Maximizing Network Lifetime using Energy-Efficient Methods with Modifiable Sensing varieties in Wireless Sensor Networks

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Abstract— We cram the aim of exposure problem for wireless sensor networks where every sensor node is capable of regulating its sensing sort. Our aspire is to amplify the network lifetime by increasing the quantity of wrap sets as many as possible. A wrap set is a split of all sensor nodes that can wrap each intention node. As an alternative of maintenance of all the sensor nodes dynamic at once, network lifetime can be extended by generating a number of wrap sets that will examine the network sequentially. We extend two polynomial time algorithms that utilize an efficient contribution procedure on spherical lists of sensor nodes for structure a diversity of wrap sets. Our proposed algorithms locate greatest number of wrap sets and devour as low power as possible for each sensor node. Our simulation results exhibit that the future algorithms better existing MRSW [1] algorithm in terms of number of wrap sets while conserving major amount of energy among the sensor nodes.

Keywords- wireless sensor networks, aim exposure, adaptable sensing range

I. INTRODUCTION

In modern years wireless sensor networks (WSNs) have attained rapid reputation due to its enormous possible into a number of claims such as military systems, biomedical applications, habitat monitoring, seismic monitoring, radiation and nuclear threat detection systems etc. [2]. WSNs are distinguished by opaque occupied a diminutive size, short battery power sensor nodes that are commonly organized in distant and hard to admit areas. A sensor node checks and accumulate data on confident attribute of the environment and exchange a few words of data to a base station. While conveying data a node can complete behaviors such as home network data procedures and can take action as an midway node in case of multi-hop communication. Even though, WSNs split a lot of links with other network systems ,as well they have a range of single delimits and constraints. An imperative anxiety in aiming variety of protocols and algorithms for WSNs is authority limited that happens due to undersized battery amount and partial weight of sensor nodes. As battery recharging or substitute is not possible due to unforgiving environmental condition, it turn into very important to save energy of the sensor nodes in turn to extend the equipped lifetime of WSNs. Energy restriction of various nodes of WSNs is authority limited that happens due to undersized battery amount and partial weight of sensor nodes. As battery recharging or substitute is not possible due to unforgiving environmental condition, it turn into very important to save energy of the sensor nodes in turn to extend the equipped lifetime of WSNs. Energy restriction of various nodes of WSNs is tackled in various ways in the text. One way is to keep the idle sensor nodes in reduced energy sleep mode, while other sensors are kept aware as these nodes are executing some operation [2]. Another advancement is to modify the transmission range so that the sensor nodes only use energy sufficient for conveying to a nearby node [2].

In this paper, we investigate the target wrapping problem in energy constrained WSNs. In target wrapping problem, N sensor nodes are exploited to observe M target nodes scattered at various positions of a WSN. Comparing such networks, objectives can be followed by choosing a group of sensor nodes as a substitute of consuming all the sensor nodes. This group is known as wrap set. By producing a number of wrap sets and assigning responsibility on them to watch network in turn will accordingly increase the lifetime of the network. In a single period of time, only the sensor nodes of a particular wrap set will be active while the other nodes will remain in sleep mode. We consider a WSN where each sensor node is related with a number of modifiable sensing varieties. By choosing various sensing varieties, each sensor node is accomplished of monitoring different number of targets. Producing the greatest amount of wrap sets in such network has been established to solve an NP-complete problem in [1]. Thus we recommend two uneven time heuristically based algorithms for deal with the aiming of wrapping problem in such networks. The problem is solved in the upcoming segment.

II. RELATED WORK

Target wrapping problem of WSNs is intensively studied in literature. Cardel et al. explored the problem of maximizing network lifetime in [3] and modeled the target wrapping problem as Maximum Set Wrap (MSC) problem. The MSC problem organizes sensor nodes into a number of sets and finds maximal possible number of sets. The authors proved that MSC problem is NP-Complete and proposed two efficient heuristic algorithms to compute the wrap sets using linear programming and greedy approach, respectively. In the greedy heuristic, a critical target is selected in each step and a sensor node that monitors that critical target as well as the maximum number of other targets is included in the wrap set. The creators of [4] well-known that residual energy of sensor nodes is not considered during the creation of set wrap.

