International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE)
ISSN: 0976-1353 Volume 21 Issue 1 – APRIL 2016.

ACCURATE STATE BEHAVIOR PREDICTION METHOD FOR WIRELESS NETWORKS IN DENSE TRAFFIC IOT APPLICATIONS

K.Yasodha[#1], G.Kamesh[*2]

[#1] *PG student, Department Of Computer Science and Engineering, Tagore Engineering College,*

[*2] *Assistant professor, Department Of Computer Science and Engineering, Tagore Engineering College,*

***Abstract*–To identify accurate node behavior of the wireless sensor networks to effectively transfer the data from one node to another node on the transmission. The effective transformation can be made available on the both measurements and effective modeling analysis of the system. Also this project present the accurate node behavior using metadata based node evaluation algorithm to effectively detect the state behavior on the wireless IOT systems. This analysis concludes that node wake up rates and active state time periods have a significant impact on the performance of the network. Increasing network lifetime is a major goal in IOT application. Network lifetime is dependent on node lifetime, which is directly affected by the energy being consumed by processes running on the node. However, if future energy consumption can be anticipated, optimization decisions can be made beforehand to increase node lifetime. This paper proposed an accurate node behavior using metadata based node evaluation algorithm. This will increase the network life time as well as the presented optimization of network parameters such as the throughput, end-to-end delay, packet delivery ratio these are the measurements identified and applied on the whole network configuration.**

I.INTRODUCTION

A. Network Lifetime

Replacement of dead nodes & maintenance of WSN deployments are nearly impossible because they consist of numerous low-cost, low-power, and energy-constrained sensors placed in extreme environments [4][5]. As the network can only fulfill its purpose while it is functional & considered alive, Network Lifetime can be used as an indicator of the maximum utility a sensor network can provide. Network lifetime also provides a parameter for evaluating the availability of the network [3]. Network lifetime is critical in design and deployment of WSNs & its applications, and is preferred to have a higher value. To increase the lifetime, there are various energy efficient and energy aware protocols developed by researchers[6], while other approaches like environmental energy harvesting[7] and wireless charging[8] are also designed to address the problem. However, in this paper, we are only interested in energy efficient and aware protocols and their approaches to increase the network lifetime by maximizing the use of available resources. Each definition of *network lifetime* can finally be reduced to the question, *"when will individual nodes fail, where network will no longer be operational?"*. Thus,we can transpose the problem of increasing network lifetime to *increasing node lifetime*. Node lifetime can be assessed by having accurate and consistent estimations of node behavior. It is very important that the process which generates these estimations is highly accurate[3]. Measurements like data freshness, data quality and network congestion provides a more *global* view on network lifetime, where the focus is moved away from individual nodes[9]. If we were to consider meta-level information(metadata) available on nodes, such as *individual voltage level*, they will provide more localized insight to the process. Moreover, these values describe each node in a unique way, we will be able to get accurate representations of nodes and their behavior.

B. Meta-data

Meta-data is often identified as 'data that describes other data'1. This definition is neither adequate nor accurate when considering WSNs. Some works define meta-data as, 'descriptive data used to describe the WSN system' where *WSN system* includes *environment*, *the nodes and their states*, *measurement data*, and the *WSN as a whole entity*[10]. In this specific research, we are only considering the aspects of nodes and their states to obtain meta-data from the network. WSN users often use *node voltage*, obtained directly or through energy models to measure node energy consumption [11] and to increase node lifetime. However, continuous polling for meta-data causes severe energy drains in the system, making its lifetime shorter. Hence, optimization decisions which were made based on these data would eventually fail. We hope to address this problem in our research, by taking an approach towards modeling the node behavior.

