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## NETWORK TOPOLOGIES IN WIRELESS SENSOR NETWORK

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*Abstract – The Wireless Sensor Network (WSN) is an emerging topic. This technology helps in many fields by using number of sensor nodes that use different types of topologies to work efficiently. In this paper, Network Topologies in Wireless Sensor Network, these topologies are described with their advantages and disadvantages.*

**Keywords** – PAN coordinator, Topology, Wireless Sensor Network, WSN.

### 1. INTRODUCTION

In today's era of science and technology, people fond of using wireless technologies. Lots of cable control devices are replaced by wireless control facilities.<sup>[1]</sup> The Wireless Sensor Network (WSN) is intelligent in comparison with traditional sensors, and some are designed to make use of in-network processing in which sensed data can be gathered in situ and metamorphosed to more abstract and aggregated high-level data before transmission.<sup>[3]</sup> The Wireless Sensor Network is a wireless and ad hoc network which has so

many types of sensor nodes. These sensor nodes are very tiny in size and they operate automatically by using computing engine. These tiny devices are comprised of sensors, computational processing ability (i.e. CPU power), wireless receiver and transmitter technology and a power supply.<sup>[3]</sup> The applications of WSN are industry automation, environment automation, Industrial monitoring, Forest fire detection, healthcare monitoring, military applications, etc.. But to make wireless devices work, a lot of energy is needed. Without energy, sensor nodes of WSN cannot able to communicate with each other. This is a common issue to fight with in WSN. Because of energy constraint, the sensor nodes slowly move towards less efficient work. For that Topology control (TC) is one of the effective strategies to save energy in WSN.<sup>[1]</sup> Typically the Wireless Sensor Network Topology is continuously subjected for alteration dynamically, but it is actually not a desired solution to boost it by infusing new sensors instead the depleted ones.<sup>[2]</sup> To solve this problem it is necessary to find out the efficient topology. The Topology Control algorithm is used to make more reliable lifetime of sensor nodes and to balance the energy consumptions between sensor nodes. The overview of Wireless Sensor Network is

presented in Figure 1.

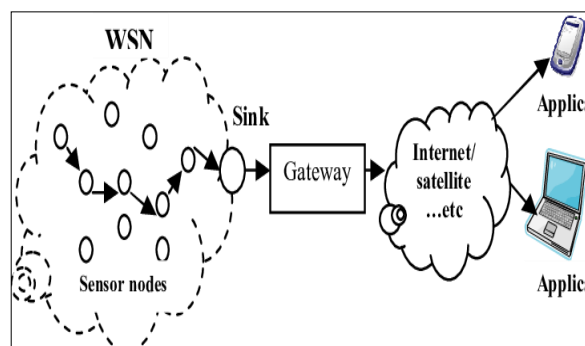


Figure 1. Wireless Sensor Network

## 2. REVIEW OF LITERATURE

Divya Sharma, 2Sandeep Verma, 3Kanika Sharma [4] (2013) in their study titled “Network Topologies in Wireless Sensor Networks: A Review” found that In Wireless Sensor Networks (WSNs), sensor nodes have limited battery power, so energy consumption is essential issue. Every sensor node can obtain its location information from GPS or other positioning system and send data to sink at any time. The characteristic of this is to divide WSN into network based on Topologies i.e. Bus, Tree, Star, Ring, Mesh, Circular, Grid. Information of the position of nodes, and those nodes are organized within the network by the Topological way.

Zhixue Wang [8] (2022) in their study titled “Reliability Analysis of Social Network Data Transmission in Wireless Sensor Network Topology” found that the reliability of data transmission in social networks is thoroughly studied and analyzed using wireless sensor network topology technology. Based on the introduction of sensor network reliability analysis-related technology, combined with the characteristics, and needs of the sensor network itself, focuses on the study of the reliability analysis of the sensor network under the state of perturbation scheme. Based on the idea of making full use of data changes to respond to the sensor state, the actual monitoring data of the wireless sensor network as the research object, selects the temporal correlation and spatial correlation of the measured environmental data as the reliability index by extracting the features of the wireless sensor network data, and proposes the Evidential reasoning rule- (ER-) based wireless sensor network data reliability

assessment model based on Evidential reasoning rule (ER) is proposed. The data are mined, analyzed, and quantified from the perspective of content popularity, and the interest indicators of nodes on data under content popularity are analyzed to derive stable interest quantification values.

