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Professional paper

NORMAL DISTRIBUTION ON ENERGY SAVING PROBLEMS FOR THE WIRELESS SENSOR NETWORK LIFE ON THE VACATION PERIOD

Shkelqim HAJRULLA[1], Loubna ALI[2], Nour SOULIMAN[3]

[1]*Department of Computer Engineering, Faculty of Engineering, Epoka University, Albania*
[2]*Department of Information Technology Engineering, Faculty of Engineering, University of Tartous, Syria*
[3]*Department of Information Technology Engineering, Faculty of Engineering, University of Tartous, Syria*
**Corresponding Author: e-mail: shhajrulla@epoka.edu.al*

Abstract

Based on math operations, we can do some analytic approaches for energy saving for the WSN life. We will study the vacation period time using numerical methods for studying the energy-saving mechanism in analytic models. Several research papers have reported that the normal distribution of a random variable has an enormous contribution in analyzing and comparing the data with each other, making the process easier according to methods used or observing the tendencies of numerous occurrences in real-life applications.

This paper focuses on analyzing two problems: the first one is the normal distribution and its special cases by solving real problems of WSN node operations and the second one is the application of standard normal distribution related to saving energy during vacation time in a certain time interval. The goal of our work is to obtain the appropriate algorithm to minimize the risk of data loss during the network vacation period, which is associated with the organization of network node structures after this period time, and to maximize the battery life of individual sensors.

For that, we will use math methods and based on probability distribution theory, we derive some distributions of the processing period duration from an arbitrary fixed time up to a variable time t. The analytic approach based on the conception of the Laplace transform and the Lagrange method performs better than the previous results. We continue by examining them through detailed calculations and graphs. We compare the predicted energy saving and the average real energy.

Keywords: numerical methods, lost packets, time charging, sensors, programming complexity

1. Introduction

For a long time, the authors studied a challenging way to solve the problem of energy saving in WSNs based on the selection of the shortest route, using various shortest path algorithms. They used the way of minimizing the costs of energy consumption can lead to an increase in the ratio of lost packets, giving a relatively small ratio of lost packets [1]. This paper discussed the problem of time delay in WSN and suggested an appropriate solution to reach that goal. In a previous article [4], we proposed a solution based on two ideas: using two cluster heads and reducing programming complexity [13]. A challenge for us was the occurrence of temporal death in some sensor nodes [9]. The energy consumption evaluation is considered using the discrete-time model [11, 12]. In the network security theory, the issue of energy saving in wireless sensor networks (WSNs) is very complicated. Many scientists studied a lot from the point of view of network security, including energy life operations, securing an adequate level of data transmission quality, and algorithms used. We use the normal distribution as a probability distribution theory [10], a distribution that is symmetric about the mean. This indicates that the data approaching the mean are more frequently occurring than data placed far from the mean. This theory states that the averages of independent, identically distributed random variables do have approximately normal distributions. Using Python program, we apply algorithms for self-organization of sensor networks to minimize the risk of data loss during transmission, which is associated with the organization of network node structures, and secondly to maximize the battery life of individual sensors [2, 3]. When the wireless sensor network is dense (the cluster size is large and the number of sensors in each cluster is large), the moving cluster head may run out of energy before ending the specific period and it's probably to end the specific period before collecting the data from all nodes in the clusters [4]. In some previous articles, the researchers discussed the wireless sensor network in the framework as the WSN suffers from the death of the network because one or more sensor nodes run out of energy. An energy-balancing algorithm for wireless sensor networks is applied [8]. So, the most of previous searches focus on reducing the consumption of energy in WSN to extend the network's lifetime [5, 6]. We use our method to reduce the delay of data collection and using the normal probability distribution, we complete the time life distributions of power energy. We can approximate the solution of the problem and compare the obtained results with the predicted one. Then, someone can use those results to calculate the errors of the process. Given some data tables and graphics, we perform visually the previous technique. Graphically, we use the normal distribution for the said problem.

We deal with the analysis of the functioning of packet network nodes and the process of network optimization by algorithms, mathematics operators, normal distributions, numerical methods, and conclusions from a comparison of graphic results. This paper presents a solution to increase the efficacy of WSN energy, but by not using of two mobile cluster heads and parallel processing technology, as in our previous article. Therefore, we also canceled the collection function of all nodes' data due to the time that the moving nodes will take to achieve this process [4]. The representation for the Laplace transforms of the distribution at arbitrary fixed time t and processing periods is presented in our research.

The distributions processing period duration and numerical results are derived. We can see the improvement in the time delay achieved by this work. In a later study, we will discuss the effect of suggestions that helped reduce the time delay on energy consumption, considered as a challenge in the field of WSN. Using the modular matrix through the Python program [7], we would be able to take the best results related to the approximation theory for the solution of the WSN problems. Normal Distribution in the standardized form is very important for our research. A standard deviation is a measure of the spread of the distribution – the bigger the standard deviation, the more spread out the scores in the population. We can show it with graphics. We analyze the distribution on the vacant period of the system as well and we give explicit results for the probability distribution function of the number of packets present in the system.

