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A Study of Efficient Connection using Mobility Property in Mobile Ad-hoc Network

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Abstract

In this paper, we proposed the context-awareness routing algorithm DDV (Dynamic Direction Vector)-hop algorithm at Mobile Ad-hoc Networks. Existing algorithm in MANET, it has a vulnerability that the dynamic network topology and the absence of network expandability of mobility of nodes. This proposed algorithm forms cluster formation using a range of direction and threshold of velocity by base-station, and we calculate exchange cluster head node probability using direction and velocity for maintaining cluster formation. DDV algorithm forms a cluster based on the cluster head node. As a result of simulation, our scheme could maintain the proper number of cluster and cluster members regardless of topology changes. In response to maintain cluster formation, we prove a continuous connection between nodes.

Keywords: *Mobile Ad-hoc networks, Direction, Topology, Velocity*

1. Introduction

Recently, the development of wireless communication technology and development of various sensor nodes, wireless sensor network has been researched, because of the development of low-power, low-cost communication technology, RF technology. Wireless sensor network consists of wireless devices that are based on various protocols for wireless transmission, processing unit for processing data. It has main characteristic like network expandability, self-recovery and multi casting. Moreover Wireless Sensor Network is originated for building temporary network when there has disaster, surveillance and the use of military, research is being expanded for ubiquitous network achieved.

MANET (Mobile Ad-hoc Network) is autonomic network that consists of nodes that has mobility, no depending infrastructure. Due to the characteristic of these, MANET has been presented in a variety of applications. Especially study of node property is actively deployed. The method of routing has a two-dimensional approach that all sensor nodes send sensing data to base station and hierarchical approach that sensor node forms cluster, cluster head node sends sensing data that is aggregated from a sensor node in the cluster, to base station. When a cluster head node discharge or do not motion in a poor environment, routing path is disconnected from the cluster head node. So network can't be smooth communication. Therefore a method of electing a new cluster head node is needed for routing recovery and expands the network lifetime. Furthermore the property of MANET, each node has various attributes such as mobility, velocity and energy. However, the node has a constraint like limited transmission bandwidth and energy, these constraints become the caused by frequent disconnection and routing recovery. The node uses also a limited resource. By the change of topology changes frequently due to node mobility, Existing routing algorithm is adopted difficult in MANET. So control message or data packet is generated excessively, network

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traffic is increased. By unnecessary energy consumption, life time of node is decreased, network lifetime, and eventually is decreased [1-3].

In this paper, we proposed the context-awareness routing algorithm DDV (Dynamic Direction Vector)-hop algorithm. Proposed algorithm forms and maintains a cluster by dynamic property like velocity and direction. We proposed algorithm in MANET, load of the network is reduced, and network topology is stably maintained.

2. Related Work

VANET (Vehicular Ad-hoc Network), similar MANET environment, is researched maintaining routing by frequently changing topology. MDBC (Moving Direction Based Greedy Routing Algorithm) uses the direction property of several properties for routing. For setting the direction of the node that has mobility, current coordinate X is bigger before coordinate X, direction of node is east. Current coordinate X is smaller before coordinate X, direction of node is west. Current coordinate Y is bigger before coordinate Y, direction of node is north. Current coordinate Y is smaller before coordinate Y, direction of node is south. When the direction of node sets, node is broadcasting hello message and stores location and direction of the neighbor node in the table. For forwarding a packet to a destination node, the node uses DREQ (Destination REQuest) and DREP (Destination RePly) and find stable routing path [4].

Lili Hu proposed GPSR (Greedy Perimeter Stateless Routing) considering direction and velocity of a node in VANET. Proposed algorithm, node sends hello message that includes velocity and direction periodically, node grasps current coordinate of neighbor node, node calculates current coordinate using velocity and direction. Current coordinates of node has shown in equation (1).

$$\begin{aligned} X_t &= X_0 + (t - t_0) * V_x \\ Y_t &= Y_0 + (t - t_0) * V_Y \end{aligned} \tag{1}$$

Where it is current time, t_0 is time that receives a hello message before, Vx and Vy means velocity. Node grasps coordinate of neighbor node by equation (1), since then node calculates probability of transmission that considers velocity and direction of node, and forwards packet [5].

