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Feasibility Study of Different Optimization Algorithms with Integrated Cost Function Technique for Routing in IoT Network

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Abstract

The routing plays crucial role in the dynamic communication networking requires to be ameliorated. The purpose of routing has to improve the efficiency of the network by calculating the parameters like cost-effectiveness, shortest path, etc. In this paper, the existing search algorithms such as Base network, Distance to zero, Distance to previous nodes and Tabu search have been accessed and then compared for the purpose of determining the cost optimization for shortest path. A large number of simulations have been conducted using MATLAB R2019a. The results revealed that Tabu search and Distance to previous node algorithms have been cost efficient in contrast to other two algorithms for smaller node count. Further, for higher value of node count Tabu search algorithm surpassed all of them even outperform Distance to previous nodes algorithm. Finally, the aim behind reviewing routing approaches has to improve efficiency of IOT network by evaluating the cost-efficient shortest path rather to discuss applicability of Tabu search approach in IOT network..

Keywords: Base network algorithm, Cost function, Distance to previous node, Distance to Zero, IOT networks, Tabu search.

1. Introduction

The Internet of Things (IoT) is hub of interconnected computing devices, digital machines and mechanical objects. All Individuals those are identified by unique identifiers abbreviated as UIDs and possesses the capability to transmit data over network without any human to machine or human to human intervention [1-4]. Presently, the IoT has emerged due to the conjunction of multiple technologies, machines, real time analytics, embedded systems and commodity sensors [4]. Conventional field of control systems, automation devices, embedded systems, wireless sensors network etc. led to the upbringing of Internet of Things as new technology. In the researcher community , the technology has been mostly used in products relating to the notion of the smart devices applied in home appliances such as home security systems, thermostats, lighting fixture and cameras etc. that backing one or more joint IoT ecosystem. It has been monitored through devices connected with that network, such as smart speakers controlled via smart cell phones.

In wide-ranging strokes, there are four key mechanisms in an IoT system

i) The thing itself (the device) ii) The local network (this can include a gateway, which translates proprietary communication protocols to Internet Protocol) iii) The Internet iv) Back-end services (enterprise data systems, or PCs and mobile devices) as depicted in Fig. 1.

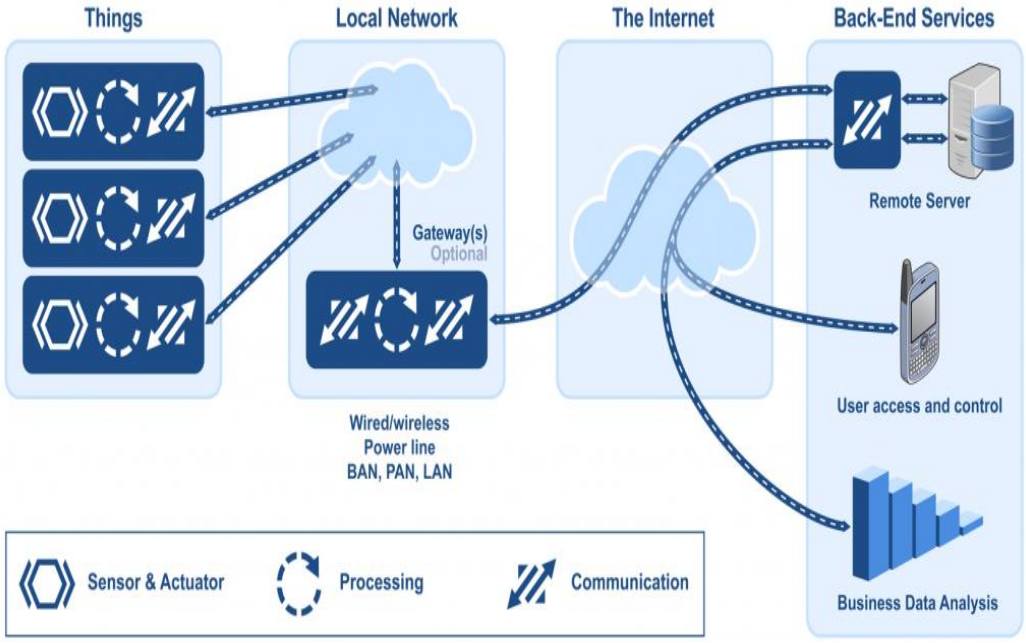

Fig. 1. The Internet of Things in view of an embedded system.

Tabu search is one of the heuristic investigation strategies for the search of best optimal solutions to combinatorial optimized troubles. Tabu list is an element of Tabu search which is used to avoid cycling. Mainly, all the recent events of the search are recorded on the Tabu list and thus put a stop to the reversal of same procedure. This strategy allows Tabu search to proficiently identify high-quality solutions [5]. This paper is based on the algorithm of Tabu search to the travelling salesman problem (TSP). The values of enviable parameter settings are accessible along with the approaches used to identify them. A comparison based on computational efficiency and superior solution has been made between Tabu search and other general search strategies. Practically, the findings of Tabu search approach have been the best solutions to the outsized combinatorial tribulations encountered [6].

