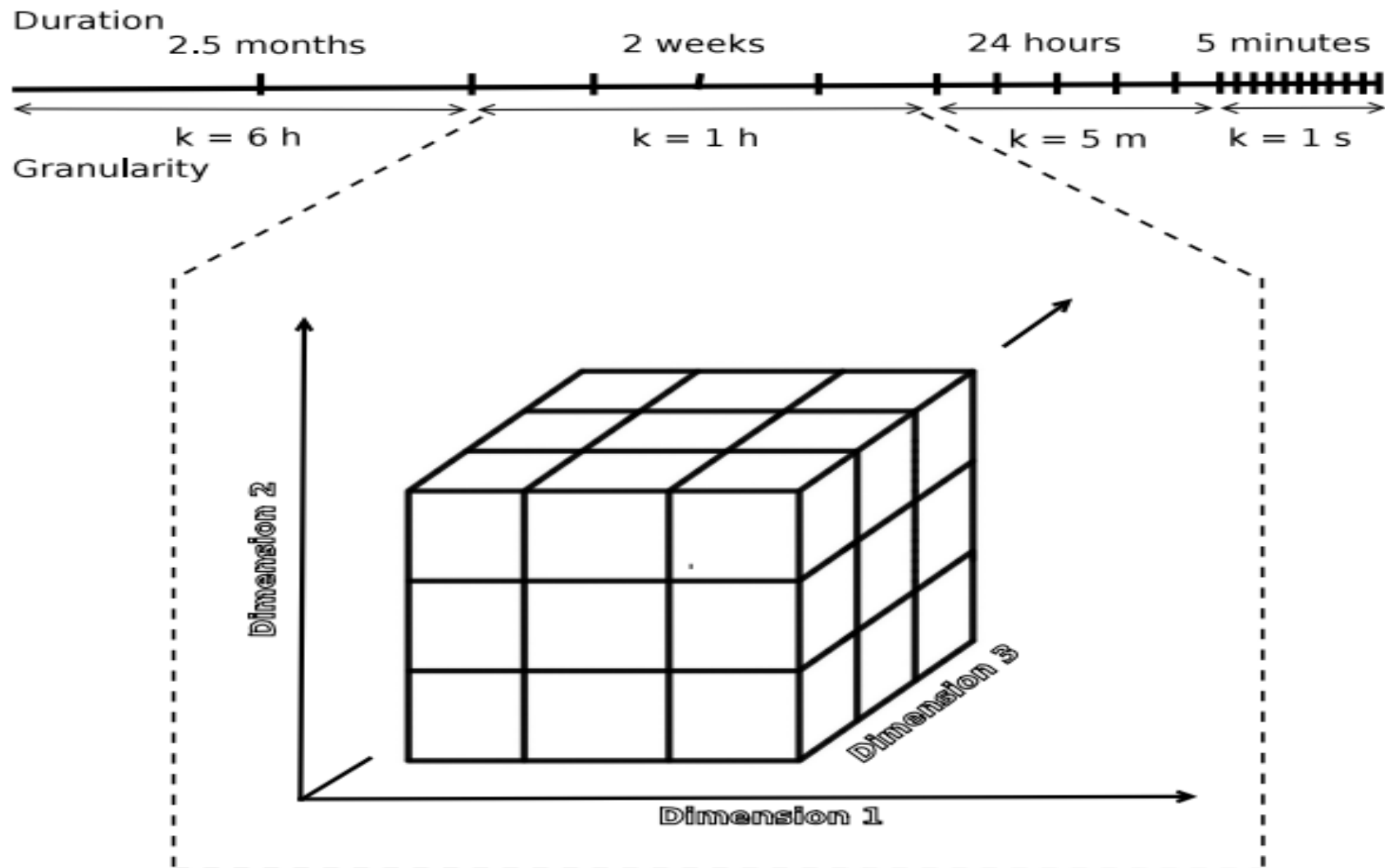
Comparison



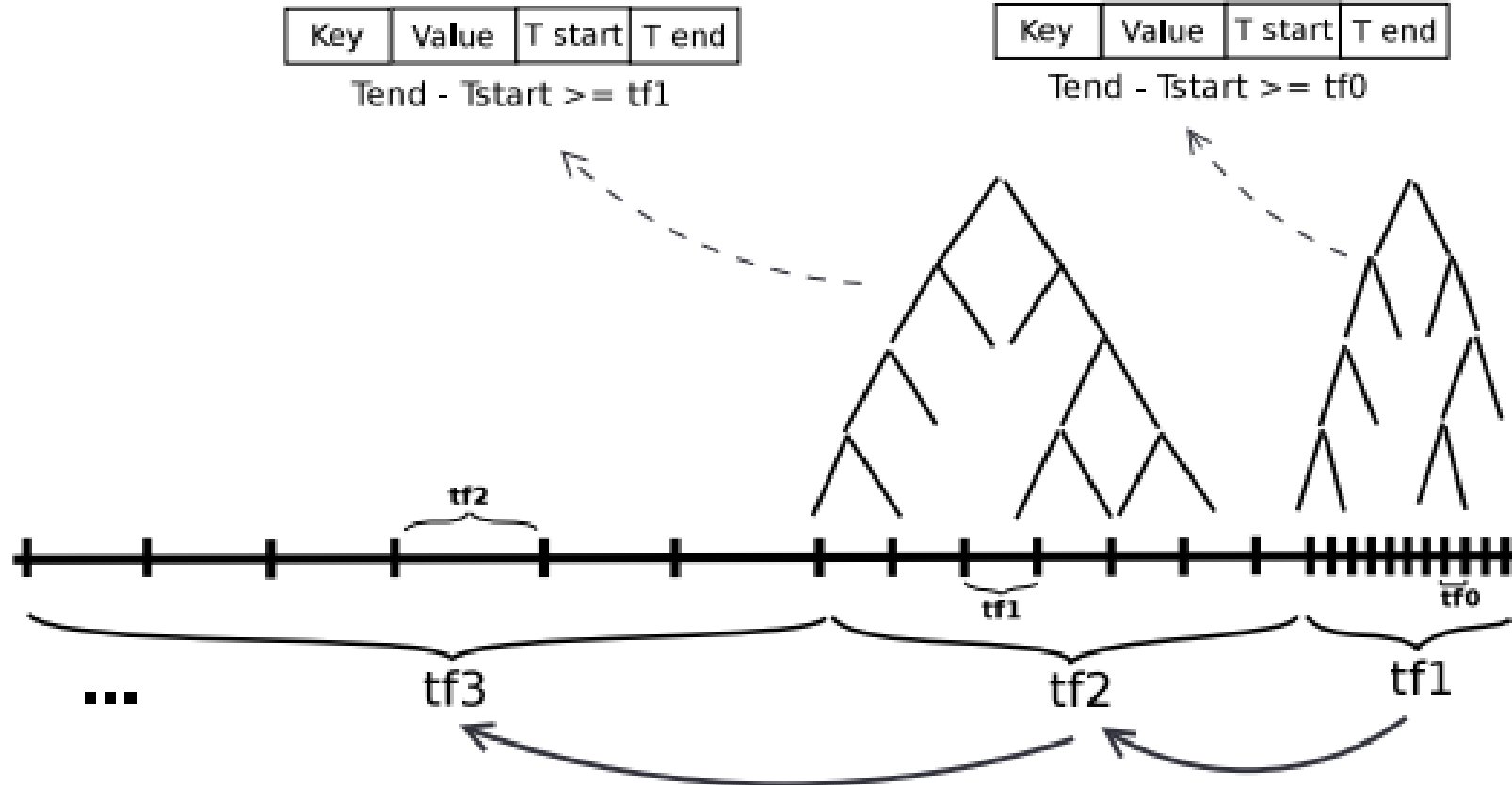
Cube Materialization & Time Dimension



Several History Cubes



History Updates





Query Types

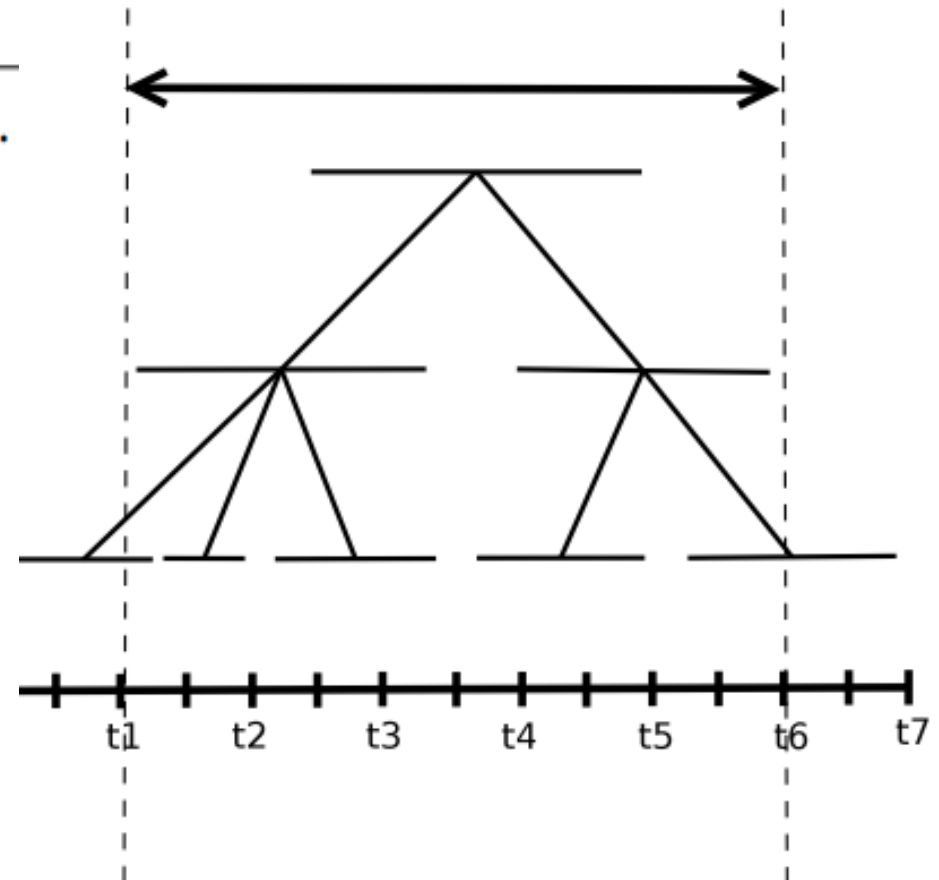
Query Types (1)

