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An Routing Algorithm in Wireless Sensor Networks Using Cluseter Tree Topology

Dr. K. Kumaravel[1] , Dr.M.Sengaliappan[2]

[1]Professor & Head, Department of Computer Science, Dr.N.G.P. Arts & Science College, Coimbatore
[2]Prof & Dean, Department of Computer Science, Kovai Kalaimaghal Arts & Science College, Coimbatore.

1. INTRODUCTION

At present, there has been a mounting requirement for connectivity between the distributed devices employed for remote instantaneous monitoring and control.

This requirement and the development in electronics and wireless communications have encouraged the growth of Wireless Sensor Network (WSN) technology as explained in Alwan& Agarwal (2009). A WSN is an integration of embedded system technology together with sensor technology, distributed computing and wireless communication technology. They allow superior grain inspection of the ambient surroundings at an inexpensive cost much lesser than currently possible. In case of hostile surroundings where human involvement may perhaps be too hazardous, sensor networks might offer a robust service. Sensor networks are intended to send out data from an array of sensor nodes to a data storehouse on a server. The developments in the integration of Micro-Electro-Mechanical System (MEMS), moreover Microprocessor and Wireless Communication technology have facilitated the use of large-scale WSNs. WSN has the adequate power to design several new applications for the purpose of managing emergency, military, and tragedy relief processes that necessitates real time information for effective coordination and planning.

Sensor nodes have the potential of sensing, data processing, and transmission, which facilitate instantaneous monitoring of the phenomenon of attention, and control by actuators inside a large-scale area by collaborating with each other as discussed in Megerian & Potkonjak (2003) WSNs possibly will include numerous categories of sensors like thermal, magnetic, seismic, infrared, visual and acoustic radar, capability to supervise an extensive variety of ambient circumstances. Despite the fact that every individual sensor possibly will have severe resource restriction in terms of memory, communication, energy and computation capabilities; huge number of them might together observe the physical world, distribute information upon critical environmental occurrences, and process the information on the fly as discussed in Akyildiz et al (2002).

The major characteristics of sensor networks comprise low energy consumption, low cost, cooperative effort and self-organizing operation as mentioned in Lambrou & Panayiotou (2009). These characteristics make it feasible to organize sensor nodes in harsh and unreachable surroundings, at the same time achieving long lifetime operation with the help of batteries and solar panels as the energy supply. The characteristics described above allow an extensive range of potential applications for WSNs, like industrial control and monitoring, precision agriculture, home automation, health and environmental observation. The overview of the WSN architecture is portrayed in the figure 1.1.

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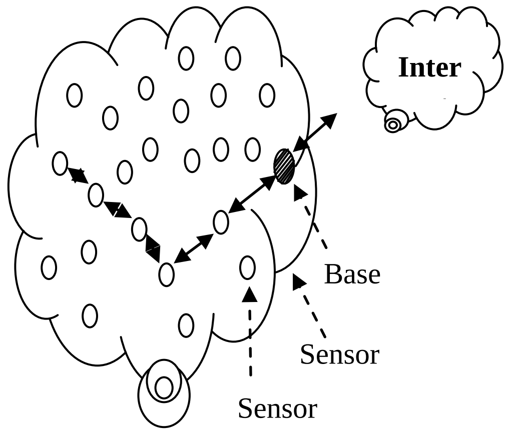

Figure 1. An Overview of a WSN

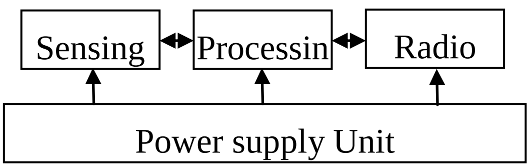

Figure 1.1 The Components of a Sensor Node

A sensor node normally includes a processing unit, a sensing unit, a radio frequency transceiver unit and a power supply unit. Figure 1.2 illustrates the component chart of a sensor node. In case of the processing unit, which typically incorporates an on-board microprocessor and also memory, manages the function of the other units and executes simple data processing. In case of the sensing unit, the sensors are linked to the processing unit by means of analog-to-digital converters, which transform the analog signals produced by the sensors into digital signals that the microprocessor can understand. The radio frequency transceiver unit is the gateway that swaps over data with other sensor nodes by means of a wireless communication channel. These components might possess different features in terms of input voltage and current utilization, and the power supply unit offers the suitable voltage and current intensities. In case of the power supply unit, energy storage constituents (e.g., a battery) are adjusted by the appropriate electrical circuitry and energy harvesting constituents (e.g., a solar panel). In accordance with the particular application, other units can be too added to the sensor node, like a location finding system and a mobilize, as discussed in Chalhoub & Mission (2010) which maintain the request for precise geographical information and the mobility of a sensor node, correspondingly.

1.1. Elements and Features of Sensor Networks

Despite the fact that modern research on sensor networks initiated on the late seventies, WSNs obtained an identity of its own at the commencement of the 21stcentury. Modern sensor networks can be regarded as living beings, typically born (configured) in a controlled atmosphere, where the entire nodes are cells that work unselfishly in the direction of a common goal. These nodes can work separately and are capable of carrying out several operations. The complete structural design of a WSN is extremely based on its intended functionality. An additional appropriate feature of these networks is that no human user straightforwardly manages the nodes: they are typically accessed through the Base Station (BS). At last, WSN are typically long-lived, and the sensor nodes might have inadequate mobility as explained in Woungang et al (2009).

