ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 8, August 2017

OPTANT- Optimized Ant Colony Routing For Mobile Ad-Hoc Networks

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Abstract: Mobile Ad hoc Network is a dynamic network where the nodes move frequently over time. Since they are mobile in nature they do not possess any standard topology. Communication between nodes happen hop-based. There may be single hop or multi hop communications. Due to non-centralized nature, the nodes in the network are prone to various difficulties. While there are various protocols that promise Routing in MANET, finding a path that satisfy user's Quality of Service requirement remain a challenge. This paper study the use of Swarm based algorithms and propose an algorithm *OPTANT* that is inspired by Ant Colony Optimization. The proposed algorithm is compared with other bio-inspired existing algorithms and the results are found favorable.

Keywords: MANET, Routing, Swarm Intelligence, Ant Colony Algorithm, Optimization, Route-discovery.

I. INTRODUCTION

A mobile ad-hoc network consists of nodes that communicate with other using wireless sensors. They do not hold any physical connection or topology. Since nodes in the network are dynamic and keeps moving, it can join or leave the network anytime. Because of this property the topology of a network changes often. In MANET, all the nodes act as both node and a router. The transmission range of each node is limited. Hence to make a transaction from a source node to another destination node, it may not be possible to accomplish in single hop manner. So, to reach a destination, a message must pass through some intermediary nodes; therefore these networks are also called multi-hop networks. Fig 1 demonstrates a simple ad hoc network

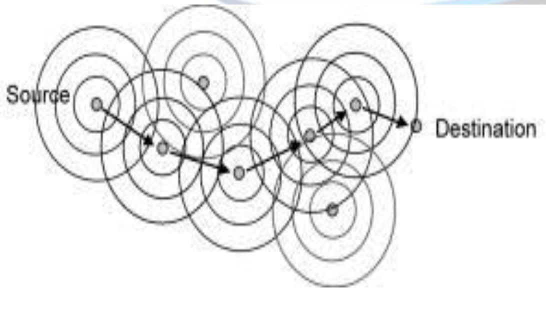

Fig. 1. Simple Ad hoc network

One of the key issues in MANET is finding the routes between nodes. Algorithms that help in finding a route from source node to destination node is called as Routing Algorithms or protocols. There are a plenty of routing algorithms exists. The routing algorithms in MANET are categorized into two:

- Proactive Algorithm
- Reactive Algorithm
- Hybrid Algorithm

A Proactive routing algorithm calculates routes before there arise a need for packet transmission. The algorithms calculate the information about the neighbouring nodes and tries to keep routing-information of all nodes every time updated. Although such proactive algorithms increases the computational overhead, they are very fast in establishing a route when there is a need for packet transmission. Examples of proactive algorithms are Destination-Sequence Distance-Vector routing (DSDV) and Optimized Link State Routing (OLSR) [1]

A Reactive routing algorithm establishes one route only when it is needed and does not try to keep routing information to all nodes always up-to-date [2]. This approach is generally more efficient, but can lead to higher delays as routing information is often not immediately available when needed. Examples of reactive routing algorithms include Dynamic Source Routing (DSR) [3] and Ad-hoc On-demand Distance-Vector routing (AODV) [4].

Finally, Hybrid algorithms use both proactive and reactive elements, trying to Hybrid Adaptive Routing Protocol (SHARP) [3].

Traditional routing protocols face many problems due to the dynamic behaviour and resource constraints in MANETs. To overcome this limitation, a routing protocol is required to have a self-organizing or an autonomous feature. An approach to achieve such feature is to use a biologically-inspired mechanism.

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Many biological systems possess the ability to maintain their stable condition themselves regardless of the external influences or dynamic conditions [4]. Ant colonies are complex biological systems that respond to changing conditions in nature by solving dynamic problems. Their ability of decentralized decision-making and their self-organized trail systems, have inspired computer scientists since 1990s, and consequently initiated a class of heuristic search algorithms, known as ant colony optimization (ACO) algorithms. These have proven to be very effective in solving combinatorial optimization problems, especially in the field of telecommunication. ACO is based on the ant foraging behaviour, utilizing pheromone deposition as a means of evaluation for the travelled route [14, 15].

