Part II
DEDS Modelling and Simulation

In the second part of this book (Chaps. 3, 4, 5, 6 and 7) we examine the modelling and simulation process within the discrete event dynamic systems (DEDS) domain. The presentation is, for the most part, guided by the general process presented in Fig. 2.4.

An important behavioural feature of DEDS models is the central role played by random phenomena. The inter-arrival times between messages entering a communication network and the time to service customers at the checkout counter of a grocery store are examples of such phenomena.

Data modelling is an essential subtask of the conceptual modelling phase in the DEDS domain. To a large extent it is concerned with correctly representing stochastic features of the SUI. Often it involves determining appropriate probability distributions from collected data. This can be a demanding and time consuming task. The project goals guide the identification of the data models that are required. The data modelling task is considerably facilitated when the SUI currently exists and is accessible because then data collection is possible. When the SUI does not yet exist (or indeed, may never actually 'exist') data modelling becomes a very uncertain undertaking and essentially depends on insight and intuition.

Chapters 3 and 4 deal with issues relating to conceptual modelling in the DEDS domain. Chapter 3 provides an overview of some key aspects of random behaviour and variables that are associated with this type of behaviour. It also lays a foundation for the important notions of input and output, and discusses data modelling. The focus of Chap. 4 is the presentation of a comprehensive framework for conceptual model development in the DEDS domain. This activity-based framework is called the ABCmod conceptual modelling framework and its purpose is to capture the structural and behavioural features of the SUI that have relevance to achievement of the project goals.

Chapter 5 introduces the traditional World Views used in creating discrete-event simulation models and shows how a conceptual model that has been formulated in the ABCmod activity-based framework described in Chap. 4 can be transformed into a simulation model based on any of these World Views.

Chapter 6 presents a novel World View called the Activity-Object World View which enables a straightforward creation of a simulation model directly from an ABCmod conceptual model. While traditional World Views require that activities be broken down into underlying events, the Activity-Object World View benefits from the contemporary object-oriented paradigm which allows the preservation of the activity constructs as objects. This preservation feature is important because it considerably simplifies the transformation step into a simulation model and, as well, renders the simulation model far more transparent since the structural and behavioural constructs of the conceptual model are fully visible within it.

The project goals have a direct impact on the way in which experimentation is carried out with the simulation program. A basic objective of experimentation is to produce values for the performance measures stipulated in the project goals. In Chap. 7, we examine how the experimentation activity has to be organized in order to acquire meaningful values for these performance measures.

Documentation is an essential part of any modelling and simulation project. This documentation can be organized in many different ways. We summarize below a particular approach that is formulated in terms of five separate documents. Each of these is briefly summarized.

1. Problem Description Document: An overview of this document was presented in Sect. 2.3.1 and we now elaborate somewhat on its contents. In particular, we adopt the perspective that it has two sections called 'the problem statement' and 'the SUI details'. The problem statement provides a concise statement of the problem to be solved while the SIU details section outlines the known information about the SUI.

   Our view of the SUI details section is very much influenced by the science research stream of thought on problem structuring outlined by Wooley and Pidd (J Oper Res Soc 32(3):197–206, 1981). It 'sees problem structuring in terms of gaining an understanding of the problem situation, mainly by gathering quantitative data, going out and looking, etc. There is a consciousness of finding out what is *really* happening, of discovering the *real* problem. Whatever is discovered in the course of this initial ferreting about will determine which aspects of the situation are modelled'. Note that an important implication here is that model development is a subsequent exercise.
2. Conceptual Model Document: This document is primarily concerned with the presentation of a conceptual model for the project (Sect. 2.3.1). However it begins with an outline of the goals of project because these have a fundamental impact upon model development (Sect. 2.3.2) and effectively serve as a perquisite for that development. As outlined in Chap. 4, we adopt the view that the conceptual model has two principle functions, namely to provide an effective communication vehicle for the various stakeholders in the project and to provide a specification for the computer program (i.e. simulation model) that will be used to carry out the experiments. Accordingly we present the conceptual model at two distinct levels: the first (the 'high level') captures the features of the model at a level of detail that is both adequate for communication and comprehensive.

The second level (the 'detailed level') provides the detail needed for simulation model development.

3. Simulation Model Document: The simulation model is a computer program artefact, and like all computer programs it is essential that adequate documentation about its overall organization be provided so that those involved with its maintenance have adequate information to carry out required tasks. The development of program code from a conceptual model is explored in some detail in Chaps. 5 and 6.
4. Validation and Verification Document: In spite of significant care taken during the development efforts that yield a simulation model, that model may be flawed. The origins of these flaws are typically categorized into one of two broad areas: inadequate understanding of the SUI's behaviour and errors introduced during computer program development. A variety of tests and safeguards are typically invoked to uncover these deficiencies and it is normally expected that these various measures be appropriately documented (Balci, The Handbook of Simulation, Chapter 10, John Wiley & Sons, New York, NY, pp. 335–393, 1998).
5. Experimentation and Output Analysis Document: This document reports on the experimentation that is carried out with the simulation program and on the analysis of results that are obtained. The implications of these results upon the original problem that motivated the study are typically included as well. This topic is explored in the discussions of Chap. 7.