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Analysis of energy efficient connected target coverage algorithm for static and dynamic nodes in IWSNs

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ABSTRACT

Today breakthroughs in wireless technologies have greatly spurred the emergence of industrial wireless sensor networks (IWSNs).To facilitate the adaptation of IWSNs to industrial applications, concerns about networks full coverage and connectivity must be addressed to fulfill reliability and real time requirements. Although connected target coverage algorithms have been studied notice both limitations and applicability of various coverage areas from an industry viewpoint. In this paper is discuss the two energy efficiency connected target coverage (CTC) algorithms CWGC(Communication Weighted Greedy Cover) and OTTC(Overlapped Target and Connected Coverage) algorithm based on dynamic node to resolve the problem of Coverage improvement. This paper uses the simulation in MATLAB represent the performance of two CTC algorithms with Dynamic node to improve network lifetime and low energy consumption and quality of service. Compare the dynamic nodes results with static nodes results.

I. Introduction

Wireless sensor networks have been largely useful to many industrial applications like as production automation smart home, large scaled structure. IWSNs shows various benefits over conventional wired industrial monitoring and control systems, including self-organization, fast deployment, flexibility, and inherent intelligent-processing capability [1]. IWSNs plays an important role in developing a highly reliable and self-healing industrial system that quickly responds to real-time events with appropriate actions. Some standardization related to industrial wireless sensor networks are ZigBee, Wireless HART, Ultra Wideband (UWB), IETF6LoW PAN, Bluetooth and Bluetooth Low Energy [2].

Industrial wireless sensor network applications can be divided into three classes. Environment sensing covers the problem of air, water and pollution. Condition monitoring covers the problems of structural condition monitoring, condition of buildings, constructions, bridges and machine conditions monitoring. Process automation provides the users with the information related the resources for production, service provision, materials [3]. Fig. 1 represent the application of wireless sensor network in industrial field.

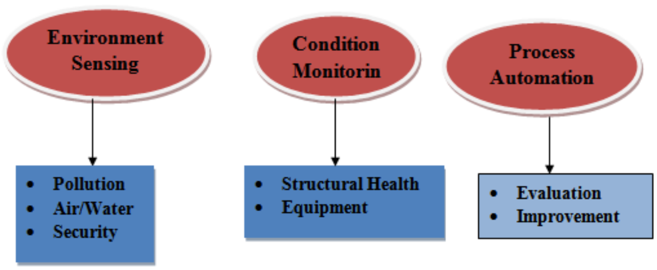

Fig. 1. Application of IWSN

The rest of the paper is organized as follows. In Section II present review related work, Section III and Section IV describes problem formation and proposed methodology. In Section V present the energy efficient connected target coverage algorithms CWGC and OTTC introduction. Section VI provides a simulation work. Finally conclusions are drawn in Section VI.

II. Related Work

In the literature, there are number of papers on development routing and connectivity of networks in a numerous of different methods. Gangjie *et. al.* [4] analyze characteristics of energy efficient coverage strategies selecting four connected coverage algorthims including communication weighted greedy cover, Optimized connected coverage heuristic, Overlapped target and connected coverage and Adjustable range set covers .They present comparison for algorithm in terms of network lifetime, coverage time , average energy consumption ,ratio of dead nodes etc., characteristics of basic design ideas used to optimize coverage and network connectivity of IWSNs(Industrial wireless sensor networks).

Wu *et. al.* [5] Represented the network lifetime maximization problem of WirelessHART network under graph routing and prove it is NP-Hard. They are proposed an optimal algorithm based on integer programming, a linear programming relaxation algorithm and a greedy heuristic algorithm to improve network lifetime of WirelessHART network. Yun Zuo et al. [6] provide a hybrid multipath routing algorithm for IWSN upgrading reliability and determinacy of data transmission

Efficient route selection algorithm based on awareness of link weight and forward energy density, traffic congestion, interference level has proposed by [7]. This algorithm used to increase network lifetime. Young Sang Yun, Ye Xia [8] designed a new framework for using mobile sink to maximizing the network lifetime. It is useful in applications that can tolerate a certain amount of delay in data delivery.

