Online aggregation & Sampling from Joins

CompSci 590.02

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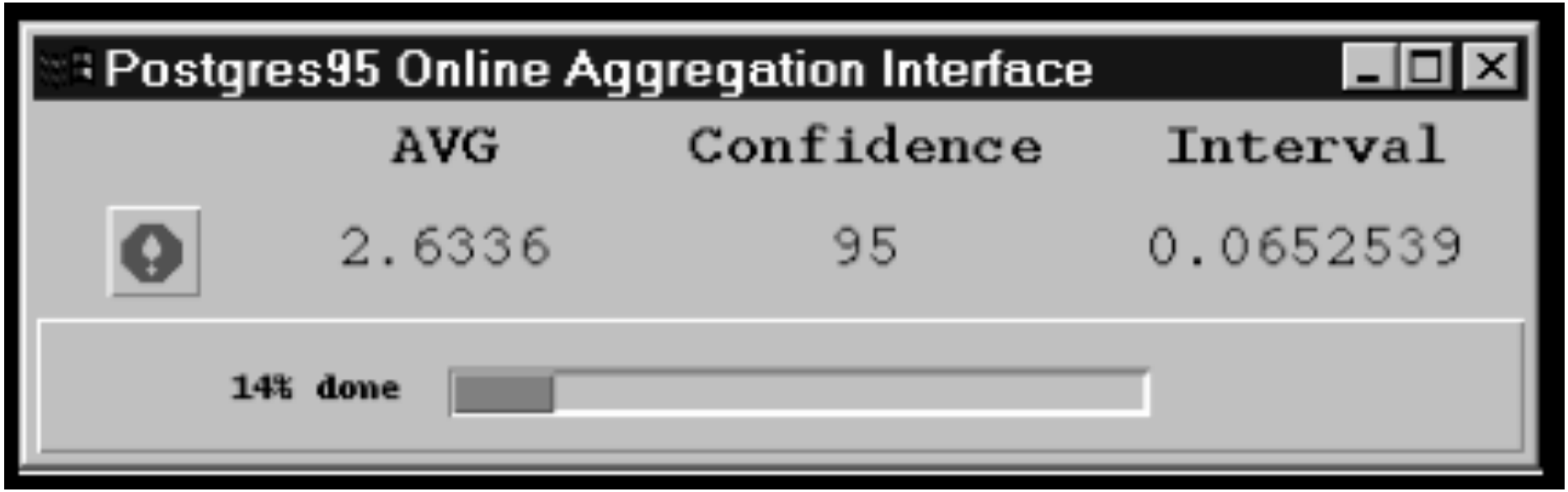
Outline

- Online Aggregation
- Ripple Joins
- On the hardness of sampling from Joins

Online Aggregation

- Most systems compute aggregated like averages/counts/ etc. exactly.
- But aggregates only provide a “summary-view” of the data.
- Why wait for an aggregate computation on the entire data?

Online Aggregation



Examples of Queries

- Select Sum(Salary) From R

DISTINCT

- Select Count(DISTINCT hashtags) from T

GroupBy

- Select Average(Grade) from STable GroupBy CourseID

JOIN

- Select Sum(Grade*Difficulty) from STable, Course

Example Scenarios

- Compute the number of individuals in the table that satisfy function F, where F is a computationally intensive property.
  - Running the query on the entire data takes O(nf), where f is the time for checking F on one record.
  - We can get an approximate answer much faster …

Example Scenarios

- Compute the sum of all elements in a database, which is partitioned on k machines.
  - Compute sum on each machine Si, and then add up all the Si's
  - Time taken to compute aggregate = max(time taken by one machine)
  - If a machine fails …

Example Scenarios

- Find the number of people in database D1 also appears in database D2
  - Exact answer needs checking |D1|.|D2| pairs of records.
  - Can we get an approximate answer faster?

Aggregations on a single table

1. Read the records of the table in a random order

2. Maintain a *running estimate* of the required aggregate

3. Compute confidence bounds on the error in the running estimate.

Random access

- Random I/Os are expensive
- Heap Scans
  - Heaps maintain the data in the order in which they are inserted
  - If insertion order is not correlated with values, then this can be used instead of a true random ordering
- Index Scans
  - If index is on an attribute that is not the same as the aggregated column
- Sampling from indexes
  - From previous class

Group-By

- E.g., Select Avg(Salary) from R GroupBy Department
- Standard technique
  - Sort the relation by the grouping attribute
  - Compute the within group aggregate by scanning the sorted output
- Sorting is a blocking operation

- Alternative : Hashing

Running Estimate

- If N is the number of tuples in the data
- If n is the number of tuples seen …

- SUM : N/n (current sum)
- COUNT: N/n (current count)
- AVG : 1/n (current sum)

Confidence bounds

Assuming the input tuples are randomly chosen.