Based on a technological point of view, a WSN is largely composed of two categories of devices: sensor nodes and base stations. The sensor nodes, in addition regarded as motes or just nodes, are small and constrained devices furnished with hardware sensors, microcontrollers, transceivers and batteries. Hardware sensors are employed to sense the physical characteristics of the environment (e.g. temperature, radiation, humidity, vibration). Micro controllers are extremely confined in both computational power and memory, however nodes are potential enough to process information on their own. Wireless transceivers facilitate nodes to work together in the direction of a common objective, like routing the information to a BS. At last, several nodes are battery-powered as a result they can stay alive in their deployment field for in excess of a year, when their internal functions are optimized.

The BS is an extremely powerful device that performs as a front-end among the services offered by the sensor nodes and the users of the network. At the same time it would seem that WSN are extremely based on the existence of this BS, the structural design of the network is not centralized. The nodes operate in a decentralized manner, managing them without accessing the BS. In reality, there are certain particular networks, regarded as unattended sensor networks, in which the BS is only available at certain moments over time. However, the BS typically plays a significant part on the overall behavior of WSN. In general, a BS gathers the entire information coming from the sensor nodes and accumulates it for later exploitation. In addition, it possibly will issue control information's to the sensor nodes with the intention of changing their behavior.

The network structural design of a WSN can be arranged in an entirely distributed way (at configuration);however it can also execute levels of hierarchy (hierarchical configurations). In case of sensor network configurations the entire nodes contribute in the decision-making process and take part in internal protocols like routing. On the subject of the services offered by WSN, they can be categorized into four major groups: alerting, monitoring, provisioning of information on-demand, and actuating. Because of the computational potentials of the sensor nodes, it is moreover feasible to re-program the network at some point in its lifetime, or might use it as a distributed computing platform under particular conditions.

- **Monitoring:** Sensor nodes can incessantly observe certain characteristics of their nearby places (e.g. computing the ambient noise level) and timely transmit these information to the BS.
- **Alerting:** Sensor nodes can confirm whether certain physical incidents are taking place, alerting the clients when an alarm is activated.
- **Information on-demand:** The network can be queried regarding the definite levels of a certain characteristic, offering information at any time the user requires it.
- **Actuating:** Sensor nodes can be capable of transforming the behavior of an exterior system (for instance, an irrigation system) in accordance with the actual state of the context (for instance, humidity of the soil).

There have been several experimental applications (starting from environmental observation to smart atmospheres) generated by the research community that take benefit of the previously discussed WSN services. For instance, sensor nodes are extremely helpful in the application of precision agriculture, in which they can enhance the quality of the crops by means of actively managed irrigation. In addition, a particular application that has drawn the attention of the industrial community is nuclear power plant observation, where sensor nodes can offer instantaneous information of the radiation intensities of both workers and physical configurations of a nuclear power plant. The possible marketplaces for WSN are expected to be boosted considerably in the subsequent years, primarily because of the recent progresses in the field. This guess is completely depends on the rapid adoption of WSN in the fields mentioned above at some stage in the last few years.

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1.2.Architecture of Wireless Sensor Network

A communication network includes a number of nodes, each of which possess certain computing power and can send out and receive messages over wired or wireless communication links. There are numerous network topologies for the utilization of communication networks and comprise completely connected, star, mesh, tree, ring, and bus. A single network possibly will comprise of numerous interconnected subnets of different topologies.

Star Topology

In case of star topology, as illustrated in Figure 1.3,the entire nodes are linked to a single distinctive node which works as a Personal Area Network (PAN) coordinator (PC).

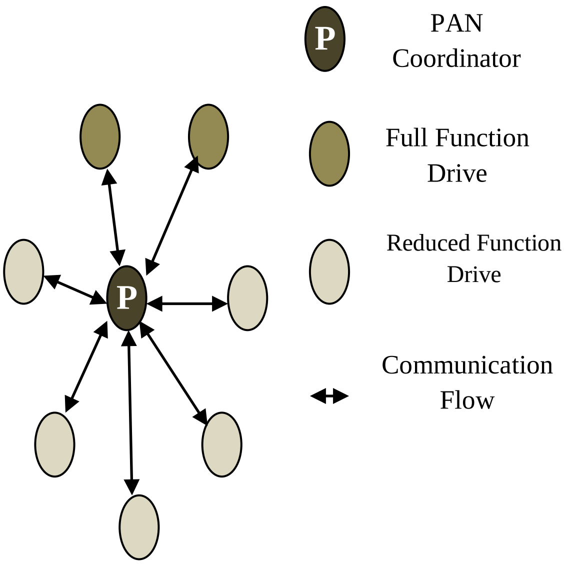

Figure : Star Topology Model

The PAN needs better message treatment, routing, and decision-making potentials than the remaining nodes. Every device eager to link the network and converse with other devices has to send its data to the PAN coordinator, which is subsequently transmitted to the destination devices. When any communication link is not working, it only influences one node however when the coordinator is not working, the complete network is demolished. Any node chosen as a PAN coordinator will obtain its battery resources quickly devastated. Taking these concerns into account, the IEEE 802.15.4 standard suggests the Star Topology for applications like home automation, toys, personal computer peripherals and games.

Ring Topology

In case of the ring topology illustrated in Figure 1.4,the entire sensor nodes execute the similar function and there is no coordinator node.

