Streaming Algorithms: Data without a disk

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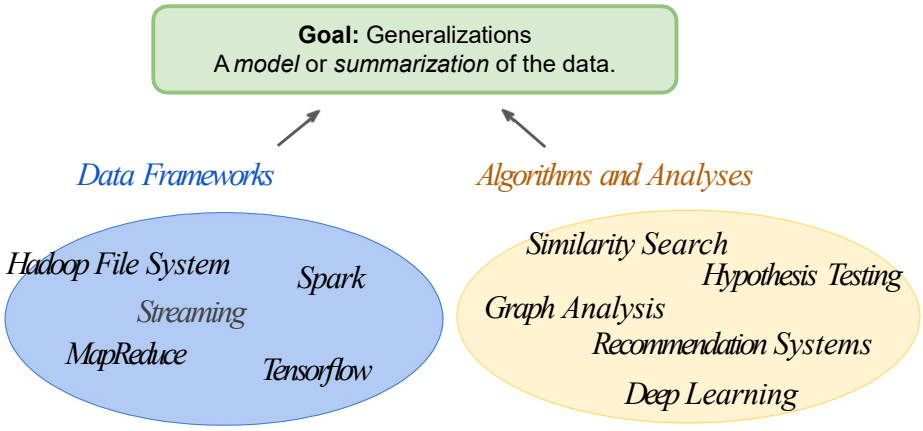
Big Data Analytics, The Class



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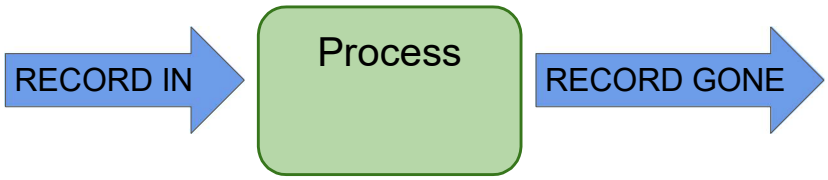
What is Streaming?

Broadly:



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Why Streaming?

(1) Direct: Often, data …

- … cannot be stored (too big, privacy concerns)
- … are not practical to access repeatedly (reading is too long)
- … are rapidly arriving (need rapidly updated "results")

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Examples: Google search queries
Satellite imagery
data Text Messages, Status updates
Click Streams

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(2) Indirect: The constraints for streaming data force one to solutions that are often efficient even when storing data.

Streaming Approx Random Sample

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Why Streaming?

Often translates into *O(N)* or strictly *N* algorithms.

(2) **Indirect:** The constraints for streaming data force one to solutions that are often efficient even when storing data. *Streaming Approx Random Sample*

Distributed IO (MapReduce, Spark)

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Streaming Topics

- General Stream Processing Model
- Sampling
- Counting Distinct Elements
- Filtering data according to a criteria

