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A Survey on Industrial Wireless Sensor Network Routing Algorithms

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Abstract - Industrial wireless sensor network play important role in developing a highly reliable and self healing industrial system that faster responds to real-time events with appropriate actions. This paper provides review of industrial wireless sensor network algorithms used in industrial application to improve network lifetime and low use of battery.

Key Words: **Industrial Wireless Sensor Network, IWSN Routing Algorithms.**

1. INTRODUCTION

In Today's Relative to industry marketplace the companies face growing requests to upgrade process efficiencies, follow with environmental regulations meet common financial objectives. Given the increasing lifetime of numerous industrial system and dynamic industrial produce market and low cost industrial automation systems are demand to increase the productivity and efficiency of that system. In traditionally industrial automation systems are performed through wired communications and wired communication cabled to be installed and need to maintain regular. Therefore, there is an urgent need of wireless industrial system for effective cost and reduce air pollution [1].

Some basic elements, such as spatially distributed sensors and actuators, one or more access points, one gateway and one network manager Structure IWSN Shown in figure-1[2].

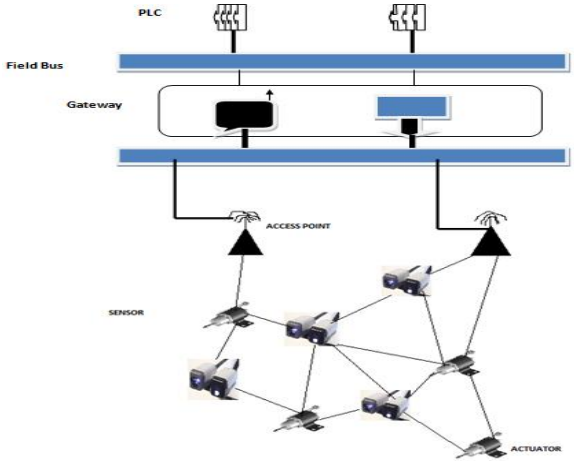


Figure.1- Example of an IWSN structure

2. RELATED WORK

Gangjie Han, Jinfang Jiang and Gerhard Hancke[3]analyze characteristics of energy efficient coverage strategies selecting four connected coverage algorthims :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).

Xiaojian Gren and Weifa Liang [4] present a new coverage quality metric to calculate the coverage quality using two different time scales. They are introduced centralized and distributed algorithms.

Chia Pang Chen and Subhas Chandra introduce a novel maximum connected load–balancing cover tree(MCLCT) algorithm .Algorithm consists of two components:1)Coverage optimizing recursive heuristic for coverage management , 2) Probabilistic load balancing strategy for routing path determination[5].

Djamel Djenouri and Miloud Bagaa [6] said that power efficient coverage in wireless sensor network by taking benefits of energy efficient harvesting capability. They studied environment includes two types of sensor nodes:1)Harvesting enabled nodes. 2) Non harvesting nodes. They use HNs for problem of relay node placement improvement few properties like as maximum network lifetime and network connectivity so on.

B.Shahi, S.Dahal, A.Mishra, V.Kumar and P.Kumar introduced the review of genetic algorithm to increase the network lifetime by tiny communication distance. They have also present application areas of wireless sensor network [7]. L.Neeraja, B.Lokeshwara Rao and B.Suresh said that standards and applications which are used in industrial wireless sensor network. They are introduced few technologies of industrial applications like as Zigbee, Wireless HART, ISA100 [8].

Qun and Mohan[9] 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. According to Manju and Arun K Pujari [10] High energy first heuristic algorithm proposed to solve the target coverage problem.HEF algorithm based on residual battery life of specific sensors.

Shaon, Amir and Matin explain the overlapped target issue [11]. 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.

H.Mastafaci and M.Meybodi [12] proposed an efficient scheduling method based on learning automata is called LAML. In which all node is equipped with a learning automation, which help to select node it proper state (active/sleep) at fix time.

Y.Kim, Yu Wang and H. Choi [13] introduced a greedy heuristic algorithm for scheduling multiple channels and multiple timeslots a time constrained industrial wireless sensor networks. Sushruta and Archanar provide a various energy efficiency improvement techniques in wireless sensor network to increase network life time [14]. Chengjie Wu, D.Gunatilaka, A.Saifullah, Mo Sha, P.B.Tiwar, Chenyang and Y.Chen [15] described 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.