2. Main Theory of the probability distribution theory

2.1 General theory description : When dealing with the graph the shape of the normal distribution function will be nearly flat on top, quickly decreasing toward the x-axis and at a point, it will slowly decrease towards the "tails" of the distribution. Frequency distribution describes a random variable, but it does not fit the normal distribution graph perfectly. The formula of the probability density function of the normal distribution is used to study the distribution of energy life.

$$f(x) = \frac{e^{-(x-\mu)^2/(2\sigma^2)}}{\sigma\sqrt{2\pi}} \tag{1}$$

where μ is the location parameter and σ is the scale parameter. Especially we use the special case of normal distribution is the standard normal distribution. For the standard normal distribution, the value of the mean is equal to zero (μ=0), and the value of the standard deviation is equal to 1 (σ=1) using the general formula:

$$f(x) = \frac{e^{-x^2/2}}{\sqrt{2\pi}} \qquad (2)$$

We formulae some knowledge for the distribution energy consumption and processing period duration of the battery is derived. Giving some numerical examples, we perform our numerical process concluding with important results.

2.2 Standardization of normal distribution: Let us take into consideration the standardization of normal distribution. To standardize a normal distribution function, we change the random variable X to Z. To do this we use the formula: $z = \frac{x-\mu}{\sigma}$. This formula shifts all the data so that they can give a mean of zero rather than μ. Note that in the standard normal distribution μ=0, (x is a particular measurement, μ is the population mean, and σ is the population standard deviation). The graphic of Normal Distribution has a peak in the middle where most people score and tapering ends where only a few people score. The area under the curve between scores corresponds to the percentage in the population between those scores. The scores on this curve are color-coded in standard deviation units. A standard deviation is a measure of the spread of the distribution – the bigger the standard deviation, the more spread out the scores in the population.

2.3 Model description: We have attached a Python Code in Appendix/Calculations, which explains the distribution of scores and result generation of normal distribution data. The method with finite absorber capacity and an energy-saving mechanism is a mix of the classical multiple vacation policy [10]. The problem is solved according to a Poisson distribution with rate λ and with a maximum system size K. Using the property of the exponential distribution for some different values of times, the following graphic representations are true. We state the representation for the probability $P(X(t))$ with a specific characteristic function and we identify the vacant (suspension) period with its duration as discussed [10], but we will not deal with the algebraic representations. The formula of total probability gives. We are interested in the probability distribution of the next state after the arbitrary processing vacant period

$$P(X(t) = m) = \sum_{j=1}^{\infty} P\big(X(t) = m, t \in I_j\big) + P\big(X(t) = m, t \in \mu I_j\big) \qquad (3)$$

Using the properties of the exponential distribution, the sequence $X(t_i)$, $i = 1, 2, \ldots$, where t_i stands for the ith processing time after the starting moment, is an embedded Markov chain for the process $\{X(t), t \geq 0\}$. The sum on the right side of the formula above is taken over all possible values of $l_1, \ldots, l_{i-1} \in \{N, \ldots, K\}$, [10]. We use the representation of Laplace transform for size distribution in the considered method with a controlled multiple vacation policy.

The second problem discusses the time between saving energy. This time is normally distribution with a mean of 50 hours and a standard deviation of 15 hours. We need to calculate the probability that the time will be between 50 and 70 hours. Given, the mean value (μ) = 50 and standard deviation, σ = 15, we are required to find the probability that y lies between 50 and 70 or P (50 < y < 70). If we consider x = 50, then z = (50 – 50) / 15 = 0. If we consider x = 70, then z = (70 – 50) / 15 = 1.33. P (50 < x < 70) = P (0 < z < 1.33) = area to the left of z = 1.33 area to the left of z = 1.33 – area to the left of z = 0 area to the left of z = 0.

P (0 < z < 1.33) = 0.9082 – 0.5 = 0.4082. The probability that saving energy has a time-period between 50 and 70 hours is 0.4082.

