10.2 Flexible Enterprise and Ellipse Strategy

10.2.1 Introduction

The flexible manufacturing system (FMS) used in production consists of a set of identical and/or complementary, numerically controlled machines connected through an automated transportation system [12]. This Central Server System (CSS) is usually controlled by a network of computers on site, for example, in a job shop [1].

This chapter [11] considers a Central Server Model (CSM) incorporating four routings and a sales center in operations management. The central server corresponds to an FMS parts warehouse, regarded as a sales/profit center. Based on Chapter 8 [3, 10], inventory, busy, idle, and blocking factors are taken as operating costs, and the operating cost sum is obtained analytically as the (expected) operating cost by [6, 7].

This two-center operating problem was first formulated by Matsui [4, 5], and was modeled as a Management Game Model (MGM) by Matsui [7]. The sales center generally seeks to maximize sales revenue, while the production center seeks to minimize operating cost. The two-center problem involves the self-optimized solution which is not necessarily realized in profit maximization.

We start by discussing the behaviors of these costs in a production center (CSS), then consider the problem of maximizing the marginal profit – net reward = sales price – operating cost – under lead time (time reliability). We use Matsui’s two-stage design [6, 7] instead of multiobjective programming. Based on [9], we apply the two-stage design and the pair-matrix table to CSM, and the ellipse shape is refound in a CSM with four routing strategies.

10.2.2 CSM with Sales

10.2.2.1 Explanations of Models

The CSM is introduced as a two-center model consisting of sales and production/service centers (Fig. 10.2.1). The two-centers are a production center with
(M-1) processing stations and a sales center with one transporter. Each station has one or more machines, for example, NC machine tools and machining centers, N parts are fixed to pallets, and the central server is assumed to have unlimited capacity.

Limited local buffers hold parts when processing machines are busy. When one or all of the limited local buffers is full, new parts carried from the transporter are blocked, that is, a “blocking” event occurs. When no parts are being processed, the machine is “idle.”

The main problem is to maximize marginal profit economics: Net profit \( EN = ER - EC \) Under lead time (reliability).

The four main routing rules involve four FMS similar to CSMs considered as queueing networks. The first is the fixed-routing model \( FR \), the second the dynamic-routing model \( DR \), the third the ordered-entry routing model \( OE \), and the fourth the hybrid-routing model \( HR \).

In the fixed-routing model, routing probabilities for carrying parts from the central server to each processing station are given and fixed. Parts are carried to the destination automatically, regardless of whether the local buffer is full. The analysis assumes that fixed-routing probabilities correspond to real distribution of routes between stations for given sets of parts, as seen in the FMS studies [12, 13, etc.].

In the dynamic-routing model, the routing mechanism is designed to send parts to the relatively shortest queue in the station that has the largest number of empty buffer spaces compared to capacity. If all stations are full, parts stay in the central buffer to be delivered later. In the analysis, routing is determined stochastically as seen in the FMS-like studies [14, 15, etc.], and others.