This paper proposes a biologically inspired algorithm OPTANT which is designed by the impulse of Ant Colony Algorithm. By adapting the behaviour of ant in searching for their food, OPTANT improves and tries to optimize the routes by increasing the throughput. Simulation results indicate its better performances compared to other methods.

II. Review of Related Works

Several literatures have been published in recent years in the field of mobile ad hoc networks addressing delay of the network, link capacity, link stability or identifying low mobility nodes. But there are relatively very little works published with regards to biologically inspired algorithms for routing in communications networks. Yet, many researchers agree that biologically inspired algorithms promise better and optimized solutions in areas like routing in ay network. A brief review of some of these algorithms is given in this section.

Lu et al.,[5] has published Adaptive Swarm-based Routing (ASR) algorithm that increases the speed of convergence and has quite good stability by using a novel variation of reinforcement learning and a technique called momentum. It is a very effective mechanism that seeks to incorporate a memory in the learning process, increases the stability of the scheme and helps to increase the learning efficiency of the network.

Belkadi et al.,[6] proposed a new QoS routing protocol combined with the flow control mechanism. The proposed routing algorithm is based on ant colony optimisation model. The routing protocol uses a new metric to find the route with higher transmission rate, less latency and better stability.

Genhang Ding et al., [7] proposed an Improved Ant Colony Algorithm (IACA). It includes multi strategies for solving QoS routing problems by changing pheromone update rule and substituting the piecewise function Q(t) for the probability constant which is chosen by ants when a route is selected. Experimental results show that the success rate of the improved ant colony algorithm in solving QoS routing problems and the ratio to obtain the optimal solution reach up to 99.81 % and 99.65 % respectively. The results are much better than those obtained by the basic ant colony algorithm.

P. Deepalakshmi et al., [8] proposed source initiated mesh and Soft-state based QoS probabilistic Multicast Routing Protocol (SQMP) for MANET based on the ant foraging behaviour. Mesh creation of proposed algorithm involves two phases namely query phase and reply phase. The multicast source node invokes query phase to initiate the mesh route discovery process. The reply phase is initiated by the multicast group receivers to multicast sources through different QoS satisfied paths. Multiple paths have been found with first rate path preference probability. The data is sent over the paths with higher path preference probability which can satisfy the bandwidth requirement and delay of applications. In NS2, 50 nodes move in the region of 1000*1000 m2 with speed of 0 to 20 m/s for a simulation period of 300 seconds. The proposed algorithm has been compared with ODMRP in terms of PDR, total bytes transmitted per data byte received with respect to mobility

Calduwel et al., [9] has proposed a biologically inspired Genetic Algorithm for optimizing routing in MANET. Packet Delivery Ratio (PDR) is considered as quality metric. The algorithm GAMNET is compared with traditional algorithms and other biologically inspired algorithms. Algorithm GAMNET promise better results compared to other traditional algorithms.

III. Ant Colony Optimization (Aco) In Routing

ACO routing algorithms take inspiration from the behavior of ants in nature and from the related field of ACO to solve the problem of routing in communication networks [10]. The main source of inspiration is found in the ability of certain types of ants to find the shortest path between their nest and a food source using a volatile chemical substance called pheromone. Ants traveling between the nest and the food source leave traces of pheromone as they move. They also favourably go in the track of high pheromone concentrations. Since shorter paths can be completed faster, they receive higher levels of pheromone earlier, attracting more ants, which in turn leads to more pheromone. This positive reinforcement process allows the colony as a whole to converge on the shortest path. It forms the basis of most of the work in the field of ACO.

To illustrate this behaviour, consider the experiment shown in Fig 2. A set of ants moves along a straight line from their nest A to a food source B (Fig 2a). At a given moment, an obstacle is put across this way so that side (C) is longer than side (D) (Fig 2b). The ants will thus have to decide which direction they will take: either C or D. The first ones will choose a random direction and will deposit pheromone along

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ISSN 2394-3785 (Online)
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their way. Those taking the way ADB (or BDA), will arrive at the end of the obstacle (depositing more pheromone on their way) before those that take the way ACB (or BCA). The following ants' choice is then influenced by the pheromone intensity which stimulates them to choose the path ADB rather than the way ACB (Fig 2c). The ants will then find the shortest way between their nest and the food source.

