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Multi-Agent Technology to Improve the Internet of Things Routing Algorithm using Ant Colony Optimization

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Abstract

Objective: To improve the Internet of Things routing algorithm using ant colony optimization based on multi agent technology. **Methods:** The IOT environment contains various types of networks and every network could use a special sort of ACO algorithmic program. This vogue depends on network's specs, status, and needs. This IOT environment had several intersections between completely different networks that result from various coverage areas, this intersections are known as overlapped areas. A Dual agent is used to generate an optimized routing algorithm in overlapped areas. The effectiveness of the proposed routing algorithmic program is measured in various terms and they are delay time, packet loss ratio, throughput, overhead of management bits, and energy consumption ratio. **Findings:** Network Simulator NS-2 is employed to evaluate the proposed algorithmic program performance. We have planned our routing algorithm to enhance our packet delivery rate and avoid the overlapped intersections victimization the multi-agent technology. With efficiency it will scale back delay and improves the packet delivery ratio with minimum route price. **Applications:** The proposed routing algorithm uses an ACO algorithm to obtain the best routing path and it will maximize the network lifetime with minimizing data gathering delay in WSN. The performance of routing protocols will increase with increasing the packet delivery ratio.

Keywords: ACO Ant Colony Optimization, IOT-Internet of Things, Multi-Agent Technology, NS-2 - Network Simulator 2

1. Introduction

Internet of things as a replacement emerging and quickly growing technology has attracted lots of attention from worldwide recently. IOT could be an internet of irregular multipoint to multipoint communication. Within the environment of IOT data transmission cannot dodge routing that directly affects the performance of IOT. The goal of each routing algorithmic rule is to direct traffic from source to destination. At a similar time, many measures of network performance like throughput, packet delays and resource utilization are considered for optimization[1] Internet of things environment consists of a large vary by restricted equipment. IOT condition includes self-sorting out system. There are two node deployment in the internet of things. The first node deployment is predefined deployment and the next one is random deployment. When nodes are set in venture, according to the demand and information is transmitted through plan way and this situation comes underneath predefined organization. In the situation of arbitrary sending, the nodes' position can't be right situating all through this case, on the grounds that the nodes are arbitrarily put, and furthermore the nodes should have the self-sorting out ability. The IOT infrastructure was shown in Figure 1.

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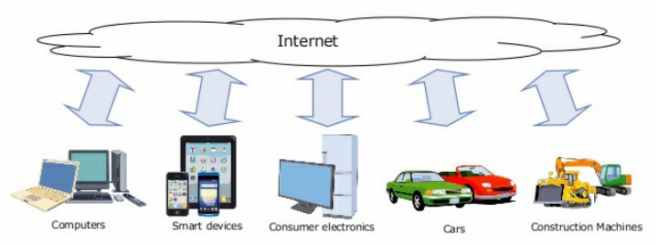

Figure 1. IOT infrastructure.

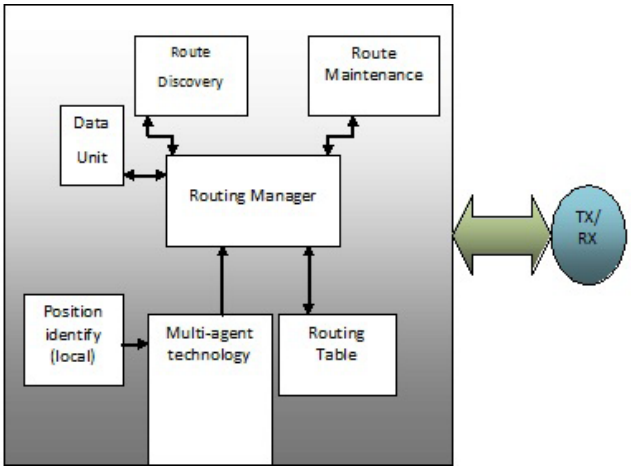

Figure 2. Architectural diagram.

The IOT systems are vitality confined, there are an expansive assortment of sensors are sent in the internet of things, so the sensors gather the ecological information occasionally in venture with right and precise recurrence. The gathered information have the component of always refresh information according to the time frame. In any case, it's not plausible for the sensors used in the standard internet of things in light of IP conventions. In light of the sensor nodes' essentials and information exchange limit are pretty much nothing. Since the sensor node is self-made, every node and its adjacent nodes will be related therefore, accumulated and transmitted data depressively with the non appearance of human impedance.

