THE USE OF SIMULATION IN PLANNING EXPANSION OF THE ST. LOUIS POLICE REAL-TIME MOTOR VEHICLE INQUIRY SYSTEM*

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ABSTRACT

A computer program, coded in GPSS, has been written to simulate the operation of the St. Louis Metropolitan Police Department's real-time motor vehicle inquiry system. Four types of inquiries are handled: vehicle (or license) checks, and additions, deletions, and modifications to stored information. Communications channels, four computers, and eleven terminals are explicitly represented in the simulator; other system equipment and types of inquiries are implicitly represented. Four experiments with the simulator are reported. These involve changes in terminal equipment, the message assembly procedure, the priority system, and system loading.

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1. Problem Description

1.1 The Scope of the Problem

The problem considered is that of modeling the St. Louis Police Department's real-time motor vehicle inquiry system, particularly the facilities which process inquiries to and maintenance of the Department's files of vehicle registration and license numbers. Physically, the system includes a configuration of computers at police headquarters and state and federal real-time data systems linked to it by communications channels. Sixty remote inquiry terminals of various types are located throughout the Department and at law enforcement agencies serving the suburban communities. It is not uncommon for the system to process more than a thousand inquiries in a single day.

According to the National Auto Theft Bureau, there were 96 million cars in use in the United States in 1969. The number of auto thefts recorded for that year was 828,000, of which over 11,000 occurred in St. Louis. About 84 percent of those stolen in St. Louis were recovered by the police, an activity in which the police were greatly assisted by the vehicle inquiry system. With the current trend toward

increasing cooperation among local police agencies, and a regularly increasing number of auto thefts each year, the Department is now faced with the need for a major expansion of its motor vehicle data services. The simulation study described in this paper was intended to illustrate for Department planners the uses to which simulation could be put in planning this expansion.

1.2 Objectives

As part of the anticipated expansion, questions arose as to the relative merits of different types of remote terminals (e.g., teletype, IBM 1050) with varying transmission rates. One objective of the study then was to provide a basis for such a comparison.

Given a configuration (and in particular, the current St. Louis facility) several algorithms for processing inquiries to the system were proposed which differed with respect to the prevailing priority system or the method of handling message assembly. Each proposal was simulated and compared on the basis of the simulation results. A final objective concerned the ability of the system to cope with increased workloads.

The basis selected for the comparison of alternatives

is the average time required to obtain a reply to an inquiry. This measure seems to best reflect the system's ability to achieve its major objective: to provide police with needed information with minimum delay. Simulation offers a powerful method of comparing, evaluating, and modifying the means to this end.

2. Construction of the Model

The simulation model was developed in stages, each stage giving a more accurate and comprehensive representation of the system. The first stage included simple models of the St. Louis computing facility, single channel communication lines to state and federal data files, and two remote inquiry terminals processing a single type of inquiry. After many stages, the final version included multiple lines to state and federal computers, eleven remote terminals, and ten types of inquiries. This still represents only a segment of the actual network but that aspect of the system in which most interest is placed is represented in detail.

A description of the system and the model are included below.

2.1 Physical System

2.1.1 Terminals and Communication Lines

The basic hardware of the St. Louis Police Department's computer center consists of an IBM 7040 data processing system and an IBM 7740 communications computer. The 7040 performs all major computation, file maintenance, and information retrieval. The 7740 handles message routing and manages the queues of messages awaiting the availability of certain communication lines. The 7040 and the 7740 are connected by a high speed data channel which allows messages to be transmitted between them virtually without delay.

Two 10.6 character per second channels connect the 7740 to an RCA Spectra 70 computer operated by the Missouri State Department of Revenue at Jefferson City, Missouri. The channels handle one inquiry at a time. One of the lines is always used if it is available when a message arrives at the 7740. It not, the availability of the second line is determined. Following the transmission of an inquiry on one of the lines, that line remains unavailable until the response is received at the 7740.

A similar arrangement exists between the 7740 and an IBM 360 computer at the National Crime Information Center (NCIC) located near Washington, D.C., except that transmission occurs at a rate of 14.8 characters per second. Operation

through these lines is identical to that to the Department of Revenue.

Input to the Department inquiry system originates from various terminals throughout the St. Louis Police Department's telecommunication system. This system encompasses teletype terminals in each of the nine metroplitan districts (two pairs of districts share common lines to the 7740), numerous teletype lines serving several police departments in St. Louis County, and a teletype terminal at the Missouri Highway Patrol. In addition, dispatchers at the department's radio room handle inquiries directly from patrolmen on the street. These inquiries are entered into the system via one of two 1050 lines to the 7740. Responses to all inquiries are returned to the originating terminal over the same line used in the initial transmission. A response is called a "hit" if information pertinent to the inquiry is located in the files, and a "miss" if no information is found.

The entire network is illustrated in Figure 1, and the transmission speeds of the various lines are summarized in Table 1.

Note: page 6 contains Figure 1 which is appended as the last page of the paper.

