Data-Driven Decision-Making
In Enterprise Applications

Introduction

Rainer Schlosser
Hasso Plattner Institute (EPIC)

April 27, 2020
The World is Full of Decision Problems
What Constitutes a Decision Problem?

- Decisions
- Objectives
- Constraints
**How to Approach Decision Problems?**

<table>
<thead>
<tr>
<th>Decisions $x$</th>
<th>When can I do what?</th>
<th>Identify.</th>
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<tbody>
<tr>
<td>Objective $F(x)$</td>
<td>What do I want to optimize?</td>
<td>Define.</td>
</tr>
<tr>
<td>Constraints $C(x)$</td>
<td>What has to be satisfied?</td>
<td>Determine.</td>
</tr>
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</table>
How to Approach Decision Problems?

Decisions $x$  
When can I do what?  
Identify.

Impact of $x$  
What happens if a certain decision is made?  
Estimate.

Objective $F(x)$  
What do I want to optimize?  
Define.

Constraints $C(x)$  
What has to be satisfied?  
Determine.

Optimization  
Max $F(x)$ over $x$ such that $C(x)$ is satisfied.  
Solve!

Data-Driven Decision-Making in Enterprise Applications - Introduction
Agenda

- Introduction ✓
- Personal Background
- Goals of the Course & Grading
- Outlook: Solution Techniques and Problem Examples
Personal Background

- Ph.D. Operations Research (2014), Humboldt-University of Berlin
- Hasso Plattner Institute, EPIC, since 2015
- Field of Research
  - Data-driven decision support
  - Focus on stochastic dynamic models
- Current Areas of Applications
  - Operations management (e.g., dynamic pricing, ordering, advertising)
  - Database configuration (e.g., data placement problems, index selection)
Agenda

- Introduction ✓
- Personal background ✓
- Goals of the Course & Grading
- Outlook: Solution Techniques and Problem Examples
Technical Information

- **Credits?** 4 SWS (V/Ü), 6 ECTS (graded)
- **When?**
  - Monday 13.30 - 15.00 VL (lecture)
  - Thursday 11.00 – 12.30 UE (exercise/questions)

  
  
  
  
  
  Start: April 27, 2020,  End: July 16, 2020

- **Where?** currently via Zoom (maybe later Room D-E. 9/10)

- **Who?** Rainer Schlosser,  rainer.schlosser@hpi.de

- **Slides?** EPIC, Teaching, Summer 2020
Structure of the Course

- **April/May:** Lectures on „Optimization Techniques“:
  (i) Linear Programming
  (ii) Integer Linear Programming
  (iii) Linear + Logistic Regression
  (iv) Dynamic Programming
  (v) Robust + Nonlinear Optimization

- **June/July:** Choose Projects, Apply/Extend Suitable Techniques,
  Work in Teams, Input/Support will be given

- **July/Aug:** Documentation of Projects Results
### Overview

<table>
<thead>
<tr>
<th>Week</th>
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<th>Topic</th>
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<tr>
<td>1</td>
<td>April 27/30</td>
<td><strong>Introduction</strong> + Linear Programming</td>
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<tr>
<td>2</td>
<td>May 4/7</td>
<td>Integer Linear Programming</td>
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<td>3</td>
<td>May 11/14</td>
<td>Linear + Logistic Regression</td>
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<td>4</td>
<td>May 18</td>
<td>Exercise Implementations</td>
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<td>5</td>
<td>May 25/28</td>
<td>Dynamic Programming                           (Thu May 21 “Himmelfahrt”)</td>
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<tr>
<td>6</td>
<td>June 4</td>
<td>Dynamic Pricing Competition</td>
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<td>June 8/11</td>
<td>Project Assignments</td>
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<td>June 22/25</td>
<td>Work on Projects: Input/Support</td>
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*Data-Driven Decision-Making in Enterprise Applications - Introduction*
Goals of the Course & Grading

- **Goal:** Develop models to compute optimized decisions for different problems & applications
- **Learn:** Optimization techniques
- **Do:** Apply & extend different optimization approaches
- **Grading:**
  - 30% Project results
  - 70% Documentation ("Projektarbeit")
Prerequisites

- Programming
  - Parameters, Data Preparation
  - Loops, Recursions, Simulations

- Basic Mathematical Background
  - Sets, Vectors
  - Probabilities, Random Variables, Expected Values

- More does not harm
  - Regression Analysis
  - Experience with Solvers
  - Game Theory
Agenda

- Introduction  ✓

- Personal Background  ✓

- Goals of the Course & Grading  ✓

- Outlook: Solution Techniques and Problem Examples
Week 2-3 – Linear (Integer) Programming

- \[ \max_{x_1, x_2 \geq 0} c'x \quad \text{s.t.} \quad Ax \leq b \]
  - Knapsack Problem
  - Matrix Inversion
  - Assignment Problems
  - Data placement problems
Week 4 – Linear / Logistic Regression

- Least squares
- Maximum Likelihood
- Estimation of Conditional Probabilities
- Demand Learning on Online Marketplaces
Week 5-6 – Dynamic Programming

- How to control processes over time
- Plan decisions over time
- Consider state transitions
- Inventory Management
- Dynamic Pricing Competition

Data-Driven Decision-Making in Enterprise Applications - Introduction
Week 7 – Choose Your Project

- Form teams of 2-3 students

- Potential projects:
  - Data placement problems
  - Index Selection
  - Dynamic Pricing
  - Competition + Game Theory, . . .

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