If Xi is the random variable corresponding to the i^{th} tuple, then X1, X2, … are independent random variables.

$$P\{|Yn - \mu| > \varepsilon\} < 2 \exp\{-2n\varepsilon^2 / (b-a)^2\}$$

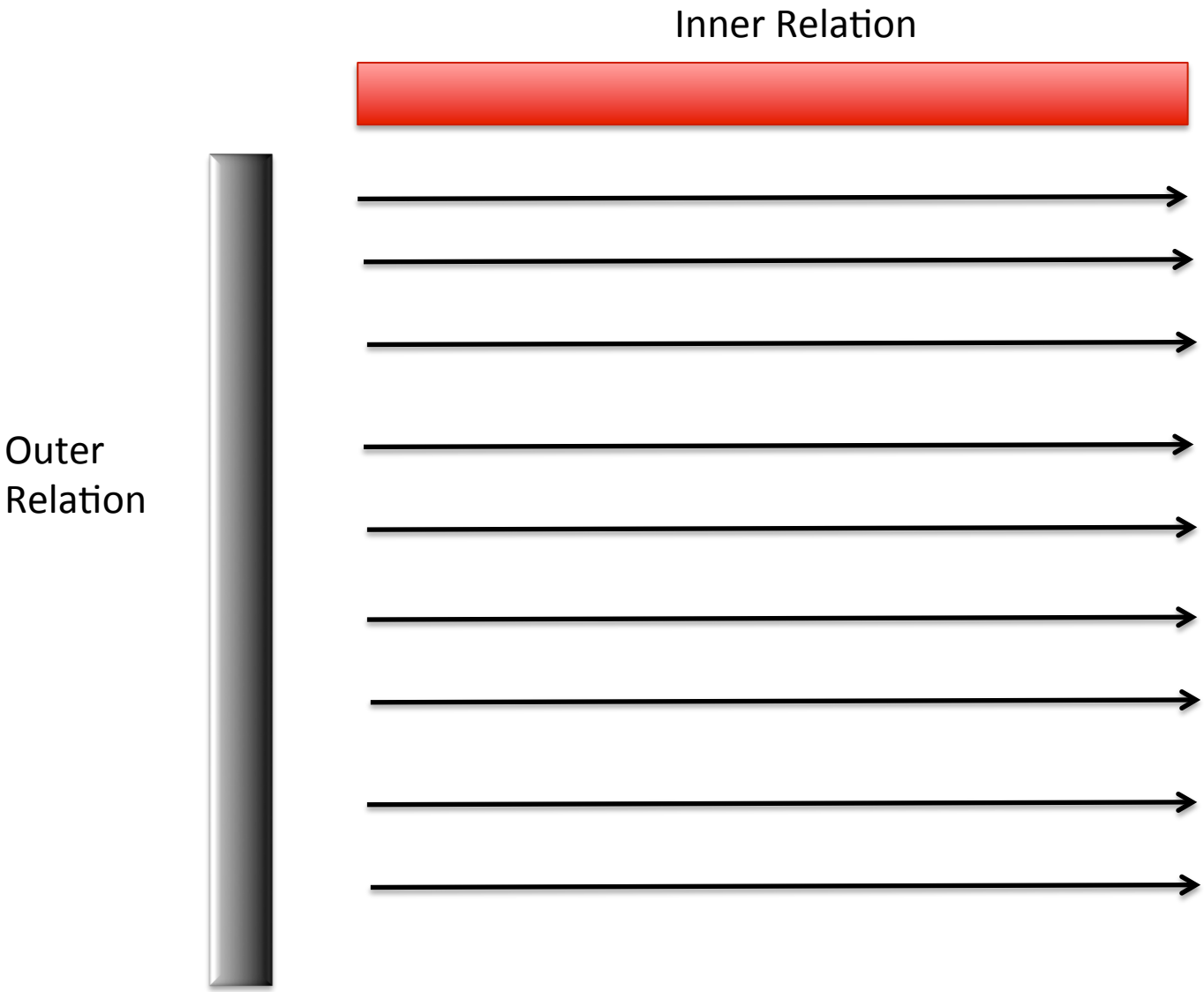
Where

- Yn is the running estimate after seeing n elements
- μ is the actual aggregate
- [a,b]: range of the values in the database