A. Hertz et al. [7] summarized the Tabu search algorithm along with its various applications for the purpose of optimizing several problems. Further, instructions have been exhibited for the implementation of Tabu metaheuristic. P. Moscato [8] scrutinized the usage of "landscapes" as four test dilemmas. Tabu search (TS) being optimization tactic within a population heuristic has been analysed. The application of Tabu search has been explored to molecular biology. S. Basu [9] discussed different conditions for Tabu search application in relation to (Traveling Salesman Problem) TSP and its associated issues. It has been noticed that earlier research work was confined to small sized problems (in terms of no. of nodes) and care has not been taken of large sized issues that has been similar to practical problems. Further, it has been reported that Tabu search find more success in case of TSPs rather than in ATSP due to instance type non-occurrence in ATSP. B. Freisleben et al. [10] presented the technique for finding the approximate solutions of symmetric and non-symmetric TSP problems. Results revealed that with the above-mentioned technique more accurate solutions have been obtained in a reasonable time when compared with results obtained via. GA techniques. M. Zachariasen et al. [11] developed a novel Tabu search technique for solving geometric TSP problems. In this approach two transitions named Lin – Kernighan and Flower have been used. Finally, results have been analysed and compared with the results reported in existing literature. F. Glover [12] introduced a novel neighbourhood structure based on the concepts of ejection chains for the formulation of TSP problems. Sharad Sharma et al. [13] reviewed the existing algorithm which is based upon nature, physics/ chemistry to get optimal solution for the open-ended problem. The application of these algorithms finds suitability in dynamic networking due to its good decision-making capabilities and access in varying environment. Sharad Sharma et al. [14] explored the vulnerability of BB-BC approach to routing in dynamic and mesh structured network and proposed cost function based structure for routing and calculating the shortest path swiftly. Sharad Sharma et al. [15] proposed bio inspired approach of ants to capitalize the network performance. It is based upon Ant Colony Optimization (ACO) algorithm and an Integrated Link Cost (ILC) measure used as link distance between two adjacent nodes. The non- linear

relation between output and input insisted the implementation of fuzzy system comprises of 81 rules. The ACO outperforms than Adhoc On-demand Distance Vector (AODV) algorithm for same WSN.

This paper is divided into seven sections. Section I presents the incentive for the current work and basic working scenario of communication among nodes in IoT network. Also, literature survey has been done in context of work earlier done to understand the routing performance of network using soft computing framework. In section II different routing algorithms have been presented for the determination of shortest path. Further, cost associated with shortest path for different routing optimization techniques has been computed. The integrated cost measure is the function of degree of nodes and display cost. Section III revealed the results obtained via. implementation of different routing approaches. In section IV conclusion of present work has been reported.

2. Shortest Path Cost Evaluation

In present work, node count has been varied from 50 to 250 with a step increase of 20% (i.e., 50, 100, 150, 200 and 250) in order to predict the shortest path and its associated cost for different routing algorithm as discussed below.

2.1 Base Approach

Base search approach relates to the fields of Global and Stochastic Optimization. Base approach has been a direct search technique. The performance of such optimization has been calculated by measuring or estimating rather than evaluating it using analytical approach [16]. This approach does not involve derivatives to explore a continuous domain. The Base approach is associated to procedures that deliver small progresses.

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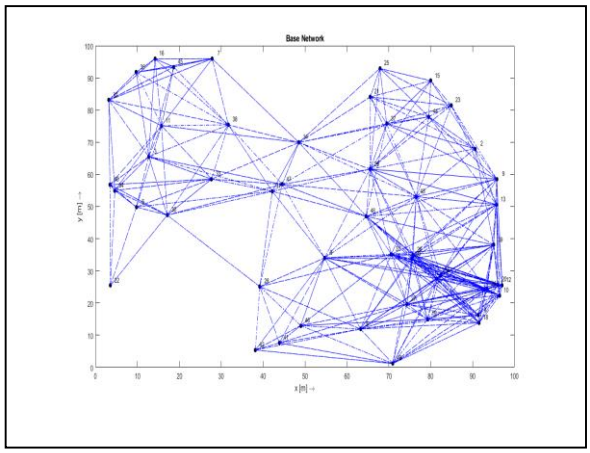

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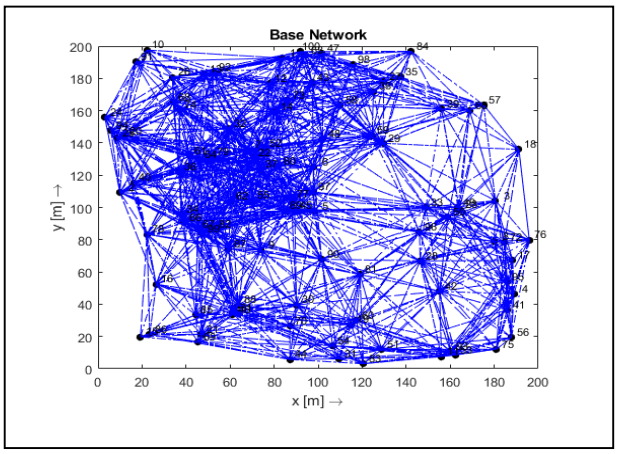

