ENERGY EFFICIENT DYNAMIC NEIGHBOR DISCOVERY SCHEDULE ALGORITHM FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

The recent rapid technological developments of Internet of Things (IoT) brought in Wireless Sensor Networks (WSNs) are more and more widely used in many applications. A WSN usually consist of a deployment of thousands of tiny nodes and a base station (BS) on an interested phenomenon. To such structured network, each node is able to gather physical information and transmit to a sink node. To communicate data from node to BS, coordination between nodes and energy efficient communication is needed. Neighbor discovery process performs vital responsibility in WSNs, due to resource constrained tiny devices in network and to maximizing the network lifetime. In recent years, many neighbor discovery schemes developed to minimize energy consumption as much as possible and at the same time make sure that discovery latency as small as possible. A node typically has two options for learning about its neighbours: synchronously and asynchronously. Given the resources available and the dynamic nature of networks, synchronization between nodes is a challenging issue. Many asynchronous neighbor discovery protocols are proposed to address issues and challenges of discovery of neighbors in WSNs with the help of probabilistic, deterministic, and quorum based approaches. In this paper, we adapt the concept of dynamic schedule based on block design and combinatorial methods for asymmetric neighbor discovery. First, we summarize need of neighbor discovery and source of power utilization in the neighbor discovery process, subsequently discussed about the difficulty of designing block design. To improve the energy utilization, we construct dynamic schedule mechanism for asymmetric neighbor discovery. We analyze the worst-case discovery latency in our proposed model with representative algorithms in the parallel research. Experimental results of our simulation represent that the worst case discovery delay significantly better than that of traditional algorithms.

Keywords: *Energy Efficient, Neighbor Discovery, WSN, Block Design, Discovery Latency*

1. INTRODUCTION

Wireless Sensor Networks [1] have great impact in industry and academic research because of the use of sensor devices in the IoT [14] and wireless communication applications have increased in recent years. A WSNs consist of collection of battery power operated small sensor devices are carefully deployed an environmental area to collect sensor dependent data and communicated to a base station (i.e., Sink node where data can processed) [2]. As we know that, these deployed batteries powered sensor nodes are remains unattended and impractical to recharge the nodes in the network, and in most of the WSNs applications such as inaccessible surveillance area, environmental disaster area, and polluted environments and even nodes not to have global identification (such as IP address), because a large number of resource constraints (low battery, low storage capacity, and low processor speed) densely deployed and it is difficult to maintain the addresses and synchronized clock drifts among nodes [2][3]. Due to this argument, established resource constraint network lifetime is a cardinal importance in WSNs. The fundamental goal of designing energy-efficient methods is to reduce power conservation in sensor nodes in order to lengthen the network's lifespan. Several aspects are considered while designing an energy efficient power management technique for WSNs. Once devices are distributed in an interested area for observation, therefore coordination among devices is required to propagate collected data to a BS. In a multi-hop wireless communication, data from phenomenon to base node is a nontrivial task without proper coordination among nodes [4][23]. After deploying nodes, it is primary functionality of WSNs nodes needs to obtain their neighbor node knowledge to communicate collected information to sink node in flat, or hierarchical architecture in a multi-hop wireless communication. If nodes are not hearing about neighbors, they remain unattended and nodes are not discovered, these nodes will consume a lot of energy in a less span of time. Hence, they are not operated and purpose of network establishment is wasted [1][2][3].

1.1 WSN Architecture and Neighbor Discovery

Neighbor discovery in WSNs, is a fundamental and non-trivial function, to obtain neighbor node information, in literature may neighbor discovery models are proposed, where neighbor discovery is a process of identifying neighbor nodes within communication range of deployed area. The obtained knowledge of neighbor nodes is useful for successive functions in WSNs such as clustering, routing, data aggregation, and also the medium access algorithm to prolong the lifespan of the tiny devices by minimizing power utilization [5].

In many traditional wired networks neighbor node information may be maintained by network administrators. We consider the problem of neighbor discovery, where this is a critical, or impractical for many WSN applications, when self-organization of nodes desired. Neighbor discovery process can be achieved in two ways: First Centralized, there is a common controller, which determines the position of nodes, find their neighbors, and inform each node. This process consumes huge amount of energy, because every node need to obtain its neighbors and report to common controller and also large numbers nodes in sensing area. Second Distributed, there is no common controller, where every node can send and receive neighbor node information, and a data packet, or a control packet simultaneously. Under this assumption this process is difficult to achieve in more

