A Performance on Simulation with Methodologies

B.K.Jaleesha, S.Shenbaga Ezhil

Abstract: Simulation had its wide application in engineering field like designing multi-dimensional components, physical science like nuclear fusion, social science like forecasting. Now a day's computer simulation is becoming more popular. To create new simulation model it is a basic step to have a clear idea about the methodologies used in simulation. The main objective of the paper is to review simulation and analyze the types of simulation models with differences. In this paper we discussed the need of simulation, the basic steps need to be followed for making a simulation model, the types of simulations based on comparative data type with specific advantages and disadvantages.

Keywords: Simulation, real system, model, variable behavior, prediction.

I. INTRODUCTION

As the word "SIMULATION" means it is an initiative process for analyzing a real problem which represents the actual characters of the physical or activating system. In general, we can say it as the predictor for operating a system.

Simulation is an operation which helps the model to predict the result even for analytically complicated real world model. Computer experiments are used to study simulation models. For natural systems or human systems scientific models are used to gain the insight into the functionality. The key issues in simulation are simplifying approximations and assumptions, model verification and validation. We can use simulation programs like FORTRON, if system is simple and SIMSCRIPT or GPSS, if the system is complex.

In a brief sense, we can say simulation is a key tool to evaluate the performance of the system which is proposed or existed. The system is simulated before an existing system is altered to optimize system performance. For example, how will a new routing network affect its performance? Which network optimizes the performance? The paper says about simulation, why it is used, how to plan for a simulation model, decisions to be consider while simulating a system, what are its classifications and types, advantages and disadvantages of simulation model.

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II. SIMULATION

Simulation is an initiation of the system of a real world action. It is a operation of system for over time.

The first step in simulation is to develop the model which represents the key characters, functions and behaviors of the process. Model represents the system itself whereas simulation is the operation or implementation on the system over time. Thus creating thing is called a model and implementation on the created things is called simulation. Simulation is mainly used in performance optimization technologies, safety engineering, testing, training, education, video games. It is also used to show the real effects of alternative conditions and course of action eventually.

III. WHY SIMULATION?

Simulation is needed because of the cumbersome of real system which is too costly, dangerous and slow. It is used to gain an insight into the system, to improve the performance of the system, to test new concepts before implementing, to gain information without affecting the real system. Simulation is based on equations, mathematical model and software programs. So the system model is a way of looking out into the world and allows us to take decisions even it is simple or complex, whereas simulation provides a appropriate result for the system model.

IV. BASIC STEPS IN SIMULATION

Simulation process has specific steps to follow which will provide a robust output. Why such steps were followed in a simulation model is defined below:

A. Problem Definition

Initial step is to identify research gap or to know the question to answer. So to define the goals of study and determine what needs to be solved. It can be stated either by policy maker or analyst. Both of them should clearly discuss the parameters going to determine the model, because the defined problem can be reformulated in the simulation model progress.

Further, the problem is defined by objective observations. Care should be taken to determine whether simulation is an appropriate tool for the investigating problem.

B. Project Planning

The objective of the problem is the question to answer. If simulation is an appropriate tool, then plan the project or work flow.

The plan must specify alternative system to consider, methods can applied to the model with effectiveness, parameters to involve, time going to take, cost consideration and expected result. So, required task should be broken into responsible work packages. Mile stones are indicated to check the process of the model which will helps us to determine the sufficient and resources available for the task to complete.

System definition is very important in project planning. Hence identify the components to be modeled and the measure of the outcome to be analyzed. If the system is complex, then defined system requires experienced simulator to provide appropriate level of value and flexibility.

C. Model Conceptualization (formulation)

Mathematical modeling is an art of science. Model should be an abstract of the problem with essential features which can assume the result and so to modify. It is the simple way to build a complex system. There should be a one-to-one way mapping between real system and the model, only the essence of real system should be in the simulation model.

Had a clear idea about actual system and basic requirements to develop the right model. For that we should create a flow chart for the system operation which will help us to understand the behavior and interaction of the variables in the system. It is better to use model user to model the system which enhance the quality of the result and confidence level of model with optimized application.

D. Input Data Collection & Analysis

The developed model will give us an idea about the type of data to be collected and a suitable analytical or statistical method for analyzing the data. There should be a constant interplay between the model construction and the needed input data. Based on the complexity of the model, the required data may change. This process took long time, so it is better to start collecting data as early as possible. It is good to collect during modeling, because during the objective study it is able to identify the type of data to be collected.