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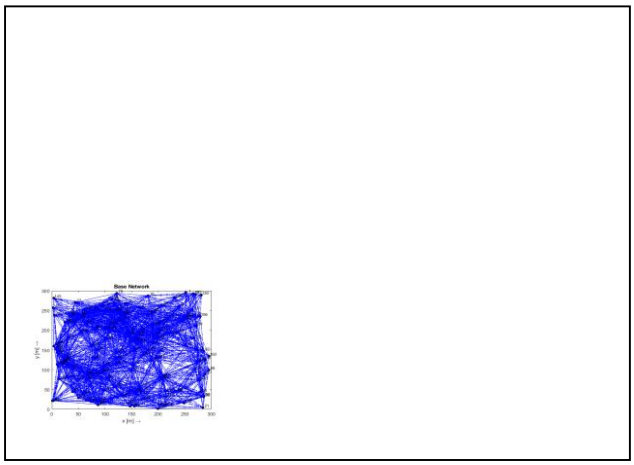

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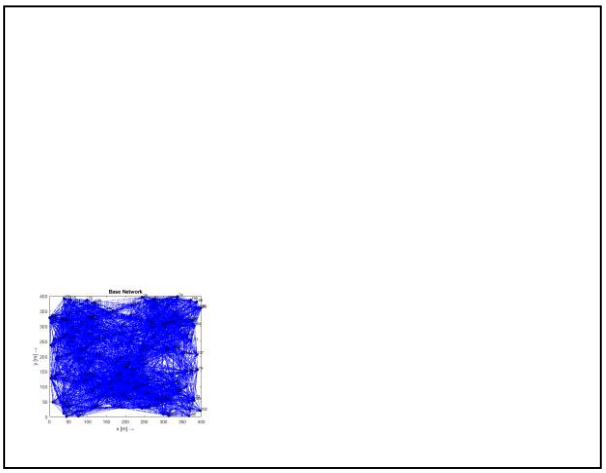

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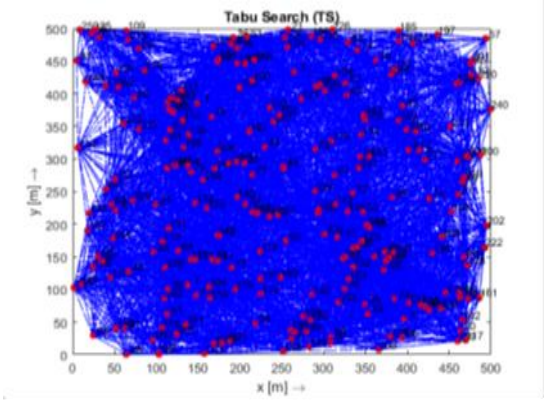

Fig. 2. Base search approach for a) 50 nodes b) 100 nodes c) 150 nodes d) 200 nodes e) 250 node

Base search approach adopted the technique which considered the entire search space using a uniform distribution probability for the purpose of model the optimal solution globally [16]. In order to comprehend the base approach node count has been varied from 50 to 250 have been considered in present work with a step increase of 20% as highlighted in Fig. 2. Each and every node has been interconnected to form a mesh network with low transmission power and routers. From the scope of wireless soft computing, the term base network has been defined pivot of local network. Base approach served as a gateway between wireless and wired network.

2.2 Distance to Zero Search Approach

The distance to zero search approach belongs to the universal set of algorithms acknowledged as Global and Stochastic Optimization. It is a direct search technique in which it doesn't involve derivatives to explore and move in the search space. The distance to zero search approach addresses the limitations of the Base approach algorithm. The methodology that has been adopted for distance to zero search approach is to calculate step size for each node by calculating the distance of each nodefrom zero node as depicted in Fig. 3 in order to reach the desired node in the search space to attain global optimization.

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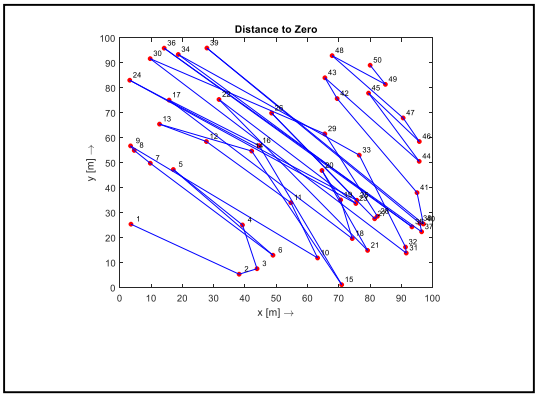

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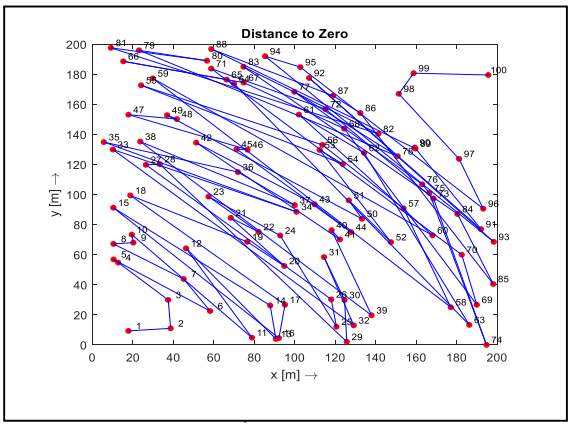

