Maximum Viability for WSN with Energy Harvesting and Cooperation by Drift Penalty and Perturbation Method

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Abstract.

There has been a rise in the quantity of research being done on wireless communication as a result of the possibilities for their wide implementation in a multitude of areas including such building automation, protection, pollution monitoring, as well as other applications. Wireless sensor networks (WSNs) have a limited storage capacity, which reduces the lifetime of edge devices. As a consequence, total system availability and reliability suffer, which is a problem for the industry. When it comes to enhance the battery's life approaches such as power generation and cooperation, which collect power from the external environment and share it among sensor network, are feasible options. Renewable energy and close cooperation are taken into consideration in this work while addressing the combined value function problem for WSNs. Initial results just on Lyapunov slides for propagation delay are obtained, and afterwards we design the enhancement as a stochastic optimum solution with a workable approach using Lyapunov slide results. We also provide an interactive algorithm was implemented the Lyapunov optimization approach with the dispersion approach and the fluctuation approach to execute generated power and movement of electricity, data transmission, transmission power, network optimization. In cloud environments, it makes an important contribution to achieve optimum functionality and a reasonable trade among vitalizing and queuing system backlog even without any relevant data about dynamical system, with no need to be worried about the computational complexity when working with a large waiting line backlog of demands. Because communication system has a linear relationship with battery performance, the simulation findings also illustrate that the proposed approach is possible for real-world use.

Keywords. ***Drift-Plus-Penalty, Energy Management, Lyapunov Analysis, Utility Optimization, WSNs***

1. INTRODUCTION

In the field of wireless sensor networks (WSNs), energy efficiency has emerged as a prominent research topic. One reason for the increased interest in energy efficiency is due to the limits imposed by the batteries that are used to power such gadgets [1]. Because of the availability of low-cost technology, the development needs for data transfer are rising all the time. As a result, wireless sensor networks (WSNs) have the potential to develop into a viable system architecture in which a large number of linked sensor nodes collaborate to acquire and fuse data originating from a variety of sources. Consequently, WSNs have the potential to be extensively used in a variety of fields [2, 3]. In contrast, wireless sensor networks (WSNs) have a variety of challenges, including data limits, data management, rechargeable electricity consumption, and computational power. Fuel efficient connectivity and decreased electricity consumption are required to address the limited lifetime of WSNs, which would be induced by the reality that the sensor networks are powered almost completely by charges. This has been regarded as the most critical problem that must be addressed quickly [3]. In various cellular connections, such as WSNs [4], mobile networks, and infomercial connections, it is being utilized as one of the innovative techniques to regulate energy consumption. Solar power is among the unique solutions in energy monitoring that has emerged in recent years. To address this issue, efforts are being made to employ extracting power, wherein the detectors are fully equipped with energy storage devices that collect and store power from the external environment, thereby increasing the life of the battery of wireless communication and boost their knowledge.

The WSN (Wireless Sensor Network) is a critical component of the Internet of Things (IoT), and it has spread to a variety of diverse applications that operate in real time. The Internet of Things and wireless sensor networks (WSNs) now have a wide range of essential and non-critical applications that affect practically every aspect of our daily lives. WSN nodes are typically tiny, battery-operated gadgets that transmit data. In this context, energy efficient data aggregation solutions with the potential to extend the network's life lifetime are very important. In contrast, the dynamic properties of the energy harvesting framework make it more difficult to establish some transmission policies that take into account a variety of node features such as harvested energy, energy needs, and the surrounding environment. For example, high energy use may result in an energy outage, resulting in nodes that are unable to function effectively. In addition, because of their limited battery capacity, sensor nodes have a limited amount of accessible energy, necessitating the development of a method that can adapt to the nodes' future status. Taking care of utility optimization in WSNs becomes more complex as a result of all of these factors.