□ Range Queries (multi-dimensional)

Algorithm 1 Stabbing query.

Require: an interval tree v and a query point t .

- 1: **if** root node r contains the point t **then**
 - 2: add r to the result list L .
 - 3: **end if**
 - 4: **if** there is any children for node r **then**
 - 5: **for** any children of v like $c(v)$ **do**
 - 6: call the algorithm for $c(v)$, t .
 - 7: **end for**
 - 8: **end if**
 - 9: return list L as result;
-

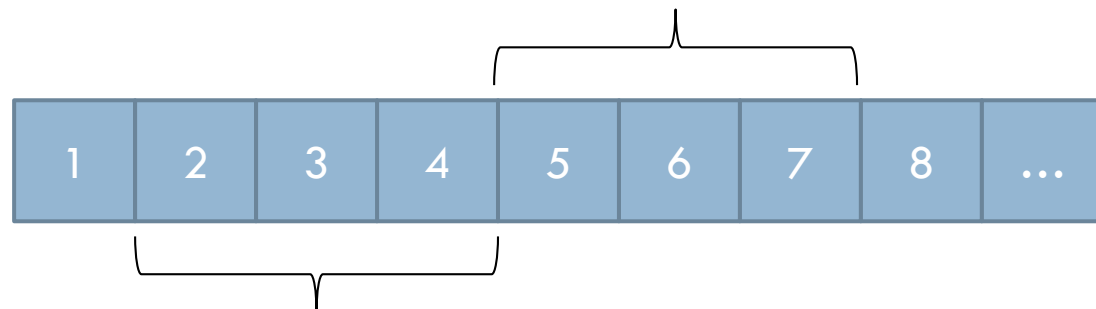


Query Types (2)