Kim et. al. [9] introduced the directional cover and transmission (DCT) problem which is to extend the lifetime of a directional sensor network while not only continuous monitoring of all targets (target coverage) and forwarding the sensed data to the sink (connectivity). They are proposed SPTS (shortest path from target to sink) greedy algorithm solve DCT problem.

An efficient scheduling method based on learning automata is called LAML provided by [10]. In which all node is equipped with a learning automation, which help to select node it proper state (active/sleep) at fix time. Chan-Myung Kim, Yong-hwan Kim and Kang-whan Lee et al. defined the probabilistic model in which the probability that the sensor detects a target depends on distance with the target within the sensing range. They also proposed heuristic algorithm called CWGC–PM (Communication Weighted Greedy Cover-Probabilistic Model) to solve the CTC (Connected Target Coverage) problem [11].

A weight based greedy (WGA) algorithm which arranges sensors in multiple set covers developed by [12]. In this research found the sensor set covers maximization problem. Furthermore, Zhang et. al. [13] provide a heuristic greedy optimum coverage algorithm (HG-OCA) for target coverage to increase network lifetime and minimizing energy consumption.

High energy first heuristic algorithm proposed to solve the target coverage problem [14]. HEF algorithm based on residual battery life of specific sensors. HEF perform better for save battery life. The comparison between CBDR (cluster based multi path dynamic routing) and EQSR (energy based routing) protocol shows that CBDR protocol provides better energy efficiency based routing and multipath routing in the sense aggregation of information between the nodes [15].

III. Problem Formulation

In Industrial Wireless Sensor Network the problem of Network coverage comes because of the large area coverage of the network and heterogeneity of the network. CWCG and OTTC perform comparatively poorly with respect to other algorithms as given the base paper. In base paper analysis four algorithms consider industrial environment using static nodes. A solution is needed to develop an energy efficient network coverage dynamic node to improve CWCG and OTTC on network lifetime methods [4].

IV. Proposed Methodology

This section describes the methodology of project. In this paper, focus on increases network lifetime and energy consumption.

1. Initially deploy Dynamic nodes and static nodes for industrial wireless sensor network.
2. Apply two algorithm Communication Weighted Greedy Cover (CWGC) and Overlapped Target and Connected Coverage (OTTC) algorithms.
3. Evaluate the result.
4. Compare the results static and dynamic nodes.

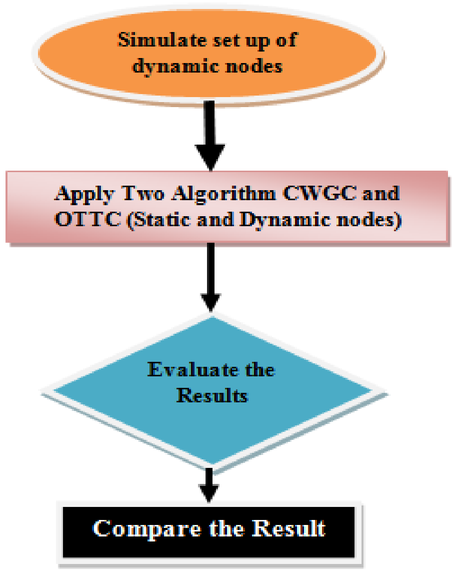

Fig. 2. Methodology

V. Energy Efficient Connected Target Coverage Algorithms

In this section introduced two algorithms in detail. CWGC and OTTC both algorithms are connected target coverage algorithm used to minimize energy consumption and increasing network lifetime.

A. Communication Weighted Greedy Cover (CWGC)

Qun and Mohan[16] introduce CWGC algorithm uses a greedy algorithm to select the source set to cover the targets and it couples the communication cost and source set selection it is called communication weighted greedy cover . CWGC algorithm to solve connected target coverage problem as a maximum cover tree(MCT) problem. Illustrate the CTC problem in figure-3 there are 10 sensors, 5 targets and 1 sink in the sensor field. The sensors that can cover one or more targets are indicated by their circles, solid circles for active source sensors and others for sleep or relay sensors. Arrowed lines are used to denote the routes used to relay data from sources to the sink. Two solutions are illustrated in Fig. 3 (a) and (b).

