International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-05, Issue-09, Dec 2019

Unstructured Architecture for Mobile ad-hoc Networks using Hybrid Protocol

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Abstract— Mobile ad hoc network (MANET) is a collection of wireless mobile nodes used to connect devices dynamically. Mobile ad hoc network is temporary network, where devices connect to other devices in the mobile range. The recent applications of MANETs are in defense operations, emergency search and rescue information system for a natural disaster, where sharing of information is done using Mobile ad hoc network. These types of network works without any fixed infrastructure. The two main challenges for designing such search algorithm are network nodes move freely in the absence of centralized control and maintaining the routing table. It is very difficult for wireless networks to keep updating routing tables, as the nodes change their positions rapidly across the network. For communication initially the source node check its routing table for the destination node if there is no entry of node then, it initiates Route REQuest message (RREQ) and broadcasts it to all nodes in the worst case (flooding). These systems creates network traffic in routing protocols such as Ad-hoc on demand distance vector routing protocol (AODV) and dynamic source routing (DSR) protocol. This Unstructured Architecture for Mobile ad-hoc networks using hybrid protocol aims to provide mobile network architecture for maintaining routing tables for mobile devices using nRF24L01 module.

Keywords: Ad-hoc, Arduino, Base node, nRF24L01, Search algorithms, Unstructured.

I. INTRODUCTION

The popularity of wireless communications technologies are rapidly growing in recent years. As a result, applications of advanced mobile wireless networks are increased. Mobile Ad-hoc networks (MANETs) are robust mobile wireless network and support effective operation through the interconnection of devices through routing nodes [1].

Developing routing algorithms for mobile ad-hoc network is very difficult as nodes are moving. One possibility of efficiently deploying and information through the nodes is by involving more effective clustering and routing algorithms. Mobile communication networks offer, variety of devices connected to the network, variety of possible interconnections and network topology because of multiple applications networks are becoming more and more complex [2].

In unstructured ad hoc mobile network, set of connected nodes carries the traffic, which is essentially made of queries, then replies, and also other control messages to search other nodes. In unstructured ad hoc mobile networks two types of routing protocols are used proactive and reactive. In proactive routing protocol more routing overhead problem and in reactive routing protocol large amount of query messages which produces network traffic and delay [3]. There is an obvious need for infrastructure independent ad hoc networking with strong support for mobility.

In this architecture we use radio modules nRF24L01 in virtue of their low cost, low power consumption, addressing the problem of miniaturization of devices and data transmission capabilities at high speed and we use both reactive and proactive routing protocol in order to gain better performance.

Key features of nRF24L01- Frequency band 2.4GHz ISM band, data rate up to 2Mbps on air, ultra-low power operation, 11.3mA TX, 12.3mA RX at 2Mbps air data rate, 900nA in power down, 22µA in standby-I, 1.9 to 3.6V supply range, 16MHz crystal, 5V tolerant inputs and compact 20-pin 4x4mm QFN package [4].

II. LITERATURE SURVEY

Several search algorithms for unstructured network have been proposed. These protocols are classified in to two categories proactive routing protocol and reactive routing protocol.

Table-driven routing protocol (proactive): In this protocol all nodes maintain routing tables of all possible nodes. Table information is updated regularly in to provide current status of network accurately. For example: DSDV, FSR, WRP, CGSR, GSR etc. DSDV (Destination Sequence

 DOI : 10.35291/2454-9150.2019.0551

Distance Vector) in which routes are maintained through periodically and event triggered routing table exchanges which has more routing overhead problem. To solve these problems we can use MANETs with some changes. The updated information is periodically transferred to all other nodes so as to get routing information in view of the network topology at all the nodes [5].

For mobile Ad-hoc network Reactive Routing Protocol is on-demand routing protocol. The two main functions protocol of protocol are Route Discovery and Route Maintenance. The discovery of new route is provided by Route Discovery function and detection of link breaks and repair of an existing route is done by Route Maintenance function. For example: DSR, AODV, TORA, ABR etc.

In Ad-hoc on demand distance vector (AODV) routing the algorithm creates routes between nodes only when the routes are requested by the source nodes, giving the network the flexibility to allow nodes to enter and leave the network dynamically. Routes remain active only as long as data packets are traveling along the paths from the source to the destination. The paths will time out and close when the source stops sending packets, AODV supports both unicast and multicast [6]. Ad-hoc on demand distance vector routing (AODV) has disadvantage that large amount of query message which produces network traffic and delay [7]. Comparing proactive and reactive routing protocol, there is a need of hybrid protocol which can eliminate routing overhead and reduce delay.