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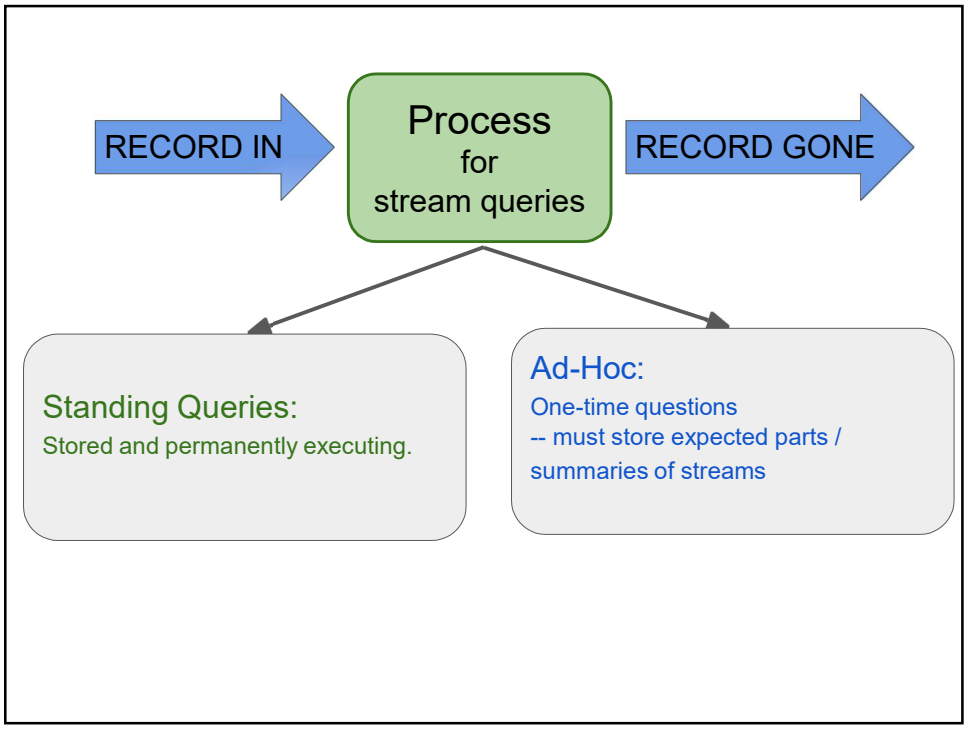
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Process
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Standing Queries:
Stored and permanently executing.
Ad-Hoc:
One-time questions
-- must store expected parts /
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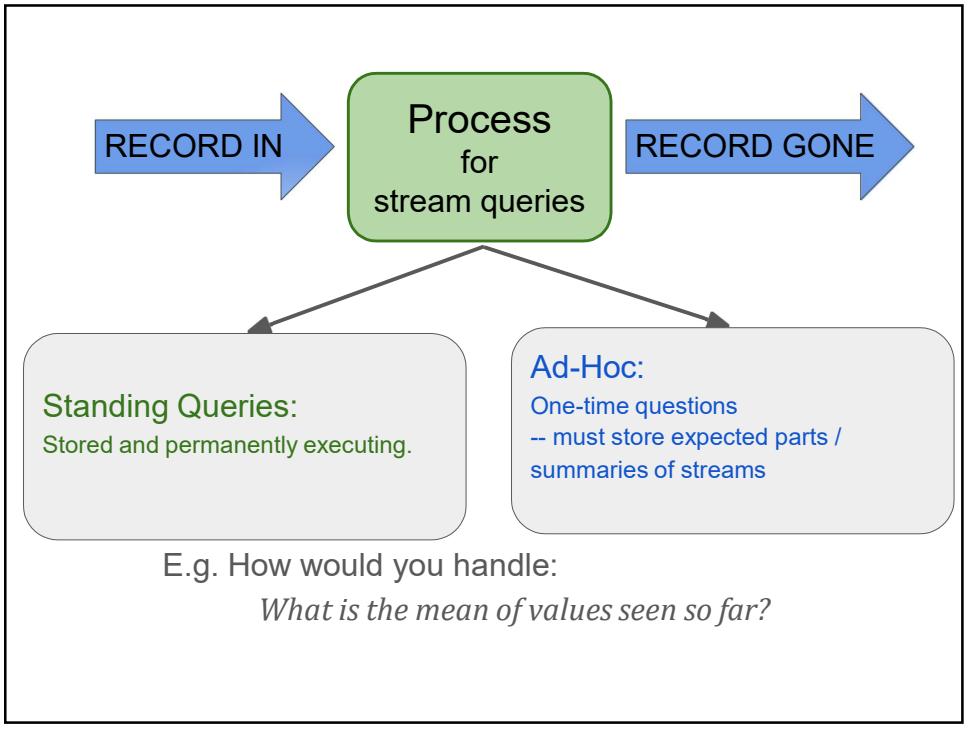
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E.g. How would you handle:
What is the mean of values seen so far?

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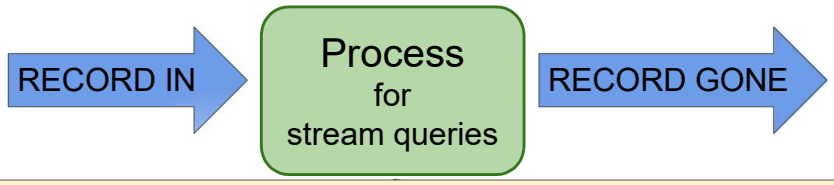

Important difference from typical database management:

- Input is not controlled by system staff.
- Input timing/rate is often unknown, controlled by users.

E.g. How would you handle:

What is the mean of values seen so far?