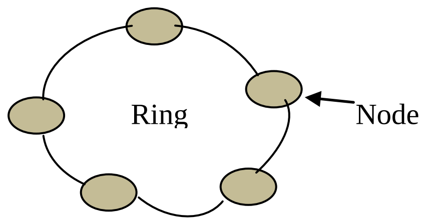

Figure: Ring Topology

Messages normally move around the ring in a single direction. However, when any link of the ring is broken, the complete communication is will not work.

Bus Topology

In case of the bus topology illustrated in Figure 1.5, the data messages will be passed on the bus to the entire nodes. If the node receives any messages, it initially verifies the destination address in the message header and subsequently makes a decision whether the message is for itself or some other node. Here, each node justpays attention to the data messages and is not accountable for retransmitting any messages when any message is lost, as a result being a passive topology.

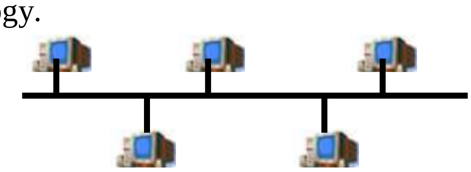

Figure: Bus Topology Model The Peer-to-Peer (Mesh) Topology

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The peer-to-peer or mesh topology illustrated in Figure 1.6 comprises a PAN coordinator, which will be the primary device to converse on the channel. The nodes in these kinds of networks are normally indistinguishable, and they are also known as peer-to-peer. In case of this topology, the communication is not consolidated and every device can openly converse with any other device in its radio limit. In view of the fact that there are numerous routing paths among nodes, the mesh topology is robust to breakdown of individual nodes or links and facilitates enhanced network flexibility. Here, the data will be directed in an ad hoc approach hopping from one device to other until it arrives at the destination. The major benefit of this topology is, even though the entire nodes might be comparable and have the similar computing and transmission capabilities, certain nodes can be assigned as 'group leaders' that take on supplementary functions.

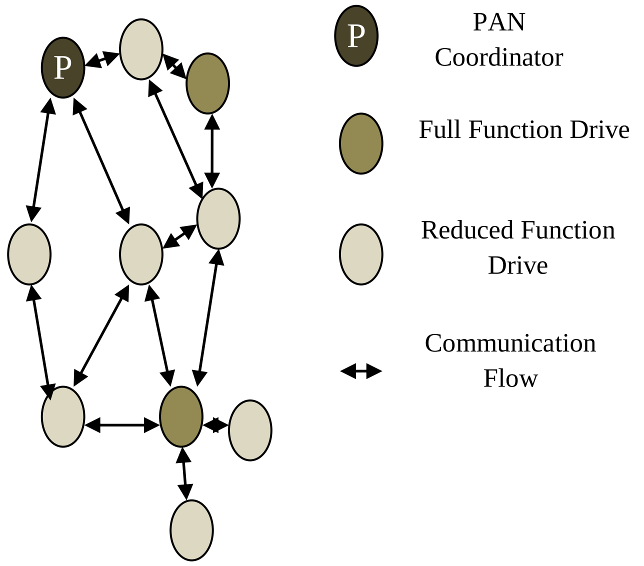

Figure : Peer-to-Peer Topology Model

When a group leader is halted, an additional node can subsequently take over these functions. On the contrary with the star topology, the resource procedure is better in the peer-to-peer topology, because the communication process does not based on a specific node.

The Cluster-Tree Topology

The Cluster Tree topology as explained in Koubaa et al (2005), illustrated in Figure 1.7 is a special case of a peer-to-peer topology where the most of the nodes are Full Functional Devices (FFD). Among them only one of them will be recommended as the PAN coordinator for the purpose of recognizing the network. This coordinator synchronizes with the entire remaining nodes and coordinators in the network. The Reduced Function Devices (RFD) will subsequently link to this cluster tree at the closing stages of a branch and links with only one FFD.

