Chapter 7
Models of Various Forms of Batching

Grouping individual jobs into sets, called batches, is a strategy frequently used in industry. One cause of batching is for the purpose of transportation between workstations. For instance, workers may require mechanical help for moving heavy items between two machines. If the mechanical help is a large machine such as a forklift, then a pallet might be loaded first before a forklift truck is requested. Another form of batching occurs when items are batched by type for the purpose of sharing a machine setup step even though the items are actually processed individually. By batching like items, only one setup need be performed for the whole set. And finally, a frequently encountered batch service process is that of a multiple service capacity resource such as an oven. Due to the slow processing rates of some heat-treatment or plating processes, large capacity machines have been developed that can process several units of an item simultaneously.

The batching phenomenon is motivated by a perceived beneficial effect of grouping. However, the impact on downstream processing stations can be significant. To illustrate, consider the batch move concept where, say \( k \), items are grouped together for the convenience of moving them to a subsequent single unit processing station. Items will arrive at the next workstation \( k \) at a time, so the workstation might be idle for a while and then instantaneously have a queue of waiting units. The variability of a batch arrival process when the batch is broken back into individuals (frequently caused by processing items simultaneously) is much greater than the inter-arrival variability of the individual items and, the workstation queueing behavior will be exacerbated. This leads to increased cycle times and larger WIP levels at the downstream workstation. In addition, the batch process itself causes an increased delay because units must wait for the completion of other units before they can be grouped and continue processing.

In this chapter, models are developed for various forms of batching and so that the benefits and costs of the grouping process under consideration can be quantified. For the setup sharing situation, there will be a trade-off between the cycle time increase and the setup time savings due to batching. The chapter is concluded with a discussion of network models that include a batch (oven-type) processing workstation. The term “job” can be confusing because in some contexts a job my refer
to an individual item and in other contexts it may refer to the entire batch. To avoid confusion, the term “item” will always be used for an individual job and never to the entire batch.

7.1 Batch Moves

Consider a situation where individual items are grouped together into fixed batches of size $k$ at the completion of processing at a workstation that processes single units. Items wait in the incomplete batch until the proper quantity has accrued and then the full batch is transported to the next workstation. (A basic assumption used throughout this text is that transportation time is negligible and, therefore, is not explicitly considered. If transportation time is significant, it can often be approximated in the model by considering the transporter as a separate workstation.) An additional assumption is made that the receiving workstation processes items individually, hence, the batch is merely a convenient transportation tool. The modeling of the batch move situation is a building block for more complex models. In addition, we will demonstrate that batch moves add to the cycle time in comparison to a system where items are moved individually. Figure 7.1 illustrates a batch move system.

To model the batch move, several aspects of the problem will have to be considered. First, the batch forming time as it contributes to each individual item, or the average item delay within a partial batch, needs to be computed. (The batch forming time is added to the cycle time of the workstation receiving the batch even though the batch forming actually takes place at the workstation sending the batch.) Then the arrival stream characteristics for the batch receiving workstation need be developed; that is, the mean arrival rate for batches and the squared coefficient of variation of the inter-arrival batch times must be computed. And finally, the modeling approach for developing the second workstation cycle time is different than our previous analyses. The cycle time model is separated into the standard components of the queue time and the service time. The queue time, however, is developed from