III. System Architecture

We consider both protocols (a) Proactive routing protocol which is based on periodic exchanges that updates the routing tables to all possible destinations, even if no traffic (b) Reactive routing protocol which is based on on-demand route discoveries that updates routing tables only for the destination that has traffic going through [8][9]. There are two ways to enhance the performance. One way is to improve the algorithm for selecting path, second way is to modify the routing algorithm by considering new characteristics for less signaling overhead[10][11]. This Unstructured network architecture aims to provide ad-hoc network architecture for maintaining routing tables for mobile devices using hybrid protocol. This will be suitable for various application needs.

In this system nRF24L01 module and Arduino Mega 256 are used for this system. Table No. 1 below shows different parameters considered for this system.

Table No.1: Parameters considered for architecture design

Sr. No.	Parameter	Details
1	Node sequence no.	05 nodes (Wireless module nRF24L01)
2	Field size	80 meters (extends as per Mesh network nodes move)
3	Protocol details	Proactive and Reactive
4	Routing table unit	YES
5	Sleep and wake up unit	No (Unstructured Architecture)
6	Delay	Round trip delay 24 m sec

When transmitting information, the main control panel uses the serial module to receive information from computer through Arduino Mega 256, while use the nRF24L01 wireless module to send information to other nRF24L01 module. We use this system for both transmitting and receiving information.

Fig.1. illustrates the unstructured architecture for ad-hoc network in mobile communication along with the node addresses.

In this architecture peers arrive and leave dynamically [12]. The real benefit of having such decentralized network is to make it very difficult to shut the network down. Unlike centralized system where the entire network relied on the server, if server fails entire network fails [13][14].

Several mobility prediction algorithms have been proposed for wireless networks [15][16]. Most algorithms make use of a history base that has a record of the previous movements of users. Taking into account the probability of user movements, regular movements of users can be predicted fairly [17][18]. The multipath routing protocols which are developed to find multiple alternative paths from Source to Destination so as to improve routing efficiency, packet delivery ratio, fault tolerance and other factors can be enhanced to increase the network utility[19][20].

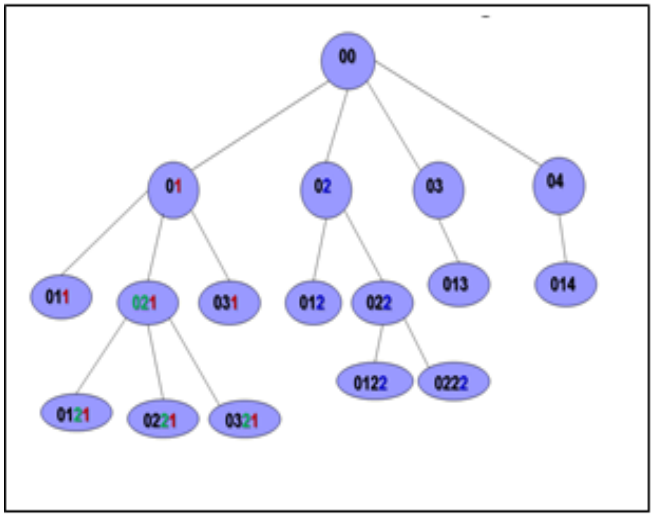

Fig.1. System architecture with network addressing

 DOI : 10.35291/2454-9150.2019.0551

Hybrid protocols are based on scatter nodes in separate groups known as clusters. In these clusters node head will maintain control over network[21][22].

Node addressing
Node 00 is the base node.
Nodes 01-05 are nodes whose parent is the base.
Node 021 is the second child of node 01.
Node 0321 is the third child of node 021, and so on.

The largest node address is 05555, so 3125 nodes are allowed on a single channel. An example topology is shown in table no. 2, with 5 nodes in direct communication with the master node, and multiple leaf nodes spread out at a distance, using intermediate nodes to reach other nodes.

Table 2 : Node addressing of wireless network modules

00										Master Node (00)
01				02		03	04		05	1st level children of master (00)
011	021		031	012		013	014		015	2nd level children of master. Children of 1st level.
111	121	221	331	112	212	113	114	214	115	3rd level children of master. Children of 2nd level.
1111	1121	1221	1331	1112	1212	1113	1114	1214	1115	4th level children of master. Children of 3rd level.

