
ABMS & DES For Modelling Emergency Department

Camila Mejía Quintero*
Paula Alejandra Escudero Marín†

EAFIT University
Medellín, Colombia

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1 Problem statement

Discrete event simulation (DES) has long been used in manufacturing and service sectors like Health Care Systems because it allows representing process, waiting times, patient flow, resources utilization, among other; DES modelling tends to ignore long-term evolutionary effects though [1].

On the other hand, Agent-Based modelling and simulation (ABMS) main approach is modelling of individual agents that interact [2]. ABMS is a very popular area of study, where human behavior affects the system; nonetheless if you model an operational system by ABMS you will probably be able to capture main features of the system though you would waste computational resources and the capacity of DES to represent the process.

One of the research questions we want to address in this research project is how do we take the advantages from each of the two simulation methodologies mentioned above to make a better model that captures by DES the process structure and by ABMS the behavior of the emergency department's doctors? We will take the Emergency Department as example to build a hybrid model, because that system has two main features such as operational and human behavior.

2 Objectives

2.1 General Objective

To develop an Agent-based Modelling and Simulation (ABMS)-Discrete Event Simulation (DES) hybrid model of an hypothetical emergency department, which represent operational aspects like resources utilization and patient flow, and behavioral aspects such as decision making and interaction of individual agents.

*Student of Mathematical Engineering, EAFIT University, Medellín, Colombia

†Tutor Professor, Department of Mathematical Sciences, EAFIT University, Medellín, Colombia

2.2 Specific Objectives

- To review the literature related to the area of ABMS & DES in health care, specially for modelling different aspects of emergency departments.
- To build a DES model capturing the main aspect of emergency departments.
- To use ABMS for representing interactions between emergency department's doctors and some decision making aspects of them.

3 Justification

The importance of this project is summed up for the following aspects:

- One of most important areas of mathematical engineering is modelling and simulation. This research project is going to study in more depth than in class aspects of two simulation methodologies and provide tools for analyzing the methodologies that are more suited to represent different types of problem.
- Health care system are important, specially emergency departments are popular because its importance of doctor's decisions because human life is in a high risk of dying every time. Most of the modelling of emergency departments is done while DES, however ABMS has not been widely used in this area. Therefore, it is important to analyze how ABMS & DES can complement each other in order to study different aspects of the performance of an emergency department.

4 Scope

The research focuses on developing a DES model of the main process in an emergency department that include arrivals, registration, triage, evaluation, test, treatment and exit. The DES model is going to be adapted from Gunal & Pidd [3].

In addition, ABMS will be used to model some aspects of doctor's behavior by using a human behavior framework called PECS [4]. PECS considers for main characteristics of human behavior: P-physical, E-emotional, C-cognitive and S-social. From those only the physical and emotional characteristics will be considered in our model.

5 Background

A large and growing body of literature has investigated different aspects of health care using modelling and simulation. Accident and Emergency (A & E) Department have enjoyed a great popularity in this area. For example, Gunal & Pidd [5] and the systematic review of Fone [6] report a widely list of papers have been published about modelling, simulation and others tool to model and represent the health care in its different areas such as hospital scheduling and organization, infection and communicable disease, costs of illness and economic evaluation, screening and miscellaneous [6].

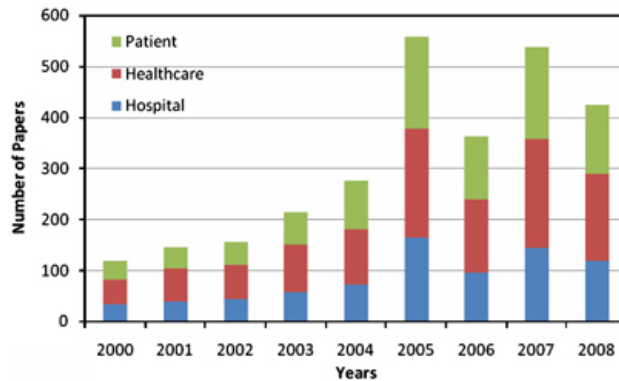


Figure 1: Number of papers in health-care simulation taken from Gunal & Pidd (2008, PP 43)

Facet	DES	ABS
World view	Top-down	Bottom-up
Time handling	Irregular time step	Fixed time-step
Randomness	Key facet of model Represents times and probabilities	Generally used only for probabilities

Figure 2: Facets of DES and ABS Modelling taken from Robinson (2010, pp 194)

Gunal & Pidd focused in DES, Figure 1 shows the numbers of the papers that they found since 2000 to 2008 about health care system using DES.

They obtained three main conclusions of their review. First the majority of the models focus in the solution of specific problems in individual area of health-care system instead of giving a general idea of the whole system. Second, it seems that health-care modellers do not reuse models produced by others but instead build their own each time, because the goal of each model is for specific hospital or institution and the last conclusion is given for what specifics processes of care could be easy represent by DES such as staff schedules, adding or removing beds, increasing the number of nurses, and other clinicians [5].

