Systems Modelling and Simulation (Introduction)

By A. Mousavi

Recommended Reading:

1. D. Kelton, R. P. Sadowski and N. Swets (2010), Simulation with Arena 5th Edition, McGraw-Hill
2. A. Mousavi (2011); Introduction to Systems Modelling and Simulation; Course Book.
3. R. G. Askin and C. R. Standridge (1993); Modelling and Analysis of Manufacturing Systems; John Wiley & Sons, Inc.
4. M. P. Groover (2001); Automation, Production Systems, and Computer Integrated Manufacturing; Second Edition; International Edition; Prentice Hall International, Inc.
5. G. L. Curry and R. M. Feldman (2011); Manufacturing Systems Modeling and Analysis; 2nd Edition; Springer

Simulation Lecture & Labs

- 2 Hours Lectures and 2 Hours Lab
- Systems Modelling & Simulation
- Assessment:
  - **Assignment (Individual)**
- Submission Deadline: See Instructions from TPO
- Guideline for Simulation part of assignment on my site
- Lecture material available on:

http://www.brunel.ac.uk/~emstaam

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:

1. Chapter 1 of the Course Book Introduction to Systems Modelling and Simulation (2011), A. Mousavi et al.
2. Chapters 1-3 Simulation with Arena 5th Edition (2010), W. D. Kelton et al

Today's Topics

1. Systems Concepts and Systems Approach
2. Modern Industrial Systems (Manufacturing, Finance, Healthcare, Transport, Supply Chain, Telecommunication, Power, …)
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

