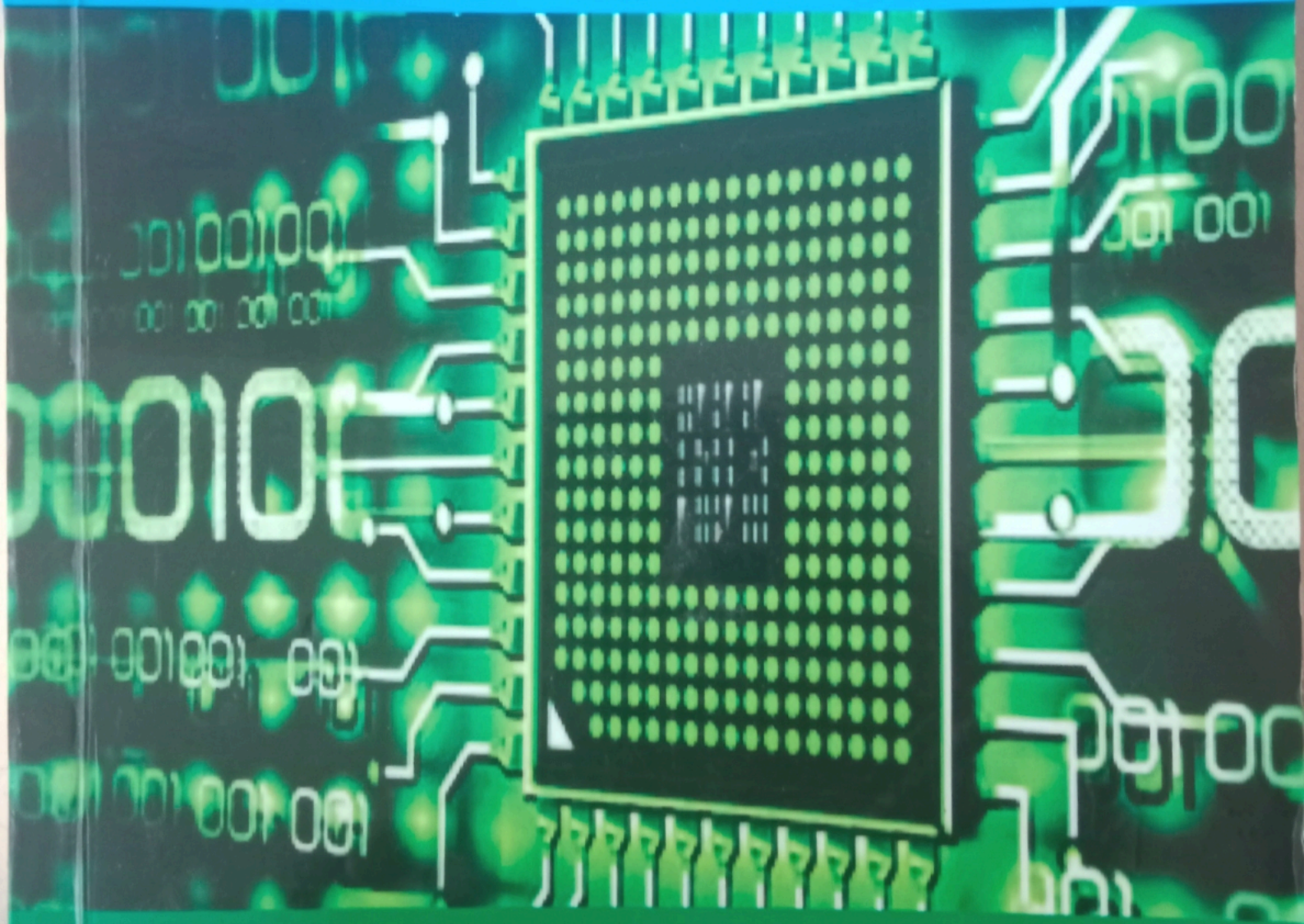
MULTICORE ARCHITECTURES AND PROGRAMMING



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Multicore Architectures and Programming

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Price: Rs.250/-

ISBN: 978-93-5361-325-9

Publisher: Self-Publishing

Printer:
Win Tech Computers,
Rajakamangalam Road,
Chettikulam Jn,
Nagercoil,
Tamil Nadu - 629 002.

