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Adaptive Duty-Cycle-Aware using multihopping in WSN

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Abstract. A wireless sensor network consists of group of sensors, or nodes, that are linked by a wireless medium to perform distributed sensing tasks. The sensors are assumed to have a fixed communication and a fixed sensing range, which can significantly vary depending on the type of sensing performed. Duty cycle is the ratio of active time i.e the time at which the particular set of nodes are active to the whole scheduling time. With duty cycling, each node alternates between active and sleeping states, leaving its radio powered off most of the time and turning it on only periodically for short periods of time. In this paper, an ADB protocol is used to manage and control duty cycles as well as regulate , monitor on going traffic among the nodes by using adaptive scheduling. Thus congestion, delay can be controlled and efficiency and performance of overall network can be improved.

Keywords: Duty Cycle, Multihop, Wireless Sensor Network, Scheduling.

1 Introduction

Wireless sensor networks have received a greater interest in application such as disaster management, border protection, combat field reconnaissance, and security surveillance. A wireless sensor network comprise of group of sensors, or nodes, that are linked by a wireless medium to perform distributed sensing tasks. Connections between nodes may be formed using such media as infrared devices or radios. Wireless sensor networks are used in a variety of applications including structural health monitoring, industrial automation, civil structure monitoring, military surveillance, and monitoring the biologically hazardous places [7],[18].

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A sensor network must be able to operate under very dynamic conditions. Specifically, our protocols must be able to enable network operation during start-up, steady state, and failure.The necessity of operation under these conditions comes about because the sensor network must, in most cases, operate unattended. Once the nodes have booted up and a network is formed, most of the nodes will be able to sustain a steady state of operation, i.e. their energy reservoirs are nearly full and they can support all the sensing, signal processing and communications tasks as required. In this mode, the bulk of the nodes will be formed into a multi-hop network. The nodes begin to establish routes by which information is passed to one or more sink nodes. Sensor nodes are expected to operate autonomously in unattended environments and potentially in large numbers. Failures are inevitable in wireless sensor networks due to inhospitable environment and unattended deployment. The data communication and various network operations cause energy depletion in sensor nodes and therefore, it is common for sensor nodes to exhaust its energy completely and stop operating. This may cause connectivity and data loss. Therefore, it is necessary that network failures are detected in advance and appropriate measures are taken to sustain network operation.

The sink node is a sensor node with gateway functions to link to external networks such as the Internet and sensed information is normally distributed via the sink node. It is a mobile node acting as an information sink, or any other entity that is required to extract information from the sensor network. Although the multi-hop network can operate in both the sensor-to-sink or sink-to-sensor (broadcast or multi-cast) modes, the bulk of traffic will belong to the former. This will put significant strain on the energy resources of the nodes near the sink, making that neighborhood more susceptible to energy depletion and failure. Nodes may fail due to other reasons such as mechanical failure. When many nodes have failed, the MAC and routing protocols must accommodate formation of new links and routes to the sink nodes. This may require actively adjusting transmit powers and signaling rates on the existing links to reduce energy consumption, or rerouting packets through regions of the network where nodes have more energy left.

The stationary node will maintain a registry as well, although its role is minimal compared to that of the mobile node. The stationary node simply will register mobiles sensors that have formed connections and remove them when the link is broken, effectively limiting participation in the connection procedures. A single Wireless Integrated Network Sensor node combines micro-sensor technology, low power signal processing, low power computation, low power, and low cost wireless networking capability in a compact system. Fig 1 gives a description of the WINS node architecture[2].

To design a system, the mobile assumes full responsibility of making and breaking connections.