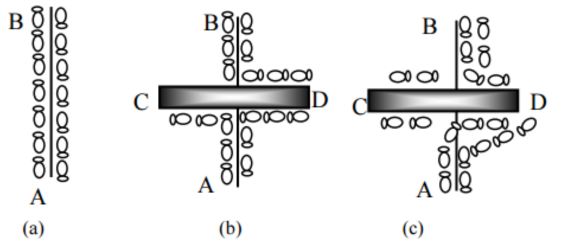

Fig. 2. Behaviour of the Ants on searching food.

A. ACO in Shortest Path Routing

Finding shortest paths maps suits much well to the problem of routing in networks. Moreover, the ability to solve these problems in a distributed way is important in communication networks, as these usually operate without a point of central control [10]. Early work on ACO routing includes the Ant-Based Control algorithm (ABC) [11] for circuit-switched wired networks and the AntNet algorithm [12] for packet-switched wired networks. The main idea behind these algorithms is that nodes in the network periodically and asynchronously send out artificial ants towards possible destination nodes of data.

Ants are small control packets, which have the task to find a path towards their destination and gather information about it. Like ants in nature, artificial ants follow and drop pheromone. This pheromone takes the form of routing tables maintained locally by all the nodes of the network. They indicate the relative quality of different routes from the current node towards possible destination nodes. Ants normally take probabilistic routing decisions based on these pheromone tables, giving a positive bias to routes of higher pheromone intensity, to balance exploration and exploitation of routing information.

B. Pheromone tables

Each node i maintains one pheromone table T_i , which is a two-dimensional matrix. An entry T_{ij}^d of this matrix contains information about the route from node i to destination d over neighbour j. This information includes the pheromone value T_{ij}^d, which is a value indicating the relative goodness of going over neighbour j when traveling from node i to destination d, as well as statistics information about the route, and possibly virtual pheromone.

C. Neighbour tables

Apart from a pheromone table, each node also maintains a neighbour table, in which it keeps track of which nodes it has a wireless link to

ACO routing algorithms has several benefits as explained below:

Adaptive – ACO algorithms are adaptive in nature by using continuous path sampling and probabilistic ant forwarding. This leads to a nonstop search of the routing possibilities.

Robust – ACO algorithms are robust. This is because routing information is the result of the repeated sampling of paths. On the one hand, the different samples are to some extent redundant, and the algorithm can therefore support packet loss. On the other hand, the use of sampling implies that routing information is based on direct measurements of the real network situation, which enhances its reliability.

Multipath - ACO routing algorithms usually set multiple paths, over which data packets can be forwarded probabilistically like ants. This can result in throughput optimization, automatic data load balancing, and increased robustness to failures.

D. Proposed OPTANT Algorithm

OPTANT (Optimized Ant Colony Routing for Mobile Ad-Hoc Networks): Let the source node S (Source node) requires data to send to a destination D with QoS requirements higher transmission rate, less delay, and more bandwidth. A list of nodes that are progressively visited by the ant is called visited nodes list are available. This list forms the route R from the source node to destination node.

Step0: [Initialize] Choose the source node S. Set ROUTE$\leftarrow$S

Step1: [Broadcast to all nodes] S initiates a *Path_Request_Ant* to destination D through all its neighbours which are in 1-hop distance from S.

Step2: [Choose next edge] : Pheromone evaporation of all the 1-hop distance nodes from source are estimated and stored in pheromone table (*Ptab-T*$_i$). The node (V_S,V_j), where,

V_S – Source Node and

V_j – each 1-hop node from V_S. { 1 >= j <= n}

$Next_j \leftarrow Max\ (C\,(T_{ij}^d))$

i is the index of source node.

Step3: [Complete route] Set ROUTE$\leftarrow$ROUTE + (V_S, V_{Nextj})

Step4**:** [Is $Next_j$ ==D?] Check if the $Next_j$ is the destination D.

