Research article

Giji Kiruba* and Benita

Energy capable clustering method for extend the duration of IoT based mobile wireless sensor network with remote nodes

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Abstract: The energy performance of IoT-MWSNs may be augmented by using a suitable clustering technique for integrating IoT sensors. Clustering, on the other hand, requires additional overhead, such as determining the cluster head and cluster formation. Environmental Energy Attentive Clustering with Remote Nodes is a unique environmental energy attentive clustering approach for IoT-MWSNs proposed in this study methodology (E^2ACRN). Cluster head (CH) in E^2ACRN is entirely determined by weight. The residual energy of each IoT sensor and the local average energy of all IoT sensors in the cluster are used to calculate the weight. Inappropriately planned allocated clustering techniques might result in nodes being too far away from CH. These distant nodes communicate with the sink by using more energy. The ambient average energy, remoteness among IoT sensors, and sink are used to determine whether a distant node transmits its information to a CH in the previous cycle or to sink in order to lengthen lifetime. The simulation results of the current technique revealed that E^2ACRN performs better than previous clustering algorithms.

Keywords: disseminated clustering; energy attentive clustering; energy utilization; remote nodes.

***Corresponding author: Giji Kiruba**, Department of Electrical and Electronics Engineering, Noorul Islam Centre for Higher Education, Kumaracoil-629 180, Thuckalay, Kanyakumari District, Tamil Nadu, India, E-mail: d.jijikiruba@gmail.com. https://orcid.org/0000-0001-9705-5099
Benita, Department of Electronics and Communication Engineering, Noorul Islam Centre for Higher Education, Kumaracoil-629 180, Thuckalay, Kanyakumari District, Tamil Nadu, India,
E-mail: beni.bless@gmail.com

Introduction

IoT sensor nodes in a typical IoT wireless sensor network (IWSN) contain sensing, broadcasting, and data processing equipment (Pottie and Kaiser 2000). Transportation traffic monitoring, smart cities, and combat surveillance are just a few of the business and farming applications that might benefit from IoT sensors. IoT sensors are arranged haphazardly and work independently in these systems. Those IoT sensors can't be easily replaced or recharged in those situations, therefore energy consumption is the most important issue to address (Akyildiz et al. 2002; Reddy et al. 2013). For WSNs, many energy-efficient broadcasting methods have been developed (Li et al. 2013). Clustering is especially useful for IoT sensor networks that require scalability to hundreds of nodes, such as broadcasting. A cluster is made up of cluster components and a cluster head (CH). CH is in charge of synchronizing the nodes in their cluster and sending collected data to a distant sink periodically. IoT nodes with high remaining energy can act as CH through occasional re-clustering. The usage of overall performance data collecting, which involves merging events from IoT nodes into a small group of relevant data, and information broadcasting to be additional energy, is expanding the network's existence. Clustering methods, on the other hand, have drawbacks, such as increased overhead during the CH selection and mission, as well as throughout the cluster formation process.

In recent years, researchers have developed many clustering-related techniques to maximize network lifetime. LEACH (Low-Energy Adaptive-Clustering Hierarchy) (Heinzelman, Chandrakasan, and Balakrishnan 2000) is a self-organizing adaptive approach that employs a distributed set of clustering configuration principles. In LEACH, CH is chosen entirely based on a predetermined opportunity; various nodes choose a cluster to associate independence on proximity to the designated CH. LEACH, on the other hand, does not guarantee that CH is shared consistently in a given context.

In LEACH a node may select to be a CH for several rounds of a procedure, for that reason consumption of energy is greater at different nodes in the environment. Hybrid-Energy-Efficient-Distributed clustering-(HEED) (Younis and Fahmy 2004) utilizes mutual energy and relaying weight to create CH. HEED normally avoids nodes in the identical broadcasting range from appropriate CH since energy is consistently disseminated throughout entire nodes. In HEED, each node should broadcast continuously with its nearby nodes for prearranged iterations at some point of CH choice; consequently, more broadcasting weight is necessary. Hence, HEED does not work for big-scale WSNs. Distributed-Energy Efficient-Clustering-(DEEC) (Qing, Zhu, and Wang 2006) is a clustering approach wherein CH are selected on the possibility of lingering energy to common energy of the environment. DEEC includes the evolution of the accurate duration of a network that is utilized to calculate the orientation energy that every node ought to dissipate during a cycle. Thus, every node it is not mandatory to have wide information of the environment. The dispensation of the common energy, overhead are the foremost disadvantage of DEEC (Rajesh et al. 2016). Furthermore, the common energy of the environment cannot exactly constitute the condition of the environment. In this research methodology, a new environment-based energy attentive clustering methodology with remote nodes for MWSNs, called Environmental Energy Attentive Clustering with Remote Nodes (E^2ACRN) is proposed.

