Counter and Summary Statistics:

Counter which are the basic for most statics are used to accumulate totals and to record current values of some level in the system. For example, in the simulation of telephone system, counter are used to record the total number of lost call, busy call, and to keep track of how many link were in use at any time. Whenever a new value of a count is established, it is compared with the record of the current maximum or minimum, and the record is changed when necessary. The accumulator sum of observation must be kept to derive the mean value and standard deviation as below:

The mean of a set of N observation x_r (r=1,2,3,4,…..,N) is defined as : Mean, $m = \frac{1}{N}\sum_{r=1}^{n} x_r$

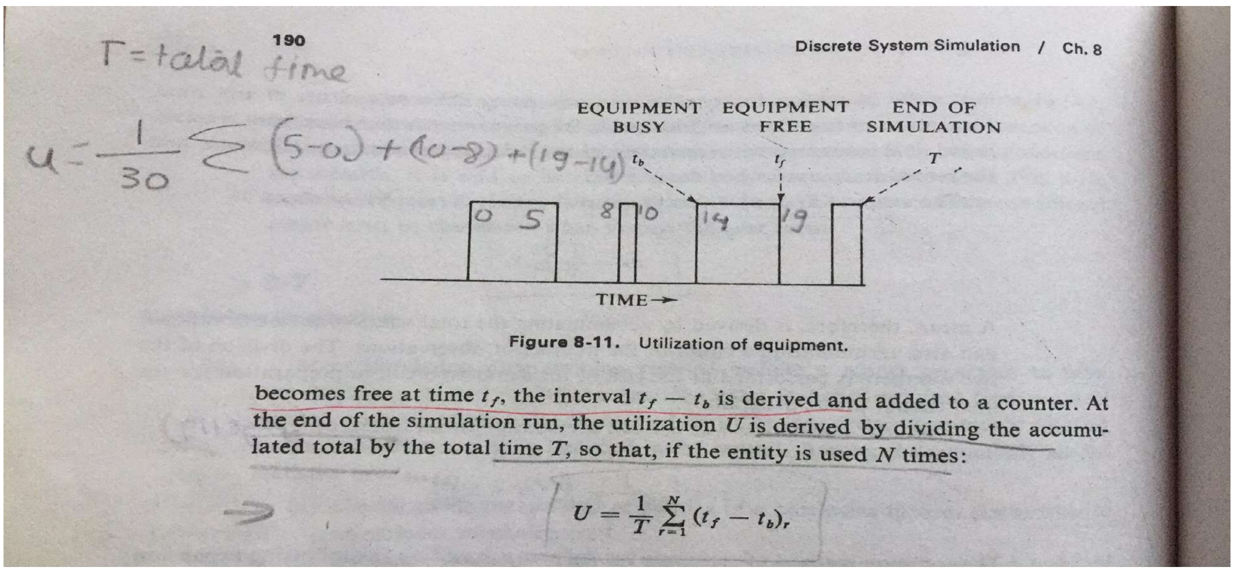
A mean is derived by accumulating the total value of the observation, and also accumulating a count of the number of observation.

And, Standard Deviation, $s = \{\frac{1}{(N-1)}\sum_{r=1}^{n}(m - x_r)^2\}^{1/2}$

The accumulated sum of the observation must be kept to derive the mean value, and so the additional record needed to derive a standard deviation is the sum of the squares.

Measuring Utilization and Occupancy:

To measure the load on some entity such as an item of equipment, the simplest way is to determine what fraction/percentage of time, the item as engaged during the simulation. Measuring those statistics is referring to as the utilization of that equipment.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T = total time

$u = \frac{1}{30} \sum (5-0) + (10-8) + (19-14)$

Figure 8-11. Utilization of equipment.

becomes free at time t_f, the interval $t_f - t_b$ is derived and added to a counter. At the end of the simulation run, the utilization U is derived by dividing the accumulated total by the total time T, so that, if the entity is used N times:

$$U = \frac{1}{T}\sum_{r=1}^{N}(t_f - t_b)_r$$

In dealing with groups of entities, rather than individual item, the calculation is similar, requiring that information about the numbers of entities involved also kept. The below figure represents as a function of time and the number of links in telephone system that are busy. To find average numbers of links in use, a record must be kept of the number of links currently in use and the time at which the last change occurred. If the number changes at time t_i to the value n_i, then , at the time of the next change t_{i+1} the quality $n_i(t_{i+1} - t_i)$ must be calculated and added to an accumulated total. The average number is used during the simulation run A, is then calculated at the end of the run by dividing the total by the total simulation time T, so that :

Formula $$U = \frac{1}{T}\sum_{r=1}^{n}(t_f - t_b)_r$$

The below figure might also represent number of entities waiting on a queues.