## 3. TOPOLOGIES IN WIRELESS SENSOR NETWORKS

The development and deployment of WSN have taken traditional network topologies in new direction.<sup>[4]</sup> There are so many different topologies of wireless sensor network likewise Bus, Tree, Mesh, Star, Ring that will be discussed in this paper.

### I. BUS SENSOR NETWORK TOPOLOGY

In Bus topology, there are sensors nodes and a common backbone is used to connect all the sensor nodes. Here, all the sensor nodes are deployed in bus orientation in wireless media.<sup>[2]</sup> One sensor node sends a broadcast message to another sensor node on the network. All the sensor nodes can see that message has been broadcasted but only the intended recipient receives the message. And only that recipient can process the message. This, Bus topology, is very easy to install but it works very well with a limited numbers of sensor nodes on a common backbone. If more than a few dozen nodes are added to a network bus, performance problems will likely result.<sup>[5]</sup> The Bus network topology system applies strategies of integrated active and passive architecture based on priority of its classification level. Because of that, this topology provides efficient bus priority control system. Also Bus network topology system minimizes the effects of motor vehicle movements in different types of traffic conditions. The overview of Bus network topology in Wireless Sensor Network is presented in Figure 2.

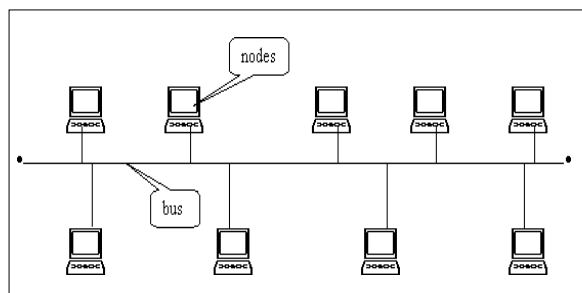


Figure 2. Bus Sensor Network Topology

sensor node is directly connected to central node, or server, there will be a minimum power consumption takes place in each client sensor node and also the client sensor node will be under the control of central node.

But when the size of the network increase so much with so many client sensor nodes connected with central node, the energy of central node will get depleted soon. The overview of Star network topology in Wireless Sensor Network is presented in Figure 3.

## II. STAR SENSOR NETWORK TOPOLOGY

The Star network topology is one of the most common sensor network topologies. [5] In Star topology, the sensor nodes are connected to directly with a centralized communication hub or switch or sink, which is known as central node. Because of central node it works like PAN (Personnel Area Network) coordinator. [3] Here, sensor nodes cannot communicate directly to each other. [4] So, the communication of the message will pass through the central node. Due to connected with central node, each sensor node will known as client sensor node and the central node will known as server. As the client sensor nodes are dependent on central node to communicate with each other efficiently, all the client sensor nodes should be implemented in the valid radio transmission range like 30 meters up to 100 meters from the server. If any of the client sensor nodes collapsed, then it will not affect the entire network [3] but if the central node is collapsed, the entire network will be crashed. Though it has advantages likewise it is very easy to design, implement and extend. [5] The performance of Star network topology is faster in comparison to other network topologies, if it has a limited client sensor nodes in the network. The faulty client sensor nodes can easily be removed from network, as it will not affect the entire working efficiency of Star network topology. Because, each client