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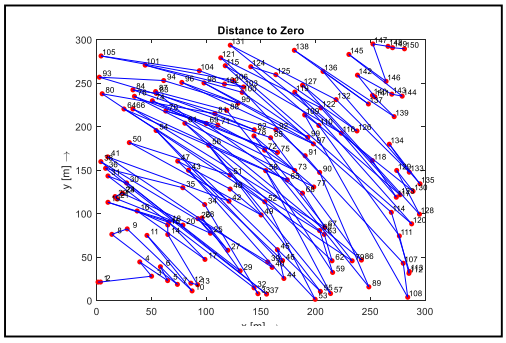

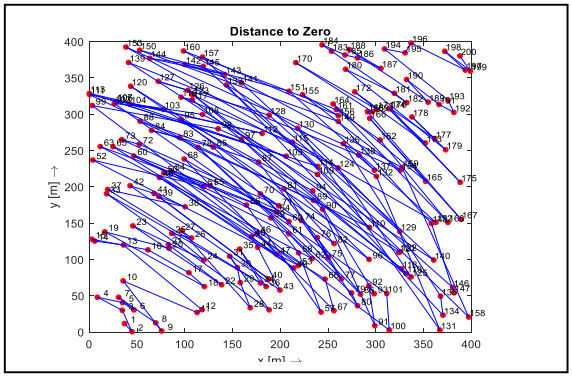

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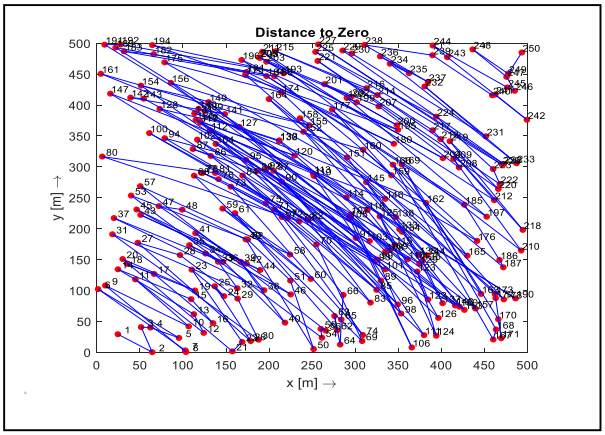

Fig. 3. Distance to zero search approach for a) 50 nodes b) 100 nodes c) 150 nodes d) 200 nodes e) 250 nodes.

2.3 Distance to Previous Node Search Approach

The distance to previous search approach algorithm is a Global and Meta heuristic Optimization approach algorithm. This approach follows practiceof an embedded Local Search approach algorithm.

It is an advanced approach to Local search algorithms. This approach is similar to Tabu search approach algorithm where the estimated cost function is very close when simulated in MATLAB. The strategy for the distance to previous search approach algorithm is to measure distance from last node to escape local optima and discover the global optima as shown in Fig. 4. Distance to previous search comprises iterative search of larger neighbourhoods for a specified local optimum till an improvement has been located after which time the search through growing neighbourhoods has been repeated.

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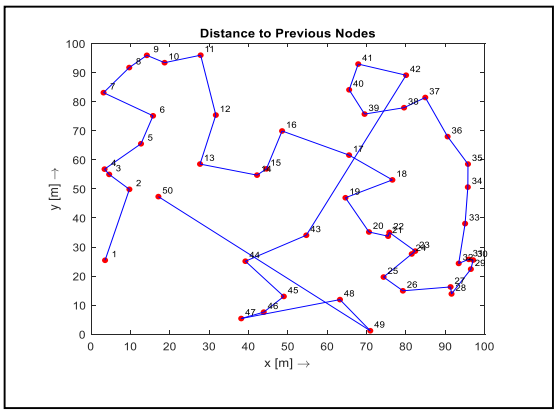

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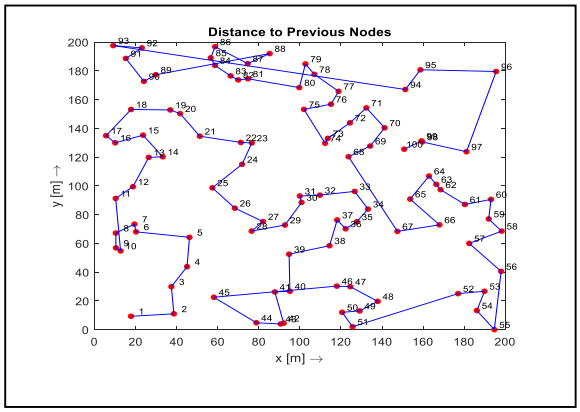

