ABSTRACT

Optimal route computation in complex real world networks has become one of the most challenging common man’s day-to-day problems. These kinds of problems are known as Single Source Single Target Shortest Path Problems (SSSTSPP) and solutions to these types of computational problems are obtained using the most popular Dijkstra’s algorithm. The computation time of the algorithm increases with the increase in network complexity. Researchers have introduced many speedup techniques to Dijkstra’s algorithm. Many of these speedup techniques use pre-processing of large datasets. These pre-processing based speedup techniques have been proven to improve the efficiency of Dijkstra’s algorithm. The bottleneck of these speedup techniques lies in the pre-processing time as more time is spent in the pre-computation of auxiliary data. Hence, researchers have focused their interest on finding improved speedup techniques for the shortest path problems to accelerate and to improve the query performance of the shortest path queries in order to reduce the pre-processing time and computation time.

In addition, it is also necessary to exploit the processing capability of the modern day computing systems which have the capacity of accommodating more than one processor. These multi-core processors can be exploited to exhibit various degrees of parallelism by suitably modifying the portions of the existing speedup techniques. The rapidly evolving field of multiprocessing systems and multi-core processors provide many opportunities for such improvements. The parallelized pre-processing based speedup techniques embodied in these types of multi-core processors will improve the efficiency of the shortest path query processing in both static and dynamic networks.

Though several speedup techniques exist, each technique has its own overhead in the pre-processing phase and in the shortest path computation phase. Minimizing this overhead is critical and there is a lot of scope for improving the efficiency by proposing combined speedup techniques for pre-processing and computation of the shortest path queries. Moreover, the quantum of work reported for parallel speedup techniques is also very less.
Therefore, the main focus of this research is to formulate new speedup techniques that have minimal pre-processing time and computation time by combining the existing techniques so that the new proposed techniques are more suitable for the present day’s complex Shortest Path Problems (SPP).

In this research work, proficient solutions are explored for static networks which use arc-flag vector for pre-processing the network data in addition to multilevel approach and bidirectional search. The proposed speedup technique namely CoBAM for static networks takes the advantage of reduced search space and computation time. Further, considering the importance of parallelization in the static networks, few parallelized speedup techniques have been devised to provide better speedup in terms of runtime and search space.

In addition to static networks, these pre-processing-based speedup techniques are considered in more realistic situations such as road networks where edge weights change with time. Therefore, the focus of research shifts towards the speedup techniques for dynamic graphs which give rise to the Time-Dependent Shortest Path Problem (TDSP). In dynamic networks, in order to address changing edge weights, a new network partitioning policy called Recursive Spectral Bisection (RSB) combined with speedup techniques have been developed. In addition, a new speedup technique, namely, the Bidirectional search combined with RSB and enclosing Ellipse (Bi-RSB-Ellipse) for dynamic networks, has been developed to provide better solutions in terms of efficient query processing.

The proposed partitioning-based speedup technique is further extended to exploit the parallelization which is better realized in dynamic networks. New parallelized speedup techniques are proposed using the bidirectional search, arc-flag method and RSB partitioning techniques.
These newly developed speedup techniques achieve significant speedup in static networks and dynamic networks. In addition, the proposed techniques result in the faster query processing and lesser update time. The proposed techniques are evaluated experimentally and statistically for different types of networks, namely, random, planar and road networks. The various performance metrics are obtained. The proposed techniques outperform the existing ones in terms of the efficient query performance metrics like speedup and Query Performance Loss (QPL).

The limitations of the speedup techniques for the shortest path problems developed in this research have also been identified and presented for further exploration.