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# A SYSTEMS ANALYSIS AND MODEL OF DRIVER LICENSING IN THE STATE OF FLORIDA

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ABSTRACT

The structure of the system that licences drivers in the State of Florida is addressed. A SLAM simulation model of the system is employed to study various working patterns in the multiple-station multiple-queue service centers that provide licences. The theory of such systems is addressed and alternate, efficient working patterns suggested. (Simulation, Queuing, Work Planning, Scheduling )

## 1. INTRODUCTION

The structure of multiple station-multiple queue service systems is addressed in this paper. The possibilities for different operating patterns and characteristics for such systems virtually is infinite. The large number of characteristic patterns and variety of such systems make development of general analytical models of them essentially impossible. Simulation analysis has been employed effectively for various types of such systems but generalizable conclusions are rare. The goal of this research is to illustrate a set of principles for alternative systemic management patterns.

The referent system was the State of Florida driver licensing offices. The study was undertaken to aid the State Auditor General in evaluating staffing and management for the offices. Long waiting lines and extended service periods had steadily grown at several licensing offices with service times for customers reaching several hours in some instances. The situation had generated enough concern by both Legislators and managers to cause the State to extend its license to six years and to add about 25 percent more examiners. While the full impact of these changes had not been felt, it was apparent that problems persisted.

An extensive analysis of the various offices in the State was initiated by reviewing data from the Department of Highway Safety and Motor Vehicle's management information system and through interviewing managers of that system. Using that data, a simulation model was developed early in the study to mimic the behavior of a single office. The Concord office in Miami was selected because it was identified by managers as one with a particularly difficult situation. The Simulation Language for Alternative Modeling (SLAM) was employed as a modeling vehicle [10]. Using the model developed for the Concord office, analysis of the work behavior patterns was attempted. This analysis with the data available proved to be inconclusive for the problem described by management could not be duplicated in the model.

This led to several assumptions about what had occurred. First, the possibility existed that there was no problem in the office, but one only had to observe the lines to conclude differently. Second, the data available in the management information system was flawed. Validation attempts with the model indeed showed significant problems with available data. The information was not adequate for customer behavior patterns nor for service distribution analysis.

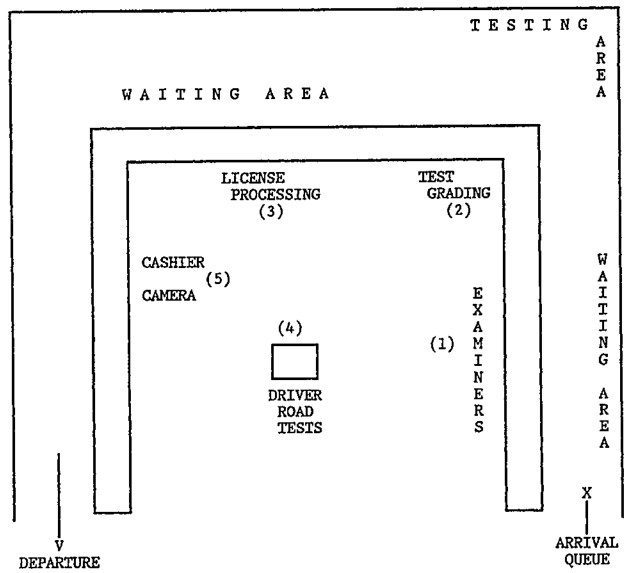
As a result, an extensive data collection effort using accepted work measurement techniques was employed to gather information about service times, about the types of licensing transactions, and other types of data needed to provide a valid model of the system. From the data gathered in this effort, a second model was developed. Its structure and the results of its use are the focus of the remainder of the discussion.

## 2. SYSTEM AND MODEL STRUCTURE

A diagram of the office is shown in Figure 1. The diagram is a structural model of the system which will be discussed in the remainder of this section. Customers arrive in a manner that creates a long line at the entrance. The arrival distribution has a non stationary mean causing the line to vary depending upon the time of day. Derivation of the shifting arrival patterns came from the data collected. The customer may require one of several different services. These are shown in Table 1.