Dedicated to

our

Beloved Parents

Preface

It gives us immense pleasure to publish the book titled "MULTICORE ARCHITECTURES AND PROGRAMMING". This book offers the fundamental and programming concepts of Multicore architectures and describes the differences between single-core and multi-core systems. It also addresses the parallel programming concepts and its challenges. This book has been framed as per the Anna University syllabus and can be used as text book for the students.

Organization of book:

Chapter 1: This chapter gives introduction to single-core and multi-core architectures. It describes the interaction between hardware and software in multicore machines. It also provides basic idea about parallel program design and explores the performance of parallel programs.

Chapter 2: This chapter deals with parallel programming challenges like synchronization and data sharing. It helps the students to understand various synchronization methods and coordination mechanism available on latest multicore machines.

Chapter 3: This chapter introduces OpenMP programming for shared memory systems. The directives and library functions used in OpenMP are explained in an understandable way. It enables the students to identify the challenges in writing efficient programs for shared memory architecture.

Chapter 4: This chapter introduces MPI programming for distributed memory systems. It helps the students to learn about various parallel programming paradigms like MPI constructs and library functions for distributed memory architecture.

Chapter 5: This chapter deals with the case study of n-body solver problem and tree search problem. Detailed implementations of these case studies using OpenMP programming and MPI programming also included. Comparison between OpenMP and MPI programming helps the students to understand the concept easily.

At the end of this book, possible two marks questions with answers and previous year Anna University question papers also included for the betterment of students.

Syllabus

MULTI-CORE ARCHITECTURES AND PROGRAMMING (CS6801)

UNIT I MULTI-CORE PROCESSORS

Single core to Multi-core architectures – SIMD and MIMD systems – Interconnection networks - Symmetric and Distributed Shared Memory Architectures – Cache coherence - Performance Issues – Parallel program design.

UNIT II PARALLEL PROGRAM CHALLENGES

Performance – Scalability – Synchronization and data sharing – Data races – Synchronization primitives (mutexes, locks, semaphores, barriers) – deadlocks and livelocks – communication between threads (condition variables, signals, message queues and pipes).

UNIT III SHARED MEMORY PROGRAMMING WITH OpenMP

OpenMP Execution Model – Memory Model – OpenMP Directives – Work-sharing Constructs - Library functions – Handling Data and Functional Parallelism – Handling Loops - Performance Considerations.

UNIT IV DISTRIBUTED MEMORY PROGRAMMING WITH MPI

MPI program execution – MPI constructs – libraries – MPI send and receive – Point-to-point and Collective communication – MPI derived datatypes – Performance evaluation.

UNIT V PARALLEL PROGRAM DEVELOPMENT

Case studies - n-Body solvers – Tree Search – OpenMP and MPI implementations and comparison.

Table of Contents

MULTICORE ARCHITECTURES AND PROGRAMMING

This book offers the fundamental and programming concepts of Multicore architectures and describes the differences between single-core and multi-core systems. It addresses various parallel programming techniques like OpenMP and MPI to increase program performance in multi-core architectures. The book is organized based on Anna University syllabus and it provides detailed explanation to understand the concepts. The main objective is to facilitate the parallel programming skills for shared and distributed memory architectures.Two marks question answers and Anna University question papers are also included, which will help students for better preparation.