Table 1

Transmission Speeds

Line	Transmission Rate (characters/sec.)
7740 to 1050 terminals	14.8
7740 to teletype terminals	10.6
7740 to NCIC	14.8
7740 to Department of Revenue	10.6
7740 to 7040	(instantaneous)

2.1.2 Inquiries

Information concerning motor vehicles which have come to the attention of the police is entered into a data file (known as the Known Auto File, or KAF) maintained by the 7040. Vehicles listed in the file include,

a) cars connected in some way with wanted persons,

b) stolen cars,

c) repossessed vehicles,

d) cars towed by the police, and

e) vehicles from which parts have been stolen.

The file also contains a listing of stolen license plates.

The motor vehicle inquiry system is one of several real-time data systems managed by the data facilities described

above. Those types of real-time inquiries which can be processed by the motor vehicle system are explicitly included inthe simulation model. A description of each of these and the related data processing tasks follows. Also given is a brief description of the non-vehicle related inquiries whose processing has some affect on the processing of vehicle inquiries.

2.1.2.1 Vehicle Checks

Vehicle Checks are those inquiries made by patrol units on the street for the purpose of determining if a vehicle is listed in the stolen file, and to obtain the owner's name and address. The inquiry is transmitted via radio to the radio room at police headquarters. There, the request is formatted and entered through one of two 1050 terminals. The inquiry proceeds through the 7740 to the 7040 which conducts a search of the St. Louis files for relevant information. Failing to locate any, a message to that effect is transmitted to the dispatcher by way of the 7740. In addition, a secondary inquiry is generated which proceeds through the 7740 to NCIC, with the response going to the dispatcher by way of the 7740. Similarly, all inquiries containing a Missouri license number result

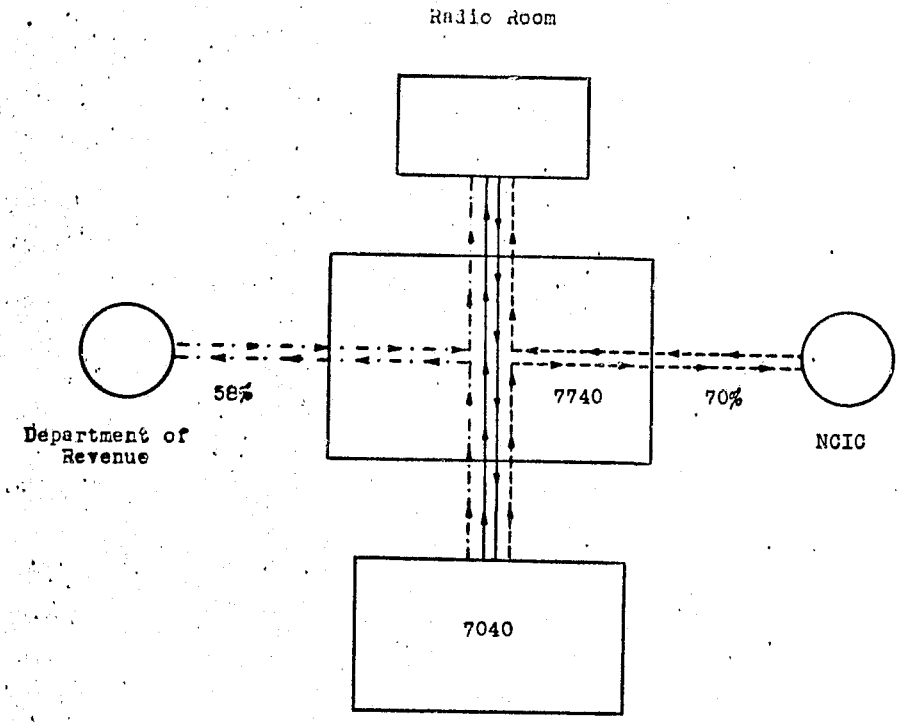
in a secondary inquiry being sent to the Department of Revenue. When the dispatcher has received all responses pertaining to the original inquiry, he transmits the reply via radio to the man on patrol. The processing of a Vehicle Check inquiry is summarized in Figure 2. The percentages given indicate the fraction of input traffic which results in an additional inquiry being sent to NCIC or Revenue.

2.1.2.2 Check Vehicle

Inquiries of this type are identical to Vehicle Checks except that they originate from the nine district station houses and are transmitted to the 7740 over teletype lines.

2.1.2.3 Enter Vehicle

Enter Vehicle messages are used to add a car to the stolen vehicle file. These messages originate at the districts and a response to each is generated in the 7040. Some messages result in a check of NCIC files (if the St. Louis file shows the car has been towed; since no statistics on the fraction of entries with tow records were conveniently available it was assumed, for expediency, that the fraction was 100%), and roughly 68 percent are checked against Department of Revenue files. This process is illustrated in Figure 3.