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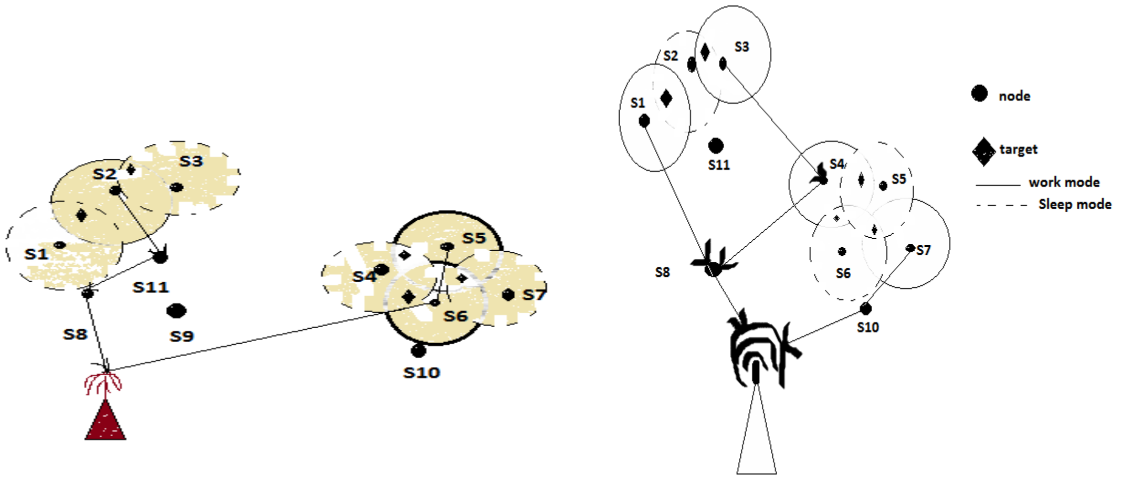

(a) (b)

Fig. 3. Maximum Cover Tree

B. Overlapped Target and Connected Coverage (OTCC)

The overlapped target issue explained by [17] shows that the sensors consume the same quantity of energy when sending and transmitting the data created from a target, anyway of how many targets a sensor monitor. However, multiple transmissions of the pair data are iterating and cause the sensors to disuse energy. This defined as overlapped target issue. Fig. 4 adjacent nodes may gather overlapped data from targets and deliver them to the sink node.