3. INDUSTRIAL WIRELESS SENSOR NETWORK ROUTING ALGORITHMS

3.1 Hybrid Multi-Path Routing Algorithm

Yun Zuo et al. [16] proposed a hybrid multipath routing algorithm for IWSN due to some drawback occur in multi path routing. In multi path routing does not guarantee deterministic sending, this is more than one is present path is present for sending data from source to destination node. Hybrid multi path routing algorithm for industrial wireless mesh network, also known as DAWMNet. Wireless mesh network structure shown in figure-2.

Combine the Dijkstra's algorithm and ACO algorithm to develop hybrid multi path routing algorithm. The enhanced Dijkstra's algorithm achieves first route setup and ACO algorithm use for route exploration and maintenance. After the initialization of a network, the

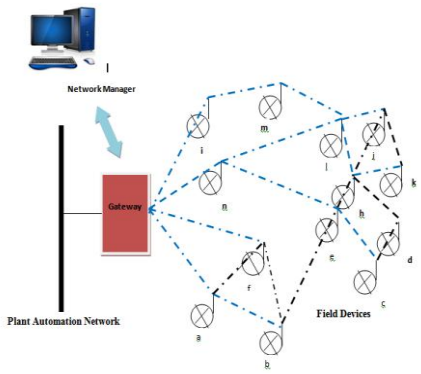


Figure.2-Network Structure of a WirelessHART

network manager applies the enhanced Dijkstra's algorithm to calculate the shortest path to every end node and remaining routes are searched by apply ACO in the route exploration stage.

3.2 Grid-Based Joint Routing and charging Algorithm

Guangjie Han, A.Qian et al. [17] described a grid based joint routing and charging algorithm for Industrial wireless rechargeable sensor networks. This algorithm solve charging problem in a proactive way. Before define grid based joint routing and charging algorithm to represent the introduction of network model. In industrial structure, numbers of sensor nodes are deployed in network, which take responsibility to sense data from environments and cooperate to transmit them to base station. Network model represent in figure-3.

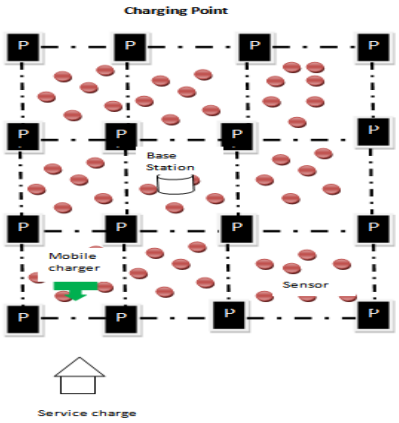
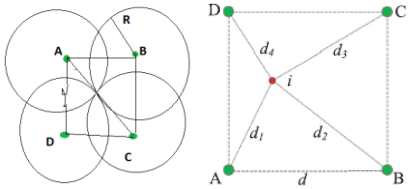


Figure.3- Network Model

Grid based joint routing and charging algorithm divided into two steps.

- In first step a new routing protocol is proposed according to the charging characteristics of the charger to balance energy consumption of sensor nodes locally (within charging grid). Below figure-4 represent calculation of power consumption.



(a) **(b)**

Figure.4- Charging Grid and power calculation

- In second step the charging manner of the mobile charger is designed specifically the charging manner includes the travelling path and the charging time at each charging point.

3.3 Efficient Route Selection Algorithm

Dr. Bhuvaneswari and S.B.Priya [18] proposed efficient route selection algorithm based on awareness of link weight and forward energy density, traffic congestion, interference level. This algorithm used to improve network lifetime.

3.3.1 Forward- aware factor based selection routing method- In this algorithm, the next-hop node is selected according to the awareness of link weight and forward energy density. Traffic congestion is experienced by the nodes when incoming traffic is much greater than outgoing traffic.

3.3.2 Reliable Guide Path Discovery- If a node has data packets to source to destination; it initiates a route discovery by flooding an RREQ (route request) message.

