Set Distributed Path by the Network Load in Mobile Ad-hoc Networks

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Abstract

Mobile Ad-hoc Network (MANET) consists of a node that has mobility. In MANET, node function as routing. So they build a network of their own, no infrastructure. Topology is exchanged due to node mobility in MANET. For reducing changed topology, hierarchical network algorithms are researched. However load-balancing of cluster head node is exceeded, assigned cluster member node can't communicate other node. To solve this problem, we proposed Load Tolerance (L.T) algorithm for distributing routing. Proposed algorithm, when the cluster head node is measured overflow load balancing, cluster member node sends a message through distributed routing path by Load-Tolerance node. As a result, the proposed algorithm improves the packet delivery ratio in cluster routing

Keywords: Distributed routing path, Load balancing, Mobile Ad-hoc network, Cluster

1. Introduction

Mobile Ad-hoc Network (MANET) consists of a node that has mobility. In MANET, each node function as routing. So they build a network of their own, no infrastructure. Topology is frequently exchanged due to node mobility in MANET, so load balancing is exchanged. For reducing frequently exchanged topology, hierarchical networks are researched. Hierarchical is the network that forms group for reducing exchange topology[1]. Exchange topology is reduced by the hierarchical network in MAENT, the network uses efficient energy consumption and has a stable load balancing[2][3]. However load balancing of certain cluster head node is concentrated, assigned cluster member node can't communicate other node[4]. To solve this problem, we proposed Load Tolerance algorithm. Proposed algorithm, when cluster head node, upper level node, is concentrated transmit of packet, storage of packet is overflow, cluster member node, lower child node, measures load balancing of cluster head nodes in efficient communication coverage. When an assigned cluster member node checks that it's cluster head node is concentrated traffic, cluster member node makes distributed routing path using a property of nodes like distance between nodes, energy, direction, velocity and communicates to other node through distributed routing path.

2. Related Work

The existing cluster routing algorithm keeps the connection between nodes in MANET, So they reduced overhead, kept communication. However, certain cluster head is concentrated packet, an assigned cluster member node can't send message to

cluster head node and another node. In RODMRP(Resilient Ontology-based Dynamic Multicast Routing Protocol) algorithm, the network composed of tree formation, a lower level node has step parent node. When a lower level node can't communicate with its upper level node, it communicates using a step parent node. In this paper, assigned lower level node measures upper level node load balancing. When the lower level node checks that load balancing of its upper level node occurs overflow, proposed algorithm resets routing path using load-tolerance(L.T) node.

DDV (Dynamic Distance Vector) algorithm, the proposed algorithm in reference work, forms and maintains cluster formation using the direction and velocity of property, the algorithm reduces change routing path by change topology and keeps communication. In DDV algorithm, cluster formation is formed by a threshold value of direction and velocity that is made by the base-station. In this paper, for selecting L.T node, we use difference of direction between nodes that suggested in DDV algorithm. Moreover, we calculate probability using other property of node for selecting L.T node.

3. System Model and Methods

The proposed L.T algorithm is which assigned cluster member node checks traffic of its cluster head node. When a cluster head node is concentrated load balancing, its cluster member node set distributed routing path of the selected L.T node. In L.T algorithm, showing the routing path, we define the relationship between nodes. The relationship of the cluster member node and the cluster head node is as follows.

$$X_M = \left\{ x_{M(i,j)} \mid x_{M(i,j)} = 0 \text{ or } 1 \right\} \quad (1)$$

$$x_{M(i,j)} = \begin{cases} 1, & \text{if node } j \text{ is among cluster head node } i \\ 0, & \text{otherwise} \end{cases} \quad (2)$$

As an equation (1) and (2) is show relationship of cluster head node between cluster member nodes. Where X_M means set of relationship that is between cluster member node and cluster head node. $x_{M(i,j)}$ shows the status of relationships like 0 or 1. 1 means that the cluster head node i and cluster member node j. 0 means otherwise. After defining between cluster member node and cluster head node, we define the relationship between cluster head nodes. The relationship of cluster head nodes is as follows.