3. Results

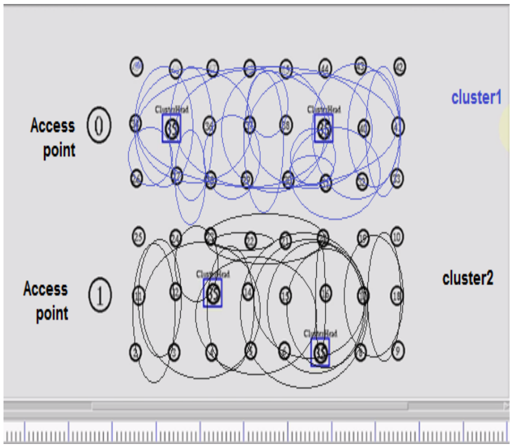

Figure 1. First scenario using one cluster's head

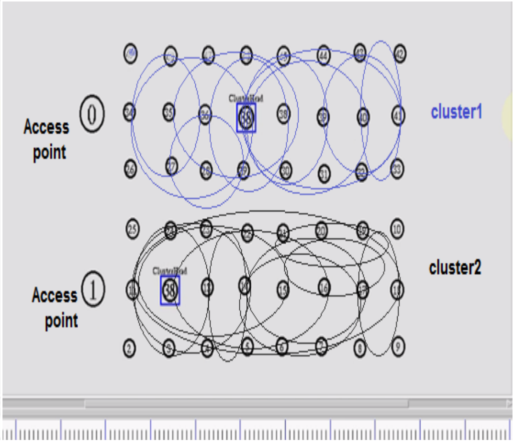

Figure 2. Second scenario using one cluster's head

To support the research proposals with practical results, an NS2 simulator was used accompanied by an Xgraph application to display the research results [4]. The figures above "Figures 1, "Figure 2," show the studied networks after placing the nodes by the network designer in the search area. For the goal of comparing the two cases, two scenarios had been applied.

The following "Figure 3," Figure 4," show the studied networks probability after placing the nodes by the network designer in the search area.

The following "Figure 5," and Figure 6," show the time delay at the end of the simulation when applying the proposed mechanism in this research. The output of the Xgraph application, "Figure 3,” shows the difference of the delay between the previous two scenarios before reducing the program complexity and the delay after reducing the program complexity. "Figure 4," shows the delay after decreasing the complexity of the software when the simulation is finished, and it was equal to 0.0025ms.

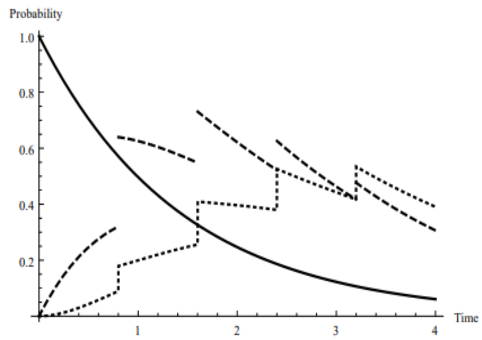

Figure 3 . $P\{X(t) = m, t \in I1\}$ for $\lambda = 1.1$

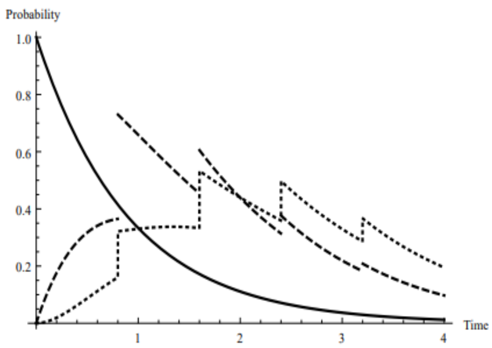

Figure 4 . $P\{X(t) = m, t \in I1\}$ for $\lambda = 0.7$

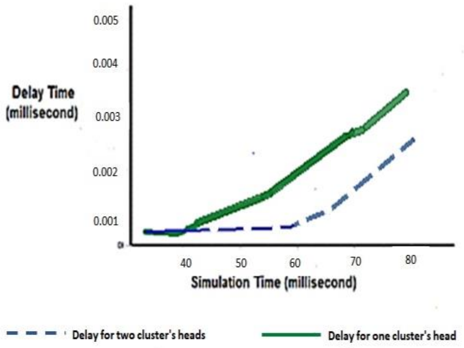

Figure 5. Difference of the delay between two scenarios.