Depending upon the type of service required, a customer will follow one of several work-station visitation patterns. The patterns for the Concord office are shown in Table 2. A computer program to analyze the data to determine the percentage of customers following a given route, the time in service, and the time they wait for service was developed. A summary of the information gained using the program is shown in Table 3. Shown in the table are the percentages of a job type that follow a given pattern. For example, 7.96 percent of type one jobs follow station pattern one. The totals and percentages for them are shown at the margins of the table.

Figure 1. Miami Concord Driver License Office




- <u>Station one examiners</u> greet applicants, determine eligibility, complete license renewal forms, check vision, distribute written test forms, and handle financial responsibility cases. Four examiners are assigned to this station.

- <u>Station two examiners</u> grade written tests and assign road tests and oral tests. One examiner is assigned to this station.

- <u>Station three examiners</u> handle license reinstatements and type original license forms. Two examiners are assigned to this station.

- <u>Station four examiners</u> administer road tests. Two examiners are assigned to this work station.

- <u>Station five examiners</u> operate the camera and cash register. One examiner is assigned to this work station.

Table 1: Transaction Types

| | | | |
|---|---|---|---|
| (1) | Renewal License | (7) | ID Card |
| (2) | Original License | (8) | Temporary Permit |
| (3) | Duplicate/Replacement | (9) | Not Eligible |
| (4) | Restriction Change/ Conversion | (10) | Road Test Only |
| (5) | Reinstatement | (11) | Information Only |
| (6) | Financial Responsibility | | |

Table 2: Concord Work-Station Patterns

(1) 1--EXIT (IMMEDIATE EXIT)
    0--EXIT (NO STATIONS VISITED)
(2) 1--4--EXIT
(3) 1--2--4--EXIT
(4) 1--3--4--EXIT
(5) 1--2--3--4--EXIT
(6) 1--2--EXIT
(7) 1--5--EXIT
(8) 1--3--5--EXIT
(9) 1--2--3--4--5--EXIT
(10) 1--2--3--5--EXIT
(11) 1--2--5--EXIT
(12) 1--3--4--5--EXIT
(13) 1--2--4--5--EXIT

Table 3: Percentages of Transactions and Station Patterns

| Job Type | Station Pattern (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | Total Number of Each Job | Percentage of Each Job |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 7.96 | .00 | .00 | .00 | .00 | 2.98 | 64.17 | 2.48 | .00 | 7.96 | 14.42 | .00 | .00 | 201 | 24.75 |
| 02 | 12.09 | .00 | 2.84 | .00 | 1.42 | 36.29 | .71 | .00 | 19.57 | 26.33 | .00 | .35 | .35 | 281 | 34.60 |
| 03 | 4.22 | 1.40 | .00 | .00 | .00 | 1.40 | 90.14 | .00 | .00 | 1.40 | 1.40 | .00 | .00 | 71 | 8.74 |
| 04 | 31.25 | .00 | .00 | .00 | .00 | 18.75 | 18.75 | .00 | 6.25 | 25.00 | .00 | .00 | .00 | 16 | 1.97 |
| 05 | 28.16 | .00 | .00 | .00 | .00 | 2.81 | 42.25 | .00 | 1.40 | 23.94 | .00 | .00 | 1.40 | 71 | 8.74 |
| 06 | 60.00 | .00 | .00 | .00 | .00 | .00 | 40.00 | .00 | .00 | .00 | .00 | .00 | .00 | 5 | .61 |
| 07 | 22.22 | .00 | .00 | .00 | .00 | .00 | 66.66 | .00 | .00 | .00 | 11.11 | .00 | .00 | 9 | 1.10 |
| 08 | 100.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 1 | .12 |
| 09 | 100.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 31 | 3.81 |
| 10 | .00 | 34.74 | .84 | .84 | .00 | .00 | .00 | .00 | .84 | .00 | .00 | 62.71 | .00 | 118 | 14.53 |
| 11 | 100.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 3 | .36 |
| 12 | 100.00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | 5 | .61 |
| 13 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | .00 | | .00 |
| Total Number of Each Station Pattern | 123 | 42 | 9 | 1 | 4 | 114 | 236 | 5 | 58 | 112 | 31 | 75 | 2 | 812 | |
| Percentage of Each Station Pattern | 15.14 | 5.17 | 1.10 | .12 | .49 | 14.03 | 29.06 | .61 | 7.14 | 13.79 | 3.81 | 9.23 | .24 | | |

Using the statistical package MINITAB, histograms were produced showing the form of the distributions for arrival times, station visitation service times, and total system times. Descriptive statistics were produced and the distributions fitted to theoretical distributions using the Chi Square Goodness of fit test and through experimentation with the various distributional shapes. The results produced the necessary distributional information for the parametric (SLAM) model.

