Study on the Probability Model of Maintenance Orders Received by the Network Center of Chongqing Three Gorges Medical College

Lei Peng, Gang Zeng

Chongqing Three Gorges Medical College, Chongqing, China

Keywords: Maintenance order, Network center, Poisson distribution

Abstract: Through analyzing maintenance orders received by the network center of Three Gorges Medical College, it is found that there are certain patterns. Through theoretical verification, this paper further proves that the number of maintenance orders obeys the Poisson distribution. The research in this paper will help the network center to better analyze the task of receiving maintenance orders from the whole school, so as to optimize the allocation of human resources and improve working efficiency.

1. Introduction

The Network Center of Three Gorges medical college is subordinate to the Science and Technology Department, and there are 8 staff members in service. In daily operation, main tasks of the network center include equipment maintenance and printer connection. Common problems in network equipment maintenance include the problem of users’ Dr.COM Dialing, the problem of users’ IE, the problem of system repair and re installation, the problem of office switches and AP, setting of the port accessing to the switch and the problem of customized network cables. The problem of printer connection also includes network printer connection and traditional printer connection. For orders of network equipment maintenance and printer connection, the number can be more than 15 or less than 5 orders per day. Through studying the probability model of order receiving, this paper hopes to find out the internal law of the number of orders received by the network center of Three Gorges Medical College, so as to provide intellectual support for the overall arrangement of the network center.

2. Observation on Orders Received by the Network Center of Three Gorges Medical College

Orders received by the network center of always come one after another. Teachers who come to seek help never come at the same time, which is exactly in line with the three conditions of Poisson distribution. First, they are small probability events. At each time point there is one repair event; different teachers never come at one single event point. Second, events are independent with each other. These events can not affect each other, and there is no connection among teachers who apply for maintenance. Third, the probability of event occurrence is stable. The probability of failure has nothing to do with the time point, but related to the length of time.

For the first condition, in the actual work of the network center, sometimes there are a lot of orders crowded together, causing the impression that repair applications “happen at the same time”. However, if we analyze carefully, it can be found that orders still come one after another. The nearest time interval can be a few seconds. Therefore, order received by the network center meets the first condition of Poisson distribution.

  DOI: 10.25236/ieesasm.2020.147

3. Probability Distribution

3.1 Distribution

The 0-1 distribution is also known as the Bernoulli distribution, which is concerned with the results of a single experiment. Suppose that we conduct an experiment, and that the result of the experiment can only be success or failure. The probability of success is p, and the probability of failure is q = 1-p. If the result of the experiment is expressed as a random variable X, then the success and failure of the event can be represented by two integers 0 and 1 respectively. The probability distribution of X will be $P(X = k) = p^k(1-p)^{1-k}$, $k = (0,1)$. We call that X satisfies the 0-1 distribution or Bernoulli distribution. There are many examples of 0-1 distribution in real life. Examples include front and back of the coin when we toss a coin, the success and failure when we shoot at the basket, and the win and lose when we buy a lottery. The expectation of 0-distribution is p and the variance is pq. [1][2]

3.2 Binomial Distribution

The Binomial distribution means to repeat the 0-1 distribution test independently for many times. It focuses on the results of multiple tests. Suppose that in a single experiment, the probability of success is p and the probability of failure is q = 1-p. The total number of times we conduct experiments is n, and the number of success is k. If the result of the test is expressed by a random variable X, then the probability distribution of X will be $P(X = k) = \mathrm{C}_n^k p^k (1-p)^{n-k}$, $k = (0,1,2,\cdots,n)$. Examples of binomial distribution in real life include, a person can repeatedly hit the target several times, and only two kinds of results are counted each time; one person shoots at the basket for several times, and only two kinds of results are calculated each time; several individuals take the exam, and only two kinds of results, pass or fail, are counted. The expectation of binomial distribution is np and the variance is npq. [1-4][9]

