ACM SIGMOD Programming Contest 2016
AKGROUP TEAM

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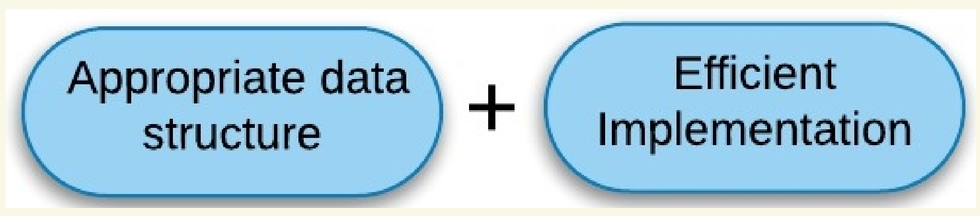
Task Overview

In graph theory, the shortest path problem is the problem of finding a path between two vertices (or nodes) in a graph such that the sum of the weights of its constituent edges is minimized.

The task is to answer shortest path queries on a changing graph, as quickly as possible.

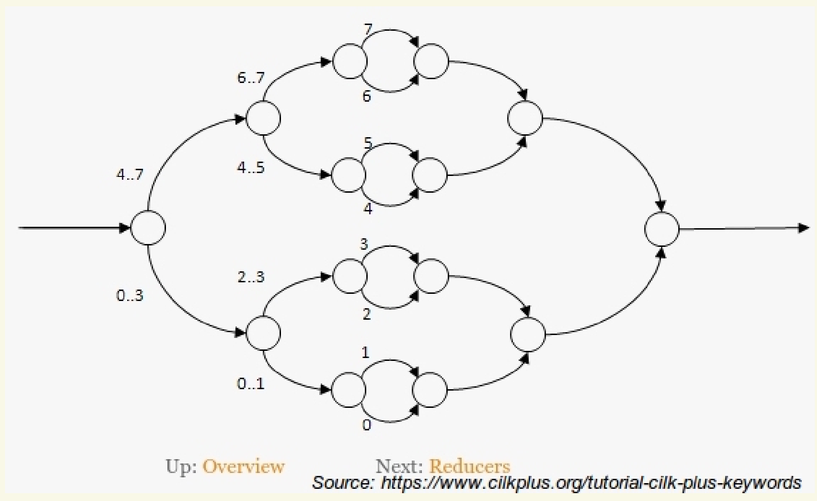
Our approach



Strategic solutions

- Optimize the data structure: adjacency list
  - Each node is identified by a number.
  - All incoming/outgoing nodes of a node are stored in a adjacency array.
  - An index array is used to store the starting position of trunk in incoming/outgoing arrays.

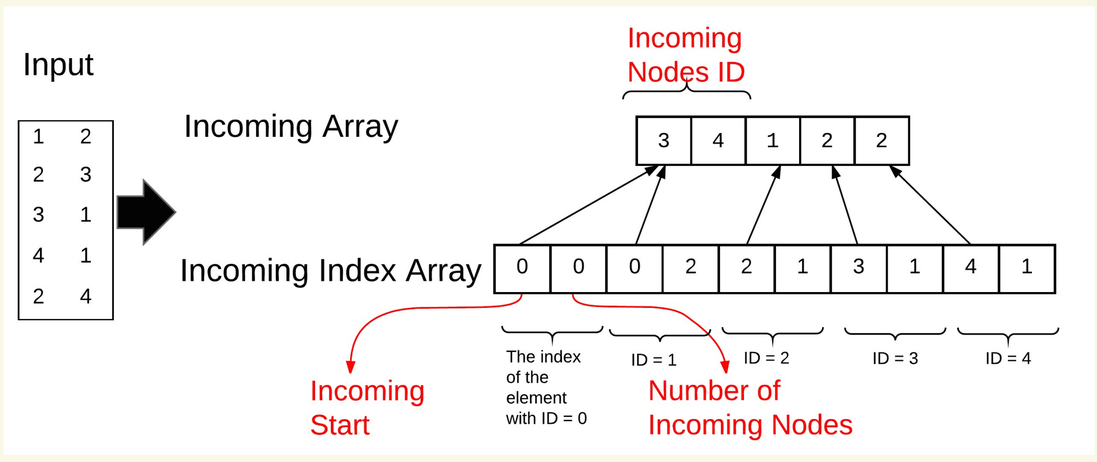
  ==> Increase the hit rate in CPU Cache
- Optimize the update actions
  - Adding a new edge: 2 ideas
    - Preallocate a bucket
      Each 32 nodes has a reserved buffer for adding new nodes, this buffer is called BUCKET. By default, BUCKET size is 8. This means a maximum of 8 nodes can be added in the interval of 32 vertices.
    - Move to the end
      Move the adjacent elements array to the end, and then add a new node at the end of the array.
  - Deleting an edge: Update only the number of incoming/outgoing in the index arrays.
- Optimize the query processing
  - **Algorithm**: Breadth First Search (BFS) is used in both directions: from incoming array and outgoing array.
  - 2 bitmap arrays are used for remarking travelled incoming/outgoing nodes.
  - Strategies to reduce the search space
    - Predict the next number of nodes in incoming/outgoing queues: calculate the total number of incoming and outgoing in each iteration.
    - Follow the direction having the smaller queue element number.
  - More jobs for multicore/multichip CPUs
    - Parallel the action batch: only for query actions: all consecutive queries will be performed in parallel in multicore/multichip CPUs.
    - Update and delete actions will be handled sequentially.
  - **Graph processing**: Use Cilk Plus to parallel queries.