Dynamic Network: In sensible applications, internet of things is ordinarily changed powerfully, for the moving of nodes normally, the association of new things, the adjustment of natural conditions will change the topology of the network[2], accordingly, internet of things should be outfitted with a dynamic flexibility.

Mass Nodes: So as to prompt right information, a lot of sensor nodes are sent inside the internet of things, consequently, it's not practical to disperse a physical address for every node.

Routing Algorithmic Program in Internet of Things: The alternatives of internet of things convey significant troubles to course seek. The standard routing algorithms, like link-state algorithm, distance vector algorithm, etc., as of now can't adjust to the dynamic changes of the internet of things. It is most likely manual for the system correspondence storm on the off chance that we tend to even now take after the standard route search algorithms. With the looks of a wide range of insightful algorithmic program in a steady progression, a few researchers apply them to the internet of things directing examination, like application of simulated annealing algorithmic program and genetic algorithmic program to resolve routing issues. The route of internet of things should have the attributes, for instance, exploitation littler correspondence overhead and process energy to figure the ideal way, and adjusting to the dynamic alteration of the topology structure in the internet of things. These attributes coordinate those of ant colony algorithmic program, for the strategy for nodes' looking for directing inside the net is to a great degree the same as that of ants scanning for sustenance, in this manner, there are additional advantages in ant colony algorithmic program when contrasted and reenacted simulated annealing algorithm and genetic algorithm.

Ant colony algorithm are normally utilized as a part of very surprising system, and ideal connection inside the system in the premise of the quality of service, and improve transmission potency of the network[3]. The promotion of wireless sensor networks (WSNs) urges professionals and building to frame new IOT applications. WSNs contain lots and lots of sensors and these sensors and they have the flexibleness to communicate with each other. These sensors are normally outfitted with some significant segments and they are as per the following, detecting, preparing and imparting parts. Such sensors will be utilized to gauge encompassing conditions inside nature encompassing them and afterward change these estimations into signals. The sensors at that point send such gathered information, some of the time by means of a radio transmitter, to a base station either specifically or by means of a few transferring sensors[4]. The IOT environment contains differing types of networks covered by internet. These systems have various particulars that repeat the character of IOT. Each system kind has its own ACO calculation for managing the directing technique.

The formation of this paper is as follows. In section II we discussed about our proposed system. In section III, we have a tendency to confer the connected work. In

section IV, we have a tendency to specify or demand the routing protocols. Section V, explains the basic ant colony algorithm and its types. In section VI, multi agent technology algorithm is demonstrated. Section VII points out the overview of NS-2 network simulator. In section VIII, we tend to show the definition and description of the simulation system. In section VIII and IX, the conclusion and references is given.

2. Proposed System

We have proposed our routing algorithm to enhance our packet delivery rate and avoid the overlapped intersections using the multi-agent technology. This multi-agent system contains agents for native management mission and others for global management mission.

These agents have totally different functions which help to improve the routing process and the functions are like execution of the routing algorithmic rule and network observation. There are four styles of these agents: the global agent, the local agent, the dual function agent, and also the monitoring agent. The global agent combines the routing path parts that are made by totally different ACO algorithms. Also, this agent contains a table to store the previous state and also the current state and predict the future state of the IOT system using the prediction algorithm. Moreover, the global agent communicates with the local agents for providing the sub-routing methods. Additionally, it communicates with the monitoring agents to be up-to-date with the present IOT system state. Concerning the local agent, it's used to execute the suitable ACO algorithm to find the optimal routing path in every local network within the IOT system; hence, it should be located in every network. This IOT environment had several intersections between totally different networks that result from numerous coverage areas, this intersection is referred to as overlapped areas. In case of overlapped areas, a dual agent should be developed to produce associate optimized algorithms from totally different ACO algorithms taking into consideration many network parameters like available bandwidth, data rate, and energy level.

3. Survey

In[4] presented two versions of Ant Net. Ant Net is one of the distributed multi-agent system and this system is inspired by the communications that are observed in ant colonies. The Ant Net multi-agent system reports the simulation results for Ant Net using metrics and it includes throughput, packet delays and resource utilization. Ant Net is composed of two sets of homogeneous mobile agents. The two versions of the algorithm had a negligible impact on the use of network bandwidth.

In[5] presented a survey of the state-of-the-art routing techniques in WSNs. In this survey they first discuss about the design challenges for routing protocols in WSNs and they also discuss about the comprehensive survey of different routing techniques. In the underlying network structure, the routing techniques are classified into three categories and they are flat, hierarchical, and location-based routing. Based on the protocol operation these protocols can be classified into multipath-based, query-based, negotiation-based, QoS-based, and coherent-based. Achieve desired global behavior with adaptive localized algorithms. However, in a dynamic environment, this is hard to model.