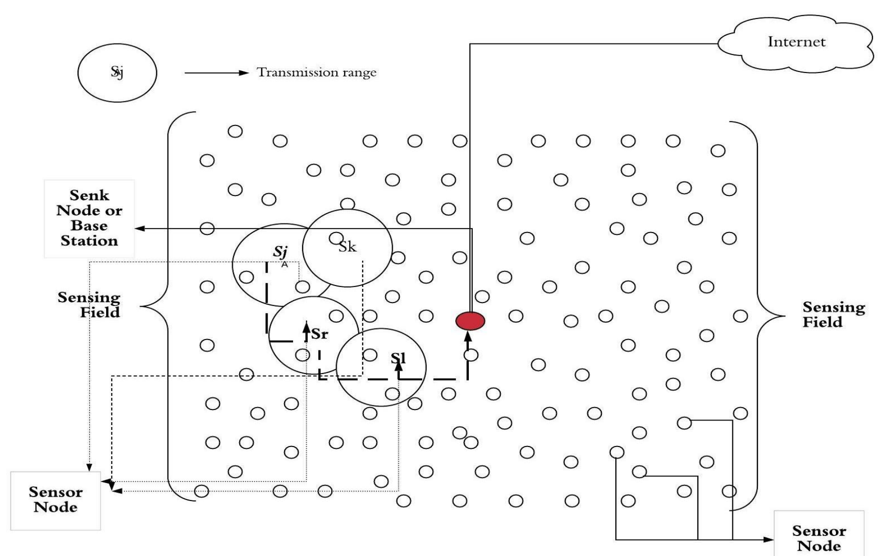

Figure 1. Wireless Sensor Network Architecture

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practical and realistic applications of sensor networks. While designing neighbor discovery techniques should consider the following notable characteristics and endurance of WSNs: i) Frequent changes of topology, ii) Nodes are densely deployed, iii) limited in memory, radio capacity, and power, iv) use broadcast communication, v) not have global identification. By keeping this huge research has been conducted and a quality of energy minimization, power utilization, and neighbor discovery approaches have been implemented in literature [6][24][26].

To achieve synchronization in wireless networks generally uses Global Positioning System (GPS). In distributed algorithms, global synchronization of the network between nodes is essential function, were set of nodes can synchronize to a common time slot and number nodes remain constant and static, and known to all nodes in the network. The use of GPS in tiny-device (small in size generally used in unattended area) causes to increase the size and cost. For a big network implies a great expense to handle common clock drift, or global synchronization among nodes [5][25]. The effectiveness of asynchronous protocols for sensor network goes beyond the probability to find a set of neighbors, these protocols generally confab peremptory information between neighboring nodes.

Power management in wireless networks implies various aspects that should be assessed during the design and implementation of Neighbor discovery, so that lifespan of sensors can be enhanced by efficient utilization of power at various phases in neighbor discovery. The power control operation mode employed in devices to increase the lifespan of the network. In Sensor network, most of energy consumed for relaying sensed data from origin to the BS. Another important aspect in multi-hop communication should be considered, each sensor node in the network performs a multiple responsibilities of origin for data and relay.

When a sensor node acts as relay node, data packets are received and forwarded to other sensor nodes. It is important to reduce unnecessary computing overhead, otherwise energy depletion of even in intermediate sensor nodes may lead to significant changes in network topology [13][21][22]. This neighbor discovery primarily classified into two types: First, the probabilistic neighbor discovery, for example, birthday protocol is a probability based asynchronous neighbor discovery model implemented to reduce energy consumption by reducing the duty cycle of a node.

Second, a meticulous two-dimensional k-array design for neighbour finding in multi-hop wireless communication is used in the Quorum-base neighbour discovery [10] paradigm. Disco, for instance, uses the Chinese Remainder Theorem and two prime integers. Utilizing an asynchronous neighbour finding methodology, U-Connect [7] was built. By creating a block-based neighbour discovery schedule that could be adjusted and had all nodes operating at the same duty cycle, Zheng et al. Based on the block-based design theory, we propose an asymmetric block-based design neighbor discovery protocol for efficient utilization of the power budget of a node to extend the network lifetime. In this model we adopted previously basic block design mechanism for neighbour discovery to support asymmetric operation, where nodes in the network are a nontrivial in WSNs [17]. Some nodes in the network are high energy expenditure, whereas other comparatively small energy expenditure nodes. It is important to design an independent duty cycle schedule based on the power expenditure of a node in WSNs. In more realistic applications of WSNs fast data delivery needed to take some kind of decisions and then the fast neighbor discovery of nodes is essential in multi-hop communications by addressing the power maintenance mechanisms. The fundamental idea behind our proposed model is adding control packets to make new block design, by using exiting features of block design.

2. RELATED WORK

Many WSN applications need neighbor discovery as a core function and numerous duty cycle and mathematical models are offered to lower the worst-case discovery delay. First, duty cycled discovery is a probabilistic asynchronous node detection algorithms, i.e., Birthday [8] and on top of the MAC protocols such as SMAC and BMAC [13][14]. As opposed to that, a variety of deterministic proposed approaches based on mathematical models, such as Quorum –based [10] algorithm is composed of $n \times n$ array in a row based order, Prime – based [7] a proper prime number selected for duty cycle, Disco [15] based on two different prime numbers, and Block design [16] based emerging to guarantee the extreme worst-case bound in neighbor node

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discovery. In sensor networks and mobile computing, the duty cycle and discovery delay of several neighbour node detection algorithms are compared in Table 1.

