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NOSOPOLIS: TOWARDS A HYBRID AGENT-BASED DISCRETE EVENT SIMULATION TOOL FOR EMERGENCY MEDICAL SERVICES IMPROVEMENT

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ABSTRACT

In this study we present the development of a conceptual framework for a hybrid agent-based discrete event simulation model within the context of emergency medical services. There are many existing simulation models of emergency medical services (EMS), but each is considered in isolation, rather than as a single node in a complex web of regional EMS. The aim of this research is to develop a hybrid approach tool, using distributed simulation technology, that would enable interactions between existing EMS models and so provide an integrated network of the different components of the EMS. This would provide possibilities for integrated efficiency improvement scenarios and system analysis. This concept is illustrated using an agent-based ambulance service model and a discrete event EMS model. The advantages of such a technique is that expensive and time-consuming models can be reused and expanded to incorporate influencing external factors.

1 POSTER OVERVIEW

Introduction: As part of a larger research project that is studying complex and large model integration, and the relationships between agent-based (ABS) and discrete event simulation (DES) techniques, we are reporting the first steps of the conceptual framework development for an ABS-DES hybrid model, where the London emergency medical services (EMS) were used as an exemplar scenario. The first part of the model is an ABS simulation of ambulance services and the second part is a DES simulation of an EMS. The EMS model is based on previous work (Eatock et al. 2011). The link between the two parts is achieved by distributed simulation techniques. At this stage, online published information by the UK NHS and the London ambulance service (LAS) has been used for the conceptual framework outline and the case study design. The objectives of this research are to develop a framework for integrating ABS and DES methodologies, which will support reusability of existing models, and to create a comprehensive tool for investigating complex EMS systems. This will be accomplished by an integrated EMSs simulation tool.

Methodology: The simulation requirements of such a large scale integration of different services are difficult to fit in a single simulation technique. Therefore, a hybrid simulation approach was adopted which supports model reuse. Reuse of simulation models has been debated among simulation experts and the advantages and disadvantages of this practice have been discussed in the literature (e.g., Robinson et al. 2004). The key issue here is that reuse saves time and money in terms of model development. Here, we introduce the conceptual framework for our tool which henceforth will be called NosoPolis (i.e., Hospital City). The proposed hybrid EMS simulation framework consists of two components. The first component

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of the *NosoPolis framework* is an ambulance service ABS model with geographical information systems (GIS) topology. Simulation agents are the hospitals, which are static and have predetermined location coordinates, the emergency calls, which are generated and have specific location coordinates, the patients, and the ambulances, which are moving on a geospatial environment and interact with it. The ABS model will be built using the RePast Simphony java-based toolkit. The second component is an EMS DES model which is based on experiences from modeling A&E departments in the UK (Eatock et al. 2011). The SIMUL8 software package will be used to develop this model. The link between those two components is achieved by distributed simulation technology which is employed for the coordination of time and data between the two models. There is a two way information flow between the two units of the EMSs (i.e., hospitals notify ambulance services of their availability, and the latter notify the interested A&E that a patient is on the way). Moreover, there is patient flow from the ambulance service to A&E. A series of Interoperability Reference Models (IRMs) have been developed and standardized to address interoperability issues between DES models. According to Taylor et al. (2009) there are four types of IRMs. However, in this project, due to model heterogeneity the above standardization of IRMs will be expanded. In this study, the interactions between the two parts of the hybrid model can be represented by a Type A.1 & Type C IRMs. Where the former indicates that there is an entity transfer, and the latter indicates that there are shared events between the two models.

Conclusions: The potential advantages of the proposed approach are: model reuse, multi-paradigm simulation, automated EMS model, increase user acceptance by GIS visualization, and accurate distance and traffic information. However, there are disadvantages too: requires knowledge of both agent-based and discrete event simulation techniques, requires distributed simulation knowledge, the lack of hybrid validation and verification techniques, and the possible increased runtime due to synchronization overhead. Despite the aforementioned disadvantages, we believe that the benefits of an integrated model approach outweigh the obstacles that might occur in the model building process. The contribution of this research is twofold. By providing a simulation tool for emergency medical services analysis, it is anticipated to equip emergency medical services management with a tool for improving quality and reducing cost in planning and training. Furthermore, this model can also be used for disaster management planning. The methodological contribution of this research will be a framework for a hybrid simulation model which integrates agent-based and discrete event simulation techniques that supports the reusability of existing models by linking them via distributed simulation technologies. The next steps of this project will be the completion and validation of the hybrid simulation model. Following the findings, improvement scenarios will be proposed and tested.

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