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DEPARTMENT OF COMPUTER SCIENCE & ENGINEERING

COMPUTER NETWORKS AND SECURITY MINI PROJECT

18CS52

"WIRELESS SENSOR NETWORKS"

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for the academic year 2021-22

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Department of Computer Science & Engineering

Certificate

This is to certify that the implementation of **CNS MINI PROJECT** entitled "WIRELESS SENSOR NETWORKS" has been successfully completed by

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of V semester B.E. for the partial fulfillment of the requirements for the Bachelor's degree in Computer Science & Engineering of the Visvesvaraya Technological University during the academic year 2021-2022.

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ABSTRACT

We advocate the use of **wireless sensor networks** in Developing Countries as we foresee they have a great role to play not only to expedite novel solutions that help mitigate development problems, but also to facilitate research activities in crucial scientific areas such as environmental monitoring, physics of complex systems and energy management. Thus we argue that there is a need for technology research and application development in the area of Wireless Sensor Networks for Development.

The history of sensor network technology originates in the firstdistribution sensing idea implementations. The continuous work of researchers and engineers over sensor networks which lately became wireless sensor networks (WSNs). Wireless sensor network is one of the g r o w i n g technology for sensing and performing the different tasks.

Such networks are beneficial in many fields, such as emergencies, health monitoring,environmental control, military, industries and these networks prone to malicious users' and physical attacks due to radio range of network, un-trusted transmission, unattended nature and get accesseasily. Security is a fundamental requirement for these networks.

CONTENTS

Chapter 1

INTRODUCTION

1.1 Overview

A Wireless Sensor Network (WSN) is a self-configuring network of small sensor nodes (so-called motes) communicating among them using radio signals, and deployed in quantity to sense the physical world.

Sensor nodes are essentially small computers with extremely basic functionality. They consist of a processing unit with limited computational power and a limited memory, a radio communication device, a power source and one or more sensors.

Sensor nodes are used in WSN with the onboard processor that manages and monitors the environment in a particular area. They are connected to the Base Station which acts as a processing unit in the WSN System.

Base Station in a WSN System is connected through the Internet to share data.

A wireless sensor network (WSN) generally consists of a basestation (or " gateway") that can communicate with a number of wireless sensors via a radio link. Data is collected at the wireless sensor node, compressed, and transmitted to the gateway directly or, if required, uses other wireless sensor nodes to forward data to the gateway. The transmitted data is then presented to the system by the gateway connection.

A modular design approach provides a flexible and versatile platform to address the needs of a wide variety of applications. For example, depending on the sensors to be deployed, the signal conditioning block can be re-programmed or replaced.

This allows for a wide variety of different sensors to be used with the wireless sensing node. Similarly, the radio link may be swapped out as required for a given applications' wireless range requirement and the need for bidirectional communications.

This allows for a wide variety of different sensors to be used with the wireless sensing node. Similarly, the radio link may be swapped out as required for a given applications' wireless range requirement and the need for bidirectional communications.

In this report we have given a detailed information on the **Simulation demonstration of WSN in Network-Simulator 2.**

We have also included the source code and the concerned protocols information in this report along with the snapshots of the output and the results.

1.2 Problem Statement

Implementation and demonstration of WSN using NS2 .
Basics of WSN Principles ,Addressing Routing in WSN.Detailed information of Dynamic Source Routing protocol (DSR) and Ad hoc On-Demand Distance Vector (AODV) routing protocol is explained.

1.3 Objective

The main objective of WSN and its protocols is to efficiently disseminate observations gathered by individual sensor nodes to all the sensor nodes in the network. Simple protocols such as flooding and gossiping are commonly proposed to achieve information dissemination in WSNs.A WSN aims to gather environmental data and the node devices placement may be known or unknown a priori. Network nodes can have actual or logical communication with all devices; such a communication defines a topology according to the application.

Chapter 2

SYSTEM ARCHITECTURE

2.1 System Architecture

The microprocessor has a number of functions including :

1) managing data collection from the sensors
2) performing power management functions
3) interfacing the sensor data to the physical radio layer
4) managing the radio network protocol

A key feature of any wireless sensing node is to minimize the power consumed by the system. Generally, the radio subsystem requires the largest amount of power. Therefore, it is advantageous to send data over the radio network only when required. This sensor event-driven data collection model requires an algorithm to be loaded into the node to determine when to send data based on the sensed event. Additionally, it is important to minimize the power consumed by the sensor itself. Therefore, the hardware should be designed to allow the microprocessor to judiciously control power to the radio, sensor, and sensor signal conditioner.

Star Network (Single Point-to-Multipoint)

A star network is a communications topology where asingle base station can send and/or receive a message to a number of remote nodes. The remote nodes can onlysend or receive a message from the single basestation, they are not permitted to send messages to each other. The advantage of this type of network for wireless sensor networks is in its simplicity and the ability to keep theremote node' s power consumption to a minimum. It also allows for low latency communications between the remotenode and the basestation. The disadvantage of such a network is that the basestation must be within radio transmission range of all the individual nodes and is not as robust as other networks due to its dependency on a singlenode to manage the network.

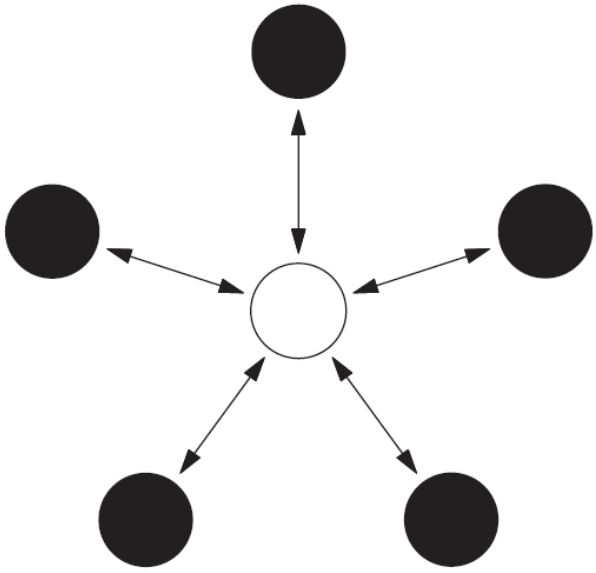


Figure 22.3.1:
Star network topology.

Mesh Network

A mesh network allows for any node in the network to transmit to any other node in the network that is within its radio transmissionrange. This allows for what is known as multihop communications; that is, if a node wants to send a message to another node that is out of radio communications range, it canuse an intermediate node to forward the message to the desired node. This network topology has the advantage of redundancy and scalability. If an individual node fails, a remote node still can communicate to any other node in its range, which in turn, can forward the message to the desired location. In addition, the range of the network is not necessarily limited by the range in between single nodes, it can simply be extended by adding more nodes to the system. The disadvantage of this type of network is in power consumption for the nodes that implement the multihop communications aregenerally higher than for the nodes that don't have this capability, often limiting the battery life. Additionally, as 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.

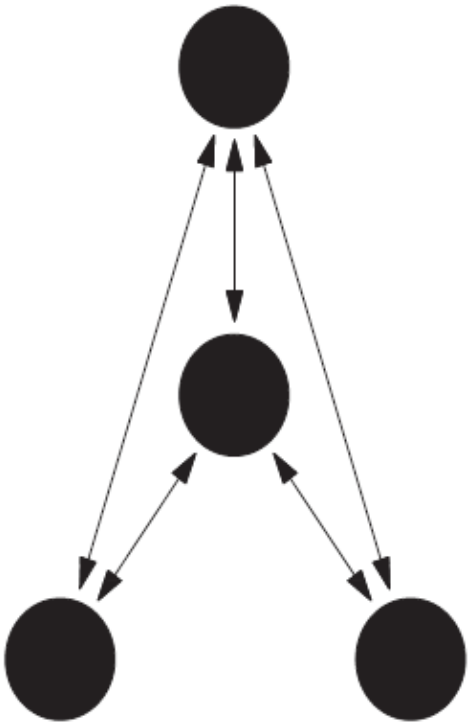


Figure 22.3.2:
Mesh network topology.

Hybrid Star – Mesh Network

A hybrid between the star and mesh network provides for a robust and versatile communications network, while maintaining the ability to keep the wireless sensor nodes power consumption to a minimum. In this network topology, the lowest power sensor nodes are not enabled with the ability to forward messages. This allows for minimal power consumption to be maintained. However, other nodes on the network are enabled with multihop capability, allowing them to forward messages from the low power nodes to other nodes on the network.
Generally, the nodes with the multihop capability are higher power, and if possible, are often plugged into theelectrical mains line.