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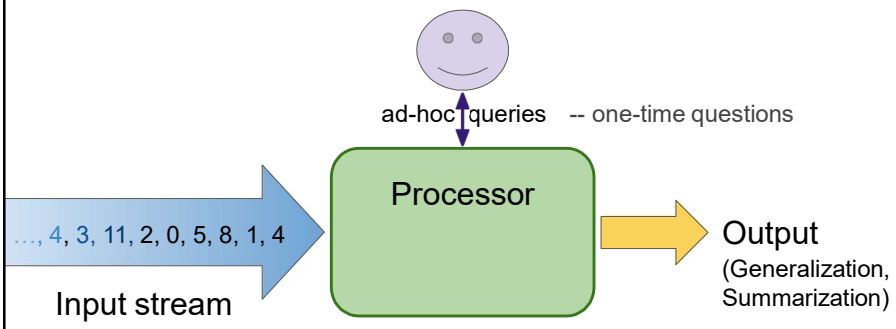
General Stream Processing Model



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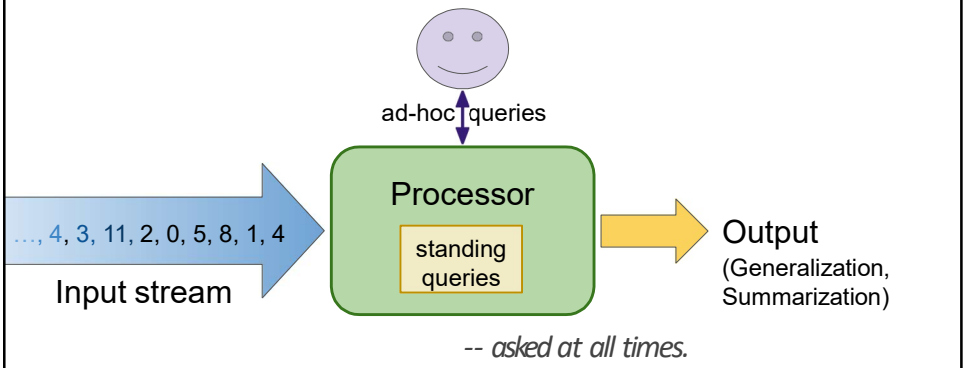

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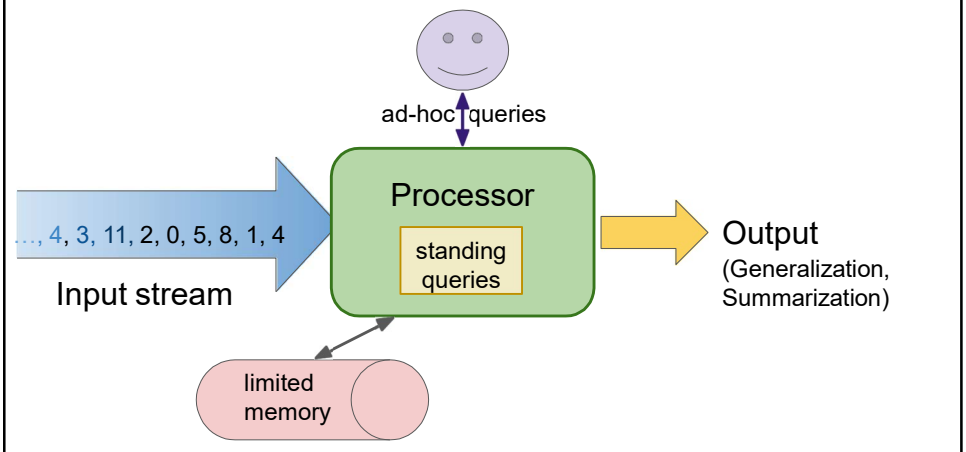

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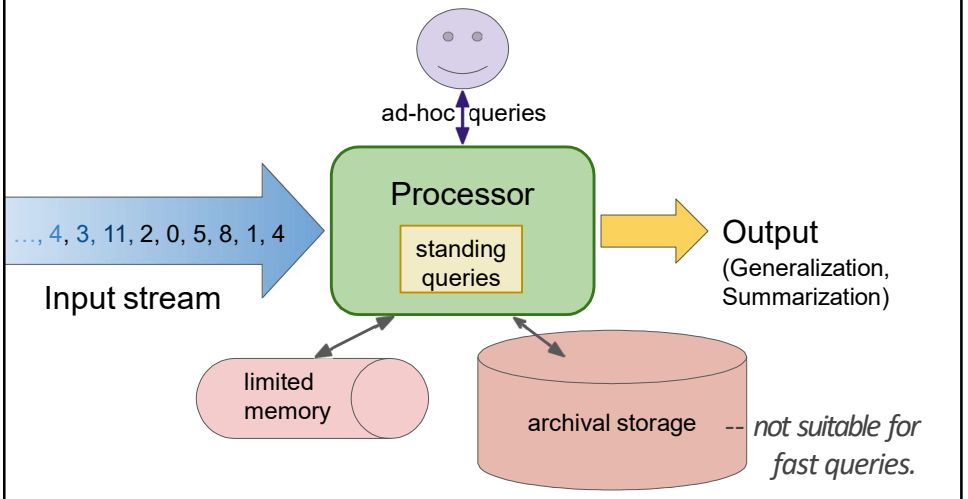