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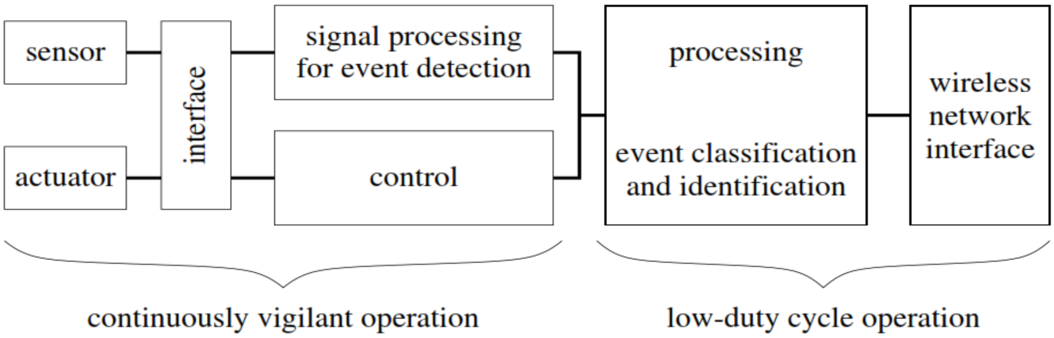

Fig 1. Node Architecture

If the invitation message, which is inherently part of the stationary MAC algorithm, is included as a shared message. Fig 2 shows general mobile scenario[2].

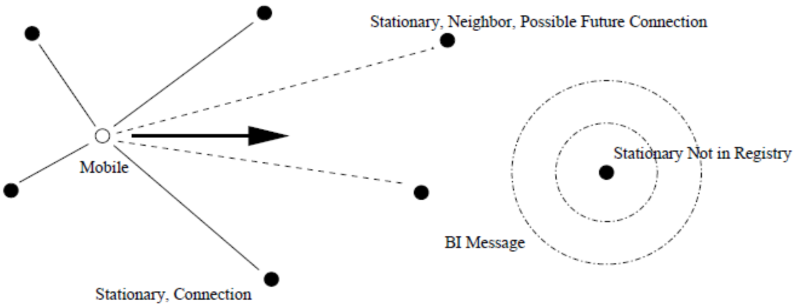

Fig 2. General Mobile Scenario

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2 Comparison between Wireless Sensor, Cellular and AdHoc Networks

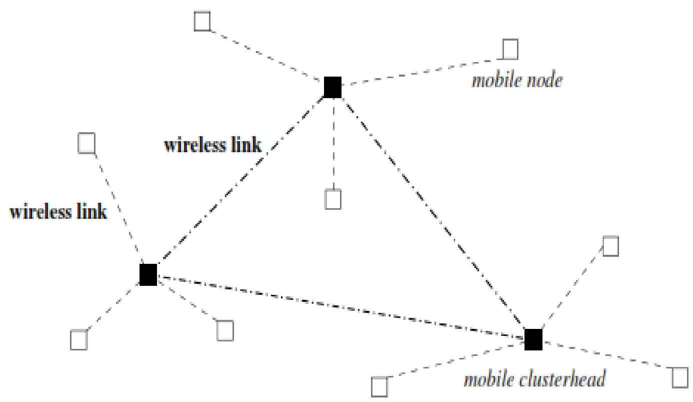

Figure 3. A Mobile Adhoc Network (MANET)

