Application of Simulation in Healthcare

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ABSTRACT
Simulation is actually a virtual design of a system over a span of time to understand how the conditions, parameters, factors or assumed circumstances would affect the system in question in the real time. Simulation finds application in various areas -- healthcare is one among them. This paper attempts to replicate a scenario of a hospital emergency room and through experimental results shows how it would perform in real time. The paper also discusses the steps involved in designing a simulation model, different software tools available for simulation and also few limitations of simulation.

Keywords
Simulation, ARENA, Waiting time, Utilization

1. INTRODUCTION
Simulation is basically a replication of the operations of the real world process or the system for the purpose of analysis and evaluation. Systems that are too complicated to analyze through analytical methods often can be studied using simulation tools. Simulation can be achieved through many tools however the basic steps to achieving simulation would remain the same.

The current paper discusses a healthcare application of simulation and presents with various limitations of simulation. The following section II explains the steps for a successful simulation. Section III & IV states the available tools for performing simulation and the applications respectively. Sections V through X present the simulation of an emergency room in a hospital. Section X discusses the limitations of simulation. New trends in process simulation modeling are given in section XI with finally section XII concluding the paper.

2. STEPS OF SIMULATION

2.1 Formulation of the problem
First, the problem at hand must be understood by the analyst properly to go ahead with the designing of the system model. After the problem has been understood and defined by the analyst, it is again important that policymakers understand the problem statement formulated and agree with the formulation as well [1].

2.2 Setting up of objectives and laying down the overall project plan
Secondly, we need to identify the objectives and the questions that the simulation would answer.

2.3 Conceptualization of the model
Starting with a simple model and proceeding with the addition of higher complexities

2.4 Data Collection
There is a deep relation between the construction of a model and the data fed to the system. With the changing model, requirement for the change in the data is inevitable.

2.5 Translation of the model
Here the model is transformed into a computer readable format using Simulation tools like Arena®, AutoMod™, and Extend™ etc.

2.6 Verification
It emphasizes on the how accurate the system designed is and how would it react with different varieties of input parameters.

2.7 Validation
It emphasizes on whether the system is doing what it was designed to do.

2.8 Experimental Designing
The entire system model is not designed and run as a whole but rather it is done so as many functions or modules, o different experimentation is done on various sub programs or functions to search for bugs.

2.9 Production runs and analysis
This is done to determine the efficiency and performance of the system.

2.10 Documentation and Reporting
Documentation is to be done in order to know how the program operates as well as in case of enhancement of the program at a later time.