Related to LEACH, E^2ACRN allows every node to utilize energy consistently by using revolution of the CH responsibility amongst every node. E^2ACRN chooses CH depends on the threshold regarding the lingering energy of every IoT sensor in every cluster to try by frivolously allocating CH, whereas LEACH chooses the CH depends on the threshold. E^2ACRN involves acclimatizing the revolving era of each node to its energy and shows the trouble of node remoteness. An inappropriately proposed clustering approach can motivate nodes to emerge as remote node from CH. Such remote IoT nodes broadcast with sink by way of ingesting a surplus quantity of energy. Additionally, the environmental common energy and remoteness amongst IoT sensors and sink is utilized to calculate whether remote IoT node transmits its collected data to a CH IoT node in the preceding cycle or to sink.

The rest of the paper is structured as follows. “Problem description” section gives initial information, which includes the problem description. “Proposed E^2ACRN approach” section portrays the proposed approach. “Simulation outcome” section offers simulation outcomes through comparing E^2ACRN and current approaches, and a quick conclusion in “Conclusion” section.

Problem description

Remote nodes

In an MWSN, the entire IoT sensor consumes energy to perceive its surroundings and transmit that information to an IoT sink node. IoT nodes in MWSNs formed using inadequately planned allocated clustering techniques can likewise get remoted as a result of sporadically determined CH, as shown in Figure 1. When the distance between them is great, the energy consumption problem of a remote IoT node broadcast with a sink may become much more apparent. Even worse, it’s prone to lose energy, resulting in a partial sensing capability. To extend network lifetime, environmental normal energy, remoteness among IoT sensors, and the sink is scrutinized to resolve whether a remote IoT node is needed to send its gathered data to an IoT CH node in the preceding cycle (Rajesh and Jaya 2019, 2020a,b).

Overall and neighboring average energy

Figure 2 demonstrates the lingering energy allocation of two hundred arbitrarily organized IoT sensor nodes. From Figure 2 it is found out that, the lingering energy allocation of the entire IoT nodes may be very choppy. Therefore, for huge-scale environments, the overall common energy of the environment cannot precisely signify the region of the complete environment. The innovative approach in Qing, Zhu, and Wang (2006) does not think about environmental normal energy (or neighboring energy). IoT nodes have to recollect the energy intensity of neighboring nodes while deciding on a CH to keep additional energy (Heinzelman, Chandrakasan, and Balakrishnan 2000). Consequently, this research methodology proposes the E^2ACRN approach to increase the existence of MWSNs by considering the nearby average energy of the MWSN IoT nodes (Rajesh and Jaya 2021).

Proposed E^2ACRN approach

This part offers about the E^2ACRN approach. In E^2ACRN the lingering energy and nearby common energy of every IoT sensor, in every cluster, pick CH. To avoid the issue of IoT node remoteness, the nearby common energy, and remoteness among IoT sensors and sink premeditate to decide whether the remote IoT node needs to transmit its information to an IoT CH node in the preceding cycle or the IoT sink. The proposed approach is as.