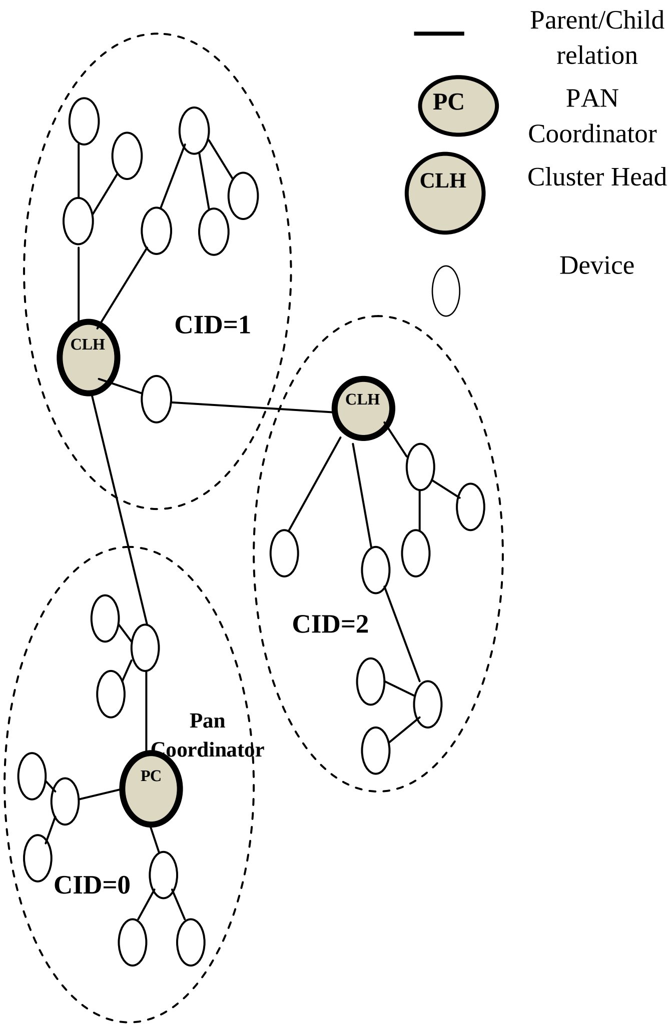

Figure: Cluster Tree Topology

The initial cluster is generated by the PAN coordinator through designating itself as CLuster Head (CLH) with a Cluster Identifier (CID) value of 0. The coordinator then selects an unexploited PAN identifier and broadcasts beacons to the entire neighboring devices. Some device which obtains the beacon can connect the network by means of requesting the CLH. When the coordinator allows this request, it appends the requesting device like the child in its neighbor list. Consecutively, the recently joined device appends the CLH as its parent in its neighboring list and initiates transmitting beacons. Any other devices who obtain these beacons might join the network at this device. When in the scenario, the requesting device cannot connect the network at the CLH, it will seek out for another parent device. In case of a large-scale Wireless Network, a mesh of multiple neighboring clusters can be produced.

1.1.3. Clustered Wireless Sensor Network

The WSNs are commonly grouped by means of the clustering schemes for enhanced efficiency and protected data transmission. By means of clustering scheme, nodes are grouped into clusters, and inside each cluster, a node with tough computing power is chosen as a Cluster Head (CH). CHs jointly form a upper-level backbone network. Subsequent to numerous recursive iterations, a clustering scheme builds a multilevel WSN structure. This formation eases communication and permits the restriction of bandwidth-consuming network processes like flooding only to the intended clusters. Within a cluster the entire organizational decisions, like data aggregation, are done by a single entity known as Cluster Head (CH). It is to be observed that it is also feasible to have an integration of the two preceding configurations into the similar network; for example, in order to keep away from circumstances where the spinal cord of the network - the CHs - stops working and the information must be directed to the BS.

As discussed earlier, sensor nodes are primarily employed for the purpose of monitoring the surroundings and alerting the BS by transmitting the collected data's. In case of Clustered Wireless Sensor Network (CWSN), the CH nodes are primarily exploited for monitoring the data transmissions and sustaining the remaining cluster members efficiently.

1.1.4 Wireless Sensor Network Technologies

At present, research interest is mounting from both engineering and academia to discover the different practical applications with the use of emerging technologies as mentioned in Shen et al (2008). There are numerous benefits and disadvantages of modern IEEE Wireless Network technologies, including 802.11x Wireless Local Networks (WLAN) (Wi-Fi), and 802.15.x Wireless Personal Area networks (WPAN) (Bluetooth, UWB and ZigBee).Wi-Fi association is a specification for IEEE 802.11 WLAN standards.

It functions in the license-free 2.4 GHz Industrial, Scientific, and Medical (ISM) band. It offers wired LAN extension or substitution in a range of market fields, e.g., home, enterprise, and hot spots. The most common benefits of Wi-Fi, comprise economical solution, broad coverage with uncomplicated availability and stability with robustness.

The Bluetooth is a limited wireless connectivity application for portable, personal, and handheld electronic devices. In addition, the Bluetooth radio operates on the 2.4 GHz ISM band. It makes use of a quick, Frequency-Hopping Spread Spectrum (FHSS) technology to keep away from the interference in the ISM band and guarantees the consistency of data

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2. ROUTING IN WIRELESS SENSOR ETWORKS

communication in hand-held gadgets and wireless computing, it is employed for the purpose of local positioning. Resembling to Wi-Fi, Bluetooth can offer several meters of localization exactness depending on the popular Received Signal Strength Indicator (RSSI) methodology.

Ultra Wideband (UWB) technologies can be employed to send out exceedingly short and low power electromagnetic pulses. The radios make use of frequencies from 3.1 GHz to 10.6 GHz, with the radio spectrum distributing over an extremely broad bandwidth. The benefits of short-range high-bandwidth UWB comprise elevated immunity to interference from other radio systems, high multipath immunity, huge data rate and fine range resolution capability as mentioned in Bensky (2004). UWB has also been employed in precision radar imaging and localization as explained in Yua et al (2006).

ZigBee represents a global medium for WMS that addresses distant monitoring and manage applications. The most significant characteristics of ZigBee are extremely low power utilization, low data rate, small complexity; and elevated consistency and security. Zigbeee dependent WSNs are employed in numerous applications, like habitat and wildlife observation, intrusion detection and war field supervision as explained in Paolo et al (2007).

Routing in WSN is one of the most active research areas and several works have been carried out in this area. Even though, several works are being introduced by research community, still there is scope for improvement. The present research work is concerned about the efficient routing approach in WSN. The next section discusses about routing in WSN.

Routing is a method of deciding a path among source and destination upon demand for data transmission. In view of the fact that, data transmission from the target region towards the sink node is the major task of WSNs, the utilized scheme to transmit data packets between each pair of source-sink nodes is a significant issue that should be concentrated in developing these WSNs.

