7.34. Modify the throughput time equation of the mean value analysis algorithm to allow for priority dispatching at workstations. In this case, each part type has a priority and parts in queue are able to proceed ahead of lower-priority part types. Assume that once the machine begins a job, it will complete the job even if a higher-priority job arrives, i.e. there is no preemption of the current job.

7.35. The MVA algorithm described in Section 7.3.2 assumes exponential service. Modify the model to allow for general service-time distributions. Hint: It can be shown that when a customer arrives to a queue, the distribution of the expected residual processing time for a job currently in process is given by: $R = \Pr(\text{Server Busy}) \cdot E(\text{Remaining Service/Busy}) = \frac{\lambda E(S^2)}{2}$ in which λ is the arrival rate and S is the service time.

CASE STUDY 7.7 *Safe-T-Lock Company*

Safe-T-Lock Company is one of North America's premier manufacturers of residential door locks. Founded in California in 1898, the company specialized in small jewelry and furniture lock sets for most of its existence. Spurred by the construction boom and migration to the southwest, the company built a facility in Arivaca, AZ in 1970 to produce residential door locks. The plant was later expanded several times and reached its current size with 185,000 square feet of manufacturing and warehousing space in 1988. Business declined soon thereafter, and Safe-T-Lock operated at a deficit from 1988 through 1992. The company even considered closing the Arivaca facility. However, residential construction began to pick up again in the mid-1990s, and plans to close the facility were discontinued. The facility turned a net profit of $3.4 million in 1998 on sales of 3,900,000 lock sets grossing $21,000,000. This profit was realized despite absorbing a significant investment to switch to more environmentally friendly cleaning and plating processes.

A knob and door lock set comprises an internal tumbler frame, a lock/key mechanism, inner, side and outer faceplates, and handles (knobs). A single-door lock contains approximately 30 (mostly metal) parts. The company is known for its high-quality brass finishes and ornate face plate designs. The inner and outer faceplates are stamped in the facility whereas most of the other metal and plastic parts are purchased outside the facility. All metal parts are cleaned, polished and finished in-house. Tumbler frames connect the inner and outer handles and house the key mechanism. The frames and key mechanism subassemblies are produced in-house and final lock sets are also assembled and packaged in-house. Tumbler frame subassemblies are produced on a semi-automated line. Lock/key mechanisms are hand-cut to specific customer codes and then inserted into the tumbler frame before being transferred to final assembly. There are two standard frames and five grades of lock/key mechanisms varying from inexpensive designs to highly secure deadbolts. Tumbler frames come in a standard size, therefore, either frame can accommodate all lock/key mechanisms.

The company distributes a catalog with over 100 face plate and handle designs each with a choice of four finishes. Several new designs are added each season. The top six designs with the smooth brass finish usually account for approximately 40% of sales. The smooth brass finish with other catalog plate designs makes up an additional 18% of sales. The other three finishes each account for approximately 12% of demand with this being evenly divided among all 100 plate designs. The remaining business is in custom-design sets. These customers either supply their own design specifications or work with the company's designers to produce the engineering drawings and required tooling.

Currently, the high-demand items that account for 40% of sales are made-to-stock. Typically, an order quantity of 500 lock sets is used for these items. Any subset of a production batch can be supplied with a common master key if requested by the customer. The company tries to maintain a promise to ship orders for these items within twenty-four hours. Customer orders for other catalog items should be met within five days and custom items should be met within two weeks.

Final assembly and packaging involves sandwiching the tumbler frame and lock/key mechanism between the inner and outer face plates, locating that assembly into the bottom plastic wrapper along with the side plate and instructions, adding the top wrapper and sealing the package with a semi-automatic snap and seal process. To ensure a correct matching at assembly, the instruction set follows the lock/key mechanism throughout the process. A serial number is engraved on the lock/key mechanism and a matching bar code is removed during packaging and placed on the instruction sheet. All material handling in the plant is done with manual push carts. The carts are used to move bins of parts to work centers from the warehouse and to transport parts between work centers. The carts have three layers and each layer can hold a container.

A container can hold up to fifteen packaged lock sets. Summary data on the production processes appear in the Table below.

Production Capacity for Safe-T-Lock Company

Department	Capacity (Lock Sets/Shift/Workstation)	No. of Workstations	No. of Shifts/Day
Parts Cleaning	2500	8	1.5
Plating	8000	2	2
Finishing	7000	2	2
Tumbler Subassembly	600	15	2
Lock/Key Subassembly	145	35	3
Assemble and Pack	3000	3	2

The facility is laid out with a process organization. All workstations of the same type are located in the same area. A centralized shipping and receiving area uses a common warehouse for storing parts and completed lock sets. The two plating and finishing lines would be difficult to move, however, the other workstations are easily moved. Setup time is approximately a half hour to change over the finishing line but minimal for other processes.

Most of Safe-T-Locks sales are through national hardware and department store chains. Customers fall into two basic categories — developers and homeowners. The developers often order large sets of locks. A typical developer order through a retailer may be for one hundred homes with three exterior doors each. The three locks destined for a single home would match identically and all the locks for an order would typically have the same finish spread perhaps over several faceplate designs. The order may require a common master key for use by the developer during construction as well as individual key codes for each house.

In the past two years, Safe-T-Lock has been plagued with shortages. Despite increasing employment and inventory levels, the company is now losing business because delivery promises are not being met. In addition, although product quality is still high, shipments are frequently returned for not having the correct combination of products. Currently, the plant employs 220 workers spread over two shifts. The plant usually operates five days per week but extends to six days per week plus possible daily overtime during the busy season of January through March, which follows the publication of the new catalog and precedes the peak home building season.

Richard Bellin was hired from the Bensen Consulting Company one month ago to become the Production Control Manager for the Arivaca, AZ manufacturing site. Mr. Bellin had been with Bensen for five years after graduating with an undergraduate degree in Industrial Engineering. Bellin initially specialized in installing MRP software while with Bensen, however, in recent years he had gained expertise in just-in-time practices and lean manufacturing. He has spent the past month trying to understand the product flow and current production process at Safe-T-Lock. He has come to the conclusion that the facility layout is logical, but poor demand forecasting has resulted in large inventories of the wrong products and shortages of hot items. In addition, the order-priority system does not match customer demand or inventory and, thus, workers are continuing to prioritize the wrong products. Yesterday, when he realized that the entire week had been spent rushing through an order for a make-to-stock part while several large customer orders were cancelled because of late delivery, Richard Bellin recognized that he had to either change the system or start looking for his next job.

Activities and Discussion Questions:

1. Draw a sketch of the production flow process.
2. Does either kanban or CONWIP seem to be an appropriate production control system? How does the current situation compare to the environmental requirements for a kanban system?
3. Propose a production control system that you believe would work for this facility. What additional information would you want to collect before deciding to go ahead with this new system?

4. How would you define the work centers for this facility?
5. What kind of relationships would you try to develop with vendors, and how would you go about establishing those relationships?
6. How would you manage the balance between make-to-stock and make-to-order items?
7. If any items are to be operated using a kanban system, give the container size, and indicate the number of kanbans required.
8. What other actions need to be taken?