3.3.3 Route selection algorithm design- In this step, the optimal path is choose based on awareness of link weight and forward energy density, traffic congestion, interference level. Based on link weight calculated the remaining energy is computed based on the subtraction from the initial energy to the processing energy.

$$w_{ij}(t) = \frac{\varsigma(E_i(t)E_j(t))^{\psi}}{(d(i,j)^3)^{\eta}(T_{ij}(t))^{\xi}} \quad (1)$$

Where, $E_i(t)$ and $E_j(t)$ are residual energy, d (i,j)= distance between two nodes, $T_{ij}(t)$ = data flow of the edge eij, Traffic congestion nodes when incoming traffic is greater than outgoing traffic.

$$T_i = (1-\alpha) \times intvl_{old} + \alpha \times intvl_{new} \quad (2)$$

3.4 InRout: A QoS Aware Route Selection Algorithm

B. Carballido et al. described [19] InRout is a multi-metric based route selection algorithm that move far away the traditional standards of using simply energy or hop count as route selection basis. InRout considers the sensor node's limited resources to each other with application QoS require. For reliable data send InRout does not demand positioning information. Thus the need for extra and often high cost indoor localization systems is removed. InRout has been specifically developed with limited memory and computational. The main operation of the InRout algorithm is based on Q-learning (QL) techniques. Steps of Algorithm-:

- Q-learning based route assessment- QL is well suited for distributed problems, like routing. It has medium requirements on memory and imposes low computational requirements on individual nodes with low overhead.

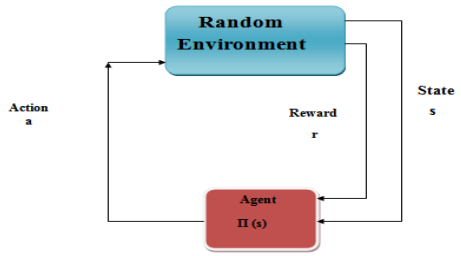


Figure.5-- Reinforcement learning model

Reinforcement Learning (RL) is a machine learning (ML) approach that finds the optimum value through trial-error iterations. The advantage of RL compared to other ML approaches is that it does not need information about the environment

except for a reinforcement signal. Q-values are estimated as follows-

i. From the current state s, select an action a. This will cause the receipt of an immediate payoff r, and arrival at the next state s'.

ii. Update Q(s, a) as Q(s, a) ≈Q(s, a) + x(r+ y.max Q (s0, a0) - Q(s, a)), where x is the learning rate and y is the discount factor (0 < x, y < 1).

iii. Go to 1

- The exploitation vs. exploration strategy.
- Memory requirements and scalability.

3.5 Dynamic Time Division Multiple Access Algorithm

Y.Yanhong et al. [20] proposed dynamic time division multiple access algorithms. Industrial wireless sensor network adopt a hierarchical structure for numerous sensors and routers. Figure-6 describes an example of the hierarchical sensor network. The links between nodes denote direct communication.

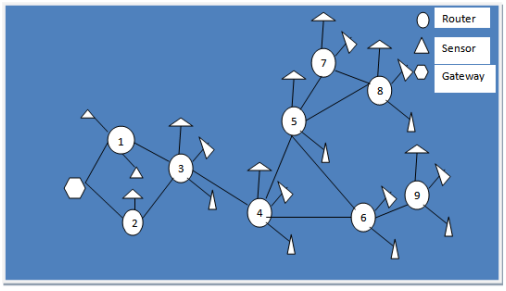


Figure.6- Hierarchical Sensor Network

Dynamic time division multiple access algorithm divided into two assignments.

i. **Intra cluster assignment-**Intra cluster assignment for a star topology can be transformed into a node coloring problem. The solution to the intra-cluster problem is divided into two phases:

- Random channel selection
- Time slots assignment

ii. **Inter cluster assignment-**Links are assigned for routing edge and other is to small size of frame to reduce the delay of a wireless sensor network.

3.6 Handoff Algorithm

According to Hossein Fotouhi et al. [21] Handoff define to the process where a MN (mobile node) loss connection from one AP and connects to another AP. In handoff algorithm used five heuristic models to design handoff mechanisms shown in figure.7.