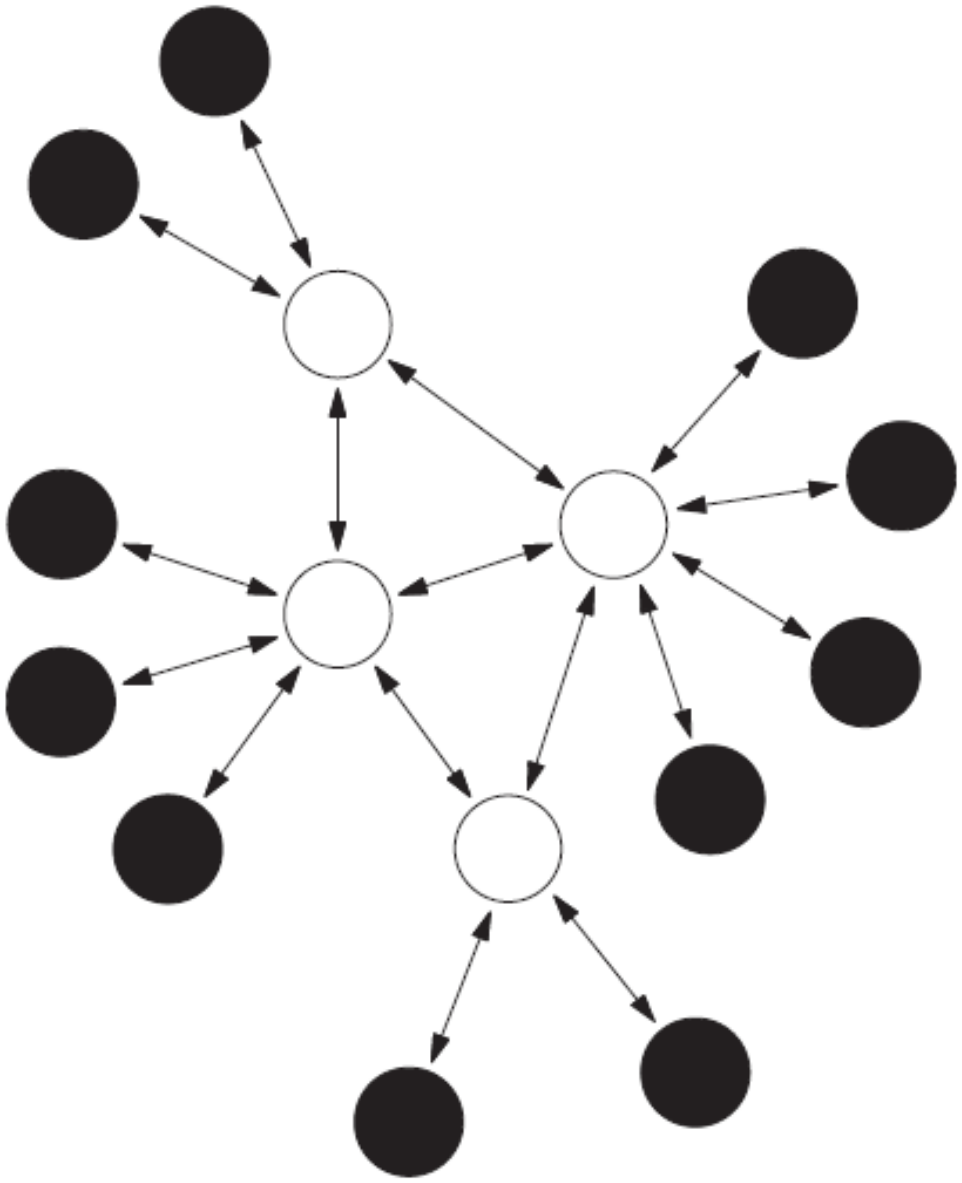
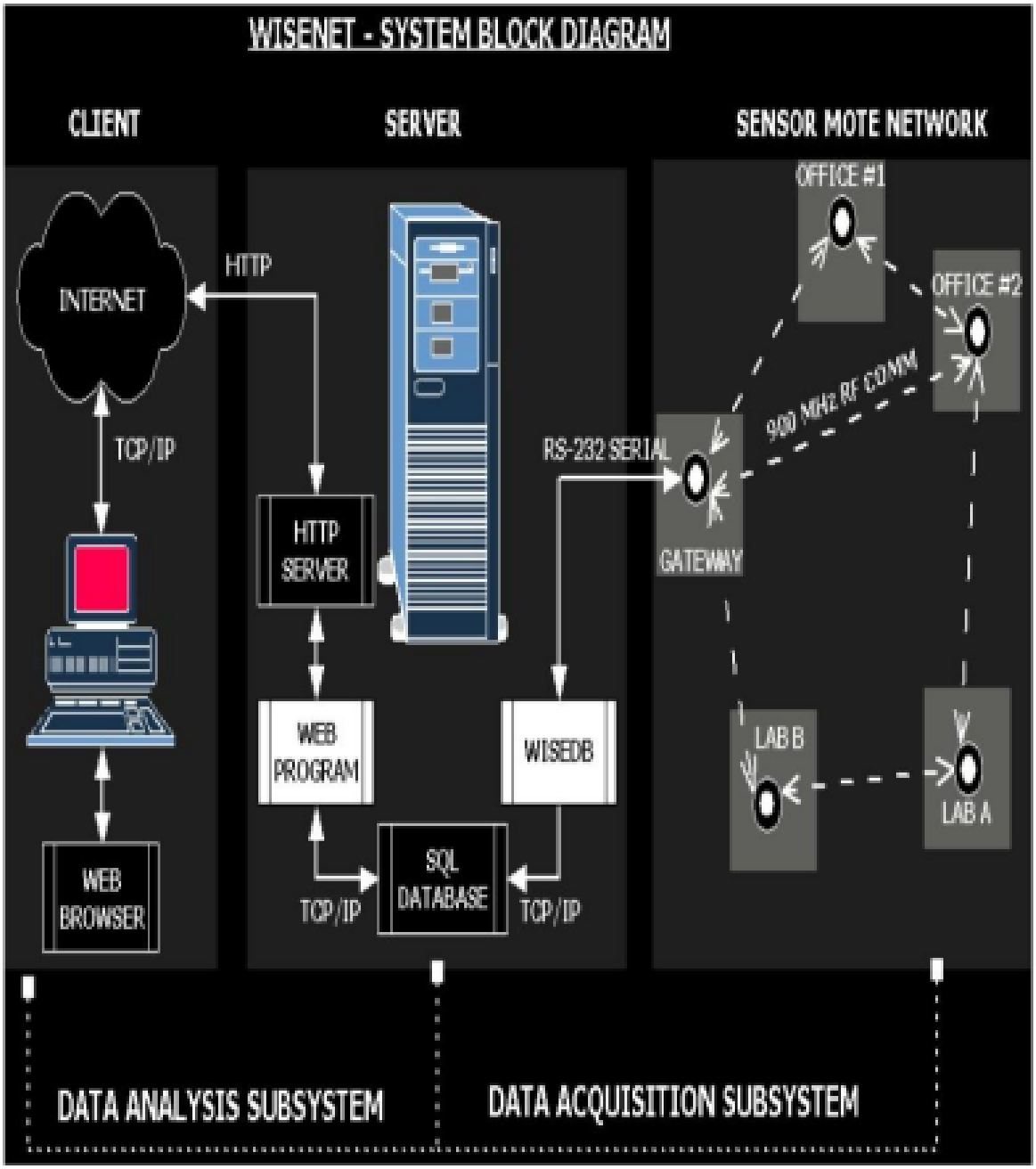


Figure 22.3.3: Hybrid star-mesh network topology.



Block Diagram of WSN Architecture

Chapter 3

SYSTEM REQUIREMENT SPECIFICATION

3 Software Requirement & Hardware Requirement

For fulfilling the requirements of WSN environment, we need tools and software which are Listed as follows:

- Ubuntu System or Windows System

- Nam 3.0

- NS 2

- tracegraph 2.02

- NSG2

- JDK1.7 or higher versions

- Tracegraph 2.02 is a great application that comes handy to ns2 users. It eliminates the need to configure and run perl/awk scripts over the trace file. Trace file analysis simplified. Though I feel that Tracegraph is still in its infancy, its existing scope just provides all that a researcher using ns2 needs.

- NS2 Scenarios Generator 2(NSG2) is a JAVA based ns2 scenarios generator. Since NSG2 is written by JAVA language, you can run NSG on any platform. NSG2 is capable of generating both wired and wireless TCL scripts for ns2.