The structure of the system is reflected in the SLAM model diagram of Figure 2. Customers arrive in a non-stationary mean exponential pattern with the mean of the pattern a function of the time of day. The type of transaction represented by each customer is then determined and a service route established. The service distributions are represented in the stations indicated at each numbered point (Station 1, Station 2, and so forth) in the model. At each work station the customer is served, statistics gathered, and the customer released to the next required station. The resource options of SLAM are employed to represent services and to facilitate representation of the work schedule.

The last part of the figure indicates the work scheduling pattern for each office. There is a staggered arrival of examiners, a morning break, a lunch period, an afternoon break, and then a staggered departure period. This is accomplished in the model using the alter node features. Keys to model structure are provided below the figure and a listing of the model is available from the author.

The model was validated by comparing its behavior to the data collected. Given the adjustments that came from this process, confidence that the model was an acceptable research device was developed. A number of policy alternatives were investigated. They are the subject of discussion in the next section.

## 3. RESEARCH DESIGN AND EXPERIMENTATION

Initial runs of the model suggested that four factors, more than others, affected the processing of applicants. These were the pattern of applicant arrivals to the office (demand); the scheduling of examiner work periods (personnel scheduling); the allocation of examiners to work stations (job assignment); and the manner in which examiners assisted one another (job flexibility). These four candidate managerial policies formed the basis of an experimental design. Each problem has been treated individually in the literature [1,2,3,4,5,6,7], but it is obvious that they strongly interact and must be simultaneously considered to accurately assess their simultaneous impact. The objective is to specifically deal with their interactions in the queuing structure discussed.

Three customer arrival patterns were selected: the current arrival pattern, a uniform arrival pattern to reflect "block scheduling," and a restricted pattern in which fewer applicants were scheduled to arrive during the lunch period. Two staffing patterns were tested: the pattern currently used by the Concord office (4 examiners assigned to station one, one to station two,

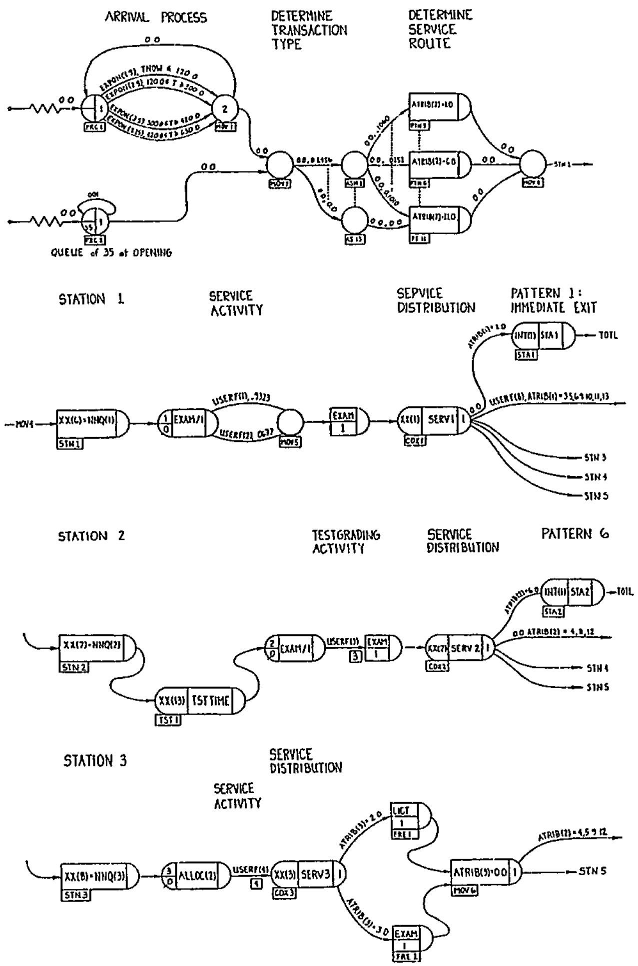



Figure 2: SLAM Model Structure
(A)