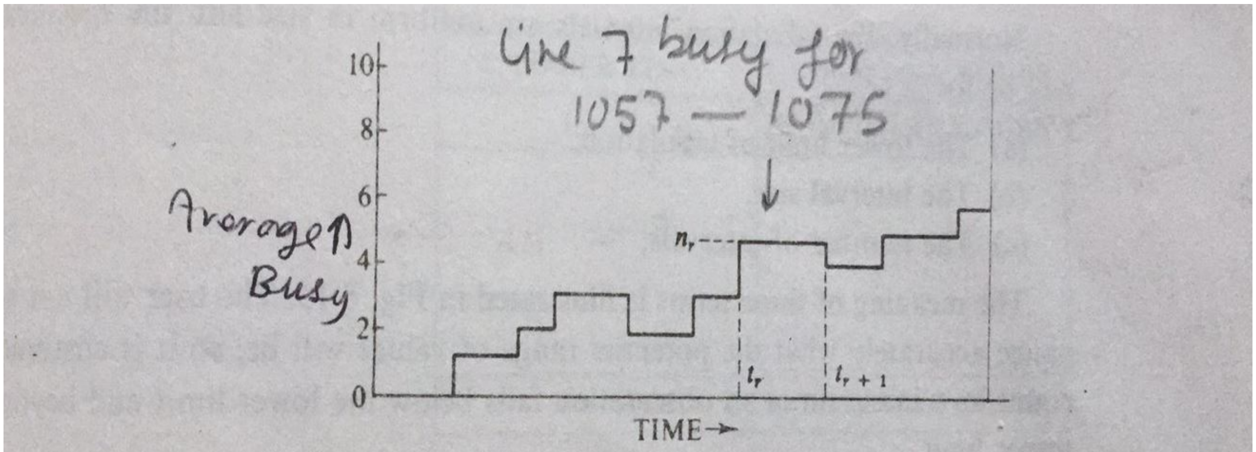


Figure 8-12. Time history of busy telephone links.

Figure 8-12 might also represent the number of entities waiting on a queue, in which case, the calculation gives the mean number of entities waiting.

If there is an upper limit on the number of entities as there was a limit in the telephone system then the occupancy is defined as the ratio of the average number in use to the maximum numbers.

Occupancy= average number in use/ maximum number

If M= links in the telephone

n_i= number of busy in the interval t_i and t_{i-1} the the average occupancy, assuming the number n_i changes n times is given by:

Occupancy, $$U = \frac{1}{NM}\sum_{r=1}^{n} n_r(t_{r+1} - t_r)$$

 # # Recording Distribution and Transit Time:

To determine the distribution of a variable it requires counting the number of times the value of the variable fall within specific interval. For the purpose, a table with location to define the internal and to accumulate the count has to be maintained. When an observation is made, the value is compared with the defined intervals and the appropriate must be incremented by one. The definition of a destination table required specified for lower limit of the tabulation, the interval size and the number of intervals. Normally, the tabulation interval sizes are uniform.