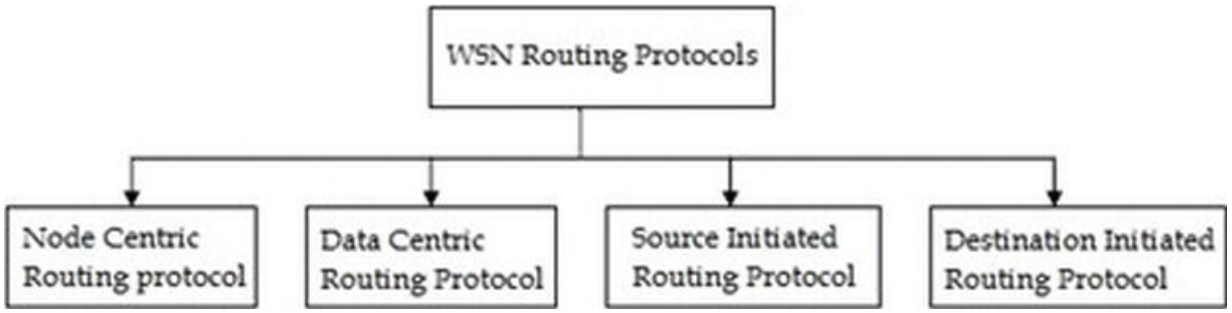
Some major functions of NSG2 are listed below:

~ Creating wired and wireless nodes
~ Creating connection between nodes
~ Creating links (Duplex-Link and Simplex-Link)
~ Creating agents (TCP and UDP)
~ Creating applications (CBR and FTP)
~ Node movement

Chapter 4

DESIGN

4.1 Algorithm



Node centric:

Low energy adaptive clustering hierarchy (LEACH)

Data-centric:

Sensor protocols for information via negotiation (SPIN)

Destination-initiated (Dst-initiated):

Directed diffusion (DD)

Source-initiated (Src-initiated):

In these types of protocols the source node advertises when it has data to share and then the route is generated from the source side to the destination. Examples is SPIN,DSR.

DSR

-Used in mobile ad-hoc network.
-Dynamic source routing protocol falls under reactive routing protocol.
-Reactive means that the routing path is decided when its needed and is not decided before hand.
-Operation is source routing , which basically means that sender knows the complete path, i.e. intermediate nodes don't keep any routing information .
-It has 2 phases
1) route discovery
2) route maintenance.

-here the source broadcasts a packet called RREQ which stands for routing request packet, it contains the following information. - unique ID - source ID - destination ID - list node, which is initially empty.

-when a node broadcasts this packet the neighboring nodes, check if they known the destination and if they don't , they append their ID to the list node, and they keep the unique id into their buffer.

-if it is observed that the unique id ,that is received by the neighboring nodes, is same as the one they just broadcasted then the incoming packet will be discarded.

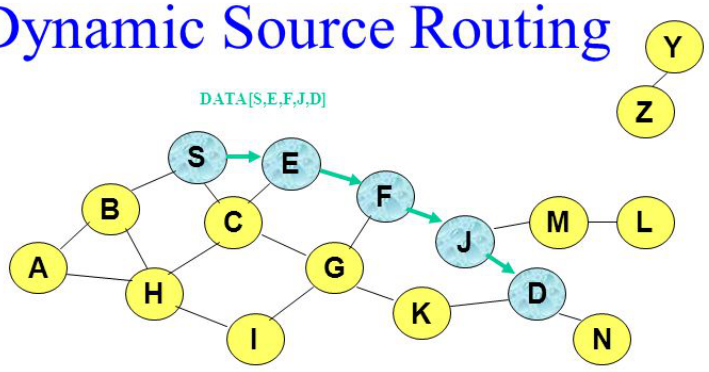
-if a certain node is the destination node then it prepares the RREP packet which stands for route reply , which contains the route record, so all the previous nodes trace it back to their source node, and now the source node is aware of the route to communicate with its destination.

-once the source node is aware of the route , it caches the route so that it can re-use the same path in case more data transmission is to be done.

-but there is a problem in this , if for some reason the link is broken it wont know if the cached path is to be removed.

-therefore for this reason route maintenance is another phase of DSR, here the previous node sends a packet called RERR which is back traced to the source to inform it to discard the cached route .

Dynamic Source Routing



- When S sends a data packet to D, the entire route is included in the packet header
- Intermediate nodes use the source route embedded in the packet's header to determine to whom the packet should be forwarded
- Different packets may have different routes, even they have the same source and destination

Hence called as dynamic source routing

Advantages

-intermediate nodes do not need to maintain up to date?routing information in order to route the packets they forward.

-The intermediate nodes also utilize the route cache information efficiently to reduce the control overhead.

Disadvantages

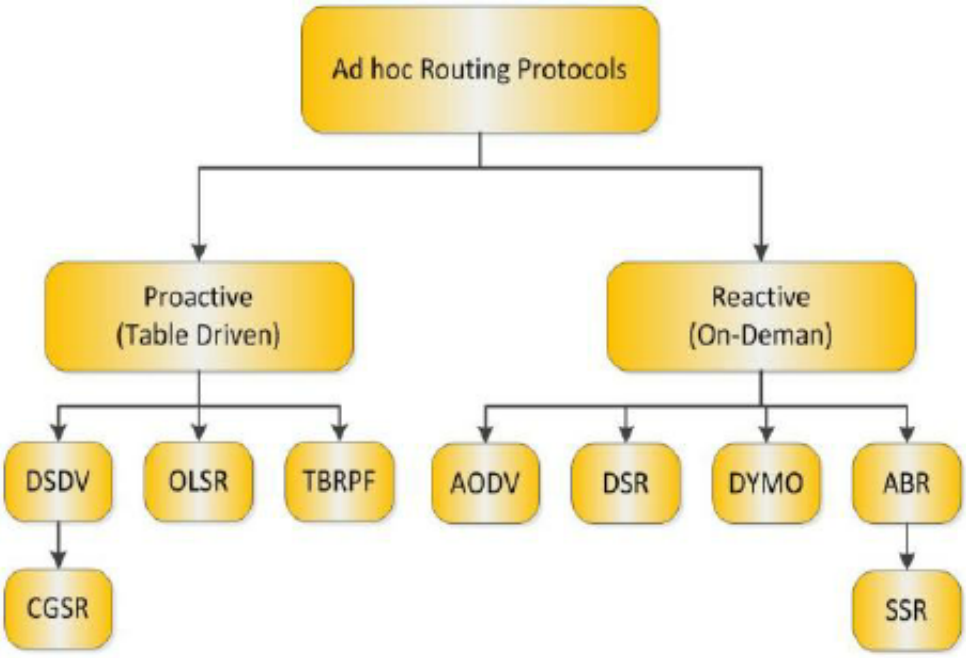
-The disadvantage of DSR is that the route maintenance mechanism does not locally repair a broken down link.

-Even though the protocol performs well in static and low-mobility environments, the performance degrades rapidly with increasing mobility.

AODV

-The Ad hoc On-Demand Distance Vector (AODV) routing protocol is intended for use by mobile nodes in an ad hoc network.

-It offers quick adaptation to dynamic link conditions, low processing and memory overhead, low network utilization, and determines unicast routes to destinations within the ad hoc network.



-Ad-hoc on-demand distance vector (AODV) is reactive on request protocol. AODV is engineered for Mobile infrastructure-less networks.

-It employs the on-demand routing methodology for formations of route among network nodes. Path is established solitary when source node want to direct packs of data and pre-set route is maintained as long as the source node needs. That' s why we call it as On-Demand.

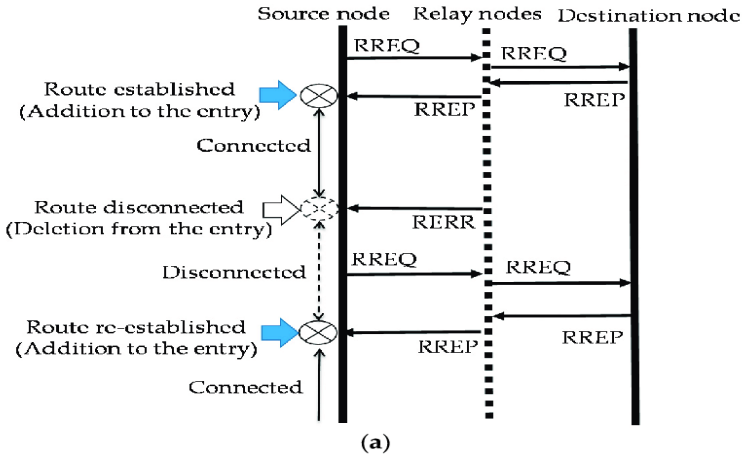
-AODV satisfies unicast, multicast and broadcast routing. AODV routing protocol directs packets among mobile nodes of wireless ad-hoc network.

-AODV permits mobile nodes to pass data packets to necessary destination node via nodes of neighbor that are unable to connect link openly.

-The material of routing tables is switched intermittently among neighbor nodes and prepared for sudden updates.