For example, in the study of bank: the objective is to reduce the length of waiting lines. So the type of data needed can be the distribution of interval arrival times, the series time distribution for tellers and the history of length distribution under various conditions. Here the last data is used to validate the simulated model

E. Model Transformation

Simulation model relating real world systems requires a great deal of information storage and computation. So it is important to change the model into computer known format. The modeler should decide the program of the simulation model in its appropriate computer language. Hence translate the developed model into a programming language using simulation tools like GPSS or to use special simulation software based on the system is simple or complex.

F. Verification

Verification is applied in the computer program of the simulation model. At this time the model should perform in the correct and proper way, otherwise there may be any difficulty in program. For complex problems, if there is any difficulty translate the model in its entirety without debugging.

Ensure the model behavior process through animation. If the input parameters and logical structure are correctly represented in the model translation then the process move to validation part. Verification is a necessary step but not sufficient until it is a valid one.

G. Validation

Validation is sufficient step because this ensures the difference exists between real system and the model. It is achieved through calibrating the simulation model. It is done by statistical analysis and an iterative process which compares the model against real system with its differences.

This step gives an insight of the model to improve the design and continued till the model accuracy is justifiable and acceptable. Additionally face validity is obtained by model review and experts suggestions.

H. Experimentation

Developing an alternative model to simulate is the experimental design. In this step we should identifythe alternatives to simulate with its decision. For each such system design it is simulated.

Decisions will be taken based on the length of the initialization period, length of simulation runs and the replication to be made of for each run. Analyze it by executing the simulation runs and comparing the differences statically. So the next step to make production runs.

I. Production Runs, Additional Runs and Analysis

Production runs and subsequence analysis are used to estimate the performance measure of the system which is being simulated. It should be analyzed whether additional runs are needed and what type of design to be modeled for that simulation. If there is a need for additional runs then it move to the production runs or else the process will go for documentation of the validation thus obtained.

J. Documentation and Report

Obtained results should be documented and given in a report form and the results are discussed. There are two form of documentation one in program form and other in progress form. Program document helps us to understand the operation of the translation model. So program modification becomes much easier and the modeler can change the required parameter which determines the relation among input parameter and output measure of the performed model.

All the results from the analysis of the simulated model should be reported clearly and confidently in the final report. This helps the modeler to review the final formulation, addressed alternative system, criteria of comparison, results obtained in the process and the suggested solution for the problem.

K. Implementations

We will get a successive implementation part based on the above ten steps

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performance. It is also based on the modeler that how he is fully and thoroughly analyzed during the entire process. If the simulation modeler fully involved during model building by thoroughly understanding the nature of the model with its output, then the implementation of the simulation model will be a successful one for the problem defined. The best output is the action identified, applied and justified.

Process Flow of the Simulation model what discussed above is give below in a flowchart format.