Recent studies on efficiency improvement approaches for thermoelectric generator nodes have been reported in peer-reviewed journals, indicating that there could be some previous research in this area. There is a description in [5 of an adjustable thermoelectric generator that can be connected to the electric cells or storage and that may be used to extend the lifetime of wireless sensor networks (WSNs). Using reinforced training methods for the creation of simulated annealing to cope with power management problems was determined to be the best course of action. Although dynamic programming (DP) often can be used to solve such multi - objective optimization problem, it is often necessary to have thorough understanding of data concerning chaotic settings. This might lead in the computational complexity when faced with a difficult congestion of requests in a queue. A significant amount of attention was paid to the improvement in accuracy on the linear Lyapunov function, which have been provided for energy conservation and price minimization and garnered a considerable amount of attention among some of the proposed schemes. Furthermore, the dispersion technique, which can be thought of as the very first Lagrangian a double methodology for optimization techniques, can also be used to tread a fine line among infrastructure achievement and response time, that can be thought of as the alignment among mobility results and network connectivity, could be used to find a balance with both power distribution effectiveness and low network. To use the Lyapunov drift technique, we are capable of building a mixed system operation, scheduling, and voltage regulation technique that delivered the includes network in a buffer with a restricted length by taking use of the Lyapunov drift technique. However, owing to the restrictions of the network architecture, this technique could only be applied to solitary WSN networks. Courtship of sustainable power and the electrical infrastructure resulting in the formation of a new diversification energy source that is more resilient to climate change. In contrast, the vast majority of studies operate on the premise that electricity demand is autonomous of each other and therefore there is no power interchange among nodes in the network. In these kind of complex systems, the energy produced in the cushion of the iot devices poses a significant challenge towards the development of an effective routing protocol, mainly due to the fact that the current power spending selection may result in a power service disruption in the coming years, which will have an impact on the advancement choices. In such chaotic environments, the electricity produced in the cushion of the edge devices poses a significant challenge to the development of an efficient routing protocol.

Throughout this article, we will be taking into account the multi-hop WSNs system. The following are the most significant contributions made by this publication.

- If we talk about wireless sensor networks (WSNs), we take account both sustainable power and collaborative behaviour, in which networks not only exchange power within itself but also gather power from their environment.
- For the purpose of maintaining system reliability, we set an top constraint on the Lyapunov drift, which means that nodes may only collect power when the size of the energy queue is less than the barrier. Specific network queue backlog constraints are provided, as well as a method for explicitly calculating the energy storage capacity needed by sensor nodes in multi-hop WSNs.
- In order to optimize the system utility in terms of data gathering rate, we define the joint utility maximization as a probabilistic optimal solution. A Lyapunov approach, paired with concepts such as slide plus penalty and perturbation technique, is used to deal with the issue in this instance. A web-based technique for power generation and communication, data transfer, power efficiency, network optimization is developed in this work and combined with some other platforms to provide a comprehensive solution. When a nonlinear Lyapunov function is employed as the foundation for the method's development, it purposely disturbs the punishment scales that are utilized for analysis in order to push the intended waiting time forward into a nonnegative quantity in place to evade the system from being under flown. Using a piecemeal approach, this structure is able to achieve the perfect functionality by considering multiple the

super capacitors and channel assignment strategy while bearing in mind the cranking amps limitation, the information transmission rate constraint, the link requirement, and the power generation limitation. No quantitative understanding of nonlinear method is necessary, as well as the plague of complexity might well be evaded also when working with a large congestion of requests.

- EDPR method, according to simulation data, provides a favorable time-averaged trade off among access and queue size when compared to other algorithms.

The rest of this work is arranged in the following manner: The preceding techniques are summarized in Section 2 of this document. Using the Lyapunov technique, we calculate the maximum bound of Lyapunov drifting and propose an internet platform for resolving the unexpected problem in Section 3. These results are reported in Section 2, along with a Lyapunov means of solving the unexpected problem. Section 4 examines the effectiveness of the suggested method via the use of numerical simulations. The outcomes of our simulations are provided in order to validate our approach. Finally, Section 5 brings our work to a close.