ISBN: 978-93-5361-325-9

INTERNATIONAL CONFERENCE ON INNOVATIVE RESEARCH IN ENGINEERING, APPLIED SCIENCE & MANAGEMENT (IC-IREASM-2019)

Editors

Prof Dr. Md Sameeruddin Khan,
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Dr. Rajeev Shrivatsava,
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&
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Research Foundation of India
For Higher Education

First Edition, 2019

ISBN –**"978-93-89522-02-0"**

Price: Rs.540/-

Size: A4

Bibliographic Information:

Title

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RFI

Year:-2019

Research Foundation of India
For Higher Education

Publisher:

Publisher & Editor in Chief, RFI (registered under the government of India book Publication acts) India

Publisher's Address:

K185, Ground Floor Sarita Vihar, New Delhi 110076

Contact: 91-8770234905

Acknowledgement

*I would like to express my sincere gratitude to all the authors, researchers and reviewers, who provided their detail research and views for "**INTERNATIONAL CONFERENCE ON INNOVATIVE RESEARCH IN ENGINEERING, APPLIED SCIENCE & MANAGEMENT (IC-IREASM-2019)**". I would like to thank my Teacher family, who supported and encouraged me in spite of all the time it took me away from them. This book could see the light of day due to generous support from the **Research Foundation of India Publication**. This volume is wholly a collective venture. This cause would not have been possible without the great efforts paid by all the authors and I am sure their valuable contributions increased the significance of the book. The readers and beneficiaries vary from academicians, professional engineers and scientists, to undergraduate and graduate students from all over the country.*

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ENERGY EFFICIENT HETEROGENEOUS CLUSTERING &MAXIMIZATION ROUTING INWIRELESS SENSOR

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Abstract - Wireless Sensor Network (WSN) is one of the quickly rising area for research and development. WSN can be seen in various fields like environmental monitoring, battle field surveillance, border security surveillance, motion tracking etc. A main issue of research in WSN is to arrange the sensors with different capabilities like power, sensing range, communication range in wireless network and route the sensed data from the sensors to a sink with dynamism. Clustering is a key technique used to lengthen the network lifetime by decreasing the energy utilization. In clustered WSN, Routing the sensory data to the sink without obstacle is impossible. So eliminating the obstacle in the routing area is essential. In this paper, grouping the sensors into clusters by energy efficient heterogeneous clustering, that often selects the cluster head from the cluster. Cluster head is selected with respect to the nodes residual energy and other parameters like transmission range and number of transmissions. In this work the connectivity is concentrated by Route identification technique with the help of shortest path algorithm to reach the sink among obstacles. Connectivity in wireless network is considered as a measure of Quality of Service. We show that the proposed system reduces the energy utilization, average hop count and packet delay of heterogeneous WSN.

Keywords: Clustering, Connectivity, Routing, Wireless Sensor network, Energy, Network Lifetime.

1 INTRODUCTION

Wireless Sensor Networks consist of many small sensor nodes that are capable of sensing wireless communication. Sensor nodes are distributed and autonomous used for different applications like human motion tracking, medical science and military environmental monitoring etc. The region is distributed with autonomous sensors. Each sensor is capable of sensing and transmitting. Sensor node senses the environment as well as transfers the data to the sink node. Coverage depends on the sensing range as well as Connectivity of the node to reach sink depends on the communication range. Connectivity can be defined as an ability of the sensor node to sense the environment and transfer all the information through the network to reach the data sink (FIGURE 1).

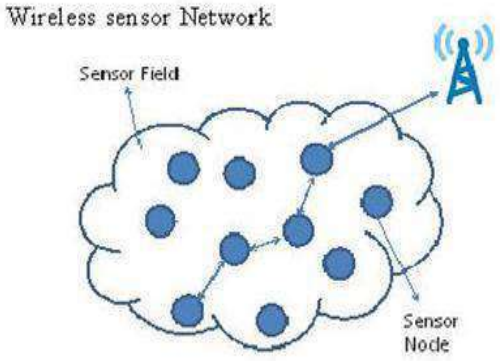

Figure 1.Wireless Sensor Network (WSN)