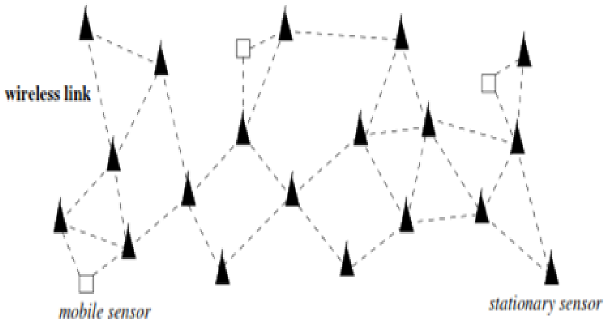

Figure 4. A Wireless Sensor Network

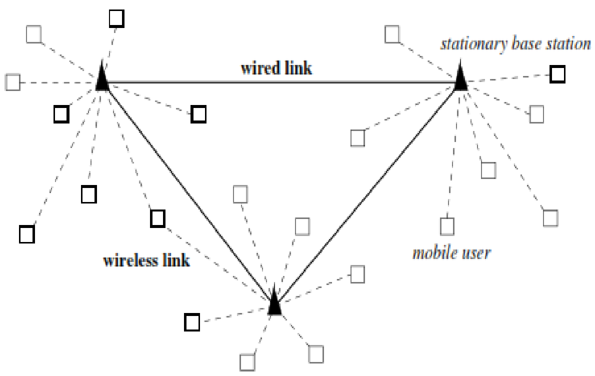

Figure 5. A Cellular Network

A MANET is an autonomous collection of mobile routers and associated hosts connected by bandwidth-constrained wireless links. Each node is envisioned as a personal information appliance such as a personal digital assistant (PDA) fitted out with a fairly sophisticated radio transceiver. The nodes are fully mobile. The network's wireless topology may change rapidly and unpredictably. Such a network may operate in a standalone fashion, or may be connected to the larger Internet.Factors, such as variable wireless link quality, propagation path loss, fading, multiuser interference, power expended, and topological changes, significantly increase the complexity of designing network protocols for MANETs.

A wireless sensor network consists of a number of sensors spread across a geographical area.Each sensor has wireless communication capability and sufcient intelligence for signal. processing and networking of the data. A WSN can be deployed in remote geographical locations and requires minimal setup and administration costs. Sensed information is relayed to a sink node by using multi hop communication. Multiple-path transmission is one of the methods for ensuring QoS routing in both wired and wireless environment [6]. WSNs difer from MANETs in many fundamental ways.Viewing a WSN as a large-scale multi-hop ad hoc network may not be appropriate for many real-world applications.The communication overhead for configuring the network into an operational state is too large. The number of nodes in a WSN can be several orders of magnitude higher than the nodes in an ad hoc network and sensor nodes that are prone to failure are densely deployed. Sensor nodes mainly use broadcast, while most MANETs are based on the Peer-to-Peer (P2P) communication paradigm. Information exchange between end-to-end nodes will be rare in WSNs. They are limited in power, computational capacity and memory, and may not have global IDs.

WSNs have a wide range of applications ranging from monitoring environments, sensitive installations, and remote data collection and analysis. In both MANETs and WSNs the nodes act both as hosts and as routers. They operate in a self organizing and adapting manner[2][26][28][31].

A Cellular network is one of the radio network distributed over land areas called cells, each served by at least one fixed-location transceiver known as a cell site or base station .When these cells joined together provide radio coverage over a wide geographic areas. Cellular networks provides the advantages such as increased capacity, reduced power use, large coverage area, reduced interference from other signals. Figure 3,4,5 shows the comparison between adhoc network, wireless sensor network and cellular network. In cellular architecture the network is partitioned into a virtual grid of cells to perform fault detection and recovery locally with minimum energy consumption [5][25][32].

3 Duty Cycle Approaches

Duty Cycle approaches can be grouped into: asynchronous DC, synchronised or scheduled DC; and hybrid approaches. Asynchronous duty cycling (ADC) is typified by Low Power Listening (LPL) and B-MAC . The radio is turned on for very short amounts of time to check for channel activity (known as channel polling). If activity is detected the radio remains on to receive data, else it turns off. Transmitting nodes precede messages with a preamble longer than the sleep time of the recipient, to guarantee they will have turned their radios on, detected the channel activity and be ready to receive before the preamble is ended. This places an energy cost on the transmitter, more so for DC rates using longer off periods. Long preambles can also increase network congestion[10][14].

X-MAC attempts to lessen the transmit burden by having receivers send an acknowledgement (ACK) as soon as they detect channel activity to cut the preamble short and start transmitting the data. Such optimisations are not beneficial to broadcasts as neighbouring nodes may have a wide range of different on times and a full-length preamble will be necessary. Leading examples of synchronised DC schemes include SMAC and T-MAC, which maintain and synchronise schedules with neighbouring nodes to record when each node is going to be turned on[30][33].