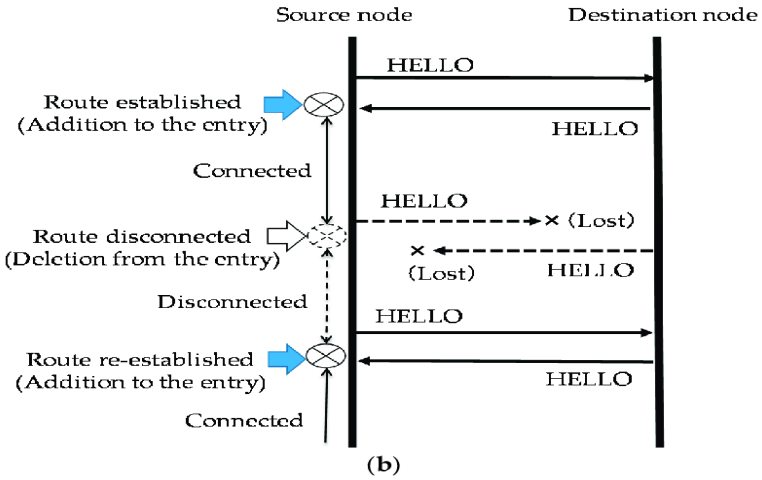
-AODV chooses shortest but round free path from routing table to transmit packets. Suppose if errors or variations come in nominated path, then AODV is intelligent enough to make a fresh new route for rest of communication.

(a) Measurement triggers with Route REPlies (RREPs) and Route ERRors (RERRs);



(a)

(b) Measurement triggers with HELLOs.?



(b)

Advantages of Ad-hoc

-One of the main advantages of an ad-hoc network is the ability to file share without having to rely on an active network connection.

-An ad-hoc network will only be useful if the plan is to transfer files between multiple devices regularly. Although many newer devices do not use or even allow ad-hoc mode, there are still a few good reasons we might want to use it.

-Since we can create ad-hoc networks in virtually any environment at any given time, this makes them quite ideal for companies, for businesses, or for general at-home usage for specific situations. Not needing extra hardware to set up an ad-hoc network creates ease of use and can cut the cost of business in most cases as well.

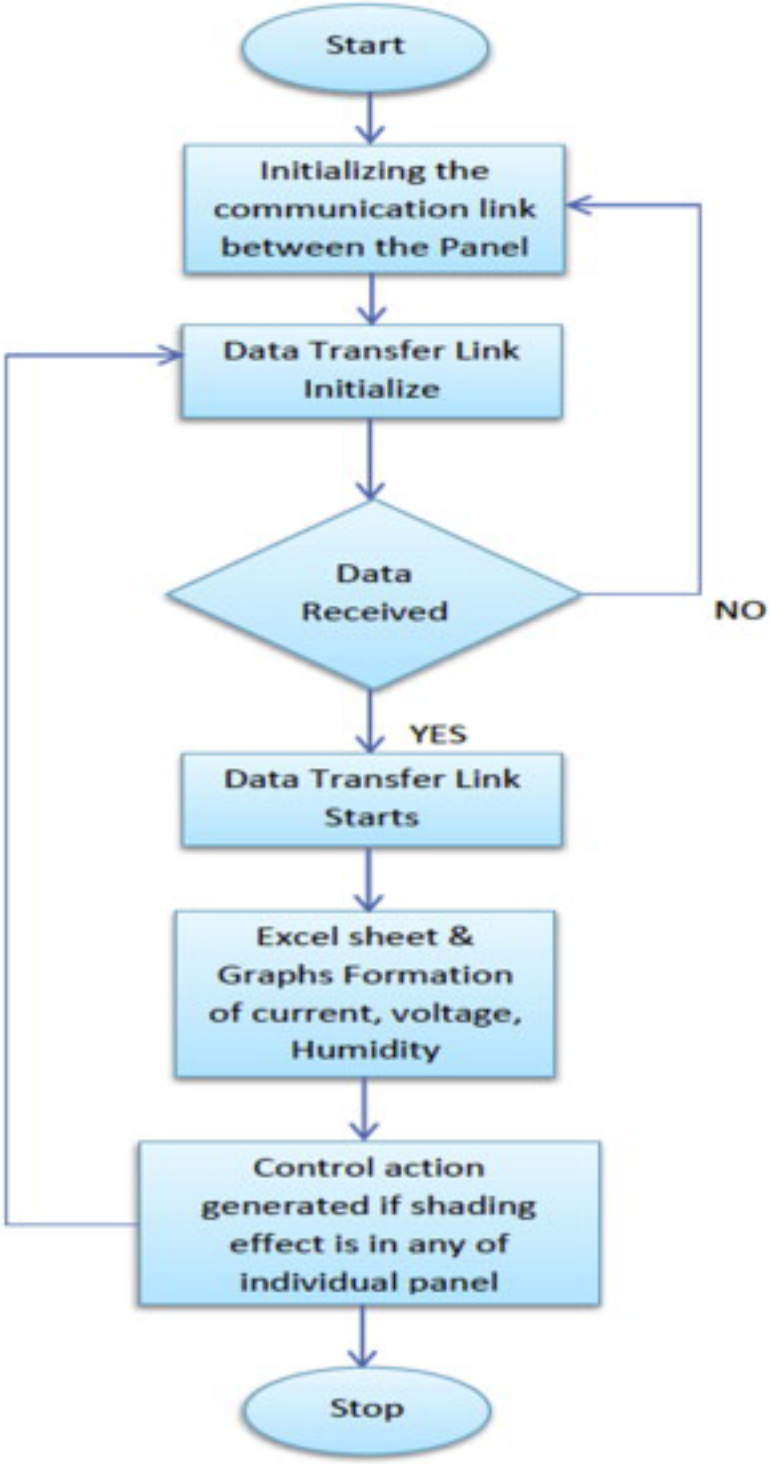
Disadvantages of Ad-hoc

-Although there are multiple advantages to using our wireless devices in ad-hoc mode, there are also some disadvantages that need to be considered as well.

-Also, the signal strength of devices cannot be measured since there is no way to track it. That is minor since most devices will be well within the range of each other at all
times.

-The most significant factor is network security when the devices are all connected with each other. There is virtually no protection while using ad-hoc mode when compared to the new security features from the Wi-Fi standard.

4.2 Flowchart



Chapter 5

IMPLEMENTATION

5.1 Source Code

```
#===================================
#     Simulation parameters setup
#===================================
set val(chan)   Channel/WirelessChannel    ;# channel type
set val(prop)   Propagation/TwoRayGround   ;# radio-propagation model
set val(netif)  Phy/WirelessPhy            ;# network interface type
set val(mac)    Mac/802_11                 ;# MAC type
set val(ifq)    Queue/DropTail/PriQueue    ;# interface queue type
set val(ll)     LL                         ;# link layer type
set val(ant)    Antenna/OmniAntenna        ;# antenna model
set val(ifqlen) 50                         ;# max packet in ifq
set val(nn)     6                          ;# number of mobilenodes
set val(rp)     DSR                        ;# routing protocol
set val(x)      2000                       ;# X dimension of topography
set val(y)      2000                       ;# Y dimension of topography
set val(stop)   11.0                       ;# time of simulation end

#===================================
#        Initialization
#===================================
#Create a ns simulator
set ns [new Simulator]

#Setup topography object
set topo       [new Topography]
$topo load_flatgrid $val(x) $val(y)
create-god $val(nn)
#Open the NS trace file
set tracefile [open WSN.tr w]
$ns trace-all $tracefile

#Open the NAM trace file
set namfile [open WSN.nam w]
$ns namtrace-all $namfile
$ns namtrace-all-wireless $namfile $val(x) $val(y)
set chan [new $val(chan)];#Create wireless channel
```