In[6] presented a multi-agent framework is proposed in which it helps the existing routing methods for improving their routing performance and helps to give better performance. In this structure, it causes every sensor node to manufacture an aggregate neighbor set in view of past routing experience. There are four distinct measurements which shows the great execution of this structure and this will based on the simulation results and they are average delivery latency, successful delivery ratio, number of live nodes and total sensing coverage. This framework uses a unique communication model called 'unit disk' communication model. In this model the sensors can impart bi-directionally on the off chance that they are with each other. In any case, generally this present reality WSNs have the sensors of uni-directional physical connections.

In[7,8] proposed a algorithm which helps to increase the lifetime of a network and they also proposed a trust level computation which additionally helps to improve the performance and lifetime of a network. Energy and packet delivery ratio are used to calculate the trust level of nodes. But the packet delivery ratio and energy as a trust worthy nodes are not suitable for the IOT environment which has overlapped areas.

4. Routing Protocols

Each routing protocol exhibit core characteristics and they have the unique features that kind the very base of its

workings. The following are the characteristics which will be most useful in an IoT environment.

Proactive vs. Reactive

Apart from hybrid approaches, there are 2 major categories they are proactive and reactive. The routing protocols either fall within the category of proactive or reactive. The main function of a proactive protocol is to gather routing information proactively, and it makes an attempt to have the entire network's topology in the last time. Typically, the periodic distribution of beacons provides nodes with insight regarding the existence and quality of connection to their neighbors. As a result of this periodic distribution it provides a great performance. The performance is better in terms of latency, however, it will create a disturbance on the battery lifetime: That is, always in networks there will be sparse traffic, and so most of the topology information exchanged can be considered protocol overhead which will drain a device's battery unnecessarily.

Reactive protocols search for routes on demand: The route discovery process (towards this specific node) is triggered only when a transmission towards another node is started. In consequence, when there is a need the topology information is only exchanged as a result it will save energy. The drawback to reactive protocols is their latency: transmissions over unknown or expired routes face delays and it will happen as a result of routes are discovered on demand, for which either the application or the routing protocol has to account by buffering or dropping data[9].

5. Ant Colony Optimization Algorithm

5.1 Basic Ant Algorithm

Ant colony algorithm is proposed by an Italian Scholar Dorigo, M who gets the motivation from the ant colony foraging process. The ant isn't extremely keen, in any case, they will arrange and work along, and that they will dependably understand the most limited way between a nourishment source and ant nest at the feed time[10]. It would seem that there's no concentrated charge that is the ants will discharge an unstable substance in its dealings, way at their rummaging, called as secretion.

The Ant settlement calculation could be a very heuristic calculation that is self-sorted out and to learn consequently as indicated by the application to the different situations. There are some exceptional elements and they are as per the following; parallelism, recovery, vigor and discreteness. The ant colony algorithmic program is foremost utilized for the following issues. The above all else the ant colony algorithm is utilized for determining the travelling salesman problem, and it's also additionally utilized for unraveling the issues of combinatorial advancement like vehicle directing issue, quadratic task issue, Job-look arranging issue and etc.

The essential stride for utilizing an ant colony algorithm for unraveling sensible issues is to produce a specific measure of manufactured subterranean ant colony, province, at that point we need to empower each ant to construct an answer or a piece of the arrangement, and the simulated ants are made on the underlying state, at that point of resulting nodes to touch base with regards to the emission focus till in the end sort a legitimate means, that is, to arrange an answer[11].

```
Begin;
  Initialize the pheromone trails and parameters;
    Generate population of m solutions (ants);
    For each individual ant k∈m: calculate fitness (k);
    For each ant determine its best position;
    Determine the best global ant;
    Update the pheromone trail;
  Check if termination=true;
End;
```

Figure 3. pseudo code for ACO.

The fundamental ant colony optimization algorithmic program is shown in Figure 3. An ant discharges the emission with the immediate extent with the appropriate response quality level, it's found inside the way, at that point the following stage is that each ant begins a substitution technique for deciding the issues until understanding the palatable arrangement.

In routing analysis, the ant colony algorithm has gotten a few accomplishments. In limited self-association organizes vitality trademark, there is a sort of straightforward kind of simple ant routing algorithms[12]. All through the phase of looking course, it permits just a single communicate directing of the neighbor nodes to discover gathering, so the steering utilization is diminished, in any case it brings about a major deferral.