2.11 Implementation
The success of this phase is dependent on the previous stages.

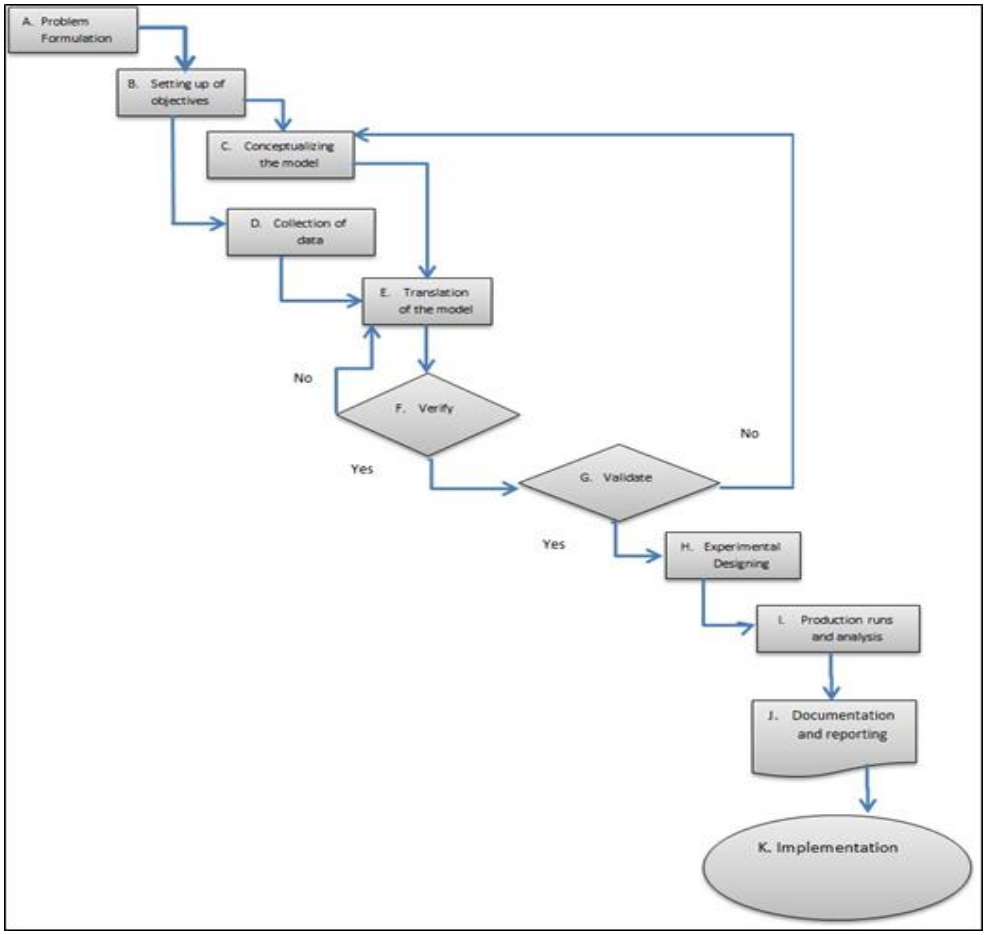

Figure 1: Steps in Simulation [1]

3. THE DIFFERENT TOOLS AVAILABLE FOR SIMULATION

3.1 Freeware or Open Source Simulation Tools

- Advanced Simulation Library – it is an open source multiphysics simulation software that is hardware accelerated. [2]
- ASCEND – It is an equation-based modeling environment. [2]
- CellCollective – It is an interactive modeling environment used in large scale biological network models for creation and simulation. [2]
- DWSIM - chemical process simulator [2]
- Facsimile - a free, discrete-event simulation library. [2]
- OpenFOAM – it is used for Computational Fluid Dynamics (or CFD) [2]

3.2 Proprietary Softwares

- 20-sim it is a simulation software for Bond graph based multi domain [2]
- Actran Finite Element based simulation software used for analyzing the acoustic behavior of mechanical systems and its different parts [2]
- Arena – this is a simulation and automation software developed by Rockwell Automation [2]
- AnyLogic – it is a Multi method simulation modeling tool for business and science which was developed by The AnyLogic Company[2]

4. SIMULATION IN REAL TIME

Application of simulation modeling can be seen in many sectors like:

- Oil and Gas Sector
- Defense simulation, modeling and training sectors
- Resource allocation and planning in the healthcare sector
- Forest Sector simulation models as methodological tools in forest policies.
- Agricultural Sector modeling
- Modeling and simulation of selected operational IT risks in Banking sectors
- Simulation in retail sector (Customer-Supplier value chain).
- Tourism sector
- Stock market
- Modeling and simulation in social care sector
- Health Care

5. SIMULATION IN HEALTHCARE

The hospital sees the arrival of its patients in a Poisson distribution with the mean interarrival time of 30 minutes. On seeing a nurse first, they are classified as CW (can wait) or NIA (Need Immediate Attention) with a probability of 45% and 55% respectively. There is only one nurse who would classify the patients, which would require 10 minutes exponentially distributed. Two doctors work the emergency room, where NIA patients have a higher priority than CW patients. NIA patient sees the doctor for an average of 45 minutes, exponentially distributed out of which , 75% of them need to go for lab tests and the remaining are allowed to go back home. Lab tests take around 30 minutes to complete and after which, these NIA patients need to see the doctor once again for further consultation. Now attending to CW patients requires about 30 minutes. CW patients as already mentioned have a lower priority than the NIA patients but have a higher priority than the NIA patients visiting for the 2nd time. The objective would be to gather relative queue information and maximum utilization of the resources to achieve near 100% efficiency. The relative simulation is done for a period of 10 days (120 hrs.).

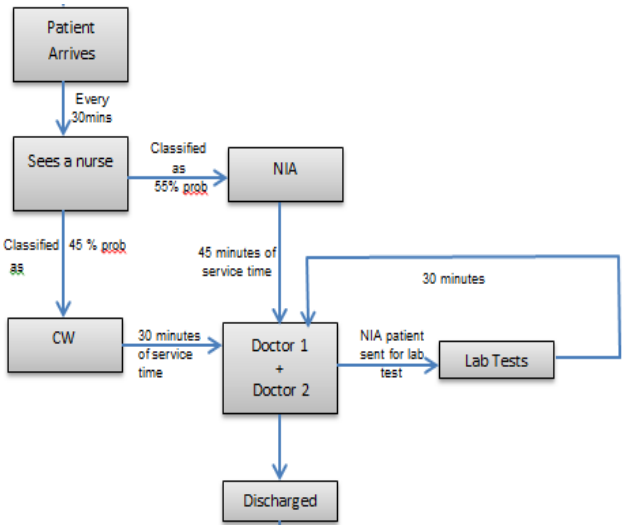

Figure 2: A schematic diagram of the emergency room simulation

6. GRAPHS AND ANALYSIS

Fig. 1, Fig.2, Fig. 3 are the representations of the waiting times of the different CW, NIA1 (without lab tests) patients and NIA2 (with lab tests) respectively. Graph 4 gives a comparative analysis of all waiting times.