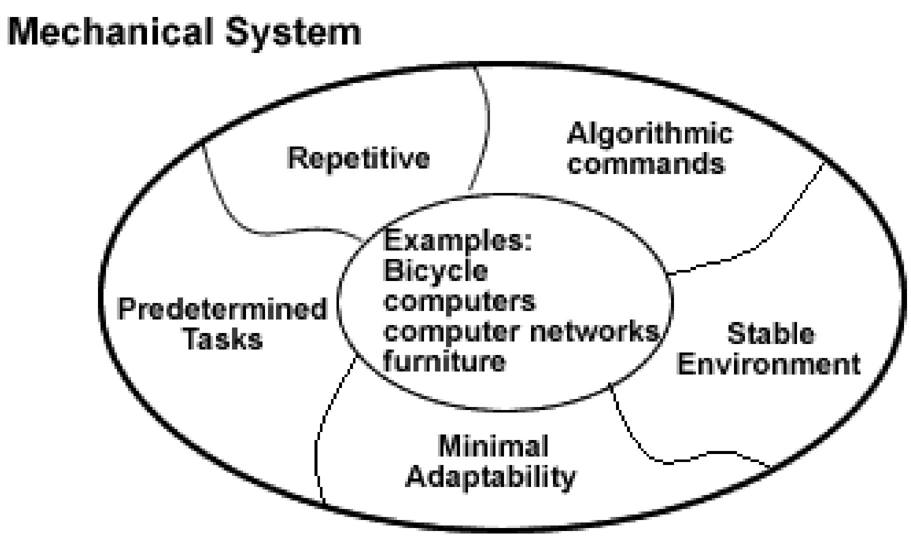


Figure 1.2

Adaptive System