Periodic control messages advertise a node's schedule to neighbours during contention periods, which are considerably longer than those for channel polling. This becomes significant during periods of inactivity when energy is spent listening when there is nothing to receive. TMAC uses a threshold time in this period after which, if no transmissions have been detected the node turns off early. ZMAC also uses scheduling, but allows nodes to "steal" each-others slots under certain conditions. Hybrid schemes combine synchronisation, schedules and preambles for use during communication[11][13][27][29].

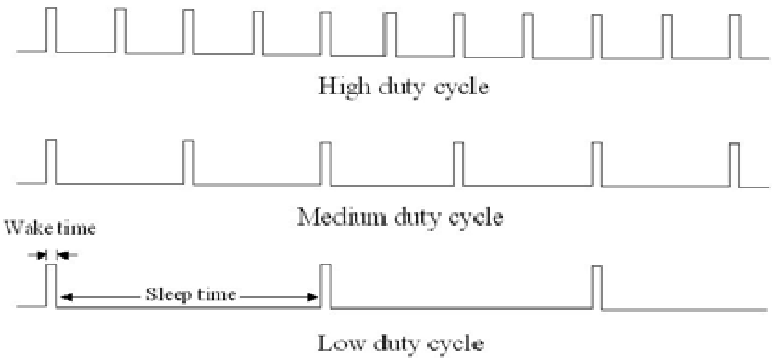

Figure 6. Multiple duty cycle levels

MAC nodes maintain schedules of when neighbours are likely to be on, allowing shorter preambles to be used that do not cover the entire off period. In a different approach, MH-MAC switches between asynchronous and synchronous modes of operation, thereby enabling contention during periods of lighter congestion and contention-free communications during periods of heavy network usage. SCP-MAC uses synchronised channel polling allowing the use of short preambles. The various duty cycle levels are shown in Figure 6[1][12][23].

4 System Models

A number of sensor nodes (N) are uniformly and randomly distributed in an area as shown schematically in Figure 7. In the simulation environment, this can be achieved by randomly assigning an X-coordinate and Y-coordinate in an area of $R\times R\ m^2$. It is assumed that all node in the network including clusterhead will be stationary and quasi-stationary.

The node with highest residual energy among the group of clusterheads is chosen as clusterhead (CH). Once selected, the clusterhead broadcast its status to all nodes in the cluster. It is not be necessary that clusterhead will always in the centre of a cluster. The clusterhead can be placed anywhere in the cluster, and it is assumed that all nodes in a cluster having a least a route to reach the clusterhead. If two or more nodes have the same highest residual energy, then selection is done randomly[16][19][20].The research on network control includes communication methods, saving power consumption, energy optimization, congestion control, topology management, routing, and modeling, simulation. The advantages of WSN are as follows:

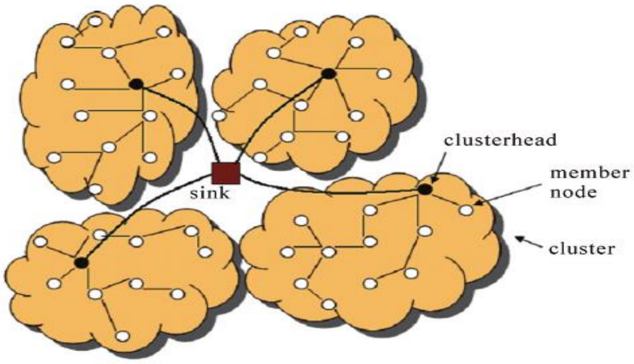

Figure 7. Network Model

A key features of any wireless sensing node is to minimize the power consumed by the system. The system architecture is shown in Figure 8. As shown in Figure, there is one host controller or we can say it as one PC which monitors and controls all the activities. All the nodes must pass through the WSN gateway.The voltages must be provided efficiently to all the devices to work the system properly.

Figure 8. System Architecture

5 ADB Protocol

ADB efficiently collects and distributes information on broadcast progress, reducing redundant transmissions, collisions, and energy consumption by allowing a node to transmit to only a subset of neighbours and to go to sleep as soon as possible.

