CHAPTER I

INTRODUCTION

The need for better traffic techniques has significantly increased during the past ten or more years because of the rapidly increasing - numbers of vehicles in the big cities all over the world. In Bangkok the capital of Thailand, the increase in numbers of vehicles had been tremendous. The problem that we often meet all the way long during rush-hours in the morning and evening of the working days is the traffic-jam condition. At intersections, the queues of one-main-line street quite oftenly block the crossing vehicles, as shown in Fig. 1-1. This causes the flow of the traffic in the network systems to become worse, in addition to producing other problems, such as, air pollution and other uneconomical problems. These traffic problems are mainly caused by improper setting of signal lights, the direction of the flow is not systematically controlled, the capacity of the street is too small, parking in the narrow street etc. But we rarely used the new technique of traffic simulation system to apply for the situation. By Modern Simulation Method making use of computer to optimize the queue in the links of network systems which carry heavy loads, the optimal timing of signal lights can be found.

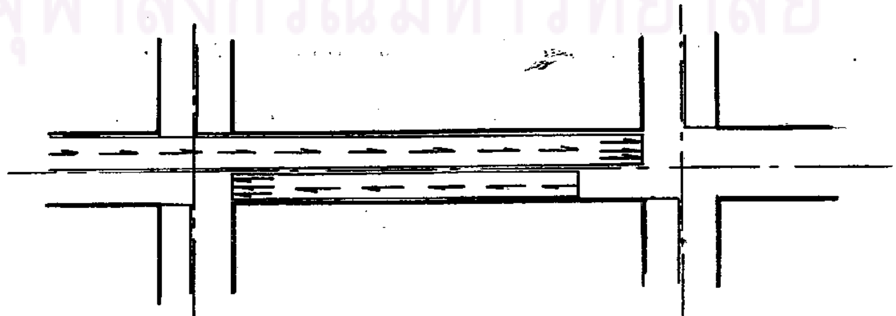

Fig. 1-1

GENERAL IDEAS ABOUT SIMULATION

P.255-256 DREW - Traffic Flow Theory & Control.

What is Simulation?

~~It is distinctly visible by~~ the following examples :

"A penny is tossed until it comes down heads. If this happens on the first toss, the player receives $1 from the bank. If heads appears for the first time on the second toss, the player receives $2, on the third toss, $4, etc., doubling each time. What should the player pay the bank for the privilege of playing this game if the game is fair?

If one has a coin handy, the simplest way to get some insight - into how much a player should pay is to play say 1,000 games and determine the aberage winnings perggame. This seemingly unscientific approach to the "gambler's ruin" or "St. Petersburg paradox," as it is also called, represents a simple illustration of Simulation.

Simulation is essentially a working analogy. It involves the construction of working model presenting similarity of properties or relationships to the real problem under study. Simulation is a technique which permits the study of a complex traffic system in the laboratory rather than in the field.

In a more general sense, simulation may be defined as a dynamic representation of some part of the real world, achieved by building a computer model and moving it through time. The term computer model is used to denote a special kind of formal mathematical model, namely, a simulated on an electronic computer. Thus, simulation consists in using a digital or analog computer to trace the time paths, with the distinction that the digital device counts and the analog device measures. This distinction is actually a fundamental one, being essentially the mathematical distinction between the discrete variable (digital) and the continuous variable (analog). The differences in capabilities between the digital and analog computer are manifest in the mathematical distinctions between summation and integration, or between difference equations and differtial equations. ")

P.256

Monte Carlo Methodes

" Often an equation arises in the formulation of a model which cannot be solved by standard numerical techniques. It may then be more efficient to construct an analogous stochastic model of the problem. Thus, essentially an experiment is set up to duplicate the features of the problem under study. The calculation process is entirely numerical and is - carried out by supplying random numbers into the system and obtaining numerical answers.