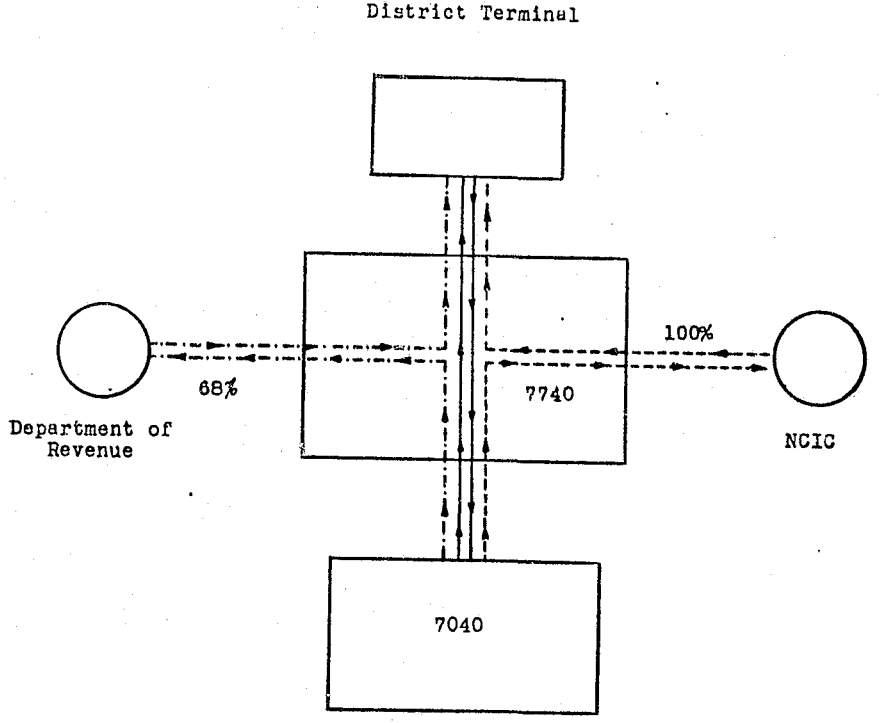
——— inquiry to and response from the 7040

------ inquiry to and response from NCIC

—·—·— inquiry to and response from the Department of Revenue

Figure 2

Vehicle Checks



——— inquiry to and response from the 7040

------ inquiry to and response from NCIC

—·—·— inquiry to and response from the Department of Revenue

Figure 3

Enter Vehicle

2.1.2.4 Modify Vehicle

Modify Vehicle messages are used to change the information stored for a vehicle listed in the stolen vehicle file. These originate at the districts and are processed in the 7040. Approximately half the checks result in the generation of secondary checks at NCIC (see Figure 4).

2.1.2.5 Cancel Vehicle

Cancel Vehicle messages accomplish the cancellation of all information stored for a vehicle listed in the stolen file. This is carried out upon the recovery of a listed vehicle. Processing of these inquiries occurs entirely within the 7040, except that a "locate" message is sent to NCIC if the cancellation concerns recovery of a stolen vehicle or stolen plates.

2.1.2.6 Other Inquiries

In addition to the vehicle processing inquiries discussed above, certain other types of inquiries are processed which do not involve the vehicle files. Vehicle Checks and Check Vehicle are affected in that their processing may be delayed while the computers or communication lines are occupied with these other types of inquiries.

