ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

Time Division Multiplexing Access Networks with Duplex Channels

Jennifer .P[1], Kannan Subramanian[2], Muthu Kumaravel .A[3]

Assistant Professor, Dept. of MCA, Bharath University, Chennai, Tamil Nadu, India [1]

Assistant Professor, Dept. of MCA, Bharath University, Chennai, Tamil Nadu, India [2]

HOD, Dept. of MCA, Bharath University, Chennai, Tamil Nadu, India [3]

ABSTRACT: A mobile ad hoc network (MANET) is a wireless network which comprise of mobile computing devices for wireless communication, without the help of existing infrastructure. How to take advantage of multiple channels in MANETs poses a serious challenging problem. A more efficient schedule in multichannel systems may be obtained by treating all the transmission slots on all channels as a two-dimensional (time and frequency) transmission scheduling problem. Few multichannel transmission protocols such as Collision-Avoidance Transmission Scheduling (CATS) have been proposed to harvest the advantage of high transmission efficiency when multiple channels are deployed. Although such protocols do provide ways to coordinate the use of multiple channels, there exist some serious problems such as the throughput fast drop-off under heavy traffic loads. This paper presents a new protocol, namely, MultichAnnel Time-Spread Scheduling (MATS), which attempts to tackle these problems. In MATS, nodes with transmission requests are divided into three groups, which carry out channel reservations in parallel and can simultaneously support unicasting, multicasting and broadcasting at the link level. MATS ensures successful and collision-free data transmissions using the reserved channels and allows multicasting and broadcasting high priorities over unicasting.

KEYWORDS: MANET, channel reservation, dynamic-connectivity.

I. INTRODUCTION

A mobile ad hoc network (MANET) is a wireless network that is comprised of mobile computing devices for wireless communication, without the help of existing infrastructure. The self-configuring, dynamic-connectivity, and fully-distributed nature of ad-hoc networks makes them very attractive for many application in tactical battle field, disaster rescue and conventions but also introduce difficult problems at the link and network layer. One important issue in mobile ad hoc networks is the medium access control (MAC) protocol which attempt to efficiently coordinate the use of the shared communication medium.

Recently multichannel systems have received a great deal of attention because of the advantages offered by such systems. Multichannel systems outperform single channel systems in several aspects:

- Multichannel Time Division Multiple Access (TDMA) systems are usually more reliable.
- Individual channels can operate at a lower rate, and synchronization is easier in multichannel TDMA systems.
- Multichannel TDMA systems have greater flexibility in response to system growth because they allow the addition of new channels.

In view of the superior performance of multichannel systems, this paper focuses on the scheduling problem in TDMA networks with multiple radio channels (multichannel). Although multi channel systems are natural extension of single channel system, the algorithm designed for single channel system cannot be used for multi channel systems. This is because single channel algorithms only attempt to optimize the transmission schedules on one channel. A more efficient schedule in multichannel systems may be obtained by treating all the transmission slots on all channels as a two-dimensional (time and frequency) transmission scheduling problem. Scheduling for such a system consists of allocating stations to different frequencies at different times (or their combinations) so that no collisions occur and

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

efficient spatial reuse of the available bandwidth can be achieved. Effective scheduling can lead to much higher channel efficiency.

1.1 Overview

The remainder of this paper is organized as follows: Section 2 deals with the issues in mobile ad hoc network. Section 3 includes related work. Section 4 focus on salient features. Section 5 explains the reservation protocol MATS. Section 6 analyzes the correctness of the reservation process. Section 7 concludes this paper. Section 9 gives references.

II. ISSUES IN MANET

Mobile ad hoc network (MANET) is a wireless network temporarily and spontaneously created by mobile stations without requiring any infrastructure or central control. Network managements and communications are typically performed in a distributed manner [1].