2. RELATED STUDY

Energy management solutions for WSN) nodes with composite energy storage that are now in use do not fully integrate the advantages of SCs and batteries, and battery deterioration continues to be an issue that reduces the lifespan of WSN nodes. According to this study, an adaptive rule-based energy management technique for extending the battery life of solar-powered wireless sensor nodes is presented. Battery deterioration is taken into account while constructing energy models, and the Poisson distribution is used to mimic the variance in power consumption at the node. It is planned to use a rule-based energy management technique that is adaptable to changes in SC capacity and load. When compared to [6,] traditional energy management solutions for WSN nodes are more efficient. In accordance with the findings of simulations, the suggested technique may extend the node lifespan from tens of days to well over a decade. As a result of this method, solar-powered WSN nodes will be available at all times of the day and night during their extended operational lives. The strategy's sturdiness is likewise put to the examination. It has been discovered that the method is adaptable to the capacity and workload requirements of the SC system. When it comes to solar-powered WSN nodes, the suggested technique is universally applicable and seems to be a potential solution to the issue of limited energy.

The short lifespan of rechargeable batteries sensor nodes is a major challenge in the use of wireless sensor networks in a variety of uses. Several strategies were modified and merged by the author in [7] in order to enhance the lifespan of a wireless sensor network. The network under consideration was created for applications involving road traffic monitoring, such as the identification of automobiles, bicycles, and people. For the purpose of determining the lifespan of sensor nodes in various real-world circumstances, extensive tests were carried out in this regard. The obtained findings demonstrate that by rotating the roles of sensor nodes, suppressing unneeded transmissions, and putting the nodes into sleep mode according to a duty cycle, the lifespan of a network for road traffic monitoring may be greatly prolonged compared to a baseline network.

Using a network model in which sensors are randomly distributed across an area to maintain watch on a number of sites of interest, the author [8] investigated the issue of WSN lifespan maximization for a model of the network (POI). Despite the fact that sensors have a constrained battery size, their number is high, and their operating ranges are similar to one another. As a result, not all of the sensors are required to be operational at all times. Furthermore, for efficient monitoring, it is sufficient to watch just a certain proportion of POIs at all times, rather than all of them, on a continuous basis. Our objective is to develop a schedule of sensor activity that allows for the most efficient evaluation of a given collection of points of interest for the greatest amount of time feasible. This paper presents three heuristic methods for scheduling sensor activity: a random and fine-tuning approach, a cellular automata-inspired approach, and a hyper graph model approach. The random and fine-tuning technique is the most straightforward. Because the results of these algorithms do not reflect optimum solutions and may be improved further, they are used as input for a local search strategy using problem-specific neighborhood functions, which uses the schedules acquired as input. An effective approach for assessing battery performance metrics such as capacity, open-circuit voltage, and state of charge (SOC) is proposed by the author in [9]. Four different battery types were exposed to different discharge rates based on the IEEE 802.15.4 protocol in order to observe the discharge parameters of the batteries. It was also tested if the combined influence of leakage currents on battery surface temperature and OCV fluctuations could be seen. It was discovered that lithium-based batteries had shorter relaxation durations than other types of batteries, allowing for rapid energy recovery while preserving rated capacity. During the discharge cycle, it was discovered that roughly 80 percent of the voltage area was flat, with very slight voltage changes occurring throughout.

Several wireless power transmission and energy recovery systems are discussed in detail by author [10], who focuses on delivering a complete assessment of the existing literature on these technologies, as well as on their prospects and problems in dispersed sensor networks [11] [12]. Updated research that are particular to wireless power transmission and energy recovery techniques are highlighted in this review, including their prospects and possible applications, as well as their limits and obstacles, classifications and comparisons [13][14]. Additionally, performance evaluation of the two radio frequency–based power extractors is explored[15]. The experimental findings demonstrate that the two radio frequency–based energy collectors with excellent power transfer effectiveness may be used for both short- and long-range operations[16] [17].

3. METHODOLOGY

For example, suppose you have a standard inter sustainable power and cooperation WSN service that works on a timetable. A variety of forms of energy, including as electrical currents, air, and renewable power are available to the destination node, which may be harvested by the nodes themselves [18]. As depicted in Figure 1, the provider node is capable of receiving and delivering power, that they're unable to get power from other sources. It is anticipated that perhaps the power gathered would be utilized for the transport of large datasets within the infrastructure. It is described as a regular directional graph G = (N,L), where N = 1, 2,..., N is indeed the collection of edge devices and L is the duration of the chart for the connections between two nodes. Endpoints wherein channels travel into neighbor node are described by the collection N(in) n, whereas vertices wherein channels move out the of source vertex are described by the collection N(out) n. Following that, we establish