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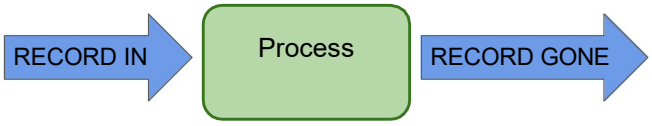
Sampling

Create a random sample for statistical analysis.



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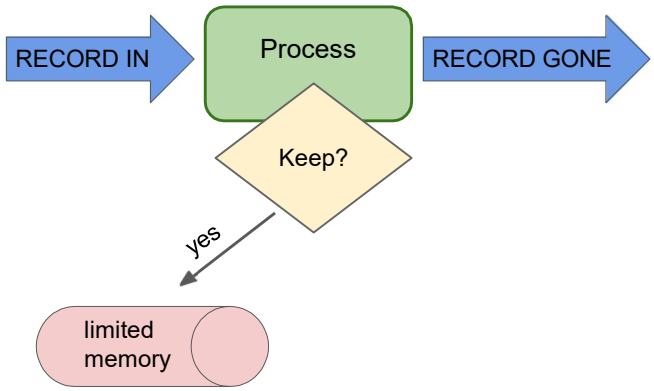

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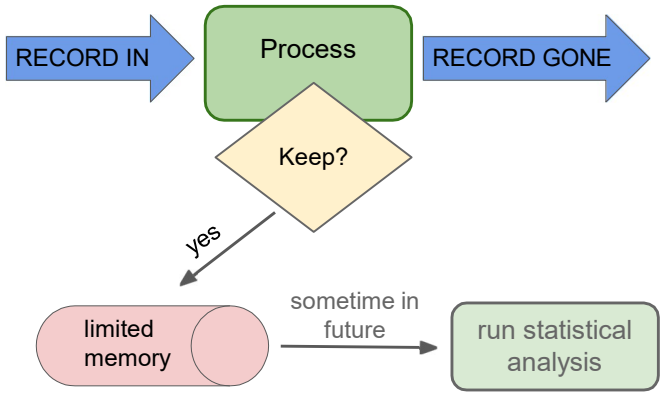

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Sampling: 2 Versions

Create a random sample for statistical analysis.

1. **Simple Sampling:** Individual records are what you wish to sample.

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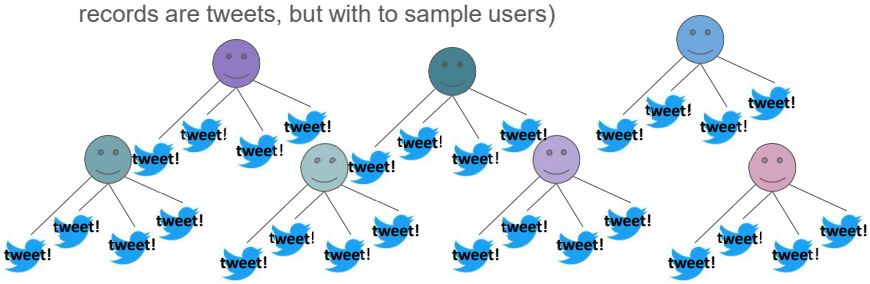
2. **Hierarchical Sampling:** Sample an attribute of a record. (e.g. records are tweets, but with to sample users)