$$X_H = \left\{ x_{H(i,i\prime)} \mid 0 \leq x_{H(i,i\prime)} \leq 1 \right\} \quad (3)$$

$$x_{H(i,j)} = \begin{cases} 0 < x_{H(i,j)} \leq 1, & \text{if cluster head node } i' \text{ is connect cluster head node } i \\ 0, & \text{otherwise} \end{cases} \quad (4)$$

As an equation (3) and (4) means relationships of each cluster head node. Where X_H means a set of relationship that is between cluster head nodes. And it has element $x_{H(i,i')}$. $x_{H(i,i')}$ shows the status of relationships as between 0 and 1. Between 0 and 1 means that the cluster head node i connects cluster head node i'. The value has lower, the connection between cluster head node has disconnected probability higher. 0 means that otherwise.

For calculating load tolerance probability of cluster member nodes and doing load balancing of cluster head node, we set a coverage of node as follows.

$$R_C = k \times R_C, \quad k = 2 \quad (5)$$

Where k is number of relay hop, R_T is the transmission range of nodes, and R_C is coverage of nodes. We know attribute and communication of node by a number of relays hops[5].
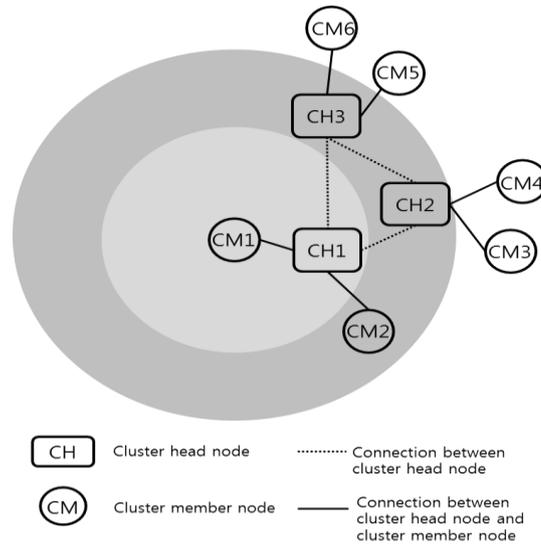
Figure 1. Example of Coverage of Node by the Hops

As shown in Figure 1, we assume the recovery coverage as number of k=2 in reference work. So cluster member node takes cognizance of assigned cluster head node besides other cluster head node.

3.1. Set Load Tolerance node

When communication coverage of node defines, cluster member node selects Load-Tolerance(L.T) node for continuous communication. So the cluster member calculates probability of selecting L.T node using properties of node such as direction, velocity, distance between nodes and residual energy.

A method calculates probability using the distance between nodes, it is calculated by comparing the distance between nodes with communication coverage. An equation is as follows.

$$P_{i'}(t)|_{dist} = \frac{dist_{i'j}}{|R_C|} \quad (6)$$

Here $P_{i'}(t)|_{dist}$ means probability, by the distance between nodes, $dist_{i'j}(t)$ means the distance between cluster head node i' and cluster member node j, when time is t.

A method calculates probability using direction, it is calculated using difference of direction in DDV algorithm, an equation is as follows.

$$P_{i'}(t)|_{Dir} = \frac{Dir_{i'j}}{|Dir_j^{rs}|} \quad (7)$$

Here, $P_{i'}(t)|_{Dir}$ means probability, by direction, $Dir_{i'j}$ means the difference between cluster head node i' and cluster member node j. Dir_j^{rs} means the threshold of difference of direction[6].

A method calculates probability using residual energy, it is calculated by comparing residual energy and initial energy, an equation is as follows.

$$P_{i'}(t)|_E = \frac{E_{i'}(t)}{|E_{init}|} \quad (8)$$

Here, $P_{i'}(t)|E$ means probability, by residual energy, $E_{i'}(t)$ means residual energy when time is t. E_{init} means initial energy.