Another kind of ant routing algorithm used a method and this method utilized a technique and this strategy can keep away from the blunder inclined node to retransmit the gathering. Be that as it may, it stretches out the ideal opportunity for nodes to process in gathering. Later the ant colony algorithm is connected to the nodes' vitality administration and to build up a substitution directing way, so they will lessen the power utilization of the nodes successfully[13].

5.2 Different Ant Colony Algorithm

Many special cases of the ACO meta heuristic have been proposed. Here are some of most prevalent varieties of ACO calculations[14]-

- Elitist Ant System (EAS)
- MMAS
- Asrank.
- ACS.
- COAC.
- Recursive ant colony optimization.

➢ **Elitist Ant System (EAS).**

The worldwide best arrangement stores discharge on every emphasis next to all the inverse ants.

➢ **Max-Min Ant System (MMAS)**

Included Maximum and Minimum pheromone sums [τmax, τmin] just worldwide best or emphasis best visit saved pheromone. All edges are introduced to τmax and reinitialized to τmax while nearing stagnation.

➢ **Rank-based Ant System (AS rank)**

All arrangements are evaluated by their length. The amount of pheromone stored is then weighted for each determination, indicated arrangements with shorter ways store extra pheromone.

➢ **Ant Colony System (ACS)**

Ant colony system might be a sort of heuristic calculation, that is this ant colony system is self-composed and to discover naturally steady with the application to the changed conditions[15].

➢ **Continuous Orthogonal Ant Colony (COAC)**

The pheromone store system of COAC is to change ants to search for arrangements cooperatively and viably. By misuse relate orthogonal style strategy, ants inside the conceivable space will investigate their picked locales quickly and proficiently, with expanded worldwide pursuit capacity and precision[16].

The orthogonal style procedure and furthermore the versatile span modification technique can likewise be stretched out to various streamlining calculations for conveying more extensive focal points in fathoming sensible issues.

➢ **Recursive Ant Colony Optimization**

It is a recursive type of ant system that divides the entire search domain into many sub-domains and solves the target on these sub domains[17]. The results from all the sub domains are compared and also the best few of them are promoting to consequent level. The sub domains appreciate the selected results are further subdivided and also the process is repeated till an output of desired precision is obtained. This technique has been tested on ill-posed geophysical inversion issues and works well[18].

6. Multi-Agent Technology using Aco Algorithm

We have proposed our routing algorithmic program to enhance our packet delivery rate and avoid the overlapped intersections using the multi-agent technology. The following are the steps concerned in ACO algorithm to enhance the IOT routing process.

STEP 1: Let the source node S and the destination D. The source node S has information to send to a goal D with QoS and it needs a higher transmission rate, less deferral and extra data transfer capacity. A rundown of nodes that are progressively visited by the ant is termed as visited nodes list. This rundown frames the route R from the source node S to destination node D.

STEP2: At first pick the source node S. They went by node list and will be instated to source node(S).

STEP3: S starts at Path_Request_Ant_colony to goal D through every one of its neighbors that are in 1-hop separate from S. The Path_Request_Ant_colony contains the source address, goal address, hop count and transfer speed utilizing multi-specialist innovation.

STEP4: After that the pheromone examination of all the 1-hop separations nodes, it partitions the IOT condition into groups ranges relying upon to organize assortments. At that point, for each range in organizing it applies the premier suitable for the ant colony algorithmic program. Every node keeps up a table known as "global agent", that indicates the quantity of reachable pheromone

on each expectation level. This amount is introduced to constant C.

STEP 5: The subsequent stage is to compute the pheromone dissipation of all the 2-hop distance nodes and understand the sub-directing ways. Inevitably, we need to ascertain the way inclination likelihood worth of each way from source S with the help of pheromone vanishing of every node.

Local Agent: A node j from an arrangement of neighboring hubs (j, k… . n) of i is picked as MPR node and it covers all the 2-hop distance nodes and its way inclination is superior to others.

STEP 6: The computed way inclination fitting to the ACO algorithmic program is superior to the necessities, and after that the way is acknowledged and stored in memory. (Monitoring Agent)

STEP7: Once the Path_Request_Ant_colony achieves the goal, it will be changed over as Path_Reply_Ant_colony and after that it advances towards the first source S. The Path_Reply_Ant_colony will take a comparable way of the relating Path_Request_Ant_colony however, it is backward bearing.