The first peculiarity is infrastructureless, i.e. there is no pre-existing hardware like base stations in traditional cellular networks or any centralized mechanism managing the network. Ad hoc networks are usually deployed in emergent and temporary situations such as accidents or public gatherings, where mobile stations (MSs) may join the network at will, move around, or become disconnected at any time. Global synchronization is hard to achieve in such situations [2]. And it is unrealistic to expect such a network to be fully connected, in which case a MS can communicate directly with every other node in the network via wireless channels.

As a result, the second important feature emerges - multihop communication. Each node in the network has to take the responsibility of relaying packets for its peers and a packet may traverse multiple nodes before it reach the destination. Two typical problems, namely hidden node and exposed node, come along with multihop communication [3].

Another major concern and interest of investigations in ad networks is energy saving. Since ad networks solely consist of mobile stations which also play the role of packets transmitters, if the battery of any single node run out, it may jeopard the connectivity of entire network besides the fact that the node itself stops being functional [4]. Hence, the network should be cleverly designed so that no battery energy would be wasted. Dynamically adjusting transmission power according to the changing environment seems to be a possible way to extend the battery life. The incorporation of directional antennas to enhance signal transmission quality and lesson inference could be another solution for the energy problem.

Because of the above-mentioned features, the state of ad hoc networks is far less predictable than that of other networks and it is quite natural for individual nodes to share the common wireless channels via distributed mechanisms [5]. Thus, how the medium access control (MAC) layer is designed to allocate the communication resources efficiently and fairly of ad hoc networks largely determines the network performance which can be measured in term of throughput, transmission delay and fairness, etc.

III. RELATED WORK

To date, most works on transmission scheduling algorithms have concentrated on the fair and conflict-free algorithms that maximize the system throughput. However, changes of network topology due to the movements of mobile nodes may render any optimal design obsolete. Many researchers have been searching for distributed sub-optimal solutions [6] [7] [8], which are designed either for broadcasting or unicasting, but not for both. In SYN-MAC [9] protocol is proposed for mobile ad hoc networks, which used binary countdown algorithm for contention resolution. SYN-MAC does gain improved throughput and packet delay. However, the performance of SYN-MAC depends on the number of contention slots and turnaround time, which is a disadvantage for wireless communications. Recently, a multichannel scheduled-access protocol named collision-avoidance transmission scheduling (CATS) has been proposed [10] to simultaneously support unicasting, multicasting, and broadcasting. In CATS, there are five minislots used for channel reservation. In the first two mini-slots, the nodes attempting to reserve a channel detect whether the intended channels are available and the nodes with existing links send signals (Beacon) to keep already reserved channels from being

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

interfered. In the third mini-slot, all nodes send their reservation requests, if any, which may result in high contention probability. In the next two mini-slots, intended nodes confirm and inform if requested links are acceptable. However, because all nodes send reservation requests in one mini-slot (i.e., the third mini-slot) simultaneously, CATS has several unresolved problems such as the sudden drop-off problem: the throughput drops to almost zero as the traffic load increases. Although a back off algorithm can be introduced to mitigate this problem, the cost is high because all nodes contend on one single mini-slot. Another problem is that broadcasting and multicasting cannot be set different priorities over unicasting because broadcasting and multicasting requests are treated equally as the unicasting requests, which results in the situation that broadcast transmission cannot be established unless unicast traffic load is very low.

IV. SALIENT FEATURES

This paper presents a new protocol for multichannel TDMA ad hoc networks, referred to as MATS (Multichannel Time-Spread Scheduling) that overcomes the existing problems in CATS. MATS has several unique characteristics:

- MATS can achieve high throughput without sudden drop-off under heavy traffic loads;
- The reservations of nodes are distributed and carried out in parallel with a short overhead;
- Broadcast and multicast can be carried out separately from unicast reservations and can be assigned different priorities

V. RESERVATION PROTOCOL MATS

This section describes the protocol basis and how the data transmission and reservation are done in MATS.