II. SYSTEM MODEL

We consider a generic Cyber Physical Systems (CPS) wireless network scenario with four clusters as shown in Fig. 1(a). Sensor data collected at the leaf nodes have to be routed to a network sink via intermittent random relay nodes known as anycast routing. The functional model of relay nodes is captured accurately in four different states namely, Sleep (*Si*), Idle-Listen (*Ii*), Active-Tx (*Ai*) and CSMA/CA as shown in Fig. 1(b). In Sleep state relay nodes sleep until assigned a wake up time. In Idle-Listen state, relay nodes broadcast a beacon to the predecessor cluster (cluster-3 is the predecessor to cluster-2) and wait for a packet from it. After successfully receiving a packet in Idle-Listen state relay nodes jump to Active-Tx state and wait for a beacon from their next cluster (cluster-2 is the next cluster to cluster-3). Time intervals between beacons observed by a relay in Active- Tx are Poisson distributed which determine the waiting time in Active-Tx state described later in the delay model of this paper. The relay nodes that are successful in receiving a beacon within a maximum of *La* slots of the Active-Tx state follow CSMA/CA flow depicted using a 3D Markov chain shown in Fig. 2(a) with backoff stages (*m*), backoff counter (*k*) and collision retries (*n*) as the three dimensions. Our primary investigation focuses on the effect of CSMA/CA retries in multi-hop scenarios with accurate state-wise behavior of relay nodes. In this letter busy channel probabilities α and β in Clear Channel Assessment (CCA1 and CCA2) states and channel sensing probability τ along with collision probability *Pc* shown in Fig. 2(a) are derived considering the effect of Sleep, Idle-Listen and Active-Tx state probabilities along with the CSMA/CA model. With basic understanding of busy probabilities in [4]–[6], one can drive the mathematical model in the following section.

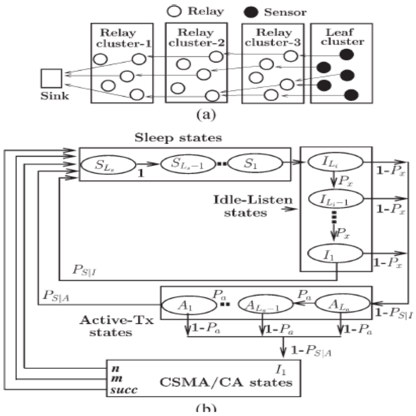

Fig. 1. (a) Network scenario. (b) Relay node state model.

A.3D Markov Chain:

The rapid and highly paced developments in wireless interaction system and allied semiconductor technology has facilitated a highly efficient and effective solution for small sized or miniaturized, economical, least energy utilization and multi objective sensor network which will effectively perform interaction over less coverage by means of wireless interaction techniques sensing nodes and hence network exhibits a tremendous and most important, powerful enhancement on existing sensing nodes or existing interaction scenarios. Additionally, these techniques facilitate highly optimized and effective interaction process. The embedding techniques for interaction process in advanced nodes or network dominantly permits the interaction process with the remote or hostile areas. The lifespan of the battery plays a vital role while ensuring the life period of node and ultimately it results into the modifying of network topology. The lifespan of sensing nodes and hence the network predominantly depends on the lifespan of battery. Therefore the effective and optimum utilization of battery is most important factor for ensuring QoS and optimized interaction network. Therefore, in advanced and emerging research scenario, the optimization and enhancing a network lifespan has become a predominant factor.This module presented an approach for the node behavior identification using the 3D Markov chain model method to identify the node behavior method

B.IEEE 802.15.4

The IEEE 802.15.4 protocol was created to specify a sub-layer for Medium Access Control (MAC) and a physical layer (PHY) for low-rate wireless private area networks (LR-WPAN) [33]. Due to its specifications such as low power consumption, low data rate, low cost, and high message throughput, it also is utilized by the IoT, M2M, and WSNs. It provides a reliable communication, operability on different platforms, and can handle a large number of nodes (about 65k). igh level of