$$D_{max} = max_n\left(\left|N_n^{(in)}\right|, \left|N_n^{(out)}\right|\right) \qquad (1)$$

defined as the sum of every node's in-degrees and out-degrees combined

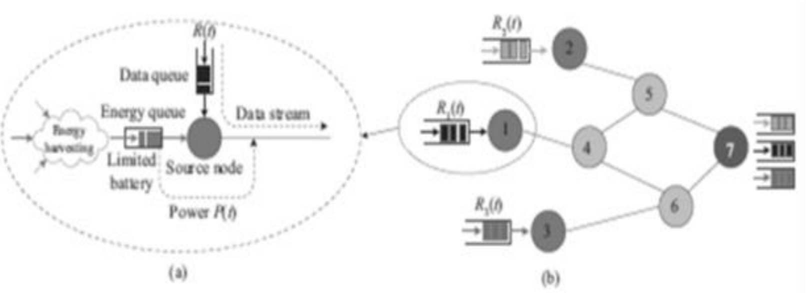

Figure 1: (a) Data retrieving process of a source node; (b) the WSN topology.

3.1. Link Capacity Model

For data transmission to take place in the WSN system, every station should be supplied with enough power to handle the workload. In the time slot t, we define the transmitted power distribution matrix as Pn(t) = n,m 2 N, where n is the number of distributed power units. The essential requirements must be met by Pnm(t) in the event that it is assumed that every unit has a restricted storage safety cushion:

$$C1: 0 \leq \sum_{m \in N_n^{(out)}} P_{nm}(t) \leq P_{max}, \forall n \in N \qquad (2)$$

3.2. Data Queue Model

Using wireless sensor networks (WSNs), information bits are provided to target endpoints in bundles, which would then be relayed throughout the systems. The queue of large datasets is described as: q(t) = q(d) n (t), n, d 2 N, t = 0, 1, 2, and so on, while q(d) relates to the quantity of continuous data d that has gathered on node n by moment sot t and is evaluated in milliseconds, and t = 0, 1, 2, and so on. Within original conditions, it is considered that now the backup and recovery equipment need not hold any big quantities of information, which results in q(d) n (0) = 0 for the data storage devices. Several conditions must be met by the delay of large datasets in order to maintain system stability:

$$\bar{q} = \lim_{t \to \infty} sup \frac{1}{t} \sum_{T=0}^{t-1} \sum_{n,d} E\left\{q_n^{(d)}(T)\right\} < \infty \qquad (3)$$

3.3. Energy Queue Model

The electricity generation, storing, and applies to the way requires that every component be equipped with such a charge that seems to have a limited ability in order to function properly. When it comes to climate change queue backlog, the formula is e(t) = "en(t), n 2 N, t = 0, 1, 2,..., t = infinite. When it comes to the electricity distribution process, the formula is " = "nm(t), n,m 2 N. Where "nm(t) denotes the source of power sent out by node n to node m, the formula is It is as a consequence that the sum of the serves a motivational function and the electricity sent never exceeds that which has been previously saved in the reservoir. The electricity distribution and transmission systems for every site must fulfill the minimum power requirements at any specific timeframe (t), which is defined as:

$$C4\colon \sum_{m\in N_n^{(out)}} P_{nm}(t) + \in_{nm}(t) \le e_n(t), \forall n \qquad (4)$$

We may create a methods on the basis of the assumption that perhaps the devices of a wireless channel have no capacity in their original conditions, en(0) = 0, 8n, which is supported by the data. We had devised a new approach that relies on a more realistic context, which would be discussed in greater detail in Section 3, wherein detectors shouldn't need to collect power all of the moment.

$$h_n(t) = \begin{cases} n_n^{(H)} h_n(t), ON \\ 0, OFF \end{cases} \qquad (5)$$

where hn(t) and bhn(t) are the technically available energy and potential energy, respectively.

