IE221: Operations Research – Probabilistic Methods

Fall 2001

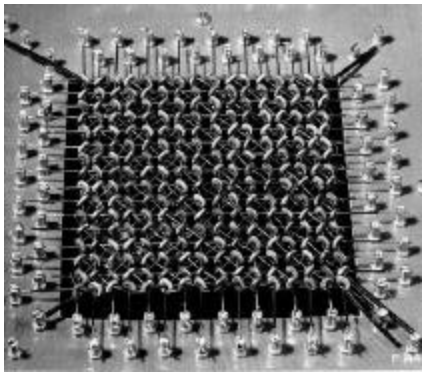
Lehigh University

IMSE Department

History of OR

- Britain, WWII (1938). Multi-disciplinary team of scientists explore how to use radar information to deploy and use fighter planes.
- United States. Mathematical models (Search Theory) used to develop optimal air search patterns for anti-submarine tactics.

Evolution of OR



1951 computer core memory

- OR moves into industrial domain (1950's), parallels computers' growth as business planning/management tool.
- Focus on development of mathematical modeling techniques to improve or optimize real-world systems.

What is Operations Research?

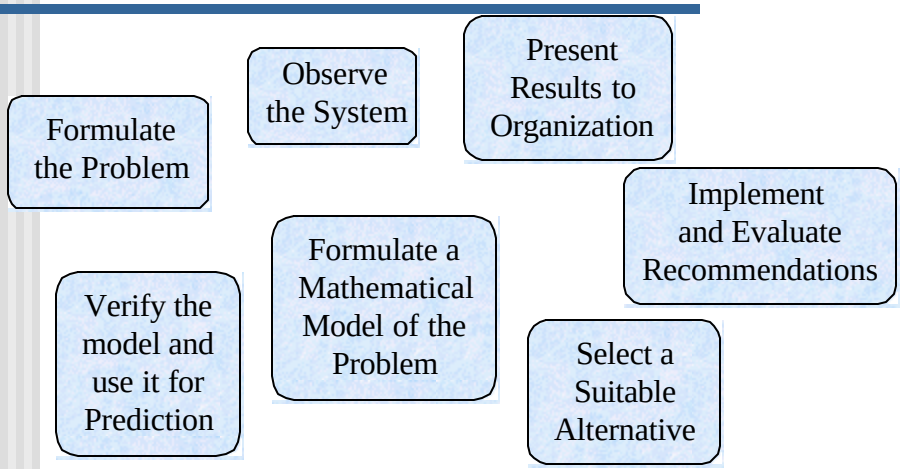
Winchester Warehouse, Winchester, KY
photo from www. winchesterwarehouse.com

- Before: application of mathematics and the scientific method to military operations
- Today: scientific approach to decision making. Seeks to determine best way to design and operate system, usually requiring allocation of scarce resources

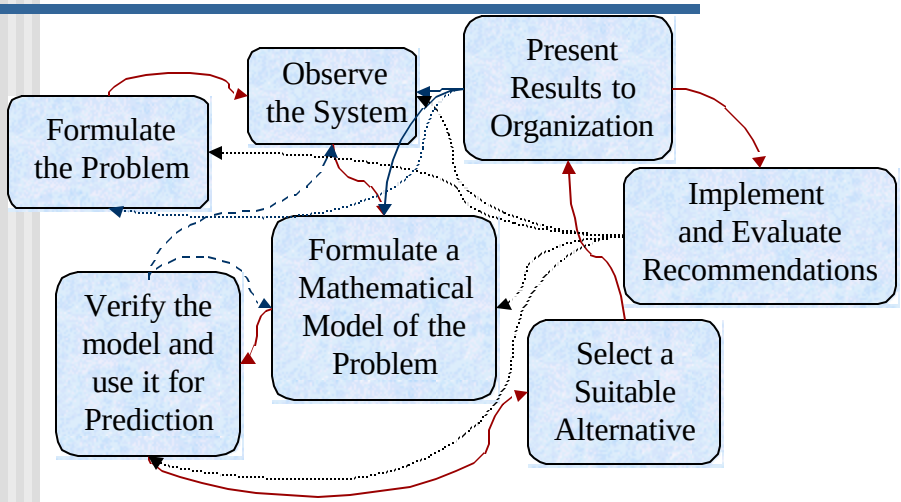
Career Opportunities

- Accounting
- Actuarial Work
- Computer Services
- Corporate Planning
- Economic Analysis
- Financial Modeling
- Industrial Engineering
- Investment Analysis
- Logistics
- Manufacturing Services
- Management Consulting
- Management Training
- Market Research
- Operations Research
- Policy Planning
- Production Engineering
- Quantitative Methods
- Strategic Planning
- Systems Analysis
- Transportation

The OR Methodology



The OR Methodology



Probabilistic Inventory Models

Steinway showroom.

- GOAL: to minimize costs associated with maintaining inventory and meeting customer demand.
- Q: When should an order be placed?
- Q: How large should each order be?

PIM: News Vendor Problem

- DECIDE: q, number of newspapers to order.
- Demand D is a random variable. D=d w.p. P(d).
- Cost incurred is c(d,q). Excess newspapers are worthless. Profit lost if vendor is understocked.

Photo by Bruce Takeo Akizuki

Probabilistic Dynamic Programming Models

St. Petersburg rapid chess club. International master Evgenija Ovod, winner of 1999 Women's Cup.

- Decision required at each problem stage.
- Several states at each stage.
- Decision chosen describes transformation from current stage to next stage.
- *Principle of optimality*: optimal decision for each remaining stage must not depend on previous states.
- Recursion links cost or reward at stage t to that of stage t+1

PDP: Parking Problem

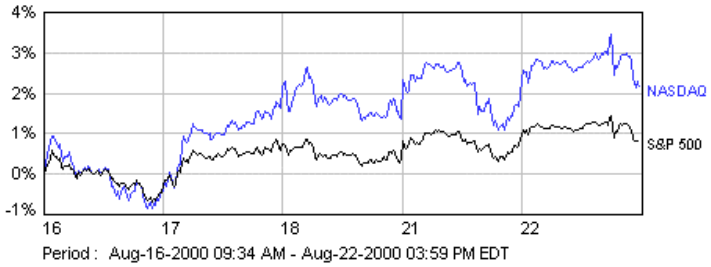
Charlottetown Airport Parking

- GOAL: Park as close to terminal as possible.
- At each empty space, decide whether to continue. No backtracking allowed.
- If not parked by the time terminal is reached, must enter paid parking lot at cost $M.

Markov Chain Models

- A Markov Chain is one type of discrete-time stochastic process.
- Memoryless Property: The probability distribution of state at time t+1 only depends on the state at time t.
- Stationarity Assumption: Transition probability from state i to j is independent of time t.

Efficient Market Hypothesis



- EMH: The daily price of a stock can be described as a Markov Chain, i.e. the probability distribution of tomorrow's price for one share of the stock depends only on today's price.

Queueing Theory

- Arrival and service process, service discipline, method for joining queue.
- Fraction of time idle?
- E(customers in queue)?
- E(time in queue)
- Distribution of number of customers in queue?
- PDF of waiting time?
- Number of servers?

Queueing monks from webshots.com

Urban Emergency Services

- Server is ambulance
- Incidents (1 emergency patient) arrive as Poisson process
- What will service time depend on?