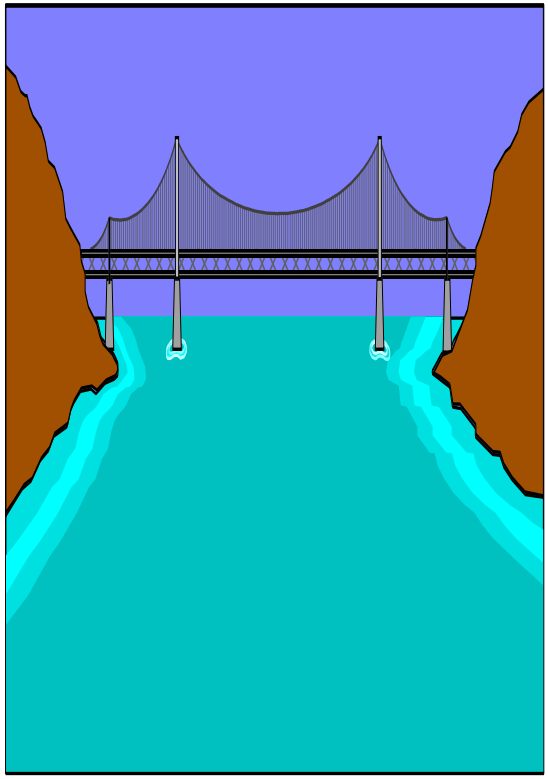
Overview of Models used for Problem Solving

Interesting problems

- Chinese Dining Philosopher's Problem
- Lift Problem
- Scheduling of Trains (Ahmedabad)
- TTD Administration
- E – Procurement Model of GM
- City Traffic Control
- OLAP Software Tools
- First Five Year Plan (Mahalanobis)
- Karmarkar's Algorithm



Research Challenges

- Optimization of Airport related Activities
- Optimization of Traffic issues
- Supply Chain Optimization (Global Terrorism)
- Demand Management – Bullwhip / Reverse Bullwhip Effect
- Retention Strategies
- Energy and Environment Management
- Optimization of PDM
- Optimization of networks
- Strategic Planning of e- enterprises
- Project Management of infrastructure

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1978

"for his pioneering research into the decision-making process within economic organizations"

Herbert A. Simon
USA
Carnegie Mellon University
Pittsburgh, PA, USA
b. 1916
d. 2001

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 1994

"for their pioneering analysis of equilibria in the theory of non-cooperative games"

John F. Nash Jr.
1/3 of the prize
USA
Princeton University
Princeton, NJ, USA
b. 1928

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2007

"for having laid the foundations of mechanism design theory"

Eric S. Maskin

1/3 of the prize

USA

Institute for Advanced Study

Princeton, NJ, USA

b. 1950

The Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel 2007

"for having laid the foundations of mechanism design theory"

Roger B. Myerson

1/3 of the prize

USA

University of Chicago

Chicago, IL, USA

b. 1951

Decision Making

- **Decision under Certainty (Operational)**

  - Statistics, Deterministic Optimization

- **Decision under Risky Situation (Tactical)**

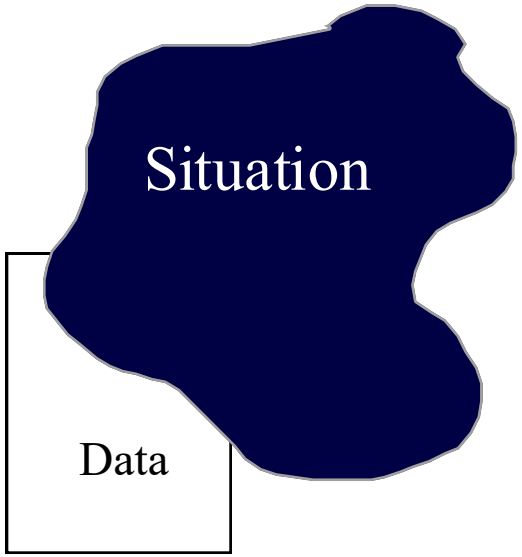
  - Probability, distributions, random variables, estimation, tests of hypothesis, Queuing Models, Simulation, Meta Heuristics