In this part, we offer an online method for solving the UOEM issue that is based on the Lyapunov optimization principle. If you are dealing with stochastic queue network difficulties, the Lyapunov approach is a valuable tool. It offers a number of benefits, including the capacity to attain an approximation excellent efficiency; the resilience in time-varying networks; and the theoretical controllability. Assuming that the Lyapunov optimization tool is utilized quickly in our configuration, it is not suitable for systems with the "no underflow" condition, which means it is difficult to deal with the source of energy C4 problem. Therefore, we establish an entire technique that integrates the notions of the dispersion technique and the fluctuation technique, amongst many other principles. For instance, the dispersion approach provides for an exchange here between congestion on the system and the efficiency of essential services, which is advantageous in many situations. The load of the power distribution method may also be disturbed at every prime time, causing the electricity backlog amount to be moved forward into a quasi number and so eliminating stream. Finally, an active algorithm for the EDPR is presented as a cooperative effort.

3.4. *Upper bound of Lyapunov drift*

For starters, a perturbation parameter of the form n, 2 N is defined for the energy queue. After that, the perturbation parameter is used to produce the disturbed parabolic Lyapunov function of the type n 2 N.

$$L\big(Q(t)\big) = \frac{1}{2}\sum_{n,d\,\in N} |q_n^d(t)| + \frac{1}{2}\sum_{n\in N} |e_n(t) - \emptyset_n|^2$$

In the case of Q(t) = q(t), e(t) represents the duration a thread has indeed been supported in the connection As a consequence, the reality that now the number of L(Q(t)) is less implies that a weaker currency of L(Q(t)) may lead in a decreased congestion of power and information queue, thereby increasing the reliability of the region. In addition, the drop in L(Q(t)) causes the information queue to oscillate within a narrow range, which really is advantageous whenever the information queue is experiencing low congestion, for illustration. It also has the advantage of causing the power queue will progress towards a certain corresponding perturbation parameter, which would be the objective level we set in order to accomplish the electricity constraint we established.

In order to maintain robustness and reliability, it is feasible to gradually reduce the Lyapunov drift at every encountering t by applying constant pressure. Therefore, in terms of maintaining system reliability, we must lower the Lyapunov drift (Q(t)), also known as C3.

3.5. Drift with Penalty Optimization

Following our discussion of the variable buffer and essential system difficulties, we will move on to the study of the value maximization problem, which will take up the remainder of this section. The challenge of minimizing a maximum bound on the system of equations within every make real - time t may be turned into a main objective is to minimize a maximum bound on the correction factor that use the dispersion strategy, which is discussed in more detail below.

As an additional power variable, we suggest the variable V, which can be any quasi variable. This has been the most important element to consider. It is possible to get the dispersion interpretation by trying to add the punishment declaration to the upper limit on drift. The payment made the following statement:

$$\Delta_{v}(\boldsymbol{q}(\boldsymbol{t})) = \Delta\big(\boldsymbol{Q}(\boldsymbol{t})\big) - \boldsymbol{VE}\left\{\sum_{\boldsymbol{n},\boldsymbol{d}\in\in \boldsymbol{N}} \boldsymbol{f}\left(\boldsymbol{R}_{\boldsymbol{n}}^{\boldsymbol{d}}(\boldsymbol{t})\right)|\boldsymbol{Q}(\boldsymbol{t})\right\}$$

The challenge in reducing the drift with penalty at each time slot is taken into consideration in the following part, where we build an online method to solve issue P2.

3.6. EDPR Algorithm

As part of the transmission approach for achieving joint utility optimization, we suggest an online algorithm in this part. According to the following definitions, the EDPR algorithm was used to develop this joint power management algorithm:

$$\emptyset_{n} = \partial(\beta V + R_{max} + P_{max} + \epsilon_{max})$$

4. RESULTS AND DISCUSSIONS

The performance of the proposed algorithm which has been built will be examined in detail in this section. Observe that detector node n collects power whenever its generating capacity is lower than that of the perturbation parameter n, as shown by the power management strategy. This indicates that the technique may achieve close to optimal value and with a low electricity buffering capacity. Advantage maximization is ensured by the high bandwidth technology, which meets our optimizing goal of maximization of utility. It is indeed clear that the complete level movement in forwarding and planning satisfies the requirement C2 because it takes the full rate activity into consideration. Underneath the assumption of zero power requirements, it is feasible to decrease the values "Pnm(t)" and "nm(t)" to their basic essentials by using a combination of voltage regulation, transportation, and workflow scheduling. We also supply favorable variables and create the suitable queues with the purpose of achieving the predetermined maximum limit of the queues, which is particularly important considering that the usage of power devices in the implementation of transceivers is quite feasible.