ADB uses unicast to reach each neighbor, so that the sender accurately learns which neighbors have been reached by the broadcast and improving reliability through the use of Automatic Repeat Request (ARQ) as part of the unicast transmission. The sender also updates each receiver with information on the progress of the broadcast, helping a node avoid redundant transmissions and allowing delegating transmission for some neighbor to another neighbor with better link quality to it. This approach allows a node to sleep as early as possible and avoids transmissions over poor links[15][17][21].

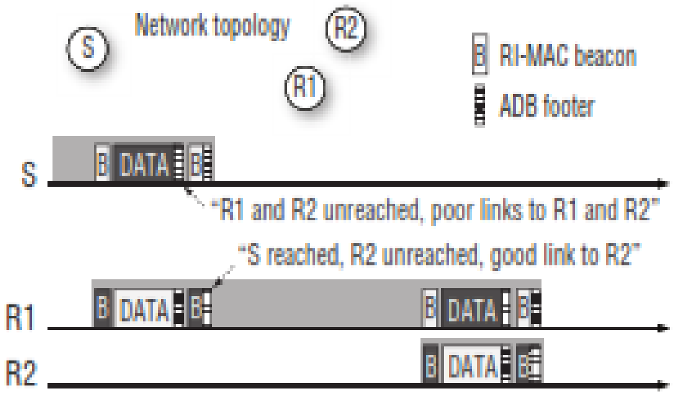

Figure 9. An overview of ADB Protocol

Figure 9. shows an overview of ADB Protocol where Node S broadcasts a DATA frame to nodes R1 and R2 via unicast transmission. The footer in DATA and ACK beacons helps S and R1 to decide which node will deliver the DATA to R2 and it also helps R2 to recognize that both S and R1 have received the DATA. ADB is composed of two basic Components [22][24][28]:

- efficient encoding of ADB control information, which helps to distribute information according to broadcasting and information for delegation decisions.
- delegation procedure, which takes a decision on whenever a broadcast DATA packet or a beacon with an ADB footer is received or overheard, determining which nodes the DATA packet should be forwarded to and which nodes should be delegated.

6 Data Aggregation

The main goal of data aggregation algorithms is to gather and aggregate data in an energy efficient manner so that network lifetime is enhanced. Wireless sensor networks (WSN) offer an increasingly Sensor nodes need less power for processing as compared to transmitting data. It is preferable to do in network processing inside network and reduce packet size. One such approach is data aggregation which attractive method of data gathering in distributed system architectures and dynamic access via wireless connectivity.

Wireless sensor networks have limited computational power and limited memory and battery power, this leads to increased complexity for application developers and often results in applications that are closely coupled with network protocols. Hop-by-hop data aggregation is a very important technique used to reduce the communication overhead and energy expenditure of sensor nodes during the process of data collection in a wireless sensor network (WSN)[4].The general data aggregation architecture is shown in Figure 10[3]. A neighbor list is maintained which contain the information of neighbor nodes. This neighbor list is used for traffic handling using transmission of packets.