- **Decision Under Uncertainty Situation (Strategic)**

  - Theory of Chaos, Catastrophic theory, System Dynamics,

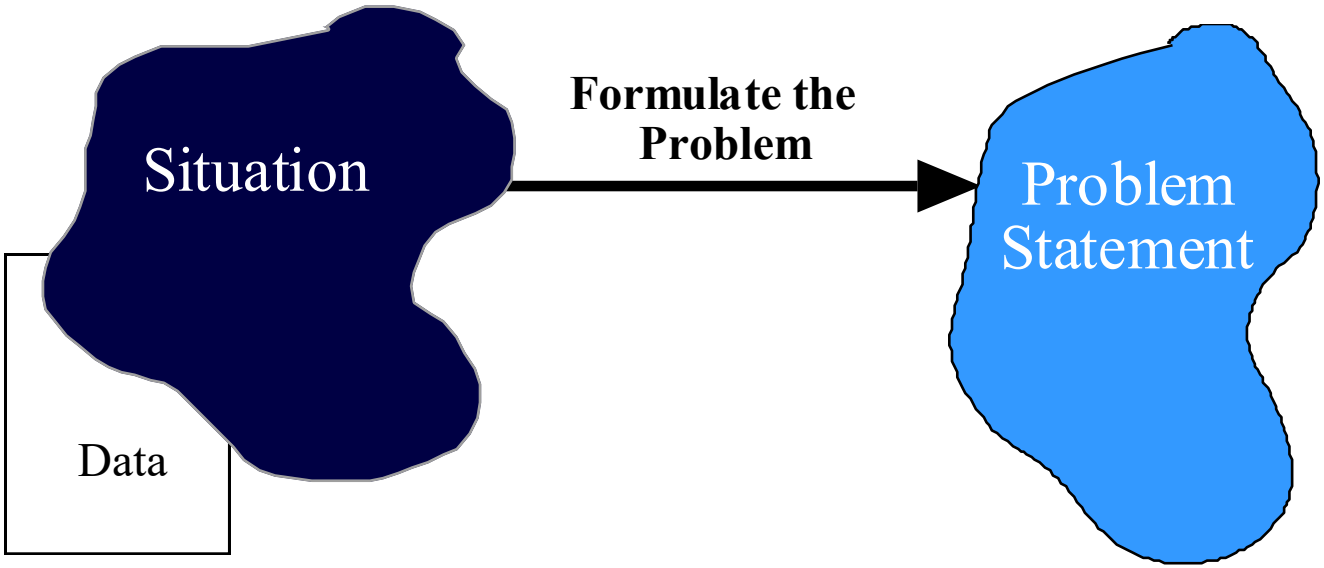
  Meta Heuristics, Game Theory

The Process: Recognize the Problem



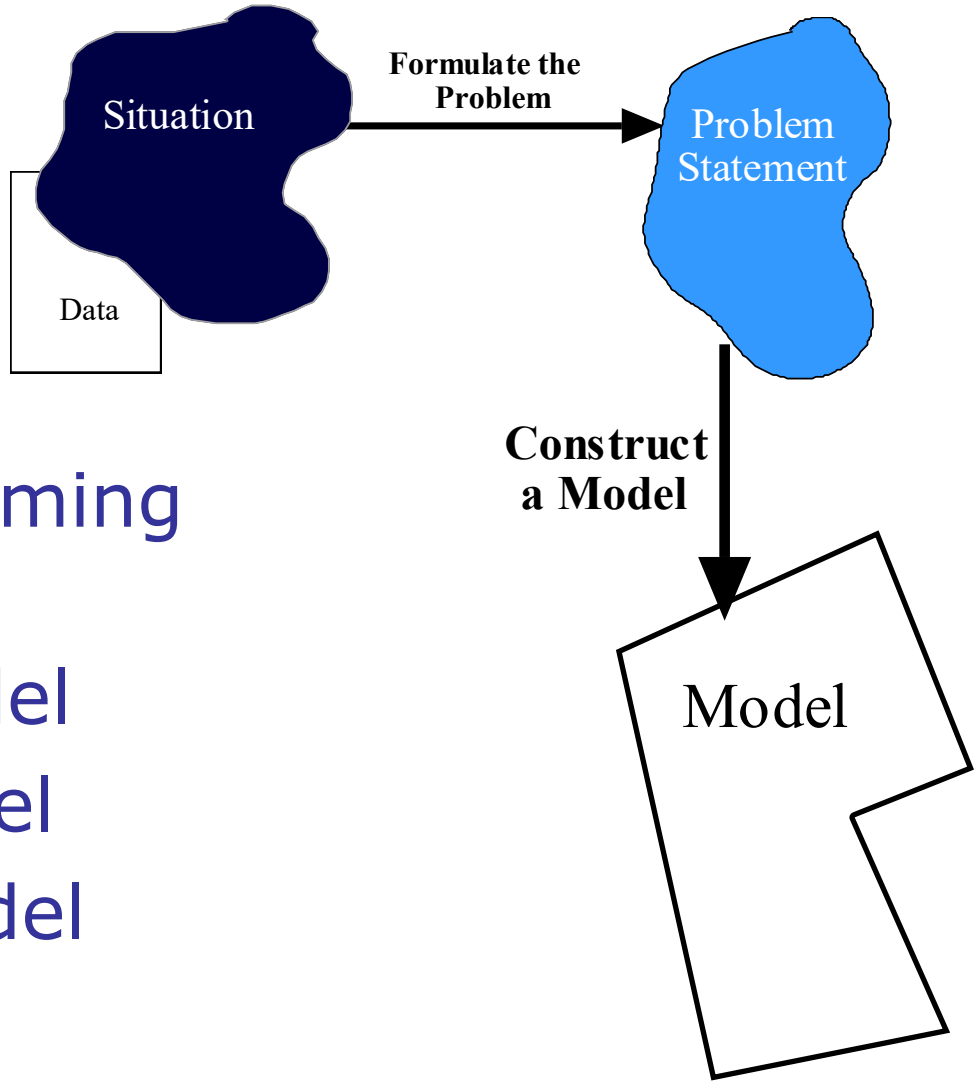
- Manufacturing
  - Planning
  - Design
  - Scheduling
  - Dealing with Defects
  - Dealing with Variability
  - Dealing with Inventory
  - …

Formulate the Problem



- Define the problem
- Delimit the system
- Select measures
- Determine variables
- Identify constraints