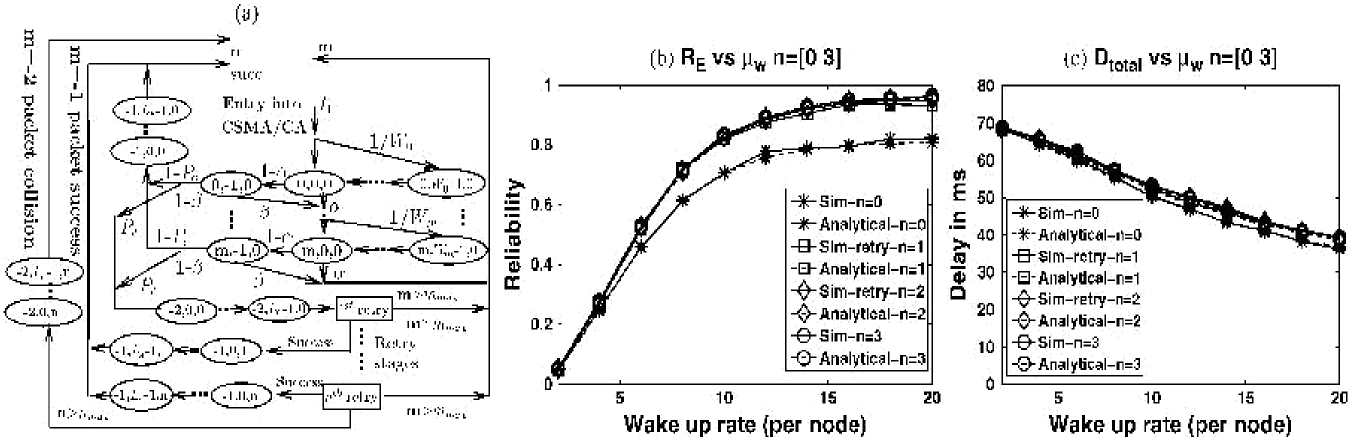

Fig. 2. (a) Three-dimensional Markov model of IEEE 802.15.4 CSMA/CA. (b) and (c): Simulation parameters for (b) and (c) are $m_0 = 3$, $m = 4$, $\lambda = 0.01$, $n = [0\ 3]$, $\mu_W = [2\ 20]$, $L_a = 100$, $L_p = 10$, $L_i = 100$, $L_S = 100$.

provide QoS guarantees. This protocol is the base for the ZigBee protocol as they both focus on offering low data rate services on power constrained devices and they build a complete network protocol stack for WSNsIEEE 802.15.4 supports three frequency channel bands and utilizes a direct sequence spread spectrum (DSSS) method. Based on the used frequency channels, the physical layer transmits and receives data over three data rates: 250 kbps at 2.4 GHz, 40 kbps at 915 MHz, and 20 kbps at 868 MHz. Higher frequencies and wider bands provide high throughput and low latency whereas lower frequencies provide better sensitivity and cover larger distances. To reduce potential collisions, IEEE 802.15.4 MAC utilizes the CSMA/CA protocol.

The IEEE 802.15.4 standard supports two types of network nodes: Full and Reduced Function Devices. The *full function device* (FFD) can serve as a *personal area network* (PAN) coordinator or just as a normal node. A coordinator is responsible for creation, control and maintenance of the network. FFDs can store a routing table within their memory and implement a full MAC. They also can communicate with any other devices using any available topology as seen in Fig. 20. The *reduced function devices* (RFD) on the other hand, are very simple nodes with restricted resources. They can only communicate with a coordinator, and are limited to a star topology. Standard topologies to form IEEE 802.15.4 networks are star, peer-to-peer (mesh), and cluster-tree (See Fig. 20). The star topologycontains at least one FFD and some RFDs. The FFD who works as a PAN coordinator should be located at the center of topology and aims to manage and control all the other nodes in the network. The peer-to-peer topology contains a PAN coordinator and other nodes communicate with each other in the same network or through intermediate nodes to other networks. A cluster-tree topology is a special case of the peer-to-peer topology and consists of a PAN coordinator, a cluster head and normal nodes.