- Top-K Queries
 - ▣ Find virtual machines or processes which use more system resources than others
 - ▣ Values exceed a pre-defined threshold.
 - ▣ Algorithm:
 - Range query + Sort

Query Types (3)

- ▣ Sliding Window Queries (**Continuous queries**):
 - Statistics values for the last k time units, for the fixed or moving values of k .
- ▣ **Fixed**: reporting the statistics after each k time units.
 - Summarize data using a set of buckets. Can be used to draw histograms.
 - Example: network throughput each 1 second or each 1 minute of execution



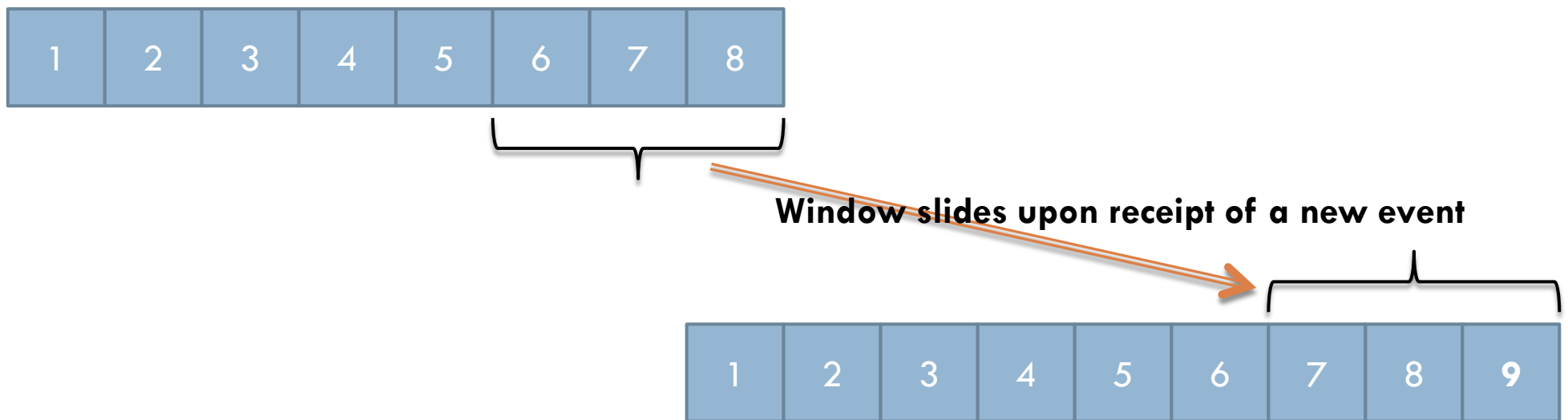
Query Types (3)

▣ Sliding Window Queries (**Continuous queries**):

- Statistics values for the last k time units, for the fixed or moving values of k .

▣ Moving: recent k time units.

- Example: CPU usage for the last 3 minutes,
 - that is updated at each second!