In case of WSNs, the network layer is typically employed to execute the routing of the incoming data. It is found that in general in multi-hop networks, the source node cannot arrive at the sink directly. As a result, intermediary sensor nodes have to pass on their packets. The accomplishment of routing tables provides the solution. These include the lists of node alternative for any particular packet destination. Routing table is the process of the routing scheme together with the assistance of the routing protocol for their creation and maintenance.

Owing to the inherent characteristics of low-power WSNs, routing in these networks is extremely challenging compared to the conventional Wireless Networks as discussed in Akkaya &Younis (2005). Initially, in accordance with the high density of sensor nodes, routing protocols are supposed to be capable of supporting data transmission over long distances, irrespective of the network size. Additionally, certain active nodes possibly will stop working at some stage in network operation because of energy weakening of the sensor nodes, hardware collapses or environmental issues, however this issue should not disrupt the standard network process. Furthermore, as sensor nodes are forcefully inadequate in terms of memory capacity, processing capability, power supply and available bandwidth, routing and data dissemination must be executed with efficient network resource utilization. Moreover, because the performance

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requisites of the WSNs are application specific, routing protocols must be capable of satisfying the QoS requirements of the application for which the network is being installed. For instance, confronts in building routing protocols for time oriented applications (e.g., disaster management and target tracking) are different from concerns that should be considered in developing routing protocols for supplementary applications like habitat monitoring.

In accordance with the aforementioned distinctions between WSNs and Conventional Wireless Networks, several routing protocols were formulated over the recent decades to tackle the routing challenges forced by the new characteristics of sensor networks. In Al-Karaki & Kamal (2004) categorized the existing routing protocols in WSNs based on two different viewpoints: (1) network structure and (2) protocol operation. Based on the network structure, routing schemes are further categorized as flat, hierarchical and location-based routing protocols. Flat routing scheme are intended for networks with homogenous nodes, i.e., the entire the network nodes have the similar processing and data transmission potentials at the same time as packet forwarding role is also similar. Directed Diffusion is discussed in Intanagonwiwat et al (2000), Sensor Protocols for Information via Negotiation (SPIN) as discussed in Heinzelman et al (1999), Rumor Routing is explained in Braginsky, & Estrin (2002), Minimum Cost Forwarding Algorithm (MCFA) is explained in Ye et al (2001), and Energy-Aware Routing (EAR) is explained in Shah & Rabaey (2002) can be embraced in this group.

In accordance with the uncomplicated structure of the flat network structural design, this group of routing protocols expresses numerous advantages like the low overhead of topology maintenance and the capability of multipath discovery. Hierarchical routing protocols were initially formulated to enhance the network scalability and energy effectiveness by means of node clustering. In this kind of routing schemes, the entire sensor nodes are grouped into clusters and one node with extra resources in each cluster is allocated as the CH. Each CH is accountable for processing the received data packets from its nearby cluster nodes, conversing with remaining CHs or the sink node, and organizing the cluster nodes. On the contrary, the entire the cluster members must sense the environment and transmit their gathered data towards the relevant CH for further processes. Even though this scheme can offer elevated network scalability, clustering task and CH substitution (which is necessary to avoid fast energy reduction of the CHs) force high signaling overhead to the network.

Numerous routing schemes like Threshold-Sensitive Energy-Efficient Sensor Network Protocol (TEEN) is explained in Manjeshwar & Agrawal (2000), Adaptive Periodic Threshold-Sensitive Energy-Efficient Sensor Network Protocol (APTEEN) is explained in Manjeshwar& Agrawal (2002), Low-Energy Adaptive Clustering Hierarchy (LEACH) is explained in Heinzelman et al (2000), Power-Efficient Gathering in Sensor Information Systems (PEGASIS) is explained in Lindsey et al (2002) and Two Tire Data Dissemination (TTDD) come under in this group. Routing schemes in the last category make use of the accurate location of the sensor nodes to construct routing decisions.

The geographic positions of sensor nodes can be acquired directly by means of Global Positioning System (GPS) devices or indirectly by means of exchanging certain information about the signal strengths obtained at each node. On the other hand, since localization support necessitates particular hardware constituents and forces considerable computational overhead to the sensor nodes, this scheme cannot be simply employed in resource-constrained WSNs. Geographic and Energy-Aware Routing (GEAR) is explained in Yu et al., (2001) and Geographic Adaptive Fidelity (GAF) is explained in Xu & Heidemann (2001) can be indicated as the geographic routing protocols.

In accordance with the protocol operation perception, the entire existing routing protocols in the aforementioned groups can be further categorized into query-based, QoS-based, multipath-based, coherent-based and negotiation-based protocols. The major inspiration in the design of negotiation-based routing protocols is to offer energy-efficient communication by means of reducing data redundancy at some point in data transmission. In this category of protocols, every sensor node appends a high-level data description to its gathered data and executes certain negotiations with its neighboring nodes to eradicate duplicated data packets. In case of the query-based routing schemes, a sink node spreads a query message all the way through the network concerning the desired sensing task. When a node senses some associated information, it propels back its collected data in the direction of the sink node through the reverse path. Directed Diffusion and Rumor Routing are two instances of the primary query-based routing protocols.