LEACH is routing protocol based cluster. All sensor nodes transmit to cluster head in cluster. Cluster head collects data through data aggregation and it is translated sink node. Features of this approach, it choice cluster head which is energy consumption high, or maximize of network life time. Each round is configuring the set-up and the steady-state. Set-up is Constitute cluster head and cluster. Steady-state is transmitted data by TDMA schedule. LEACH isn't energy conversing because head selection is probabilistically. Also, if between cluster head node and base-station be located far energy consumption is not effective way [6, 7].

3. System Model and Method

We proposed DDV algorithm that performs and maintains cluster formation that considers move properties such as direction and velocity. The existing clustering algorithm has a problem that topology is changed frequently by node mobility. According to the mobility of the node, this proposed algorithm performs cluster formation that has the same nodes which has the same direction and velocity.

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In this paper, when performing a cluster formation, has an assumption. First, the base station is located in the center of the network. Second, network area is divided four regions by the base station. As shown in Figure 2, the base station is assumed to be located at the center of the network. In addition, it has been divided into four regions based on the base station.

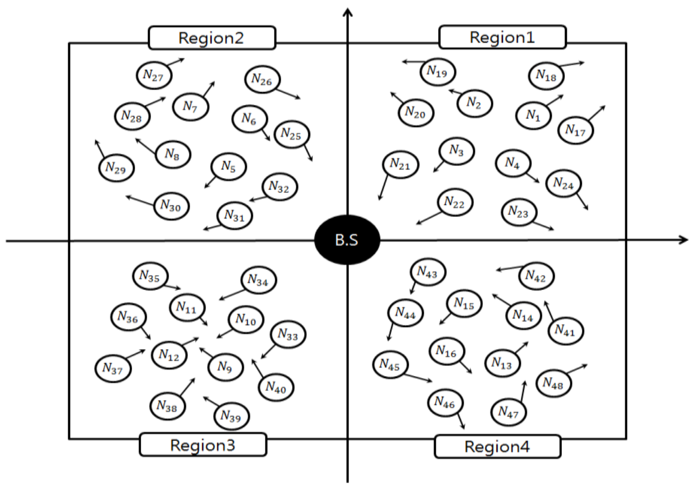

Figure 1. Initialize Direction and Velocity of Node

The process of electing initial cluster head node follow as Figure 2. The cluster head is selected randomly in each region, the cluster head will be able to find a node that has the same attribute information. If the node is across each zone, direction and velocity belong to the similar region. Each node has a mobility situation in which you break away from the area occurs. In this case, when the moved to another area, Cluster in their region located on the last formed. Thus, cluster head sends a message that was elected to the neighbor nodes. The node received the message selects the head node in which the direction and speed is similar.

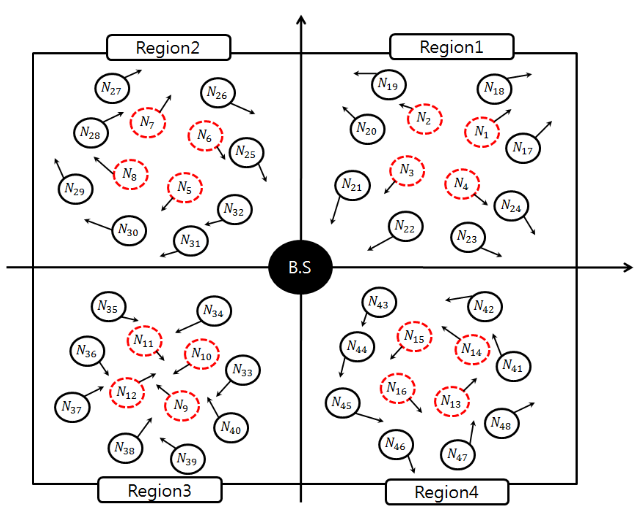

Figure 2. Selection of the Initial Cluster Head Node

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Then cluster formation is finished such as Figure 3. When the cluster formation is set up, network has a routing structure that cluster member node sends a message to cluster head node, the cluster head node sends a message to the base station.