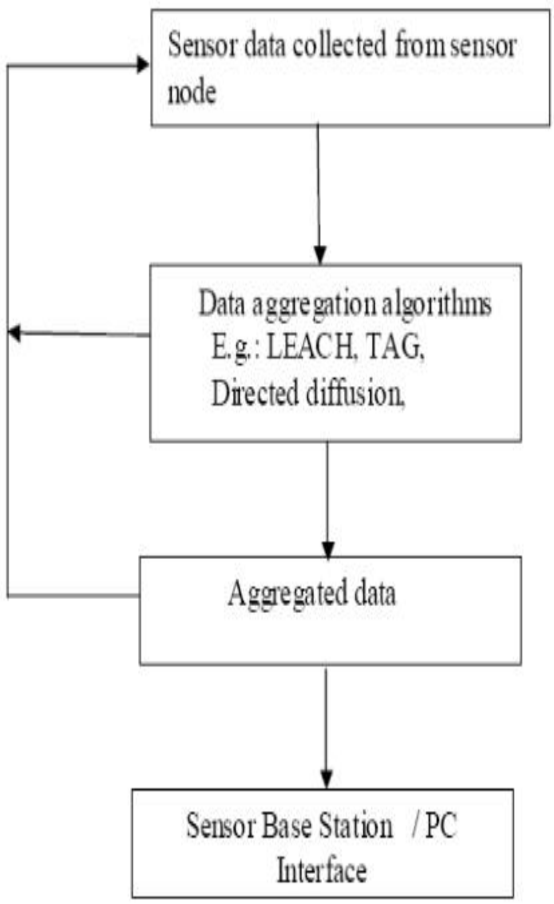

Figure 10. General Architecture of Data Aggregation

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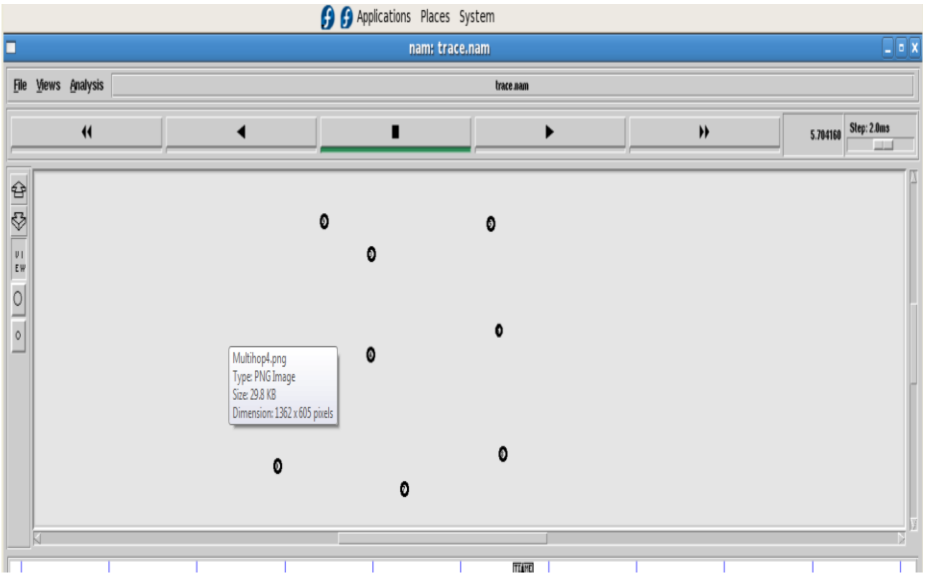
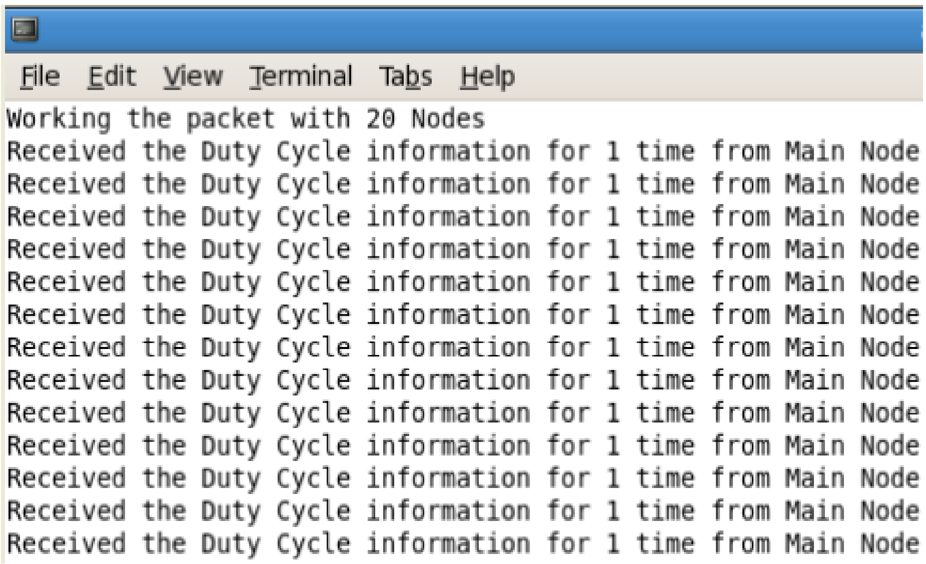
7 Simulation result

