IE 514: Optimization Methods for Large-scale Network-based Systems

Credit hours: 4
Instructor: Lavanya Marla

Topical Outline:

1. Shortest paths on acyclic networks, labeling algorithms
2. Generalized shortest paths and labeling algorithms
3. Multi-commodity flows (and differences from the minimum-cost network flow problem)
    a. Column generation (relation to duality)
    b. Branch-and-price
    c. Branch-and-price and cut
    d. Decomposition techniques (Dantzig-Wolfe decomposition etc.) and related solution methods
4. Lagrangean relaxation, formulations and solution techniques
5. Airline Schedule Planning models – Set-covering and set-partitioning problem formulations
    a. Case study: Crew Scheduling
    b. Composite variable modeling
    c. Solution techniques with adapted column generation
6. Airline Schedule Planning models – composite variable modeling
    a. Case study: Airline Fleet Assignment
    b. Composite Variable modeling with multiple types of composites
    c. Combining multiple multi-commodity flow formulations
7. Data-driven Modeling
    a. Case study: Ambulance Allocation
    b. Simulation-optimization framework
    c. Submodular problem formulations
8. Large-Scale neighborhood search
    a. Case study: Vehicle routing and metaheuristics using large-scale neighborhood search
9. Stochastic modeling in large-scale integer programs
    a. Brief introduction to stochastic programming
    b. Case study: Stochastic Crew Scheduling
10. Robust Optimization for integer programs
    a. Network flow modeling using worst-case modeling
11. Operational Learning
    a. Case study: Big Data Newsvendor problem

The course will present the concepts through real-world case-studies drawn from airline schedule planning, freight and last-mile logistics, emergency systems, vehicle routing and newsvendor problems.

Required Textbooks:

1. Network Flows: Theory, Algorithms and Applications, by Ravindra K. Ahuja, Thomas L. Magnanti and James B. Orlin – First Edition
2. Column Generation, by Guy Desaulniers at al (e-book available through UIUC libraries, https://vufind.carli.illinois.edu/all/vf-uiu/Record/13561817)
3. Stochastic Optimization – Anton J. Kleywegt and Alexander Shapiro -
    a. http://www2.isye.gatech.edu/~anton/stochoptiebook

Learning assessments:

Homeworks will incorporate smaller versions of real data extracted from consulting case-studies and students will be implementing models in Java/C++ and CPLEX.

Homeworks	40%
Mid-term	25%
Class project	35%