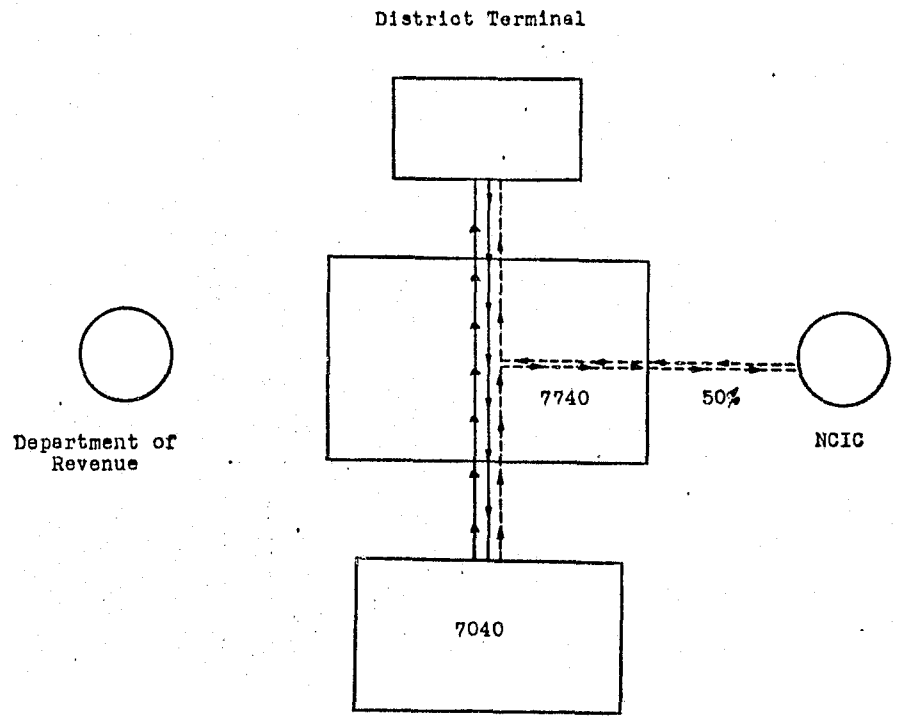


Figure 4
Modify Vehicle

For example, one type, known as Host Inquiries, are generated within the 7040 for transmission to and processing at the Department of Revenue when the availability of the system permits. Lines between the 7740 and the districts, the radio room, and NCIC are not affected (Figure 5). Enter Arrest inquires serve the purpose of adding arrest records to department files. In the current system participating suburban agencies may not use this type of inquiry. An Enter Arrest is processed in the 7040 and automatically generates a "wanted" check to NCIC (Figure 6). A "miss" rarely occurs in the 7040 on this type of inquiry (this happens if the entered record has not been properly edited); for this reason the model assumes a hit every time. Responses from each are transmitted to the originating terminal. Check Arrest inquiries are likewise generated at the districts and other remote terminals for the purpose of interrogating the Department's arrest files. Processing occurs completely within the 7040 with a single reply sent to the point of origin. Finally, Personnel Inquiries and Additions and Modifications to arrest records (known as Add-Mod inquiries) originate at external terminals and are processed entirely within the 7040. During their processing, other checks are delayed within a queue in the 7040.