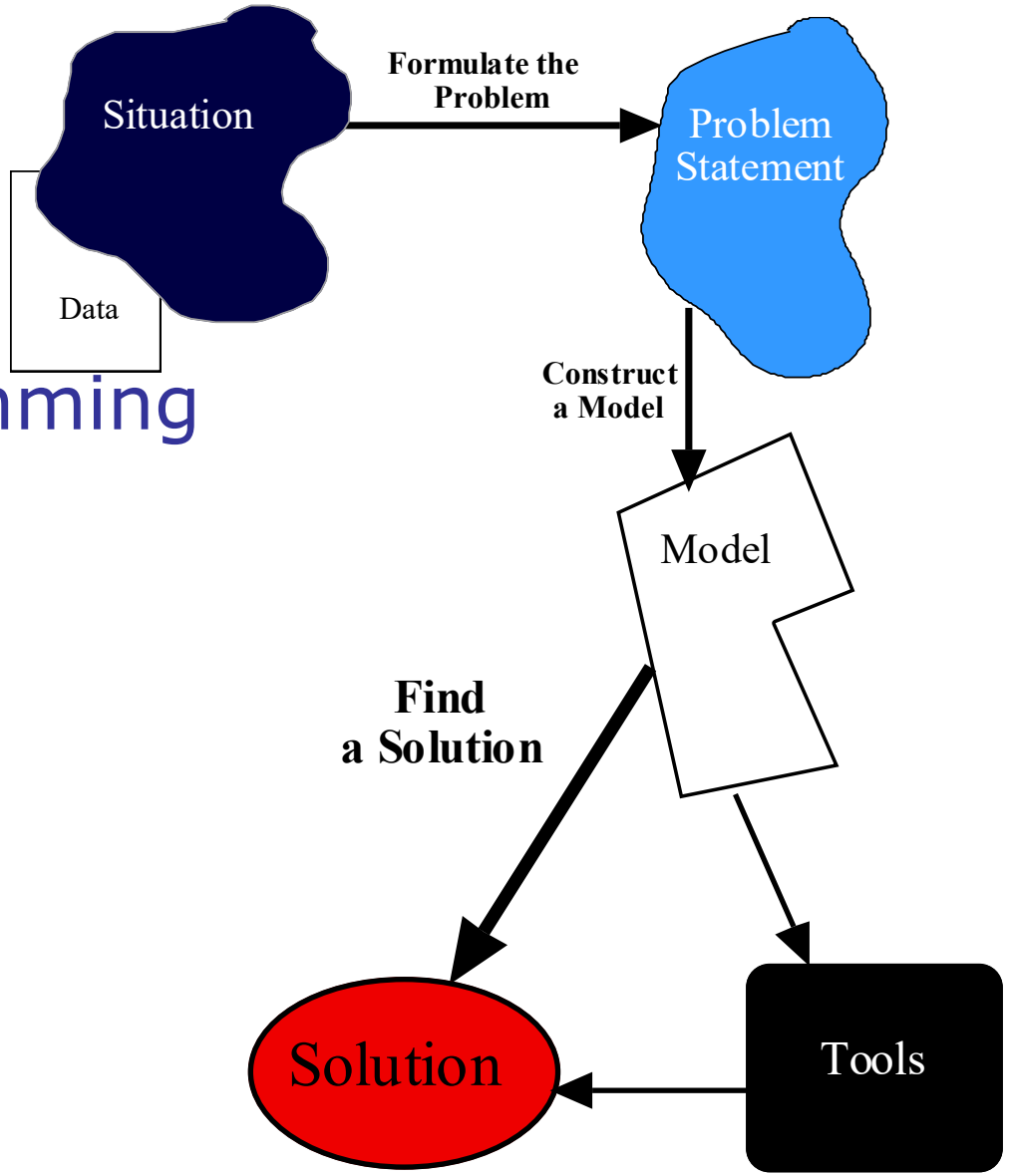
Construct a Model



- Math. Programming Model
- Stochastic Model
- Statistical Model
- Simulation Model

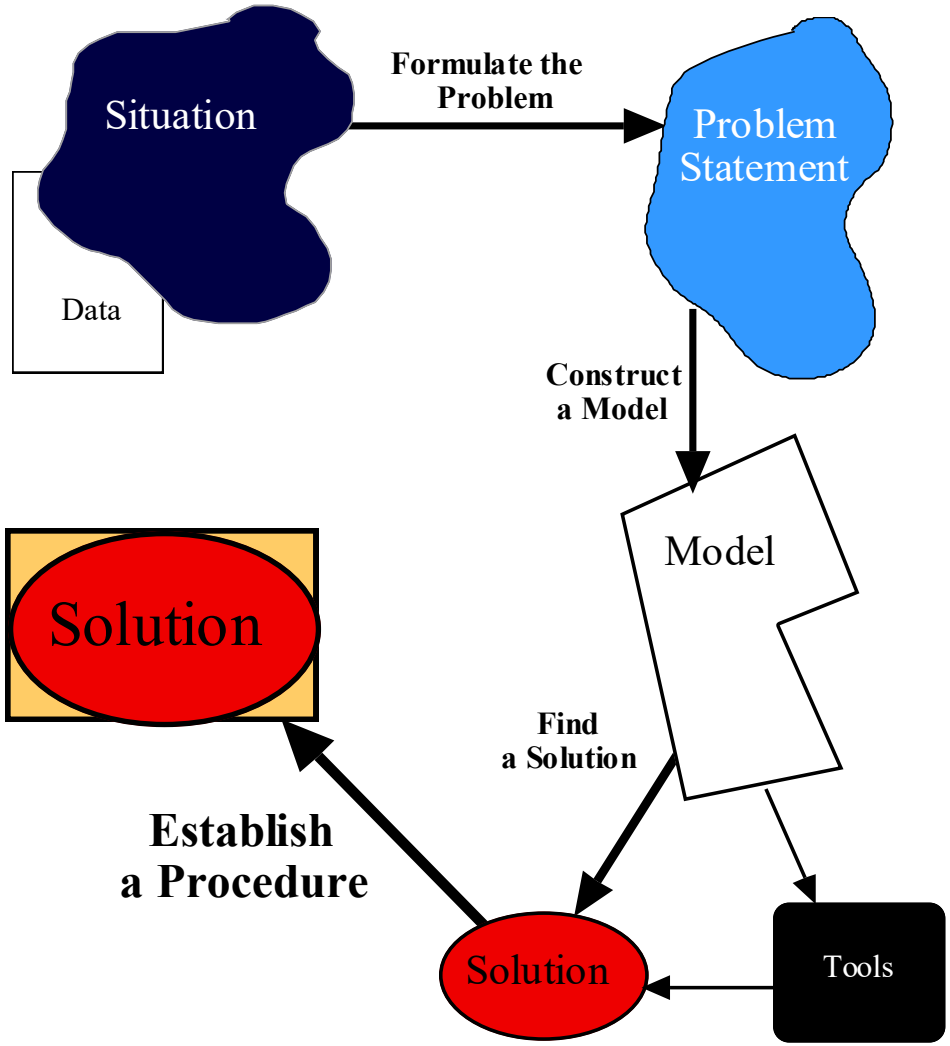
Find a Solution

- Linear Programming
- Nonlinear Programming
- Regression
- Direct Search
- Stochastic Optimization
- Trial and Error



