

# 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. Distributionally Robust Optimization
12. 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 – Partially available online
2. Column Generation, by Guy Desaulniers et 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 (tentative):**

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	25%
Mid-term	15%
Class project	60%