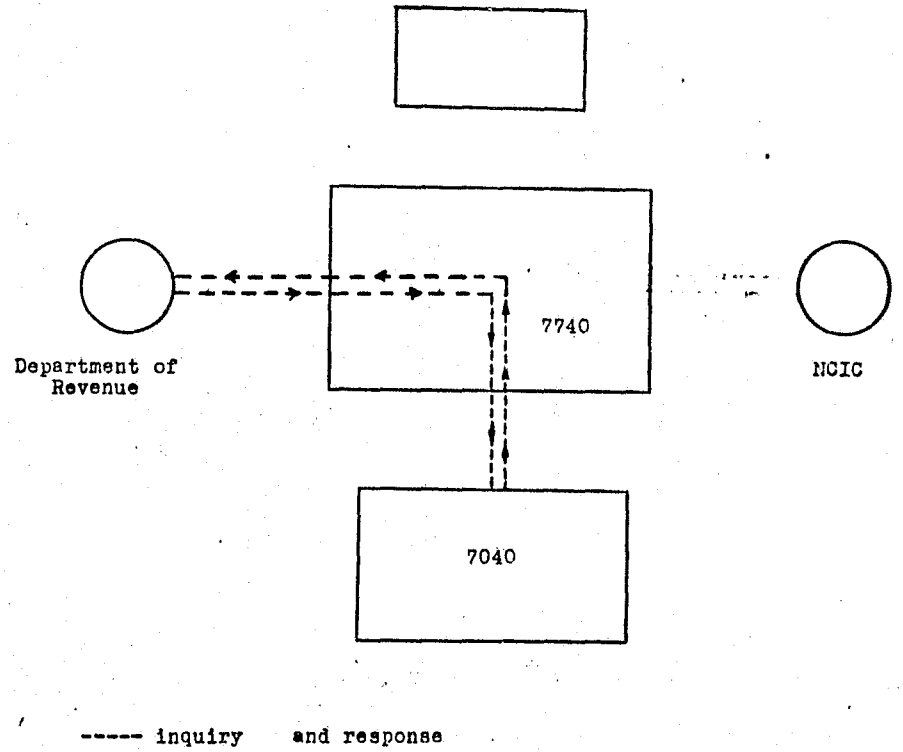


Figure 5
Host Inquiries

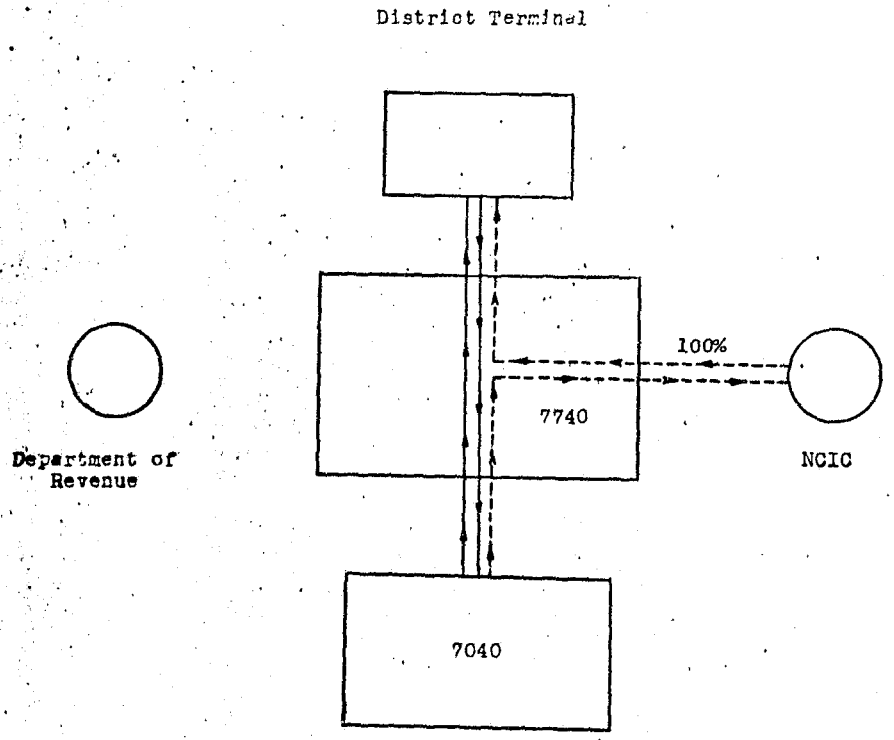


Figure 6

Enter Arrest

2.1.3 Priority System

The order in which arriving inquiries are processed within the 7040 is controlled by a priority system which assigns a number from zero to six to each request, with six being the highest priority. Vehicle Checks are given a priority of six. Inquiries such as Cancel Vehicle are given a low priority since delays in processing these are generally inconsequential. To prevent low priority requests from being held indefinitely in the 7040's queue the priorities of inquiries in the queue are increased by one every time an inquiry is serviced by the computer. In this way, all inquiries eventually attain the highest priority and are processed. The initial priority of each type of inquiry represented in the simulation is given in Table 2.

Table 2

Inquiry Priorities

Inquiry type	Priority
Vehicle Check	6
Check Vehicle	3
Enter Vehicle	2
Modify Vehicle	2
Check Arrest	2
Enter Arrest	2
Personnel Inquiries	2
Add-mod to Arrest Record	2
Cancel Vehicle	1
Host Inquiries	0

A system of priorities is also imposed on all lines connecting the 7740 with district and dispatcher terminals. Messages from the 7740 to the terminals are given preference over those transmitted from the terminals. Consequently, inquiries can be entered into the system from the districts and the radio room only at those times when the system has no messages to send in the other direction.

2.2 The Simulation Model

Because of the stochastic nature of the inquiry system, the simulation model was programmed using the General Purpose Simulation System (GPSS) software package. The resulting program contains 498 GPSS blocks. Simulation of 36 hours of real-time operation requires approximately 3 minutes of CPU time on an IBM 360/50 computer. The following sections discuss the aspects of the physical system which were included in the model, those which were omitted, and the assumptions made.

2.2.1 Extent of the Model

Inquiry traffic of all types whose processing might introduce delays in the processing of Vehicle Checks is explicitly represented in the model. This includes each

of the types of inquiries discussed above. Inquiries which originate at the districts or at the radio room (e.g., Vehicle Checks, Cancels, Enter Arrests, etc.) are followed in the model from the time the terminal operator first seeks to transmit the inquiry to the 7740 until all resulting responses have been received at the terminal. All inquiries generated at terminals other than those in the districts and the radio room are followed in the model only from the time the input message reaches the 7740 until the response leaves the 7740 for the inquiring terminal (this is the only period when such inquiries can affect the processing of Vehicle Checks). For this reason, arrest record Additions and Modifications, and Personnel Inquiries were represented as if generated and terminated within the 7740. Certain other types of inquiries were omitted entirely because of their low arrival rates (e.g., Field Interrogation Reports, which average only 10 per day on busy days, and Wanted Checks, arising from Enter Arrest inquiries, which rarely exceed 100 per day).

The Department of Revenue and NCIC computers, and channels connecting them with the 7740, are represented in the model. Queues are allowed to form on each of the seven

lines from the nine districts to the 7740, and on the two lines from the 1050's in the radio room to the 7740. A queue is also included within the 7040. Within the 7740, a total of eleven queues are possible (i.e., on the lines to the remote terminals, to NCIC, and to the Department of Revenue). Inquiries in each queue are serviced according to their priorities and on a first-in, first-out basis for items of equal priority.

To simplify the model, the actual method of handling priorities was modified. When an inquiry is first generated, it is assigned a priority from 0 to 6 which it retains until processing within the 7040 is completed. At that time, all inquiries, regardless of their original priority, are assigned a priority of 8. This ensures preferential treatment on the lines leading from the 7740. No attempt is made to increment the priorities of inquiries in the queue within the 7040.

The model also accounts for down time of computers in the system. In actuality, when a computer is down, say at NCIC, when the i - th inquiry arrives, this usually indicates a higher probability that the machine will be down for the i + 1st inquiry. In the model, however, the probabilities that the i - th and i + 1st will find a part of

the system up or down are treated as independent and equal to the overall rate of reliability of the machine involved (i.e., 0.95 for the Department of Revenue and 0.945 for NCIC). This approximation seems reasonable in view of the fact that inquiries finding one of the facilities unavailable (down) are not saved and therefore do not contribute to a built-up queue at a later time.

2.2.2 Assumptions Regarding Arrival and Service Rates

All inquiries are assumed to occur with negative exponential interarrival times. Service times and transmission times, on the other hand, are assumed to be deterministic. The time required to process an inquiry once service is begun is governed by the number of milleseconds needed to execute each instruction of the appropriate programmed code. Similarly, transmission times depend entirely upon the length of the message involved and the characteristics of line in use. For a specific type of inquiry and communication line, both of these factors are very nearly uniquely determined.

