Writing About Operations Research – The Introduction

- A OR project report typically contains the following sections:

  0. Abstract
  1. Introduction
  2. Literature Review
  3. Input Data
  4. Model
  5. Experiment Setup
  6. Results
  7. Conclusions and Future Work

- The purpose of the **introduction** is to give your reader the big picture of your project:
  - What is your project about?
  - Why is it important or interesting?

- You can think of the introduction as an expanded version of the introduction, model, and data sentences of the six-sentence abstract.

- Here is a suggested outline for an introduction:

  1. **Background.** (1-3 paragraphs)
     - Start by providing some background information on your project.
     - Discuss the general project topic – assume your reader knows nothing about it.
     - Convince your reader that your project is interesting or important.
  2. **Problem description.** (1 paragraph)
     - Next, briefly describe your problem.
     - Describe the system you are studying and the data involved.
     - Describe what you want to find out about the system you are studying.
  3. **Methodology.** (1-2 sentences, at the end of previous paragraph)
     - Finally, give a short overview of how you propose to solve your problem.
     - Describe what kind of model you are using with your data to solve your problem.
     - Briefly mention why the model you are using is appropriate.

- Writing the introduction (and all the other sections) is an iterative process.
  - With high probability, you won't get your introduction right the first time around.
  - Your problem description and methodology will probably evolve as you work on your project.
  - This is natural! You can always go back and revise it.
  - Experienced researchers and analysts do this all the time.

Introduction, slightly edited, from

> S. J. Ward (Class of 2017), J. Foraker, N. A. Uhan. Resilient course and instructor scheduling in the Mathematics Department at the United States Naval Academy. *Military Operations Research* 23(3): 21-46, 2018.

Introduction

Colleges and universities continually face the problem of constructing a schedule for courses, instructors, and students that respects various constraints and objectives such as room availability, curriculum conflicts, and the preferences of students and faculty. Such *university timetabling* problems have been widely studied for the past several decades, beginning as early as 1969 (Thornley, 1969). Due to the size of many academic departments and the number of potentially conflicting objectives and constraints that must be considered, university timetabling is a task ideally suited for operations research techniques.

Creating schedules for courses and instructors at the United States Naval Academy (USNA), the undergraduate college of the United States Navy, has some interesting challenges. One such challenge is the uncertainty of available manpower: an instructor may or may not be able to teach in the upcoming semester. This happens often with USNA's military officer instructors, whose start and end dates at USNA are sometimes uncertain for a variety of reasons, such as extended deployments and sudden reassignments (e.g., individual augmentation). The availability of instructors, both civilian and military, is also affected by events such as long-term illnesses and family crises.

At USNA, the course and instructor schedule for the next semester is published near the end of the previous semester. Students (i.e., midshipmen) register for their courses around the same time. Unfortunately, disruptions to the published schedule, such as the sudden loss of an instructor, can occur between registration and the start of the next semester. However, in most cases, a course cannot simply be canceled if the instructor is no longer available to teach. Through an act of Congress, the academic program at USNA is 47 months (8 semesters) of study, and no more (United States Naval Academy, 2016). This fixed length program requires USNA to put the highest priority on ensuring students get their required classes. This involves, among many things, adjusting the course and instructor schedule. When a disruption occurs, the schedule must change to guarantee that students can take the courses they need to meet their graduation requirements on time. Generally speaking, course offerings are handled at the department level. This means that even a minor disruption can cause widespread changes to an existing schedule, creating a trickle-down effect that requires significant effort across multiple departments to address. As a result, having a timetable that is *resilient* – one that requires a minimum number of changes in the face of disruption – is an important consideration.

In this work, we study the problem of scheduling the courses and instructors in the Mathematics Department at USNA in a resilient manner. Every semester, the department needs to schedule around 70 instructors and 150-180 course sections into 30 class periods and 30 rooms. To model the discrete choices involved in scheduling and the random nature of disruptions, we formulate a stochastic integer linear program that schedules these courses, instructors, and rooms. In addition to maximizing instructor preferences and minimizing the number of rooms assigned to instructors, this stochastic integer linear program minimizes the expected number of changes required in the schedule if a disruption were to occur, given a subjective probability distribution over a finite set of possible disruption scenarios. We run our model on a number of instances derived from actual data from the past three years, and investigate the effect of emphasizing different parts of the objective function on the running time and resulting schedules.