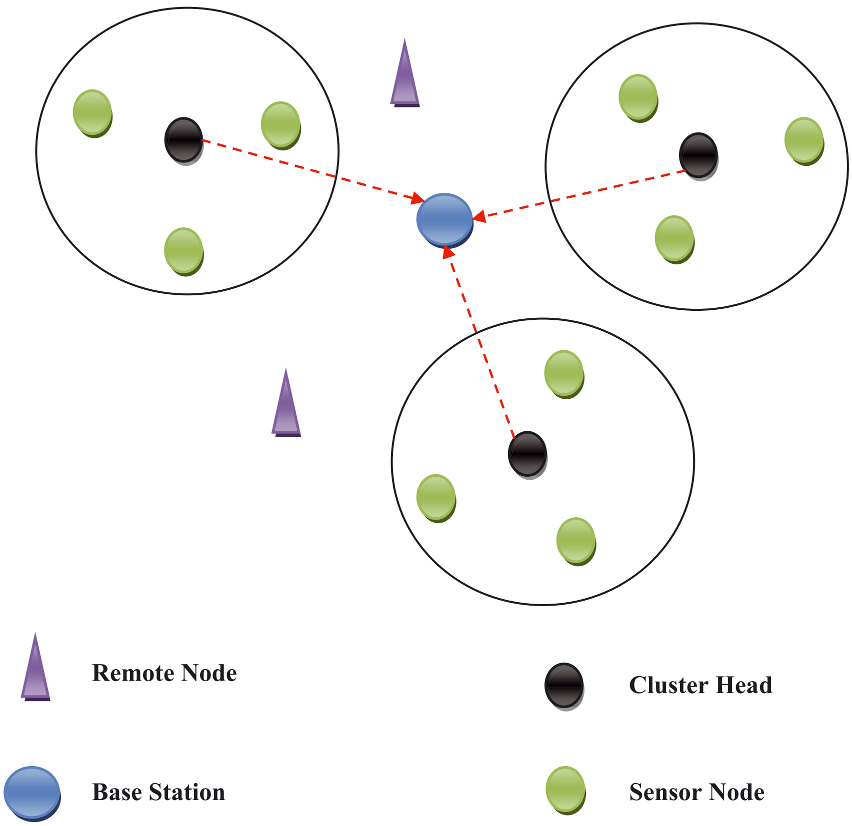

Figure 1: Remote nodes.

Cluster head choice procedure based on lingering energy and environmental common energy

A cluster head choice rule is divided into numerous cycles. At every cycle, every IoT node decides a cluster-head related to a threshold, which is deliberate by the recommended proportion of cluster-heads for the complete environment. In every cycle, every IoT node decides an arbitrary value among zero and one. If the value is less than a threshold, then the IoT node becomes a cluster-head for the present cycle. The threshold $T(V)$ for the IoT node V is as in equation (1).

$$T(V) = \begin{cases} P/(1 - P \times (pc \bmod (1/P)) & \text{if } V \in G \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

where, P is the preferred chance of cluster-heads, pc is the present cycle value, and S is the group of IoT nodes as non-cluster-heads in the preceding cycle.

At the initial cycle (pc = zero), every IoT node has a chance P of turning into a cluster head. The IoT nodes to cluster heads in cycle zero cannot become cluster heads for the successive cycles. Every IoT node might now not contain equal lingering energy as processing takes place. If the entire IoT nodes apply the similar value P for cluster head choice. The lingering energy of every IoT node cannot properly dispense, and the IoT nodes with lessening energy might malfunction rapidly than those with greater energy. E^2ACRN approach of desiring a distinctive P depends on

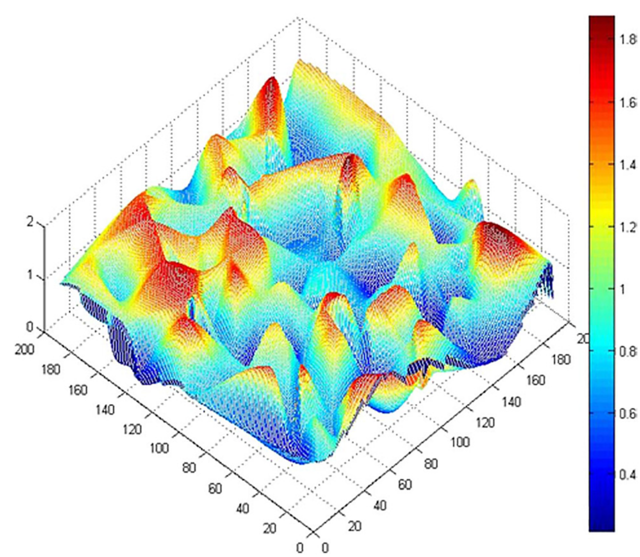

Figure 2: Lingering energy allocation of arbitrarily arranged IoT sensor nodes.

lingering energy and the environmental common energy of entire IoT sensors in every cluster to extend the existence of the network.