One of the simplest and most powerful applications of this idea is the evaluating the area of bounded area. Surround the area with a square, normalizing to make its side of unit length. Taking a point in the area at random, the probability that it lies in area A is simply A. If a large number of points are taken at random, it follows that the - proportion of these lying in the area is an estimate of A (see Fig. 1-2). The general equation for evaluating a definite integral, using the point-distribution method, as it is called, is

$$\int_a^b f(x)\,dx = (b-a)y_{max} P[\,Y < f(X)] \tag{1.1}$$

where

$$X = (b-a)\,RN + a \tag{1.2}$$

and

$$Y = y_{max} RN \tag{1.3}$$

Thus, the point-distribution method consists of choosing two random numbers, the first between a and b and the second between 0 and some number which is greater than or equal to the maximum of f(x) in (a,b), or y_{max}. If the first is regarded as the abscissa and the second as the ordinate, the probability that the point will fall below the curve to the area of the indicated rectangle (see Fig. 1-2). This provides the basis for obtaining the value of the definite integral using Eq. (1.1), which is of course the area under the curve. This method yields an accuracy proportional to $n^{1/d}$ where n is the number of points and d is the number of dimensions. The whole idea can be generalized to higher dimensions and the result remains true.

A scheme based on the mean-value theorem appears to be more efficient. The theorem states that if f(x) is continuous in (a,b), there exists a point T in (a,b) such that

$$\int_a^b f(x)\ dx = (b-a)\ f(T) \qquad (1.4)$$

This is accomplished by generating a sequence of random numbers X between a and b and calculating the average of f(x) :

$$f(T) = n^{-1} \sum_{i=1}^{n} f(X_i) \qquad (1.5)$$

where X is given by Eq. (1.2) as before.

Simulated Sampling (Simulation)

There is no universally accepted terminology distinguishing Monte Carlo, random walks, and simulation. However, the first two concepts are probabilistic in nature, whereas simulation may be either probabilistic (digital) or deterministic (analog). In the study of vehicular traffic, use of the word simulation without any qualification will usually imply the use of a digital computer. A Monte Carlo method is often reserved for a procedure in which the process sampled has been modified to increase precision, whereas the term simulation is used when the process sampled is a close model of the real system. If the latter subtlety is subscribes to one must concede that one advantage of simulation over a Monte Carlo method is that the detailed results give a direct qualitative impression of what the behavior of the system should look like under the conditions postulated.

Although Monte Carlo and the random walks methods have contributed to the evolution of the art of simulation on a digital computer, the most significant origin lies in the theory of mathematical statistics. In its infancy, the subject of statistics consisted of the collection and display in numerical and graphical form of facts and figures from the fields of histogram, or frequency chart, and the transformation of statistics began when it was realized that the occurence of such diagrams could be explained by invoking the theory of probability.

Since a probability distribution is by its nature, in most cases, composed of an infinite number of items, whereas frequency charts by their nature are composed of a finite number of items, the latter had to be thought of as samples from an underlying theoretical probability distribution. Tocher explains how the problem then arose of how to describe a probability distribution, given only a sample from it. Because of the seemingly immense mathematical difficulties associated with this, such steps as were taken required experimental verification to give early workers confidence. Thus was born the sampling experiment. A close approximation to a probability distribution was created; samples were taken, combined, and transformed in suitable ways; and the resulting frequency chart of sampled values compared with the predictions of theory.

It is not hard to visualize situations arising where some method of sampling is indicated but where the actual taking of a physical sample is either impossible or too expensive. In such situations, useful information can often be obtained from some type of simulated sampling. Typically, simulated sampling involves replacing the actual universe of items by its theoretical counterpart, a universe described by some assumed probability distribution, and then sampling from this theoretical population by means of random numbers. Theadvent of automatic digital computers to perform the tedious calculations associated with these sampling experiments has revitalized this as a possible approach to the solution of problems still beyond the reach of analysis. The method of taking such a sample is called simulation; the decision problems which rely heavity on such sampling methods are often referred to by the catchall label of Monte Carlo methods. 27

Random Numbers

p.263

We have seen that random numbers are required in the sampling experiments associated with simulation. Humans are too full of associations to think up truly random numbers - no one would pick three 4s in a row, although such a sequence might be part of random series.

The idea of using tables of random numbers was introduced by Tippett, who constructed a table of 10,400 random digits by taking the terminal digits of entries in a census table. The RAND Corporation used an electronic roulette wheel to prepare the million-digit book of random-natural phenomena have been used to produce randomness, although some controversy exists about the validity of such procedures. Even a few philosophers have argued whether any digits commited to tabular form can still be regarded as random, regardless of how they were obtained. For practical purposes, these arguments are irrelevant; one is forced to accept any phenomenon as random whose behavior is not predictable by any obvious deterministic laws and shose numbers satisfy several standard tests of randomness to ensure, for example, that each decimal digit occurs with equal frequency without any serial correlation.