Figure

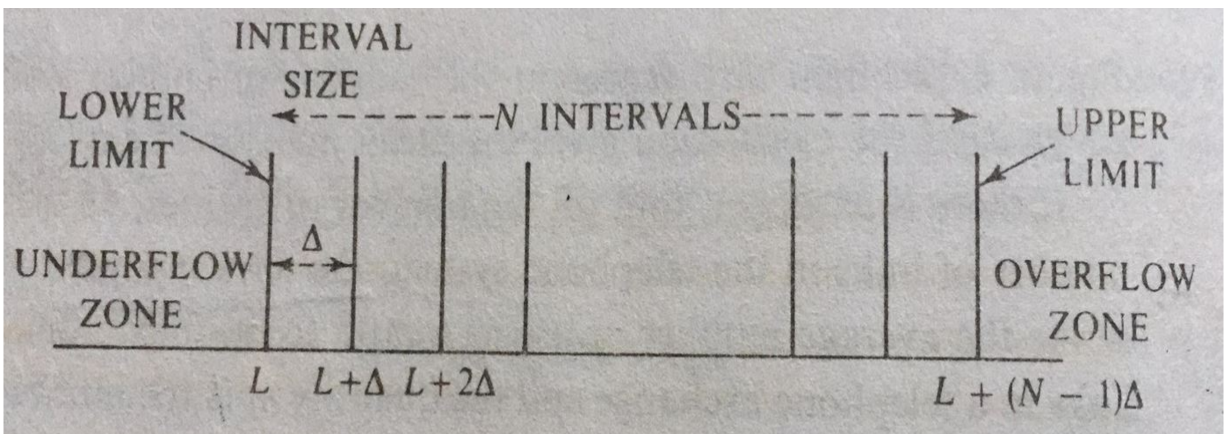


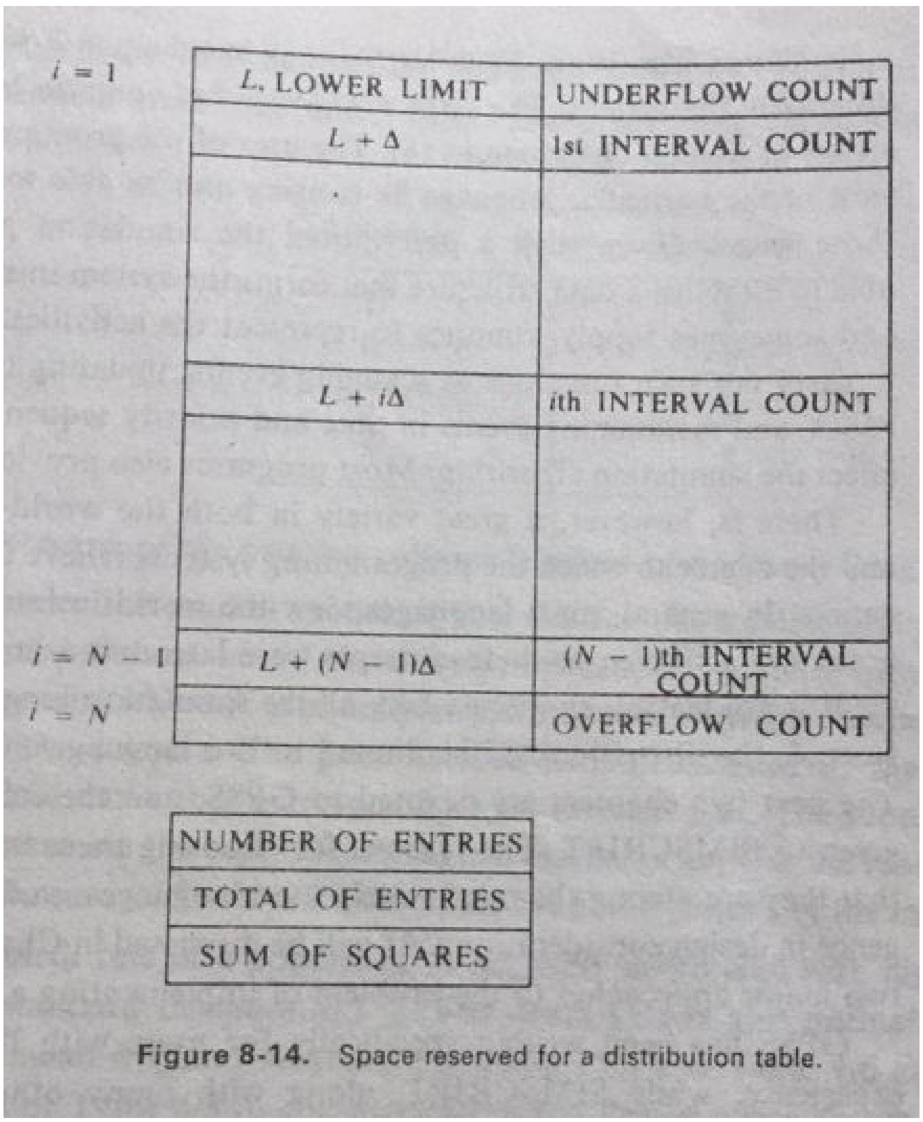
Figure 8-13. Definition of a distribution table.

Generally, it is required to keep the count, the number of times and observation falls below the lower limit and beyond the upper limit rather than to obtain accuracy the potential range of valuation. To determine the mean and standard deviation, it will be required to accumulate number of observation (X_t) and the sum of squares $(X_t)^2$. For each observation X_t ,

- One is added to appropriate counter
- X_t is added to the sum, $\sum(X)_t$
- $(X_t)^2$ is added to the sum $\sum(X_t)^2$

The space required for the tabulation shown in figure below:

Table



$i = 1$	L, LOWER LIMIT	UNDERFLOW COUNT
	$L + \Delta$	1st INTERVAL COUNT
	.	
	$L + i\Delta$	ith INTERVAL COUNT
$i = N - 1$	$L + (N - 1)\Delta$	$(N - 1)$th INTERVAL COUNT
$i = N$		OVERFLOW COUNT

NUMBER OF ENTRIES
TOTAL OF ENTRIES
SUM OF SQUARES

Figure 8-14. Space reserved for a distribution table.

Since values of observation are matched an interval the derived destination is an approximation. However, note that the mean and standard deviation will be accurate within the accuracy limit of the computer even if some observation fall outside the table limits.

The instances when the observations are made are determined by the native of random variables being measured. To understand this, consider the following two examples:

1) To measure the mean waiting time for a service, an observation must be taken as each entity starts to receive a service so that the times at which the observations are tabulated are randomly spaced.
2) To measure the distribution of the numbers of entities waiting, observation should be taken at uniform interval time. The final output weight also expresses the data in other commercial form as required. For example, cumulative distribution may be given or the distribution may be resolved to express the counts as percentage of total observation. These all results are calculated at the end of simulation.

   A clock is used in the manner of time stamp to measure transit time. When an entity reaches a point from which a measured of transit time is to start. A note of the time of arrival is made. Later when the entity reaches the point, at which, the measured ends, a note of the clock time upon arrival is made and these two clock time noted are used to computer the elapsed time.