3. Data

Since the system under consideration consists primarily of computing machines and data processors, it is itself capable of and, in fact, daily involved with accumulating and displaying large amounts of pertinent and valuable

statistics. From this data, information pertaining to arrival rates, individual district activity, and mean numbers of each type of inquiry was obtained. Data on message lengths and service times was drawn from the experience of the staff of the St. Louis Police Department's computing facility.

Sample sizes used in obtaining data on the incidence of the different inquiries varied with the type of inquiry and the accessibility of the source data. For example, the statistics used to determine the arrival rates of Vehicle Checks were collected for the first eighteen days of 1970. Data on the occurrence of Enter, Modify and Cancel Inquiries at each of the nine districts represents a period of one week in March, 1970, while the breakdown of Check Vehicle traffic among the districts represents the first fifteen days of March. District activity in Enter Arrest and Check Arrest inquiries presents something of a problem. Volume handled in any particular district varies widely from day to day. Averaging of this acticity over a period of days is likely to produce a distribution of arrivals distinctly unrepresentative of the true situation. For this reason, data from a single typical busy day was used.

A summary of the average message lengths of the various inquiries is given in Table 3, and the corresponding service times for these inquiries at the different facilities of the system is displayed in Table 4. Finally, Table 5 gives a breakdown of the average daily activity for each type of inquiry at the district and radio room terminals.

4. Validation of the Model

In order to verify the adequacy of the model, the results of simulation runs performed at each stage of development were checked for consistency. For example, at the stage when single lines to NCIC and the Department of Revenue were replaced by a pair of lines, a decrease in service time was expected (and observed). Comparison of the activity of certain pivotal blocks of the model (such as the generate blocks and those representing state and federal processing) indicates approximate agreement with that expected from actual experience. Finally, the model was subjected to independent appraisal by staff members of the St. Louis Police Department who found it to coincide quite adequately with the actual inquiry system.

In one respect, however, the model does not approximate the actual system. Results of the simulation runs

Table 3

Message Lengths (characters)

Inquiry type	Input message to 7740	Response from 7040(hit)	Response from 7040(miss)	Response from NCIC (hit)	Response from NCIC (miss)	Response from Dept.Rev.(hit)	Response from Dept. Rev. (miss)
Vehicle Check	44	622	118	222	133	266	89
Check Vehicle	53	622	118	222	133	266	89
Enter Vehicle	395	99	99	222	133	266	89
Modify Vehicle	95	500	35	222	133	-	-
Cancel Vehicle	245	87	87	-	-	-	-
Check Arrest	120	950	40	-	-	-	-
Enter Arrest	190	310	-	520	60	-	-
Host Inquiries	-	-	-	-	-	158	60
Personnel Inquiries	-	-	-	-	-	-	-
Add-Mod	-	-	-	-	-	-	-

Table 4

Service Time (seconds)

Inquiry type	7040	NCIC	Dept. of Revenue
Vehicle Check	6	2	2
Check Vechile	5	2	2
Enter Vehicle	20	2	2
Modify Vehicle	25	2	-
Cancel Vehicle	37	-	-
Check Arrest	16	-	-
Enter Arrest	11	2	-
Host Inquiries	2	-	2
Personnel Inquiries	3	-	-
Add-Mod	9	-	-

Table 5

Mean Daily Terminal Activity

District	Vehicle Check	Check Vehicle	Enter Vehicle	Modify Vehicle	Cancel Vehicle	Arrest Inquiries
Radio room	398	-	-	-	-	-
1	-	15	5	0	2	6
2	-	9	4	0	1	3
3	-	39	19	3	6	23
4	-	26	8	1	0	0
5	-	15	7	1	5	4
6	-	19	12	2	3	2
7	-	32	17	2	7	17
8	-	31	14	2	8	29
9	-	30	20	2	6	20

indicate a maximum total response time of little more than 3 minutes. As any patrolman will indicate, this is simply not the case. Additional delays occur in relaying responses received at the radio room terminals to the radio dispatchers seated at their consoles, and in awaiting a free moment of air-time when the dispatcher can broadcast the reply to the inquiring officer. Hence, the actual response time as seen by an officer in the street may be considerably greater than 3 minutes (perhaps as much as 15). In view of this, the data derived from the simulation is more usefully interpreted as the terminal response time rather than the delay experienced by an inquiring patrol unit. A lack of data regarding this additional delay prevented its incorporation into the model.

5. Experimentation with the Model

As mentioned in Section 1, four experiements were performed. Each involved a comparison of certain measures of effectiveness between a run of the model of the system as it now exists and a simulation of the model with a specific change injected. All runs, except those of the last experiment described below, simulated approximately 36 hours of operation of the inquiry system. In addition, the system

was placed in simulated operation for approximately three (simulated) hours before accumulating data in order to avoid the empty and idle state.

The primary measures of effectiveness used to compare and analyze the different simulation runs include the mean service time for Vehicle Checks, the mean service time for Check Vehicle inquiries; the maximum service times for each, the maximum queue lengths, and the utilization of the 7040. Secondary output variables include mean and maximum service times for other types of inquiries. Mean waiting times, while important, are included in service time statistics. Data obtained relevant to the above measures of effectiveness for each experiment are summarized in Table 6.

The experiments are described in the following sections.