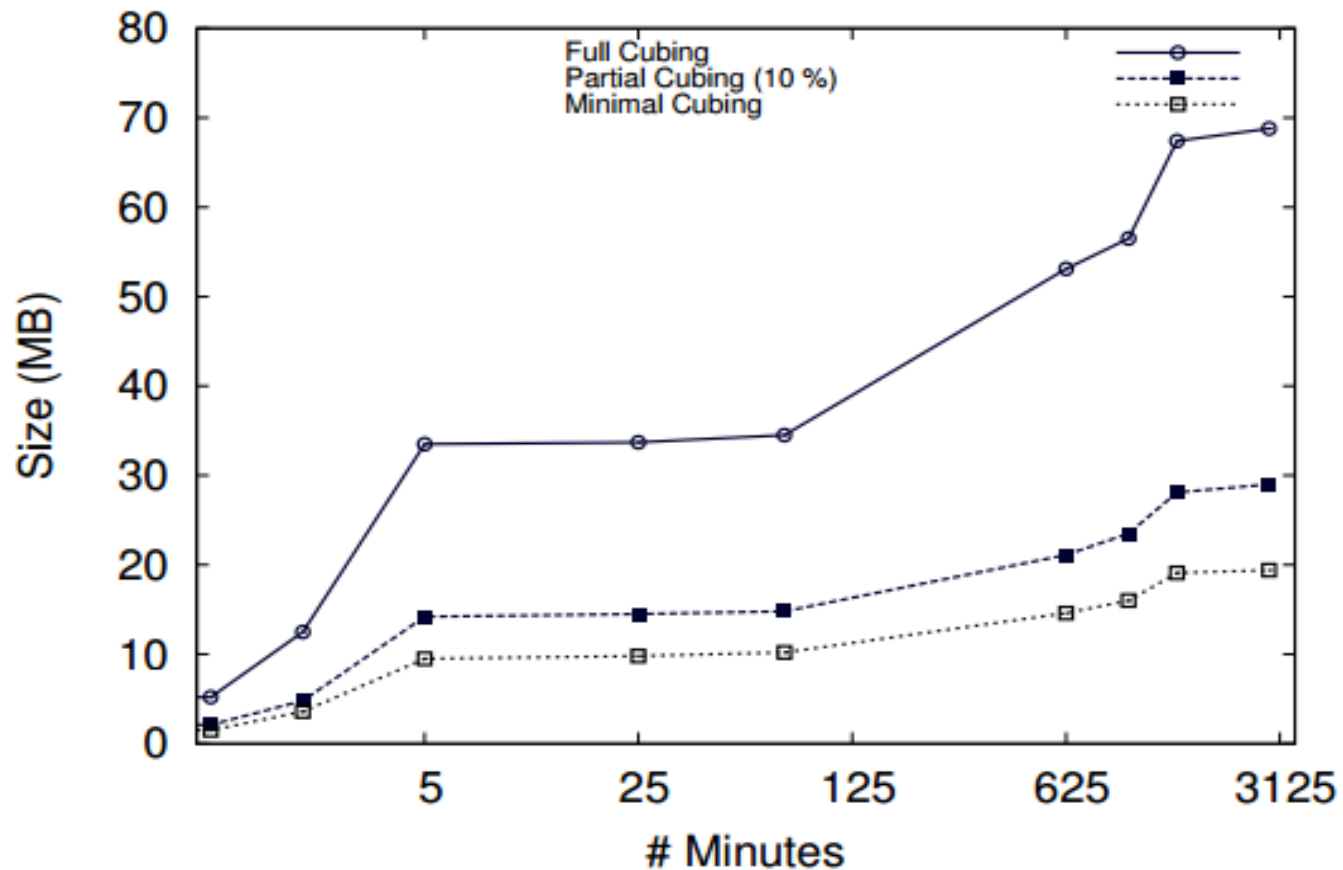


Query Types (4)

- **Multilevel Queries**
 - **Group by, drill down or roll up operations over any dimensions.**
 - With minimum materialization strategy:
 - Any other level statistics (higher levels) are computed on the fly using the leaf nodes.
 - With partial materialization strategy:
 - Using directly for the nodes that are stored in the database + on the fly for the other values
 - With full materialization strategy
 - All queries are answered directly using the stored values.