Online Aggregation over Joins

- How to generate a random ordering of pairs of tuples from the Join of a relation?
  - Option 1: Compute the join and then read the output of the join in a random order – BLOCKING!
  - Option 2: Nested Loop Join (over random orderings of the two tables)

Nested Loop Join



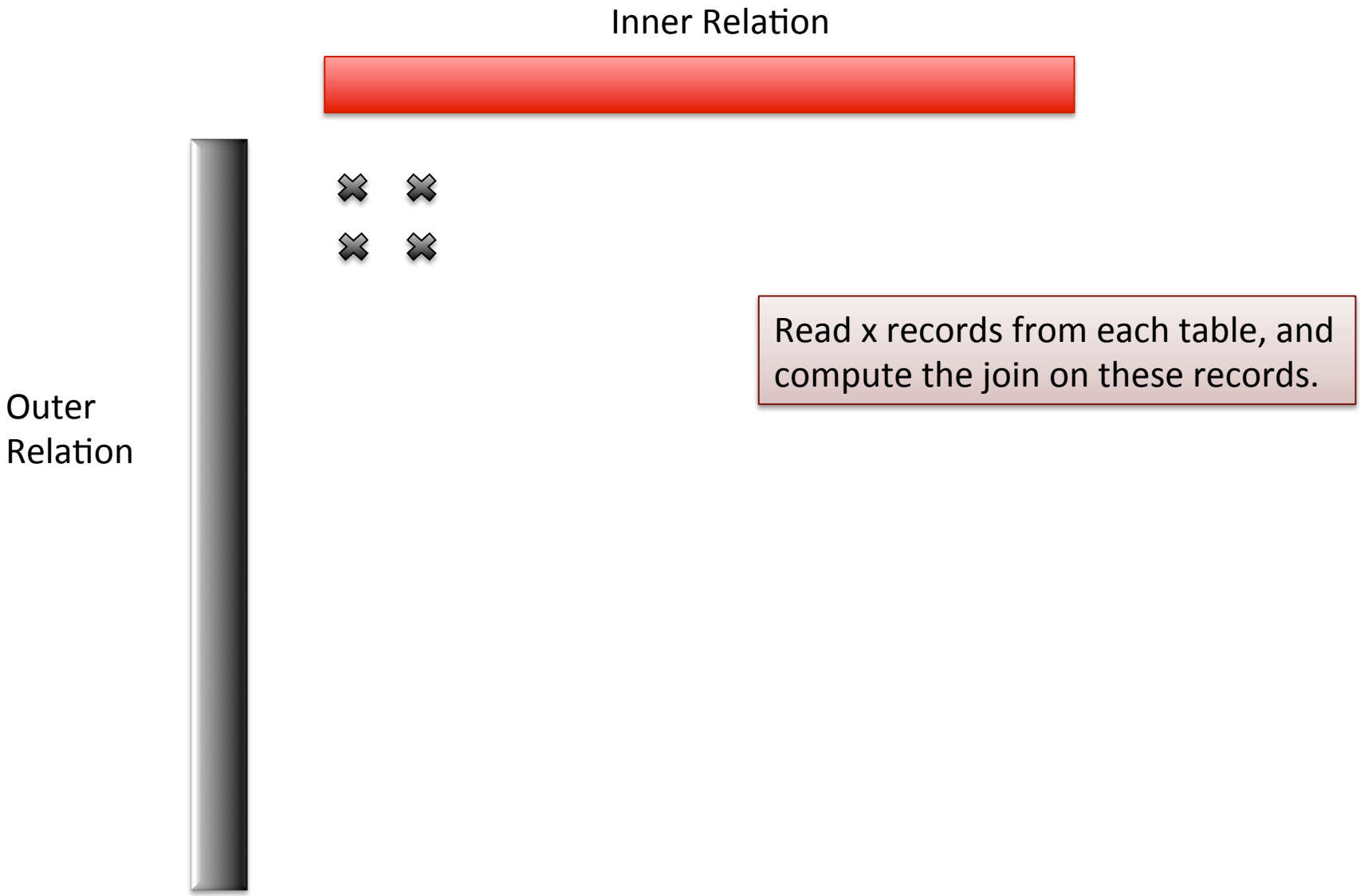
Nested Loop Join