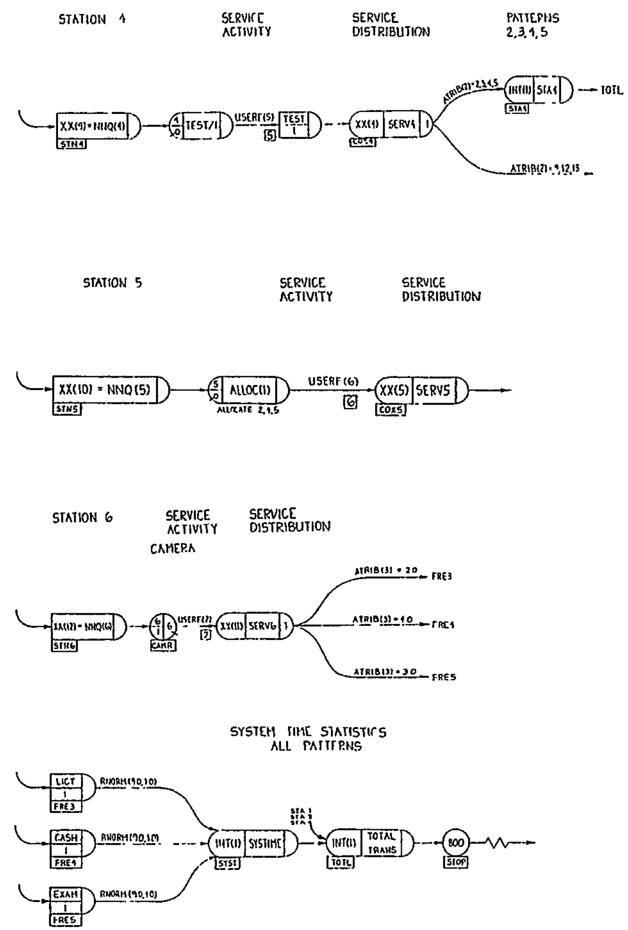
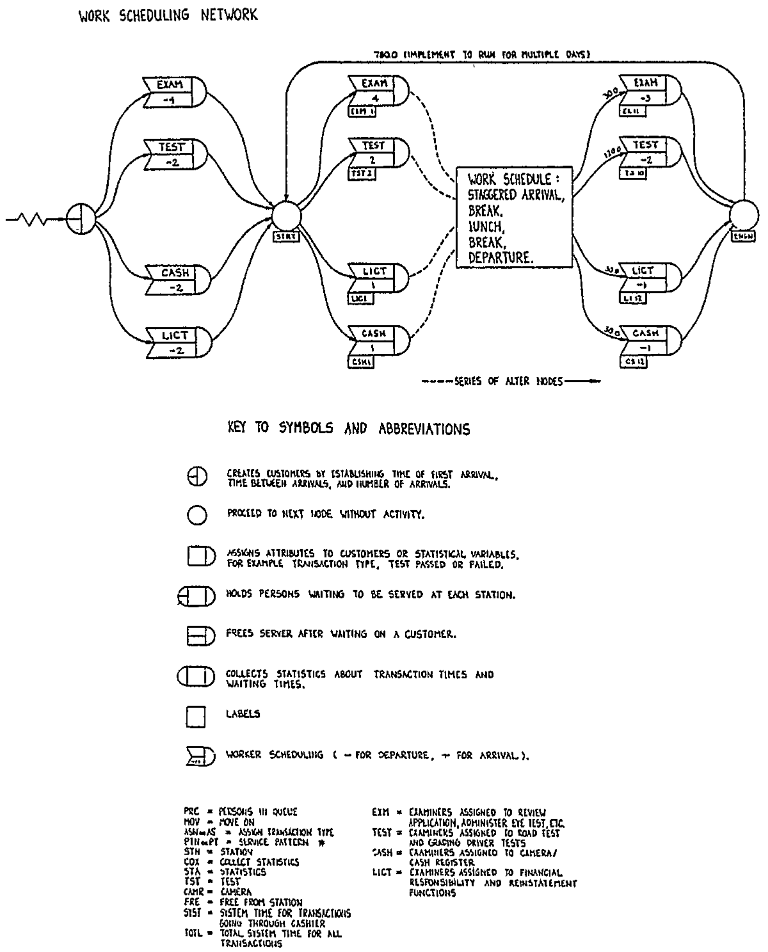