Let $E_{\text{c-eng}}$, $i(\text{pc}-1)$ be the environmental common energy of IoT node V in its cluster C at the cycle pc − 1, Q_{nn} is the quantity of IoT nodes in a cluster, and $E_{\text{leng}}(\text{pc})$ is the lingering energy of the IoT node V. The environmental common energy $E_{\text{c-eng}}$, $i(\text{pc}-1)$ as equation (2).

$$E_{\text{c-eng}}, i(\text{pc}-1) = \sum_{i=1}^{Q_{nn}} E_{\text{leng}}(\text{pc})/Q_{nn} \tag{2}$$

$$P_i = P \times \left((E_{\text{leng}}(\text{pc}) / (E_{\text{c-eng},} i(\text{pc}-1) \right) \tag{3}$$

As proven in equation (3), P_i is the possibility that IoT node V is preferred as a Cluster Head within the cycle pc, and P is the preferred chance of cluster heads. If $P_i = P$ for every IoT node V, the network accomplishes a steady. Wherein every IoT node has the equal lingering energy that produces a possibility threshold in equation (4) that every IoT node V makes use of, to decide it as a cluster-head in every cycle.

$$T(V) = \begin{cases} P_i/(1 - P_i^{*}(\text{pcmod}(1/P_i))) & \text{if } V \in G \\ 0 \quad \text{otherwise} \end{cases} \tag{4}$$

Remote IoT node and its data broadcasting method

Remote IoT nodes transpire in an MWSN in the subsequent scenario. After the cluster head determination procedure is completed, every decided CH relays a link request message to IoT nodes within the environment. If an IoT node gets join request information from, and IoT node it might choose to enroll in the cluster that's neighboring it. Such IoT nodes that do not acquire join request information are taken into account as remote IoT nodes. Data broadcasting techniques for remote IoT nodes can be determined consistent with the situation in the preceding cycle and present situation. In E^2ACRN First-Order Radio-Model (FORM) (Heinzelman, Chandrakasan, and Balakrishnan 2000) is utilized as energy utilization for data among IoT nodes. The energy value for broadcasting n-bit information is $n(E_{\text{elec}} + \varepsilon_{\text{amp}} \times R^2)$, where R is remoteness among the IoT nodes. E^2ACRN approach decides how an IoT node broadcast its facts no longer only by way of the remoteness among IoT nodes and sink with its lingering energy (Giji Kiruba and Rajesh 2018). The IoT node i capture data and broadcast straightforwardly to sink if $E_{\text{leng}}(\text{pc}) \geq E_{\text{c-eng}}$, $i(\text{pc}-1)$ and $R^2_{i,s} < R^2_{i,}\ \mu + R^2\ \mu_s$ or else, the IoT node i broadcast to sink via intermediate IoT node μ, that's CH IoT node in the preceding cycle. The broadcasting energy costs C_{straight} and $C_{\text{intermediate}}$ as in equations (5) and (6).

$$C_{\text{straight},i} = n\left(E_{\text{elec}} + \epsilon_{\text{amp}} \times R^2_{i,s}\right) \tag{5}$$

$$C_{\text{intermediate},i} = n\left(2E_{\text{elec}} + \epsilon_{\text{amp}} \times \left(R^2_{i,}\mu + R^2\,\mu_{,s}\right)\right) \tag{6}$$

where

μ – Preceding cycle cluster head.
i– Present IoT node.
s– Sink IoT node.
R – Remoteness.
$E_{\text{leng}}(\text{pc})$ – Lingering energy of IoT node i.
$E_{\text{c-eng}}$, $i(\text{pc}-1)$ – Environmental common energy of cluster c-eng for cycle pc–1.
C_{straight} – Straightforwardly broadcasting energy.
$C_{\text{intermediate}}$ – Intermediate broadcasting energy.
E_{elec} – Energy of Electronics.
ε_{amp} – Amplifier energy.

Imagine the perspective among the threshold from the IoT node i to broadcasting IoT node μ and threshold from broadcasting IoT node μ and sink s is θ and associated with the cosine algorithm in equation (7),

$$R^2_{i,}\mu + R^2\,\mu_{,s} < R^2_{i,s}, \text{ if } \cos(\theta) < 0 \tag{7}$$

$C_{\text{straight},i} > C_{\text{intermediate},i}$ iff $\cos(\theta) < 0$ in equation (8) as

$$R^2_{i,s} - R^2_{i,}\ \mu + R^2\ \mu_{,s} > E_{\text{elec}}/\epsilon_{\text{amp}} \tag{8}$$

