

Lesson 1. Introduction

What is operations research?

- “The most influential academic discipline field you’ve never heard of” [Boston Globe, 2004]
- **Operations Research (OR)** is the discipline of applying advanced mathematical methods to help make better decisions
- “The Science of Better” [INFORMS slogan]
- “A liberal education in a technological world” [Thomas Magnanti, former Dean of Engineering at MIT]
- Numerous applications, e.g.
 - logistics
 - manufacturing
 - workforce scheduling
 - finance
 - marketing

OR and the military

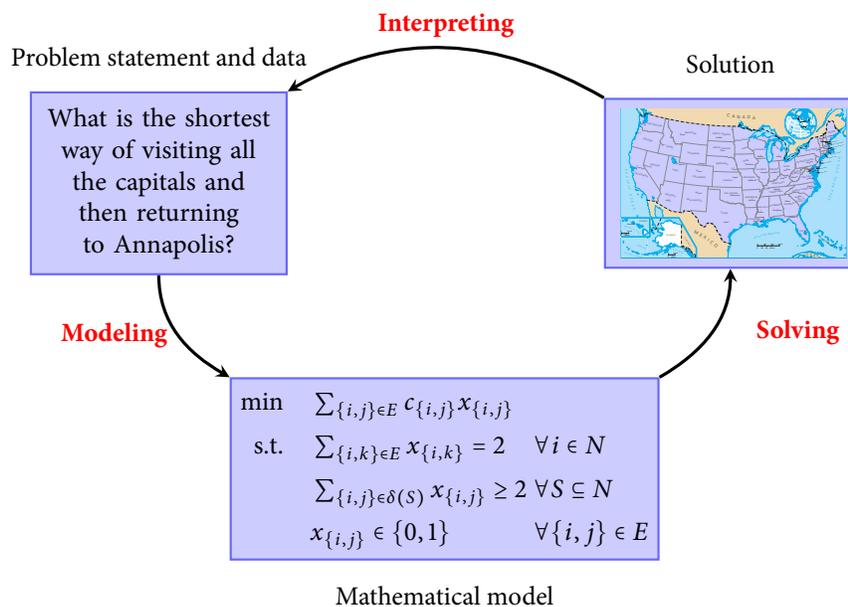
- The military uses OR to improve decision making in a variety of ways, e.g.
 - force composition
 - weapon selection
 - search and detection
 - flight operations scheduling
 - training and personnel assignment
- Assessment Division (OPNAV N81) at the Pentagon
- The Naval Postgraduate School has one of the oldest and most well-respected OR departments in the US
- *Naval Research Logistics* is a prominent academic journal featuring research in OR

The traveling salesperson problem

- A salesperson located in Annapolis wants to visit clients in each of the 48 state capitals of the continental US and Washington DC
- What is shortest way of visiting all the capitals and then returning to Annapolis?
- Entire books have been written on the TSP

- 1962: contest by Proctor and Gamble - best TSP tour through 33 US cities
- 1998: The Florida Sun-Sentinel's Science page ponders Santa Claus's traveling problem
- The TSP has even been used to make art
- One of the most popular problems in operations research
- Numerous applications in expected and unexpected places
 - Circuit board manufacturing
 - Genome sequencing
- Your turn! Try to find the shortest way of visiting all the capitals and then returning to Annapolis
- What about 13,509 cities in the US?
- Sophisticated mathematical techniques are our best bet

The OR approach



Goals for this course

- Modeling
 - Recognize opportunities for mathematical optimization
 - Formulate optimization models – **linear programs** – that capture the essence of the problem
 - Illustrate applications of real-world problems
- Solving
 - **Algorithms** to solve these mathematical models
- Detailed topic list and schedule is on the syllabus

Optimization is everywhere

- “Minimize” time it takes to get from class to class
- “Maximize” the company’s profits
- (Moneyball) “Best” lineup for the Oakland A’s
- We are always trying to make **decisions** in a way that meets some **objective** subject to some **constraints**
- Some success stories of optimization helping solve complex real-world decision-making problems ...

Package delivery

- UPS has an air network consisting of 7 hubs, nearly 100 additional airports in the US, 160 aircraft of nine different types

- Decision:

- Objective:

- Constraints:

- UPS credits optimization-based planning tools with identifying operational changes that have saved over \$87 million to date, reduced planning times, peak and non-peak costs, fleet requirements

Sports scheduling

- ACC Basketball earns millions in revenue annually, almost all from TV and radio
- TV networks need a steady stream of “high quality” games, NCAA rules, school preferences and traditions
- Decision:

- Objective:

- Constraints:

- Optimization approaches yields reasonable schedules very quickly

Radiation therapy

- High doses of radiation can kill cancer cells and/or prevent them from growing and dividing
- Can also kill healthy cells!
- Radiation can be delivered at different angles and intensities

- Decision:

- Objective:

- Constraints:

- Many successes reported using different types of optimization models

Next...

- Formulating a small optimization model