3.3 Poisson Distribution

The Poisson distribution is concerned with the distribution of a random variable, namely the number of rare events occurring over a period of time. The probability distribution function is $P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$. The parameter λ is the average number of random events happen in per unit time (or unit area). There are three conditions for the occurrence of the Poisson distribution: small probability events, independent events and stable probabilities. In real life, examples of the Poisson distribution include, babies born in a hospital in a period of time, the number of requests received by the network server in a period of time, vehicles passing through the high-speed port in a period of time, and so on. The expectation and variance of the Poisson distribution are both λ. [5-9]

4. Probability Distribution of Orders Received by the Network Center

4.1 Binomial Distribution of Orders Received by the Network Center

We set the working time from 8:00 a.m. to 6:00 p.m., which is 10 hours or 36000 seconds. Assuming that the number of orders received by the network center is every day, then we can get the probability of repair orders arrive in one second, P = λ / 36000. We assume that multiple orders can't come in the same second after we investigate a lot of data and refer to historical experience.

We get that the total number of events in a day is n = 36000; the probability of success is p = λ / 36000; the probability of event failure is 1-p = 1 - λ / 36000. According to the formula of binomial distribution, the probability of network center receiving k orders a day is as follows.

$$\frac{36000!}{(36000-k)!k!}\left(\frac{\lambda}{36000}\right)^k\left(1-\frac{\lambda}{36000}\right)^{36000-k} \qquad (1)$$

4.2 Poisson Distribution of Orders Received by the Network Center

In last paragraph, we set the unit of time to "seconds", so we get 10 hours, or 36000 units of time. If we set the unit of time to a unit smaller than seconds, such as microseconds or milliseconds, then the total number of time periods we get will become very large. Now let's set the unit of time to be very small, and let it approach 0, then we will get infinite n, which can be substituted into the formula

$$= \lim_{n\to\infty} \frac{n(n-1)(n-2)\cdots(n-k+1)}{k!} \frac{\lambda^k}{n^k} (1-\frac{\lambda}{n})^{n-k}$$

$$= \lim_{n\to\infty} \frac{n(n-1)(n-2)\cdots(n-k+1)}{n^k} \lambda^k \frac{1}{k!} (1-\frac{\lambda}{n})^{n-k}$$

$$= \lambda^k \frac{1}{k!} \lim_{n\to\infty} \frac{n(n-1)(n-2)\cdots(n-k+1)}{n^k} \lim_{n\to\infty} (1-\frac{\lambda}{n})^{n-k}$$

$$\because \lim_{n\to\infty} \frac{n(n-1)(n-2)\cdots(n-k+1)}{n^k} = 1$$

$$\because \lim_{n\to\infty} (1-\frac{\lambda}{n})^{n-k} = e^{-\lambda}$$

$\therefore$ the original formula = $\lambda^k \frac{1}{k!} e^{-\lambda}$

Sorting out the formula we can get $\frac{\lambda^k e^{-\lambda}}{k!}$

We find that this is exactly the formula of Poisson distribution, so it can be proved that the order receiving probability of the network center conforms to the Poisson distribution.

5. Experimental Analysis

We use the program to calculate the probability [10], and get the probability distribution map when taking different values of λ (i.e 3, 5, 7, 9 respectively), as shown in Figure 1. In the graph, the abscissa is the value of k and the ordinate is the probability p.

