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SIMULATION MODELING

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Simulation involves designing a model that imitates a real system and conducting repeated experiments to evaluate or understand the actual system. Since optimal solutions may lack a mathematical model, simulation relies on trial and error, providing approximated results.

Applications: System simulation optimizes processes and resource utilization across manufacturing, healthcare, finance, and logistics. It identifies bottlenecks, streamlines workflows, and enhances operational efficiency, such as simulating patient flows in healthcare.

Advantages	Disadvantages
i. Realistic representation of complex systems.	i. Simplifying assumptions may oversimplify complexities.
ii. Risk-free experimentation.	ii. Validity depends on accurate models and data.
iii. Time and cost efficiency.	iii. Development and maintenance costs can be high.
iv. Performance optimization.	iv. Interpreting results can be challenging.

NOTE: Before using simulation, consider (i) problem type and analytical solutions (ii) resource availability (iii) costs and (iv) data availability.

MODELING IN PROBLEM SOLVING

Models help solve real-world problems without the constraints of cost, danger, or impossibility. Types of Models:

- *Mental Models:* Our understanding of how things work.
- *Analytical Models:* Suitable for static systems, often using tools like spreadsheets.
- *Physical Models:* Tangible representations.
- *Computer Simulation Models:* Explore dynamic systems and their behavior over time.

Analytical vs. Simulation Modeling: Analytical models work for static dependencies, while simulation models are better for dynamic, nonlinear systems.

Queuing Theory is an example of analytical modeling for systems with queues. Components:

- *Entities:* Elements in the system.
- *Queues:* Waiting lines, typically following FIFO priority.
- *Resources:* Processing units that can be idle, busy, or inactive.

Performance Measures:

- *System Time:* Total time entities spend in the system.
- *Queue Time:* Time entities spend waiting.
- *Time-Average Number in Queue:* Average number of entities in the queue.
- *Resource Utilization:* Ratio of time a resource is busy to total simulation time.

BASIC STEPS IN SIMULATION

Simulation involves a set of fundamental steps to ensure success. These steps include:

- *Problem Definition:* Define goals, determine simulation suitability.
- *Model Development:* Identify components, performance measures. Create model using flow charts. Gather, analyze data.
- *Model Translation & Testing:* Translate model into programming language. Ensure model accuracy.
- *Experimentation & Analysis:* Run simulations. Compare system performance.
- *Documentation & Implementation:* Prepare report/presentation. Discuss results, implications, recommended actions.

TYPES OF SYSTEMS IN SIMULATION MODELS

The main objective of a simulation model is to collect observations about a system over time. A **system**, defined as a set of inter-related components working towards a common goal, can be conceptualized in various ways, influencing the modeling process. General classifications of systems include whether they are deterministic or stochastic, and static or dynamic (see Figure 21.1). Understanding these distinctions helps in choosing appropriate simulation approaches based on the nature of the system.

Figure 21.1 Types of Systems