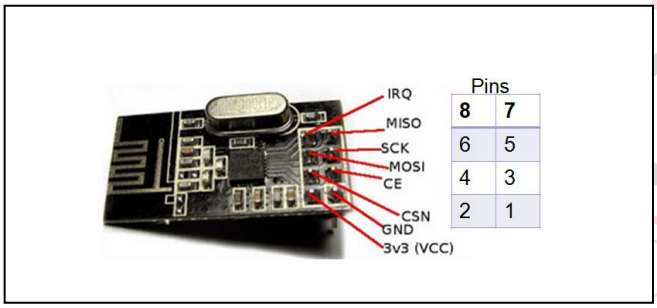

Fig.2. nRF24L01 module

Fig.2. shows nRF24L01 module is used as transmitter and receiver which operates on 2.4 GHz ISM band. nRF24L01 is ultra low power wireless device.
nRF24L01 wireless module Specification:
Name of the module: NRF24L01
Role: Transceiver
Frequency: 2.4 GHz
Interface: SPI
Data rate: Configurable on-air data rate of 250 kbps,
1 Mbps or 2 Mbps
Operating voltage: 1.9 to 3.6 V
Range: 80 Meters
Package: 20-pin 4 × 4 mm QFN
Two modes of operations are defined

RX mode: nRF24L01 radio is trans receiving device module, Rx mode is kept active to enable receiving mode. To use this mode PWR_UP and CE pin set high. When RX mode is set to high then Received Power Detector (RPD) will be available to receive at receiver. The RF signal must be present before at least 40 µs the RPD is set high. The nRF24L01remains in RX mode until MCU configures it to power down mode.

TX mode: nRF24L01 radio is used as transmitter device when Tx mode is kept active to enable transmitting mode. The TX mode is an active mode for transmitting packets. To enter this mode PWR_UP bit set high, PRIM_RX bit set low and a high pulse on CE for more than 10 µs. The nRF24L01 plays transmitter role in TX mode until it sends packet from transmitter.

IV. Result and Discussion

The goal of this practical experimentation was to discover routes for mobile communication. The test was carried out in an open space. The first stage of this is to measure network address for individual transmitter. The communication range for each node is 80 meters. The nodes were gradually moved away in steps of 10 meters. The node network addressing was displayed on terminal window.

In this section, the results are shown for the five node communication. Each node has assigned a node ID from 01 to 05. We have used COM port development tool which is simple serial port (COM) terminal emulation program.

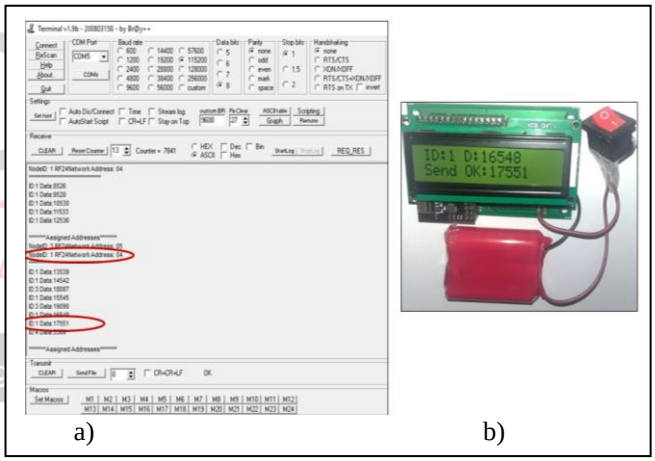

Fig.3. a)Terminal window showing network
b) nRFL01 module ID:01 address and data received from ID:1

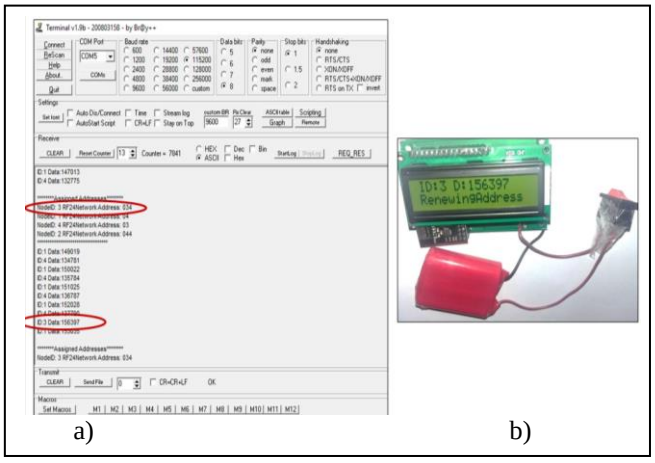

Fig.4. a)Terminal window showing network
b) nRFL01 module ID:03 address and data received from ID:3

