

AS/A Level Computing Syllabus 2011

Section 3

- System Software Mechanisms -
 - Machine Architecture -
 - Database Theory -
 - Programming Paradigms -

Chapter 3.7

Simulation and Real-time Processing

3.7 Simulation and Real-time Processing

3.7.1 APPLICATIONS OF REAL-TIME COMPUTING

Definition: A real-time system is the one which can respond/process the input quickly enough to affect the next input/decision.

- The real-time systems are needed in situations where there is a need to make a decision quickly.
- The response time, however, depends on certain conditions such as
 - In what situation the system is being used?
 - What are the input and output requirements and methods?
 - What is the complexity of the decision and processes to reach that decision?

Example:

- A nuclear reactor may start to react too violently.
- The sensors will pick up the readings and send input to the controlling program.
- The control program takes the decision to insert the graphite rods to slow the reaction down.
- The readings from the sensors (input) must be processed immediately. This is a real-time processing system. It is not important how quick the output (insertion of graphite rods) should be. The decision making time is important.

3.7 Simulation and Real-time Processing

3.7.1 APPLICATIONS OF REAL-TIME COMPUTING

ADVANTAGES OF REAL-TIME COMPUTING

- The system will make decision immediately which can be vital in making critical decisions.
- Real-time systems can eliminate the need of human supervision in certain situations.
- Real-time systems can help save human lives, equipment and environment catastrophes by providing timely feedback.

DISADVANTAGES OF REAL-TIME COMPUTING

- Real-time systems are almost always dedicated systems and can not do anything else in order to keep the decision time short.
- Real-time systems need expensive hardware and software in order to provide the best response time.

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3.7.2 THE FEEDBACK LOOP; INPUT AND OUTPUT; SENSORS AND ACTUATORS

Definition: A sensor is a device that can measure a physical quantity such as light, heat, motion, pressure etc.

- Sensors are important devices as they let a computer system read data from the outside world automatically that otherwise would be impossible/impractical for a human.
- Sensors can be either analog or digital.
- A digital sensor is the one that provides output in digital form. For example, a pressure pad may sense pressure (analog quantity) as someone steps on it, but it can send output to a processor in digital form (YES, pressure is there; or NO, pressure is not there).
- An analog sensor is the one that provides output in analog form. It will require an analog-to-digital convertor (ADC) device to convert the output into digital form so that a processor can read it. For example, a thermistor sends output in the form of varying voltages (analog).

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3.7.2 THE FEEDBACK LOOP; INPUT AND OUTPUT; SENSORS AND ACTUATORS

Definition: An actuator is a mechanical device that can accept signals from the computer and turn them into physical movement.

- Actuators are commonly used in devices that are needed to be controlled by a computer system.

Example:

- Turning a robot in a different direction.
- Opening and closing an automatic door.

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3.7.3 THE USE OF ROBOTS

Definition: A computer controlled mechanical device that is sufficiently flexible to be able to do a variety of tasks.

- Robots are now becoming an essential part of our lives.
- Robots are extensively used in manufacturing industry to lower the production cost and to raise/maintain product manufacturing standards.
- Robots, although very expensive to buy, are considerably cheaper in the long run.
- Robots are consistent. This means that whatever quality they produce, they produce day in and day out.
- Robots can also be used in situations which could be dangerous to humans, such as disarming explosive devices, venturing into earthquake affected areas, parts of a nuclear reactor where radiation exposure is high etc.
- Robots are now extensively being used in space research and exploration where humans can't survive.

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3.7.3 THE USE OF ROBOTS

DISADVANTAGES OF USING ROBOTS

- Robots may not be able to adapt to unexpected situations.
- Although the use of robots has not totally eliminated the need for human work force, it does create a certain level of unemployment.
- Involvement of humans in places where robots are used is reduced mostly to supervision and requires highly qualified technical personnel.
- Robots do break down due to extensive use and require periodic maintenance.

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3.7.4 USES OF SIMULATION

Definition: Use of a computer program to predict the likely behavior of a real-life system is called a simulation.

- Simulations involve constructing mathematical models of a system and testing them, usually under controlled conditions.
- By changing different variables in the model, many different situations can be tested and experienced.
- Interactive simulations allow the user to 'interact' with the simulation by accepting live input and responding to it in real-time.

Advantages of Using Simulations

- **Low cost alternative:** A simulation is usually a low cost alternative to experiencing the actual situation. For example a flight simulator is a low cost alternative to using an actual aircraft to train pilots.
- **Simulating dangerous situations:** A simulation can allow testing of skill and equipment without actually engaging into dangerous situations. For example, an explosives expert can test a disarming technique without using live explosive.

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3.7.4 USES OF SIMULATION

Advantages of Using Simulations

- Ability to change scenarios: A simulation can provide the facility to change input data for variables to test outcomes of different scenarios. For example, commercial airline pilots can experience different weather conditions in the flight simulator controlled by the training instructor.
- Better testing and learning tool: A simulation can allow the user to test his/her skill and technique before actually using it in the real world. For example, doctors can perform operations of virtual patients and perfect their technique before operating on real patients. Other examples include testing of financial strategies for governments and testing of new designs by engineers before building the prototypes.
- Great entertainment tool: A simulation can provide rich entertainment and gaming experience for the user. For example, flight and car driving simulators have been around for decades and allow the users to enjoy the excitement of flying an aircraft or driving an expensive sports car.

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3.7.4 USES OF SIMULATION

Disadvantages of Using Simulations

- A simulation is a very complicated piece of software. It requires very complex programming usually involving artificial intelligence (AI).
- Simulations, in almost all cases, are very expensive to design and built. Not every organization can easily afford to buy a professional-level simulation software.
- There is always chances of simulations producing results with a certain degree of error as a direct result of technical mistakes in programming or data being used to generate the simulation.
- Simulations can not reproduce situations that are impossible to be represented by mathematical models.
- Simulations require very expensive and powerful computing equipment in order to produce the desired experience. These computer systems are almost always dedicated computers, or computers with enough resources that they can load balance (make adjustments in order to minimize response time and avoid overloading of the system) the computing requirements of such complex software.

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3.7.5 VARIATION OF PARAMETERS AND CONDITIONS; TIME STEPS

- A simulation would not be much of a use if the user can not test different data inputs and their reactions.
- For example, there are many different variables that can affect the performance and design of a car.
- In order to test all these variables, many prototypes need to be built with design variations.
- This might not be feasible to apply in real life due to financial constraints and can result in cars with poor performance, design or quality.
- Using a simulation can allow the engineers to extensively test design and performance in virtual environments before building prototypes.