Figure 2: SLAM Model Structure
(B)

Figure 2: SLAM Model Structure
(C)




two to station three, two to station four, and one to station five) and a pattern in which one examiner from station one was reassigned to station five. Three examiner work schedules were tested: the schedule currently used by the Concord office (7 a.m. to 6 p.m.); a 7 a.m. to 7 p.m. office schedule with some examiners working from 7 a.m. to 6 p.m. and some working 8 a.m. to 7 p.m.; and a 7 a.m. to 6 p.m. schedule changing the schedule of examiner breaks and lunch periods. Three patterns of work assistance were selected. In the first, station four examiners helped stations three and two, and station one examiners helped station five. In the second, station four examiners helped station three, and station five examiners helped station two. In the third, station four examiners helped station three, and station one examiners helped station two.

This structure provides a four factor design with three levels for three of the factors and two levels for the other. The 3x3x3x2 design yields 54 possible combinations or policies for evaluation. The design matrix is shown in Figure 3. Initial testing suggested that three observations in each cell would be adequate given the variation in the output variable: average customer-waiting time. Each observation constituted a day where about 275 customers required service.

The one way ANOVA model was used to test simultaneously the differences between the policies [9]. The model form used was: $Y_{ij}=\mu+\gamma_j+\varepsilon_{ij}$. The results are reflected in the analysis of variance table shown in Figure 4. (Only fifty policies were tested because of a computer limitation. The four apparent "worst cases" were dropped.) The F ratio was highly significant indicating that some policies versus others created statistically different output results.

The Sheffeé and Duncan multiple range procedures were applied to the data to determine which policies were different from others. The more conservative Sheffeé procedure failed to produce any conclusive evidence of differences whereas the Duncan test yielded a set of candidate policies for further testing.

Figure 3: Design Matrix

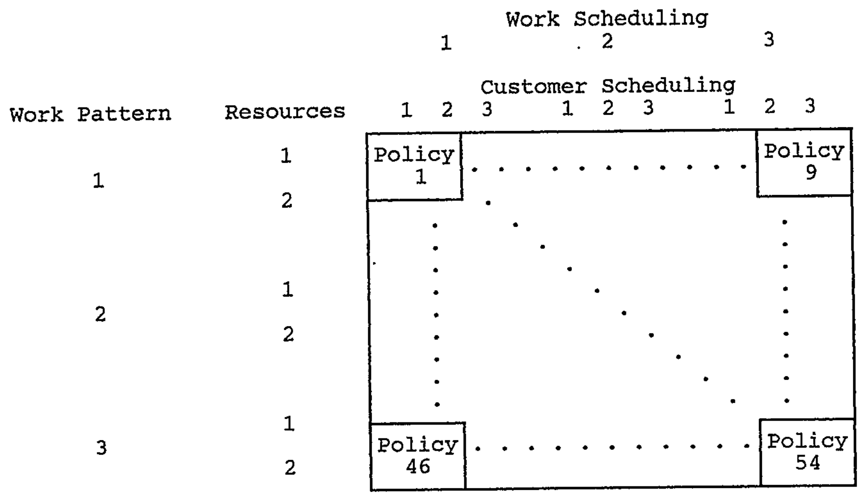



Figure 4: ANOVA Results (all policies)

ANALYSIS OF VARIANCE

| Source | D.F. | Sum of Squares | Mean Squares | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 49 | 111506.9433 | 2275.6519 | 14.381 | .0000 |
| Within Groups | 100 | 15823.7077 | 158.2371 | | |
| Total | 149 | 127330.6510 | | | |

Since there were relatively large standard error estimates for the means of policies chosen, seven more data points were added to each cell and the one way procedure repeated. The means (average waiting time), standard deviations and error estimates are shown in Figure 5. It is obvious that the system behavior is quite variable.