STEP 8: The higher need way lean towards the ideal routing and will be considered as the best way and information transmission can be begun along that way.

STEP 9: Concerning the dual agent, it's employed in the overlapped areas that will contain nodes from totally different networks. This agent determines the ACO algorithmic program that ought to be employed in case of various networks intersections. In t the higher variety of one network nodes means the higher priority of exploitation the ACO algorithmic program for that network taking into consideration the energy level of each node within the selected network.

STEP 10: Checking dual agent (balanced energy) all the nodes update the energy level to their neighbors

If (Less Energy in Routing Nodes) {
Inform Source to Regenerate RREQ
} else {
Continue the Route
}

Source will select the route based on balanced energy level in all the paths.

// *avoid overlapped *//
If (Path has low energy modes) {
Choose Different Path
Else {
Choose the same path}

7. Overview of NS-2 Simulator

NS2 is an open-source event-driven simulator designed specifically for analysis in computer communication networks. NS2 has ceaselessly gained tremendous interest from industry, academia, and government. NS is primarily helpful for simulating native and wide space networks. Though NS2 is fairly straightforward to use once you get to grasp the simulator, it's quite troublesome for a primary time user, as a result of there are few user-friendly manuals.

NS-2 is an occasion driven parcel level system test, system created as a piece of the VINT (Virtual Internet Test bed) extend. In 1995 Version 1 of NS was created and with variant 2 out of 1996. The NS2 with C++/OTCL is a combination include. Adaptation 2 of NS2 have been encased in a dialect which is alluded to as Object orientated Tcl (OTCL). Scripting is an open supply bundle accessible for each Win32 and Linux stages.

For making and designing a system NS2 utilizes OTcl, and utilizations C++ to run reenactment. All C++ codes should be gathered and it must be connected for making an executable file. The accumulation time is not immaterial, Since the assemblage of NS2 is genuinely expansive. OTcl, then again, is a translator, not a compiler. Any adjustment in an OTcl record does not require aggregation. OTcl does not change over every one of the codes into machine dialect, in light of the fact that each line needs more execution time. At last, C++ is quick to run, however ease back to change. It is reasonable for running a substantial reenactment. Then again, OTcl, is ease back to run, yet quick to change. It is along these lines reasonable to run a little reenactment more than a few redundancies (each may have distinctive parameters). NS2 is built by joining the benefits of these two dialects. Figure 4 demonstrates the incorporation of C++ and OTcl.

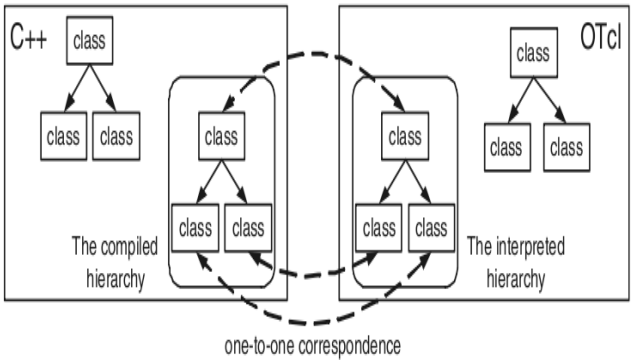

Figure 4. Integration of C++ and OTcl.

NS2 has a few and expanding utilizes incorporate the accompanying assessing the execution of existing system conventions, to gage new system conventions before use, to run extensive scale tests impractical in genuine analyses, to recreate a scope of ip systems. NS-2 is a protest orientated discrete occasion test system. Test system keeps up a run-down of occasions and executes one occasion after another.

8. Simulation Description

Simulations were done to analyse the performance of proposed algorithm. The simulation infrastructure includes four networks which communicate with each other. Figure 4 shows the simulation infrastructure. The aim of our proposed algorithm is to improve routing for IoT environment using multi agent technology, which includes global agent, local agent, monitor agent and dual agent using ant colony optimization. Each network use its own ant colony algorithm which depends on its network specification managed by local agent. The global agent maintains the overall path, when there is a change in the network nodes, the monitoring agent will update the information to global agent. The purpose of dual agent is to generate an optimized algorithm, whenever an IoT environment has an overlapped region. Based on energy, the dual agent will generate an optimized algorithm.

