Chapter 16
Speeding Up Decision Support:
Investigating the Distributed Simulation of a Healthcare Supply Chain

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ABSTRACT

Discrete-Event Simulation (DES) is a decision support technique that allows stakeholders to conduct experiments with models that represent real-world systems of interest. Its use in healthcare is comparatively new. Healthcare needs have grown and healthcare organisations become larger, more complex and more costly. There has never been a greater need for carefully informed decisions and policy. DES is valuable as it can provide evidence of how to cope with these complex health problems. However, the size of a healthcare system can lead to large models that can take an extremely long time to simulate. In this chapter the authors investigate how a technique called distributed simulation allows us to use multiple computers to speed up this simulation. Based on a case study of the UK National Blood Service they demonstrate the effectiveness of this technique and argue that it is a vital technique in healthcare informatics with respect to supporting decision making in large healthcare systems.

INTRODUCTION

Computer simulation, or just simulation, is a decision support technique that allows stakeholders to conduct experiments with models that represent real-world systems of interest (Pidd, 2004a). It has been widely used for many years in domains such as manufacturing, logistics and telecommunication.. However, its use in healthcare is comparatively new. It is only really during the last decade that the application of simulation in health care has grown

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substantially (Fone et al, 2003). Healthcare needs have also grown in the same period and healthcare organizations become larger, more complex and more costly. There has never been a greater need for carefully informed decisions and policy. Computer simulation is valuable as it can provide evidence of how to cope with these complex health problems. It can be used as an alternative to "learning by doing" or empirical research (Royston, 1999). Furthermore, if carried out correctly, simulation modelling gives stakeholders the opportunity to participate in model develop and, hopefully, gain deeper understanding of the problems that they face. As a result, decision-makers and stakeholders can gain a new perspective on the relationships between the available resources, the level of the system's performance and the overall quality of the healthcare provision.

Many successful studies have been reported using simulation to address health care system problems (Jun et al, 1999; Cooper et al 2007). Of these, four simulation approaches have been used. These are Monte-Carlo Simulation, Agent-Based Simulation, System Dynamics and Discrete-Event Simulation. Monte-Carlo Simulation has its roots in World War Two and is a simulation technique that uses a sequence of random numbers according to probabilities assumed to be associated with a source of uncertainty, for example, stock prices, interest rates, commodity prices, etc. (Rubinstein, 1981). In healthcare, Monte-Carlo Simulation has been used to evaluate the cost-effectiveness of competing technologies or healthcare strategies that require the description of patient pathways over extended time horizons. It is the main approach to modelling used in economic evaluations in health care interventions when there is a need to increase the number of states in the model to overcome the homogeneity assumptions inherent in Markov models and decision trees (Barton et al., 2004). Agent-Based Simulation is a computational technique for modelling the actions and interactions of autonomous individuals in a network, called agents, with a view to assessing their effects on the system as a whole but not independently. It is a technique used since the mid-1990s to solve a variety of financial, business and technology problems. Its application in the healthcare sector is not yet widespread but is has been used to study problems such as the spread of epidemics (Bagni et al., 2002). System Dynamics comes from Industrial Engineering in the 1950's and is a modeling approach that takes a holistic view of the problem. In healthcare, Systems Dynamics is used to model health systems from a more integrated or top-level approach. This simulation technique can assist the design of healthcare policies by examining how the fundamental structure might influence the progressive behaviour of a system. It takes into consideration factors such as the time variation both of tangible elements, such as waiting times and health care costs, as well as intangible, such as patient anxiety and the effects of various pressures on purchasing decisions (Taylor and Lane, 1998). In Discrete-Event Simulation, a technique that emerged in the UK in the late 1950's, systems are modeled in greater detail than with Systems Dynamics and with more complex temporal dependencies than with Monte-Carlo Simulation. It involves the modelling of a system as it progresses through time and is particularly useful for modelling queuing systems (Robinson, 1994). Discrete-Event Simulation is therefore particularly well-suited to tackle problems in healthcare where, for example, resources are scarce and patients arrive at irregular times (for example in A&E departments). Some of the applications of Discrete Event Simulation is therefore to forecast the impact of changes in patient flow, to examine resource needs (either in physical capacity of beds and equipment or in staffing), to manage patient scheduling and admissions or to investigate the complex relationships among the different model variables (for example, rate of arrivals or time spent in the system). Discrete-Event Simulation therefore allows decision makers (namely, health policy makers, administrators and hospital managers) to effectively assess the efficiency of existing