For calculating probability of load balancing, load balancing define by capacity and flow of the node.

$$lb_i(t) = \frac{flow_i(t)}{C_i} \times \frac{1}{C_i^\alpha}, \alpha = 1, 2, 3, \dots \quad (9)$$

Here, $lb_i(t)$ means load balancing of node, when time is t. $flow_i(t)$ means the amount of flow packet in node i. C_i means a capacity of node i for storing packet. C_i^α means a condition of node by condition of network, the value is different by constant number α. A load balancing has a value between 0 and 1. the value is higher, the mount of storage of node i is smaller. A method calculates probability using load balancing, it is as follows.

$$P_{i'}(t)|_{lb} = 1 - P_{i'}(t) \quad (10)$$

Here, $P_{i'}(t)|_{lb}$ means probability, by load balancing.

For calculating select L.T node probability, multiply each probability of property by each weight of property. An equation is as follows.

$$P_{i'}(t)|_{L.T} = \left| \begin{matrix} P_{i'}(t)|_{dist} \times \omega_{i'}(dist) + P_{i'}(t)|_E \times \omega_{i'}(E) \\ +P_{i'}(t)|_{Dir} \times \omega_{i'}(Dir) + P_{i'}(t)|_{lb} \times \omega_{i'}(lb) \end{matrix} \right| \quad (11)$$

$$\omega_{i'}(attr) = \{\omega_{i'}(dist) = \beta, \omega_{i'}(E) = \beta, \omega_{i'}(Dir), \omega_{i'}(lb)\} \quad (12)$$

Here, i means cluster head node, j means cluster member node. i' means cluster head node that is located in communication coverage of cluster member node j. $P_{i'}(t)|L.T$ means the probability of selection L.T node. $\omega_{i'}(dist)$, $\omega_{i'}(Dir)$, $\omega_{i'}(E)$, $\omega_{i'}(lb)$ mean weight of each property. An equation (11) means, node has various properties, we consider various node's condition. When node's property has a relationship of attention, the sum of node's property is 1. For example, distance and energy have the relationship, sum of weight value of distance and the weight value of energy must 1. When a cluster head node has a probability of select L.T node in a communication of cluster member node, the cluster member node chooses the cluster head node as L.T node that has maximum probability.

Algorithm 1: The process of selection L.T node

```
Begin
LT_i(t)←φ
a = 0 , b = 0
tmp LT = 0
while(a≠(N-G))
   while(b≠G)
       if (CH[b] has in CM[a] of coverage) and (CH[b] ∌ CM[a]) then
           calculate P_b(t)|_{L.T} of CH[b]
       if (P_b(t)|S.P of CH[b] is max value) then
           tmp LT ← CH[b]
            b ← b+1
   end
 LTi(t)← tmp LT
  a ← a+1
end
output probability of L.T node all cluster member node i LT_i(t)
end
```

For selection L.T node, the cluster member node searches the cluster head node in communication coverage and calculates the probability of selection L.T node. When a cluster head node has maximum probability, the cluster head node is selected L.T node.

3.2. Set Distributed Routing Path

When a relationship of nodes defines by an equation (1)~(4), routing path of each node expressed as an equation (13) and Table 1.

$$Path_{(j,Des)} = \{x_{M(i,j)}, x_{H(i,Des)} \mid x_{M(i,j)} \cup x_{H(i,Des)}\} \quad (13)$$

Table 1. The Table of Routing Path

Priority	S	1	2	3	…	…	Des-1	Des
Node ID	#	CH3	CH4	CH6	…	…	CH9	#

Here, Des means destination node, S means source node. In equation (13), routing path between a source node and destination node are defined by the relationship between nodes.

For continuous communication, cluster member node stores load balancing and probability of selection L.T of the cluster head node that is located in communication coverage in status table. The status table is expressed as an equation (14) and Table 2.

$$\text{Table}_{status(j)} = \left\{ x_{M(i,j)}, x_{H(i,i')} \middle| lb_i, lb_{i'}, P_i\ (t)|_{L.T}, P_{i'}(t)|_{L.T} \right\} \quad (14)$$

Table 2. The Status Table of Cluster Member Node

CHID	CH1	CH2	CH3	CH5
Load balancing	0.54	0.96	0.10	0.38
$P_i(t)|_{L.T}$	0.32	0.25	0.96	0.40