One of the deterministic protocols proposed in Searchlight [11], based on the symmetry between any two neighbor nodes to minimize the discovery delay in WSNs. In this mode node extends active slot over a complete time slot, and also studied about the clock drifts in problems in a network. [9], proposed a model is enhanced to use traditional Integer protocols beside the non-integer simulation, and code based neighbor discovery model utilizes a coding method to enhance the worst-case discovery delay in a sensor network by imparting the real number. This protocol even has a stationary active time slot, which cannot accomplish a variable active time slot. Panda [15], proposed emerging concept for WSNs i.e., energy harvesting neighbor discovery model. In this paper, they addressed neighbor discovery, design issues and challenges in more important for event tracking, and monitoring applications in WSN and implemented protocol called PANDA (i.e., Power Aware Neighbor Discovery Asynchronous), where each node can operate in three modes such as reception, transition, and sleep. For energy harvesting, node is enabled with solar cell (i.e., Sanyo AM 1815 Amorphous). And results of proposed protocol achieved high discovery rate (i.e., 94%) by carefully determining the node sleep and listen durations with the help of developed Power Configuration Algorithm (PCA).

Prime-based protocol [7] was created to address the conceptual and practical challenges of symmetric and asymmetric neighbour finding in asynchronous problems in WSN applications including continuous location tracking, monitoring, and social networking. To avoid node synchronization in between nodes in mobile networks, or sensor network proposed energy efficient low-latency neighbor discovery protocol called U-Connect [7], and provided the theoretical and analytical formulation for asynchronous neighbor discovery by careful designing of slot nodes. In this proposed protocol, a discovery schedule for a mobile node function of $X(m1, t) = 0$, where m1 is a mobile node inactive mode at a particular instant of time t, and other hand function of $X(m2, t) = 1$, indicates node m2 in discovery mode at time t. Therefore, $X(m1, t) = X(m2, t) == 1$describes both mobile nodes m1 and m2 are in discovery mode. To examine the low-duty cycle mobile wireless sensor network [15], proposed a protocol for dynamic network topology changes. A proactive algorithm implemented for neighbor discovery by reducing the long time standby delay. Along with minimizing waiting delay, this protocol also grabs accurate neighbor discovery by determining the next set of neighbor node movement. Finally, proposed algorithm simulation results significantly reduce energy consumption and delay.

Neighbor discovery is a considerable topic for both research and industry of wireless sensor and mobile computing applications and it is a difficult task, where the network is self organized. A framework based on a deterministic protocol called Hello [3], to derive energy efficient duty cycles for either symmetric or

Table 1: Comparison OF Neighbor DISCOVERY Algorithms Duty Cycle AND Latency

Algorithm	**Asymmetric?**	**Parameter**	**Duty Cycle**	**Latency**
Quorum	No	n	$\frac{2}{n}$	n^2
Disco	Yes	Prime (P_1,P_2)	$\frac{1}{P1}+\frac{1}{P_2}$	P_1P_2
U-Connect	Yes	Prime (P)	$\frac{3}{2P}$	P^2
Searchlight	Yes	t	$\frac{2}{t}$	$\frac{t^2}{2}$
Combinatorial	Yes	P	$\frac{2}{P}$	P^2+P+1
BAND	Yes	Prime (P_1,P_2)		$(P1^2+P1+1)(P2^2+P2+1)$

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asymmetric approaches. Simulation results evidence that it provides better worst-case discovery latency in an asymmetric duty cycle. In WSNs, neighbor discovery process practically very fundamental and difficult in self organization, resource constrained, and mobility node scenarios. The existence of a neighbor node cannot be guaranteed for communication. To minimize the idle-listening in sensor node neighbor discovery by introducing more beacons, this accomplished protocol model called TMLL[16] and also addressed channel occupancy ratio. This proposed protocol Nihao, for energy efficient asynchronous neighbor discovery for symmetric and asymmetric by using the notion of balance factor. The simulation results of Nihao show that it significantly better by considering the channel occupancy ratio.

More importantly, in many realistic applications of WSNs, due to node compatibility and environmental surroundings may change at a time being. Hence, more variable neighbor discovery approach is important for a asymmetric WSNs [12][13][14]. In this paper, we proposed an adaptive neighbor discovery algorithm which is based on combining block designs and circular shift block design by using combinatorial problem, and this model used in complex environments including stationary and mobile scenarios.

The remainder of the paper is structured as follows: Fundamental definitions of the block design with regard to neighbour discovery are provided in Section 3. The design of the proposed algorithm is then presented in Section 4, followed by Section 5's evaluation of the proposed algorithm's performance in comparison to prevalent existing neighbour discovery protocols, and Section 6's conclusion.

3. FUNDAMENTALS OF NEIGHBOR DISCOVERY

In this section, we propose BIBD framework to describe the neighbor discovery operation. The use of block design in various applications increased and it is a well known combinatorial problem. The problem represented in a variety of forms, one of the popular models is Balanced Incomplete Block Design (BIBD) [17]. BIBD inception is a well known NP-hard and that gives tremendous standards for optimization algorithms. The fundamental idea behind BIBD is an arrangement of divergent intents into b blocks, such that each block contains exactly k different intents, each intent occur in exactly r different blocks, and every two divergent intents occur together in exactly λ blocks. In recent years BIBD is used in different fields such as experimental design, coding theory [3][7], network security and cryptography problems [7], clustering [2][4], distributed systems [4][5], and wireless sensor networks among others.

The basic definition and terminology are defined in the proposed algorithms as follows.