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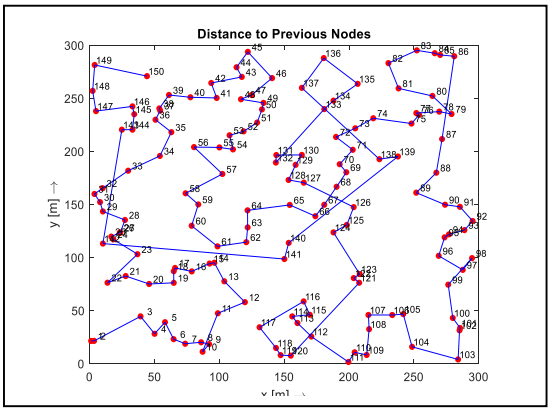

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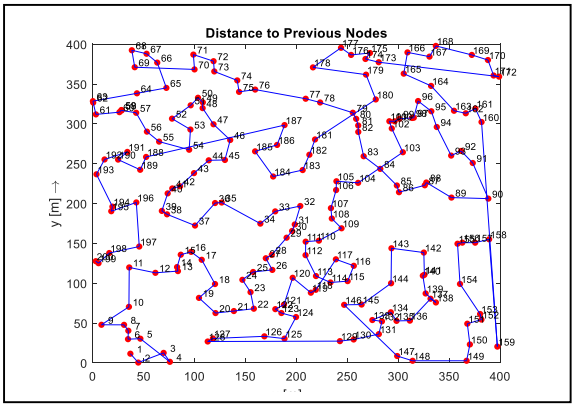

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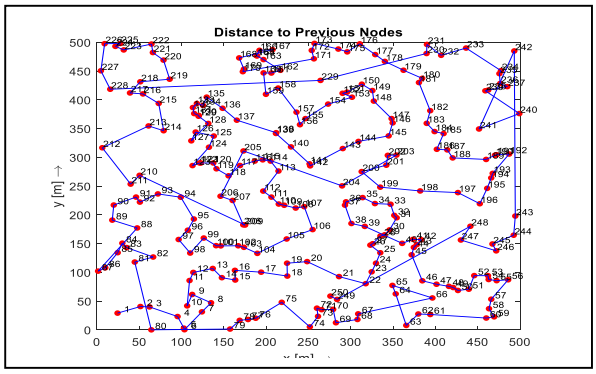


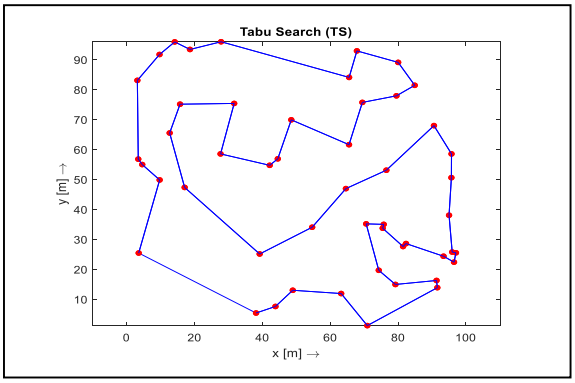
Fig. 4. Distance to previous nodes search approach for a) 50 nodes b) 100 nodes c) 150 nodes d) 200 nodes e) 250 nodes.

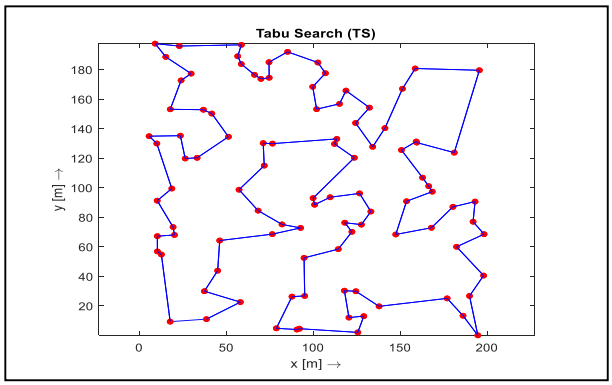
This approach has been motivated by three principles:1) a local minimum for one neighbouring node may not be a local-minima for another neighbouring node, 2) a global minimum is a local minimum for all conceivable neighbouring nodes 3) for many problem cases local minimum is comparatively close to global minimum.

2.4 Tabu Search

Tabu Search is an optimized global algorithm, a Meta or Meta heuristic strategy for governing an embedded experiential technique. Tabu Search is a mother of large number of derivative techniques that present memory assemblies in Meta heuristics. The motive of the Tabu Search approach is to oblige an embedded heuristic from recurring to lately visited areas of the exploration space, stated as cycling. The approach of an algorithm is to sustain a short-term memory of the explicit transitions of latest moves within the exploratory space and avoiding forthcoming moves from not doing those changes as depicted in Fig. 5.

a) b)





