



Research Paper

Eradication of Hidden Node Problems in IEEE 802.11 ah Based IoT Network

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ABSTRACT: Station grouping among nodes in any network is the most widely used improvement technique since it plays an important role in organizing large number of stations in a network. It partitions stations into homogenous groups, accommodating large number of stations to transmit at the same time. This paper proposes an enhanced method to improve station grouping, eliminating hidden nodes and yields more efficient resource allocation and transmission by introducing maximum value entropy algorithm, and results simulated to show improvement in the network.

KEYWORDS: resource allocation, station, network, nodes, simulation.

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I. INTRODUCTION

The Internet of Things (IoT) ultimately envisions connecting tens of billions of low-power and resource-constrained devices to the Internet. This will result in ultra-dense deployments of sensors and actuators, with thousands of them coexisting in a small geographical area.

Enabling this vision will require novel wireless communications solutions that scale properly to such extreme proportions. IEEE 802.11ah standards support the more than 6000 stations (nodes) in the IoT network. It executes the RAW (Restricted Access Window) slot allocation mechanism to avoid the contention in the network. Here, the RAW based mechanisms segregate the network into different groups [1]. There have been many works concentrate on the station grouping in the IEEE 802.11ah based IoT network. In [2], authors have contributed Enhanced Traffic-Adaptive RAW Optimization Algorithm (E-TAROA) algorithm for station grouping. E-TAROA implements traffic based station grouping procedures in the IoT network. The traffic load of the stations based grouping mechanism is introduced in the IoT network [3]. The regrouping algorithm is used to reduce the hidden node algorithm in the IEEE 802.11ah based IoT network [4].

II. MOTIVATION

The RAP based network provides high scalability to the IEEE 802.11ah based IoT network. To achieve high scalability, AP coverage area is divided into multiple sectors [5]. But, none of the works utilizes the proper mechanism to sectorize the network. Thus increases the hidden node problem. In order to reduce the collision over data packet transmission, AP allocates RAW slots to the stations [6]. Most of the preceding works doesn't adjust the RAW slot size aptly with respect to the current state of the stations. It tends to reduce the throughput of the network. Reducing network delay is a big issue in terms of both registration and data transmission [7]. It is because of the lack of finding the proper threshold for authentication control and queue management in RAP. In other to eradicate these issues:

- We put measures in place in the IEEE 802.ah protocol to reduce hidden node problems by deploying optimization algorithms together with the prevalent network parameters.
- And compare the performance of these algorithms with already existing methods used in IEEE 802.ah Network.

III. REVIEW OF RELATED WORKS

Le *et al.* [8] have introduced real-time station grouping based approach in IoT using the IEEE 802.11ah standard. Here, the Traffic-Adaptive RAW Optimization algorithm (TAROA) is used to group the stations present in the network. It groups the stations based on the current traffic conditions and packets frequency. TAROA is highly suitable for the real time environment. However, Le *et al.* don't concentrate on the RAW slot adjustments procedures thus increases the contention overhead in the network. Pranesh *et al.* [9] has offered station grouping strategy to provide fair channel access to the stations present in the IEEE 802.11ah based IoT network. Here, the analytical model is used to select the appropriate group size for the stations. The analytical model utilizes the beacon model and beacon interval to select the optimal group size for the stations. The analytical model reduces the association delay in the network. Still, stations are grouped without considering the essential parameters such as SINR, distance and so on. Thus affects the throughput in the IoT network.

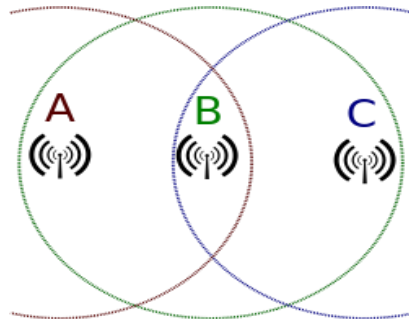


Fig.1 Hidden Node Problem in Network

Sabin *et al.* [10] have pointed out the device grouping mechanism for fast and efficient channel access in the IoT network. Here, the network is segregated into various sectors where each sector comprises of the multiple groups. In these groups are formed based on the number of devices and their locations. And then, it allocates slots to the stations in the network. This way optimizing the network reduces the hidden node problem. Though, interference during the data transmission is not considered thus increases the packet loss rate. Tian *et al.* [11] have introduced the multi objective based station grouping in the IEEE 802.11ah network. In this, surrogate modeling is used to estimate the RAW performance in order to measure throughput efficiency. Model based RAW Optimization Algorithm (MoROA) is utilized to provide effective station grouping. Here, the throughput of each station is considered for the station grouping process. It optimizes the RAW slot based on the traffic conditions. However, it doesn't suitable for the high scale network due to less flexibility.

IV. METHODOLOGY

The registration is a significant process in the IEEE 802.11ah based IoT network. Each station in the network, must undergo registration process in order to participate in data transmission hence, each station registers itself initially to the AP present in the network. So far, there have been many works focused on registration in the IEEE 802.11ah based network. However, the limited number of works only concentrates on selecting suitable ACT for the registration. Since, registration time must be reduced in the network to attain better performance.