The third group of routing schemes (i.e., QoS-based routing schemes) is primarily intended to meet QoS requirements of different applications (e.g., reliability, delay, and bandwidth). The major intention of these schemes is to set up a trade-off among energy utilization and data quality. Sequence Assignment Routing (SAR) scheme is explained in Sohrabi et al (2000), SPEED, Multipath Multi-SPEED (MMSPEED) is explained in Tian et al (2003), Energy-aware QoS Routing Protocol is explained in Felemban et al (2006) and Delay-minimum Energy-aware Routing Protocol (DERP) is explained in Akkaya &Younis(2003) can be recognized as the QoS-aware routing protocols. On the contrary of single-path routing schemes, multipath routing protocols permit each source node to discover multiple paths in the direction of the sink node to enhance network performance. There are numerous protocols in this group like Braided Multipath Routing and N-to-1 Multipath Routing Protocol. In view of the fact that in WSNs, the entire network nodes cooperatively process the flooded data, the last category of routing schemes is dedicated to the consistent data processing-based routing schemes. In this category, data packets are transmitted to the aggregators with the intention of reducing data redundancy. As a result, energy efficiency is the major function of these routing schemes. Routing schemes like Directed Diffusion, SAR and SPIN make use of data aggregation and can be classified as the coherent data processing-based routing protocols. Based on this point, the multipath routing scheme is primarily focused and the associated issues that should be considered in the planning of these schemes for WSNs.

3. ROUTING CHALLENGES AND DESIGN ISSUES

Depending on the application, several planning and design goals/constraints have been taken for Sensor Networks. Since the functioning of a routing protocol is strongly related to the architectural model, the routing challenges and inferences of sensor network architecture are highlighted in following paragraphs as mentioned in Megerian & Potkonjak (2003).

Most of the network structural designs assume that sensor nodes are immobile, because there are extremely few setups that make use of

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mobile sensors. Network dynamics is sometimes necessary to support the mobility of sinks or CHs (gateways).

Route stability becomes an important optimization factor, in addition to energy, bandwidth etc, and a routing message from or to moving nodes is more challenging. So, the sensed event can be either dynamic or static depending on the application.

Node deployment is application dependent and affects the performance of the routing protocol. The deployment is either deterministic or self-organizing.

In deterministic situations, the sensors are manually placed and data is routed through pre-determined paths. Where as in self-organizing systems, the sensor nodes are scattered randomly creating an infrastructure in an ad hoc manner. In latter the position of the sink or the cluster-head is also crucial in terms of energy efficiency and performance. When the distribution of nodes is not uniform, optimal clustering becomes a pressing issue to enable energy efficient network operation.

During the creation of an infrastructure, the process of setting up the routes is greatly influenced by energy considerations. Since the transmission power of a wireless radio is proportional to distance squared or even higher order in the presence of obstacles, multi-hop routing will consume less energy than direct communication. However, multi-hop routing introduces significant overhead for topology management and medium access control. Direct routing would perform well enough, if all the nodes were very close to the sink. Most of the time sensors are scattered randomly over an area of interest and multi-hop routing becomes unavoidable.

Every packet that is transmitted over a network should be delivered to the destination node before its deadline; otherwise it will be an invalid packet. Therefore the packets are scheduled based on the certain parameters. The packet dropping rate of the routing protocol would be high if the packet didn't reach before deadline. Therefore packet scheduling is also considered as a one of the important issues or challenge in wireless sensor routing.

Data delivery model to the sink can be continuous, event driven, query-driven and hybrid, depending on the application of the sensor network. In the continuous delivery model, each sensor sends data periodically. In event-driven and query-driven models, the transmission of data is triggered when an event occurs or the sink generates a query. Some networks apply a hybrid model using a combination of continuous, event-driven and query-driven data delivery. The routing protocol is highly influenced by the data delivery model, especially with regard to the minimization of energy consumption and route stability.

In a sensor network, different functionalities can be associated with the sensor nodes. Depending on the application, a node can be dedicated to a particular special function such as relaying, sensing, and aggregation, since engaging the three functionalities at the same time on a node might quickly drain the energy of that node.

Similar packets from multiple nodes can be aggregated to reduce the transmission. For this, sensor nodes might generate significant redundant data. Data aggregation is the combination of data from different sources by using functions such as suppression (eliminating duplicates), min, max, and average.

The above mentioned parameters decide the efficiency and performance of routing protocol in WSN. The parameters such as packet scheduling, data delivery or packet delivery, energy constraints are the major aspects focused in this research work.

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4. MOTIVATION OF RESEARCH

In the recent years, several WSNs have been installed to carry out several information processing processes like tracking, detection or classification. Sensor Networks were primarily put into practice largely for defense applications, particularly the two significant programs the Distributed Sensor Networks (DSN) and the Sensor Information Technology (SenIT) building the Defense Advanced Research Project Agency (DARPA). WSNs were extremely successful in the military sensing and later have turn out to be a fundamental part of military command, communications, control, intelligence and computing, reconnaissance, surveillance, and targeting systems. In case of the battlefield circumstance, they offer rapid deployment, fault tolerance security and self-organization of the network.

The efficiency and the performance of the above mentioned applications largely depend on the performance of the routing schemes. The parameters such as scheduling, throughput, packet delay, delivery ratio are mainly focused in this research for constructing the efficient routing protocol in WSN. Integrating clustering in WSN is observed to provide significant results. This has motivated the utilization of cluster based techniques for efficient routing in WSN in this research work.