III. MATHEMATICAL MODEL

We formulate the proposed model in two stages by deriving the transition probabilities for all states in Fig. 1(b) in the first stage and then follows the formulation of CSMA/CA model in second stage. In the rest of our discussion μw indicates average wake up rate per node in a cluster consisting of N nodes, La and Li are length of active and idle slots respectively. In Eq. (1), Px is the transition probability of a relay node to move into the next Idle-Listen slot from the current one, when there is no packet arrivals at a given slot with an average of λ Poisson arrivals and Pa indicates the transition probability of a relay node to move into the next Active-Tx slot from the current, when there is no beacon arrival at a given slot with an average of λa Poisson arrivals shown in Eq. (4). Using Eq. (1), the probability of a node transitioning to Sleep state from the last slot of Idle-Listen ($PS|I$) and Active-Tx ($PS|A$) states can be obtained as shown in Eqs. (2) and (3) respectively. Finally $PS|\mathrm{CSMA}$ in Eq. (5) indicates the transition probability of a node from CSMA/CA state to the first slot of Sleep state which should always equal to one

$$Px = \exp(-\lambda),\ Pa = \exp(-\lambda a) \qquad (1)$$

$$PS|I = PSLs|I1 = PLix \qquad (2)$$

$$PS|A = PSLs|A1 = PLaa \qquad (3)$$

$$\lambda a = \mu w * N \qquad (4)$$

$$PS|\mathrm{CSMA} = PSLs|\mathrm{CSMA}m + PSLs|\mathrm{CSMA}n + PSLs|\mathrm{CSMA}succ = 1 \qquad (5)$$

$$PS0 = PS0PLix + PS0\_1-PLix\_PLaa + PS|\mathrm{CSMA}b0,0,0. \qquad (6)$$

In Eq. (5), $PSLs|\mathrm{CSMA}m$ and $PSLs|\mathrm{CSMA}n$ are the probabilities to enter into the first slot of Sleep state when the received packet is discarded in CSMA/CA after exceeding maximum m and n respectively. $PSLs|\mathrm{CSMA}succ$ is the probability of the node to enter the first slot of Sleep state after the node successfully forwards the packet. Eq. (6) can be simplified to arrive at probability $PS0$ of a node to stay in the first sleep slot at any given time slot in terms of $b0,0,0$, where $b0,0,0$ is the probability of a node to stay in the first CCA1 slot of the CSMA/CA model

$$P\mathrm{CSMA} = \sum_{i=0}^{m}\sum_{k=0}^{Wi-1}\sum_{j=0}^{n} b\mathrm{i,k,j} + \sum_{j=0}^{n}\sum_{i=0}^{m} b\mathrm{i,-1,j} + \sum_{j=0}^{n}(\sum_{k=0}^{Ls-1} b\mathrm{-1,k,j} + \sum_{K=0}^{Lc-1} b\mathrm{-2,k,j}) = Z1 * b0,0,0 \tag{7}$$

$$PS + PI + PA + P\mathrm{CSMA} = 1 \tag{8}$$

$$PS0[Ls + \sum_{i=1}^{Li} P^{i-1}{}_{x} + (1 - Plix)\sum_{i=1}^{L_a} P^{i-1}{}_{a}] + Z1b0,0,0 = 1. \tag{9}$$

The probability of a node to reside in CSMA/CA state (PCSMA) at a randomly given time slot is the sum of backoff, CCA2, success and failure state probabilities respectively given in Eq. (7).

In Eq. (8) PS, PI , PA and PCSMA indicate the probabilities for a node to reside in Sleep, Idle-Listen, Active-Tx and CSMA/CA states respectively in any given random time slot. All probabilities PS, PI , PA and PCSMA of Fig. 1(b) can be written in terms of $PS0$ and $b0,0,0$ as shown in Eq. (9). After getting the relation for $b0,0,0$, we derive α, β and τ expressions utilizing $b0,0,0$ in a similar methodology shown in [6]. Numerical methods are used to solve highly nonlinear α, β, τ and $b0,0,0$ to arrive at a closed form solution. Both node and cluster probabilities (α, β, τ and Pc) are in close agreement with less than 5% deviation due to equal number of nodes in each cluster and random selection of relay nodes. Reliability and delay of the proposed model are derived and analyzed in the following section.