Heterogeneous wireless sensor network consists of different types of sensor nodes with different, communication range energy and sensing range. Each sensor nodes are battery powered (energy). Energy being the most important one because the battery present in the sensor node cannot be replaced often. The node has a non-rechargeable battery which is impossible to replace batteries in most sensor fields. To lengthen the lifetime of the WSN, clustering is the key technique. Clustering will dynamically re-assign the member nodes in the cluster. Therefore, the network disconnection due to energy drain out nodes can be avoided. Energy consumption of the sensor node is reduced to increase the lifetime of the network. Only some work are focused on lifetime maximization in heterogeneous WSN. The paper is organized as follows: In chapter I, addressed about the introduction and issues in WSN. Related work, methodology and issues. discussed about the proposed system. Deals with the methodologies used to maximize network lifetime Results and Discussion. Conclusion of the paper. At the end is the list of references.

2 RELATED WORKS

Clustering used to extend the lifetime of a sensor network by reducing energy consumption. Connectivity is the very essential attribute for data transmission. Clustering also increases network scalability. Researchers in all fields of wireless sensor network believe that nodes are homogeneous, but some nodes may be of different energy to prolong the entire lifetime of a WSN and its reliability. A distributed approach to determine if a sensor in WSN is a cluster head to meet the preferred connectivity requirements [1]. Cluster based routing in WSN is used to reach network scalability and maximize lifetime [2]. The existing methods for prolonging the lifetime of WSNs focuses on the issues of device placements [3], data processing [4], routing [5] and topological management [6]. In[7]Energy aware algorithm for the selection of sensor and to identify the relay node. Shortest path algorithm is used for choosing the path. In [8] ABC Based Sensor Deployment. Schedule the sensor nodes to achieve network lifetime. Target coverage is provided. Maximized coverage not provided for heterogeneous type of network.On observing the existing work, the techniques are applied only in the homogeneous type of WSN and not in the heterogeneous network.

3 PROPOSED WORK

In the proposed work, to reduce the energy consumption and to maximize the network lifetime an Energy efficient Heterogeneous Clustering (EHC) technique and a Route identification technique in clustered WSN among obstacles are used. Sensor network are often deployed in remote areas. As the energy capability of the nodes is restricted and battery powered, some method are introduced to preserve energy to avoid node failure. Clustering is one of the key and old concepts for energy consumption and to increase the lifetime of a sensor node in a network. After deployment of the sensor nodes randomly in the region of interest, each sensor nodes in the field try to form as a cluster. Each node only interacts with a small set of sensor nodes within the transmission range. At the beginning all the nodes are not clustered. Each node in the clustering process use different types of messages like Broadcast message, State message and Join message.

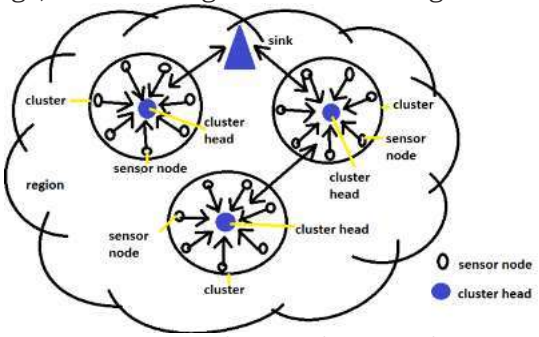

Figure 2.Clustered Networks

Each node broadcasts a message to all its neighbors. According to the number of received messages and with respect to the residual energy and delay the node will decide by itself to be a cluster head. The node with high residual energy will have less delay. Once the delay expires the node will give a state message to its neighbors as a cluster head. All other nodes will give a join message and form as a cluster (FIGURE 2). Each cluster head can form a connected network. Cluster head will communicate with sink node and transfers data. Energy efficient heterogeneous clustering is the proposed technique which works with the heterogeneous type of sensor nodes. Here heterogeneity means the nodes with different energy level, transmission range, sensing range etc. are grouped as a cluster. EHC form a clustered WSN. It performs the cluster formation and the cluster head identification in a distributed manner. Route identification technique with shortest path algorithm which avoids obstacles is used to identify the shortest route to reach the sink node for communication (FIGURE 3). After routing path has been established by cluster heads it will form a connected network. The cluster head identification should be changed time to time dynamically to increase the network lifetime. This dynamic cluster formation will reduce the energy consumption and increase the network lifetime.