5. PROBLEM SPECIFICATION

Dynamic nature of the WSN is a challenging factor to be considered in developing the routing algorithm. Existing routing algorithms such as MUSTER, TEEN, APTEEN etc are not resourceful in sustaining the dynamic characteristics of Wireless Networks such as deployment, localization, synchronization, data aggregation, dissemination, database querying, architecture, middleware, security, designing less power consuming devices, abstractions and cannot achieve sufficient quality of service results in various applications. Cluster based routing protocols are mainly use the parameters such as distance; energy etc in wireless sensor network in order to achieves optimal routing results. Thus the designing a novel routing protocol based on clustering algorithms such as fuzzy c means, fuzzy possibility c means are used which is also used to achieve routing parameters such as throughput, delay, delivery ratio etc in routing.

6. OBJECTIVES OF THE RESEARCH

The main objective of the thesis is to develop new approaches for providing energy efficiency, congestion controlled, and quick data delivery for WSNs. A detailed literature survey is done for developing an idea about the solutions already provided for these problems. This thesis investigates the performances of certain existing approaches and formulated an efficient scheme for satisfying its intention. The proposed protocol is aimed at reducing the delay, congestion control and energy consumption by using clustering and packet scheduling algorithms. The proposed algorithm is compared with some of the existing routing protocols to assess its effectiveness.

The research objective also includes:

- To study and analyze the node behaviors in detail by grouping the nodes into Clusters
- To Construct a cluster tree by analyzing the routing key components such as distance between the nodes , residual energy of the nodes
- To design Packet Scheduling Algorithms in the proposed routing by analyzing the

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protocols such as Time division multiple access (TDMA), Space-Time Division Multiple Access (STDMA) and Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)

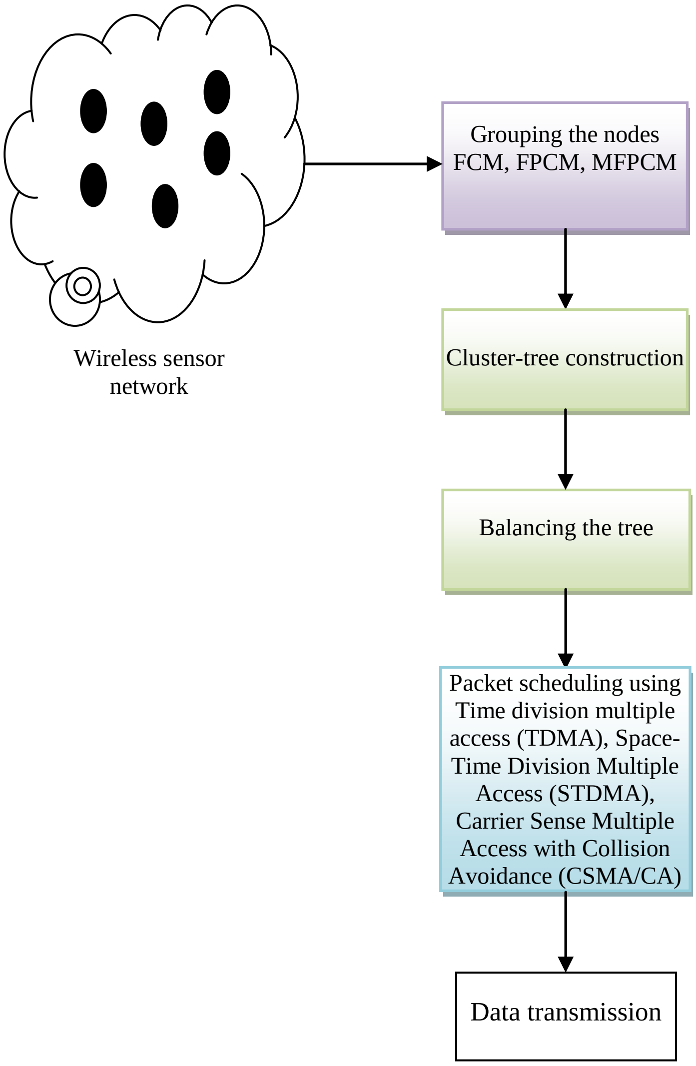

Figure : Architecture of Proposed Routing Algorithm

The overall architecture of the proposed tree based routing protocol is shown in the Figure 1.8. The wireless sensor nodes are first grouped using the clustering algorithms such as FCM, FPCM and MFPCM. Then, the cluster tree is constructed using the distance and constructed tree is balanced. The packet scheduling algorithm is introduced using hybrid protocols such CSMA/CA with TDMA and CSMA/CA with STDMA. The proposed routing protocols are used to improve the performance of the network by reducing the delay, improving the throughput, and reducing the congestion and collision.

7. RESEARCH CONTRIBUTION AND METHODOLOGY

This study proposes a self-organized routing protocol for Wireless Sensor Networks, through tree based routing algorithms, where the parameter constraints are integrated with the specific routing protocol. It offers better performance as they can explore the optimal path meeting out the QoS constraints under the conditions of the dynamic nature, inadequate resources, and different environment conditions. In Wireless Networks, tree based routing protocol desires to perform three characteristic features are as follows: First optimal path determination by satisfying the demand of the QoS parameters. Secondly, resource reliability in which network resources can be adequately used up without the need to pre-reserving the resources. The third feature is transmitting the data between the nodes. Data is collected from each and every node present in the cluster tree and the collected data is transmitted efficiently using protocols such as TDMA, and STDMA.

Improved General Self-Organized Tree-Based Routing Protocol

Self-Organized Tree-Based Energy-Balance Routing Protocol contains four phases to solve the routing issues in Wireless Networks. In this work, GSTEB protocol is enhanced using the cluster tree topology and introducing the load balancing scheme in GSTEB. Routing protocol divides network into many clusters, and by calculating the distance, the proposed protocol constructs a routing tree for each cluster. In routing tree, most number of children for cluster nodes is determined. The Protocol manages load balancing, using routing tree, node's neighbors average queue length and residual energy of nodes as parameters.

