Finding Frequent Item Pairs

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Background

- Basket: a set of items someone bought together in one time
  - eg. {apple, milk, coffee, orange}

- We want to find item pairs that appear together "frequently" in baskets
  - {a,b,c}, {a,b,d}, {a,b,e}, {a,b,f}
  - [a,b] appears frequently !

Background

- Frequent pair
  - Given threshold s, the pairs whose appearance frequency > s are called frequent pairs

Brute-force Method

- Count frequency of every possible pair

- n distinct items
  - n*(n-1)/2 pairs
  - space complexity: O(n^2)

- Suppose 10^5 items, counts are 4-byte integers
  - 5 *10^9 pairs
  - 2 *10^20 (20 GB) memory needed

How to improve?

- If [a, b] are frequent pair,
  - frequency([a,b]) > threshold
- Then
  - frequency(a) > threshold
  - AND frequency(b) > threshold

- Therefore, find frequent individual item first!

Find frequent items

- Read baskets and count the frequency of each individual item
  - Space complexity: O(n)

- Find the items with frequency > threshold

- Split the dataset into a number of subset and count item frequencies in parallel (MapReduce)

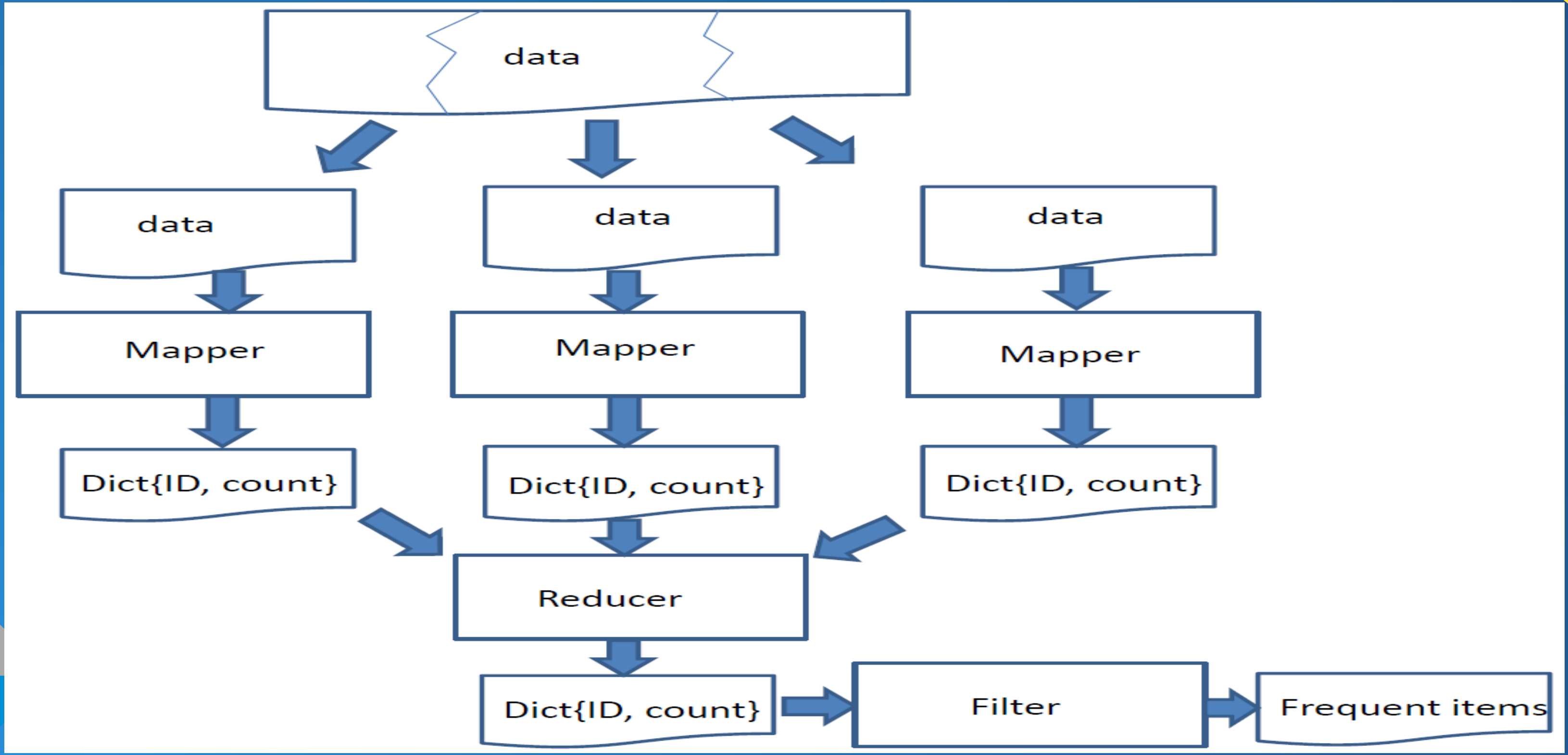
Find frequent pairs

- Method 1
  - Generate a list of possible frequent pairs based on results from single count (O(m^2) space)
  - For each basket, iterate through the list to check if each pair exist
  - Time complexity: O(m^2*L*N), L is the length of a basket, N is the number of baskets