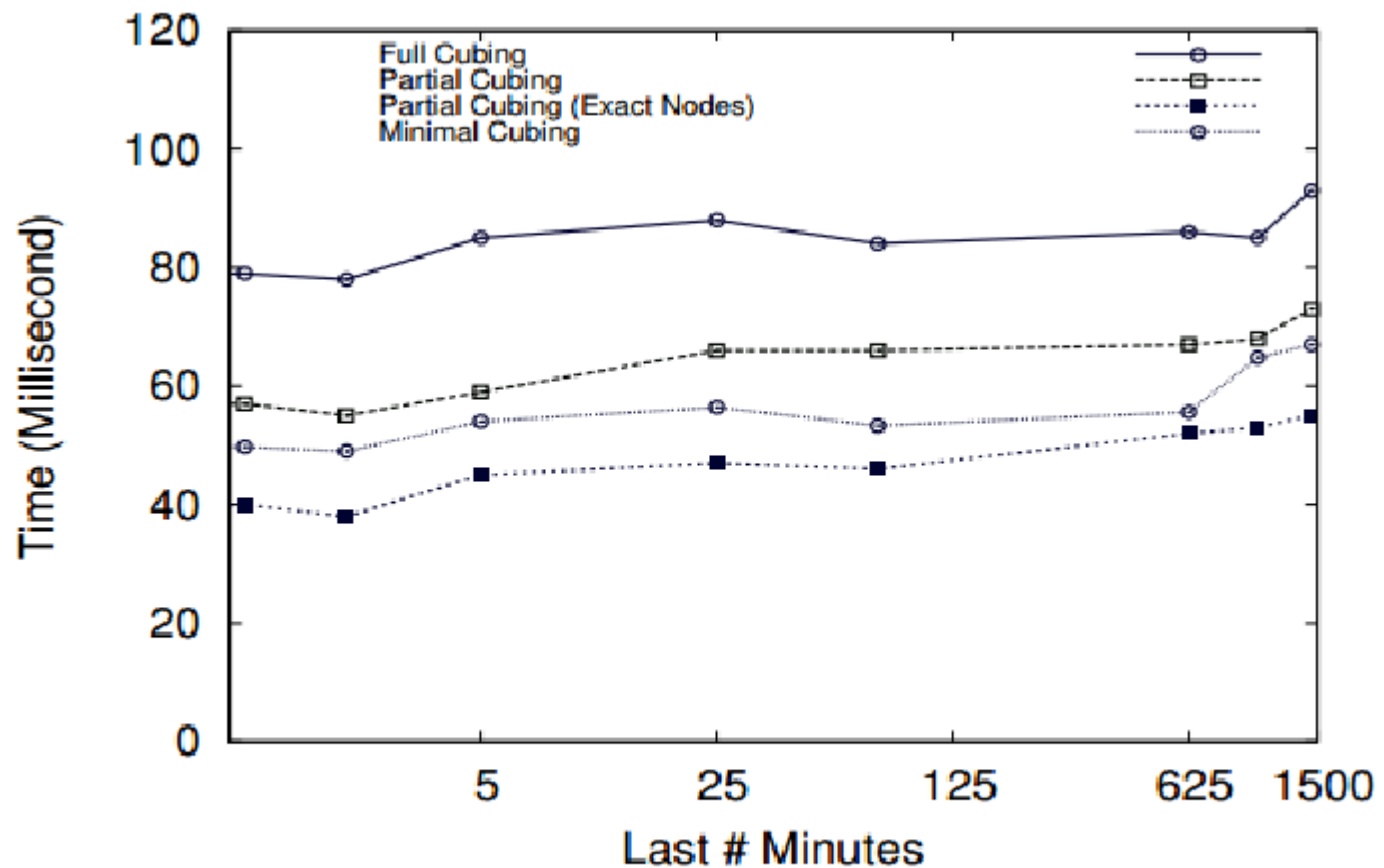
Query Types (4)

□ Memory usage



Query Types (4)

□ Response time



Response time for roll-up queries.

Conclusion

- The “Cube Data Model” and corresponding algorithms are presented for performing OLAP analysis over trace streams.
 - ▣ As an extension to the **STATE SYSTEM**.
 - ▣ Tilted time frame instead of normal time frame.
 - ▣ Different Query types:
 - Multi-dimensional, multi-level .
 - Fixed and moving sliding windows queries.
 - Top-k queries.
 - Range queries.

A scenic view of a waterfall cascading into a pool of water, surrounded by lush green forest and moss-covered rocks. The waterfall is the central focus, with water falling from a high point into a pool below. The surrounding area is filled with dense green foliage and large, moss-covered rocks. The overall atmosphere is serene and natural.

Thank you for your attentions

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Key	Value	T start	T end
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$$T_{end} - T_{start} \geq tf1$$

Key	Value	T start	T end
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$$T_{end} - T_{start} \geq tf0$$