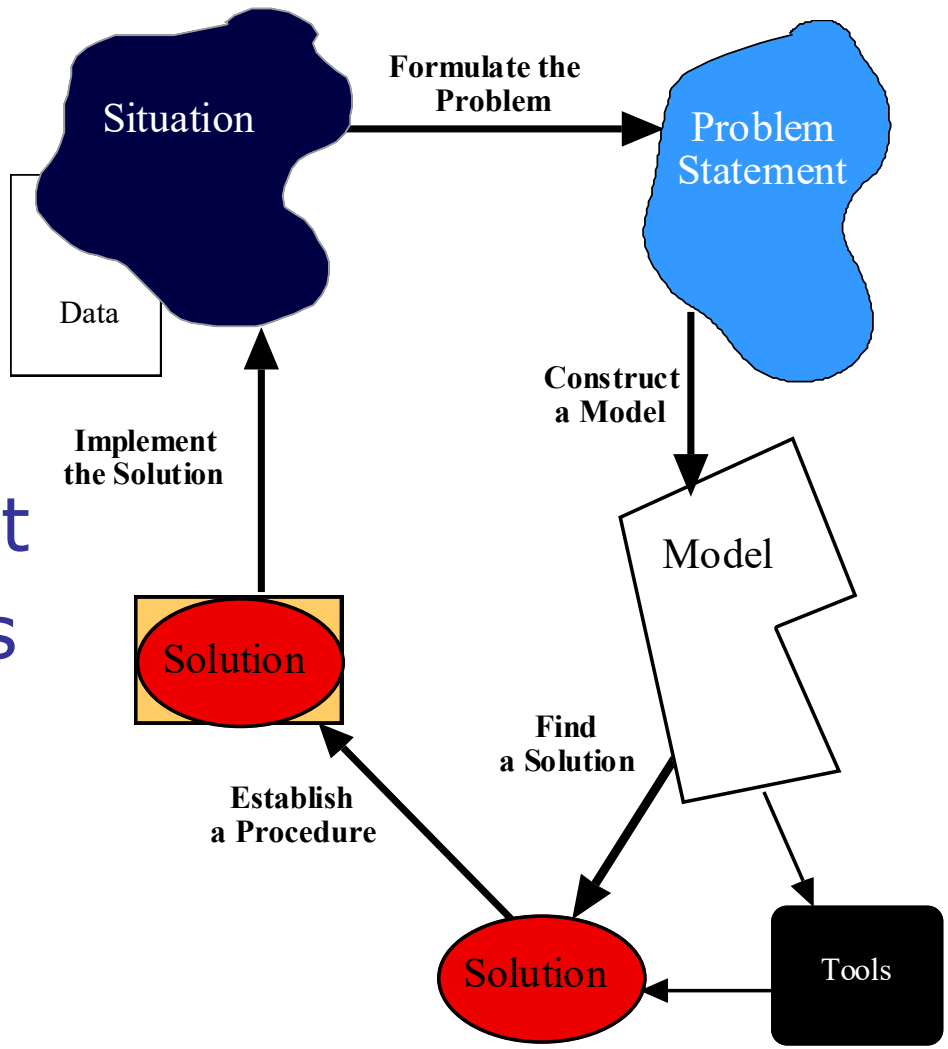
Establish a Procedure

- Production software
- Easy to use
- Easy to maintain
- Acceptable to the user



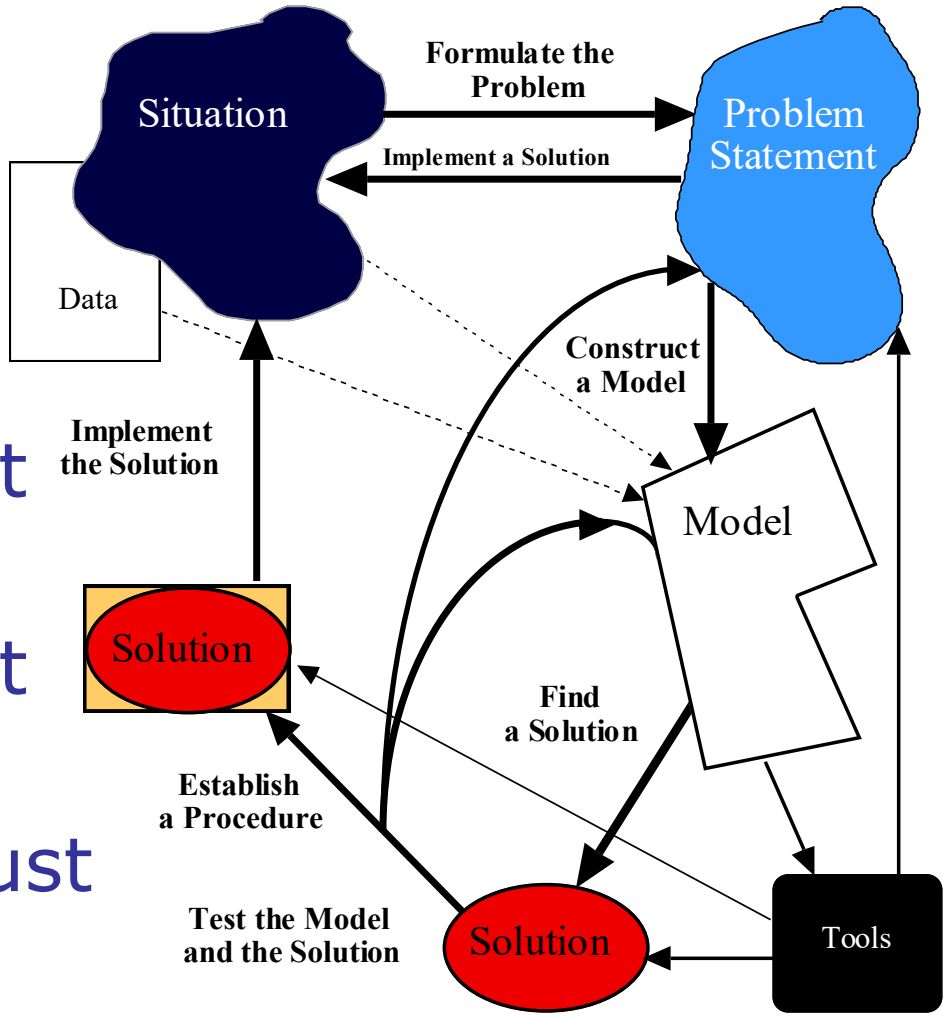
Implement the Solution

- Change for the organization
- Change is difficult
- Establish controls to recognize change in the situation



The Goal is to Solve the Problem

- The model must be valid
- The model must be tractable
- The solution must be useful