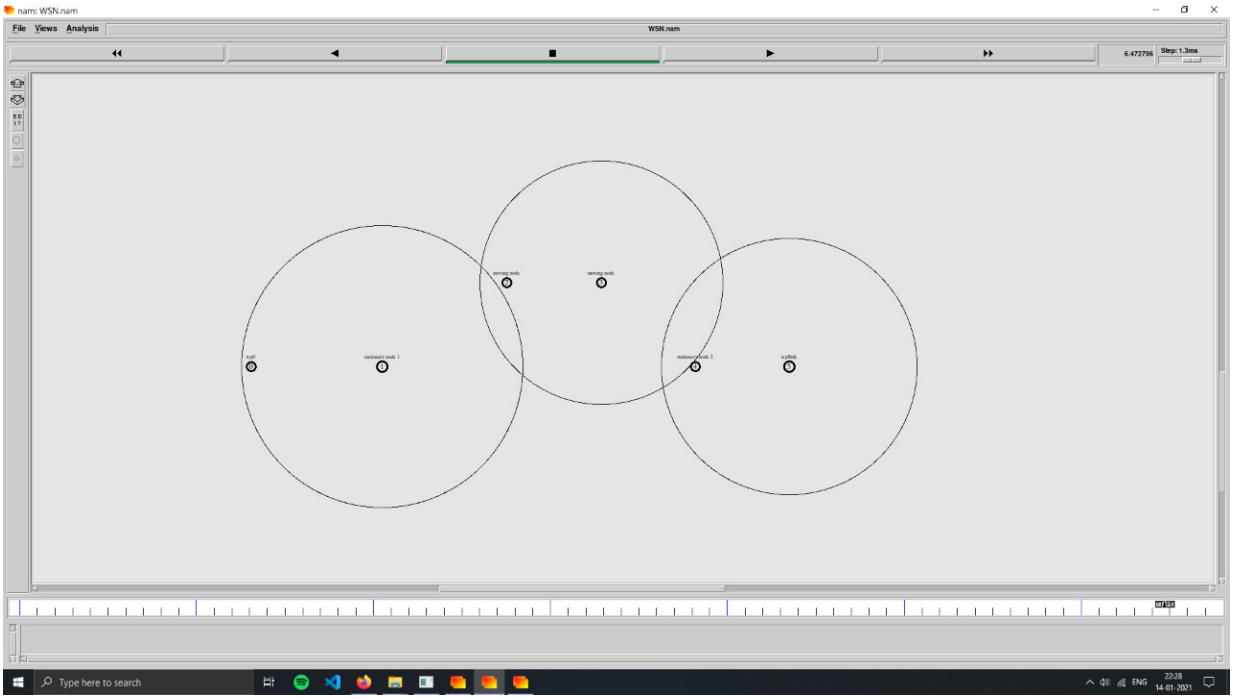
```
#===================================
#     Mobile node parameter setup
#===================================
$ns node-config -adhocRouting  $val(rp) \
                -llType        $val(ll) \
                -macType       $val(mac) \
                -ifqType       $val(ifq) \
                -ifqLen        $val(ifqlen) \
                -antType       $val(ant) \
                -propType      $val(prop) \
                -phyType       $val(netif) \
                -channel       $chan \
                -topoInstance  $topo \
                -agentTrace    ON \
                -routerTrace   ON \
                -macTrace      ON \
                -movementTrace ON

#===================================
#        Nodes Definition
#===================================
#Create 6 nodes
set n0 [$ns node]
$n0 set X_ 300
$n0 set Y_ 500
$n0 set Z_ 0.0
$n0 label "tcp0"
set n1 [$ns node]
$n1 set X_ 600
$n1 set Y_ 500
$n1 set Z_ 0.0
$n1 label "stationary node 1"

set n2 [$ns node]
$n2 set X_ 700
$n2 set Y_ 900
$n2 set Z_ 0.0
$n2 label "moving node"

set n3 [$ns node]
$n3 set X_ 800
$n3 set Y_ 900
$n3 set Z_ 0.0
$n3 label "moving node"
```

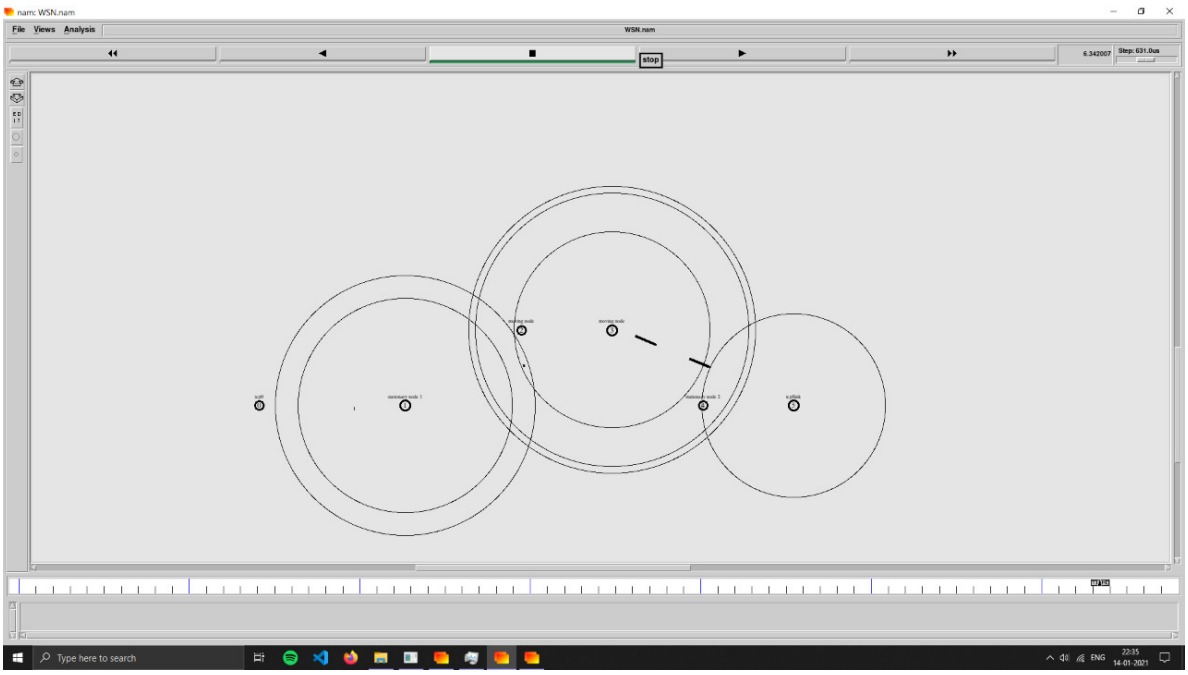
```
set n4 [$ns node]
$n4 set X_ 900
$n4 set Y_ 500
$n4 set Z_ 0.0
$n4 label "stationary node 2"

set n5 [$ns node]
$n5 set X_ 1000
$n5 set Y_ 500
$n5 set Z_ 0.0
$n5 label "tcpSink"
#=================================
#       Generate movement
#=================================
$ns at 0 " $n0 setdest 500 500 20 "
$ns at 0 " $n1 setdest 350 500 5"
$ns at 2 " $n2 setdest 700 100 80 "
$ns at 2 " $n3 setdest 800 100 80 "
$ns at 6 " $n4 setdest 950 500 5 "
$ns at 6 " $n5 setdest 1050 500 5 "


#=================================
#       Agents Definition
#=================================
#Setup a TCP connection
set tcp0 [new Agent/TCP]
$ns attach-agent $n0 $tcp0
set sink0 [new Agent/TCPSink]
$ns attach-agent $n5 $sink0
$ns connect $tcp0 $sink0
$tcp0 set packetSize_ 1500
#=================================
#       Applications Definition
#=================================
#Setup a FTP Application over TCP connection
set ftp0 [new Application/FTP]
$ftp0 attach-agent $tcp0
$ns at 4.0 "$ftp0 start"
$ns at 10.0 "$ftp0 stop"
```

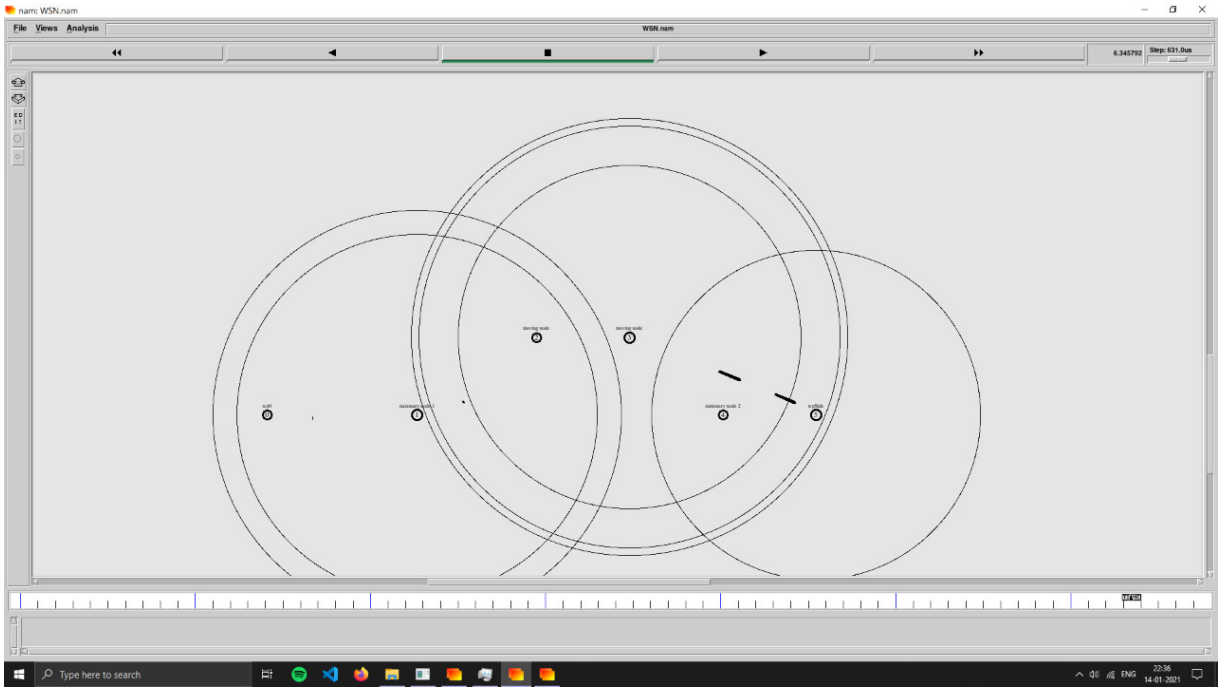
```
#=================================
#       Termination
#=================================
#Define a 'finish' procedure
proc finish {} {
    global ns tracefile namfile
    $ns flush-trace
    close $tracefile
    close $namfile
    puts "hello there"
    exec nam WSN.nam &
    exit 0

}
for {set i 0} {$i < $val(nn) } { incr i } {
    $ns at $val(stop) "\$n$i reset"
}
$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "finish"
$ns at $val(stop) "puts \"done\" "
$ns run
```

