Systems Modelling and Simulation (Introduction)

By A. Mousavi

Recommended Reading:
2. A. Mousavi (2011); Introduction to Systems Modelling and Simulation; Course Book.
Simulation Lecture & Labs

- 2 Hours Lectures and 2 Hours Lab
- Systems Modelling & Simulation
- Assessment: 2 Assignments
  - Assignment (Individual)
  - Project (Group) – Not applicable to DL students
- Submission Deadline: See Instructions from TPO
- Guideline for Simulation part of assignment on my site
- Lecture material available on:
  http://www.brunel.ac.uk/~emstaaam
Objectives

1. To encourage system thinking
2. Provide background to systems modelling concepts
3. Opportunity for a practical appreciation for discrete event simulation
4. Combine theory and practice (Skill based)
Structure

- 20% General systems and modelling approaches including: systems layout, supply chain and logistics
- 20% Analytical Methods such as Queuing Theory and stochastic analysis
- 60% Discrete event simulation – principles and practice.
Assessment

1. Assignment 1 (A1): Worth 50% - Individual assignment

2. Group simulation project: Group members choose a System that lends itself to DES. The task is to identify various components of the system, determine the key processes, design system layout, understand the criteria that drives the events, and model the system using simulation techniques and simulation software. Analyse results and write project report.
Today’s Discussion

In order to maximise your learning experience I suggest you cover the following:


Today’s Topics

1. Systems Concepts and Systems Approach


3. Decision Making in complex environments

4. Simulation and Modelling a tool
Some Concepts

- System
- Manufacturing/Industrial System
- Systems Engineering
System

A set of interacting elements that seek a common goal.

Figure 1.1
Principles of Systems

1. An assembly of components
2. Components are connected in organised manner
3. A logical objective or purpose
4. Components work together towards the common objective
Design or Study the State of a System

- Identify the components of the system to be designed or studied
- Understand the role and relationship between the components and the inputs and outputs
- Recognise and capture the logical interrelationship between the components, inputs and output
- Infer from the inputs, outputs and the interrelationships the State and Objectives
Systems Engineering

- Combination of theoretical knowledge and the ability to visualise things in their totality

Therefore

- Having the capability to design, maintain and interpret the state of something using *Scientific means* makes one a Systems Engineer

For example: Mechanical Engineer, Manufacturing, Electronics, …
Types of System (Schools of Thought)

- Mechanist → Total sum of members
- Organists → survival of the fittest (adaptation)
- Viable/Sustainable Systems
Mechanical System

Figure 1.2
Adaptive System

Figure 1.3
Viable or Sustainable Systems

- Govern complex interactions

- Active Learning, continuous monitoring & control, and aggressive prediction

- The Viable Systems not only adapt to changes but also influence and change the environment to their advantage

- Reinvention – Creativity – Innovation
Viable or Sustainable System

Figure 1.4
Systems Philosophy

19th – Mid 20th century

Mechanists

Total = Sum of Parts

Mid 20th – 1st Quarter 21st century

Adaptive

Organisms

Viable/Sustainable

† Active Learning
† Aggressive Prediction
† Inventive
† Master Complexity
† Influence & Change its Environment

2025 - …
Key factors in a viable system (Human)

1. Maintain Energy Level
2. Maintain Fluid Level (Metabolism)
3. Recuperate
4. Avoid Danger
5. Reproduce
6. Prosper
Adaptation + Viability → Prosper

Data Processing Centre
Real-Time & Historical

Decision

Communication Construct (nervous system)

5 Senses

Information pyramid

decision
data process
comm. cons.
sensors

Figure 1.1

A. Mousavi
Modern Industrial Systems (MIS) and Viable Systems Analogy

Shopfloor Key Performance Factors:

1. Supply Chain
2. Resource Utilisation
3. Inventory Control
4. Productivity (Waste Management) and Yield Control (efficiency)
5. Work-in-Process (WIP)
6. Customer Satisfaction
7. Profitability and viability
Information Architecture of a Viable System

Figure 1.6: The Information Architecture of a Viable Industrial System – SingIX by A. Mousavi et al.
Decision Making and nature of data

- Overwhelming
- Conflicting
- Differ in nature
- Inaccurate
Data Modelling & System Performance Analysis

- Data modelling is the process of preparing and translating input data into meaningful information in a specified time span.