Incomplete: cannot fit all nodes in each block, Balanced: each pair of nodes allowed together λ times, v nodes, b blocks, r copies, and k nodes

Slot Number	0	1	2	3	4	5	6							
S_A	0	1	0	0	1	1	0	0	1	0	0	1	1	0
S_B						0	1	0	0	1	1	0	1	0

Figure 3. Illustrates The Same Duty Cycle Schedule In Asymmetric Neighbor Discovery

Slot Number	0	1	2	3	4	5	6
S_A	0	1	0	0	1	1	0
S_B	1	0	0	0	1	0	

Active Sleep Common Active time slot of both Schedule

Figure 2. An Example Of A Duty Cycle Schedule For Node A And B

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per block. The total number of nodes is $kb = vr = N$

i) We assume each sensor node has a unique ID, and each node operated in one of two modes alternatively such as an active and sleep. Hence, a node in the active mode (i.e., node turning on its radio) performs neighbor discovery and communication. On the other hand, a node turns off its radio and move into sleep mode to save energy of a node.

ii) We assume λ indicates the discovery time, i.e., least waiting time required to discover neighbor nodes within their communication range of each other without any collisions.

iii) We let T indicates the total number of equal length time slots for each in a schedule, noted as s in Figure 2, then we define the length of each slot.

iv) We design BIBD in a schedule period denoted as ʙ, where $\{ʙ = ʙ1, ʙ2, ʙ3, \ldots\ldots\ldots, ʙn\}$. The process BIBD is a sequence of 0's and 1's represents active and sleep modes. For example, figure 2 reflects that discovery function a schedule period between two neighbor nodes A and B. Each time slot in the schedule period last for discovery latency the schedule generated for the two nodes are SA = $\{0,1,0,0,1,1,0\}$ and SB =$\{1,0,0,0,1,0,1\}$ respectively.

v) We assume that if two or more neighbor nodes are in work mode for a particular time slot or time period asymmetrically, and these nodes are within the communication range of each other, then the node will collide with another node in the channel utilization.

vi) Discovery between two nodes appended, when the schedules of nodes in a network are overlapped at least given threshold without any collisions. We combine two block designs to guarantee neighbor discovery between nodes by reducing worst case discovery latency to prolong the network lifetime.

Definition: A duty cycle is the percentage of the ratio a node that the number of active time slots over the total number of time slots (i.e., active & sleep) per a given time interval.

$\sigma = (w/t) \times 100$

Where w is a number of active time slots, t is the total number of time slots in the schedule and σ is a duty cycle of a node. From figure 3, the duty cycle of S_a and S_b is approximately 43% (i.e., $\frac{3}{7} \times 100$).

***Problem of Symmetric Neighbor discovery**:* All the devices in sensor network have same duty cycle schedule to discover neighbor nodes and for communication. The varied applications of WSNs such as continuous monitoring fields and mobility of the sensor nodes, it is impractical to discover neighbors with same duty cycle. On the other hand, it is important to design an asymmetric duty cycle schedule for neighbor discovery in heterogeneous WSNs. In figure 4 illustrates the problem of same duty cycle schedule in asynchronous WSNs that leads to the worst-case discovery latency.

Slot Number	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
S_a	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1	0	0	0	1
S_b	0	0	0	1	0	1	0	0	0	0	0	1	0	0	1	0	0	0	1	0	1

Figure 4. Different Duty Cycle Schedule Using BIBD

Definition: BIBD consists of the five tuples <v,b,r,k,λ>, where v is a set of nodes into b subsets of nodes such that, each node belongs to r different subsets, and at least one pair of nodes appears together in exactly $\lambda < b$subsets. We use incidence matrixχ = {χij}v × b, for representing the solution to BIBD problem in which a v × b binary matrix. It is easy to represent that each row corresponds to a node schedule and each column indicates a time slot, and that corresponding schedule contains exactly r ones, k one's per column, and a common active slot for any pair of devices in rows is λ. The Figure 3, demonstrates the appearance of the incidence matrix (χ) illustrating possible solutions to a $\langle 7,7,3,1 \rangle$ - BIBD and symmetric $\langle 14,14,4,1 \rangle$ - BIBD.

Hence, node A allows in r blocks to have balanced incomplete, each other node is appropriate. Probably, there is k-1 other units in a block and v-1 other nodes, the total number of nodes is:$kb = vr = N$, the number of times each pair occurs together is $\lambda(v-1) = r(k-1)$, where λ is an integer. Our possible strategy to construct this is –choose $\binom{v}{k}$blocks and assign each a different k node combination. The number of copies is $r = \binom{v-1}{k-1}$ and $\lambda = \binom{v-2}{k-2}$.

Problem of Asymmetric Neighbor Discovery: proposed in Disco [15], and Searchlight, where all the nodes in the network choose an independent duty cycle, then it makes difficult synchronization between neighbor nodes in self organized and resource constrained heterogeneous WSNs. In this section, we address the procedure of the BIBD–based asymmetric neighbor discovery under the framework presented in the previous section. The main objective for the each node is to obtain the optimal duty cycle schedule, when the frequent topology changed environments. We divide the duty cycle schedule into several equal length time-slots, which is the same for each node in existing neighbor discovery protocols such as Birthday [8], Disco [15], U-Connect [7], Diff-Codes, and Searchlight [11]. However, the same duty cycle schedule has intrinsic limitations: unbalanced presentation under different scenarios, because of node and network dynamic nature. Moreover the density and the movement of the node in various environments are completely different. The power consumption for communication required to be as minimum as possible.