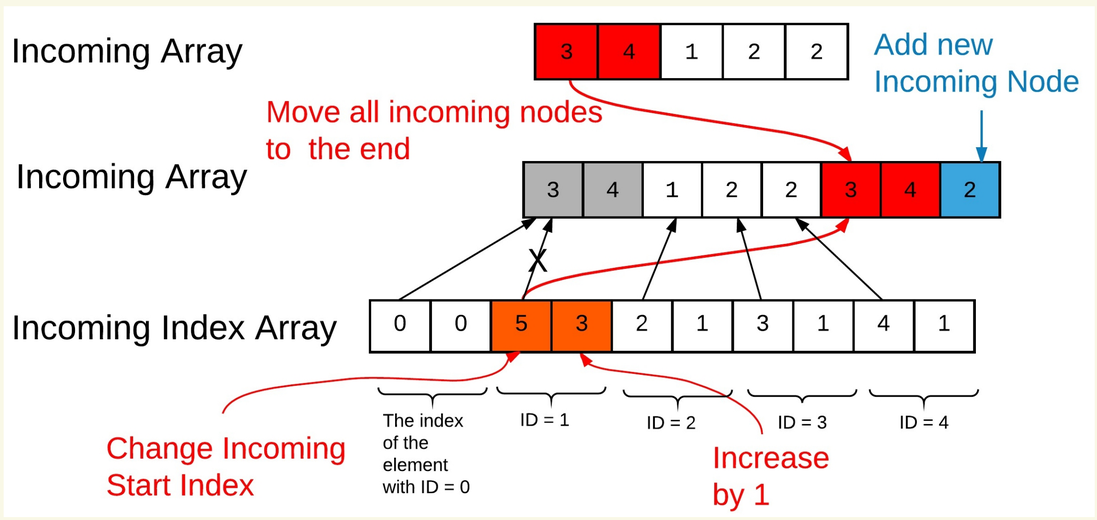
Source: https://www.cilkplus.org/tutorial-cilk-plus-keywords

Implementation

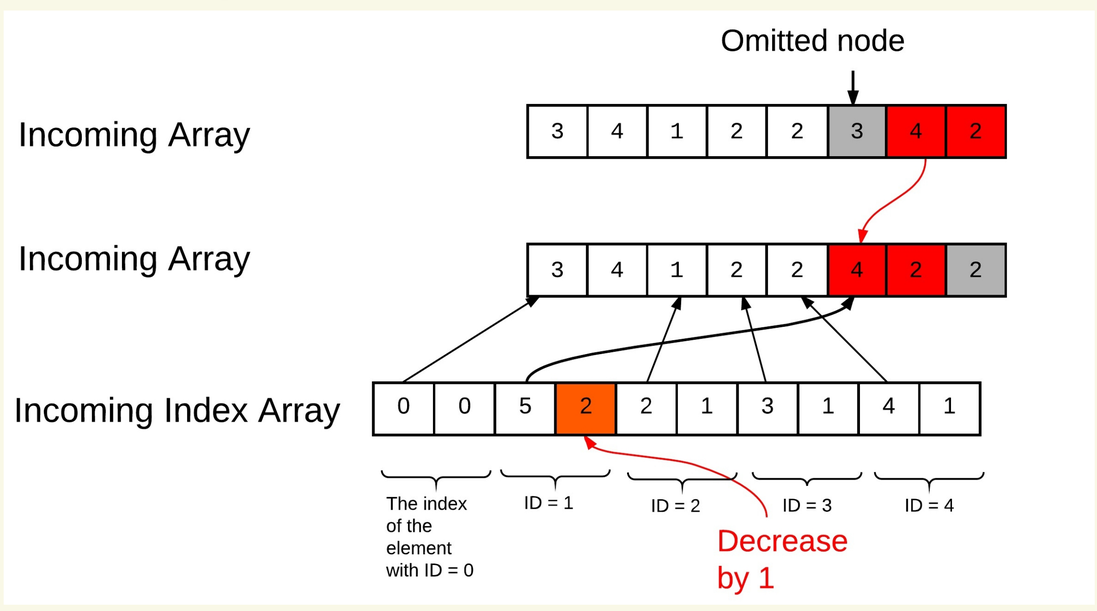
DATA STRUCTURE:



ADD: edge(2 1)



DELETE: edge(3 1)



QUERY:

- Global incoming queue and outgoing queue are used for each time searching the shortest path. Then, each searching thread will only use proper in/out queues determined by an interval of global in/out queues.
- Each searching thread will also own the proper in/out map slots computed from the global in/out maps. Once the searching is finished, these in/out slots will be cleared for the next search.
- Cilk Plus is used for performing queries in parallel.

Experimental result

- Language: C
- Evaluation Machine:
  - CPUs: 2 x Intel E5-2620v2
  - Main Memory: 20GB
  - Operating System: Ubuntu 14.04 Linux
  - Software: Automake 1.15, gcc5.2.1

Small	Medium	X-Large	XX-Large
0.118	0.494	1.284	2.878

Final test result