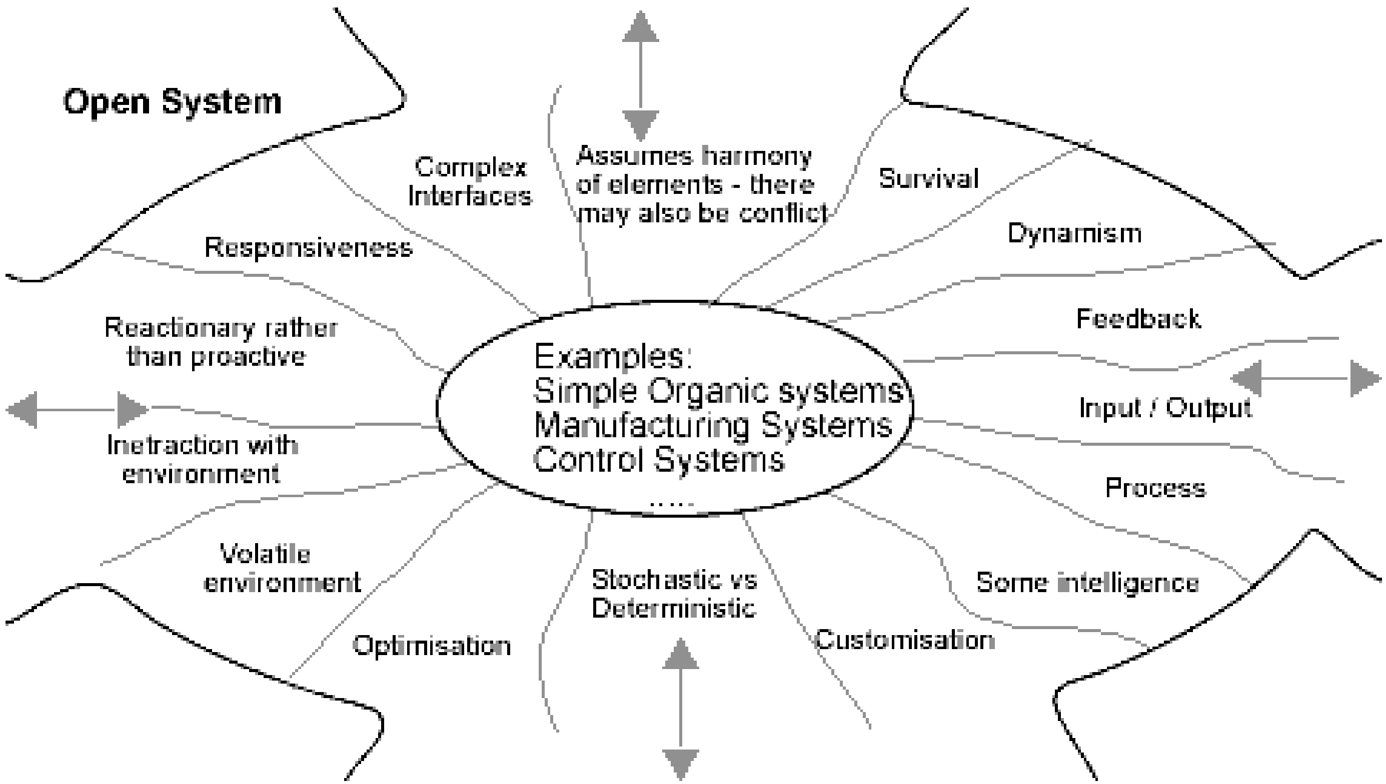


Figure 1.3

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