The proposed algorithm for the most part focus on optimization of generating better solutions in the reproduction, and we cannot consider the direct factors that reflect the neighbor discovery in various complex environments, and we use a BIBD based algorithm to obtain the suitable an asymmetric neighbor discovery schedule, We consider the average power conservation of our proposed model and typical protocols as each node the energy conservation between symmetric and asymmetric consider for our model. In deterministic duty cycle, the average energy consumption is well constructed in Birthday protocol [8], the energy consumption is variable because of the randomize duty cycle schedule.

Let us assume that we have a varied list of sensor nodes and make the wireless network operate in the asymmetric approach for neighbor discovery. Figure 4, demonstrate assumed different duty cycle schedule to different nodes in network i.e., $\langle 7,7,3,1 \rangle$ - BIBD for node Sa and $\langle 14,14,4,1 \rangle$– BIBD for node Sb as follows: The duty cycle of a node Sa using BIBD is 43% and duty cycle of a node Sb with the help of BIBD is 29%. Another OR and XOR model used to combine two duty cycles to make more energy efficient block design based schedule constructed and duty cycle of resultant schedule is 13%, but leads to worst-case discovery latency in asymmetric scenario for neighbor discovery.

In this paper, we explore the subsequent more frequent research arguments that involve neighbor discovery problem in asymmetric approaches, such as 1) How to enable an efficient dynamic neighbor discovery schedule in a node by using BIBD, 2) How can we validate two neighboring nodes make efficient multi-hop communication in asynchronous wireless networks, and 3) How can we enhance the worst case discovery latency an asymmetric neighbor discovery approaches proposed in existing neighbor discovery models. Same duty cycle schedule scenarios, i.e., symmetric strategy the energy consumption of proposed model have an average among existing protocols. In asymmetric schedules the power consumption not in constant level and it is varied. Therefore, we ended up that our proposed algorithm still more efficient than popular existing protocols at similar energy consumption.

Asymmetric Neighbor Discovery Algorithm: The fundamental scheme of the neighbor discovery is illustrated in Algorithm.

Input: The input of the algorithm consists of the BIBD problem parameters and as the algorithm parameters.

Output: The output of the algorithm is the best efficient node dependent schedule will be elected during the neighbor discovery process.

1. Network with 'N' nodes.
2. repeat
3. for every node in 'N", perform initial neighbour discovery
   a. Suppose node 'S_a'with in communication range of 'S_b'.
   b. if Sa and Sb Schedule overlapped
      i. Sa and Sb are neighbours
   Otherwise
      ii. Node's dynamically adapt discovery schedule by rotating the initial neighbour discovery schedule.
4. Nodes can communicate data to BS.
5. If Node energy sufficient for communication, but no neighbour node information
   a. Go to step 3
   Otherwise
   b. Terminate from Network.
6. Return Nodes

4. DYNAMIC SCHEDULE BASED NEIGHBOR DISCOVERY

In recent years, the applicability of block design theory is very predominant. Block design is used in order to enhance the process of extracting information from a field of experiments. A BIBD-(v, b, k, r, λ) is organization v intents in b block each of size k, where$k < v$, if:

i) Each node allowed exactly $r = \frac{bk}{v}$ times.
ii)Each node adapted greater than once per block.
iii) Each pair of its node allowed in exactly λ times, i.e., $\lambda = r(k-1)(v-1)$ blocks.

In this section, block designs are developed by the procedures of set of shifts. Model of set of shifts proposed by Iqbal [], initially designed only for balanced incomplete block designs and sub sequentially used for neighbor balanced designs. It has following important features:

1. Let $S_m = [p_{m1}, p_{m2}, p_{m3}, \dots, p_{k-1}$ be a circular shift, where $1 \leq p_{m1}, p_{m2}, p_{m3}, \dots, p_{(k-1)} \leq (v-1)$, then implemented the block design will be $L_m = (0, p_{m1}, (p_{m1} + p_{m2}), (p_{m1} + p_{m2} + p_{m3}), \dots, (p_{m1} + p_{m2} + p_{m3} + p_{(k-1)}) \bmod v$.
A design is balanced incomplete block if each node of S*m along with its complement contains all slots $1, 2, 3, \dots, v-1$ equally λ times.
2. Let $S_m = [p_{m1}, p_{m2}, p_{m3}, \dots, p_{k-2}$ be a circular shift, where $1 \leq p_{m1}, p_{m2}, p_{m3}, \dots, p_{(k-1)} \leq (v-2)$, and ∞ = v-1, then implemented the block design will be $L_m = (0, p_{m1}, (p_{m1} + p_{m2}), (p_{m1} + p_{m2} + p_{m3}), \dots, (p_{m1} + p_{m2} + p_{m3} + p_{(k-2)}) \bmod v-2$.
A design is balanced incomplete block if each node of S*m along with its complement contains all slots $1, 2, 3, \dots, v-1$ equally λ times.