If($Next_j$ == D)

{

Path_Reply_Ant is forwarded towards the original source. The *Path_Reply_Ant* will take the same path of the corresponding Path_Request_Ant but in reverse direction.

}

else

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Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 8, August 2017

{
Set S ← $Next_j$
Goto Step1:
}

Step5: Stop

In view to justify the proposed algorithm, the following scenario is presented in Fig. 3.

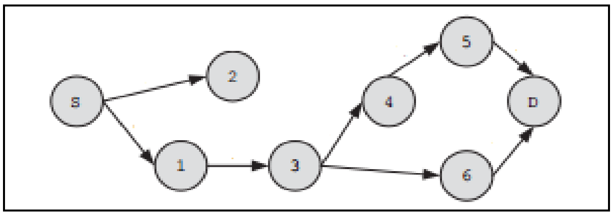

Fig. 3. Group of Nodes showing their next-hop nodes

Fig. 4 explain the way Route Request (RREQ) is being forwarded in most Ant Colony Optimization algorithms.

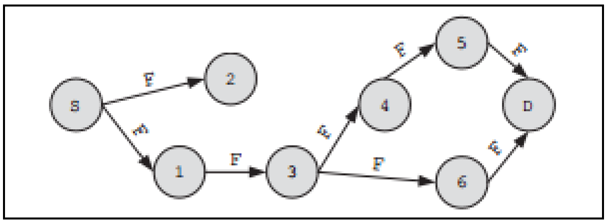

Fig. 4. RREQ forward in Traditional ACO Algorithm

E. OPTANT Algorithm

In OPTANT algorithm, the Pheromone evaporation of all the 1-hop distance nodes from source are estimated and stored in pheromone table 1 (*Ptab-T*$_i$). The corresponding network scenario representing the (*Ptab-T*$_i$) is shown in Fig. 5.

TABLE I
PHEROMONE TABLE (*PTAB-T*$_i$)

	S	1	2	3	4	5	6	D
S	-	4	2	-	-	-	-	-
1	-	-	-	4	-	-	-	-
2	-	-	-	-	-	-	-	-
3	-	-	-	-	4	-	2	-
4	-	-	-	-	-	3	-	-
5	-	-	-	-	-	-	-	3
6	-	-	-	-	-	-	-	3

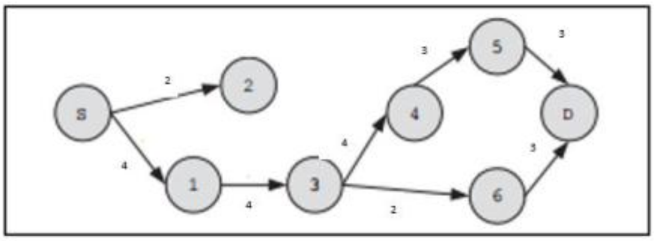

Fig. 5. Network scenario based on Table 1.

The RREQ forwarded by OPTANT algorithm by using the table (*Ptab-T*$_i$) is represented in the following figure Fig. 6.

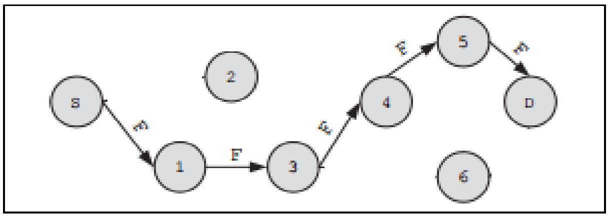

Fig. 6. RREQ forward in OPTANT

F. Comparison of Traditional ACO and OPTANT

A comparison of number of RREQs forwarded by traditional ACO algorithm and OPTANT algorithm for the given scenario in Fig. 3 is presented in the below table 2 and a graph is shown in Fig. 7.