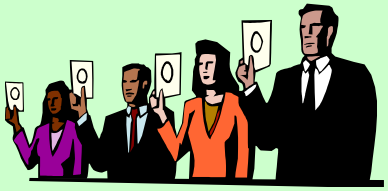


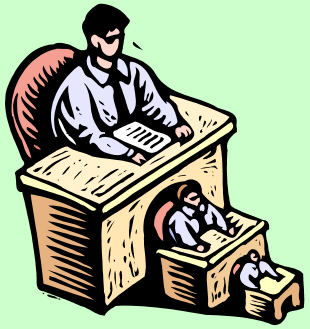
Experimental Design

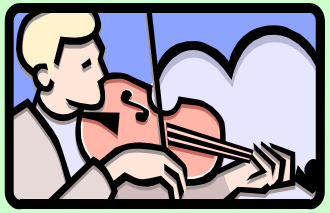
1. Mathematical Programming Models

Models	Objectives
Allocation Models 	Concerned with the allocations of scarce resources so as to optimise the given objective function (profit,loss or ROI) subject to certain constraints (boundary conditions). ▪ LPP – Product mix, Blending ,Investment. ▪ TP – Airline fleet utilization. ▪ AP - Sales persons with customers in different territory.
Inventory control models 	▫ Determining optimal order quantities and frequency considering demand/unit time, cost of placing orders, inventory cost, shortage costs. ▫ Raw Material, Finished Goods, Work In Progress.

Models	Objectives
Waiting Line (Queuing) 	Objective is to minimize the sum of costs providing service and costs of obtaining service, primarily in terms of time spent in queue. - Hospital, Bank ,petrol bunk, Boarding a bus, Restaurant, Accessing internet.
Markovian Models 	Applicable in the situations where the status of the system, called its 'states' can be defined by some descriptive measure and where the system moves from one state to another on a probability basis. - Consumer buying patterns, forecast bad debts, planning personnel needs, analyze equipment replacement.

Models	Objectives
Sequencing Models 	Are concerned with the selection of an appropriate sequencing of performing a series of jobs to be done on service facilities so as to optimize efficiency measure of performance of the system. - Shop floor activities , Jobs in computer networks.
Replacement Models 	Formulating the appropriate replacement policy in situations when some items or machinery need replacement for one reason or the other.
Simulation Models 	A special class of mathematical models in management decision making. It is an experimental method used to study behaviour over time.

Models	Objectives
Decision theory 	Assist in analyzing complex problems with numerous alternative and possible consequences. States of decision — Consequences Certainty — Deterministic Risk — Probabilistic Uncertainty — Unknown Conflict — Influenced by an opponent
Game theory 	Models a conflict situation and helps us to improve the decision process by formulating appropriate strategy.

Models	Objectives
Integer programming 	Used when one or more variables can take only integer values - No. of trucks in a fleet, No. of generators in a power house.
Dynamic programming 	It is a method of analysing multistage decision process, in which each elementary decision is dependent upon those preceding it, as well as upon external factors - Knapsack problems, search techniques, reliability design, TSP, Flow shop scheduling.
Network Models 	A project is any human undertaking with a clear beginning and clear ending. These models enable us to cope with complexities and inter-dependencies involved in large projects. PERT and CPM are used for planning, Scheduling and controlling complex projects. - Flyover construction, satellites building.

Models	Objectives
Goal Programming 	▫ Multi objective – Objectives are assigned Target value and a relative priority on achieving these levels. ▫ Goal constraints are formulated positive and negative deviational variables are introduced. ▫ Decision variables and Deviational variables are involved. ▫ Applications ▪ Man Power Planning ▪ Water resources ▪ Portfolio Selection ▪ Transportation ▪ Marketing ▪ Production Planning & Scheduling ▪ Quality Control