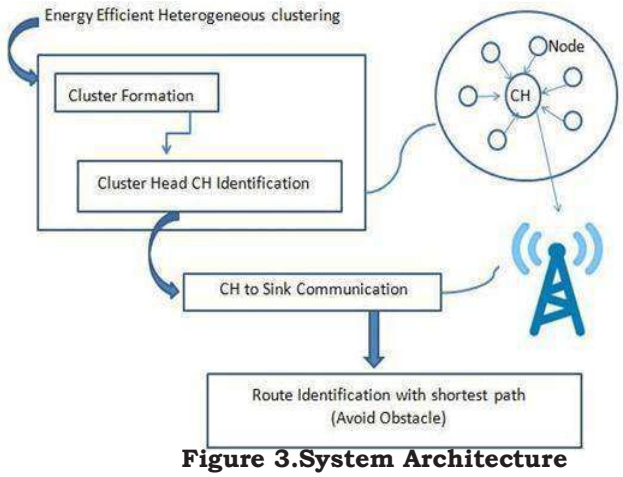

Figure 3.System Architecture

In this paper, the lifetime of the network is the time from the start of the network operation till the death of the first sensor node in the network. The lifetime of the WSN is divided into trips to balance the energy usage among sensor nodes. At the start of the trip, each and every sensor involves in the cluster formation and cluster head election using EHC. Each sensor sense the data and forwards it to the cluster heads, which in turn routes the data to the sink node using route identification technique.

4 METHODOLOGIES

4.1 Energy efficient Heterogeneous Clustering

The sensor nodes are distributed randomly on the sensing field. Energy efficient Heterogeneous Clustering (EHC) will form the cluster and cluster head identification in a distributed approach.

4.2 Cluster Formation:

After deploying the sensor node n in theregion of interest. The node in the region will makes decision independently. Clustering is a key technique toform cluster and is completely distributed. The nodes in the field are formed as a small region called cluster. And each cluster will elect a node as a cluster head. Steps to form a cluster and cluster head identification is discussed in the cluster head identification phase.

4.3 Cluster Head CH identification:

In this work, n nodes arerandomly deployed in the network. Each nodehas initial energy E(i), transmission power P(Tx) and other required parameters by the time they are deployed. The main purpose of the cluster head CH selection is to determine the normal nodes and the cluster head in the network. Every cluster head should be connected with the sink node directly or through some another CH. Now the competition is set among each node that is qualified to be a CH. Node can be identified as a CH only when it has a high residual energy E(r) and with less delay D.Initially each node is given with E(i) and P(Tx) as input. Process each node separately in each trip.

Step 1:
For current node C(n), in the current trip C(r) calculatethe number of transmissions n(Tx) while sending the broadcast message to all the neighbor nodes. This broadcast message is given to say the neighbor about the survival of the node. The n(Tx) can be calculated as the number of node count each node receives.

Step 2:
For the current node C(n) calculate the residual energyE(r) with E(i), P(Tx) and n(Tx) as input with the following formula.

$$( ) = ( ) - [( ) * ( )]$$

Step 3:
Calculate the Energy Consumption Rate ECR for C(n)with E(i), E(r) and the Current Trip CR as input.

$$= ( ) - ( ) - 1$$

Step 4:
Calculate the Delay D for C(n) with E(i), E(r), random number x which can be 0 or 1 and the Round Trip Delay RTD.

$$= ((( ) - ( )) +) * ( )$$

Step 5:
Repeat the steps for all the nodes. By doing this the node with high residual energy and with less delay will be identified easily.