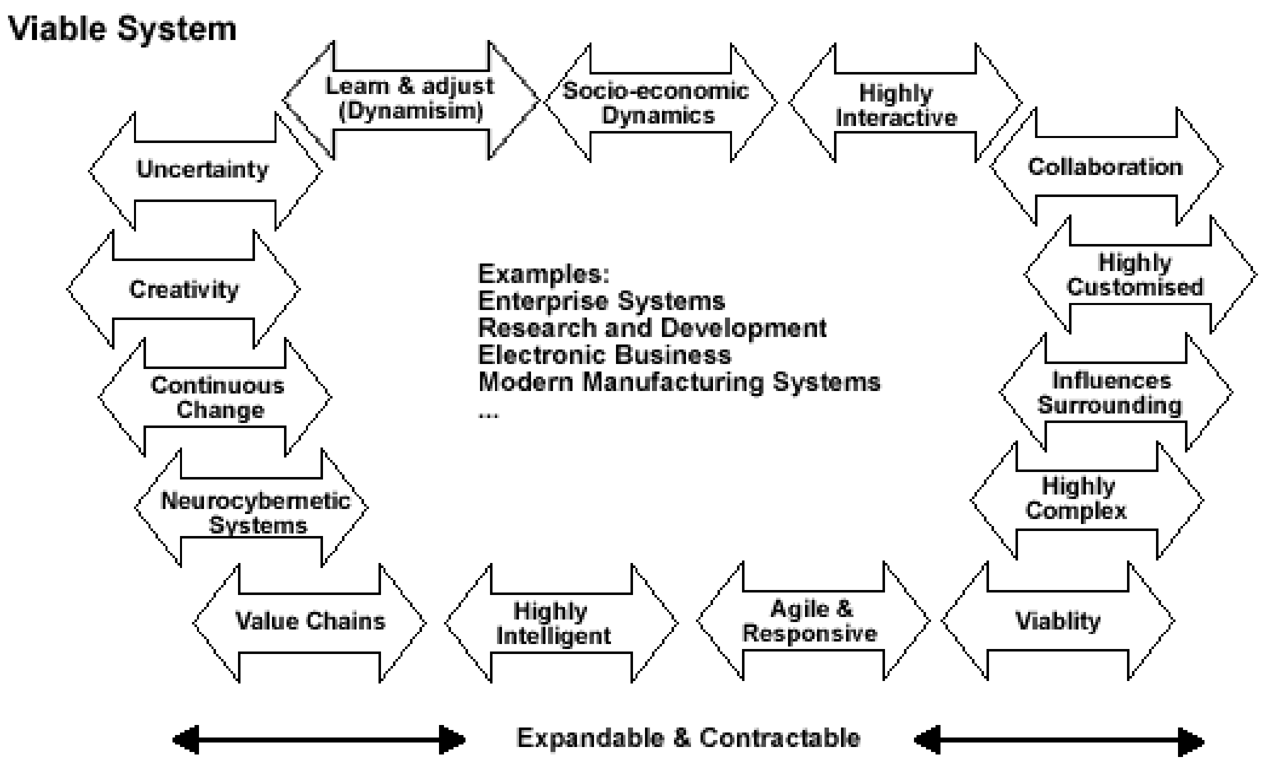
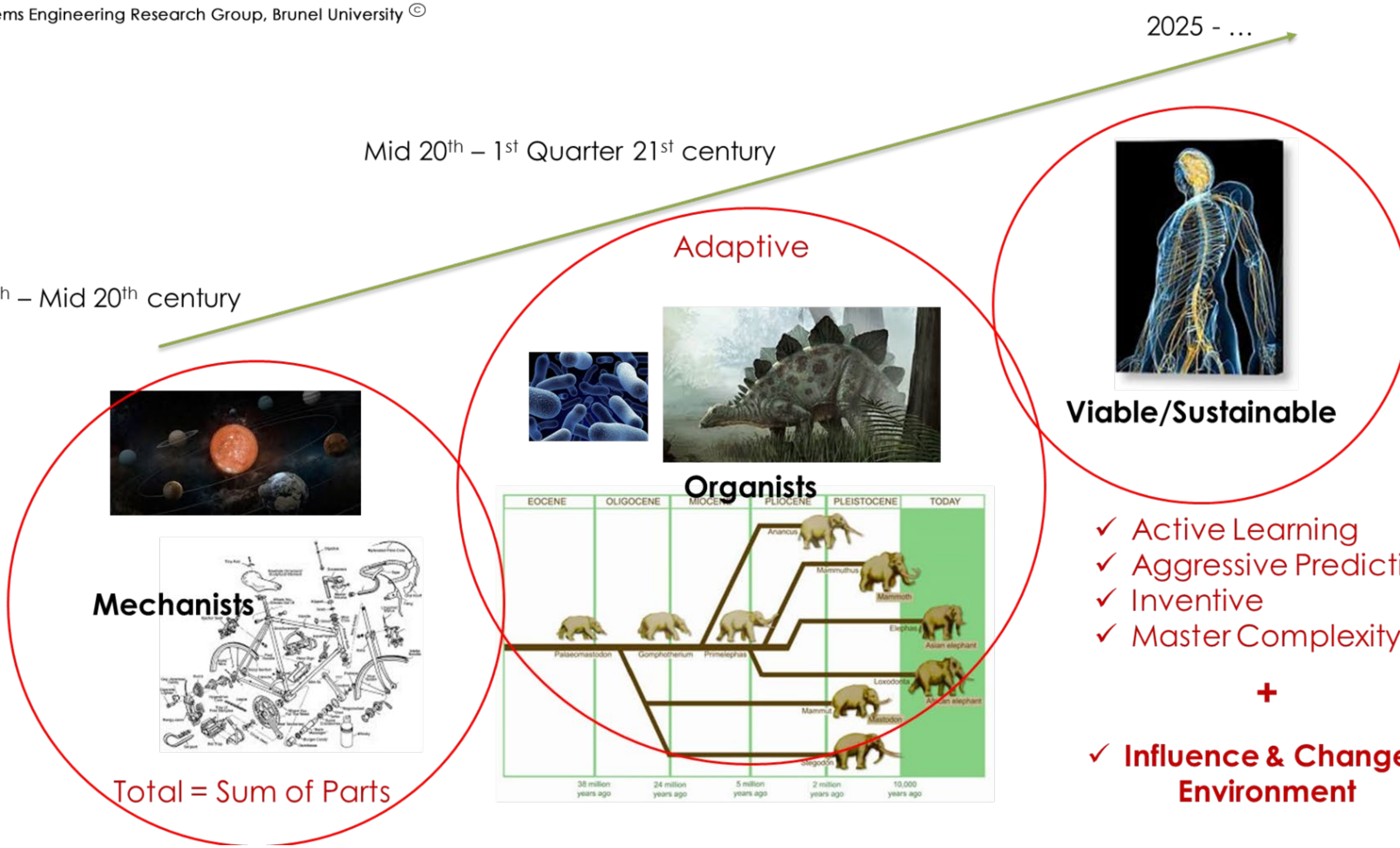


