Modeling and Problem Solving

Gonca Yıldırım

Department of Industrial Engineering
Çankaya University

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Objectives of Today’s Lecture

- another definition of Industrial Engineering and a part of what we do
- basic steps in problem solving
- some types of models used in Industrial Engineering
Industrial Engineering

According to Institute of Industrial Engineers (IIE)

“Industrial Engineering (IE) is concerned with the design, improvement, and installation of integrated systems of people, material, equipment, and energy …”

Another definition

Industrial engineers are scientific problem solvers.
What types of problems do Industrial Engineers solve?

Codec: Industrial and Systems Engineers Make a Difference Everywhere
Problems...

- typically do not go away unless we do something to resolve them.

This intervention is called **Problem Solving**.
How do Industrial Engineers solve problems?

1. Define the problem
2. Observe the system
3. Build a model of the system
4. Verify the model and solve the model
5. Select a suitable alternative
6. Present the results to the organization
7. Implement and evaluate the recommendations
What is a “Model”? 
What is a “Model”? 

Figure: Mersin International Port Building.
What is a “Model”?

- A **model** is a representation of the reality that captures the essence of reality.
- Most models we build are **mathematical models**.
Modeling Examples: 1. Simulation

A simulation model

- mathematical model
- imitates the behavior of a system over a period of time
- helps observing the system behavior and performance of the system as statistical observations
- used to model complex systems containing randomness

➡️ A MOSIMTEC Emergency Department Simulation Model
A queueing model

- mathematical model
- deals with waiting lines (or queues)
- deals with randomness in arrival and service
- branch of Operations Research
Modeling Examples: 2. Queueing

\( T \): Time period
\( A \): Number of arrivals
\( C \): Number of departures
\( W \): Waiting time
\( S \): Service time
\( R \): Response time
  (waiting plus service)
\( \tau \): Mean interarrival time
\( \lambda \): Arrival rate
\( \mu \): Service rate

\[
\lambda = \frac{A}{T} \quad \mu = \frac{1}{S}
\]

\[
X = \frac{C}{T}
\]
Modeling Examples: 3. Network

Shortest route from here to Esenboğa Airport?
Modeling Examples: 3. Network

What if we have hundreds of nodes and arcs?
Modeling Examples: 3. Network

- A network optimization model

Conceptual model

Minimize total travel duration *under the following conditions*

- Start from source node (origin)
- Each node visited must be departed
- End at the sink node (destination)

Mathematical model

Minimize \[ \sum \sum c_{ij} x_{ij} \]

subject to

\[ \sum_{j} x_{ij} - \sum_{k} x_{ki} = \begin{cases} 1, & i = s \\ 0, & \text{otherwise} \\ -1, & i = t \end{cases} \]

\[ x_{ij} \geq 0, \quad (i,j) \in A \]
Modeling Examples: 3. Network

- Use an **optimization package** and **code the model** to solve it.

```plaintext
Set i cities / boston, chicago, dallas, kansas-cty, losangeles
    memphis, portland, salt-lake, wash-dc /

r(i,i) routes

 Alias (i,ip,ipp)

Parameter uarc(i,ip) undirected arcs /
    boston .chicago 58, kansas-cty .memphis 27
    boston .wash-dc 25, kansas-cty .salt-lake 66
    chicago .kansas-cty 29, kansas-cty .wash-dc 62
    chicago .memphis 32, losangeles .portland 58
    chicago .portland 130, losangeles .salt-lake 43
    chicago .salt-lake 85, memphis .wash-dc 53
    dallas .kansas-cty 29, portland .salt-lake 48
    dallas .losangeles 85
    dallas .memphis 28
    dallas .salt-lake 75 /

Parameter darc(i,ip) directed arcs
    orig(i,i) origin mapping;
    darc(i,ip) = max(uarc(i,ip),uarc(ip,i));
    r(i,ip) = yes$darc(i,ip);
    orig(i,i) = 1 ;

Display darc, orig;

Variables x(i,ip,ipp) arcs taken
    cost total cost or length

Positive Variable x;

Equations nb(i,ip) node balance
    cd cost definition;
    nb(i,ip)$ (not orig(i,i)) .. sum (ipp$darc (ipp,ip), x(i,ipp,ip))
    = g = sum (ipp$darc (ip,ipp), x(i,ip,ipp)) + 1;
    cd.. cost =e= sum ((i,i,ipp), darc(ip,ipp)*x(i,ip,ipp));

Model route shortest route / all /;
Solve route minimizing cost using lp;
```
Inventory: Stock

- Companies keep inventories in order to
  - meet demand of customers on time (in general)
- Keeping inventories is costly
  - Ordering, purchasing and inventory holding costs
Modeling Examples: 4. Inventory

- Economic Order Quantity (EOQ) Model

![Diagram showing inventory level over time with points at 0, T, 2T, 3T where orders of size Q are placed at these points in time.]

*Place an order of size Q at these points in time*
Economic Order Quantity (EOQ) Model

\[
TC(Q) = \left(\frac{KD}{Q}\right) + cD + \left(\frac{hQ}{2}\right)
\]

Find \( Q \) that minimizes \( TC(Q) \)
The scientific approach to decision making involves the use of models.

There are many different types of models.

Modeling is an art and it takes practice.
As future Industrial Engineers, you will

- be problem solvers
- model systems

Study hard to get ready for an exciting and rewarding career!