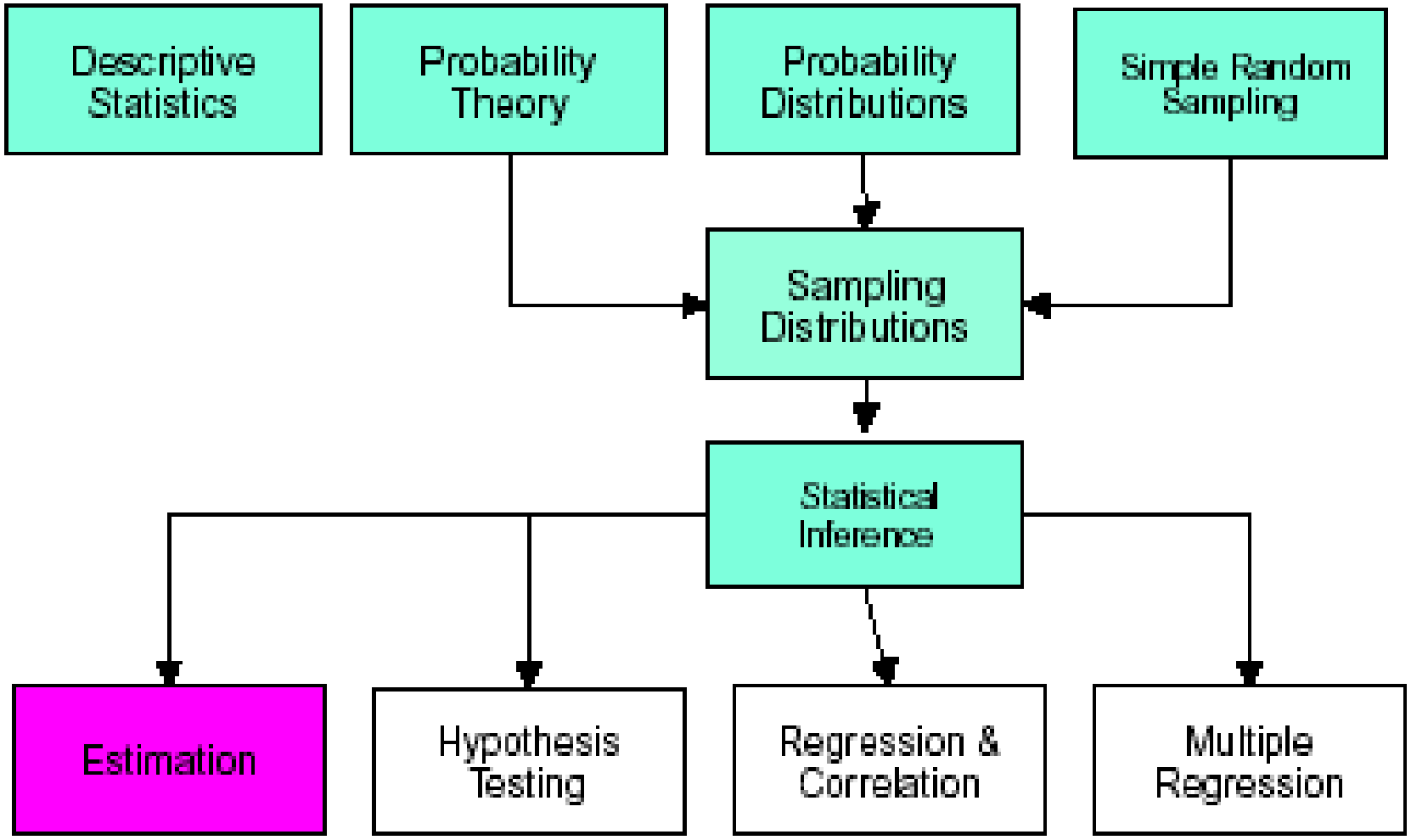
Successful OR Applications

Company	Year	Problem	Techniques Used	Annual Savings
Hewlett Packard	1998	Designing buffers into production line	Queuing models	$280 million
Taco Bell	1998	Employee scheduling	IP, Forecasting, Simulation	$13 million
Proctor & Gamble	1997	Redesign production & distributon system	Transportation models	$200 million
Delta Airlines	1994	Assigning planes to routes	Integer Programming	$100 million
AT&T	1993	Call center design	Queuing models, Simulation	$750 million
Yellow Freight Systems, Inc.	1992	Design trucking network	Network models, Forecasting, Simulation	$17.3 million
San Francisco Police Dept.	1989	Patrol Scheduling	Linear Programming	$11 million
Bethlehem Steel	1989	Design an Ingot Mold Stripper	Integer Programming	$8 million
North American Van Lines	1988	Assigning loads to drivers	Network modeling	$2.5 million
Citgo Petroleum	1987	Refinery operations & distribution	Linear Programming, Forecasting	$70 million
United Airlines	1986	Scheduling reservation personnel	LP, Queuing, Forecasting	$6 million
Dairyman's Creamery	1985	Optimal production levels	Linear Programming	$48,000
Phillips Petroleum	1983	Equipment replacement	Network modeling	$90,000

Limitation of OR

1. Magnitude of Computations
2. Non-Quantifiable Factors
3. Gap between Manager and Operations Researcher
4. Money and Time costs
5. Implementation

2. Stochastic Models



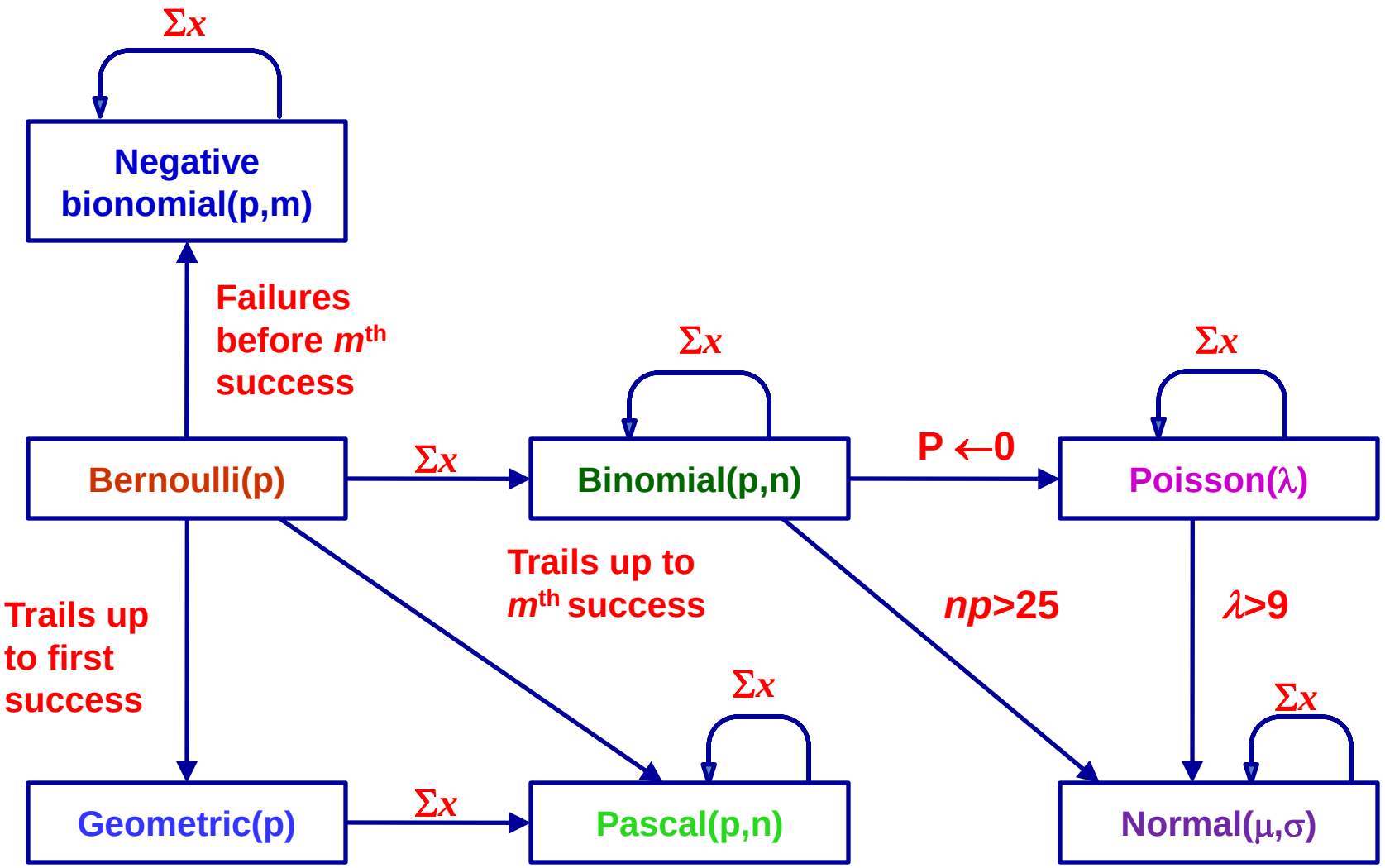
Applications of Probability Distributions