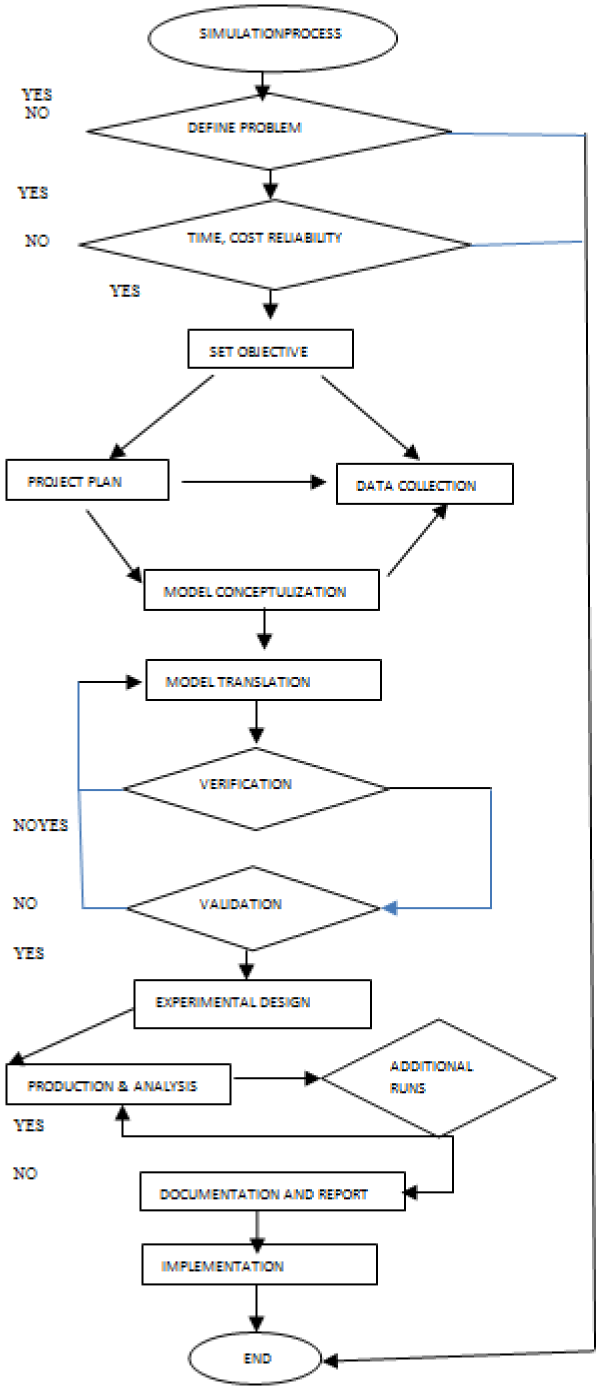

Fig. 1

Types of Simulation

According to the behavior of the real system, the simulation methodology should be chose. Simulation methods are classified into:

A. Discrete Vs Continuous Simulation

(a) Discrete Simulation

A discrete event simulation (DES) operates the system in a discrete sequence of events in time. The events will occurs in a particular instant of time which changes the state of system, but there will no change in consecutive events. So the model will jump from one event to other in time. A recent method in DES is three-phased approach. Here, the first phase is to jump the next event, second phase is to execute all events unconditionally and the third phase to execute all events conditionally. This method will simulate the events in an ordered way and is efficient for computer resources.

Example

The best examples for DES operation are building a model of queues like customer arrival, customer departure, number of customers in the queue (0 to n), and teller status (busy/idle).

In particular, one help-desk operator of two desks

(i) Busy helping someone

(ii) Waiting for a call to come in

Event1: customer starts describing problem to help desk

Event2: customer completes telephone conversation

Simulation Model:

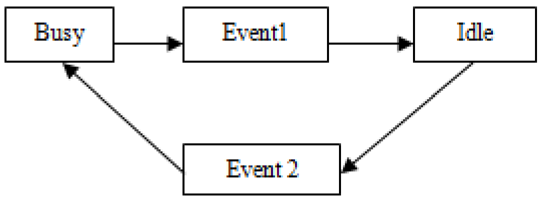

Fig. 2

Simulation starts at t=t0=0

- First customer arrives at t1,so t=t0+t1
- Help desk requires ts time to resolve issue
- Hence first customer leaves at t= t0+t1+ts
- Second customer arrives at t2

If t2 < t0+t1+ts, then customer must wait

If t2 > t0+t1+ts, then customer start service.

(b) Continuous Simulation

Continuous simulation tracks the response of the system continuously without jumping in time. That is, it response a set of differential equations. It represents the function on real numbers for the change of the system. It is a conceptual model. It has high level programming language using ODE and PDE. Continuous simulation views the value of potentially an infinitesimally short amount of time.

Example

Physical phenomena like rigid body motion, electric current flow, fluid flow, heat flow are the best examples for continuous simulation modeled by a set of differential algebraic equations (DAEs).

In particular, the adjustment of a price P response to non-zero excess demand for a product model can be given in continuous time as $\frac{dP}{dt} = \lambda f(P,....)$ where left side is

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the derivative of price with respect to time, λ is the speed parameter of positive finite number and f is the excess demand function.

Multi-disciplinary systems are the combination of discrete and continuous type. For high-fidelity, hybrid modeling and simulation is required in which both discrete and continuous are applied.

Modelica and VHDL-AMS are the simulation languages which supports mixed modeling system.

B. Deterministic Vs Stochastic Simulation

(c) Deterministic Simulation

This simulation contains fixed variables, mostly of difference equations. It has known inputs and so produces unique set of solution. These simulation models are used to capture the underlying mechanism of a process. The outputs are precisely determined through known relationship among states and events. It deals with systematic and definitive (certainty) outcomes without error.