5.1 MATS Basics

An ad hoc network is a collection of communication devices referred to as nodes, which can exchange information. Every node can reach a given subset of other nodes, depending on the transmitting power and the topographic characteristics of the surrounding area. An ad hoc network can be thought of as a set of network nodes and a set of edges between nodes capable of reaching each other. Nodes linked by an edge are considered to be neighbors. MATS assumes that every node has the same transmitting power, which makes the reachability graph of the network symmetric [12]. Each node sends messages in synchronous time slots. In every time slot, each node acts either as a transmitter or a receiver. The node acting as a receiver in a given slot receives a message if exactly one of its neighbors transmits in this slot. If more than one neighbor transmits to a node in the same slot, a collision occurs and the node receives none of the messages. The multiple radio channels (multichannel) are classified into different radio channels: a control channel (CCH), a broadcast data channel (BCH), and data channels (DCH). The CCH is used for transmission of control packets, the BCH for broadcasting, and DCHs for multicasting and unicasting. A channel reservation means that a node reserves a time slot and a radio frequency for transmission, two factors used to determine a channel.

5.2 Protocol Description

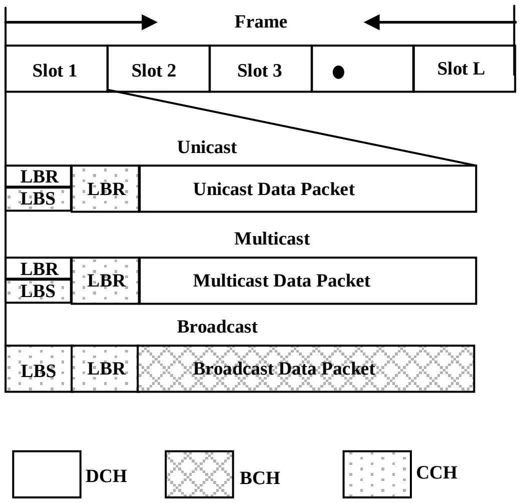
MATS, carries out channel reservation in away that nodes with reservation requests are divided into three groups, send their requests asynchronously in different minislots and carry out reservations in parallel for the remaining reservation process with a short overhead. Fig. 1 shows the basic operation of MATS one time frame consists of L slots in MATS and every node reserves a slot beforehand for transmission. Each slot has two parts, one part consisting of six mini-slots (MS1–6) used for reservation and the other part consisting of a single mini-slot (MS7) used for data transmission [11]. Small control packets called beacons carrying necessary reservation information are sent during MS1–6. In general, a beacon specifies the source address, the destination address, the reserved or intended broadcast and multicast slots, and the reserved or intended data channel. After a node succeeds in making a reservation in MS1-MS6, it will transmit data in the following MS7 and continues transmitting from MS3 to MS7 in the same slot of the following frames until the flow (stream of packets) is over. MS7 can be much longer than the other mini-slots because it is used for data transmission.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015



LBS: Link reservation Beacon of Sender
LBR: Link reservation Beacon of Receiver

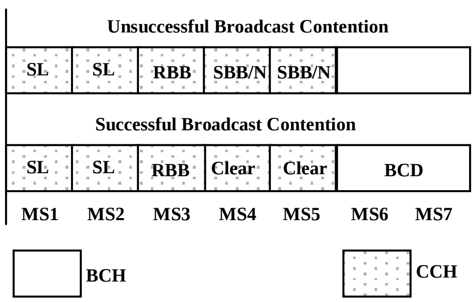
Figure. 1 Basic operation in MATS

5.2.1 Data transmission in MATS

Figure 1 illustrates how data are transmitted over reserved links without interference. Every sender transmitting during the current slot sends an LBS (Link reservation Beacon of Sender) over the CCH in MS1 to prevent other nodes from attempting to establish multicast or broadcast links, while nodes receiving during the current slot send an LBR (Link reservation Beacon of Receiver) over the reserved DCH to prevent other nodes from attempting to establish unicast links with the same intended DCH [13]. In MS2, nodes receiving during the current slot send an LBR over the CCH to prevent possible interference from attempts by other nodes to establish multicast or broadcast links. For a node with broadcast or multicast request, only when detecting the CCH clear in both MS1 and MS2, indicating that none of its neighbors is transmitting or receiving, it will then continue the reservation process. For a node with unicast request, it just needs to know none of its neighbors is receiving over the intended DCH in order to continue the reservation process. Otherwise, nodes with requests will abort their reservation processes. By sending LBS and LBR, the reserved links are prevented from being reserved and used by other nodes [14].