Chapter 6

RESULTS/SNAPSHOTS



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WSN.nam
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ENG
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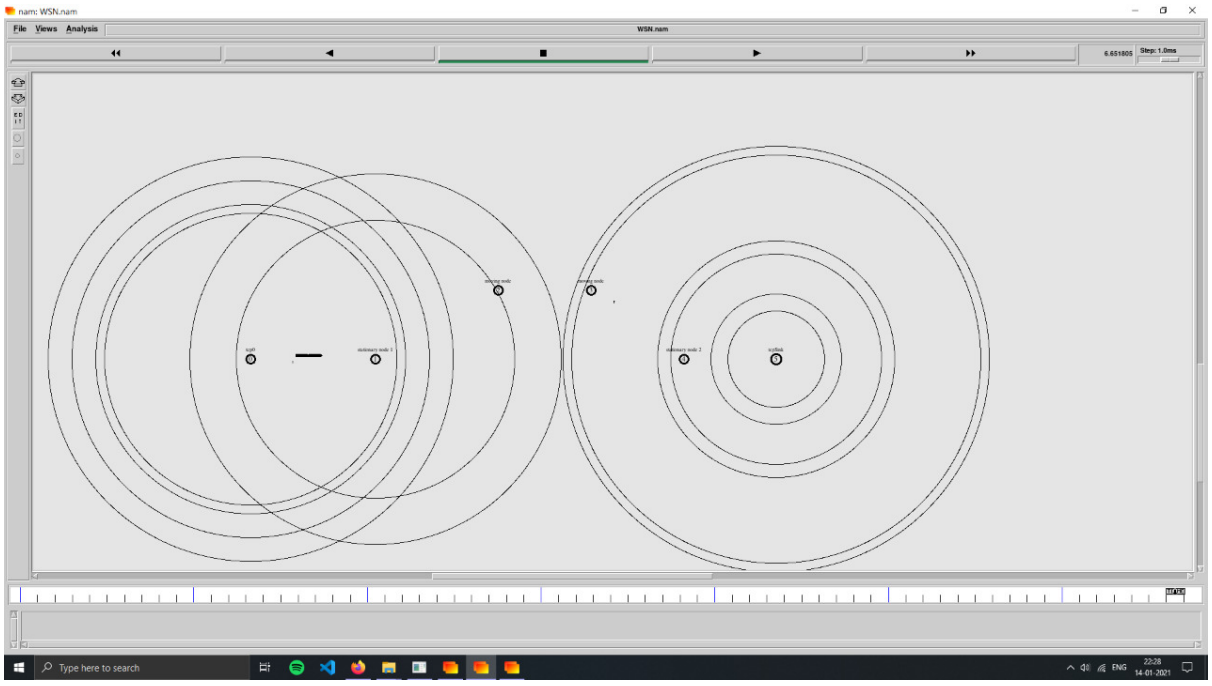
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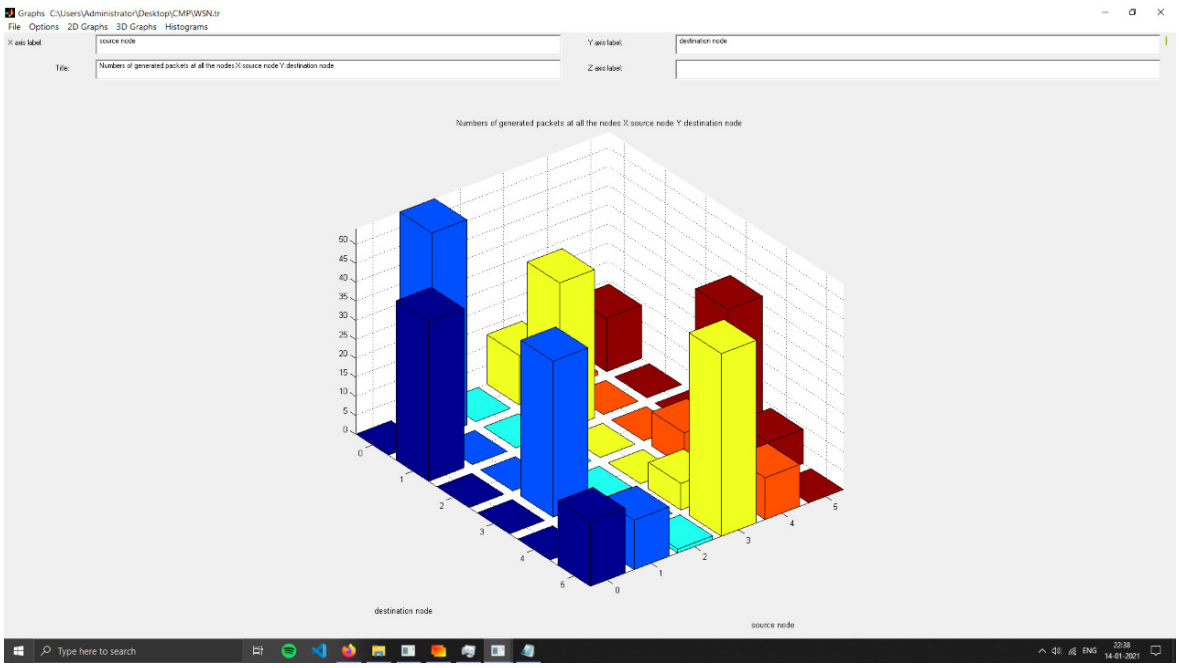
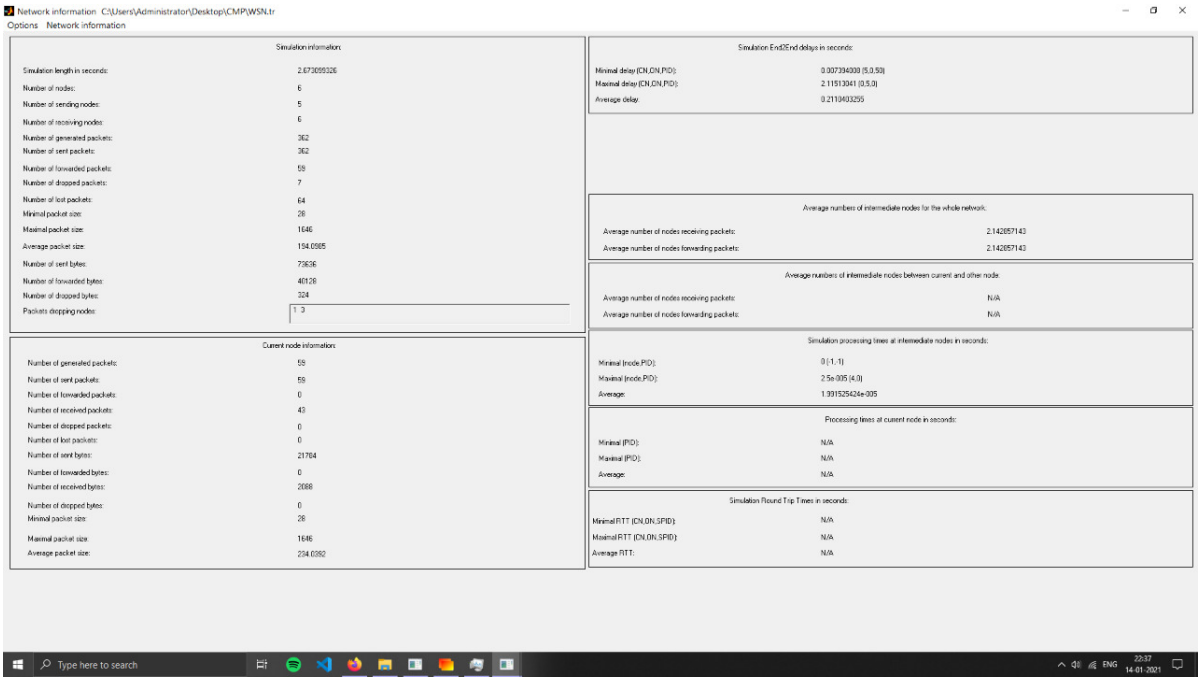
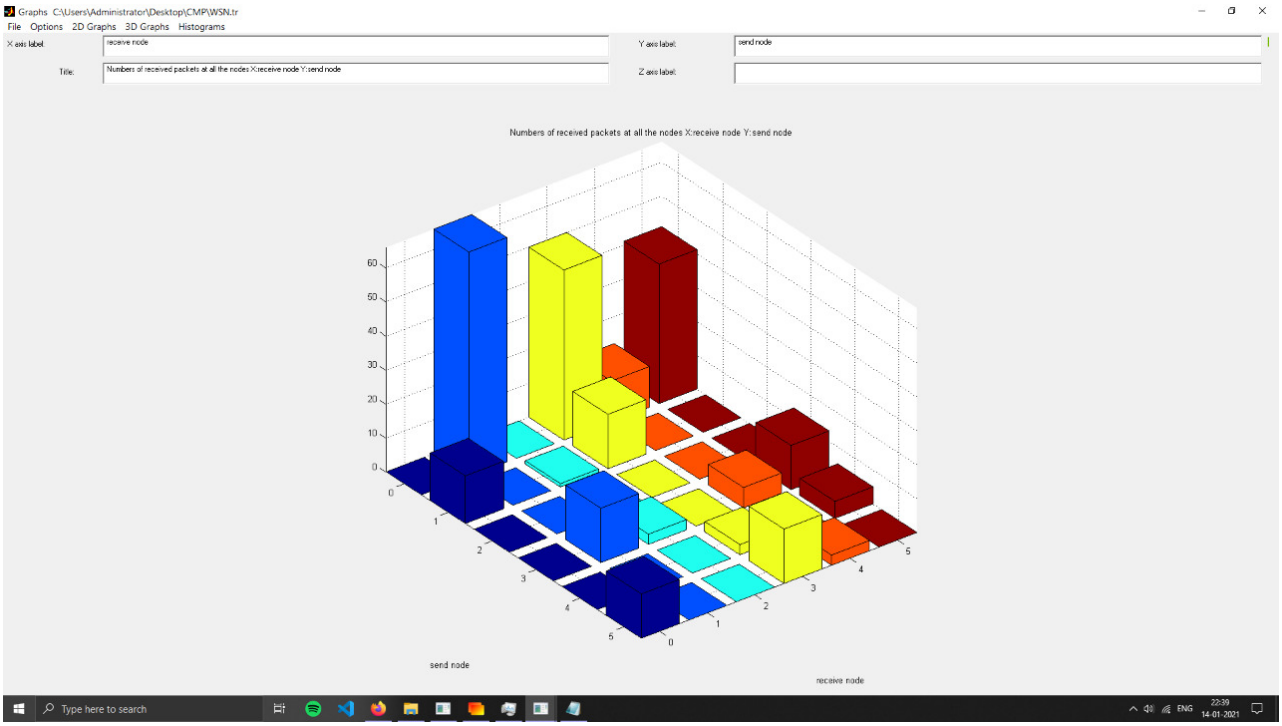