5.1 Terminal Equipment

In the first experiment, the teletype terminals in use at each district (presently having transmission rates of 10.6 characters per second) were replaced with 1050 terminals which have a transmission rate of 14.8 characters per second. This change was accomplished in the simulator by multiplying the transmission times to and from the districts

by a factor of $10.6/14.8 = 0.716$.

No other transmission speeds were investigated since expanded use of the 1050s is the only change currently contemplated.

As seen in Table 6, the mean response time for Vehicle Checks decreased by less than 1.5 records. To tes the significance of this change, a t-test was applied using

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_p \sqrt{1/N_1 + 1/N_2}}.$$

with $N_1 + N_2 - 2$ degrees of freedom where $\bar{x}_1$ and N_1 are the mean response time and sample size for the simulation of the present system and $\bar{x}_2$ and N_2 are the corresponding parameters in the simulation of the modified system. S_p^2 is the pooled sample variance given by

$$S_p^2 = \frac{(N_1 - 1)S_1^2 + (N_2 - 1)S_2^2}{N_1 + N_2 - 2}.$$

Sample standard deviations are given in Table 7.

Table 7

Sample Standard Deviations

	(Seconds)
Present System	25.1
1050s Replacing Teletype	21.4
Message assembly in 7740	29.0
Modified Priorities	25.1
Increased Traffic (double)	25.5
Increased Traffic (quadruple)	35.7

Table 6

Experimental Results

Experiment	Mean response time(sec.)for Vehicle Check	Mean response time(sec.)for Check Vehicle	Maximum response time(sec.) for Vehicle Check	Maximum response time(sec.) for Check Vehicle	Maximum queue length	Mean utilization of 7040
Present system	54.35	61.41	115	145	3	.176
1050's replacing teletypes	52.91	53.28	125	120	4	.171
Message assembly in 7740	63.22	72.02	185	145	6	.179
Modified priorities	54.35	61.41	115	145	3	.176
Present system with volume of inquiries increased by a factor of 2	57.49	64.21	125	185	4	.273
Modified priorities & increased vol.	56.52	65.68	120	160	4	.262
Vol.increased by factor of 4	65.97	76.78	200	180	6	.492
Mod.priorities & increased vol.	63.97	73.69	200	175	6	.465

Using this test the decrease in response time was found to be insignificant at a 5% level of significance ($t = 1.45$). Since 1050s already existed on the lines carrying Vehicle Check inquiries, this is not unexpected. On the other hand, the 8 second decrease in response time for Check Vehicle inquiries was highly significant ($t = 15.3$). In other words, the improvement in service to the district terminals, as indicated inthe simulation output, is very unlikely to be the fortuitous result of a string of good random number draws.

5.2 Message Assembly

Any Vehicle Check or Check Vehicle entered into the system can result in up to three responses (i.e., from the 7040, from NCIC and from the Department of Revenue). In the existing environment, each of these messages is independently returned to the dispatcher or teletype operator who must save them until all have been received. If responses from several different inquiries are outstanding at some district, responses from one are often mixed in with those of another. By assembling the responses for a given inquiry within the 7740 before transmitting them to the inquiring terminal this problem is circumvented. To investigate the effect of such a change on the processing

time for Vehicle Checks and Check Vehicles, the simulation model was modified in such a way that the separate messages were assembled before transmission to the inquiring terminals. As shown in Table 6, the mean response times for both types of inquiries showed increases of roughly ten seconds, increases found to be statistically significant using the same t-test as applied above. While statistically significant, the operational inconveniences of an additional ten second delay are probably minimal compared to those of manual message assembly at the terminals.

5.3 Modified Priority Structure

The message input to the 7740 from a district terminal for a Check Vehicle inquiry is transmitted in approximately five seconds. The transmission time for responses to certain types of inquiries (e.g., Check Arrest) can be as long as fifteen minutes (e.g., in the case of a common name), although most rarely exceed three minutes. Since a higher priority is given to output from the 7740 than to input to it, it is thus possible for processing on a Check Vehicle to be delayed in this manner up to fifteen minutes. To test the effect of even a minor delay, 90 seconds was used as the delay figure. If, on the other hand, the Check Vehicle

inquiry is admitted to the 7740 before transmission of the response to an earlier inquiry is begun, processing of the check can virtually be completed and the reply awaiting transmission when the line again becomes available. To investigate such a modification, the priority structure of the simulated model was altered to give incoming Vehicle Checks priority over responses to previous inquiries. No reduction in response times was observed with the current system loading. A small reduction was observed, however, under increased loadings. At quadruple loading the reduction was significant at the 10% level for Check Vehicle inquiries ($t=1.37$), but not for Vehicle Checks ($t=1.26$).

5.4 Increased System Loading

To study the effects of increased rates of arrival of various inquiries, those rates pertaining to district and dispatcher traffic (Checks, Enters, Cancels, etc.), Personnel Inquiries, and Check and Enter Arrests were uniformly intensified. In particular, simulation runs were made under the present level of operation and at traffic levels increased by factors of two and four.