Growth gi of the IoT node i for every time when the information broadcasted to sink with $C_{\text{straight},i} > C_{\text{intermediate},i}$ be premeditated as in equation (9).

$$gi = \epsilon_{\text{amp}} \times \left(R^2_{i,s} - \left(R^2_{i,}\ \mu + R^2\ \mu_{,s}\right)\right) - E_{\text{elec}} \tag{9}$$

The entire growth Ψ for every cycle portrayed in equation (10) whilst there are r remote IoT nodes which utilize intermediary broadcasting manner with a lesser broadcasting cost, in preference to a straight broadcasting manner with a better broadcasting cost.

$$\psi = \sum_{i=1}^{n} xi \text{ where } xi = gi \quad \begin{cases} \text{if } C_{\text{striaght},i} > C_{\text{intermediate},i} \\ 0 \quad \text{otherwise.} \end{cases} \tag{10}$$

Simulation outcome

This part, portrays a performance estimation of E^2ACRN approach in NS2 Foremost configurable factors utilized in our simulations in Heinzelman, Chandrakasan, and Balakrishnan (2000) are exposed in Table 1. Imagine a sink

IoT node to be in the middle of the environment. The performance of E²ACRN is compared with performance in Heinzelman, Chandrakasan, and Balakrishnan (2000), Younis and Fahmy (2004) and Qing, Zhu, and Wang (2006). In the first approach, LEACH choice of CH is primarily based on a prearranged opportunity. In the subsequent approach, DEEC, CH choice depends on the opportunity of the ratio of lingering energy to the average energy of the environment. In REAC, CH is decided on its nearby average energy. At last, E²ACRN, CH is determined on environmental average energy, whether the remote IoT node sends its observed data to a CH IoT node in the preceding cycle or the sink straightforwardly. E²ACRN compared with normal disseminated clustering protocols such as LEACH and DEEC with the overall performance factors such as the variance of energy altitude, quantity of nodes active over time, number of facts received at the sink, and the common lifetime.

1) The variance of energy altitude: Figure 3 indicates the comparison among the variation of lingering energy allocation created by the DEEC and E²ACRN approaches. The variation of the energy range of entire IoT nodes is the most important measure of the lingering energy with local or overall common energy in LEACH, REAC, DEEC, and E²ACRN. An excessive variance specifies that the overall average energy of the network cannot precisely constitute the condition of the complete network. The performance of E²ACRN is enhanced by two causes. At first, IoT sensors broadcast a packet to determine sink position. For requesting and responding, the IoT-sensors diminish the energy consumption. Another cause is traffic, due to traffic intersection among IoT-sensors which utilize an enormous amount of energy so that IoT-sensors expire rapidly than the exact timeframe, which lessens the system lifetime of this calculation.

2) The quantity of active IoT nodes: The time duration of the initial IoT node active in the environment to relay facts to the base station. Figure 4 shows, the increase of environmental average energy, with a lesser dilemma of remote IoT nodes. The existence and quantity of active IoT nodes in E²ACRN are higher than in as seen in different approaches. Even though incomplete data broadcast may arise on remote IoT nodes, E²ACRN method can nevertheless safeguard the low energy IoT nodes which are remote from the sink.

3) The quantity of facts received at the sink: Figure 5 indicates that the number of facts obtained at the sink became better in E²ACRN approach than in LEACH, REAC, and DEEC methodologies. The result suggests that E²ACRN can assist facts broadcasting from IoT nodes to sink in the environment. In this, delay and throughput are evaluated. Delay is time utilized to relay the facts from sender IoT to receiver IoT. Delay was calculated in seconds, and it is demonstrated in Figure 6. Throughput is the number of facts received per second. Throughput among IoT nodes is exposed in Figure 7.

$$\text{Throughput} = \text{Amount of relayed facts/relaying time} \tag{11}$$

Table 1: Environment factors for simulation.

Factors	Value
Network environment	200 × 200
Amount of IoT nodes	200
Sink location	100,100
Initial energy	2 J
Cluster head possibility	0.1
E_{elec}	50 nJ/bit
ε_{amp}	100 pJ/bit m²
Cycle	25

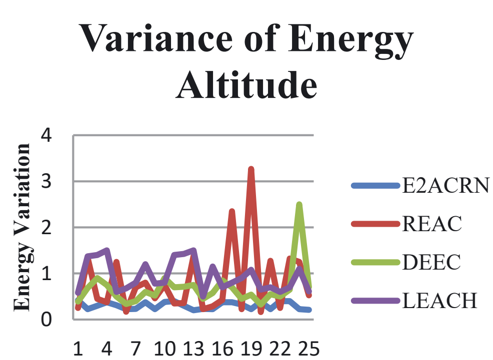

Figure 3: A variance of energy intensity.