C.Meta data based node evaluation algorithm

Under the non beacon-enabled or point-to-point mode, the access control is governed by non-slotted CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance). According to this medium access protocol, nodes have to sense the radio medium before starting any transmission. If the channel is busy, the transmitting device has to wait a random time (set in terms of a number of "backoff" periods) before listening to the radio again. Otherwise, if the channel is idle, the device can transmit the packet and will have to wait for an acknowledgment message from the reception point. If the acknowledgment is not received in a predetermined period the node will proceed to retransmit the packet (up to a maximum number of attempts). Similarly, if two nodes begin their transmission simultaneously or a transmitting node is unaware that the radio medium in the receptor is busy, a packet collision will occur. Collisions strongly degrade the performance of CSMA algorithm as they prevent the packets to be properly received so that they have to be retransmitted (inducing delay or even data losses if retransmissions fail after applying the typical backoff algorithm of CSMA). In this module we presented a meta data based node evaluation algorithm that will find the accurate behavior of node prediction and make it energy efficiency and improve the network lifetime.

A. Reliability Model

The reliability of a relay node can be determined by deriving the failure probabilities. Failure can occur due to exceeding m, n and active timeout. Considering these cases, the reliability of node k (Rk) is given in Eq. (11). RE in Eq. (12) depicts the end-to-end reliability calculated over h independent links/clusters/hops. y indicates the probability of a node transitioning to next retry after successfully sensing the channel from any of the m stages shown in Fig. 2(a)

$$Rk = 1 - (x^{\mathrm{m+1}}(1 + y) - y^{\mathrm{n+1}})(1 - p^{La}{}_{a}) - P^{La}{}_{a} \tag{11}$$

$$RE = \prod_{k=1}^{h} Rk \tag{12}$$

B. Delay Model

Total delay incurred by an individual node for forwardinga packet successfully is contributed by
CSMA/CA delay andactive state delay. Delay due to CSMA/CA is given in (13)

$$D\mathrm{csma} = Ts + D\mathrm{avg} + (Ts + D\mathrm{avg})\times[\frac{y}{1-y} - \frac{((n+1)*\_y(n+1)))}{1-y\mathrm{n}+1} \tag{13}$$

$$D\mathrm{avg} = 2Sb[1 + 0.25\{\frac{1-bll}{1-bm+1}[2W0\frac{1-2bm+1l}{1-2bl} - \frac{3(m+1)bm+1l}{1-bl}] + + \frac{3bl}{1-bl} - (W0 + 1)\}] \tag{14}$$

$$P(\mathrm{delay}=i)|\mathrm{success} = \frac{Pi-1a\ (1-Pa)}{1-Plaa} \tag{15}$$

$$D\mathrm{active} = \_Lai=1(i)\frac{pai-1(1-pa)}{(1-paLa} \tag{16}$$

$$D\mathrm{total} = (D\mathrm{csma} + D\mathrm{active} * Sb) * h. \tag{17}$$

In Eq. (13), Davg indicates the backoff delay and is derived in Eq. (14) by taking expectation over m stages of CSMA/CA, where Dcsma of a link can be obtained from computing average probability of success after j retries. Ts and Sb are packet transmission time and unit backoff time, bl is max$\{\alpha,\ (1 - \alpha)\beta\}$, $W0$ indicates minimum backoff window. Lp and Lc are length of time slots required for successful packet transmission and collision respectively and Tc indicates packet collision time. In Eq. (16), the average number of active slots (Dactive) that a node waits before a beacon arrives is obtained. Finally total delay which is the sum of delays incurred by CSMA/CA and

Active states computed over *h* independent links is given by Eq. (17).