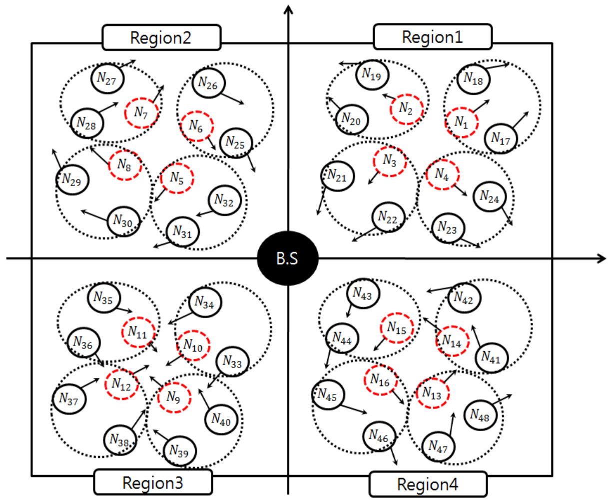

Figure 3. The Process Clustering after Selection Cluster Head Node

As shown in Figure 4, node X and node Y are included transmit range of cluster head node A and cluster head node B. In this case, as shown in the efficient clustering method which select cluster head node. In the existing algorithm, the node selects cluster head node that is closed by a node regardless of direction and velocity. However, in DDV algorithm, the node compares direction and velocity of itself with cluster head node property, the node selects cluster head node that has similar direction and velocity. For example, although node X has been a formed cluster head node A and cluster head node B. Node X compared the directions and velocity of a cluster head node with itself, node X selects cluster head node B which is similar property. So a load of the network is reduced and topology is maintained stable.

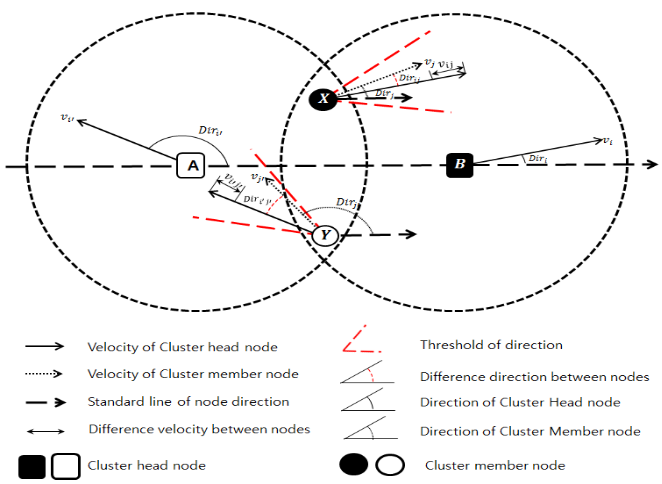

Figure 4. Relative Friendship with Cluster Head Node about Attribute (Velocity, Direction, Location, Energy and Transmit Range)

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3.1. Cluster Formation Process

By above assumption, the base station is located in center of network area, initial cluster performs cluster formation by the process. The network is divided four regions by the base station, the method expressed as an equation (2).

$$\{Region_z | Region_z \in Network\ area\} \quad (2)$$

Where, $Region_z$ have divided the network area by the base station. Next, for electing initial cluster head node, base station sets range of direction. The method of set range of direction expressed as an equation (3) and (4). We express a range of direction as rs. When rs is bigger, Set of range of direction become broader.

$$\{\mathrm{rs} | 0 < \mathrm{rs} \leq \infty\} (3)$$

$$Dir_{BS} = \{\mathrm{rs} | [\alpha\pi/\mathrm{rs}, (\alpha+1)\pi/\mathrm{rs}], \alpha = 1, 2, 3, \ldots, \mathrm{rs}-1\} (4)$$

