

AC 2010-894: A META STUDY OF DISCRETE EVENT MODELING AND SIMULATION (DES) USED BY HEALTHCARE INDUSTRIES

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A Meta Study of Discrete Event Modeling and Simulation (DES) Used by Healthcare Industries

Introduction

Discrete event modeling and simulation (DES) is a popular tool in widely varying fields for identifying and answering questions about the effects of changes on processes. The manufacturing and business sectors have been using DES since the early 1980's. Because of issues related to economic and social factors, the healthcare industry appears to have begun using DES to improve its services and care.

The authors have taught with and used DES software, Arena® and ProModel, in process analyses over the past decade and were intrigued by the usage of DES software especially in the healthcare field. Using healthcare problems that have been analyzed using DES software would give students exposure to realistic situations which they may actually experience (e.g., waiting to be seen in an emergency room).

This concept has application, especially in engineering and technology education, through being able to use real life examples in teaching DES concepts and software. This would give students a better appreciation of the use of DES software in analyzing processes. An excellent source of real life examples can be found at the Winter Simulation Conference¹. The papers presented over the past 10 years of the Winter Simulation Conference were analyzed for such examples to be used in courses such as Systems Modeling or Modeling and Simulation Languages.

In addition, the projects described in each paper were analyzed for characteristics that would be useful for use as potential student projects. These projects could also be used as the basis for engineering and technology students to become involved in health care DES research.

One of the first characteristics analyzed was the ranking of the DES software products being used. Figure 1 shows that across all sectors, business, healthcare, and government, Arena® has been shown to be the most prevalent DES software. However, there is some DES software that is designed specifically for the healthcare sector. For example, ProModel Corp. has a special version of their process modeling DES called MedModel². To apply a more systematic procedure to aid in classifying the papers analyzed for where DES is being used in healthcare, the North American Industry Classification System (NAICS)³ was chosen.

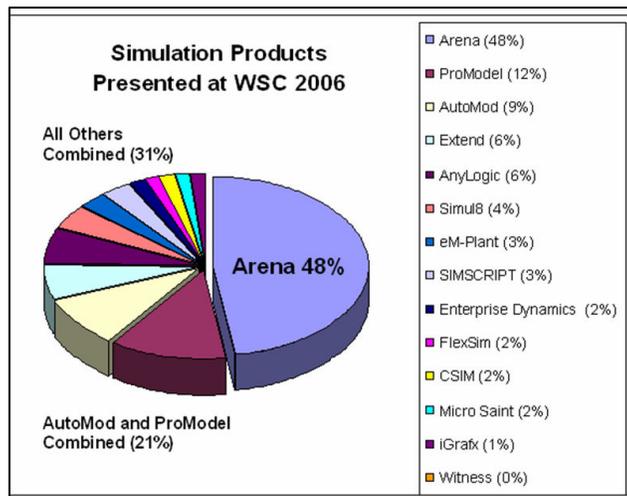


Figure 1. Ranking of DES Software¹

NAICS Sector Codes

The NAICS is a numerical coding system which organizes businesses and industries in 20 sectors. The NAICS was developed by the US government to be used by certain federal agencies to classify businesses and industries. According to the US Census Bureau³ the system is used for “collecting, analyzing, and publishing statistical data related to the business economy”. This appears to be an appropriate system to use for a Meta study of which areas of the medical industry are using DES. The NAICS uses a series of sector codes to classify all businesses and industries. Employing the NAICS sector codes for medical fields as the defining categories, the papers presented for the past 10 years of the Winter Simulation Conference were analyzed and tabulated for those codes. NAICS Sector Code 62

comprises establishments providing health care and social assistance for individuals. The sector includes both health care and social assistance because it is sometimes difficult to distinguish between the boundaries of these two activities. The industries in this sector are arranged on a continuum starting with those establishments providing medical care exclusively, continuing with those providing health care and social assistance, and finally finishing with those providing only social assistance⁴.

Results

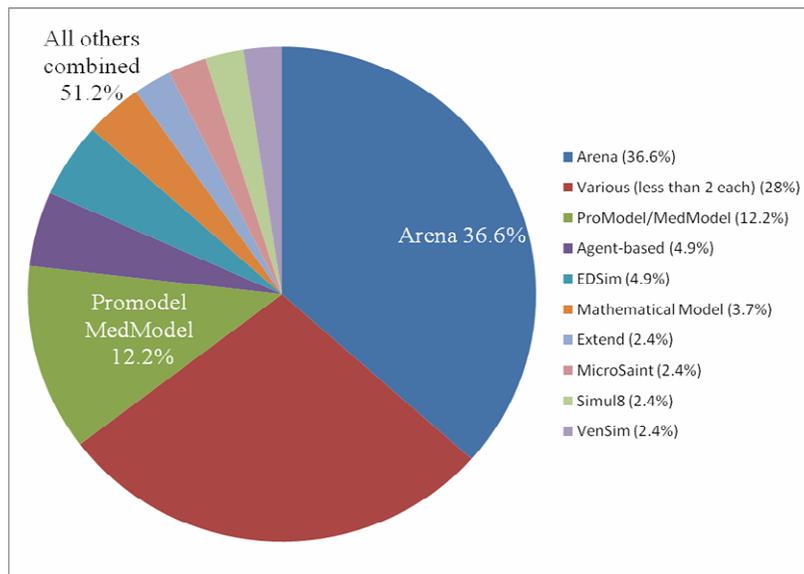
From the 97 papers reviewed, it was found that several medical areas were prominent in the use of DES while other areas were not represented at all. Some papers were categorized under multiple codes with a result of 101 total observations. Table 1 shows that one NAICS Sector Code (622110 General Medical and Surgical Hospitals) comprised 44.6% of the studies examined and 3.36% of the NAICS codes were represented. The most prevalent topic within 622110 NAICS code was emergency rooms/departments (45.8%), followed by inpatient services (16.7%), outpatient services (14.6%), OR (12.5%), Pharmacy (8.3%), and lastly ICU (2.1%).