Find frequent pairs

- Method 2
  - For each basket, generate a list of frequent single items, then generate a list of possible frequent pairs and count
  - Iterate through all baskets
  - Time complexity: O(L^2*N)
  - L is usually much smaller than m^2

Parallelization

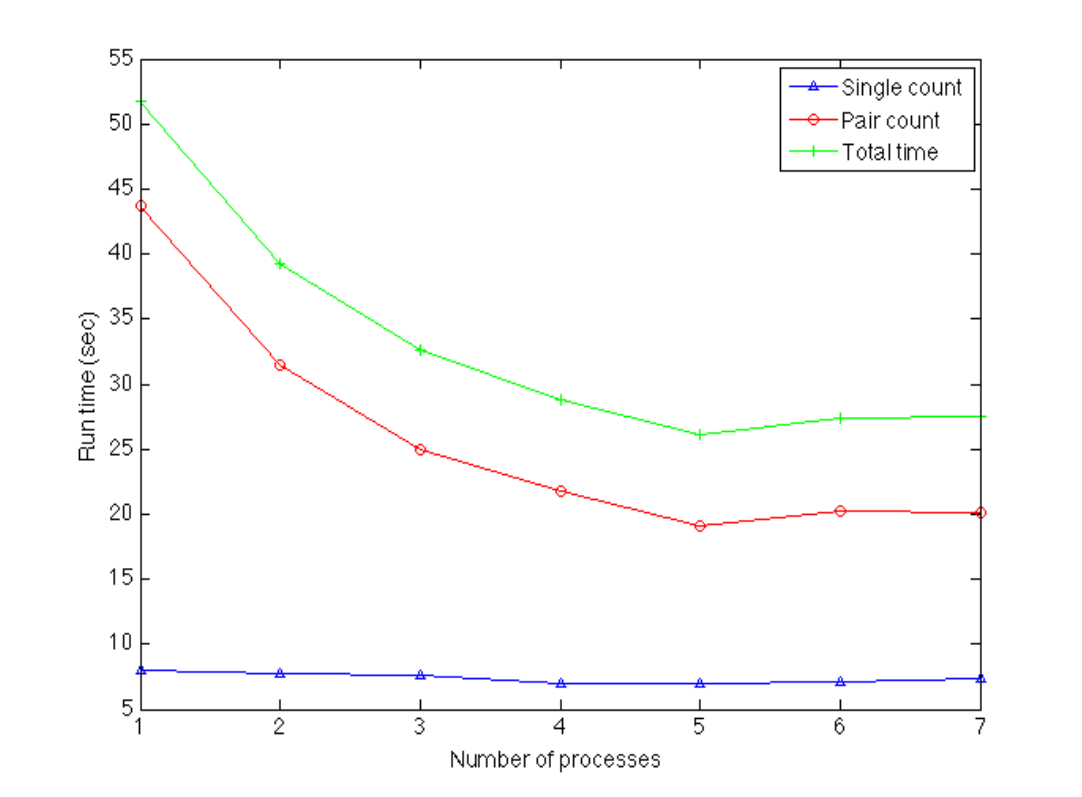


Dataset

- 999,002 transactions
- 41,270 distinct items

Parallelization performance

1.7 GHz Intel Core i5
2 cores



Improvement on Memory Usage

- Based on frequent individual items, we generated a set of possible frequent paris,
  - Define these pairs as “**candidate pairs**”

- What if the number of candidates pairs are very large?
  - eg. not fit in memory

Hash Table

- Create a hash table with a number of buckets
- For each candidate pair, hash it to one bucket
- We only count the frequency of each bucket, not the candidate pair
- Space Complexity
  - O(k), k is the # of buckets
  - Typically, # of buckets << # of candidate pair

Hash Table

- Frequent bucket
    - Frequency(bucket) > threshold
- If a bucket contains frequent candidate, then it must be frequent bucket
- Only the candidate pairs in frequent buckets need to be considered
- In our test, this method saves about 65% memory

Thank you !

Q & A?