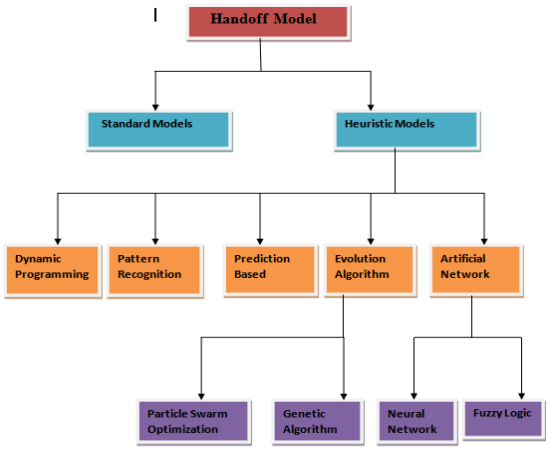


Figure.7- Handoff Model

Handoff algorithm proposed based on RSS (received signal strength) level, velocity of MN and traffic load, energy level and link quality and AP depth level(no. of hops to sink nodes) Handoff Algorithm used for mobility management mechanism. Handoff algorithm procedure following in two steps:

1. First Step (Initial assessment)
2. Second Step (Handoff)

First Step – In first step deciding whether to do handoff or not, trying to reject unnecessary

handoff. A mobile node transmits messages to its current AP, expecting some acknowledgement message. It then infers the need for handoff from the RSS average of the acknowledgement messages and from the speed of the mobile node, if available. If the decision is to handoff, the mobile node moves to the second step.

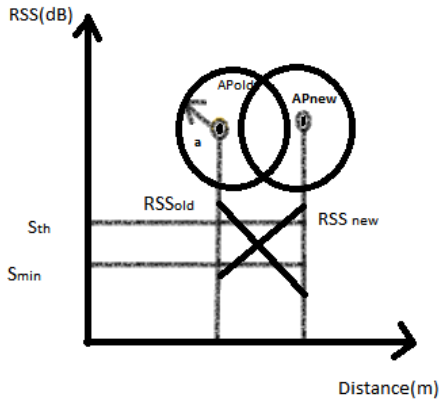


Figure.8- Analysis of Handoff in first Step

Second Step –In second step the quality of the radius link between the mobile node and find nearby APs is assessed using the F-LQE link quality estimator and handoff heuristic is improved by taking into considering other characteristics of the APs like as their energy level, traffic load and depth level.

3.7 Optimized Connected Coverage Heuristic

According to Dimitrius and Christos [22] OCCH algorithm is efficient algorithm to protect the critical nodes from forwarding data. It can be calculated that a target, which is covered by the less number of sensors is the bottleneck in cases of the network lifetime. This type of target is called as a critical target. The sensor nodes that monitor the critical targets are defined the critical nodes. Increment the communication weight of critical node is choosing to transfer data can be decreased show in figure 9.

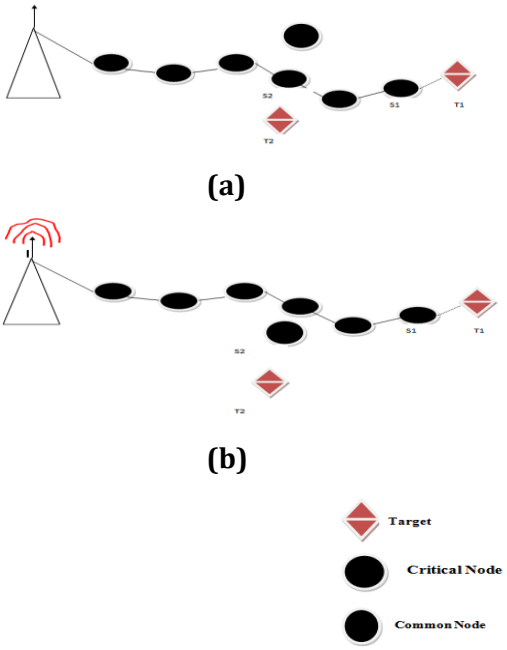


Figure.9-Remove traversing a node that covers a critical target

4. CONCLUSIONS

Industrial wireless sensor networks (IWSNs) are important part of smart city. IWSNs are used for process measurement and control applications in harsh and noisy industrial environments. In this paper present overview of IWSN routing algorithm used to reduce energy consumption and to improve network lifetime.

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