$$\lim_{t\to\infty} \boldsymbol{inf}\ \boldsymbol{f}_{\boldsymbol{tot}}\big(\boldsymbol{F}(\boldsymbol{T})\big) = \lim_{t\to\infty} \boldsymbol{inf} \sum_{\boldsymbol{n},\boldsymbol{d}} \boldsymbol{f}(\bar{\boldsymbol{r}}_{\boldsymbol{n}}^{\boldsymbol{d}}(\boldsymbol{T})) \geq \boldsymbol{f}_{\boldsymbol{tot}}(\boldsymbol{r}^{\boldsymbol{t}}) - \frac{\bar{\boldsymbol{B}}}{\boldsymbol{V}}$$

Given that Pnm(t) > 0 is not the best decision, we can demonstrate that Pnm(t) > 0 cannot be the ideal choice. Throughout our technique, attributed to the reason that constraints C1 and C4 are actually superfluous, as aforementioned in the segment on energy monitoring, the power generation connectivity can still have necessary power for information transfer. This result is in accordance observations. In our technique, the electricity connectivity will still have sufficient power for transmission of data. Researchers are capable of fulfilling the power flow condition while also increasing the height of the power queue forward into a quasi number in order to minimize stream by carefully shifting the emphasis of taking decisions at every period.

Through the use of simulation, we analyze the overall performance of the proposed EDPR method. Inside the WSN system depicted in Figure 1, there seem to be a total of seven nodes, with the very first three nodes acting as destination node, the next two nodes functioning as relay nodes, and the final node functioning as sink. Receiving data feeds from nodes 1 through 3, which are then routed to the sink node 7 through relay nodes 4 through 6, and then to the sink node 7. It is the responsibility of Nodes 1, 2, and 3 to accept data streams and deliver them to Node 7. The link state Snm(t) is allocated with equal probability to the values 1, 2, and 3. It implies that unit power can transmit two packets while the connection is in excellent condition, however it can only send a single packet when the link is not in good condition.

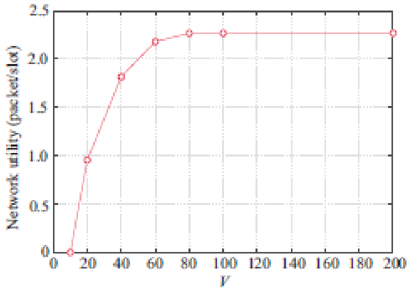

Figure 2: EDPR utility

The utility feasibility of the new EDPR algorithm is shown in Figure 2 for a variety of values of the control variable V. When V is little and there is no data transmission taking place, the utility function is 0 at the very beginning of the process. Increasing V causes the moment efficiency of the entire system to rapidly converged to its optimum solution, which in this example is around 2.27 packets per slot, as the valuation of V increases.

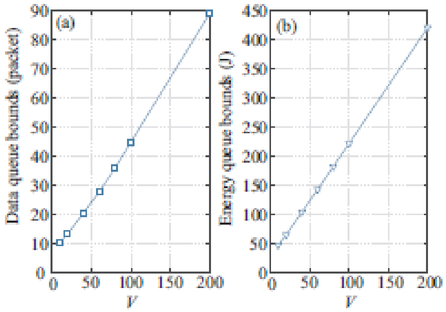

Figure 3: (a) Data queue mean and (b) EDPR energy queue

On the graph in Figure 3, we depict the average data queue limits as well as the energy batch limits with respect to various V. It is logical to assume that a bigger V will result in more queue congestion. Both of them increase in a manner that is close to linear with V, which is consistent with Theorem 2. The resulting practical application is highly beneficial since we can simply design the size of energy storage systems for sensors as a result of this result.