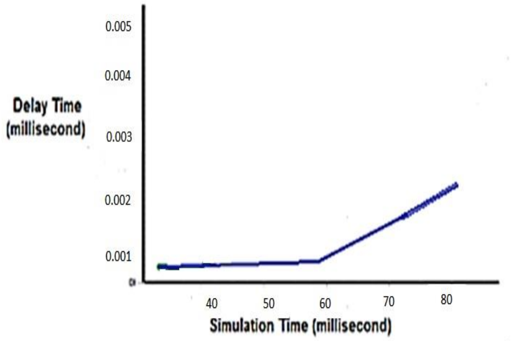

Figure 6. Delay after reducing the complexity

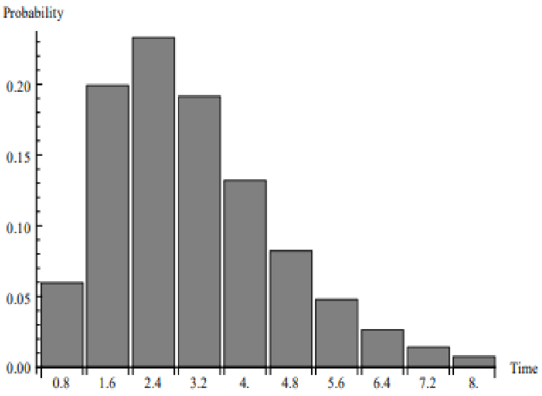

Figure 7. Distribution of vacant period for λ = 1.1

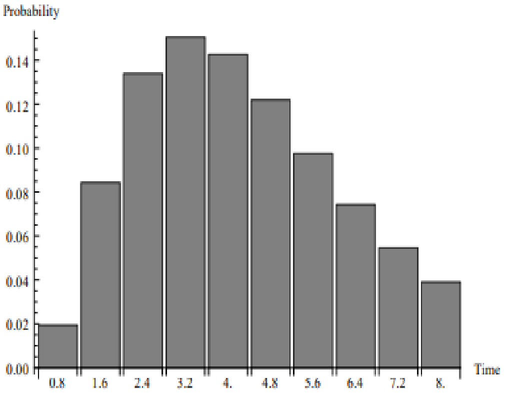

Figure 8. Distribution of vacant period for λ = 0.7

The above figures "Figure 7," Figure 8," show the delay between two scenarios and the delay after reducing the complexity. In addition, it shows that the maximum of the distribution moves to the right with the decrease of λ [10].

Further, our program investigates the number of packets at the completion epoch of the vacant period of energy. The following figures "Figure 9," Figure 10,” represent different values of λ in different cases.

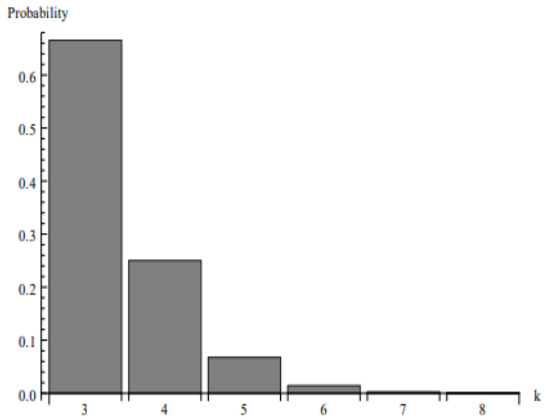

Figure 9. Number of packets at the vacant period for λ = 1.1

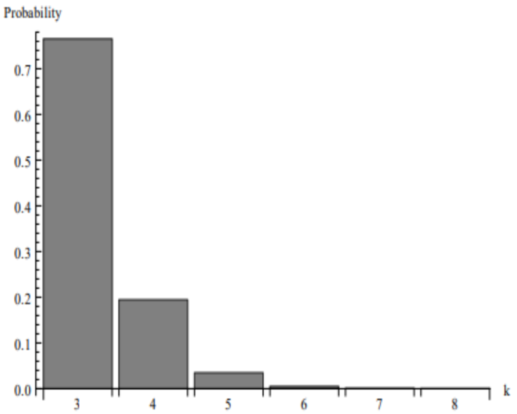

Figure 10. Number of packets for λ = 1.1

4. Conclusions

Our program investigates the behavior of the probability distribution of the vacant period duration. The paper represents it for different values of λ in different cases. It shows that the greater the arrival intensity, the greater the probability that the vacant period will finish.

We have used desmos graphing and Python programming to achieve correct results throughout the article. Python provides a simpler graphing methodology and desmos makes the graph more readable. The vacation period related to the standard normal distribution is studied, applying the analytic approach based on the idea of the embedded Markov chain, integral equations, and renewal theory.

In this paper, we have introduced how it makes the data to be easier for an analytical approach. We have also standardized the normal distribution function in the research application. Through the calculations, we also proved that standardization would make the data comparison easier and faster. On the other hand, we analyzed how normal distribution predicts the failure of energy conservation in terms of time and predicting the time interval for the next period of energy conservation to fail.

Through normal distribution, we have proved that data distribution in relationship with each other is comparable and easier to read and analyze. Additionally, we have also observed a symmetry in the mean for the real-valued random variables under fair conditions.

A future study will be organized to benefit from the interest's coverage in the places where sensor places are hard to reach, to reduce the period of collecting information on the network and consequently conserve energy. Shortly, we will address the problem using the Hamiltonian operator. The operator can used to approach the Hamiltonian simulation in saving WSN energy, as we can use it in quantum computing to handle computational complexity and algorithms needed for simulating systems. Hence, we will discuss how the Euler-Lagrangian equation can be used to solve the same problem more efficiently. We exemplify this formalism with some widely studied models, including the standard formulas for each method, simulations, and graphs.

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