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Fig.3. a) shows terminal window for COM5 port which is connected to Arduino Mega 256. Nodes are apart from each other in the network and fifth node relays data to the first node and other nodes acts as relay so it can pass data from node fifth back to first node.

For node ID:01 network address is 04 and node ID:03 is having network address 05. Fig.3. b) shows nRF24L01 module whose ID is assigned as 01 and the data sent 17551 is ok as it is received by base node which is connected to computer and results are shown in terminal window.

Network use two or more wireless hops to convey information from a source ID to destination ID. Fig.4. a) shows network address for node ID:3 is 034, network address for node ID:1 is 04, network address for node ID:4 is 03, network address for node ID:2 is 044. Node ID:1 and node ID:4 are directly communicating to base node. Node ID:3 and node ID:2 are communicating through intermediate node ID:1 to base node, which is 2nd level children of master of base node. Node ID updates network address periodically. Fig.4. b) displays renewing of address of node ID:3.

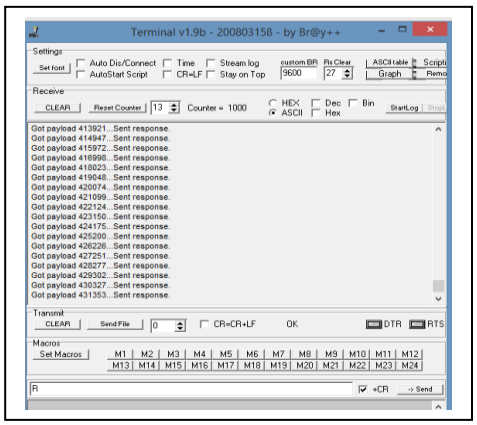

Fig.5. Receiver acknowledge Terminal window

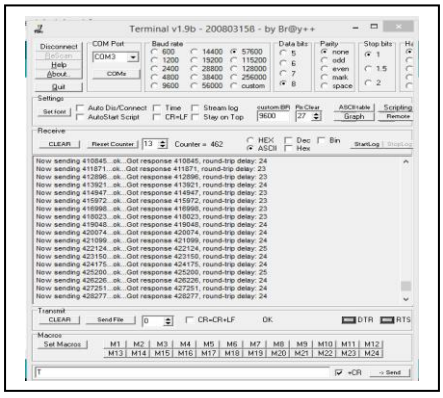

Fig.6. Transmitter Terminal window showing round trip delay

Fig.5. shows receiver acknowledge terminal window which sends acknowledge response to the sender device. Devices are communicating either directly when devices are in communication range or indirectly when devices are not in range. Fig.6 shows transmitter terminal window, which shows round trip delay for communicating devices.

Table No.3: Round trip Delay between two nodes

Sr. No.	Transmitting Node	Receiving Node	Round trip Delay (ms)
1	ID:1	ID:2	24
2	ID:2	ID:3	24
3	ID:3	ID:4	23
4	ID:4	ID:5	25
5	ID:5	ID:1	25

Table number 3 shows delay between transmitting and receiving node. Average delay between two node communication is 24 ms.

V. CONCLUSION

In this paper an experimental setup that was developed specifically for mobile nodes to maintain minimum delay between transmitting and receiving node. A protocol stack was built from scratch for node to node communication using node addressing. Field experiments were carried out and were able to find node addresses for multiple nodes by periodically updating network addresses and minimum delay of 24ms is required for round trip delay.

The common problem associated with network is mobility management. We consider both protocols Proactive routing protocol and Reactive routing protocol. Overall system performance can be improved by dynamic connectivity factor using protocol RREQ. As nodes arrive and leave dynamically the real benefit of having such decentralized network is to make it very difficult to shut the network down and higher degree of coverage. Future work will focus on to further study behavior of network as we increase the number of mobile nodes.

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 DOI : 10.35291/2454-9150.2019.0551