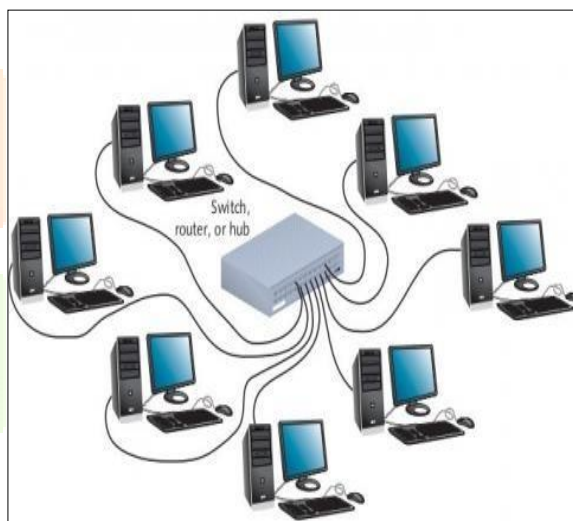


Figure 3. Star Sensor Network Topology

## III. RING SENSOR NETWORK TOPOLOGY

As the name suggests, the Ring topology's sensor nodes are connected with exactly two other neighbor sensor nodes in a ring form. All messages travel through a ring in the same direction (either clockwise or counterclockwise). [4] All the sensor nodes can transmit the data through packets with all other sensor nodes by using neighbor sensor nodes because it does not have any central node. It means, the message will broadcast from each and every sensor node in a continuous pathway in the network but only

intended sensor node will receive and process on the message. Although, in comparison of bus topology, the ring network topology performs better in heavy traffic load. Due to sensor node to sensor node connection, this topology is easy to install and easy to reconfigure while removing or adding a sensor node. The faulty sensor nodes are easy to identify and isolate. As message has to broadcast from entire network, it is very time consuming and energy consuming topology. The Ring network topology has less communication capabilities. Congestion of traffic and double path communication.<sup>[4]</sup> In Ring network topology, communication delay is directly proportional to number of nodes in the network.<sup>[6]</sup> If any of the sensor nodes fails to work efficiently in the sensor loop, entire network will be crashed. Nowadays, ring topology is not preferred much in applications.<sup>[3]</sup> The overview of Ring network topology in Wireless Sensor Network is presented in Figure 4.

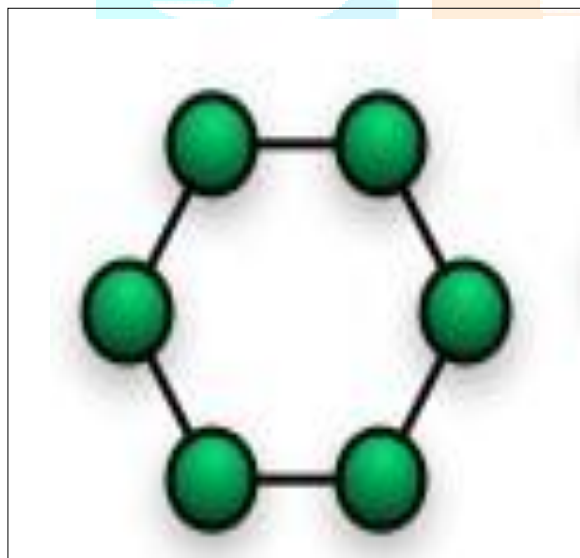


Figure 4. Ring Sensor Network Topology

#### IV. MESH SENSOR NETWORK TOPOLOGY

Mesh topologies are most commonly found in wireless networking. Sensors networks can also be described by their logical topology – the method they use to move data around the network.<sup>[5]</sup> A Mesh network allows transmitting data to one node to other node in the network that is within its radio transmission range.<sup>[7]</sup> In Mesh network topology, sensor nodes are connected with

each other. Mesh network topology is allowed for multi-hop communication. If any sensor node which is out of radio transmission range wants to communicate or broadcast the message to other sensor node, then multi-hop communication can use intermediate sensor nodes to communicate or broadcast the message to the desired sensor node. Mainly there are two types of Mesh network topology. One is Partially connected mesh and another is Fully connected mesh. In the former one, one sensor node will be connected to more than one sensor nodes in a network as shown in Figure 5. In the Fully connected mesh network, one sensor node is connected with another sensor node as shown in Figure 6. This network topology has the advantage of redundancy and scalability.<sup>[7]</sup> The radio transmission range for sensor node is not limited up to some. So that, removal or addition of a sensor node is very easy. It will be easier to identify and also to isolate the faulty sensor node in a network. The disadvantage of this type of network is in power consumption for the nodes that implement the multi-hop communications are generally higher than for the nodes that don't have this capability, often limiting the battery life.<sup>[7]</sup> If the number of communication hops to a destination increases, the time to deliver the message also increases, especially if low power operation of the nodes is a requirement.<sup>[7]</sup> This network is large and requires huge investment.<sup>[5]</sup> If any of the sensor node fails to communicate or to broadcast the message efficiently, the nearest remote sensor node will communicate or broadcast the message automatically. That it means the mesh network topology heals itself automatically and so that no communication gap will be there to transmit the message to intended sensor node.