- There are various techniques:
  - As simple as logical AND, OR and IF for binary systems
  - Complex data mining techniques such as; Statistical Process Analysis, Genetic Programming, Fuzzy Inference Analysis, Bayesian Belief Networks, ...
Systems Modelling and Simulation a Powerful Tool

- Mechanism used to translate collected data during a time span into performance analysis

- Note that there is a mechanism and technique in acquiring information which is then used for modelling purposes
Historical and Real-Time Data

- Attributes of Historical Data:
  1. Collected over period of time
  2. Validated and verified through statistical means
  3. Prepared and presented for modelling purposes. For example, average time an operator/machine spends on a job, average number of people who arrive at a counter in a bank in per hour
  4. This data is normally collected at different times over a period of time
  5. The data can then be used to produce *Predictive* data, for example estimated average waiting time in a queue

*Do not fret!*
Real-Time data

- Attributes of Real-Time Data
  1. Introduction of real-time data acquisition technologies (also see SCADA) vast opportunity for us
  2. Help improve the quality of previously gathered data

Intrigue you with …
Relationship between data acquisition, real-time modellers and DES

Figure 1.7: A Schematic overview of Integration of Data Acquisition Systems with Real-time Data Modellers, Simulation Packages and Post Simulation Modellers
Simulation (What? Why?)

1) Simulation involves the modelling of a process or system in such a way that the model mimics the response of an actual system to events that take place over time. (Schriber 1987).

2) Simulation is the process of designing a model of a real system and conducting experiments with this model for the purpose of understanding the behaviour of the system and evaluating various strategies for the operation of systems.

Simulation reflects the behaviour of the real world in a small and simple way.
Classification of Simulation

- Iconic
  
  Flight or driving simulators,

- Symbolic

  Symbolic simulation models are those which the properties and characteristics of the real system are captured in mathematical and/or symbolic form.
Symbolic Simulation

This simulation can include:

- Detailed information about system components
- Closely conform to the unique aspects of each manufacturing system
- Evaluate time-variant behaviour
- Provide system specific quantities to measure performance
Types of Simulation

- Static vs. Dynamic
- Continuous vs. Discrete
- Deterministic vs. Stochastic
Applications

- Manufacturing
- Banks and ATMs
- Transportation/logistics/distribution operation
- Health Services (Hospitals, A&E, Ambulance, etc)
- Computer network
- Business process (insurance office)
- Chemical plant
- Fast-food restaurant
- Supermarket
- Emergency Services
- Supply chain
- Energy and Power Supply and Distribution Systems
Where?

- Analysis of the current system
- Change
- What-if Scenarios
- System does not exist
Benefits of Simulation

1. Improves decision making with minimal cost
2. Compress and expand time (allows speeding up or slowing down specified conditions)
3. Reasons behind specific system conditions
4. Explore possibilities with minimal expenses
5. Diagnose problems (understand the complex interactions between elements of the system)
6. Identify system constraints and limitations
7. Develop a general understanding of the behaviour of the system
Benefits of Simulation cont.

8. Visualise the plan
9. Build consensus by creating objective opinion
10. Prepare for change
11. Prudent investment
12. Training the project team
13. Specify system requirements at design stage
14. Capture complexity
Modelling

A model is a representation of an actual system.

- Descriptive : example Simulation
- Prescriptive : example Operational Research
Simulation Modelling

**Model** – set of assumptions/approximations about how the system works

- Study the model instead of the real system … usually much easier, faster, cheaper, safer
- Can try wide-ranging ideas with the model
- Model *validity* (any kind of model … not just simulation)
  - *Care in building to mimic reality properly*
  - *Level of detail*
  - *Get same conclusions from the model as you would from system*
What did we talk about?

- Syllabus and Assessment
- Principles of Systems Engineering
- Information and Analysis tools for Viable/Sustainable Systems
- Briefly Simulation & Modelling