Graphs C:\Users\Administrator\Desktop\CMP\WSN.tr
File Options 2D Graphs 3D Graphs Histograms
X axis label: source node
Y axis label: destination node
Title: Numbers of generated packets at all the nodes X source node Y destination node
Z axis label:
Numbers of generated packets at all the nodes X source node Y destination node
destination node
source node
Type here to search
ENG
22:38
14-01-2021


Network information C:\Users\Administrator\Desktop\CMP\WSN.tr
Options Network information
Simulation information:
Simulation length in seconds: 2.673099326
Number of nodes: 6
Number of sending nodes: 5
Number of receiving nodes: 6
Number of generated packets: 362
Number of sent packets: 362
Number of forwarded packets: 59
Number of dropped packets: 7
Number of lost packets: 64
Minimal packet size: 28
Maximal packet size: 1646
Average packet size: 154.0565
Number of sent bytes: 73636
Number of forwarded bytes: 40128
Number of dropped bytes: 324
Packets dropping nodes: 1 3
Current node information:
Number of generated packets: 55
Number of sent packets: 59
Number of forwarded packets: 0
Number of received packets: 43
Number of dropped packets: 0
Number of lost packets: 0
Number of sent bytes: 21764
Number of forwarded bytes: 0
Number of received bytes: 2088
Number of dropped bytes: 0
Minimal packet size: 28
Maximal packet size: 1646
Average packet size: 254.0282
Simulation End2End delays in seconds:
Minimal delay (CN,ON,PID): 0.007394000 (5,0,50)
Maximal delay (CN,ON,PID): 2.11513041 (0,5,0)
Average delay: 0.211040255
Average numbers of intermediate nodes for the whole network:
Average number of nodes receiving packets: 2.142857143
Average number of nodes forwarding packets: 2.142857143
Average numbers of intermediate nodes between current and other node:
Average number of nodes receiving packets: N/A
Average number of nodes forwarding packets: N/A
Simulation processing times at intermediate nodes in seconds:
Minimal (node,PID): 0 (1,1)
Maximal (node,PID): 2.5e-005 (4,0)
Average: 1.391525424e-005
Processing times at current node in seconds:
Minimal (PID): N/A
Maximal (PID): N/A
Average: N/A
Simulation Round Trip Times in seconds:
Minimal RTT (CN,ON,SPID): N/A
Maximal RTT (CN,ON,SPID): N/A
Average RTT: N/A
Type here to search
ENG
22:37
14-01-2021

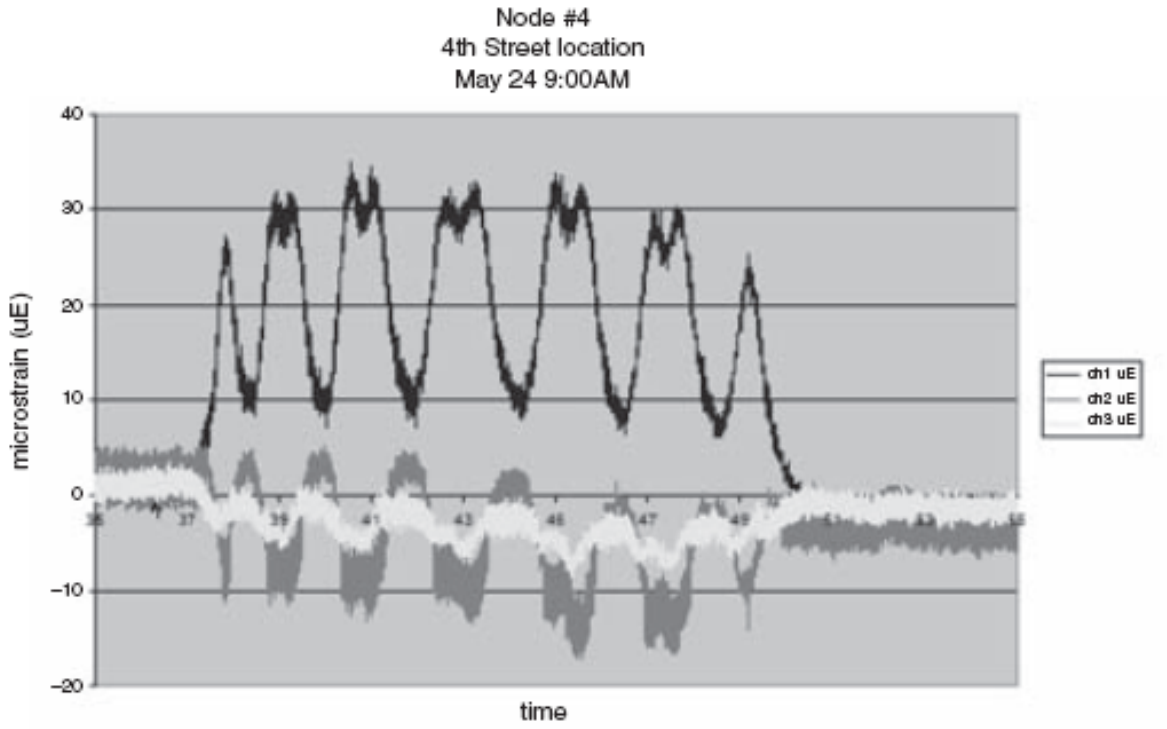

Graphs C:\Users\Administrator\Desktop\CMP\WSN.tr
File Options 2D Graphs 3D Graphs Histograms
X axis label:
receive node
Y axis label:
send node
Title:
Numbers of received packets at all the nodes X:receive node Y:send node
Z axis label:
Numbers of received packets at all the nodes X:receive node Y:send node
60
50
40
30
20
10
0
0
1
2
3
4
5
send node
receive node
Type here to search
ENG
22:39
14-01-2021

Chapter 7

APPLICATION

This low-power event-driven data collection method reduces the power required for continuous operation from 30 mA if thesensors were on all the time to less than 1 mA continuous. This enables a lithium battery to provide more than a year of continuous operation.

Resolution of the collected strain data was typically less than 1 microstrain. Other performance specifications for these wireless strain sensing nodes have been provided in an earlierwork .

