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Parallel algorithms for multi-source BFS and its applications

ABSTRACT

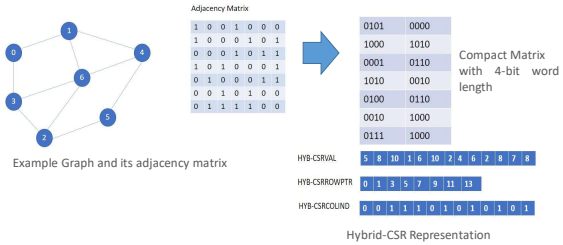
Many scientific and technical problems are related to large size data with networked nature, such problems can be well represented in the form of graph data structures. The efficient parallel graph algorithms are important in solving problems of various domains. These days GPUs are effectively used for computational expensive algorithms to solve the graph analytics problems. The graph traversal algorithm required for these problems are independent and hence can be executed in parallel. Multi-source BFS is an interesting problem where breadth-first search is performed from multiple source nodes. It demonstrates its use in solving various other problems such as algorithms to find betweenness centrality, diameter computation, shortest path calculations. computational problems, graph algorithm utilizes the Our Multi-BFS algorithm provides a space-saving and faster solution to multi-source BFSs on GPU. We use unique hybrid-CSR representation for graph storage and linear algebra method (SpMM) to perform BFS from multiple sources. The current results show a promising algorithm to solve various graph analytics problems.

OBJECTIVE

In our research work, we intend to perform Breadth First Search simultaneously from multiple sources on GPU. We demonstrate hybrid-CSR representation for real-world unweighted directed/undirected sparse graphs which can efficiently utilize the limited memory of GPUs. Inspired by the popularity of GraphBLAS, we use linear algebra method of BFS computation. Consider G as the graph matrix and X as another sparse matrix with 1 set only at positions of source nodes. Repeated multiplication of the graph matrix G with sparse matrix X yields the BFS traversal of the graph.

METHOD

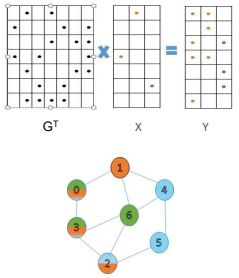
Hybrid-CSR Graph Representation



Example Graph and its adjacency matrix

Hybrid-CSR Representation

Multi-Source BFS using Matrix-Matrix Multiplication



Hybrid-CSR-based Multi-BFS algorithm

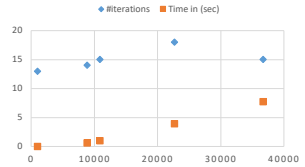
Input: Graph G^T of size N *M (in hybrid-CSR format), Matrix X of size N*M (in compact Matrix format)

Output: Matrix Y (in compact Matrix)

```
1.  Procedure Multi-BFS
2.    for each thread 'rowG' in G  in parallel do
3.       for all 'rowX' in X do
4.             Sum <-- 0
5.             Bit<--rowIndex*M
6.             for k from ROWPTR[rowG] to
    ROWPTR[rowG+1]
7.                         col <-- COLIND[k]
8.                         sum OR= G[rowG][col] AND
    X[rowX][col]
9.                   if (sum != 0) then
10.                        Setbit Y[rowG][bit]
11.                        break
12.                  end if
13.            end for
14.                  bit <-- bit+1
15.      end for
16.   end for
17. end Procedure
```

Current results

The below chart shows time in seconds and number of iterations to complete the BFS from all the nodes when we test our data on the graphs which can fit on the GPU. The graphs are undirected and unweighted ranging from 1000 nodes to 36000 nodes.



Conclusion

The next phase of our work focuses on:

- Applications of Multi-BFS such as Graph Centrality computation, diameter computation, shortest path calculation.
- Multi-BFS on dynamic graph and static graphs.
- Multi-BFS on the graphs that cannot fit in GPUs. In this overlapping of data transfer and BFS computation is simultaneously done to get the desired results.

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