5.2.2 Making a reservation for Broadcast

Fig. 2 shows the process for reserving broadcast link. The algorithm for broadcast reservation



RBB: Request Broadcast Beacon BCD: Broadcast Data
SL: Sender Listens SBB/N: Stop Multicast Beacon /Noise

Figure. 2 Broadcast reservation

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

is given below.

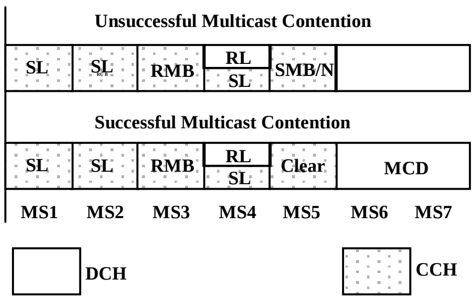
- MS1: Node which wants to reserve a broadcast link listens on the CCH.
- MS2: Upon detecting clear over CCH in MS1 the node continue to listen on the CCH.
- MS3: If the channel is clear on both MS1 and MS2, the node sends a RBB (Request Broadcast Beacon) over CCH. Otherwise it stops its reservation process. At the same time, nodes that are neither transmitting nor receiving listen on the CCH.
- MS4: The sender listens on the CCH in this minislot. Nodes that are neither transmitting nor receiving listen on the CCH send SBB (Stop Broadcast Beacon) if they detect collision in the previous minislot.
- MS5: If the active broadcast node detects SBB or noise in MS4, it realizes that its reservation request has failed. Otherwise it continues to listen on CCH. In case of clear status in MS5 it successfully reserves the channel.

Upon successful reservation the node can send data from sixth minislot onwards over BCH. To continue its transmission in the next slot, the active broadcast node sends LBR in MS1. After making the reservation it can send data from third minislot onwards. By sending LBS, the reserved link is prevented from being reserved by others.

5.2.3 Making a reservation for Multicast

Fig. 3 shows the process for reserving multicast link. The algorithm for broadcast reservation is given below:

- MS1: A node which wants to reserve a multicast link listens on the CCH.
- MS2: Upon detecting clear over CCH in MS1 the node continue to listen on the CCH.
- MS3: If the channel is clear on both MS1 and MS2, the node sends a RMB (Request Broadcast Beacon) over CCH. Otherwise it stops its reservation process.
- MS4: The active multicast node listens on CCH to determine if there is a SBB sent by a node that detects a collision in MS3. The node receiving a RMB listens to the intended DCH in MS4.



RMB: Request Unicast Beacon MCD: Multicast Data
SL: Sender Listens RL: Receiver Listens
SMB/N: Stop Multicast Beacon /Noise

Figure. 3. Multicast reservation

- MS5: The multicast receiver node sends SMB (Stop Multicast Beacon) over CCH, if the intended data channel is not clear. Otherwise it sends back no signal. Only after detecting no signal over CCH in MS4 and MS5, it recognizes that multicast request is successful.

Upon successful reservation the node can send data from sixth minislot onwards over DCH. To continue its transmission in the next slot, the active multicast node sends LBR in MS1. After making the reservation it can send data from third minislot onwards. By sending LBS, the reserved link is prevented from being reserved by others [15].