In the status table of cluster member node, when the cluster head node, assigns the cluster member node, has a minimum value of load balancing, cluster member node make a conclusion that cluster head node is concentrated traffic and set distributed routing path. The process of setting distributed routing path is expressed as Figure 2.
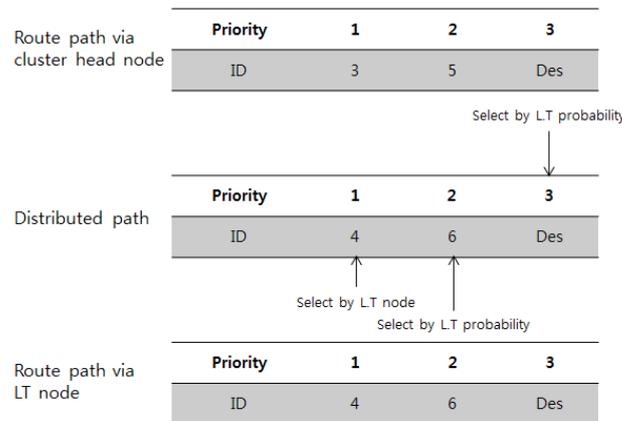

Figure 2. The Procedure of Setting Distributed Routing Path in the Routing Table

As shown in Figure 1, cluster member node forms routing path L.T node instead of its cluster head node. Since then, L.T node measure a probability of selection L.T node of other cluster head node in communication coverage, L.T node has chosen cluster head node that has the maximum probability of selection L.T node. The above process is repeated, when the routing path reaches destination node, cluster member node communicates using distributed routing path. The process of setting distributed routing path is expressed as an equation (16)

$$s.t\ x_{M(i,j)} \times lb_i(t)\ is \max value \quad (16)$$

$$D.Path_{(j.j')} = \left\{ X_M, X_H | x_{H(j,i')} \times max P_{i'}(t)|_{L.T} \right\}$$

Here, **D.Path**$_{(j,j')}$ means to distribute routing path source node **j** to destination node **j'**. The process of set distributed in the network is expressed as Figure 3.

(a) Before Distributing Routing Path Network

(b) Set Distributed Routing Path Using Status Table
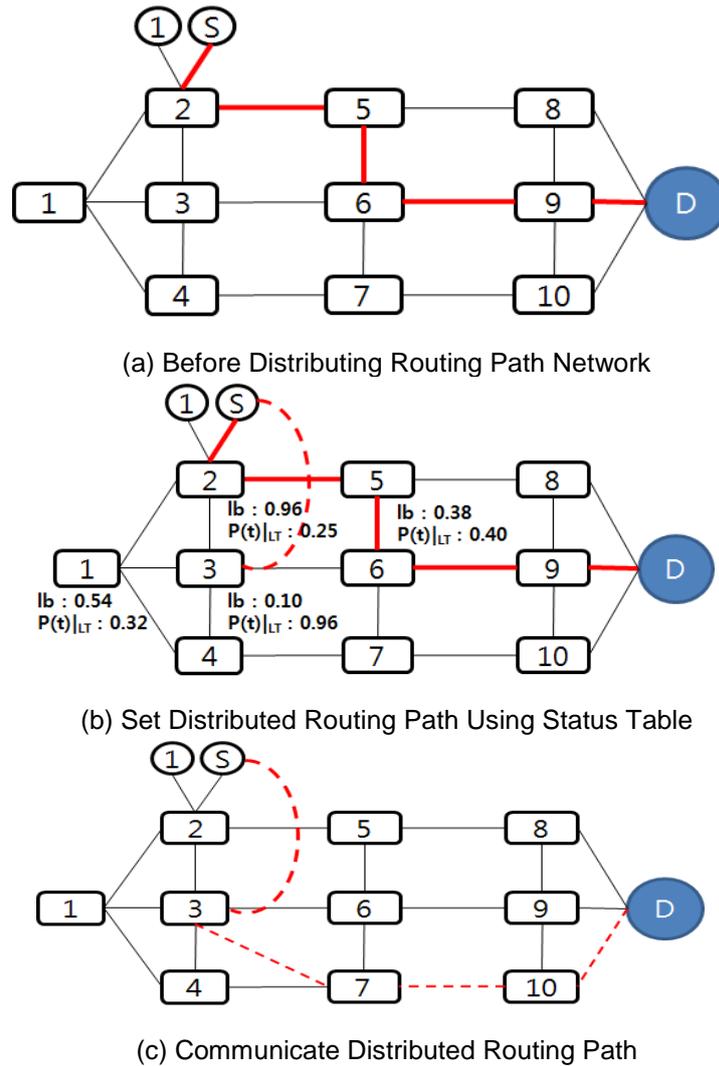