As an outcome of a sensor node wrapping maximum number of goals is selected repeatedly in every wrap set and this node quickly exhausts energy. The creators recommend a new energy-efficient algorithm by in view of the go beyond ping target nodes and the residual energy of sensor nodes. In [5], Pyun et al prospect a sensor scheduling algorithm for
Multiple Target Wrapping (MTW) problem. They considered periodic sensing requests where a sensor node senses and accumulates data from targets sequentially. Their proposed algorithm calculates the transmitting energy of a sensor node as the summation of energy consumed for every target node it wraps and also assigns a responsible sensor for each overlapped target by making the other redundant sensors free from monitoring the same target node. In [6] Berman et al. suggested an efficient data structure to represent the monitored area with at most $n^2$ points assuring the full wrapping. They have provided some effective centralized sensor monitoring algorithms to maximize the network lifetime. Moderately, wrapped area is also monitored in these algorithms and several distributed protocols are introduced with trade-off between communication and monitoring power consumption. Cardei et al. effected the Connected Set Wrap (CSW) problem in [7].

We compare the results of our algorithms with an existing algorithm in literature: Modifiable Range Set Wrap (MRSW) [1]. The authors of [1] considered the target wrapping problem for WSNs consist of sensor nodes with multiple sensing varieties. For each sensor $s_i \in S$, a contribution value $\Delta B_p = \Delta T_p / \Delta E_p$ is determined. $\Delta T_p$ indicates the increase in the number of unwrapped nodes if the sensing range is increased from $r_p$ to $r_p$ and is calculated as $\Delta T_p = T_{r_p} - T_{r_p}$ where $T_{r_p}$ and $T_{r_p}$ are the set of target nodes wrapped by $s_i$ at sensing range $r_p$ and $r_p$, respectively. $\Delta E_p$ is the increase in energy if the range of sensing is updated from $r_p$ to $r_p$ and is calculated as $\Delta E_p = e_p - e_p$ where $e_p$ and $e_p$ are the energy consumed by $s_i$ at sensing range $r_p$ and $r_p$, respectively. A sensor node $s_i$ with the highest $\Delta B_p$ is selected to participate in a wrap set. The sensing range of $s_i$ is updated to $r_p$ and target nodes wrapped by $s_i$ for sensing range $r_p$ are removed from other sensor nodes wrapping sets. Dual heuristic based distributed algorithm (DHD-CS) has been introduced in [9]. Here each sensor node has in sequence about its fellow citizen nodes and range of each sensor to its maximum value.

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<thead>
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<th>TABLE I. NOTATION USED FOR ALGORITHMS</th>
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If the sensor perceives no targets within its $r_{max}$ then it goes to sleep mode. If a node starts a main concern timer based on its utility function. The creators of [10] deal with the problem of increasing the network lifetime while using the network connected nodes. They noted the connection between target wrapping and network connections of nodes and establish a normal condition to attain both and finally suggested a allocated and restricted algorithm to construct wrap sets while using connections among the active sensor nodes. According to the algorithm, a connected dominated set is constructed that is pruned to get rid of superfluous sensor nodes and then both dominator and dominate nodes are participated to wrap target nodes by adjusting their sensing varieties. In [11] the creators intended on increasing the network lifetime directly rather than increasing the number of wrap sets. They devised a mathematical model of the problem using a linear program comprising of exponential number of variables and solved it using an existing approximation algorithm proposed by Garg-Konemann [12]. Their model works with non-uniform batteries that allow smooth sensing range variations and also facilitates assigning fractional time to each wrap sets. The authors asserted that their move toward achieved four times performance improvement as compared to MRSW [1] proposed by M. Cardei. In [13], the creators studied energy-efficient wrapping problems here in the study, their wrapping formulations and the relations made along with an summary of the suggested solutions. The wrapping formulations vary depending on a number of delimiters like deployment methods, network connectivity and power consumption.