Fig 12(a), (b) shows the packet received from one node to another along with duty cycle information





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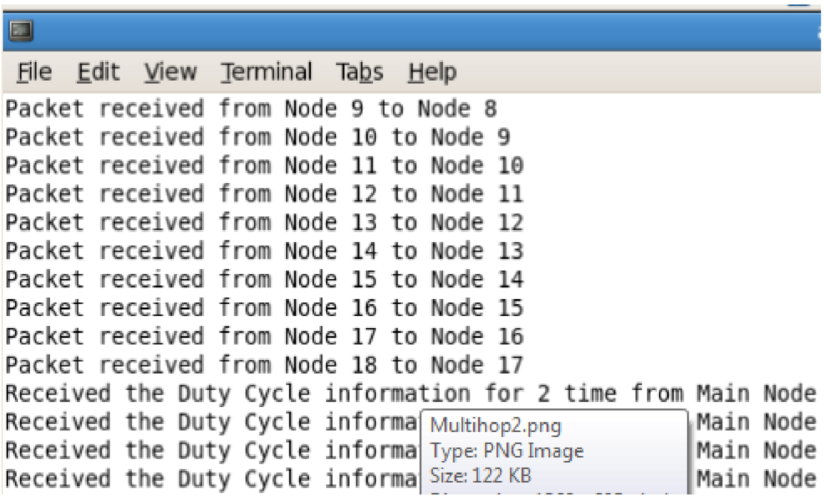

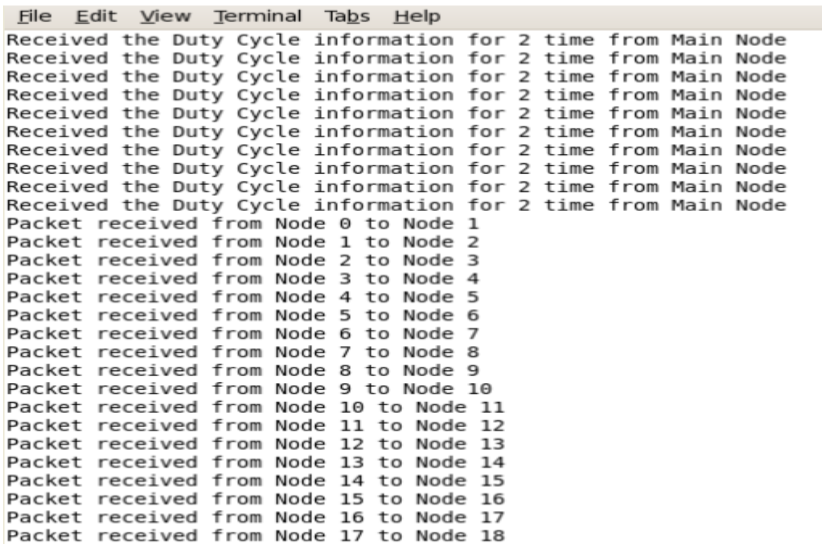

8 Conclusion

In this paper, wireless sensor network architecture is introduced along with the scenario of adhoc and cellular network. Also the simulations which uses the ADB protocol is shown using NS-2. Reducing redundant transmissions, collisions, and energy consumption by allowing a node to transmit to only a subset of neighbours and to go to sleep as soon as possible. Path selection or route selection by maintaining the neighbor list. By maintaining neighbor node's information in neighbor list, nodes are scheduled for active and sleep modes i.e., duty cycle has been assigned to each nodes and thus the traffic has been handled more efficiently.

9 Future Work

More functionality can be added to improve the existing performance by using techniques such as compression, secure transmission, etc.

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