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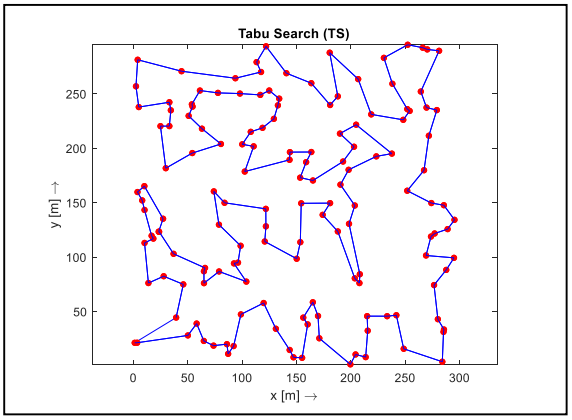
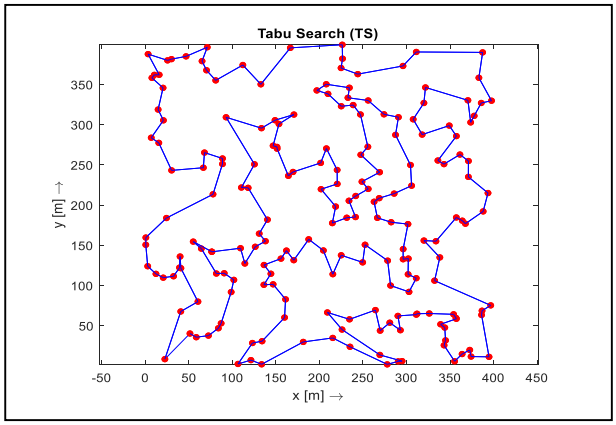




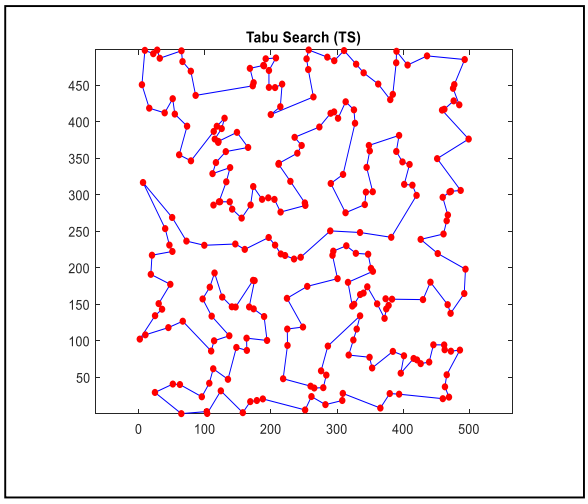
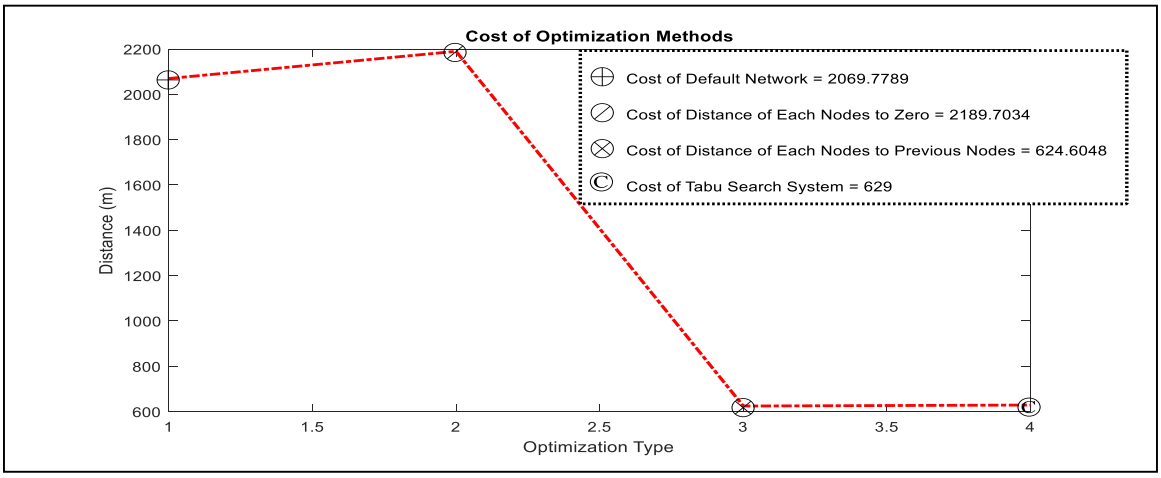


Fig. 5. Tabu search for a) 50 nodes b) 100 nodes c) 150 nodes d) 200 nodes e) 250 nodes.

3.Results and Discussion

Simulated results have been drawn for all the search algorithm approaches by considering 50, 100, 150, 200 and 250 node count, respectively and it has been revealed from Figure 6 that cost related with Distance to previous node has been minimum (i.e., 624.6048) in comparison to all other approaches followed by Tabu search algorithm for lower value of node count i.e., 50. Distance to zero search approach has been the least efficient technique as it costs highest (i.e., 2189.7034) out of all the approaches for lower node count. Further, Base search approach algorithm in which the nodes have been interconnected with each other outperformed Distance to zero search approach as it cost less in comparison to Distance to zero approach algorithm. However, for greater node value (≥ 100) Tabu search algorithm proved to be cost efficient in contrast to all other approaches as the cost associated with it has been minimum as shown in Fig. 6. Therefore, it is cleared that Tabu search algorithmhas been the most preferable technique in a real time scenario that has to be implemented in IoT devices.

a)