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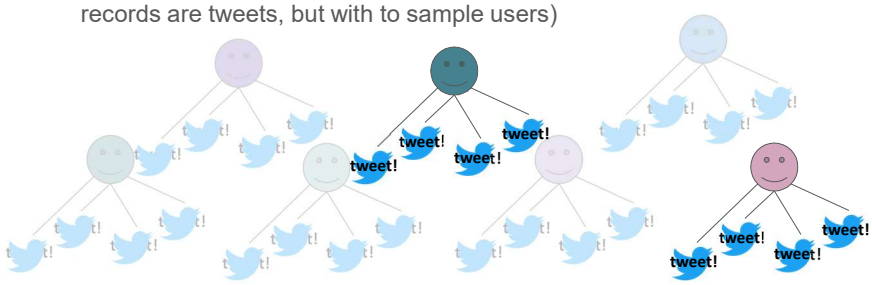

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if ?: #keep: e.g., true 5% of the time
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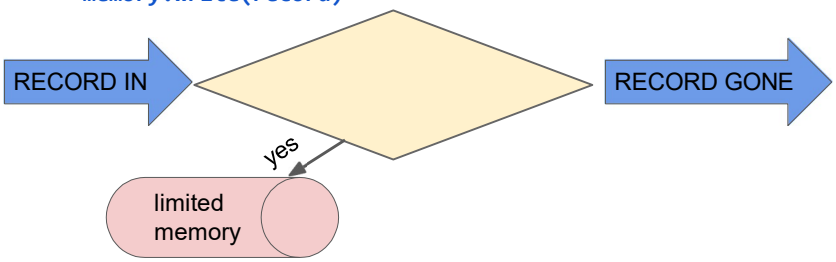

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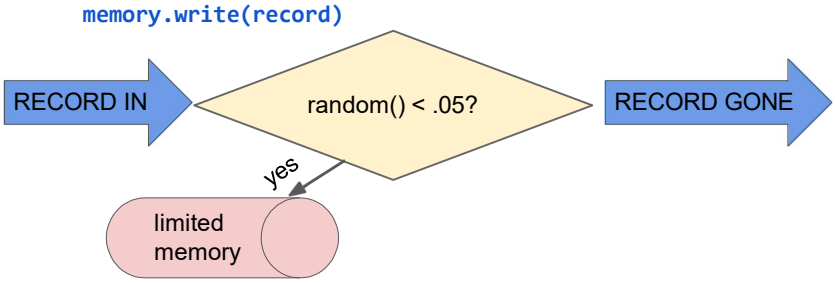

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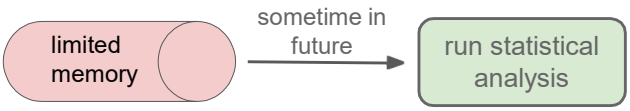
Problem: records/rows often are not units-of-analysis for statistical analyses

E.g. user_ids for searches, tweets; location_ids for satellite images



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2. **Hierarchical Sampling:** Sample an attribute of a record.

(e.g. records are tweets, but with to sample users)

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Solution: ?

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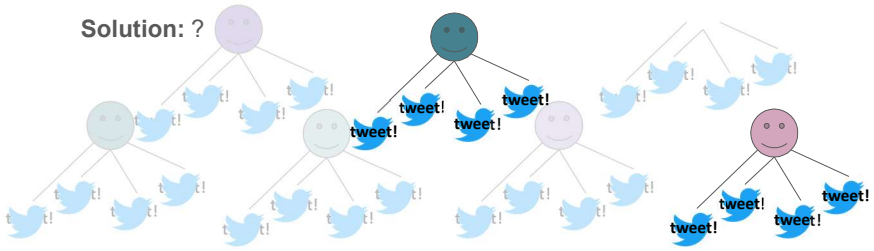

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Solution: instead of checking random digit; hash the attribute being sampled.

– streaming: only need to store hash functions; may be part of standing query

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Sampling

2. **Hierarchical Sampling:** Sample an attribute of a record.
   (e.g. records are tweets, but with to sample users)

```
record = stream.next()
if hash(record['user_id']) == 1: #keep
    memory.write(record)
```

Solution: instead of checking random digit; hash the attribute being sampled.
– streaming: only need to store hash functions; may be part of standing query

How many buckets to hash into?

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Counting Moments

Moments:

- Suppose m_i is the count of distinct element i in the data
- The kth moment of the stream is $\sum_{i \in \text{Set}} m_i^k$

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- The kth moment of the stream is $\sum_{i \in \text{Set}} m_i^k$

- 0th moment: count of distinct elements
- 1st moment: length of stream
- 2nd moment: sum of squares
  (measures *uneveness;* related to variance)

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