5.2.4 Making a reservation for Unicast

Unicast senders are divided into two groups NTRU1 and NTRU2 in order to spread reservation requests in time to quickly resolve possible collisions. The available radio channels are divided into two sets $C1$ and $C2$ with $c1$ and $c2$ channels, respectively, where $c1 + c2 = c$. Before a node starts reservation for unicast, it randomly selects a radio channel. If the selected radio channel belongs to $C1$, then the node recognizes that it belongs to NTRU1, otherwise it belongs to NTRU2.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

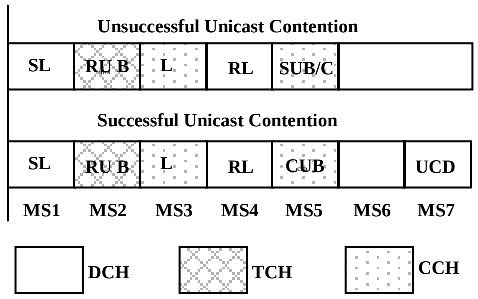
International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

Assume that Node A is attempting to reserve a unicast link to send data to Node B. This can be analyzed in two ways. (1) Node A belongs to NTRU1, and (2) Node A belongs to NTRU2.
Fig. 4 shows the process for reserving unicast link if the Node A belongs to NTRU1.

- MS1: Every receiver of an existing link sends an LBR over a reserved DCH. Node A listens on the intended DCH and, if the DCH is busy, stops the unicast reservation process.
- MS2: Node A sends a RUB (Request Unicast Beacon) over a TCH (Temporary CHannel)–DCH determined beforehand and known by all nodes.
- MS3: Nodes A and B listen on the CCH like any other receiver candidates.

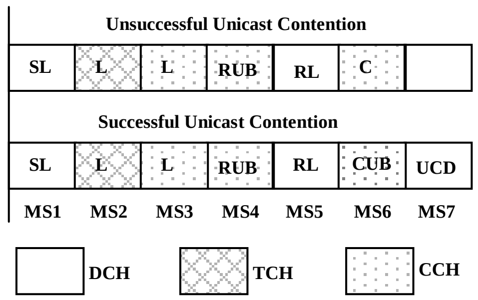


RUB: Request Unicast Beacon UCD: Unicast Data
SL: Sender Listens CUB: Concur with Unicast Beacon
RL: Receiver Listens, L: Node without receiving and sending listens SUB/C: Stop Unicast Beacon/Clear

Figure. 4. Unicast group 1 reservation

- MS4: If Node A receives a RBB or a RMB as the intended receiver in MS3, then it interrupts its reservation and behaves as a receiver of a broadcast or a multicast in the remaining mini-slots. If Node A detects a collision in MS3, it sends an SBB over the CCH in this slot. If Node B confirms that the CCH is clear or has a collision in MS3 and receives a RUB as the intended receiver in MS2, it listens on the DCH indicated in the RUB.
- MS5: If Node B confirms that the DCH indicated in the RUB is clear in MS4, it sends a CUB (Concur with Unicast Beacon) over the CCH. If the intended DCH is not clear in MS4, Node B sends an SUB (Stop Unicast Beacon) in case of a collision detected in MS3 or does nothing if there is no collision detected in MS3. Only when Node A receives a CUB, is the reservation declared successful.

The TCH used in MS2 is selected from the set of DCHs. The TCH can be any arbitrary DCH known by all nodes because the use of TCH will not affect the reserved links due to the fact that the existing link transmissions do not begin before MS2. In MS3, the node that sent or received a RUB in MS2 also has the possibility of receiving a RBB or RMB as an intended receiver. If Node B received RUB in MS2 and no correct RBB or RMB in MS3, it listens over DCH in MS4, and then sends SUB or CUB in MS5. In the meantime, the sender of RBB realizes failure of broadcast reservation on finding any signal or noise. In this way, Node B can avoid missing possible unicast reservation [4].
Fig. 5 shows the process for reserving unicast link if the Node A belongs to NTRU2.