(c) Communicate Distributed Routing Path

Figure 3. Example the Process set Distributed Routing Path

As shown in Figure 2, S means source node that sends packet, D means destination node that receives the packet. Figure 2 (a) is the network that is not adopted distributed routing path, cluster member node sends packet to cluster head node. Figure 2 (b) is a process set distributed routing path, cluster member node measures load balancing of its cluster head node. When the cluster head node has a low value of load balancing, the cluster member node selects L.T node and sets distributed routing path. Since then, as shown in Figure 2 (c), cluster member node communicates using distributed routing path.

Algorithm 2: The process of setting distributed routing path

Initialize max_CH
Initialize CH_status
// head node route path
for j=0 to G
  for i=0 to (N-G)
      if (CH[i] is located R_C of CM[j]) then
          Check load balancing of cluster head node by CH Path$_{(i,Des)}$ at Table$_{status(j)}$
  end
  max_CH ← find max $P_i(t)|$L.T of cluster head node in RC
end
output changed route path D.Path$_{(j,j')}$
end

Here, for setting distributed routing path by L.T node, a cluster member node compares the probability of selection L.T node, a cluster head node, has the maximum probability of selection L.T node, is formed in the distributed routing path. Also selected cluster head node compares the probability of selection L.T node of other cluster head node in communication coverage, and chooses the cluster head node for setting distributed routing path.

4. Simulation and Result

Simulation evaluated LT algorithm that compares random cluster algorithm. Simulation parameter is as follows. The simulation time is 300 second. Simulation measures packet delivery ratio every 30 seconds.

Table 5. Simulation Configuration

| Parameter	Value
Area	100 x 100
Velocity (m/s)	1 ~ 16
Number of cluster head nodes	16
Number of nodes	100, 200, 300, 400
Jammer range(m)	30
Transmission cycle (Sec)	1
Pause time (Sec)	30, 60, 90, 120, 150, 180, 210, 240 and 270
Simulation time (Sec)	300

Figure. 4 shows the packet delivery ratio about LT algorithm and random cluster algorithm. As shown in Figure. 5, Regardless of the number of nodes, LT algorithm holds the packet delivery ratio of 80~100%. However, the random cluster algorithm holds the packet delivery ratio of 40~60%. So we check what LT algorithm is higher than random cluster algorithm and is kept at a packet delivery ratio.
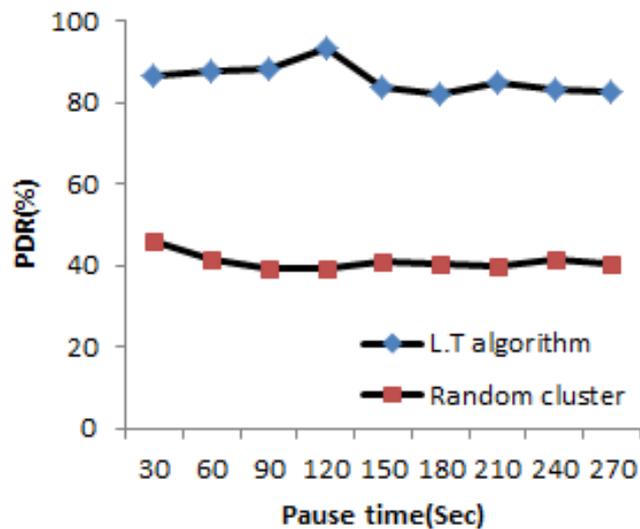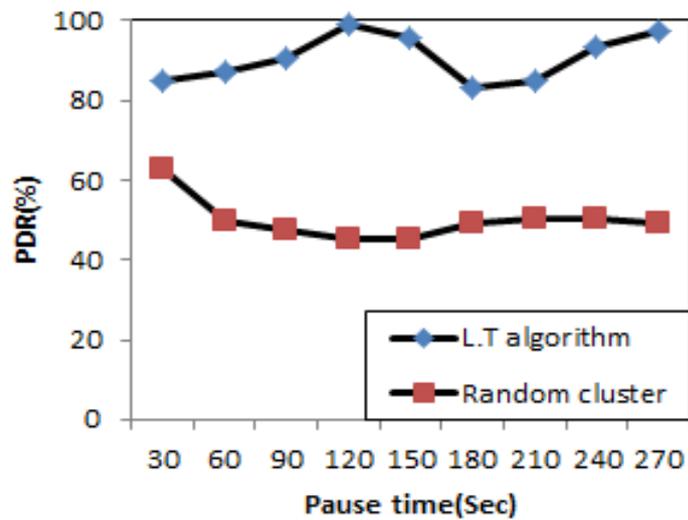