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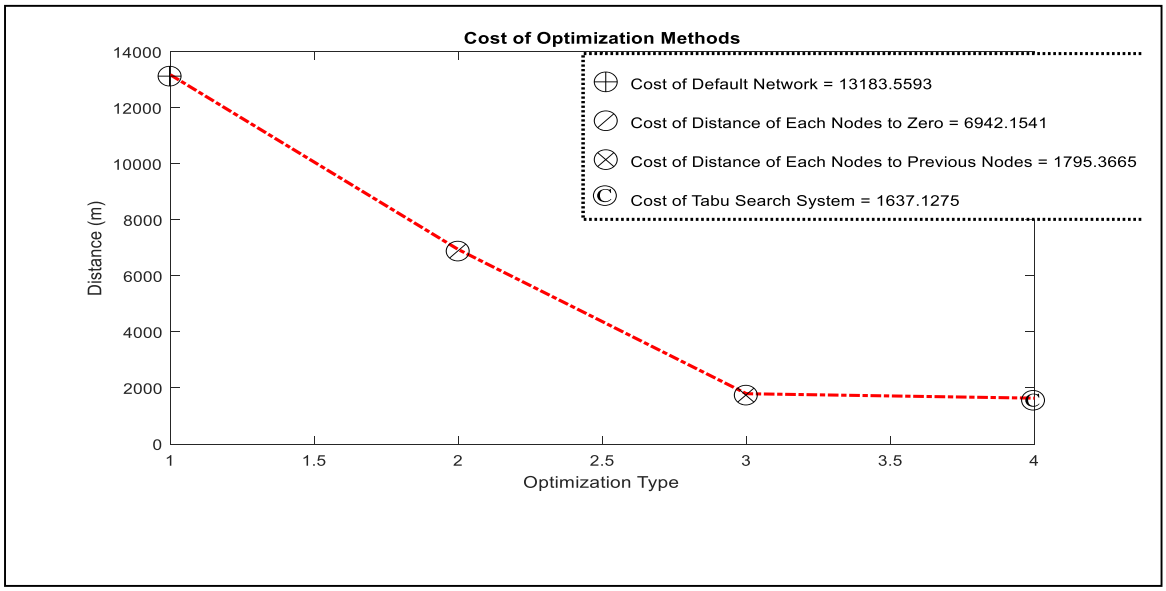
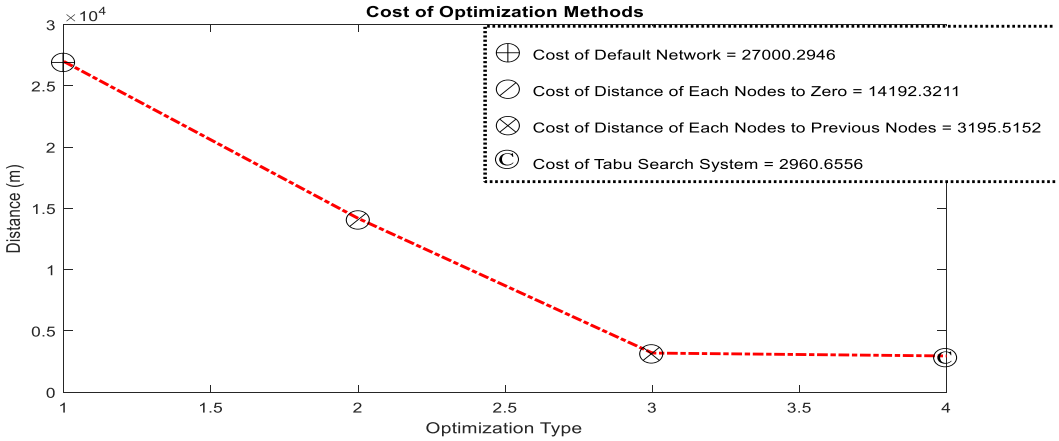
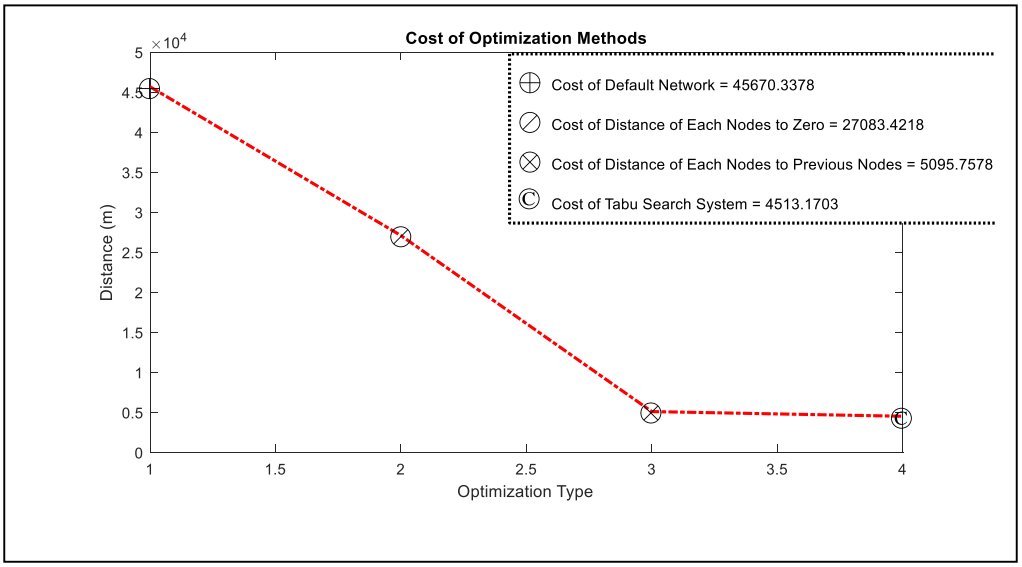