TABLE II
COMPARISON OF RREQ FORWARDED

Algorithm	No. of RREQ forwarded
Traditional ACO	8
OPTANT	5

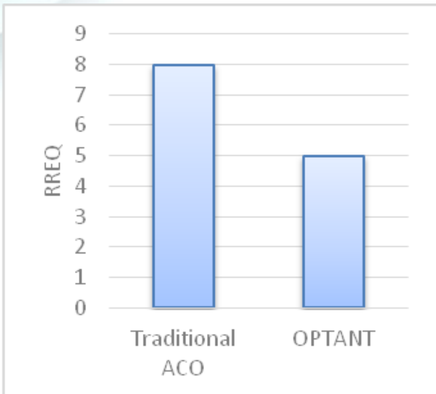

Fig. 7. Comparison of RREQ in ACO and OPTANT

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com

International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 4, Issue 8, August 2017

According to OPTANT algorithm, the RREQ is sent only to the edges that has maximum pheromone value. Hence number of RREQs sent will be reduced. This increases the speed of estimating the optimum path.

IV. Experimental Results And Discussion

Experimental results are derived using Network Simulator 2. Each simulation runs are executed for 500s. Number of nodes in MANETs varied between 25 nodes and 50 nodes as described in Table 3.

TABLE III
NS2 Simulation Parameters

Parameters	Values
Number of Nodes	25 to 50
Area Size	1500 X 1500
Mac	802.11
Radio Range	500m
Simulation Time	100, 200, 300, 400 and 500 Seconds
Traffic Source	FTP
Packet Size	512 Bytes
Mobility Model	Random Way Point
Speed	2,4,6,8 and 10m/s

Result evaluation: In this section, the implementation of OPTANT algorithm is compared with AntHocNet [13] algorithm. The Simulation is executed on two different dimensions. First OPTNET underwent a test by increasing the frequency of packets and later by increasing the node density in the simulation environment.

Fig. 8 shows the comparison of Packet Delivery Ratio (PDR) between OPTANT and AntHocNet. A slight difference is observed. The PDR of OPTANT is higher than AntHocNet for lesser packet frequency. As the packet frequency set high, the performance of OPTANT reduced.

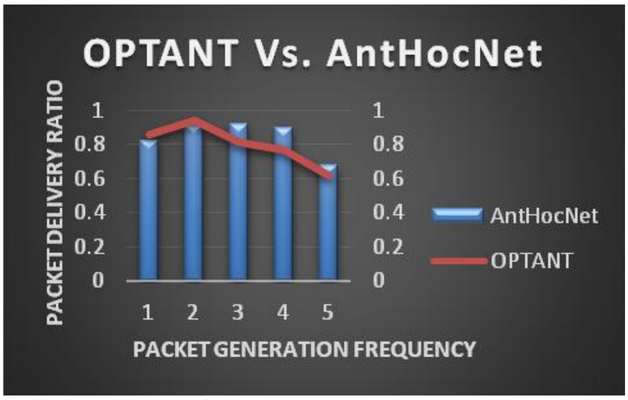

Fig. 8. Comparison of PDR in varying Packet Generation Frequency

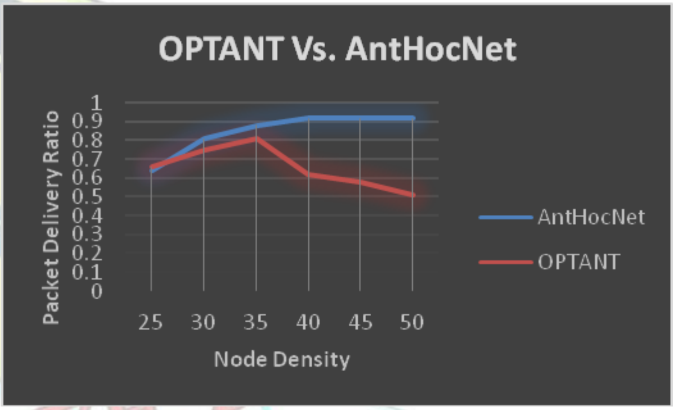

Fig. 9. Comparison of PDR in varying Node Density

Fig. 9 represents the comparison of Packet Delivery Ration between both algorithms. It is observed that when the density of node is less both the algorithms performed similar manner. But OPTANT deteriorated on higher node density.

V. Conclusions & Future work

The OPTANT is intended to improve the performance of MANET by considering Ant Colony Optimization method in routing protocol. In the case of packet frequency, Proposed algorithm does outperform AntHocNet in terms of packet delivery ratio. When the packet frequency is increased, both the algorithms respond in the same way. Although it is an accepted fact that the performance of MANET increase as the number of nodes increases, OPTNET responds undesirably on increasing the node density. It is also observed that further study is required in order to improve the PDR with increased node density.