RUB: Request Unicast Beacon UCD: Unicast Data

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

SL: Sender Listens CUB: Concur with Unicast Beacon
RL: Receiver Listens, L: Node without receiving and sending listens

Figure. 5. Unicast group 2 reservation

- MS1: The behaviors of nodes are the same as those described for NTRU1 above.
- MS2: Nodes A and B listen on the TCH like other receiver candidates.
- MS3: Nodes A and B listen on the CCH like other receiver candidates.
- MS4: If Node A correctly receives a RBB or RMB inMS3, it abandons its own reservation and behaves as a broadcast or multicast receiver in the remaining minislots. Similarly, if Node A receives a RUB sent from a node of NTRU1 in MS2, it stops its own reservation and behaves as a receiving candidate. Otherwise, Node A sends a RUB over the CCH.
- MS5: Upon receipt of a RUB from Node A in MS4, Node B listens on the indicated DCH.
- MS6: If Node B detects that the intended DCH is clear inMS5, it sends a CUB over CCH and, if Node A correctly receives the CUB, the unicast link is then established successfully.

As shown above, in MATS, nodes with broadcast, multicast and unicast send requests RBB, RMB and RUB in different mini-slot, that RBB and RMB in MS3, RUB of NTRU1 in MS2 and RUB of NTRU2 in MS4, leading to a lower contention probability. In contrast, all requests are sent in one mini-slot in CATS. In MATS, when nodes of one group send requests, the other nodes can listen and receive the requests from other nodes if there is no collision [7]. In the meantime, the reservation processes of three groups are in parallel, so MATS only consumes a short overhead.

VI. ANALYSIS OF THE RESERVATION PROCESS

This section analyzes the correctness of the reservation process.

New Broadcast or multicast links will not interfere with each other

If more than one node transmits a RBB or RMB, the neighboring node of the active nodes will detect a collision and therefore the link can not be established. So new broadcast or multicast links will not interfere with each other.

New Broadcast or multicast links will not interfere with the existing links.

After detects a clear signal in MS1 and in MS2 only the node starts its reservation process. Clear signal in MS1 and MS2 means that none of the neighbor of the active node transmits or receives on the intended channel.

New Broadcast or multicast links will not interfere with other unicast links.

The active unicast node will listen on CCH in MS3. If it detects collision it will send SBB or SMB in the next mini slot, resulting in interruption of broadcast or multicast reservation [5]. Also if the node receives RBB or RMB as the intended receiver, it will stop making a unicast request.

New Unicast links will not interfere with the existing links.

The active node sends RUB if and only if none of its neighbor is receiving data on the intended DCH, which is confirmed by listening on the DCH in MS1. And also a new unicast link will not be interfered by existing links. Because the receiver of the unicast transmission will listen on intended DCH in MS4 (Group 1) and MS5 (Group2). If the receiver had a clear signal in these minislots only they will send CUB which is the identity for successful reservation.

New Unicast links will not interfere with the each other.

The sender and the receiver of a new unicast link cannot simultaneously be a sender or receiver of another unicast link because if a node sends or receives a RUB in MS2, it will ignore other RUB in MS4.

VII. CONCLUSION

This protocol provides an efficient way to coordinate the use of multiple channels in mobile ad hoc network. MATS is distributed and simultaneously supports unicasting, multicasting and broadcasting. MATS improve the throughput by dividing the nodes in network into three groups, which decreases collision probability. MATS avoids sudden throughput drop-off problem in previously known protocols. MATS also allows the multicasting and broadcasting to bear higher priority over unicasting.

ISSN(Online): 2320-9801
ISSN (Print): 2320-9798

International Journal of Innovative Research in Computer and Communication Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 1, January 2015