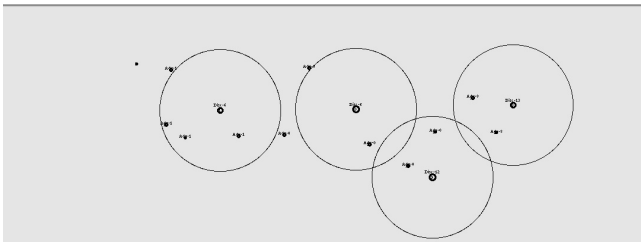

Figure 5. Simulation Infrastructure.

In our simulation, each node in a network has its own energy, whenever a transmission occurs there is a loss in node energy. When a node lost its full energy then there will a packet loss. In overlapped regions we have two or more paths, so when a node lost its energy limits some other node will send notification like EtH-Eager to Help. The dual agent consider the EtH and generate an optimized algorithm to avoid packet loss in overlapped regions. The measurement parameters were packet delivery ratio, energy consumption ratio, overhead of control bits and throughput. Figure 6 and 7 shows the packet delivery ratio and energy consumption ratio.

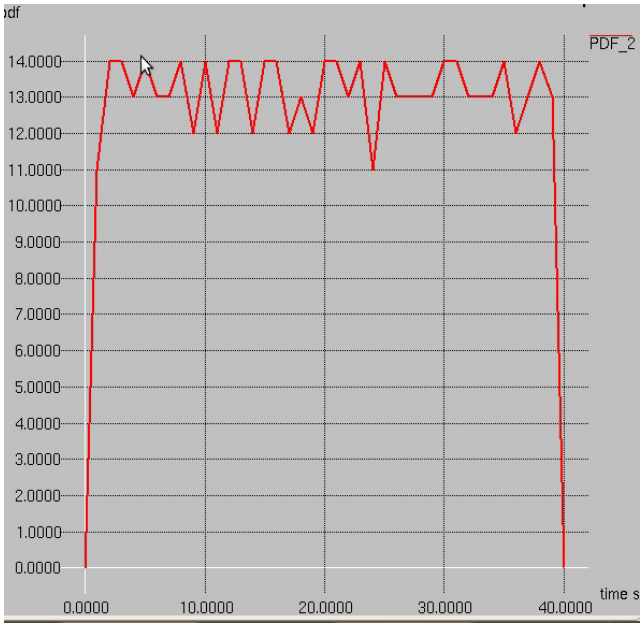

Figure 6. X Graph Packet Delivery Ratio.

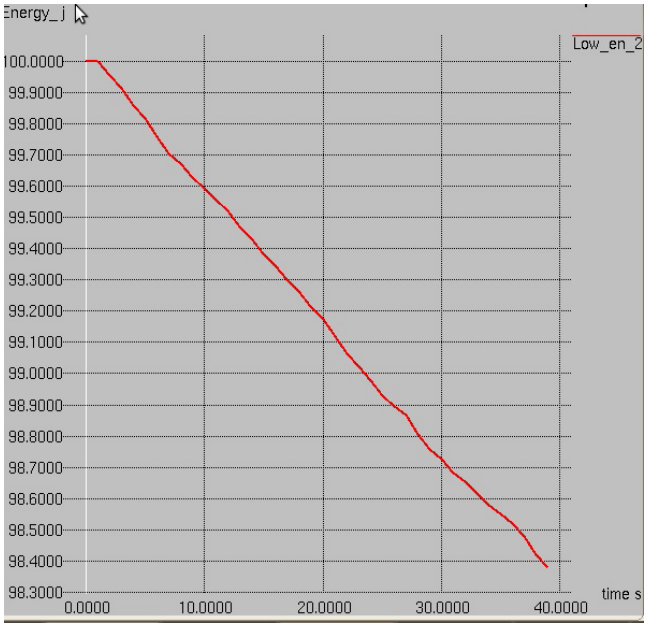

Figure 7. Graph for Energy Consumption.

9. Conclusion

In this project, a routing algorithm, which selects the optimal routing path within the IoT system, is proposed. This routing algorithm controlled the use of ACO algorithms in the IoT system to obtain the best routing benefit. The proposed algorithm divided the IoT environment into different areas depending on network type. Then, it selected the ACO algorithm that was suitable for

each network. Furthermore, the proposed algorithm considered the routing problem in the overlapped areas that may arise in the IoT system. A dual agent has been developed to produce an optimized algorithm from different ACO algorithms taking into consideration many network parameters such as available bandwidth, channel capacity, and energy level. In future, when a node is not covered by a network bandwidth, a DtD-Device to Device model can be developed to avoid a connectivity problem. In DtD model, when a node is not covered in a bandwidth, the neighbor node use its own energy to communicate with that node.

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