Inner Relation

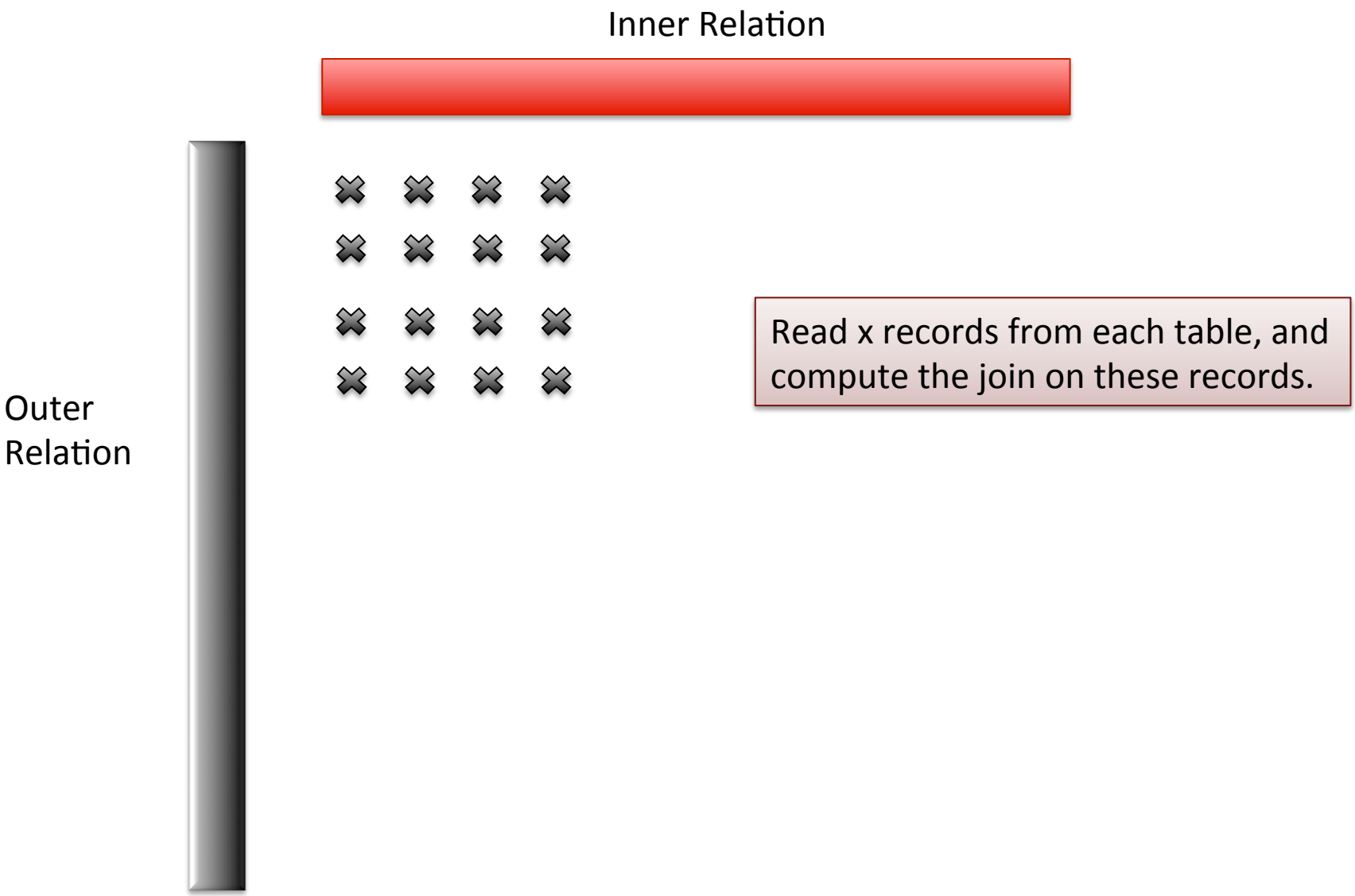
Outer Relation

Unnecessary work is done if:
- Values in the inner relation are roughly the same
- Output of the aggregate is not very sensitive to the values in the inner relation

Ripple Join


Inner Relation
Outer Relation
Read x records from each table, and compute the join on these records.