IV. ANALYTICAL RESULTS

The proposed anycast clustered multi-hop analytical model's accuracy is validated by emulating a scenario similar to that shown in Fig.1(a) which has 4 clusters with 10 nodes each. The proposed emulation model has the following assumptions: Congestion due to ACK and interference from other 2.45 GHz users is negligible. Each relay node switches among 3different channels for Tx, Rx and beacon modes to interference from other 2.45 GHz users is negligible. Each relay node switches among 3 different channels for Tx, Rx and beacon modes to reduce interference between nearby nodes of different clusters. We first analyze the effect of CSMA/CA retries (*n*) on *RE* and *D*total. Fig. 2(b) and (c) plots *RE* and *D*total versus μw respectively for 4 different values of *n*. *RE* and *D*total are observed to be increasing and decreasing respectively with increase in μw as the average waiting time to receive a beacon in active state decreases and failures in active state due to active timeout are reduced. *RE* is observed to increase by 15% and *D*total is increased by 6 slots with single retry after collision compared to the "no-retries" scenario. Improvement in *RE* and *D*total with higher retries (*n* = 2 & 3) compared to *n* = 1 is merely visible, as the probability to have successive collisions for a node is minimal. Degradation in *RE* and *D*total is observed when analysis is performed by incrementing number of nodes (N) for 4 different λ as shown in Fig. 3(a) and (b). Degradation in *RE* is valid since increase in channel congestion values (α and β) results in more packet drops and collisions due to exceeding

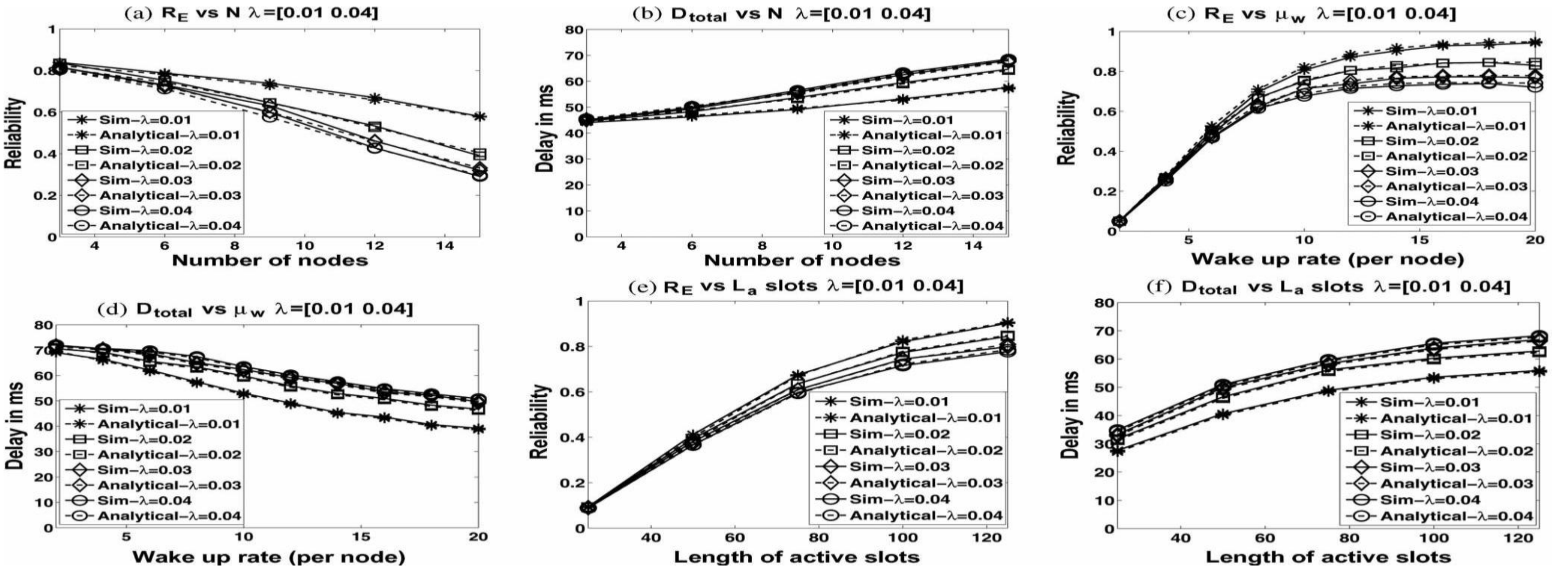

Fig. 3. Parameters for (a) and (b): $m_0 = 3$, $m = 4$, $\mu_W = 10$, $n = 1$, $L_a = 100$, $N = [3\ 15]$, $\lambda = [0.01\ 0.04]$; (c) and (d): $m_0 = 3$, $m = 4$, $n = 1$, $L_a = 100$, $\mu_W = [2\ 20]$, $\lambda = [0.01\ 0.04]$; (e) and (f): $m_0 = 3$, $m = 4$, $n = 1$, $L_a = [25\ 125]$, $\lambda = [0.01\ 0.04]$, $\mu_W = 10$; parameters fixed for all 6 scenarios: $L_p = 10$, $L_c = 10$, $L_s = 100$ and $L_i = 100$