Figure 1.4

Systems Philosophy



- ✓ Active Learning
- ✓ Aggressive Prediction
- ✓ Inventive
- ✓ Master Complexity

+

- ✓ **Influence & Change its Environment**

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

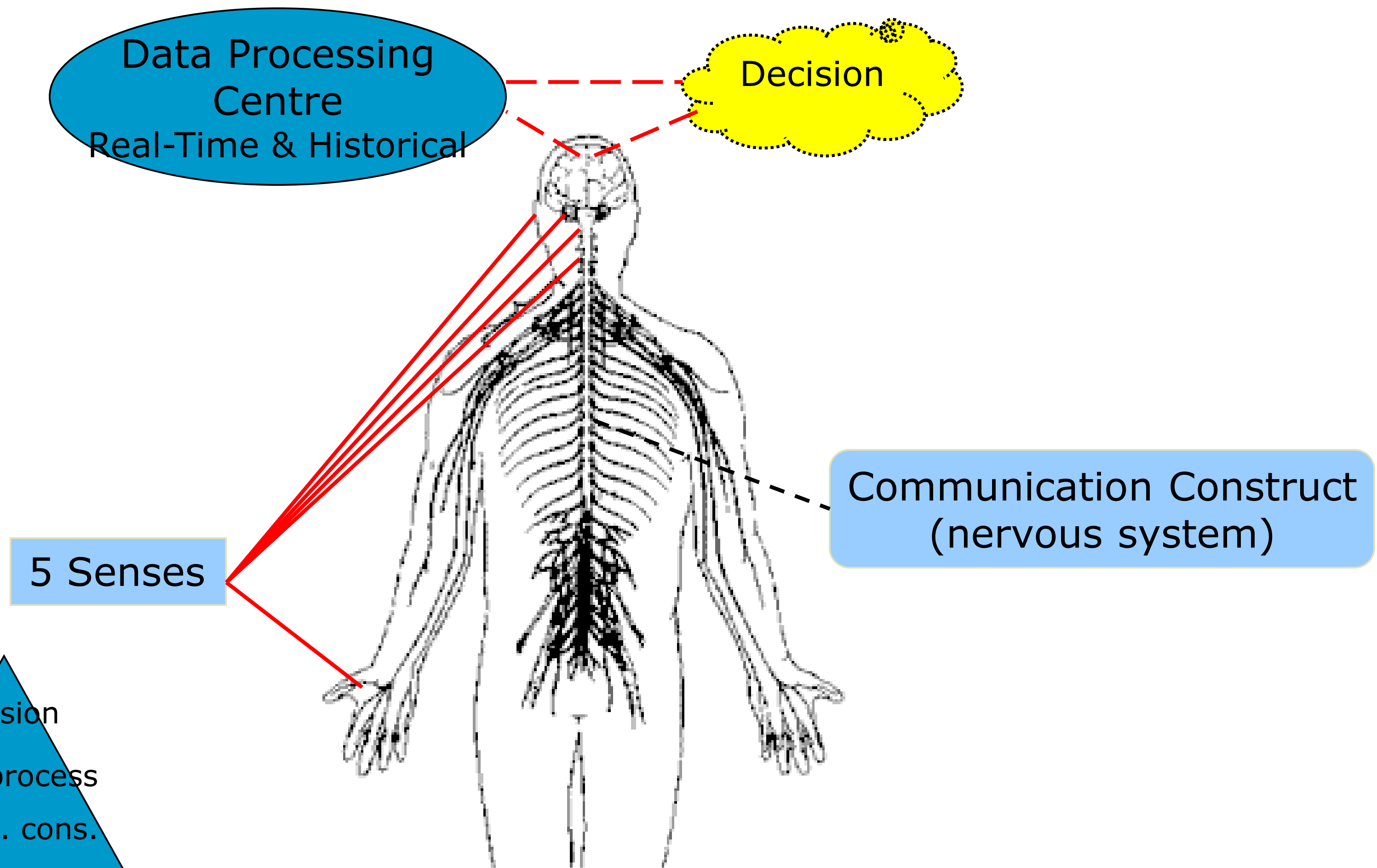
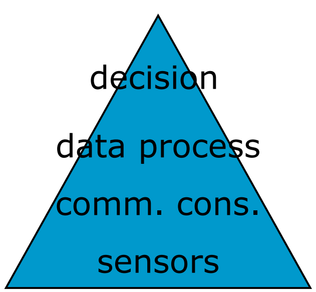