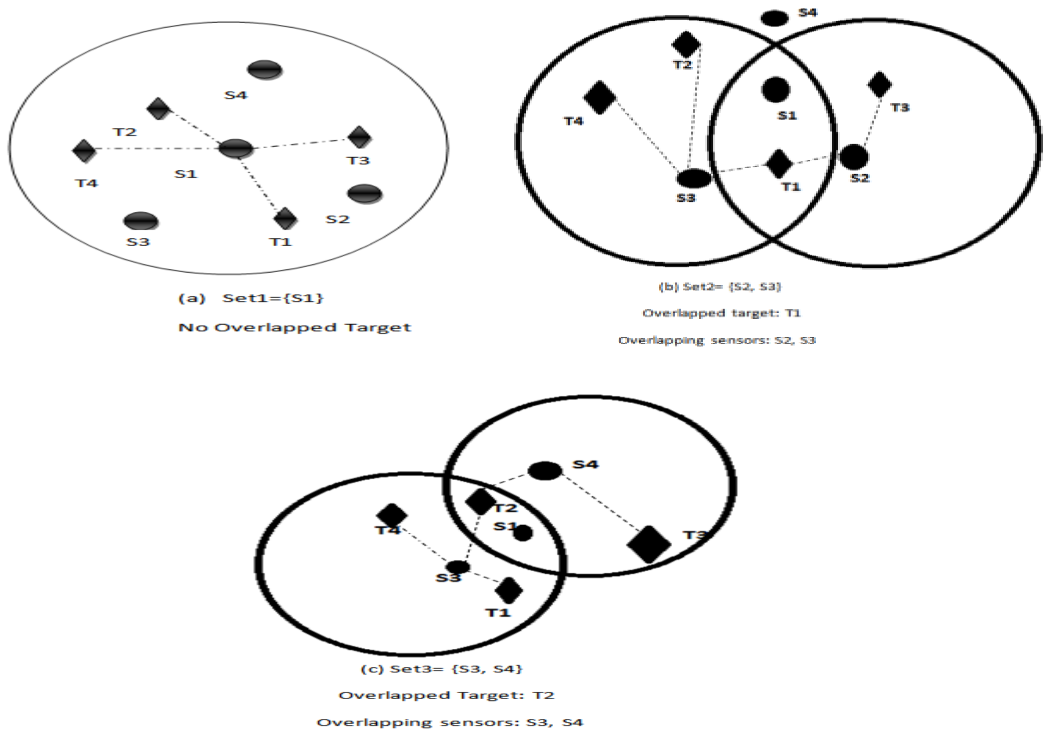

Fig. 4. Overlapped target and corresponding overlapping sensors in joint sets

OTCC algorithm to protect redundant coverage and transmission, it is sufficient that data created from an overlapped target is transferred only one time. Reference [18] provides OTCC algorithm to eliminate the redundancy caused by the overlapped target. The redesign the OTCC problem and make the maximum cover and non-duplication transmission graph (MCNTG) problem by developing a new graph model called CT (Cover and Transmission). To remove MCNTG problem using heuristic algorithm known as shortest path based on targets and using greedy method to create a maximum number of the active group of sensors and find unique route from all the target to the sink node.

VI. Simulation

A. Simulation Environment

In this paper simulation used the MATLAB environment. In firstly declared the deployment area with 30 nodes deployed randomly for the simulation of OTTC and CWCG algorithms for network coverage. This work implemented the principle of the algorithm with static node by firstly placing the nodes and then calculation of the distance to be adjusted is done using the distance table. The strategy is repeated for OTTC and CWCG algorithms in which the node is kept dynamic where the node keeps on moving in the network which is taking full advantage of the enhanced coverage. Simulation parameters are listed in Table 1.

Table 1. Simulation parameters

Parameter	Value
Network Area	600*600
Number of nodes	30
Initial energy of nodes	300 mJ (Milijoules)
Energy of coverage calculation ECC	1 – 50 mJ
Energy of movement EM	1 – 100 mJ
Node Distance	40m

B. Evaluation Metrics

In order to evaluate the algorithms comprehensively their properties through the following five metrics:

1. **Energy Consumption-** It is the amount of energy consumed by a sensor node while performing the tasks of sensing, computing and communicating in the network.
2. **Ratio of dead nodes-** The ratio of the number of nodes that run out of energy to the number of deployed nodes.
3. **Average Throughput-** Average throughput is defined as the average rate of successful message delivery across a network
4. **Average End to End delay-** End-to-end delay measures the delay in the delivery of a packet i.e. the time gap between the transmission and reception of the packet from a source node to the sink. Average end-to-end delay gives the average delay suffered by all the packets in the network.
5. **Average jitter-** Average jitter of a network measures the variability over time of the packet latency across the network.

C. Performance Analysis

In this paper mainly focus on analysis and compared with existing work on static nodes in IWSN and new approach using dynamic nodes using various parameters such as, energy consumption, ratio of dead nodes, Average throughput, average end to end delay, average jitter.

Fig. 5 represent the dynamic sensor nodes deploy using CWGC and OTTC algorithm and dynamic nodes collect the data randomly move different coverage areas.

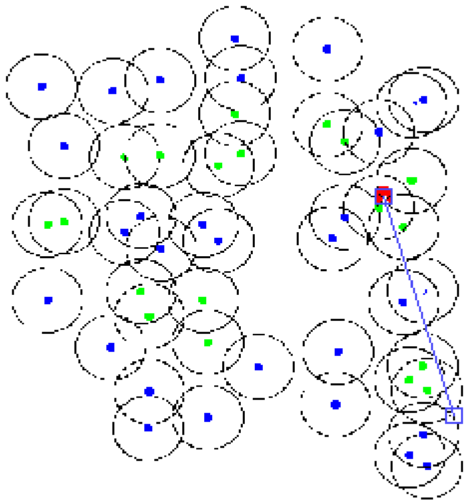

Fig. 5. Coverage with Dynamic node

Fig. 6 present previous work static nodes deploy using CWGC and OTTC algorithms. In this base station set fixed location to collect data.