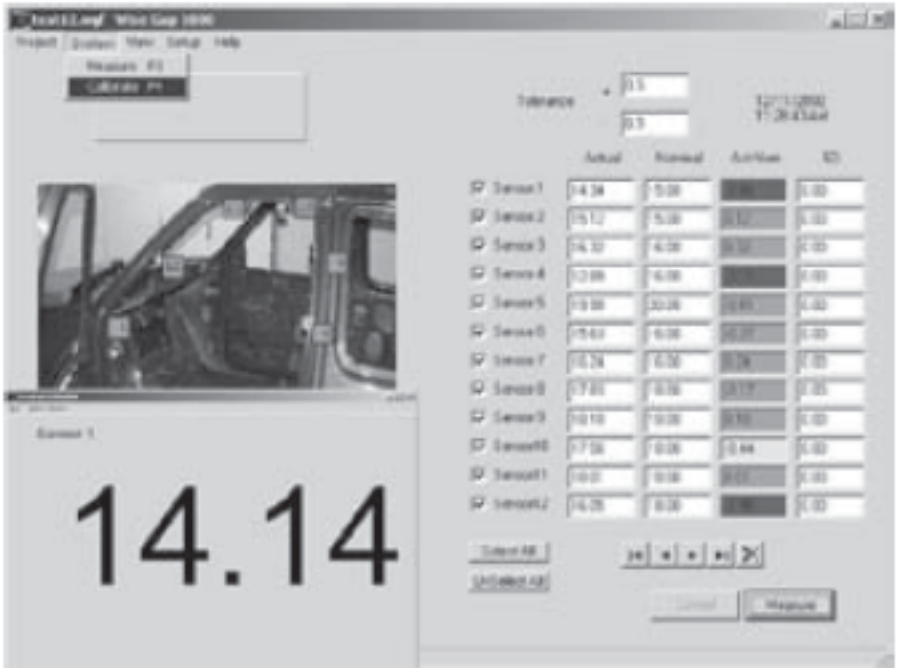


Application Highlight – Civil Structure Monitoring

One of the most recent applications of today’ s smarter, energy-aware sensor networks is structural health monitoring of large civil structures, such as the Ben Franklin Bridge, which spans the Delaware River, linking Philadelphia and Camden, N.J. The bridge carries automobile, train and pedestrian traffic. Bridge officials wanted to monitor the strains on the structure as high-speed commuter trains crossed over the bridge.

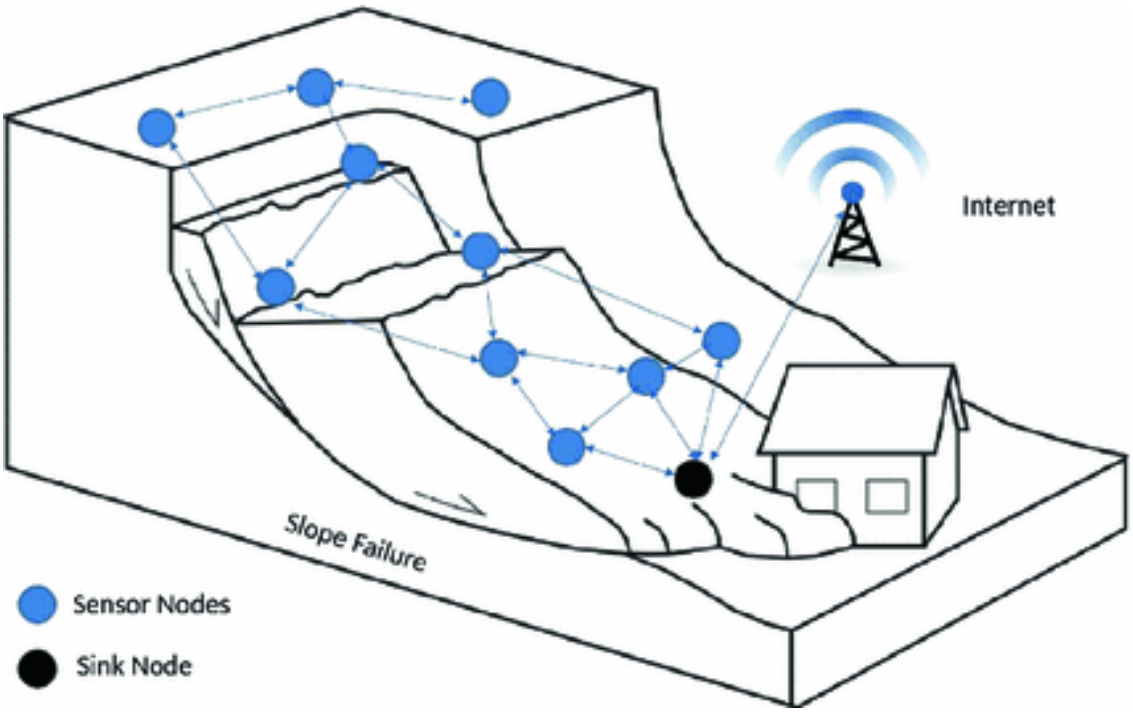
Industrial Automation

In this application, typically ten or more sensors are used to measure gaps where rubber seals are to be placed. Previously, the use of wired sensors was too cumbersome to be implemented in a production line environment. The use of wireless sensors in this application is enabling, allowing a measurement to be made that was not previously practical.

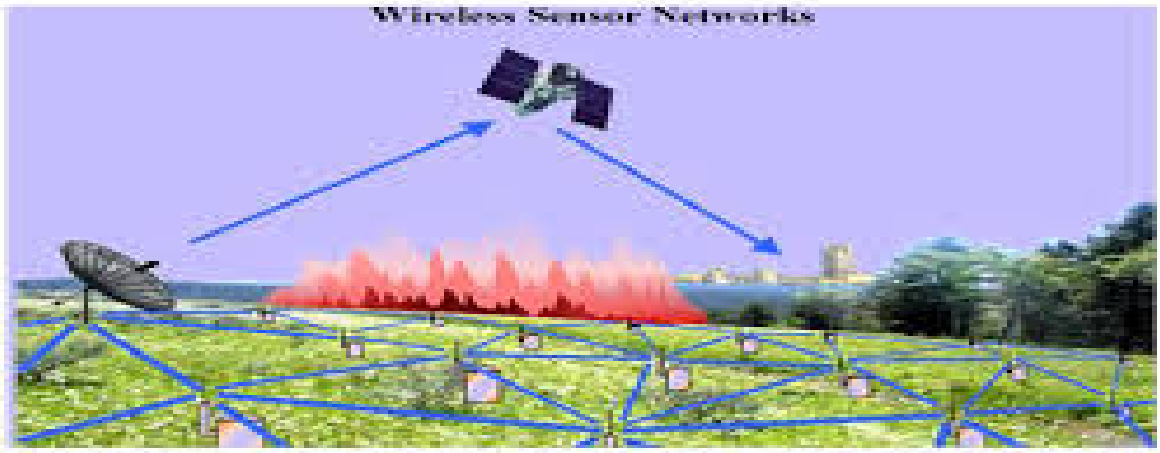


Structural Health Monitoring – Smart Structures

Sensors embedded into machines and structures enable condition based maintenanceof these assets. Typically, structures or machines are inspected at regular time intervals, and components may be repaired or replaced based on their hours in service, rather than on their working conditions. This method is expensive if the components are in good working order, and in some cases, scheduled maintenance will not protect the asset if it was damaged in between the inspection intervals. Wireless sensing will allow assets to be inspected when the sensors indicate that there may be a problem, reducing the cost of maintenance and preventing catastrophic failure in the event that damage is detected. Additionally, the use of wireless reduces the initial deployment costs, as the cost of installing long cable runs is often prohibitive. In some cases, wireless sensing applications demand the elimination of not only lead wires, but the elimination of batteries as well, due to the inherent nature of the machine, structure, or materials under test. These applications include sensors mountedon continuously rotating parts, within concrete and composite materials, and within medical implants.



Forest fire detection



A sensor node installed in Bangladesh to monitor water quality (Courtesy of Nithya Ramanathan)

Chapter 8

CONCLUSION

Wireless Sensor Network must be designed to meet a number of challenging requirements including extended lifetime in the face of energy constraints , scalibility, and automonous operations. Wireless Sensor Network are getting smaller and faster , increasing their potential applications in commercial , industrial , and residential environments.

However , the limit of applications depends only upon the sensors used and the interpretions of the data obtained . As the technology improves and new-low power digital sensors become more readily available , notes will increase functionality without increasing power consumption and will expand the wireless sensing market.

The flexibility , fault tolerance , high sensing fidelity , low-cost and rapid deployment characteristics of sensor network create many new and exciting applications areas for remote sensing. In the future , this wide range of application areas will make sensor network an integral part of our lives. However , realization of sensor network needs to satisfy the constraints introduced by factors such as fault tolerance, scalibity, cost, hardware, topology change, environment and power consumption.

Since these constraints are highly sringet and specific for sensor network, new wireless and ad hoc networking techniques are required. Many researchers are currently engaged in developing the technologies needed for different layers of sensor network and protocol stack

Chapter 9

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