Figure 1.1



Information pyramid

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

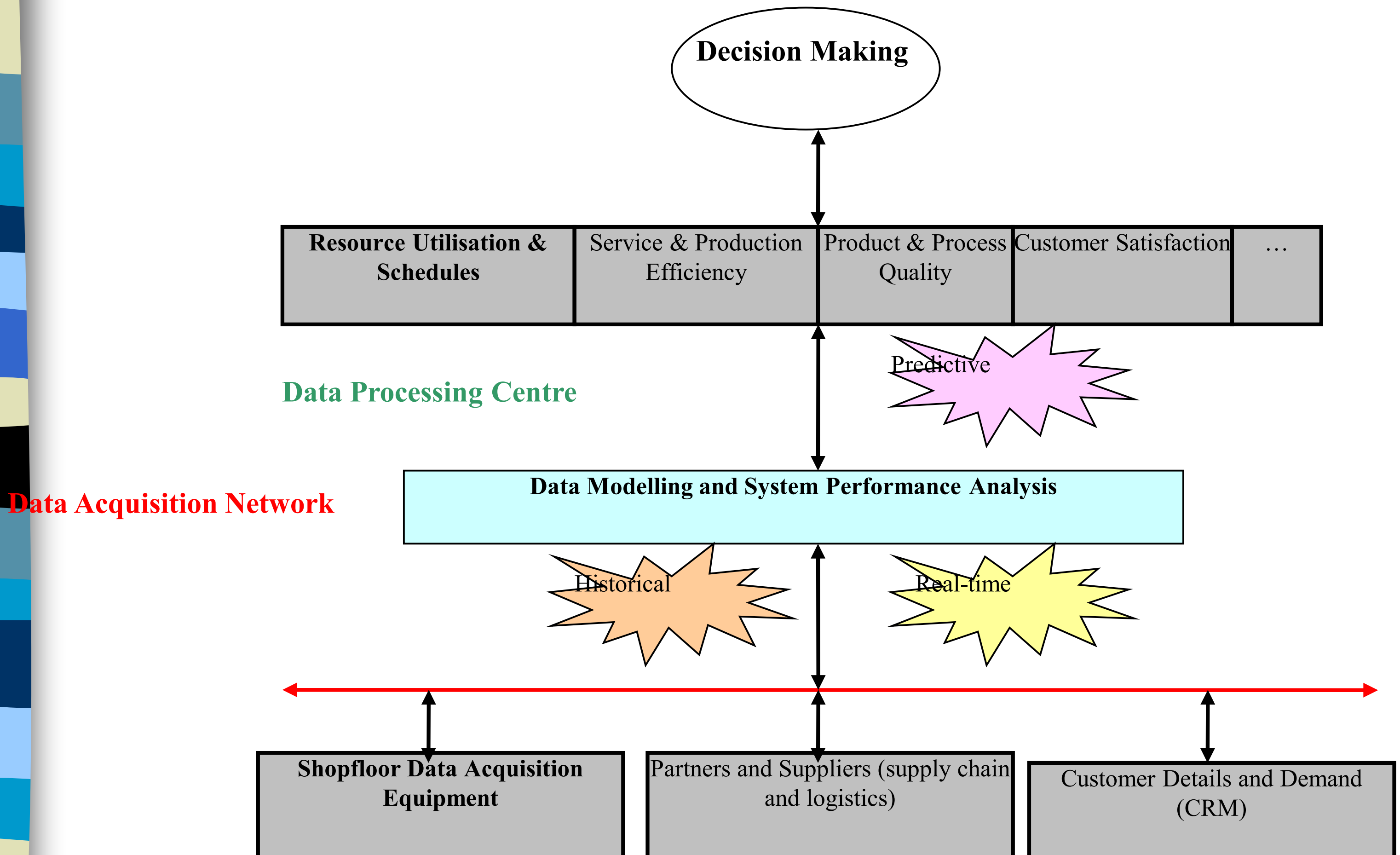


Figure 1.6: The Information Architecture of a Viable Industrial System – SinglX by A. Mousavi et al.

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 technique:
  - **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

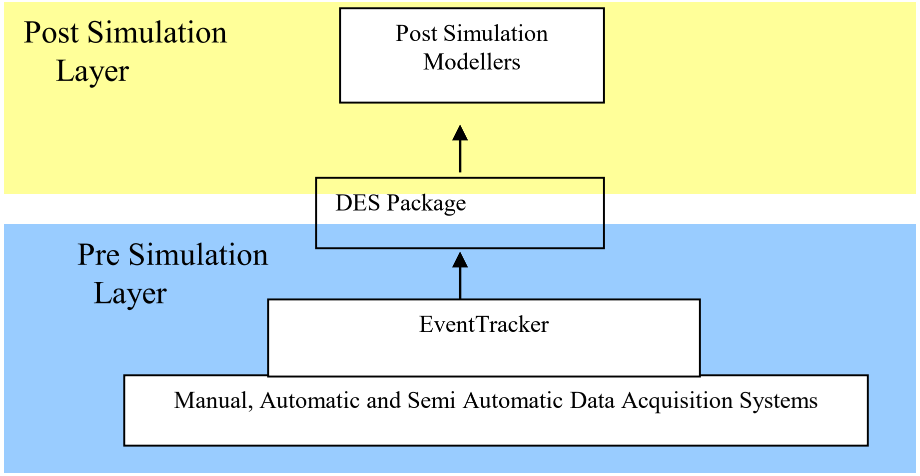


Figure 1.7: A Schematic overview of Integration of Data Acquisition Systems with Real-time Data Modellers, Simulation Packages and Post Simulation Modellers

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