It is a useful approximation of reality which is easier to build stochastic model, that is, Stochastic model=deterministic model+ random error.

Example

Mostly used in the study of population, climate development, some area of engineering, chemical reaction and policy making.

In particular, to determine the return on a five year investment with an annual interest of 7 percentage

The model is just the fixed equation: F=P(1+r/m)Ym which helps in predicting the next scenario

(d) Stochastic Simulation

✓ Model representing random phenomena, defined by sample space, events within the space and probabilities. It is a statistical analytical tool which estimates the output on the basis of past data or the probability of an event occurring again. This simulation model will create a projection with a set of randomized values. Process is repeated until a sufficient data gathered. Produce different (uncertainty) results with same initial conditions showing possible alternate solutions.

Example

The common models are rainfall level in a district, number of accidents, census rating.

In particular, single chemical reaction model

$A \quad k \quad \Phi \longrightarrow$

where A = Chemical species of interest, k = rate constant of reaction, Φ = chemical species of further interest, with k.dt gives the probability of randomly chosen molecule of the specimen reaction in [t, t.dt].

C. Static Vs Dynamic Simulation

(e) Static Simulation

This type of simulation is used in the models representing the system of objects with their interrelationship. Static model is one which does not consider time.

General model be in the form: u(t)={u1(t),u2(t),……….un(t)} depends only on variables and for fixed time with output form as: y(t)={y1(t),y2(t),……….yn(t)}.

Example

Common models of this type are for mechanical and electrical systems in mature area (single domain), Mechanical interactions between multiple rigid bodies (multi domain) of mechatronic system. In particular, the numerical method for approximating displacements and stresses in a model by breaking geometry into a set of finite elements. Solve it by PDE on assumed boundaries. Model for the solid work is

$[M]d^2x/dt^2+[C]\ dx/dt+[K]x=F\ (t)$, where [M] is inertia matrix, [C] is dampling matrix, [K] is stiffness matrix and F is the fixture model.

(f) Dynamic Simulation

The simulation model variables deal with time change of the system. It is a steady state and time based process. Iterative steps followed for time. Nothing in life is truly a steady state, hazards exists within transient condition. It is the best predictive control process of a system over time change.

General model form: u(t)={u(t1),u(t2),……,u(tn)} where the variable value depends on time with output form as: y(t)={y(t1),y(t2),……,y(tn)}.

Example

Common models are birth rate, population of cells and virus.

In particular, automobile velocity from force balance model is

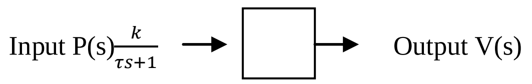

Fig. 3

where input is gas pedal and output is the velocity in seconds. In the system K is the gain and τ is the time constant. Solve the system model using linear equations.

V. ADVANTAGES AND DISADVANTAGES OF SIMULATION

A. Advantages

✓ * Best suited method to analyze complex system

✓ * Provide an idea of the system behavior without building

✓ it.

✓ * Comparing to analytic models provides accurate result.

✓ * Gives an alternate solution.

✓ * Predicts the unexpected behavior of the system.

✓ * Decision/policy making is faster and reduces risk of the

✓ Real system.

B. Disadvantages

✓ * It is so expensive to build a simulation model.

✓ * Sometimes it is difficult to interpret.

✓ * It will not generate optimal solution.

- ✓ * Decision maker should provide all information about the
- ✓ System for testing.

VIII. CONCLUSION

The plan discussed over the design of Simulation Model clearly helps to handle the data capable of running the model. The types of Simulation given in the basis if comparitive way provides a lean and straight view on the suitable model to be applied as per the data on hand. Discussed simple examples helps the reader to note the difference of each methodology of simulation easily. Specifically noted advantages and disadvantages leads the decision maker to clarify whether simulation suits them for making decision.

Simulation generates a way of predicting solutions for different operating systems deterministically or randomly based on time or structure. Though it is an expensive method because of using computer resources, it gives a simplified representing model of the real systems with certain strengths and limitations to follow for an optimized value.On the basis of the real system, if the simulation model is correctly framed with its original characteristic resembling variables it predicts or yields an approximate optimization. Simulation is the best decision maker and so it is mostly applied in engineering and business fields in production, designing, customer service and new project planning before implementation in local or global level.

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