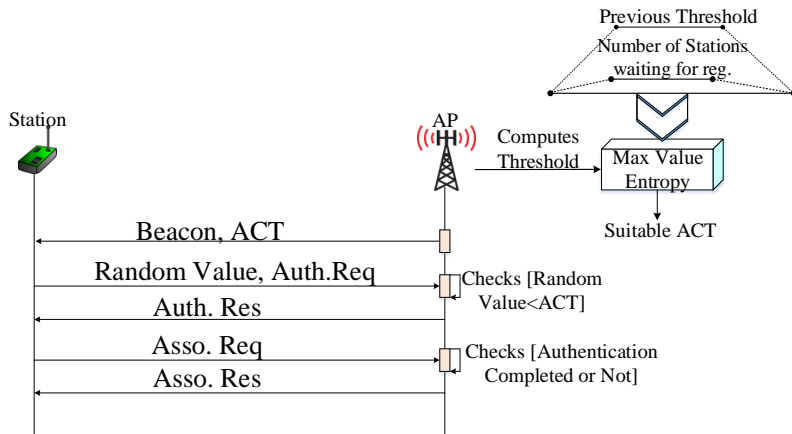


Fig.2 Maximum value entropy based registration procedure

Figure 2 depicts the Max Value based registration process in the IEEE 802.11ah based network. At first, AP broadcasts the beacon for the authentication/association process. Along with beacon, it also attaches the ACT. AP must dynamically adjust the ACT based on the number of stations waiting for the authentication/association processes. But most of the cases, AP doesn't allocate proper ACT for the registration. Since, when the number of station increases AP must reduce the ACT to reduce the contention. Likewise, when station count is less AP must increase the ACT to reduce registration delay. In order to provide proper ACT in our work, we utilize the Max Value Entropy. The proposed Max Value Entropy sets the suitable threshold for the authentication/association process by considering the number of stations waiting for authentication/association process ($N_{s,w}$) and previous threshold ρ_{ACT} .

The max value entropy function estimates the maximum value for the threshold selection process. The estimation of the suitable value for ACT using the max value entropy function is expressed as follows:

$$H[X] = \sum_{i=1}^n P[X_i] \log P[X_i] \quad (1)$$

Here, the maximum value function $P[X_i]$ is estimated as follows:

$$P[X_i] = f(\rho_{ACT} N_{s,w}) \quad (2)$$

Using the above equations, max value entropy function estimates the ACT for the registration process. Each time beacon transmission, it attaches an estimated ACT using the max value entropy. Then, each station selects one random value within the range of [0-1022] and transmits it with the request. After receiving the station request, it checks the selected number is less than the ACT value. If it satisfies the threshold, then only it continues the authentication and association processes. In our network, we dynamically change the ACT value based on the aforesaid processes. Hence, we reduce the registration time in the IEEE 802.11ah based IoT network. Thus increases the further data transmission processes involved in the network. The time complexity of our the proposed max value entropy is $O(n\sigma)$. Here, the n represents the number of samples and σ represents the objectives. The time complexity of proposed entropy is less than the other existing entropy.

The pseudocode for the Max Value Registration (for eradication of hidden node in a network) is as follows:

Algorithm: Max-Value Entropy Search (MES)

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1: function MES ( $f, D_0$ )
2:   for  $t = 1, \dots, T$  do
3:      $\alpha_{t-1}(\cdot) \leftarrow \text{APPROX-MI}(D_{t-1})$ 
4:      $\mathbf{x}_t \leftarrow \arg \max_{\mathbf{x} \in \mathcal{X}} \alpha_{t-1}(\mathbf{x})$ 
5:      $\mathbf{y}_t \leftarrow f(\mathbf{x}_t) + \epsilon_t, \epsilon_t \sim \mathcal{N}(0, \sigma^2)$ 
6:      $\mathcal{D}_t \leftarrow D_{t-1} \cup \{\mathbf{x}_t, \mathbf{y}_t\}$ 
7:   end for
8: end function

9: function Approx-MI ( $D_t$ )
10:  if Sample with Gumbel then
11:    approximate  $\Pr[\hat{y}_* < y]$  with  $\mathcal{G}(a, b)$ 
12:    sample a  $K$ -length vector  $\mathbf{r} \sim \text{Unif}([0, 1])$ 
13:     $\mathbf{y}_* \leftarrow a - b \log(-\log \mathbf{r})$ 
14:  else
15:    for  $i = 1, \dots, K$  do
16:      sample  $\tilde{f} \sim GP(\mu_t, k_t | D_t)$ 
17:       $\mathbf{y}_{*(i)} \leftarrow \max_{\mathbf{x} \in \mathcal{X}} \tilde{f}(\mathbf{x})$ 
18:    end for
19:     $\mathbf{y}_* \leftarrow [\mathbf{y}_{*(i)}]_{i=1}^K$ 
20:  end if
21:  return  $\alpha_t(\cdot)$  in Eq. (6)
22: end function

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Pseudocode description: Entropy search methods use an information-theoretic perspective to select where to evaluate [12]. They find a query point that maximizes the information about the location $\mathbf{x}^* = \arg \max_{\mathbf{x} \in \mathcal{X}} f(\mathbf{x})$ whose value $y^* = f(\mathbf{x}^*)$ achieves the global maximum of the function f .

V. CONCLUSION

This novel optimization scheme as mentioned in the above work is deployed to improve the performance and efficiency of IEEE 802.11 ah IoT and makes them to fit in to any high broadband access network. By using the pseudocode (Algorithm) together with the prevalent network parameters, it is simulated and the results obtained will be crosschecked with already existing technique to show that anticipated improvement in service delivery.

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