Sl.No.	Application	Type of distribution
1.	Ticket Control Problems	
2.	Field of Games	
3.	Modeling of Accidents statistics	
4.	Geographical distribution of plants	
5.	Sickness Absence	
6.	Life time of animals	
7.	Duration of industrial stoppages	
8.	Queuing Models involving multiple queues	
9.	Probability of completion of projects	
10	Tool wear	
11.	Income distribution of society	

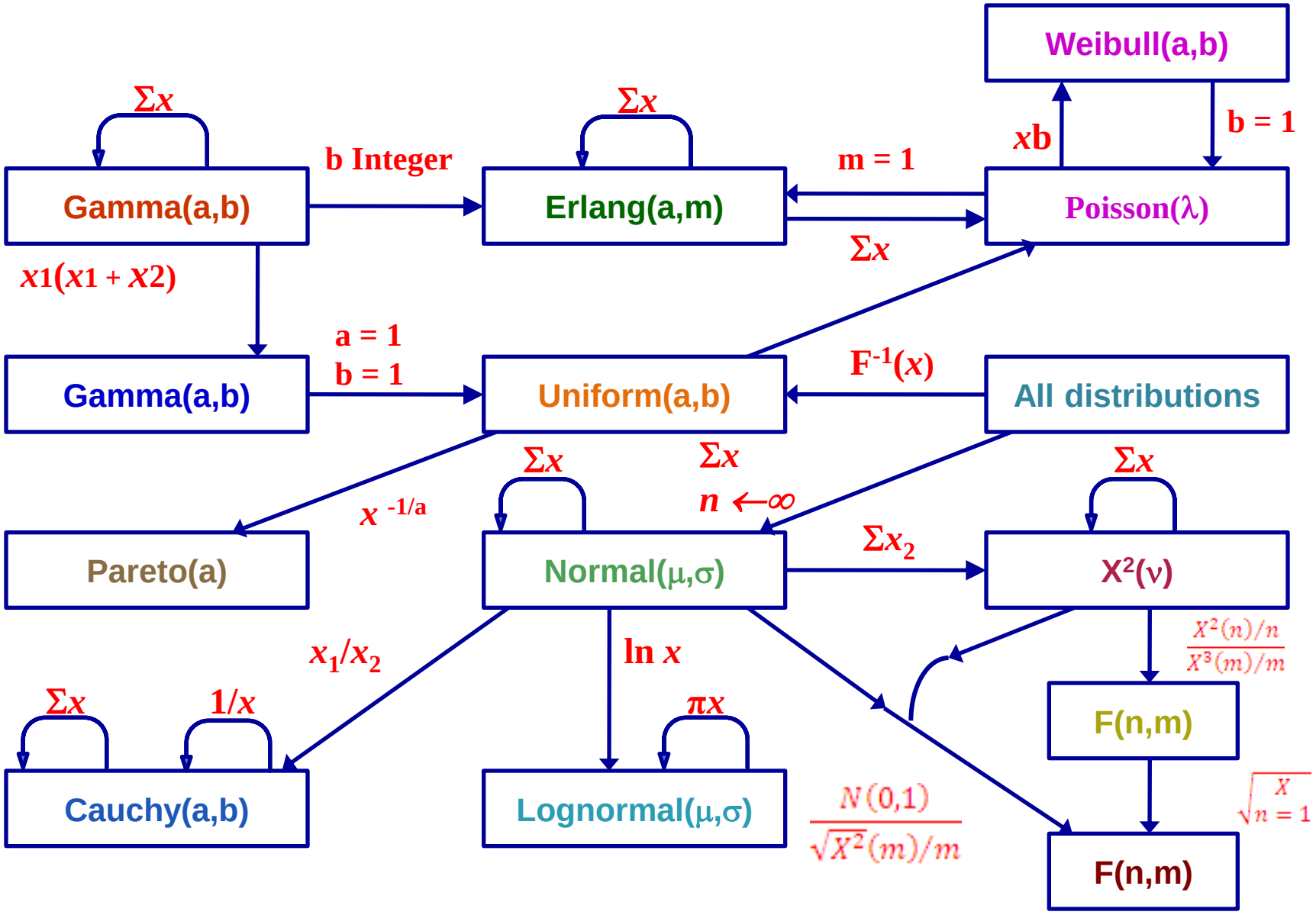
Applications of Probability Distributions

Sl.No.	Application	Type of distribution
1.	Ticket Control Problems	Geometric
2.	Field of Games	Binomial
3.	Modeling of Accidents statistics	Negative Binomial
4.	Geographical distribution of plants	Poisson
5.	Sickness Absence	Poisson
6.	Life time of animals	Gamma
7.	Duration of industrial stoppages	Weibull
8.	Queuing Models involving multiple queues	Exponential
9.	Probability of completion of projects	Beta
10	Tool wear	Beta
11.	Income distribution of society	Pareto

Relationships among Discrete Distributions



Relationships among Continuous Distributions



Applications of Probability Distributions

Type of Distribution	Applications
Binomial Distribution	• Field of games. • Genetics. • Sampling of defective parts in a stable process. • Testing items as they come off an assembly line
Negative Binomial Distribution	• Modeling of accident statistics. • Birth and death processes. • Market research and consumer expenditure- • Lending library data. • Biometrics data
Poisson Distribution	• Arrival rates in queuing models. • Arrival of telephone calls. • Defects in semiconductor manufacturing. • Defects in all aspects of quality control. • Molecular distribution. • Stellar distribution. • Geographical distribution of plants

Applications of Probability Distributions

Type of Distribution	Applications
• Log Normal Distribution	• Distribution of particle size in naturally occurring aggregates. • Dust concentration in industrial atmosphere. • Distributions of minerals present in low concentration. • Duration of sickness absence. • Physicians' consultancy time. • Lifetime distribution in reliability. • Distribution of income
• Gamma Distribution	• Lifetimes of animals. • Lead times of products. • Personal income data. • Population about a stable equilibrium. • Inter-arrival times. • Service times