The ANOVA table for this set of data is shown in Figure 6. Results indicate a difference in policies at the .05 level of significance. The Duncan procedure showed no significant difference between policies 7, 13, 16, and 31. These policies share the common property of block scheduling (uniform arrival rates). In fact, of the initial data set (54 policies), some 65 percent of the policies that yielded significantly better performance measures had uniform arrivals as a common attribute. These results lead to several conclusions about the nature and behavior of the system. These will be discussed in the next section.

Before presenting this discussion, however, the issue of the interaction among the policies will be addressed. As noted earlier, consideration of these interactions is important as this is an integral feature of such systems and one where the impact is impossible to mitigate. To provide information about the interactions, a four way factorial experiment was performed using the design matrix of Figure 3. While high order (3 or more) interactions are most difficult to interpret, two way interactions are more straightforward. The data indicate a significant interaction among job assignment and job flexibility and among work scheduling and job assignment. Given this, they should be strong candidates for study in analysis of these type systems.

CONCLUSIONS

The system appears to be quite sensitive to the manner in which workers aid each other when work loads vary among the stations and as noted, to the pattern of customer arrivals. Given the analysis, it is evident that a recommendation to provide uniform customer arrival rates is warranted. The eight policies with the lowest mean waiting times all had uniform arrival patterns. Such behavior is to be expected as a system will have some average processing capacity over time and will behave favorably when system work loads are balanced to its service capacity.

The effect of the pattern in which workers aid each other is less obvious. Very little has been documented about job flexibility with most of its treatment coming as an aside in job training studies [4]. The patterns of flexibility studied were not the only ones possible, but those that were easiest to implement in the system. The length of queues in the system varies as

Figure 5: Candidate Policies for Further Testing

| Policy | Mean | Deviation | Error | Minimum | Maximum | 95 Pct Conf Int for Mean |
|---|---|---|---|---|---|---|
| 7 | 62.9700 | 9.4541 | 2.9897 | 48.4900 | 74.8000 | 56.2069 to 69.7331 |
| 1 | 73.8090 | 13.8502 | 4.3798 | 47.2300 | 95.8000 | 63.9012 to 83.7168 |
| 13 | 63.0070 | 8.5302 | 2.6975 | 50.6900 | 77.5300 | 56.9049 to 69.1091 |
| 16 | 63.9130 | 8.7145 | 2.7558 | 46.3200 | 77.0000 | 57.6790 to 70.1470 |
| 31 | 71.2300 | 7.6709 | 2.4258 | 58.9600 | 82.9000 | 65.7426 to 76.7174 |

Figure 6: ANOVA Results (Selected Policies)

ANALYSIS OF VARIANCE

| Source | D.F. | Sum of Squares | Mean Squares | F Ratio | F Prob. |
|---|---|---|---|---|---|
| Between Groups | 4 | 1059.6889 | 264.9222 | 2.710 | .0418 |
| Within Groups | 45 | 4398.8337 | 97.7519 | | |
| Total | 49 | 5458.5226 | | | |

flexibility patterns are altered. For example, when the cashier works alone, a line begins to grow at that station. If station 3 workers are allowed to aid the cashier, queue buildup is shifted to station 3. For the current structure, a pattern where workers at the station with the largest number of people (in this case, station 1) assigned are allowed to help any other station seems most effective. Because the heuristics for the help patterns have not been fully developed and studied, a good bit more experimentation with flexibility must be conducted before any definitive conclusions can be drawn.

The most important conclusion of the study is the reaffirmation of the necessity to approach such systems with methods that allow their study without restricting assumptions. The model reported in this paper provides a vehicle with which to analyze management options for this type of multistation service system. The next step in the research is to address fully the flexibility issue.

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