Table 1. NAICS Numerical Sector Codes

NAICS Code	Description	Qty
622110	Hospital, general medical and surgical	45
621111	MD's (medical doctors, except mental health) offices (e.g., centers, clinics)	7
923120	Administration of public health programs	7
622310	Specialty (except psychiatric and substance abuse)	6
621512	Labs, Medical Radiological or X-Ray	5
621991	Organ donor centers, body	5
621493	Freestanding emergency or urgent medical care centers and clinics (except hospitals)	4
236220	Hospital construction	3
621511	Medical Laboratories (non radiological or x-ray)	2
325412	Pharmaceutical preparations (e.g., capsules, liniments, ointments, tablets) manufacturing	1
621498	All other outpatient care centers	1
524114	Hospital and medical service plans	1
922190	Other justice, public order, and safety activities	1
621112	MD's (mental health)	1
	NOT Identifiable	12

There were 82 studies (84.5%) that had identifiable DES software that was used for the study. It was found that the healthcare industry follows the trend of the overall use of simulation in that Arena® was the most commonly used software (36.6%) followed by Promodel/Medmodel (12.2%) as depicted in Figure 2.

Figure 2. DES Software Ranking in HealthCare



Some basic organizational information about the papers are shown in Table 2. As expected the overall majority of the DES studies were performed in the USA. The USA studies represent 13 states while the Outside USA studies represent 18 countries. Interestingly, the number of

universities that participated in the studies was nearly the same between inside and outside the USA.

The large number of studies by consultants in the USA compared to outside the USA may become a spark for consultants outside USA to capitalize on this gap. Also, the larger number of studies of hospitals/medical centers inside the USA compared to outside could spark additional research by universities outside USA. This additional information provides some ideas for both domestic and international faculty to know what they may need to focus on for case studies or class projects.

Table 2. Type of Organizations in the Study

Organization	Inside USA	Outside USA
University/University Medical Center	27%	31%
Hospital/Medical Center	10%	1%
Business/Pharma	1%	2%
Consultants	22%	3%
Organ Donor Centers	1%	--
High School	1%	--
Government Agencies	--	1%
Total	62%	38%

Besides the sector codes shown above, some unusual aspects of studies or study areas were found. Below is a brief list of some of these areas that could be incorporated into modeling and simulation courses as projects, class presentations, etc.

1. Explore using a contrary approach of not including the patient as the driving factor in a simulation study of a medical facility or process⁵.
2. Developing ways to reduce appointment lead time and patient no show rate in an MD office, imaging center, or other medical facility⁶.
3. Explore more optimizations of all factors studied in an ED or other medical facility.
4. Explore nontraditional ways to predict arrival time⁸.
5. Explore patient flow methods through an ED or other medical facility^{9,10,11}.
6. Explore buffering techniques for waiting times¹².
7. Evaluate pharmacy inventory, ordering and delivery within a hospital or medical center^{13,14}.
8. Create optimized designs of ED, Outpatient Centers, or Imaging Centers without regard to limitations^{10,15,16,17}.
9. Identify ways to optimize the time for screening exams in EDs^{11,18}.
10. Explore insurer benefits from a simulation of how to get information efficiently from screening tests¹⁹.

Summary

The fact that ER/ED comprises nearly 50% of the studies within the 622110 NAICS Sector Code indicates that that area still needs further research. Inpatient services, outpatient services, and

OR appear to be critical as well. Outside of the 622110 NAICS Sector Code it would appear that several areas could benefit from further study. These include doctor's offices, pharmaceuticals, medical radiological (x-ray) labs, and public health programs.

Although there are numerous DES software available, including software specific to the healthcare industry, it was found that Arena® and Promodel overwhelming comprised the software used. Based upon this study it would appear that DES graduate and undergraduate students do not have to be exposed to healthcare specific software in order to conduct projects in the healthcare industry.

This paper provides only one area of study that could be applied in the teaching DES. Because healthcare is currently a predominate topic in society it would be a timely topic to discuss in a DES class. It would appear that students would need to understand basic DES concepts that apply to all simulations. A DES class could use healthcare as a primary area to teach the concepts of arrivals, flow, capacity, queuing times, costs, etc. Meta-studies of other WinterSim conference tracks could provide other topical areas for the development of case studies. It is hoped that this study will help those involved in using DES to identify areas of healthcare research interests and possible consulting activities.

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