From the standpoint of checking out computer programs, there are advantages in having a reproducible sequence of numbers instead of purely random numbers. Program for digital computers can be written which will output a sequence of numbers which satisfy the various statistical tests of randomness that have been deviced. Random numbers such as these, which are generated in a nonrandom fashion, are called pseudo random numbers. In automatic computation, the storage of the large volume of random number used becomes a serious problem. It is this storage problem that has led to the abandonment of the use of tables of random numbers in computers. A satisfactory computer program for generating pseudo random numbers should (1) require little storage space in the computer, (2) be relatively fast in operation, and (3) generate a sequence of numbers that satisfies the tests of randomness. The following section describes how such programs are written. //

p. 263

Generation of Pseudo Random Numbers

" Pseudorandom-number generators may be divided into two groups: those in which the resulting sequences can be predicted theoretically and those in which theoretical prediction is impossible.

An example of the latter group is generated by the midsquare technique. An n-digit number R_0 is squared and from the resulting 2n digits the n middle digits are taken as the next random number R_1. The number R_1 is then squared and the process repeated. This technique, as are all practical techniques, is cyclic - that is, the sequence repeats itself. However, one disadvantage of this particular method lies in the possibility of obtaining a zero term during the cycle.

In order to appreciate the more sophisticated approach to random-number generation involving techniques in which the resulting sequences can be predicted theoretically, one should review a few fundamentals of number systems, computer operation and number theory.

OUTLINE OF RESEARCH

Scope of Study

It is known that, the purpose of this research is to find the optimal queue-length of vehicles between intersections. Before setting the simulated model, attention must be paid to all variables which are needed for the computer model. The following variables will be considered: queue-length; number of bounds at intersection; volume of vehicles; rate of flow or number of vehicles per interval of time; the form of frequency distributions of input vehicles; detector counters for counting the number of vehicles passing a given point; the generation of random numbers; the generation of arrivals and services; number of lanes of street; probability for turn-left, turn-right and go straightforward of vehicles; probability of servicing time for vehicle to cross an intersection; phase ration; cycle of timing; period of time to be considered as the peak-hour period. All variables mentioned are taken into account in the study of this research.

Limitation and Assumptions of Research

The limitation and assumptions of the research are briefly descirbed below:

(a) 4-bound intersections will be used as the model.

(b) Number of lanes must be greater than or equal to three.

(c) 2-phase or 4-phase of signalized control is used.

(d) The speed of vehicles is assumed to be constant.

(e) **Queue-length can be converted to the length of link linearly.**

(f) **The period of time to be considered as the rush-hour period is fixed for 2-hour or 7200 seconds. (It can be changed to others if the different computer systems are used).**

(g) **The unit of time using here is an integer form of second, no any fractions of time to be used as instantenous time. (According to the real world of traffic situation, the unit of time, as second, is enough for simulating without disturbing the systems).**

(h) **The fundamental cycle of timing using here is 120 section per cycle, actually this can be changed to any numbers.**

(i) **The basic intersection to be considered is shown in Fig.** 3-1

(j) **The detector is fixed for W-bound of the basic inter-section as shown in Fig.** 3-1.

(k) **The minimum headway or the gap between two vehicles is given about 1 second, according to The Shifted Exponential Distribution given by Gerlough.**[1]

(l) **Initialized queue of each bound is assumed to be zero, it may have the value if it is desired.**

(m) **The starting phase for N-S bound is red phase, and the other W-E bound is green phase.**

(n) **Assume that the ember phase is very small to effect the system, because it is not talked about delay time at**

---

[1] J.M. Aitken, Traffic Engineering & Control :"Simulation of Traffic Conditions at an Uncontrolled T-junction," October 1963, pp 354.

an intersection.

(p) Assume no interfering among lanes. (This is the ultimate assumption that the drivers should or must follow the traffic law.)

(q) Poisson distribution or in the ~~orther~~ other word Exponential Distribution is applied for the input distribution at the outer-bounds for free flow condition.

(r) The mean of Poisson distribution using here, follows the mean of the data collected from some parts of Bangkok.

(s) The application of the model is shown in Fig. (Apply for 2-intersections.) The optimal queue-length between the intersections is the objective.

(t) IBM 1130 system and programming are used for setting the traffic model.