COLLEGE OF ENGINEERING AND COMPUTER SCIENCE
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

Ahmad Qutbuddin

for the degree of Doctor of Philosophy (Ph.D.)

"Spatial Network Big Database Approach to Resource Allocation Problems"

October 18, 2021, 11:30 a.m.
Virtual Dissertation

DEPARTMENT:
Electrical Engineering and Computer Science

ADVISOR:
KwangSoo Yang, Ph.D.

PH.D. SUPERVISORY COMMITTEE:
KwangSoo Yang, Ph.D., Chair
Shihong Huang, Ph.D.
Mihaela Cardei, Ph.D.
Feng-Hao Liu, Ph.D.

ABSTRACT OF DISSERTATION
Spatial Network Big Database Approach to Resource Allocation Problems

Resource allocation queries for Spatial Network Big Database are challenging as the size, variety, and update rate of spatial datasets exceed the capacity of commonly used spatial computing and spatial database technologies to learn, manage, and process the data with reasonable effort. The output of queries must be concise and easy to understand. At the same time, the information must be very descriptive and useful. My research aims to address these challenges through the development of fundamental data processing components for advanced spatial network queries that clearly and briefly deliver critical information. This thesis studied two challenging Spatial Network Big Database problems: (1) Multiple Resource Network Voronoi Diagram and (2) Node-attributed Spatial Graph Partitioning.

To address the challenge of query processing for multiple resource allocation in preparing for a disaster or disruption, we investigated the Multiple Resource Network Voronoi Diagram (MRNVD) problem. Given a spatial network and a set of service center nodes from k different resource types, the Multiple Resource Network Voronoi Diagram (MRNVD) problem partitions the spatial network into a set of Service Areas that can minimize the total cycle distances of graph-nodes to the allotted k service center nodes with different resource types. The MRNVD problem is important for critical societal applications such as assigning essential survival supplies (e.g., food, water, gas, and medical assistance) to residents impacted by man-made or natural disasters. The MRNVD problem is NP-hard; it is computationally challenging due to the large size of the transportation network. We propose a novel approach for MRNVD that can efficiently identify the best routes to obtain the k different resources. Experiments and a case study using real-world datasets demonstrate that the proposed approach creates MRNVD and significantly reduces the computational cost.

To address the challenge of multi-attributed graph partitioning, we explore the Node-attributed Spatial Graph Partitioning (NSGP) problem. Given a spatial graph and a set of node attributes, the Node-attributed Spatial Graph Partitioning (NSGP) problem partitions a node-attributed spatial graph into k homogeneous subgraphs that minimize both the total $RMSE_{rank1}$ and edge-cuts while meeting a size constraint on the sub-graphs. $RMSE_{rank1}$ is the Root Mean Square Error between a matrix and its rank-one decomposition. The NSGP problem is important for many societal applications such as identifying homogeneous communities in a spatial graph and detecting interrelated patterns in traffic accidents. This problem is NP-hard; it is computationally challenging because of the large size of spatial graphs and the constraint that the sub-graphs must be homogeneous, i.e. similar in terms of node attributes. We propose a novel approach for finding a set of homogeneous sub-graphs that can minimize both the total $RMSE_{rank1}$ and edge-cuts while meeting the size constraint. Experiments and a case study demonstrate that the proposed approach partitions a spatial graph into a set of homogeneous sub-graphs and reduces the computational cost.

BIOGRAPHICAL SKETCH
B.S., King Fahd University of Petroleum and Minerals, Dhahran, Saudi Arabia, 2010
M.S., University of Central Florida, Orlando, Florida, 2017
Ph.D., Florida Atlantic University, Boca Raton, Florida, 2021

CONCERNING PERIOD OF PREPARATION
& QUALIFYING EXAMINATION

Time in Preparation: 2019 - 2021

Qualifying Examination Passed: Spring 2019

Published Papers:

A. Qutbuddin and K. Yang, “Node-attributed Spatial Graph Partitioning,” Preparing for submission to *IEEE Transactions on Knowledge and Data Engineering*.

A. Qutbuddin and K. Yang, "Multiple Resource Network Voronoi Diagram," in *IEEE Transactions on Knowledge and Data Engineering*, (Early Access), 2021, doi: 10.1109/TKDE.2021.3088147.

Herschelman, R., Qutbuddin, A. & Yang, K., “Conflict-Free Evacuation Route Planning,” *Geoinformatica* (Early Access), 2021, doi: https://doi.org/10.1007/s10707-021-00435-0.

Yang, K., Nam, K.W., Qutbuddin, A., Reich, A., Huhn, V., “Size constrained k simple polygons,” *Geoinformatica*, Volume: 25, Issue: 1, 2021, pp. 43–67, doi: https://doi.org/10.1007/s10707-020-00416-9.

D. Bereznyi, A. Qutbuddin, Y. Her, and K. Yang, “Node-attributed Spatial Graph Partitioning,” in *Proceedings of the 28th International Conference on Advances in Geographic Information Systems (SIGSPATIAL '20)*. Association for Computing Machinery, New York, NY, USA, 2020, pp. 58–67, doi: https://doi.org/10.1145/3397536.3422198.

A. Qutbuddin and K. Yang, “Multiple Resource Network Voronoi Diagram,” in *11th International Conference on Geographic Information Science (GIScience 2021) - Part I*, Volume: 177. Schloss DagstuhlLeibniz-Zentrum fur Informatik, 2020, pp. 11:1–11:16.