As can be seen in Table 6, significant increases in response time occur as the loading is increased, but even at quadruple loading the maximum response time observed

was just over three minutes, and the maximum message queue was only 6. This indicates that the present system is capable of providing adequate service in the face of a fairly substantial increase in workload.

6. Conclusions

Based on the experiments performed, the following conclusions have been made:

1. The system as it now exists is well capable of handling an increased volume of inquiry traffic without developing unmanageable queues or unacceptable delay times. Indeed, if a 25% increase in response time were tolerable, all inquiry rates can be increased by as much as a factor of 4.
2. Response time can best be shortened by replacing teletype terminals at the district stations with 1050 terminals.
3. If an increased loading of the system becomes a reality, a slight decrease in service time for Vehicle Checks could be expected from the modification to the priority structure indicated in Section 5.

4. The assembly of messages by the 7740 will inevitably result in a delay of several seconds in the arrival of responses to Vehicle Checks. This delay must be balanced against the increased convenience and efficiency of the operations at the district terminals.

It is hoped that this study will illustrate the usefulness of simulation for dealing with the planning problems faced by police administrators. Simulations such as this one can provide relatively inexpensive experimental devices with which to evaluate proposed changes, not only in data services, but in other areas of police operations as well.

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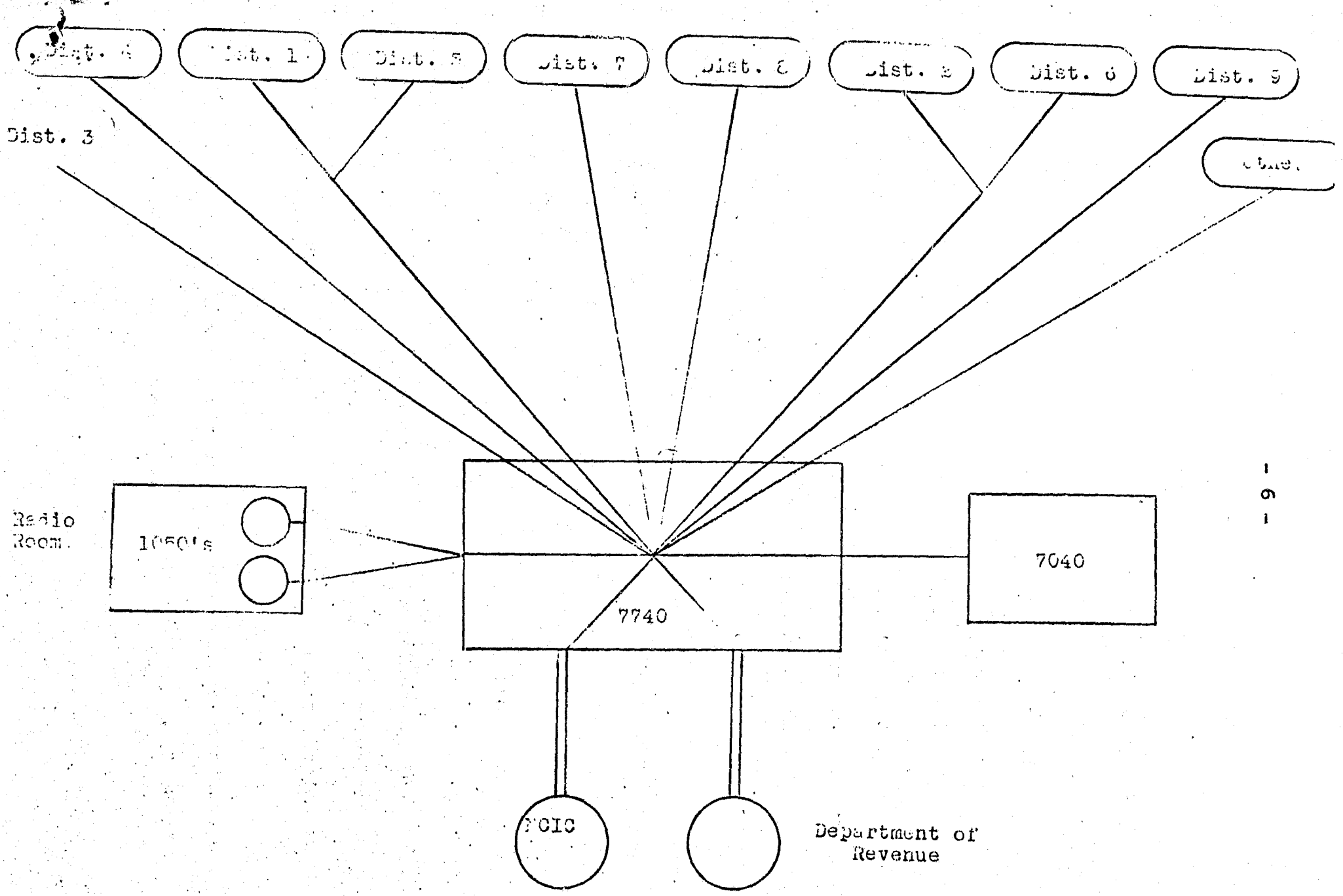

Figure 1

Modeled Components of the Police Inquiry System