Identify the cluster head CH (broadcast message)

```
Input initial energy E(i), transmission power P (Tx)
Begin
for each node (Current node C(n))
{
  For each round (Current trip C(r))
    {
      Calculate number of transmissions n(Tx);
      Calculate the residual energy e(r) with E(i), p(Tx), n(Tx);
      Calculate Energy Consumption Rate for C(n);
      Calculate delay D for C(n);
      }
}
Pick Random Number x in (0,1);
Assume P(D), Q(D) as delay of First node, Second node;
Process all the nodes;
For each node
    {
      Compare p and q and capture the less d node;
       If (P(D)<Q(D) && high E(r));
```

```
      {
P(D) with less D;
       Node announces itself as CH to nearest nodes;
       }
       Else
       {
P(D) with high D;
         With act as normal node;
         }
    }
End;
```

Figure 4.Identification of the Cluster head

Consider two nodes for assumption P, Q. Let P(D) and Q(D) be the delay of first node and the second node. If P(D) is less than Q(D) then P will announce itself as CH to Q. Else the delay is higher and P will act as a normal node in the cluster (FIGURE 4). The node with higher E(r) will have less delay. So the higher E(r) nodes delay will expires soon and it will give the state message as CH to the neighboring nodes. Now the other nodes will give a join message to the CH and acts as a normal node. Thus the cluster is formed and the CH is identified. After sometime, CH will be re-elected with respect to a threshold value THv. This is done dynamically time to time.So that the nodes will not drain its energy so soon and go under death. This will increase the network lifetime and reduce the energy utilization.

4.4 Route Identification Technique

Cluster head is identified and it is allowed to communicate with the Sink S to form a connected network.

Network Connectivity: Connectivity is considered as ameasure of quality of service. In order to avoid disconnection with the nearest nodes. The connectivity depends on the communication range and should identify the shortest path to during data transfer, the node has to maintain its connection Reach the sink.

Route Recognition: For identifying the shortest route toreach the sink, initially input the clustered WSN. Consider n is a node, for each n with the help of the graph method send data to the CH. If n is a cluster head send data to the sink S. If the CH does not has the nearest node as the sink node then send the data to the nearest CH to reach S. If n is an obstacle, avoid the obstacle and apply the shortest pathalgorithm (Dijkstra) to reach the sink node with shortest path. Consider the clustered network as a Graph G and take a node as Source src. Assume the node as the vertex v. For each vertex in G, assign the distance as infinity, distance to src as zero and the current cost to be infinity. Starting nodes distance is permanent and for all other nodes it's temporary. U is the node with smallest distance. Q is the set of all nodes in the graph G. If a calculated distance of a node is smaller as the current one, update the distance and set the current node as previous node. Set the node with minimum temporary distance as active. Set its distance as permanent. Repeat the process to identify the shortest route to the sink node from each CH (FIGURE 5)

Route identification technique

```
Input clustered wsn
For each node
 {
  If ( n is a node )
     {
       Send data to cluster head CH;
     }
Else if ( n is a CH )
     {
       Send data to nearest CH or sink S;
      }
     If ( n is an obstacle )
       {
```

```
        Apply SPA on vertex ;
        Function Dijkstra( graphG; source arc )
        For each v in G
Distance(v) = 8;
Previous(v) = undefined;
Distance(src) = 0;
          Q = all nodes in G;
          While ( Q is not empty )
             {
             U = node in q with smallest distance(u);
            Remove u from Q;
            For each nearest node v of u
                {
                  a = distance(u) +  distance between(u,v);
if (a < distance (v))
                   {
Distance(v) = a;
Previous(v) = u;
                     Return previous();
                    }
                }
Else
 {
  Send data to nearest CH or sink S;
 }
 Else
 {
Identify n;
 }
```

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