References

[1]. FJ Arbona Bernat, ``Simulation of Ant Routing Protocol for Ad-hoc networks in NS-2", Faculty of Electrical Engineering, Mathematics and Computer Science Network Architectures and Services Group.

[2]. S. Giordano, I. Stojmenovic, and I. Blazevic. Position based routing algorithms for ad hoc networks: A taxonomy. Ad Hoc Wireless Networking, 2003.

[3]. Madhumita Dash, Madhusmita Balabantaray, "Routing Problem: MANET And Ant Colony Algorithm", *International Journal of Research in Computer and Communication Technology*, Vol 3, Issue 9, September – 2014.

[4]. P. Deepalakshmi1, Dr. S. Radhakrishnan, "Ant Colony Based QoS Routing Algorithm For Mobile Ad Hoc Networks", *International Journal of Recent Trends in Engineering*, Vol. 1, No. 1, May 2009

[5]. Y. Lü, G. Zhao, F. Su, and X. Li. "Adaptive Swarm Based Routing in Communication Networks", *Journal of Zhejiang University Science JZUS 2004*, vol. 5(7), pages 867-872, 2004

[6]. M. Belkadi, M. Lalam, A. M'zoughi, N. Tamani1, M. Daoui and R. Aoudjit, "Intelligent Routing and Flow Control in MANETS", *Journal of Computing and Information Technology - CIT* , pp.233-243, March 18, 2010.

[7]. Genhang Ding, L. Shi, X. Wu and Y. Zhang, "Improved Ant Colony Algorithm with MultiStrategies for QoS Routing Problems", *IEEE 8th International Conference on Natural Computation*, p.p. 767-771, 2012.

[8]. P. Deepalakshmi and S. Radhakrishnan, "Source-Initiated QoS Multicasting Scheme For MANETS using ACO", *IEEE International Conference on Process Automation, Control and Computing (PACC)*, pp. 1-4, 2011.

[9]. Calduwel Newton, Prasanna Ranjith, Mary Jane Aragon, "Optimizing Routing in MANET using Genetic Algorithms", *International Journal of Applied Engineering Research (IJAER)*, Research India Publications, Volume 10, pp. 40124-40129

[10]. Gianni A. Di Caro, Frederick Ducatelle, and Luca M. Gambardella, "Ant Colony Optimization for Routing in Mobile Ad Hoc Networks in Urban Environments", IDSIA / USI-SUPSI Dalle Molle Institute for Artificial Intelligence Galleria 2, 6928 Manno, Switzerland, Technical Report No. IDSIA-05-08 May 2008.

[11]. R. Schoonderwoerd, O. Holland, J. Bruten, and L. Rothkrantz. Antbased load balancing in telecommunications networks. Adaptive Behavior, 5(2):169–207, 1996.

[12]. G. Di Caro and M. Dorigo. "AntNet: Distributed stigmergetic control for communications networks", *Journal of Artificial Intelligence Research (JAIR)*, 9:317–365, 1998.

[13]. Gianni A. Di Caro, Frederick Ducatelle, and Luca M. Gambardella, "Ant Colony Optimization for Routing in Mobile Ad Hoc Networks in Urban Environments", Technical Report No. IDSIA-05-08, Dalle Molle Institute for Artificial Intelligence Galleria 2, 6928 Manno, Switzerland, May 2008.

[14]. Y. Bevish Jinila, K. Komathy (2014), "Distributed and secured dynamic pseudo ID generation for privacy preservation in Vehicular ad hoc networks", Journal of Applied and Theoretical Information Technology, Vol. 66, No.1, pp. 126 – 134, ISSN : 1992-8645.

[15]. Y. Bevish Jinila, K. Komathy (2015), "Rough Set Based Fuzzy Scheme for Clustering and Cluster Head Selection in VANET", ELEKTRONIKA IR ELEKTROTECHNIKA, Vol.21, No.1, pp.54-59, ISSN : 1392-1215.