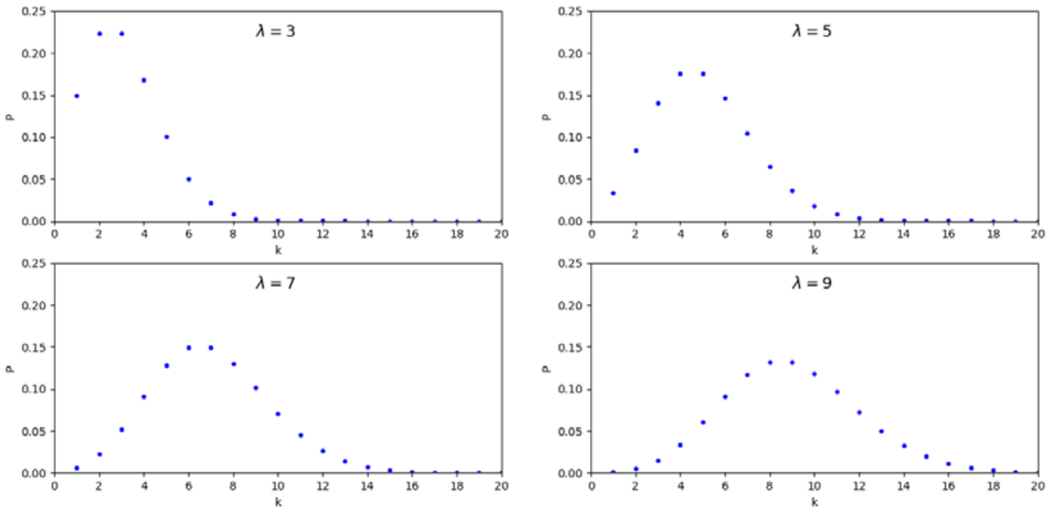

Fig.1 The Probability Distribution Map

It can be found that the probability peak values of all points do not exceed 0.25, and the probability distribution shows a symmetrical trend when λ is more than 5. According to previous work experience, the average number of maintenance forms received by the network center is 7 a day, so λ is taken as 7. It can be seen from the figure that the four points with the highest probability are k = 5, 6, 7 and 8. This shows that, based on previous data, we get the most likely number of orders received by the network center every day as (5,6,7,8).

6. Summary

Through theoretical verification, this paper proves that the probability of orders received by the Network Center of Three Gorges Medical College obeys the Poisson distribution; numbers of orders with large probabilities are also obtained through experiments. This research can help the network center to better analyze the task of receiving maintenance orders from the whole school, so as to optimize the allocation of human resources and improve the working efficiency.

Acknowledgement

This work was financially supported by the Chongqing Three Gorges Medical College under Grant "Research on Website Group Data Monitoring Based on Word Embedding: Taking Chongqing Three Gorges Medical College as an Example" (Grant NO. 2019XZYB13).

References

[1] X.L. Wan, Approximate calculation and application examples of binomial distribution, Science and Technology Vision, vol. 23, pp. 135-137, 2019.

[2] Y.F. Zheng, The application of binomial distribution model in management -- and on the quantitative method of management, Journal of Heihe University, vol. 11 (01), pp. 75-77, 2020.

[3] Application of multivariate zero floating negative binomial distribution model in aging research in the United States, [online] Available: https://doi.org/10.13860/j.cnki.sltj.20191107-002.

[4] C.H. Wu, Two parameters of binomial distribution, Studies in College Mathematics, vol. 23 (01), pp. 115-119, 2020.

[5] Q. Xiao, R.C. He, J.N. Yu, et. al, Modeling taxi sharing probability and waiting time based on Poisson distribution, China Journal of Highway and Transport, vol. 31 (05), pp. 151-159, 2018.

[6] X.H. Li, Y.C. Zhao and J.P. Zhao, Research on optimal cluster heads of Poisson distribution in wireless sensor networks, Communications Technology, vol. 53 (02), pp. 335-340, 2020.

[7] Y.R. Xia, J. Wu and D.Q. Ye, Poisson distribution and the development of probability theory -- Simon Daniel Poisson, Chinese Journal of Disease Control and Prevention, vol. 23 (07), pp. 881-884, 2019.

[8] Z.Y. Tang, Point Cloud Reduction Algorithm Based on Poisson Distribution K-means Clustering, Taiyuan University of Technology, 2019

[9] D. Zhang, Relationship between several common probability and statistical distributions, Journal of Xianyang Normal University, vol. 34 (02), pp. 51-54, 2019.

[10] X.Q. Ye, Application of Python in the teaching of probability theory and mathematical statistics, Chinese and Foreign Entrepreneurs, vol. 08, pp. 226-227, 2020.