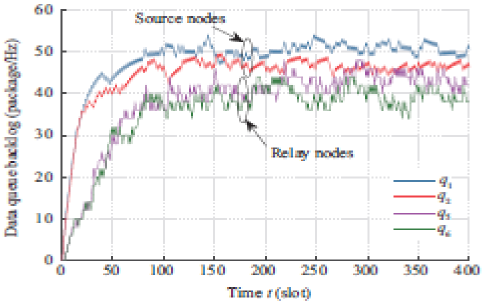

Figure 4: Data queue backlog vs. Time

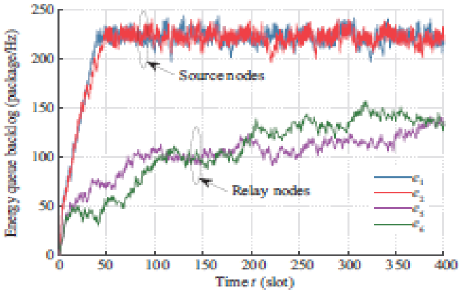

Figure 5: Energy queue backlog vs. Time

In order to research the continuous updating procedure typical of queues, the renewal operation of continuous data queuing q1, q2, q5, and q6 in Figure 4 and energetic queues e1, e2, e5, and e6 in Figure 5 are depicted in the similar circumstance setting with V = 100. It could be seen in the data that the congestion of queues is all restricted to a specific maximum bound, which allows the system to stay stable. The delay of destination node 1, 2 is also bigger than that of the delay of nodes in the network 5, 6, as seen in the graph, which is another point to note. Furthermore, regardless of whether the queue is composed of information or power, the rear nodes gradually tend toward stabilisation when the front nodes had attained equilibrium.

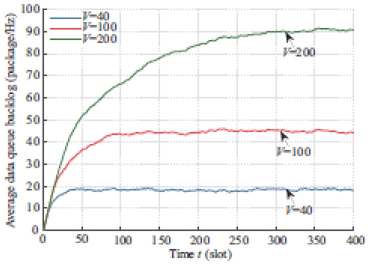

Figure 6: Mean data queue backlog vs. time

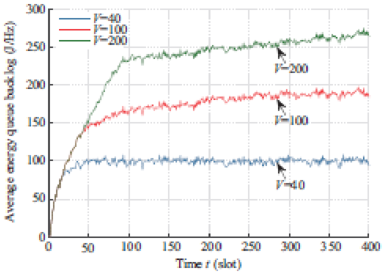

Figure 7: Meanenergy queue backlog vs. time

Information queue and power queue mean backlogs as a time - dependent are shown in Figures 6 and 7, respectively, for a range of controller parameters V in the information buffer and power queue, respectively. With the help of these two charts, we can observe that now the average packet backlog first increases as time slot t increases, and then eventually stabilises together around reasonable figure. Whenever it refers to the influence of V, a bigger V serves to a higher battery of the secure channel, while a lower V serves to the entry of the solid situation into the system occurring quicker in the system. This study provides more confirmation that V does, in fact, impact the barter among electric effectiveness and network connectivity in the context of energy efficiency. If current queues are contrasted with data queues, the frequency fluctuation of power queues is larger, which is logical considering that the stations in the WSN collect and transfer amount of energy.

5. CONCLUSION AND FUTURE SCOPE

Using renewable energy and team cohesion, we explore combined power enhancement in inter wireless sensor networks (WSNs). It is ascertained that a top limitation on the Lyapunov drift is needed for system demand. This top limitation on the Lyapunov drift can also be used to quantify the accurate cell voltage needed for edge devices. The Lyapunov structure is used to come to terms with the probability optimal solution, and we propose an internet algorithm was implemented the dispersion with punishment method with the modification procedure to address the problem. When moment and immediate stabilization restrictions, as well as network conditions, are taken in to account, this technique improves the rechargeable batteries memory and spectrum sharing policy in conjunction with one another. The EDPR technique, which could be used to create the highest amount of value in a distributed environment, does not necessitate the use of statistical data about dynamical system. It also contributes to the construction of a time-averaged compromise between access and queue backlog, which is beneficial in many ways. Aside from that, the simulated findings also demonstrate the linear correlation between the different transfer and queuing sizes, which may be extremely useful in real-world deployments of transmitting data networks, such as those used in telecommunications.

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