Packet Scheduling based General Self-Organized Tree-Based Routing Protocol

GSTEB protocol is enhanced using the cluster tree topology and introducing packet scheduling in IGSTEB. Routing protocol divides a network into many clusters, using distance and proposed protocol constructs a routing tree for each cluster. In routing tree, parent and child relationship is determined. The balanced cluster tree is formed using the network parameters such as node's neighbors average queue length and residual energy of nodes.

Efficient Packet Scheduling With Congestion Control Protocol for Cluster Tree Topology

Packet Scheduling and Congestion Control Protocol (PSCCP) improves network efficiency, throughput as well as packet delivery ratio and minimize delay. In this process, Space-Time Division Multiple Access (STDMA) presented, the first position-based TDMA scheduling algorithm in WSN. STDMA is a topology-transparent scheduling protocol that guarantees unique transmitter within the cluster tree topology. The system applied for the cluster tree topology is formed by using MFCM. The problem of scheduling collision-free broadcasts by a node (also called node activation) to all its neighbors without any other packet interfering in its transmission is solved by using this proposed PSCCP protocol in WSN.

8. ORGANIZATION OF THESIS

Chapter 1: Introduction about Routing Protocol for Wireless sensor Networks

Wireless sensor network (WSN) is widely considered as one of the most important technologies for the twenty-first century. In this chapter, architecture of Wireless Sensor Networks, routing protocols in Wireless Sensor Networks (WSN), types of routing are studied in detailed manner. Importance of routing and load balancing, important factors for routing are also discussed and the problem of the existing routing protocols are also presented. The importance of the following factors, e.g., limited energy supply, limited computing power, and limited bandwidth, traffic analysis and packet scheduling of the wireless links connecting sensor nodes are explained

Chapter 2: Literature Survey on Routing, Congestion Control and Packet Scheduling Algorithms in Wireless Networks

In this chapter, the details of the existing routing protocol methods such as LEACH, HEED, PEGASIS, TBC, PEDAP and GSTEB are studied. Then the importance of the tree based routing protocol which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes is explained. A Study on the existing congestion control methods and what are the parameters are used in earlier work to analysis the congestion results, existing packets scheduling methods during data transmission phase from source to destination path in the Wireless Sensor Network (WSN) are also discussed.

Chapter 3: Improved General Self-Organized Tree-Based Routing Protocol for Wireless Sensor Network

WSN consists of low-cost nodes with limited battery power, and the battery replacement is not easy for WSN with thousands of physically embedded nodes, which means energy efficient routing protocol should be employed to offer a long-life work time. To achieve the aim, it is not only needed to minimize total energy consumption but also to balance WSN load. In this chapter, the details of the Novel tree based routing protocol which builds a routing tree using a process where, for each round, BS assigns a root node and broadcasts this selection to all sensor nodes are discussed.

Chapter 4: Improved Tree based Routing Protocol and Packet Scheduling Methods for Wireless Sensor Network

The Packet Scheduling Algorithm (PSA) is the algorithm that schedules all packets from source to destination in order to reduce network congestion. When the PSA is implemented, packet collisions will be minimized with increasing of throughput. In this chapter, the details of packet scheduling and routing algorithm during data transmission phase are presented. In order to reduce the overhead or delay scheduling of packets from source to destination, Cluster Tree Packet Scheduling (CTPS) is proposed.

Chapter 5: An efficient Congestion Control Methods for Improved Tree based Routing Protocol and Packet Scheduling methods for Wireless Sensor Network

In Wireless Sensor Networks (WSNs), congestion occurs, for example, when nodes are densely distributed with high flow rate. Congestion may cause packet loss, which in turn lowers throughput and wastes energy. Therefore congestion in WSNs needs to be controlled for high energy-efficiency, to prolong system lifetime, improve fairness, and improve Quality of Service (QoS) in terms of throughput and packet loss ratio along with the packet delay. In chapter 5 a novel method is proposed to overcome the problem of congestion control in Wireless Sensor Network, where the importance of the node is calculated to each node, based on queue length occupancy.

Chapter 6: Conclusion and Scope for Future Work

In this chapter, methods used in this work to perform routing, congestion control and packet scheduling are discussed. The major problems of the existing works are also discussed in this chapter and how this work has been extended to next stage is also mentioned and its application is also discussed.

9. SUMMARY

This research mainly focuses on developing the tree based routing protocol using clustering and packet scheduling algorithm to improve the overall performance of the network. The Proposed Routing Protocol (PSCCP) has parameters as the objective function such as throughput, delay, packet loss for dealing with an optimal path for node routing. In this research work, improved self organized routing protocols are used to overcome the drawbacks of the individual algorithm. The proposed routing protocol obviously shows its improvement in the QoS parameters like delay, packet loss and the throughput.

Authors:

Dr. K. Kumaravel, working as a Professor & Head , Dept of Computer Science, Dr.N.G.P. Arts & Science College, Coimbatore. He has more than two decades of Experience in Teaching & Research**.**

Dr. M. Sengaliappan, working as a Professor & Dean, Dept of Computer Science, KKCAS College, Coimbatore. He has more than two decades of Experience in Teaching & Research**.**