The procedure of circular rotation is a particular approach of creating circular shift BIBD. Where v intents are labeled as $[0, 1, 2, \dots, v-1]$ and we believe that, the creation of equal reproduction binary block design, where each element of the incidence matrix, $\dot{M}$ is either 0 or 1 for v intents in $(b = v)$ blocks of size k. The function of creation is to distribute to the first schedule in the mth block the intent m, $(m = 0, 1, 2, \dots, v-1)$. We used to represent this vector as w_i, where the intents allocated to the first schedule in each of v blocks respectively. In order to derive the object allocation of the remaining schedules in each block, we circularly rotate the object allocated in the first schedule. To derive the circular rotate, let w_i represents the distribution of intents to the ith schedule in each block. Where ath element of w_i is the intent allocated to schedule i of block A. A circular rotate of size q_i when relate to schedule i, such that $w_i = (w_i + q_{i1})$, where the addition is mod v, 1 indicates a vector of ones, 1≤i ≤ k-1 and 1≤qi ≤v-1.We consider to avoid a intent distribute more than once in a block guarantee that the sum of any consecutive rotates, any three consecutive rotates and so on the sum of k-1 consecutive rotates, is equal to 0 mode v. By considering this, Q may consist of any composition of rotates along with repeats, and rotate entail only range from 1 to $\left(\frac{v}{2}\right)$ both are included [19][20].

To demonstrate the above function of circular rotate creation, let us consider creation of design for v=5 and k=3. The necessary rotates are defined as $Q = [1,2]$, where two possible design alternatives are $Q_1 = [1,1]$ and $Q_2 = [1,2]$. The complete block design for Q1 and Q2 are represented in following manner.

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The properties of a block design depend on the number of combinations between the pair of intents. An existence between intents appears when both intents are in the same block. In block design 1, for intent 0 the existence with each other of the intents 1,2,3, and 4, specifically are 2,1,1,2, on the other hand in design 2, for intent 0 their corresponding existence are 1, 2, 2, 1.To represent the number existence between intents can be retrieved from Q. Here we consider a circular rotate Q_1 [1, 1], to create the block design 1, and observe that the number of existing between intents are symmetric. The creation of circular rotate enables that if we adapted to obtain the neighbors of intent 0, then the neighbors of all other intents follow the same model.

If a node *p* active on time slot in a schedule *i* in block *j*, then the node *q*, active on time slot $(i+1) mod\ (k+1)$ is the right neighbor of node *p* in that block. The node on time slot $(i-1) mod\ (k+1)$ in block *j* is the left-neighbor of node *q* in block *j*.

*For example: v=7, k=3*and by using the set of circular rotate [1, 2] then block design $\langle(013),(124),(235),(346),(450),(561),(602)\rangle$, and *v=7, k=4* and by using the set of circular rotate [2,2,2], then block designwhere the columns represent block. The circular rotate model of creation ensures that if node *p* has every other node as a neighbor an equal number time.

Property 1: A neighbor discovery of balanced for *v* nodes in $b=(v\ \times v)$ blocks of size *k* can be created using n set of circular shifts $S_1, S_2, \ldots, S_n$ if and only if the sets $S_1, S_2, \ldots, S_n$ and the shifts $\sum S_1, \sum S_2, \ldots, \sum S_n$ (Where is the sum of all the shifts in list)., contain between them all the possible shifts $1, 2, 3, \ldots, v-1$, an equal number of times, where both each shift and its complement are counted.

Property 2: Suppose that D_1 and D_2 are two designs for $v-1$ intents such that in D_1 there are $b_1 = n_1 v$ blocks of size $k-1$ and the intents copies is c1 and in D_1 there are $b_2 = n_2 v$ blocks of size $k-1$ and the intents copies c_2. Let $S_{1i} (i = 1, 2, 3, \ldots, n2)$ be the set of rotates used to create D_2. A neighbor balanced design for v intents in $b1 + b2$ blocks of size k and copies $c1 + c2$ can be created by appending intents v to each of the blocks in blocks in D_2 and taking the

	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0
S_a	0	1	0	1	1	0	0	0	0	0	1	0	1	1	1	1	0	0	0	1	0	1	0	1	1	0	0	0	0
				0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3
S_b				0	0	0	1	0	1	0	0	1	1	0	1	0	0	0	0	1	0	1	0	0	1	0	1	1	0

	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0	1	2	3	4	5	6	0
S_a	0	1	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1	0	0	0	1	0	1	1	0	0	0
				0	1	2	3	4	5	6	7	8	9	10	0	1	2	3	4	5	6	7	8	9	10	0	1	2	3
S_b				0	0	0	1	0	1	0	0	1	1	0	0	0	0	1	0	1	0	0	1	1	0	0	0	0	1

Figure 5a: Duty Cycle Schedules Of Node A And B With Circular Shift Asymmetric Approach
Figure 5b: Duty Cycle Schedules Of Node A And B Without Circular Shift Asymmetric Approach

complete design as consisting of all the blocks in D_1 and D_2 [19][20] if:

i) $S_{1i}(i = 1, 2, \ldots, n1)$, and $S_{2j}(j = 1, 2, 3, \ldots, n2)$, contains every shift and its complements times
ii) $b2 = c1 + c2, and$
iii) The first intent in each block D2 and the k^{th} intent in each block of D2 contain between them – complete copies of intents $1, 2, 3, \ldots, n$.