III. PROPOSED ALGORITHMS

In this section we present two polynomial time algorithms to address the target wrapping problem in WSNs consist of sensor nodes with Modifiable sensing varieties. Some basic notations used to explain the algorithms are presented in Table.

A. Modifiable Range Set Wrap with pushback (MRSW_P)

**Algorithm**

This algorithm generates for each target $t_i \in T$, a list $L_i$ of Sensor-Range (SR) combinations wrapping $t_i$. A SR combination denoted by $s_{f_k}$ signifies that sensor $s_i$ wraps a specific target with sensing range $r_k$. Each $L_i$ is represented as a circular list. If a $t_i$ is wrapped by $r_j$ of a sensor $s_j$ all the varieties of $s_j$ greater than $k$ are eliminated from $L_i$. For example, if a target $t_i$ is wrapped by a sensor $s_j$ with sensing range $r_j$ all the greater varieties $r_2$, $r_3$, $r_4$, etc. are omitted from $L_i$ even though they wrap $t_i$. Each $L_i$ is sorted in ascending order of the contribution value $B_k$ of its elements. MRSW_P chooses among the elements with highest value of each $L_i$ depending on 3 criteria:

**Criterion-1**: SR combination with highest $B_k$ value

**Criterion-2**: SR combination with highest $t_k$ value

**Criterion-3**: SR combination with the lower $e_k$ value

After choosing a SR combination, MRSW_P checks if it wraps any other targets $t_j$ and skip $L_i$ in subsequent considerations for constructing a wrap set. SR combinations are repeatedly chosen based on the above mentioned criteria until all targets are wrapped. Residual energy of each sensor node is informed at this point and the chosen SR combinations for the current wrap set are pushed back to the corresponding lists. The whole process is repeated to create another wrap set until one of the $L_i$ becomes empty. A SR combination is removed from the $L_i$ if its required energy go beyond the residual energy.

B. Modifiable Range Set Wrap with selective pushback (MRSW.SP)

**Algorithm**

This algorithm is similar to our MRSW.P algorithm and differs only in the way push back operation is employed. This
algorithm maintains a selection procedure that decides a particular SR combination to be pushed back. A new selection measure \( \textit{Energy Ratio} \) denoted by \( \Phi \), is introduced that is a ratio of \( E_{\text{rez}} \) to \( e_i \) for a particular \( s_{r_2} \). This value indicates the future usability of a specific \( s_{r_2} \). The more is its value, the more is its probability of using in a wrap set in future. MRSW_SP pushes back the SR combination with minimum \( \Phi \). The progression continues until one of the lists gets empty. The aim of using selective pushback operation is to ensure a better residual energy distribution for sensor nodes.

The pseudo code for MRSW_SP is shown in Algorithm 1. We present only the pseudo code of MRSW_SP as the pseudo code for MRSW_P is almost identical except MRSW_SP is augmented with a selection procedure. The time complexity of both algorithm is \( O \left( tM \log_2 N + tM^2 \right) \) where \( M \) is the number of targets, \( N \) is the number of sensors, \( i \) is the number of wrap sets generated and \( i \) is upper-bounded by \( N \times (E/e_i) \) that corresponds to the case when all the targets are wrapped by all sensors with range \( r_i \).

Fig. 1 shows a WSN consists of 4 sensor nodes \( \{s_1, s_2, s_3, s_4\} \) and 3 target nodes \( \{t_1, t_2, t_3\} \). Each sensor has 2 Modifiable sensing varieties referred as \( r_1 \) and \( r_2 \) where \( r_1 < r_2 \). We assume the sensing area of each node is a disk centered on the sensor node where the radius of the disk is equal to its corresponding range. In the Fig. 1, \( r_1 \) is shown with bold solid line and \( r_2 \) with the light dotted line. If \( t_1 \) is wrapped by \( r_1 \) of \( s_1 \) then we will denote the wrapping relationship as \( t_1 \Rightarrow s_1r_1 \). Thus the wrapping relationships as depicted in Fig. 1 are:

\[
\begin{align*}
& t_1 \Rightarrow s_1r_1, s_2r_2, s_3r_2, s_4r_2, \\
& s_1r_2, t_2 \Rightarrow s_1r_1, s_2r_2, s_3r_2, s_4r_2, \\
& s_2r_2, t_3 \Rightarrow s_1r_1, s_2r_2, s_3r_2, s_4r_2, \\
& s_3r_2, s_4r_2.
\end{align*}
\]