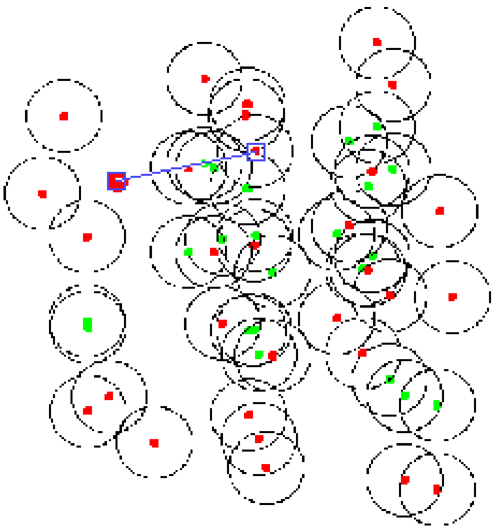

Fig. 6. Coverage with Static node

1) Energy Consumption

Fig. 7 shows that energy consumption can be calculated under condition which are having 30 nodes randomly deployed in a 600*600 network size, every nodes has distance minimum 40m in network. The average energy consumption is large because most of the nodes require to be awakened for sensing. To solve large energy consumption problem need of coverage and connectivity. In terms of CTC, only some of the nodes have energy consumption for data sending and receiving. Two algorithms performance, CWGC and OTTC, in static nodes and dynamic nodes. In static nodes both algorithm overlapped to each other and consume more energy to data sensing. In dynamic nodes both algorithm combine CWGC+OTTC for data sensing and relaying. Dynamic nodes consume less energy than static nodes.

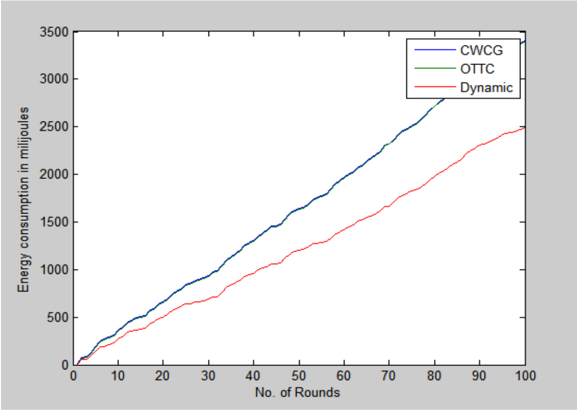

Fig. 7. Energy Consumption

2) Ratio of dead nodes

The number nodes graph shows that the detail of node dead during the simulation of the network. It shows that is dynamic node performs better because the network energy efficient. Fig. 8 shows the ratio of dead nodes.

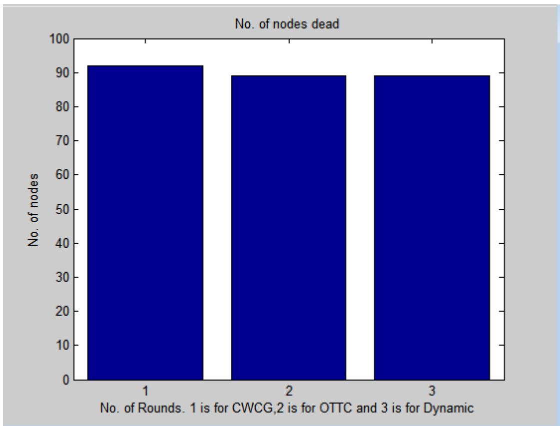

Fig. 8. Ratio of dead nodes

3) Average Throughput

In the throughput since the energy consumption is small the transmissions are more effective so the network does not go under any congestion and the network also has very high packet transfer rate. So the throughput is very high in case of dynamic sink. Fig. 9 shows static nodes CWGC and OTTC algorithms the value of throughput is low while in case of dynamic nodes value is high.