Ripple Join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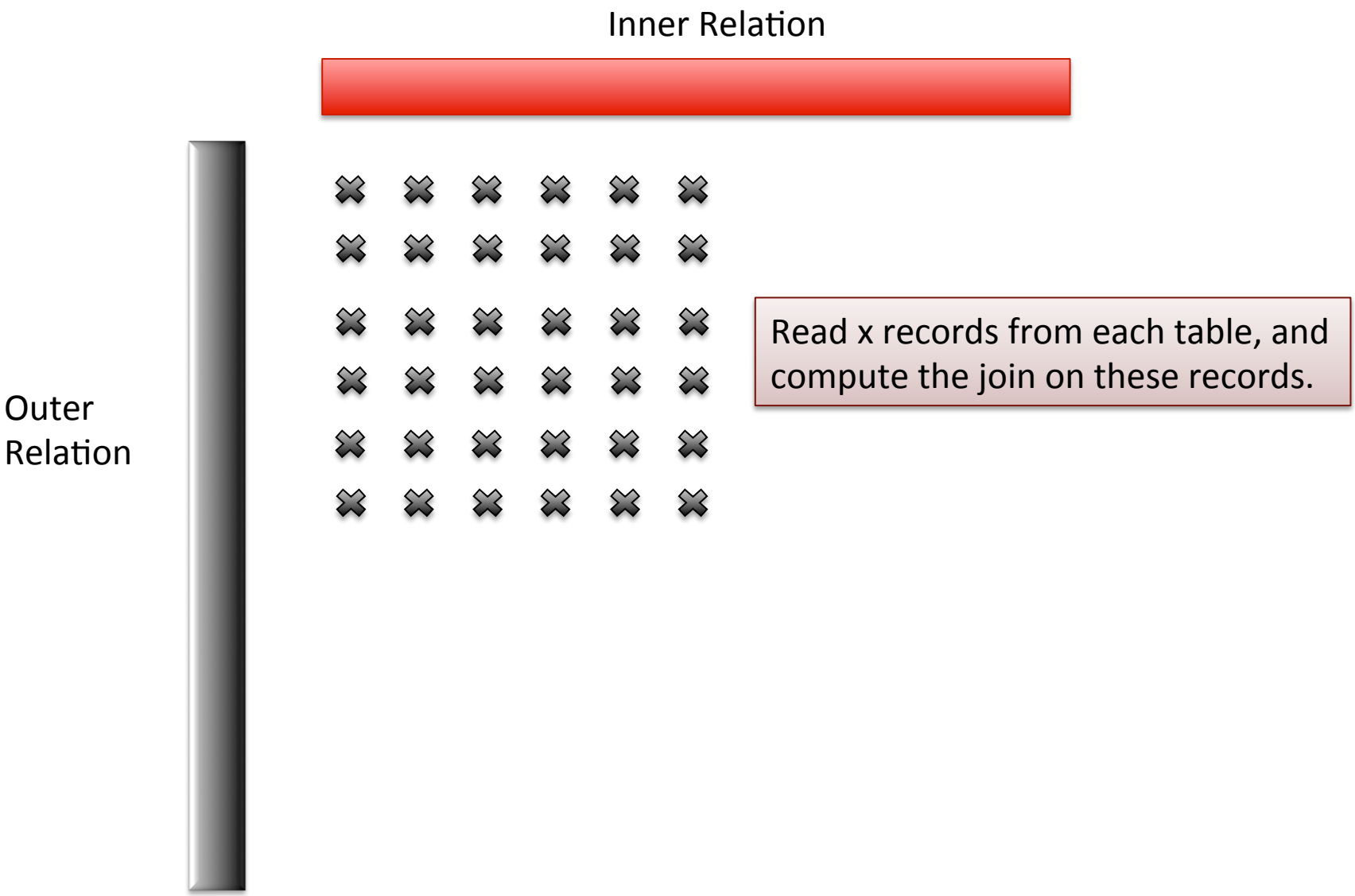
Ripple Join


Inner Relation
Outer Relation
Read x records from each table, and compute the join on these records.

Online aggregation with Joins

- The output tuples are no longer independent samples from the underlying distribution
  - Why?

Difficulty of Join Sampling

- Sample(Join(R,S)) ≠ Join(Sample(R), Sample(S))

- R: {(a, x0), (b, x1), (b,x2), …, (b,xn)}
- S: {(b,y0), (a,y1), (a,y2), …, (a,yn)}

- In R x S: Half the records have ‘a’ and half the records have ‘b’

- In Sample(R): probability ‘a’ appears is very small.

Using statistics

- If we know for each tuple t ε R, how many tuples it joins with in S (call it $n_S(t)$)

- Pick a random tuple t ε R
- Include it with probability proportional to $n_S(t)$

Summary

- Online aggregation helps provide approximate answers without waiting for the exact answer
- Requires iterating over a random order of the data
- Sampling over Joins is difficult.