On the other side, there is lack of work in using hybrid models (DES & AMBS), Stewart Robinson [2] makes emphasis that DES is not appropriate for modelling a complete operational system due to it cannot help with detailed decisions about the layout of service operations where customers are present. Hence, he proposes the ABMS to approach for representing the customers and service staff as agents in order to model these interactions the overall system behavior emerges.

It is also specified the difference between those methodologies by Figure 2.

6 Methodology

The first step is a summary of the literature review of the use of agent-based modelling and discrete-event simulation in health care specially for modelling emergency departments, there are

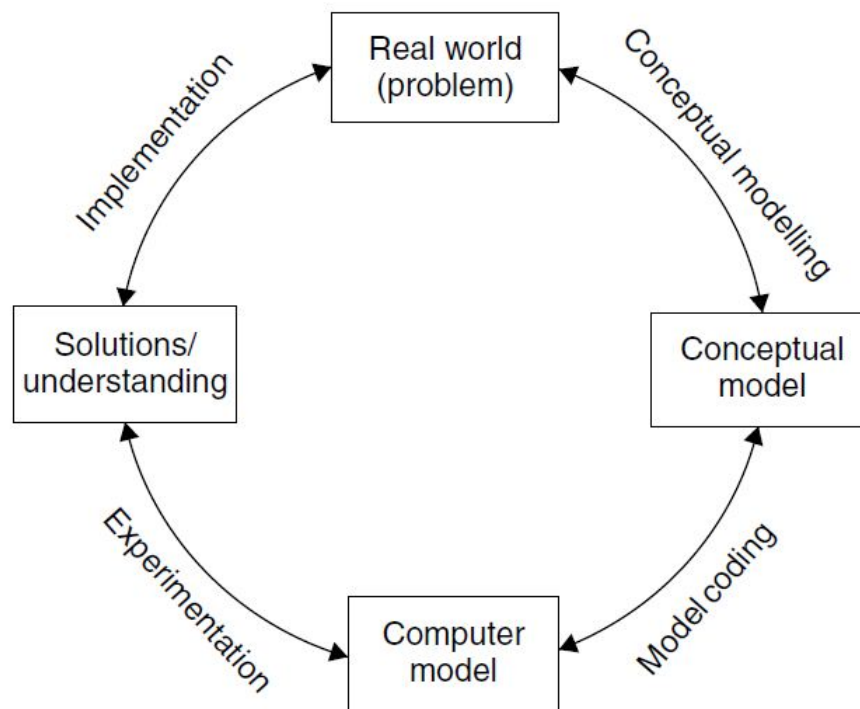


Figure 3: *Simulation Studies: Key Stages and Processes.* (Brooks, R.J. and Robinson, S., *Simulation 2000*, Palgrave Macmillan)

a lot reviews of the use of DES in this area, whereas ABMS has briefly reviewed. The summary will be used considering previous reviews done by others researchers.

The second step is the development of the ABMS & DES model. As any simulation the process of developing model is relatively standard, we will use the methodology proposed by Tako and Robinson [7] (see Figure 3), where they summarize some of the main steps. The first step is the problem formulation, the second step is the development of conceptual model, since we are going to have two different types of models, the conceptual model will be done in two main parts: the DES model development will be based in the conceptualization that Gunal and Pidd [3] have already done. For the ABMS model, we are going to use the framework called PECS [4] to represent some aspects of human behavior focusing in physics, emotional and cognitive conditions.

Once we have defined both of conceptual models, we are going to start the modeling coding using Anylogic [8], it is a software multi-propose, allows to use DES, ABMS and DS (Dinamic System Simulation) on the same time what helps to find an easy way to construct hybrid models.

Finally, we are going to make the verification, "comparing the computer model with the conceptual model description", [9] and analyze the results.

7 Schedule

Dates	Activity
July 20th - 24th	Literature Review
July 27th - 31st	Literature Review and pre-project
August 19th - September 11th	Conceptual model construction and Software approaching
September 14th - 18th	Model codification
September 25th	Oral progress report
September 28th - October 23th	Model development
October 26th - 30th	Simulation model verification and analysis
November 6th	Final project report
November 9th - 13rd	Preparation of final project presentation
November 20th	Final project presentation

8 Budget

EAFIT University provides data bases for the literature review, software licenses to implement the computer model and the tutor professor.

9 Intellectual property

According to the internal regulation on intellectual property within EAFIT University, the results of this research practice are product of Camila Mejía as student and Paula Esudero as tutor professor.

In case further products, beside academic articles, should be generated from this work, the intellectual property distribution related to them will be directed under the current regulation of this matter determined by EAFIT University [10].

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