Applications of Probability Distributions

Type of Distribution	Applications
• Weibull Distribution	• Wear out lifetimes in reliability. • Wind speed. • Germination of seeds. • Duration of industrial stoppages. • Migratory systems. • Thunder storm data
• Exponential Distribution	• Queuing models involving multiple queues. • Reliability theory. • Radioactivity
• Beta Distribution	• Hydrologic variables in power plants. • Logarithm of aerosol sizes. • Activity timing in PER T analysis- • Isolation data in photovoltaic system analysis. • Porosity or void ratio in soil. • Phase derivatives in communication theory. • Dissipation rate in breakage models. • Proportion in gas mixtures. • Steady state reflectivity • Tool wear

Applications of Probability Distributions

TYPE OF DISTRIBUTION	APPLICATIONS
Discrete uniform distribution	Statistics
Erlang distribution	All queuing models
Extreme value distribution	Growth models, astronomy, human life times, radio active emissions, strength of materials, flood analysis, seismic analysis, rainfall analysis, learning curve models.
Inverse Gaussian distribution	Brownian motion, repair times, reliability and lifetimes, diffusion process

Applications of Probability Distributions

TYPE OF DISTRIBUTION	APPLICATIONS
Logistic distribution	Growth model for population, weight gains, business failures
Log logistic distribution	Complex business failures, product cycle time.
Pareto distribution	
Pearson 5 distribution	Income distribution of a society, city population size, occurrence of natural resources, stock price fluctuations, size of firms, brightness of comets, error clustering in communication circuits
Triangular distribution	Time taken to complete task, time taken to respond to an emergency, time taken to re air a tool.

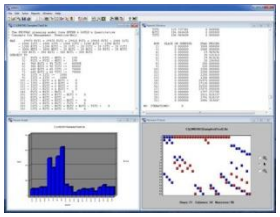
3. Simulation Models

High

Interaction and complexity of variables

Low

Optimization
LPP, AP, TP, IP, MILP

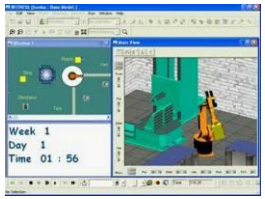


Lingo

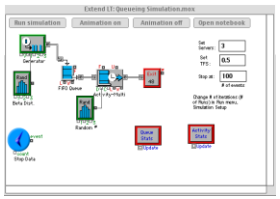
TORA

STORM

Discrete Event
Dynamic Simulation (DEDS)

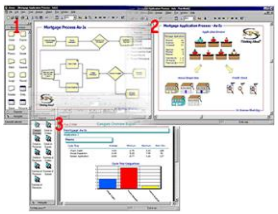


Witness

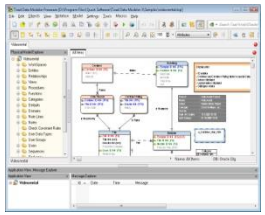


Extend

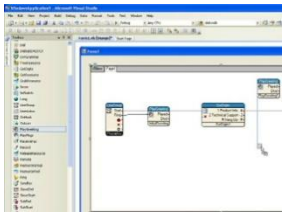
Promodel



Arena

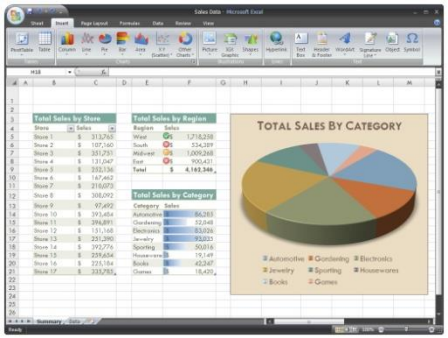


Quest

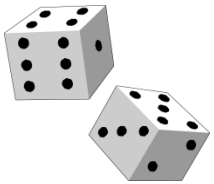


IRIP

MS Excel



Montecarlo Simulation



Low → Randomness → High

Newer Applications (Indian Context)

1. Manufacturing Automation System
2. Supply Chain and Logistics including Multimodal TS
3. Healthcare Systems
4. Retail Supply Chain Network
5. Intelligent Transport System (Public)
6. Cloud Supply Chain Network
7. Performance of B2B and B2C Markets
8. Lean and Green SCs
9. Smart Cities (WET)
10. Banking and Insurance
11. Computer and Telecommunication Networks
12. Modeling Computer Information Systems
13. Airport Simulation
14. Service Sciences

4. Statistical Models

- Descriptive Statistics
- Sampling
- Classification and Regression Trees
- Cluster Analysis
- Conjoint Analysis
- Correlation and Similarity Measures
- Design of Experiments
- Discriminant Analysis
- Factor Analysis
- Linear Models – Regression, ANOVA, Hypothesis Testing
- Logistic Regression
- Loglinear Models

5. Advanced Statistical Models

- Missing Value Analysis
- Mixed Regression
- Multidimensional Scaling
- Non Linear Models
- Non Parametric Statistics
- Partially Ordered Scalogram analysis with Co-ordinates
- Path Analysis
- Perpetual Mapping
- Power Analysis
- Probit Analysis
- Rank and Ridge Regression
- Set and Canonical Correlation
- Signal Detection Analysis
- Smoothing
- Spatial Statistics
- Survival Analysis
- T Tests
- Test Item Analysis
- Time Series
- Two Stage Least Squares

6. Multi Criteria Decision Making (MCDM) Techniques

Analytic Hierarchy Process
Analytic Network Process
Elimination and Choice expressing Reality
Preference ranking organization method for enrichment evaluation
Technique for order performance by similarity to ideal solution
Multi-criteria optimization and compromise solution
Decision making trial and evaluation Laboratory
Simple multi-attribute rating technique

7. Meta Heuristics / Soft Computing / AI Techniques

- Genetic Algorithm
- Grey System Theory
- Neural Networks
- Rough set Theory
- Bayesian Networks
- Decision Tree
- Case based reasoning
- Particle swarm optimization
- Support vector machine
- Association rule
- Ant colony Algorithm
- Dempster Shafer theory of evidence