Lacking sufficient power, storage, and processing capacity of a node in sensor networks, and it can operate on sleep, and active periods. A node must use the energy efficient schedule to prolong node lifetime. Although, a neighbor discovery process comes out with a new discovery schedule, its presence is detectable by beacons. In this paper, we proposed a model to design efficient neighbor discover schedule for asymmetric approaches based on the circular shift -BIBD, in which BIBD is used to design the schedule for each node in the network, and circular shift used to reconstruct the schedule to minimize the worst-case discovery delay in the existing system. Our proposed model has a stable duty cycle ratio compared with other existing asymmetric neighbor discovery protocols and a relatively low worst-case discovery delay.

Let us consider $\langle v, b, k, r, \lambda\rangle - BIBD$, where *v* is node schedule contains a series of active and sleep time slots, *k* represents the number of active slots, and λ number times a node detect another node, r indicates the adapted circular rotates and $v = b$. For example $k = 4$, *v* is prime and $\frac{v-1}{k}$ is not a multiple of *k,* the set of circular shifts to create Circular Shift BIBD are given as $[1,1,1], [2,2,2], [3,3,3]$.

Figure 5, demonstrates the creation of circular shift balanced block design schedule for asymmetric wireless sensor networks, where S_a and S_b are duty cycle schedules for node A and B as follows:

Let assume $\langle 7,7,3,1\rangle$ - BIBD for node Sa and $\langle 11,11,4,1\rangle$– BIBD for node Sb. Where node A has seven equal time slots in the schedule and node B has eleven equal time slots in the schedule. Both have at least one common slot for discovery and communication. Therefore, for given the example indicates the adapted circular rotates and $v = b,\ k = 3,4$, v is prime and $\frac{v-1}{k}$ is not a multiple of k, the set of circular shifts being [2, 2] to create Circular Shift BIBD. Duty cycle schedule for Sa: $\{0,1,0,1,1,0,0\}$and Sb: $\{0,0,0,1,0,1,0,0,1,1\}$.

5. IMLEMENTATION AND PERFORMANCE EVALUATION

In this portion, we have evaluated proposed model and reference protocols on the NS-2 environment. We consider different neighbor discovery protocols to evaluate the primary metric of neighbor discovery in the asymmetric scenario such as discovery latency, and energy consumption of circular shift BIBD and estimate its interpretation with other protocols in literature; they are *Quorum, BAND, U-Connect, Disco and Combinatorial.* In this paper, we already discussed that proposed model has a stable duty cycle ratio compared with other existing asymmetric neighbor discovery protocols and a relatively low worst-case discovery delay. Primarily, we consider two important aspects of neighbor discovery in asynchronous wireless sensor networks such as power consumption and latency. The following discusses the trade-off between power usage and discovery delay.

Power Consumption: Every node spends some amount battery power to make a neighbor discovery, the overall amount of power used by each sensor node in the wireless network during neighbour discovery.

Discovery Latency: The total elapsed time that all sensor nodes in the network exhausted during the neighbor discovery process. Generally, node duty cycle and discovery latency are two important metrics for neighbor discovery by which energy organization measured. Although, there is a general tradeoff between these two: a smaller duty cycle normally assists greater discovery latency, and vice versa.

Table 2: Simulation Model Parameter Configuration

Parameter	Configuration
Basic Protocols	: MAC, CSMA/CA
Network Traffic	: CBR
Length of Time slot	: 15ms
Transmission -25dBM battery power consumption	: 17.5 Ma

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Transmission -25dBM battery power consumption	: 8.5 mA
Deployment of sensors	: Random
Receive Power consumption	:19.7mA
Deployed area	: 500 x 500
Sensors communication rage	: 20m
Number of Devices	:100
Node mobility	: Random

To compare the performance of the representative protocols in this simulation research, we use this evaluation measure; Table 2 lists the suggested model's implementation parameters. In this simulation framework, 100 sensor nodes are dispersed at random over a 500 × 500 m area of interest. Utilizing network-active characteristics like transition, reception, and CPU activity, we add up each device's energy usage. For each procedure of discovering a neighbour, we calculate the whole network's average energy usage. We evaluate significant asynchronous neighbour discovery protocols as BAND, Combinatorial, Disco, U-Connect, and Quorum based on different duty cycles when using the parameters for the various neighbour discovery processes shown in Table 3. We calculate the discovery delay and power consumption for each typical protocol using these factors. To provide an asymmetric duty cycle schedule, we use combinatorial algorithms and the circular shift balanced incomplete block architecture. To prevent network interferences, sensor devices are randomly placed relatively near together. Any two neighbouring nodes can cooperate with one another. In order to avoid node synchronization of wakeup schedule, we use balanced incomplete block design along with circular rotate before neighbor discovery initialization. We analyze the performance of proposed circular shift BIBD and compare it with Disco, U-Connect, and BIBD where these protocols can adapt an asymmetric approach. We use asymmetric duty cycle ratio(R) is designed in U-Connect to analyze the efficiency of asymmetric dynamic schedule, and then R can be described as follows: For instance, low duty cycle of node is 5% and that of a higher duty cycle of node is 20%, then asymmetric ratio (R) is 4.