We consider the initial energy of sensor node \( E=2 \) unit. Energy consumed for range \( r_1 \) is \( e_1 = 0.5 \) unit and for \( r_2 \) is \( e_2 = 1.0 \) unit. We describe the working procedure of MRSW_SP on the WSN illustrated in Fig. 1. Here we explain only the first wrap set formation using MRSW_SP. The initial lists generated by MRSW_SP are shown in Fig. 2. Here, \( s_{r_1} \) is chosen as it has the highest contribution value and it wraps both \( t_1 \) and \( t_2 \). As shown in Fig. 3, target \( t_2 \) is wrapped by the combination \( s_2r_2 \). So the first wrap set formed is \( \{s_{r_1}, s_{r_2}\} \) that finally upgrades as \( \{s_1r_1, s_2r_2\} \).

**Algorithm 1. Pseudo code for MRSW_SP for Constructing Wrap Sets**

**INPUT:**

- \( S: \{s_1, s_2, \ldots, s_N\} \)
- \( T: \{t_1, t_2, \ldots, t_M\} \)
- \( E: \text{Initial Energy of each } s_j, 1 \leq j \leq N \)
- \( R: \{r_1, r_2, \ldots, r_9\} \)

**OUTPUT:** A collection of wrap sets \( C = \{C_i\}, 1 \leq i \leq K \)

for each target \( t_i \in T \) do

for each sensor \( s_j \in S \) do

Calculate \( dist_i \) from \( t_i \) to \( s_j \)

for each range \( r_i \in R \) do

if \( dist_i \leq r_i \) then

Calculate \( t_{r_i} \) and \( \Phi_r \)

Calculate \( B_{\Phi_r} = t_{r_i} \times \Phi_r \)

insert \( s_{r_i} \) into \( L_i \)

end if

end for

end for

Sort \( L_i \) in ascending order of \( B_{\Phi_r} \)

\( q := 0 \)

while any \( L_i \) is not empty do

for each \( L_i \) do

Remove top \( s_{r_i} \in L_i \) with \( E_{\text{rez}} < e_k \)

end for

Sort all \( L_i \) on top element \( s_{r_i} \) value of \( B_{\Phi_r} \)

\( q ++ \)

min_sensor := 0

min_energy := \( E \)

min_list := 0

\( T_{\Phi_r} := T \)

while \( T_{\Phi_r} \) is not empty do

Choose the top element \( s_{r_i} \in L_i \) with highest value

Insert into \( C_q \)

Update the sensing range of \( s_j \) to \( r_i \)

for each \( t_i \) wrapped by \( s_{r_i} \) do

Mark \( L_i := \text{USED} \)

end for

Update \( E_{\text{rez}} \) of \( s_j \)

if \( E_{\text{rez}} < \text{min_energy} \) then

min_sensor := 0

min_energy := \( E \)

min_range := \( r_i \)

min_list := \( L_i \)

\( q := i \)

end if

end while

Push back \( \text{min_sensor} \) with \( \text{min_range} \) into \( L_i \)

end while

**Figure 1. WSN with 4 sensors and 3 targets**
We conducted extensive simulations in order to evaluate the performance of our proposed algorithms and compared the results with the existing MRSW [1] algorithm. The main performance metrics used were the network lifetime measured by the number of wrap sets and residual energy distribution of sensor nodes.