REFERENCES

1. J. J. Garcia-Luna-Aceves and E. L. Madruga, “The core-addidted mesh protocol,” IEEE, vol. 17, no. 8, Aug. 1999.
2. M. Grossglauser and D. Tse, “Mobility increases the capacity of ad hoc wireless networks,” IEEE/ACM Trans. Networking, vol. 10, Aug. 2002.
3. Leena Sankari S., Masthan K.M.K., Aravindha Babu N., Bhattacharjee T., Elumalai M., "Apoptosis in cancer - an update", Asian Pacific Journal of Cancer Prevention, ISSN : 1513-7368, 13(10) (2012) PP. 4873-4878.
4. L. Butty’an and J.-P. Hubaux, “Enforcing service availability in mobile ad-hoc WANs,” in Proc. 1st IEEE/ACM Workshop on Mobile Ad Hoc Networking and Computing, Aug. 2000.
5. Subhashree A.R., Parameaswari P.J., Shanthi B., Revathy C., Parijatham B.O., "The reference intervals for the haematological parameters in healthy adult population of Chennai, Southern India", Journal of Clinical and Diagnostic Research, ISSN : 0973 - 709X, 6(10) (2012), PP. 1675-1680.
6. C. Zhu and M. S. Corson, “A five phase reservation protocol (FPRP) for a mobile ad hoc networks,” in Proc. IEEE INFOCOM, vol. 1, Mar. 1998.
7. J.-H. Ju and V. O. K. Li, “TDMA scheduling design of multihop packet radio network based on Latin squares,” IEEE J. Select. Areas Commun., vol. 17, Aug. 1999.
8. Ramaswamy S., Sengottuvelu S., Haja Sherief S.H., Jaikumar S., Saravanan R., Prasadkumar C., Sivakumar T., "Gastroprotective activity of ethanolic extract of Trachyspermum ammi fruit", International Journal of Pharma and Bio Sciences, ISSN :0975-6299, 1(1) (2010) Art-no.17
9. A. Ephremides and T. Truong, “Scheduling broadcasts in multihop radio networks,” IEEE Trans. Commun., vol. 38, Apr. 1990.
10. Cidon and M. Sidi, “Distributed assignment algorithms for multihop packet radio networks,” IEEE Trans. Comput., vol. 38, Oct. 1989.
11. Kumar S.S., Karrunakaran C.M., Rao M.R.K., Balasubramanian M.P., "Inhibitory effects of Indigofera aspalathoides on 20-methylcholanthrene- induced chemical carcinogenesis in rats", Journal of Carcinogenesis, ISSN : 1477-3163, 10() (2011) Art.no.1.
12. Chlamtac and S. Kutten, “A spatial-reuse TDMA/FDMA for mobile multi-hop radio networks,” in Proc. IEEE INFOCOM, Mar.1985.
13. H. Wu, A. Utgikar, and N.-F. Tzeng, “SYN-MAC: A distributed medium access control protocol for synchronized wireless networks,” ACM Mobile Networks and Applications Journal, vol. 10, Oct. 2001.
14. Kumaravel A., Meetei O.N., "An application of non-uniform cellular automata for efficient cryptography", 2013 IEEE Conference on Information and Communication Technologies, ICT 2013, ISSN : 1681-8016, (2013) pp.1200-1205.
15. Z. Tang and J.J. Garcia-Luna-Aceves, “Collision-avoidance transmission scheduling for Ad-Hoc networks,” in Proc. IEEE ICC, vol. 3, June 2000.
16. R.Karthikeyan, Dr.S.R.Suresh, An Approach for Real Time Testing Reliability& Usability Testing Process, International Journal of Innovative Research in Computer and Communication Engineering, ISSN (Online): 2320 – 9801,pp 644-651, Vol. 1, Issue 3, May 201
17. P.Ramya, dr.nalini, effective navigation queryresults based on biomedicaldatabase, International Journal of Innovative Research in Computer and Communication Engineering, ISSN: 2249-0183,pp 36-39, volume 1 Issue 3 No4- Dec 2011
18. P.Kavitha, Authentic Learning Activities withPedagogical Stylistics – Enhancing InE-Learning Websites, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801,pp 1211-1215, Volume 1, Issue 6, August 2013
19. N.Priya, VANET Based Adaptive Traffic SignalControl, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801,pp 1201-1208, Vol. 1, Issue 6, August 2014
20. N.Sakthi Priya, Cervical Cancer Screening and ClassificationUsing Acoustic Shadowing, International Journal of Innovative Research in Computer and Communication Engineering, ISSN(Online): 2320-9801,pp 1676-1679, Volume 1, Issue 8, October 2013