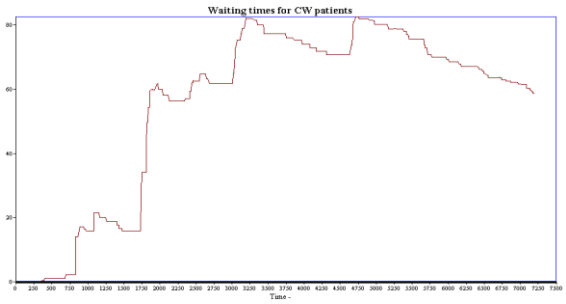

Fig.1: Waiting times for CW patients (all figures in minutes)

Fig.2: Waiting times for NIA patients who do not have to get any lab tests done (namely NIA1) (all figures in minutes)

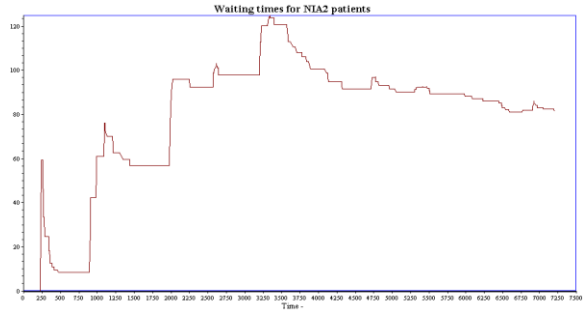

Fig..3: Waiting times for NIA patients with lab tests to be done (namely NIA2) (all figures in minutes)

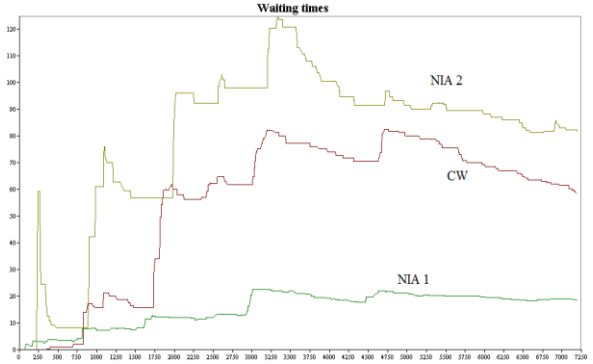

Fig. 4: Comparative analysis of all waiting times

It is clearly understandable from graph 4 that, NIA2 patients have a certain amount of waiting time associated, more than the others. The readings as mentioned in Table 1 and 2 give a clear picture of the utilizations of the different aspects of the Emergency Room system.

7. RESULTS

Table 1: The waiting times (in minutes) for an observation stretching over 120 hrs

Identifier		Average	Minimum	Maximum
Nurse	% Busy	33.826	--	--
	Number Scheduled	1.0000	1.0000	1.0000
	Utilization	33.826 %	--	--
Doctor	Number Busy	1.4231	0	2
	Number Scheduled	2.0000	2.0000	2.0000
	Utilization	71.156 %	--	--

Table 2: The utilization of the various resources: 1 Nurse and 2 Doctors

Identifier	Average	Minimum	Maximum	Observations
CW	58.75	.00000	289.37	115
NIA1	18.652	.00000	97.011	125
NIA2	81.476	.00000	438.18	94

8. OBSERVATIONS

The results show that though there is a lot of waiting time. So some enhancement of the system needs to be done in order to increase efficiency. One might argue about increasing the resources, however this is not a proper solution as the resources have idle time and are not 100% utilized. So we need to re-think the system before signing off for the system to go live.

9. LIMITATIONS OF SIMULATION

- Good Simulation models require large amounts of computer time hence are often computationally expensive. Thus simulation is very time consuming and expensive.[1]
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- Simulations do not provide solutions but rather generate a way of evaluating solutions.
- Simulations only provide a set of the systems responses to different operating conditions, Hence it lacks precision which is often difficult to measure.
- Simulations produce different solutions in repeated runs as they employ trial and error methods.
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10. NEW TRENDS IN PROCESS SIMULATION MODELLING

One of the most commonly used methodologies in information Systems and operation management research.[3] Now a days the methods and applications of modeling and simulation and commonly used in emerging areas of, but are not confined to –

- Computer Science: Computer networking and communications, high performance computers, real time systems, mobile and intelligent agents and language design.
- Engineering Technology: System engineering and design, aerospace, traffic system, microelectronics, robotics and air traffic.
- Physical Science & Life Science: Physics, Biology, Chemistry, sociology, biomedicine.
- Simulation models are totally dependent on their creators.
- Simulations like any other programs are prone to bugs hence need debugging.
- Model Building needs special training. It is learned over time and through experience.
- Simulation results may become difficult to interpret. Most simulation outputs are random variables, so it can be hard to distinguish whether an observation is a result of system or randomness

11. CONCLUSION

It was observed that without the aid of simulation, it would not have been easy to understand the functioning of the system and the tradeoffs associated with the system. With the help of simulation we can come to a firm ground as to what needs to be done next, in order to increase the efficiency of the system.

12. REFERENCES

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