Table 3: Framework Setting For Simulation Study Under An Symmetric Scenario

Algorithm	R=1 DC=10%	R=2 (DC=10% and 5%)	R=5 (DC=10% and 2%)	R=10 (DC=10% and 1%)
Quorum	p=19	m=39	m=99	m=199
U-Connect	p=13	p=29	p=73	p=149
Disco	$p_1 = 17$, $p_2 = 23$	$p_3 = 37$, $p_4 = 43$	$p_1 = 93$, $p_2 = 103$	$p_3 = 197$, $p_4 = 199$
Combinatorial	(91,10)	(381, 20)	(2451, 50)	(9507,98)
BAND	(147,15)	(511,27)	(2821,60)	(10431,112)

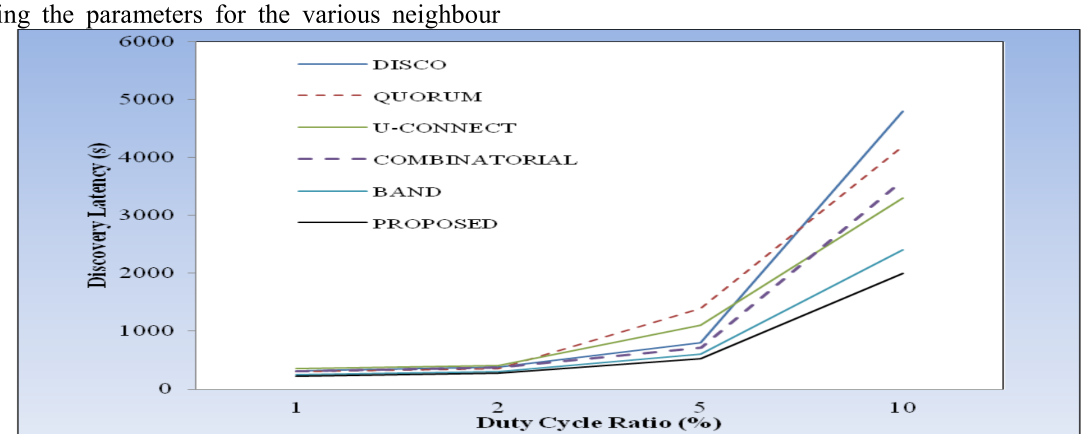

Figure 5. Discovery Latency in Asynchronous Approach

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Wee demonstrate the worst-case discovery latency of five divergent neighbor discovery algorithms from 1% to 10 % duty cycle and shown in figure 5. The simulation results shows that worst-case latency values for all different neighbors discover protocols. The graph exhibits that the case of 1% to 2% duty cycles combinatorial, BAND, and proposed algorithms gives enhancement in terms of the worst-case discovery latency. In fact proposed model significantly better compare with parallel research for detection of neighbors. Figure 6, shows the energy consumption among these representative protocols for neighbor discovery based on the amount of battery utilized by each radio interaction for all network nodes and averages the power utilization of the typical radio communication. However, in the case of 1% to 10% duty cycle indicates that the number of active slots are generally impacts the energy consumption.

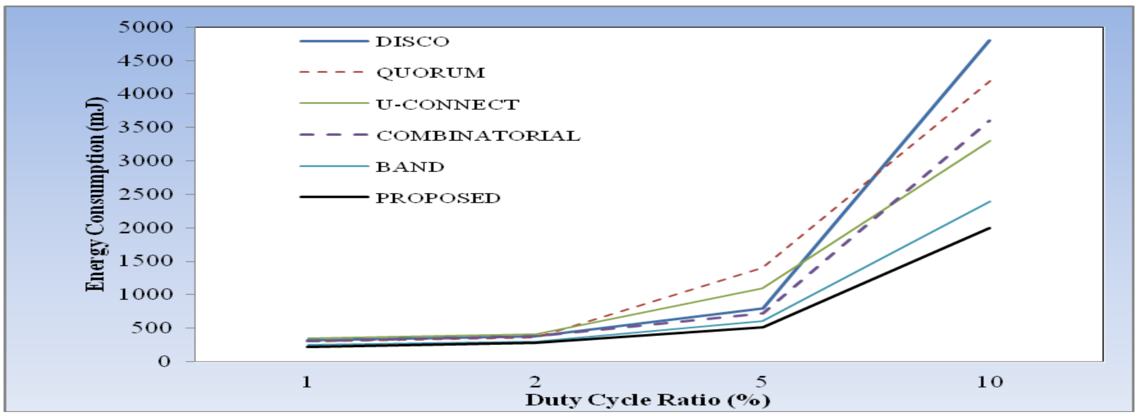

Figure 6, Energy Conservation in an Asynchronous Approach

6. CONCLUSION

In this study, we describe a neighbour finding protocol for asynchronous wireless sensor networks based on circular shift balanced incomplete block design. Finding every node that a certain node may directly interact with is a technique known as neighbour discovery. Despite the fact that the neighbour discovery function has a new discovery schedule and that beacons may detect its existence, the suggested model considerably increases the pace of discovery and increases the lifespan of sensor nodes. Sensor nodes often use independent active or sleep scheduling in the network protocol to achieve a longer lifespan for the nodes and to limit the source of energy waste and asynchronous WSNs' energy consumption.

The result of proposed simulation results compared with representative protocols, our model decreases the time required to complete the neighbor discovery process. Proposed model guides node to choose its independent duty cycle schedule for wireless sensor networks and our model has a stable duty cycle ratio compared with other existing asymmetric neighbor discovery protocols and relatively low worst case discovery delay.

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