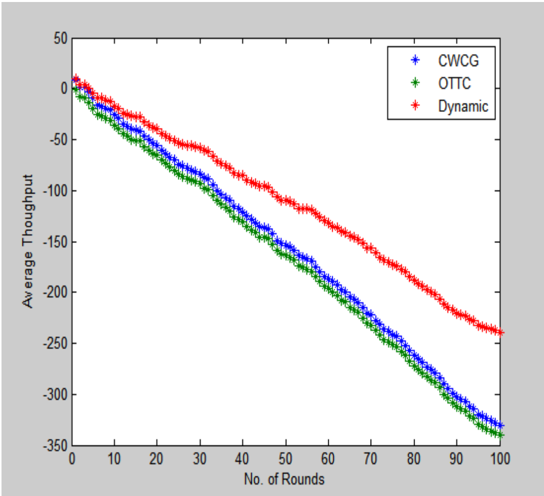

Fig. 9. Average Throughput

4) Average End to End delay

Fig. 10 describes graph of end to end delay. In CWGC and OTTC for static nodes end to end delay value high and in case of dynamic nodes the end to end delay between packets is very low because throughput value high in the case of dynamic node.

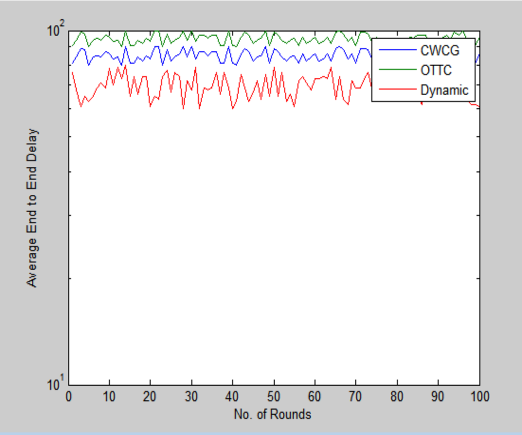

Fig. 10. Average End to End Delay

5) Average Jitter

Fig. 11 shows that the value of average jitter is high in case of CWGC and OTTC algorithm for static nodes than dynamic nodes. In dynamic nodes jitter the delay is very less and the rate is very constant, it is that the jitter in the end to end delay is very less.

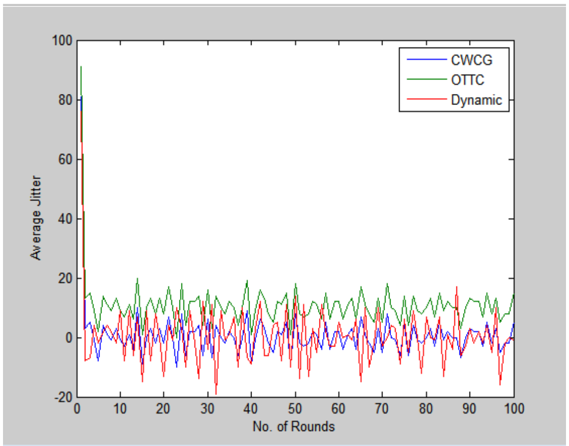

Fig. 11. Average Jitter

VII. Conclusion

In this paper analysis of energy efficient connected target coverage algorithm for static and dynamic nodes in industrial wireless sensor networks. CWGC (Communication Weighted Greedy Cover) Algorithm is scheduling sensor node activity to allow redundant nodes to enter the sleep mode and OTTC (Overlapped Target and connected Coverage) are eliminating the redundancy caused by overlapped targets selected to maximize network lifetime while maintain sensing coverage and network connectivity. Previous work authors introduced static sensor nodes in IWSN using four algorithms CWGC, OTTC, OCCH (optimized connected coverage heuristic), AR-SC (adjusted range set cover) [4]. In new approach deploy dynamic nodes using CWGC and OTTC algorithm. Energy-efficient connected target coverage approaches ensure that selected nodes are prioritized and remain connected to the control sink even if other nodes die out, while also working towards extending the energy lifetime of the essential nodes and the network as a whole. In this paper, use Energy consumption, Number of dead nodes, Throughput, End to End Delay and Jitter. In all five parameters the results obtained show improvement in the previous algorithms

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