maximum m and n. More delay (Dtotal) with increase in λ is primarily due to degradation in DCSMA. Fig. 3(c) and (d) plots RE and Dtotal versus μw for four different λ. From the figures one can infer the importance of λ in the performance of the network. Increase in μw reduces average waiting time in Active-Tx state and the chances for packet being dropped because of active timeout are less. The increase in λ results in channel congestion, leading to more packet failures due to active timeout and more delay due to backoff stages. Fig. 3(e) and (f) plots RE and Dtotal versus La for four different λ. RE was enhanced and Dtotal was growing higher with increase in La as the chances of beacon reception before active timeout increases significantly.

The Result compared with the existing system and also the proposed system that uses the different parameters that are throughput, end-to-end delay, packet delivery ratio, number of error should be calculated through this module. Packet delivery ratio: the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

∑ Number of packet receive / ∑ Number of packet send

The greater value of packet delivery ratio means the better performance of the protocol. End-to-end Delay: the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

∑ (arrive time – send time) / ∑ Number of connections

The lower value of end to end delay means the better performance of the protocol.Packet Lost: the total number of packets dropped during the simulation.

Packet lost = Number of packet send – Number of packet received.

The lower value of the packet lost means the better performance of the protocol

V. CONCLUSION

Increasing network lifetime is a major goal in IOT application. Network lifetime is dependent on node lifetime, which is directly affected by the energy being consumed by processes running on the node. However, if future energy consumption can be anticipated, optimization decisions can be made beforehand to increase node lifetime. This paper proposed an accurate node behavior using metadata based node evaluation algorithm. This will increase the network life time as well as the presented optimization of network parameters such as the throughput, end-to-end delay, packet delivery ratio these are the measurements identified and applied on the whole network configuration. However, if future energy consumption can be anticipated, optimization decisions can be made beforehand to increase node lifetime. We propose a system to predict energy usage of each node by using its residual voltage as a meta-level information.

REFERENCES

[1] P. Park, C. Fischione, A. Bonivento, K. H. Johansson, and A. Sangiovanni-Vincentelli, “Breath: An adaptive protocol for industrial control applications using wireless sensor networks,” *IEEE Trans. Mobile Comput.*, vol. 10, no. 6, pp. 821–838, Jun. 2011.

[2] P. Di Marco, P. Park, C. Fischione, and K. H. Johansson, “Analytical mod-eling of multi-hop IEEE 802.15.4 networks,” *IEEE Trans. Veh. Technol.*, vol. 61, no. 7, pp. 3191–3208, Sep. 2012.

[3] J.-H. Jeon, H.-J. Byun, and J.-T. Lim, “Joint contention and sleep control for lifetime maximization in wireless sensor networks,” *IEEE Commun. Lett.*, vol. 17, no. 2, pp. 269–272, Feb. 2013.

[4] P. Park, P. Di Marco, C. Fischione, and K. H. Johansson, “Modeling and optimization of the IEEE 802.15.4 protocol for reliable and timely commu-nications,” *IEEE Trans. Parallel Distrib. Syst.*, vol. 24, no. 3, pp. 550–564, Mar. 2013.

[5] Y. R. V. Prasad and P. Rajalakshmi, “Analytical model of adaptive CSMA-CA MAC for reliable and timely clustered wireless multi-hop com-munication,” in *Proc. IEEE WF-IoT Conf.*, Seoul, Korea, Mar. 6–8, 2014, pp. 212–217.

[6] S. Pollin *et al.*, “Performance analysis of slotted carrier sense IEEE 802.15.4 medium access layer,” *IEEE Trans. Wireless Commun.*, vol. 7, no. 9, pp. 3359–3371, Sep. 2008.