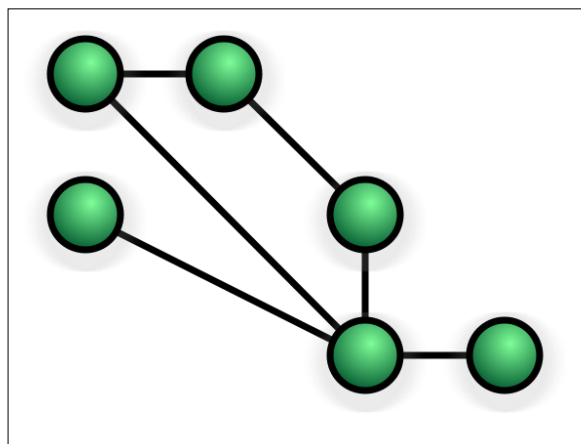


Figure 5. Partially connected Mesh Sensor Network Topology

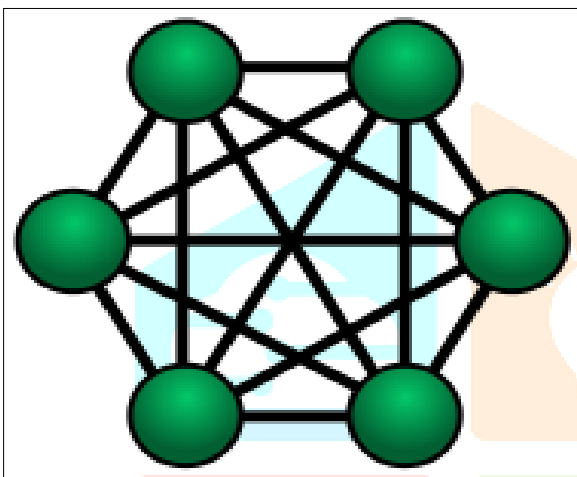


Figure 6. Fully connected Mesh Sensor Network Topology

be easily possible, and also error detection becomes easy.<sup>[5]</sup> There is problem into the load balancing scheme at each level of the fat tree and there is communication in between two nodes.<sup>[4]</sup> Tree network topology is difficult to manage because it is has so many sensor node paths and also has all path have so many sensor nodes to manage. It needs heavy bus cable to generate levels. If any of the bus cable breaks, whole tree network topology will collapse.

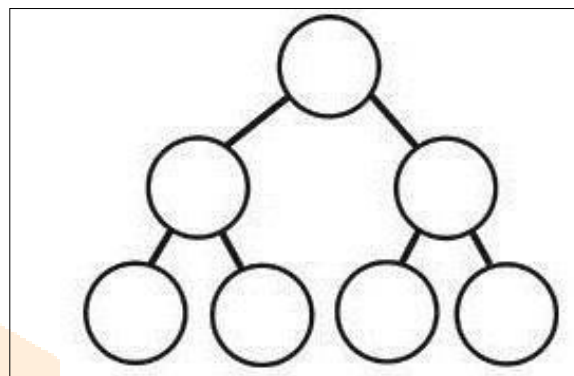


Figure 7. Tree Sensor Network Topology

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#### V. TREE SENSOR NETWORK TOPOLOGY

The Tree topology is also called as cascaded star topology.<sup>[5]</sup> The Tree network topology is a hierarchy of sensor nodes. Just like a simple root in a tree, it has the highest level of hierarchy or a central hub which is known as root node. All other sensor nodes are connected with root node as shown in Figure 7. Tree network topology has many levels of sensor nodes. In sensor network path may be single hop or multi hop, sensor node for getting data sense the environment and sent them to sink and sensor forwards them to its parent after receives data messages from its children.<sup>[4]</sup> The message or data should be broadcast into minimum time complexity with shortest path spanning. The tree network can be considered a hybrid of both the Star and Peer to Peer networking topologies.<sup>[4]</sup> The main advantage of the tree network topology is that expansion of a network can

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