In all our simulations, we used Java Platform (JDK 7). We nodes randomly in a geographic area of 100m × 100m. The number of sensor nodes is denoted by N and we considered networks with 20, 30, 40, 50, 60 and 70 nodes. We used 10 target nodes in all our simulations and the number of target nodes is denoted by M.

For each sensor node, we specified P sensing varieties r1, r2, …, rp and the values of P were chosen between 2 to 4. As sensing range we selected between 30m to 60m with an increment of 10. The initial energy E of each sensor node was set to 10. For each value of N and M = 10, we generated 100 networks and the results are averaged over 100 networks. We used the linear energy consumption model described in [1] to calculate e for each ri. Using (ΣE/2 ≥ C) to calculate the contribution value does not depend on the number of SR combinations increases as we increase the number of sensing varieties. As our algorithms always select sensor node with greatest contribution value, it gives us better choice in selecting wrap sets that results in an improved network lifetime. In case the contribution values are equal, we check two extra criteria instead of arbitrarily breaking the tie. These tests give us better choice in producing wrap sets and also better network lifetime than MRSW. Although our algorithms do not exhibit good performance for P = 2 but network lifetime increases as the value of P is increased. For P = 2, we used r1 = 30m and r2 = 60m, while for P = 3 and 4, we utilized r1 = 30m, r2 = 40m, r3 = 50m and r4 = 60m. By assigning midway values of 40m and 50m between 30m and 60m, most of the targets are wrapped by 40m or 50m instead of using 60m. As we can use less energy for 40m and 50m in case of P = 3 and 4, it saved energy that ultimately increases the number of wrap sets. B.

IV. SIMULATION RESULTS

As shown in Fig. 7, MRSW_SP generates about 90.16% and 16% more wrap sets as compared to that of MRSW and MRSW_P algorithm at N = 60, respectively. MRSW_P attains an improvement of 63.96% over MRSW at the same value of N.

We can conclude that network lifetime produced by our algorithms is longer than that of MRSW. This happens because the number of SR combinations increases as we increase the number of sensing varieties. As our algorithms always select sensor node with greatest contribution value, it gives us better choice in selecting wrap sets that results in an improved network lifetime. In case the contribution values are equal, we check two extra criteria instead of arbitrarily breaking the tie. These tests give us better choice in producing wrap sets and also better network lifetime than MRSW. Although our algorithms do not exhibit good performance for P = 2 but network lifetime increases as the value of P is increased. For P = 2, we used r1 = 30m and r2 = 60m, while for P = 3 and 4, we utilized r1 = 30m, r2 = 40m, r3 = 50m and r4 = 60m. By assigning midway values of 40m and 50m between 30m and 60m, most of the targets are wrapped by 40m or 50m instead of using 60m. As we can use less energy for 40m and 50m in case of P = 3 and 4, it saved energy that ultimately increases the number of wrap sets. B.

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residual energy of a sensor node. This means that in [1], the algorithm uses the same wrap set until one of its sensor nodes is exhausted completely. Our algorithms generate a variety of wrap sets instead of repeated wrap sets. The selected elements are pushed back in order to create different wrap sets each time that doesn’t exhaust a sensor in quick succession. The energy preservation among the sensor nodes is also improved as our algorithms always try to include sensors with minimum possible sensing range into a wrap set.

![Figure 4 Comparison graph of all the algorithms](image-url)

**V. CONCLUSION**

In this paper we worked on constructing energy efficient target wrapping models for WSNs with Modifiable sensing varieties. We developed two polynomial time greedy algorithms using certain pushback methods to generate wrap sets. These algorithms use circular lists of sensor nodes along with efficient contribution formula that help in building different wrap sets as the number of sensing varieties is increased. Simulation results proves that our algorithms are better than existing MRSW algorithm in terms of total number of wrap sets and establish uniform expenditure of energy among the sensor nodes.

In future we are interested to refine the contribution formula to take into consideration the critical targets. Data aggregation and routing are also important factors for conserving energy. We can accumulate these two cases with our existing algorithms and increase the versatility of our approaches.

**REFERENCES**