(a) number of nodes = 100
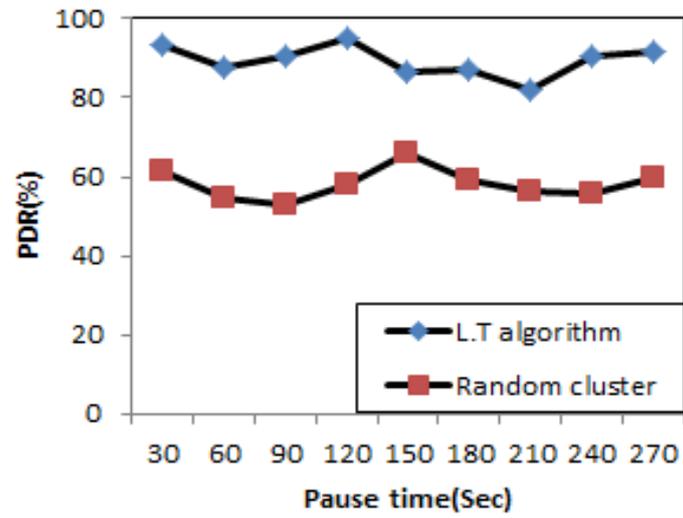
(b) number of nodes = 200
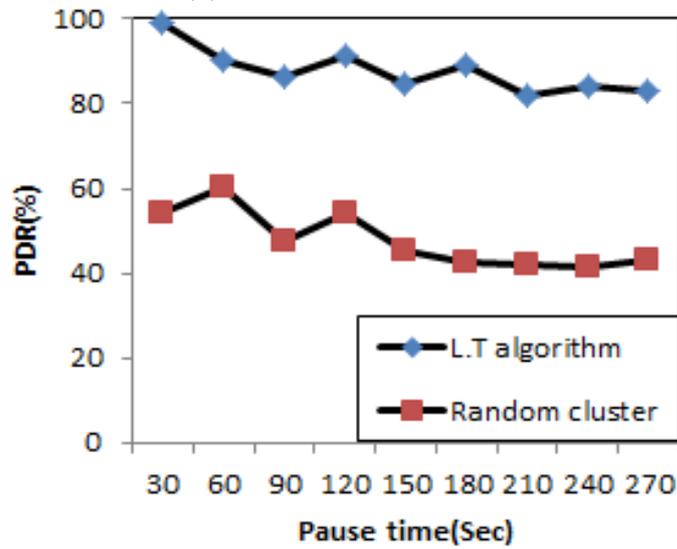
(c) number of nodes = 300

(d) number of nodes = 400

Figure 5. Packet Delivery Ratio with LT Algorithm

5. Conclusions

In this paper, we proposed LT algorithm. LT algorithm selects LT node by attribute of node such as direction, load balancing, and energy. When a cluster head node is concentrated packet, cluster member node maintains communication using distributed routing by LT node. Simulation result, packet delivery ratio is higher than random cluster when the network has jammer or packet is concentrated in cluster head. According to network characteristics such as increasing the network area, many jammer, Research result is different. So we need more study considering the characteristics of the network.

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