Cost of Optimization Methods
Cost of Default Network = 13183.5593
Cost of Distance of Each Nodes to Zero = 6942.1541
Cost of Distance of Each Nodes to Previous Nodes = 1795.3665
Cost of Tabu Search System = 1637.1275
Distance (m)
Optimization Type

c)


Cost of Optimization Methods
×10^4
Cost of Default Network = 27000.2946
Cost of Distance of Each Nodes to Zero = 14192.3211
Cost of Distance of Each Nodes to Previous Nodes = 3195.5152
Cost of Tabu Search System = 2960.6556
Distance (m)
Optimization Type

d)


Cost of Optimization Methods
×10^4
Cost of Default Network = 45670.3378
Cost of Distance of Each Nodes to Zero = 27083.4218
Cost of Distance of Each Nodes to Previous Nodes = 5095.7578
Cost of Tabu Search System = 4513.1703
Distance (m)
Optimization Type

e)

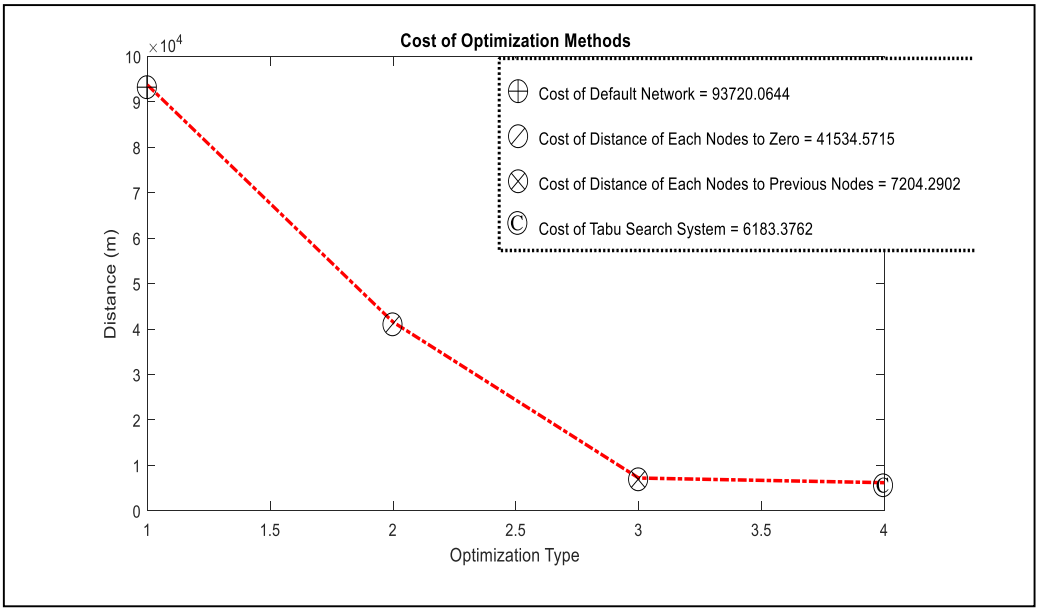


Fig. 6. Cost comparison simulated results for all algorithms for a) 50 nodes b) 100 nodes c) 150 nodes d) 200 nodes e) 250 nodes.

Different routing algorithm has been implemented in MATLAB R2019a. Further, results have been computed and reported in Table 1.

Table 1 Results of different optimization methods obtained with varying network size

Routing algorithm	Node count (n)	No. Of links = n(n-1)/2	Path cost
Base search	50	1225	2069.7789
	100	4950	13183.5593
	150	11175	27000.2946
	200	19900	45670.3378
	250	31125	93720.0644
Distance to zero search	50	1225	2189.7034
	100	4950	6942.1541
	150	11175	14192.3211
	200	19900	27083.4218
	250	31125	41534.5715
Distance to previous node	50	1225	624.6048
	100	4950	1795.3665
	150	11175	3195.5152
	200	19900	5095.7578
	250	31125	7204.2902
Tabu search	50	1225	629.00
	100	4950	1637.1275
	150	11175	2960.6556
	200	19900	4513.1703
	250	31125	6183.3762

4.Conclusion

The communication within mesh network has been more complex as the number of node increases. In present study, cost involved in calculating shortest path using different optimization techniques has been compared. Results revealed that for smaller node value Distance to previous node proved to be cost efficient

techniques among all other approaches whereas the cost has been maximum in case of Distance to zero search approach. Further, for greater node value Tabu optimization technique outperformed Distance to previous node algorithm approach as it established least cost function for greater node value. Finally, results motivated that Tabu search algorithm finds its applicability in IOT devices where it encounters with real time situations.

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