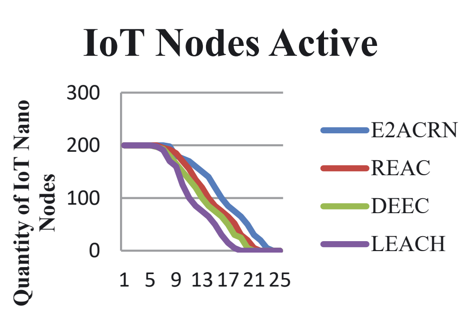

Figure 4: Quantity of IoT nodes active over a cycle.

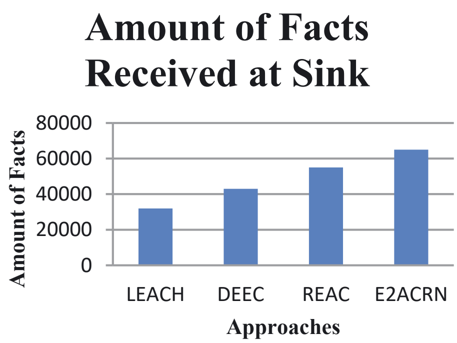

Figure 5: Amount of facts received at the sink.

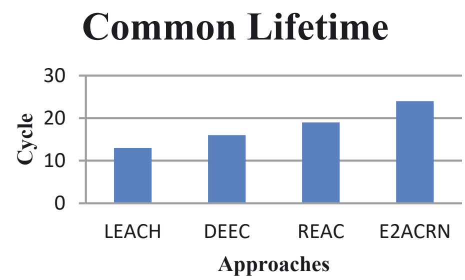

Figure 8: The common lifetime of environment for 25 simulations.

4) The common lifetime: The energy exploitation of diverse methodologies related to standard energy consumption per IoT node and complete energy consumption in the environment. The standard energy consumption per IoT node implies the standard energy demolished by each IoT node. The evaluation takes place to compute their standard energy consumption per IoT node and entire energy consumption in 200 IoT nodes until CH expires. Figure 8 suggests the common lifetime in 25 cycles. It demonstrates that there may be a substantial enhancement in lifetime via E^2ACRN. The environmental lifetime in E^2ACRN is higher than as seen in different approaches and may lengthen approximately as much as 40% of the environmental lifetime. Furthermore, the remote node dilemma is solved so that it can extend the whole environmental lifetime.

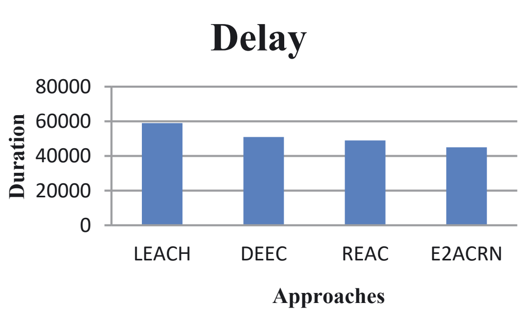

Figure 6: Delay while relying upon facts.

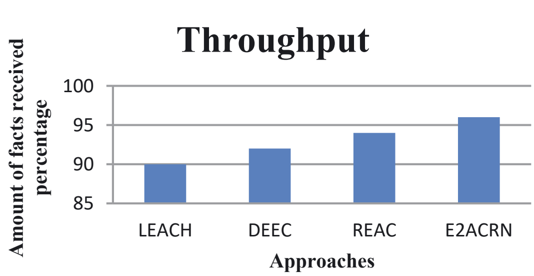

Figure 7: Throughput among IoT nodes.

Conclusions

An IoT-MWSN is an aggregate of wireless transmission and IoT sensors. The environment should be energy capable and constant, with extended lifetime. The E^2ACRN approach offered in this research method gets a better cluster head choice procedure and resolves the difficulty of remote IoT nodes. The simulation effects expose that the performance of the approaches utilized in E^2ACRN to better the lifetime and balance of an environment is an extra positive feature of the E^2ACRN compared with different approaches.

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