Where, Dir_{BS} is Range of directions that are divided on the basis of the base station. rs is number of resolution. An equation (5) means the method of electing a cluster head node.

$$\mathrm{CH} = \{N_i | N_i \in Region_z \wedge Dir_i \in Dir_{BS}\} (5)$$

The method of measuring similarity of direction is compared differences of direction between nodes and set threshold of direction using a range of direction rs. Measuring similarity of direction is as follows.

$$Dir_{ij} = |Dir_i - Dir_j| (6)$$

$$Dir_i^{rs} = \{Dir_{ij} | Dir_{ij} \leq |\pi/rs| \wedge N_j \in Region_z\} (7)$$

Where, Dir_{ij} is difference of direction between node i and node j. Dir_i^{rs} is threshold of direction, rs is number of resolution. The method of measuring similarity of velocity between nodes is comparing differences of velocity between nodes and set a threshold of velocity using a deviation of velocity, the method is expressed as an equation (8) and (9).

$$V_{ij} = |V_i - V_j| (8)$$

$$\Delta V_i = \{j | V_{ij} \leq |\sigma_{vi}| \wedge N_j \in Region_z\} (9)$$

Here, v_{ij} means a difference of velocity, $\triangle v_i$ means threshold of velocity. The Cluster head node selects cluster member node using measuring similarity of direction and velocity by equation (6)-(9), the method is as follows.

$$CM_i = \{j | Dir_{ij} \in Dir_i^{rs} \wedge V_{ij} \in \Delta V_i\} (10)$$

$$HG_i = \{CM_i | CM_1 \cup CM_2 \cup CM_3 \cup \ldots \cup CM_i\} (11)$$

Where, CM_i means group of selected cluster member nodes, HG_i means a network that is performed cluster formation by groups of cluster member node.

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Algorithm 1: Initialize cluster formation of DDV

```
Begin
initialize CH // initialize Region_z and CH
initialize Region_z
G ← 0 // initialize G is 0
for a = 0 to z  // select cluster head node
    for b = 0 to N-1
        if (V[b] is located Region_a ) then
            Regin_a ∋ V [b]
        if (V[b] is located center of Region_a and different direction of CH) then
          CH[G] ← V[b]
          G = G+1
    end
end
for a = 0 to G // initialize cluster formation
    for b = 0 to N-1
        if (Region including CH[a] ≡ Region including V[b]) then
          // calculate between CH[a] and V[b] about
          // difference direction and velocity
          Dir_CH[a]V[b] ← | Dir_CH[a]  - Dir_V[b] |
          v_CH[a]V[b] ← | v_CH[a] − v_V[b] |
          // if V[b] is similar direction and velocity with
          // cluster head node CH[a],
          // register cluster member node of CH[a]
          if (0 ≤ (Dir_CH[a] / |Dir_V[b]^rs|) ≤ 1) and (0 ≤ (v_CH[a] / |△v|) ≤ 1) then
            CM_a ∋ V[b]
    end
end
output cluster head node group CH
        all cluster member node group of cluster head node i CM_i
end
```

As shown in Algorithm 1, for initial cluster formation, network is dividing network area. Velocity and direction is compared threshold of velocity and direction that sits by the base station. When a node is similar in velocity and direction, the node is selected cluster head node, and the node information is stored in CH. Selected cluster head node compares velocity and direction of normal node and their velocity and direction in each region. When the normal node and the cluster head node are similar in velocity and direction, the normal node is registered as cluster member node, the normal node is stored in CM_i.

3.2. Cluster Head Node Replacement Procedure

For reducing the load of network, exchange cluster head node is needed. Since then performing cluster formation, the process of maintaining cluster has been as follows. Cluster member nodes calculate successful probability, by direction, velocity and residual energy. The method is expressed as an equation (12) [6, 7].

$$f_j\left(E_j(t)\right) = \max\{P_j(E_j(t)) | P_j\left(E_j(t)\right) = \sum_{j\in CM_i} \frac{G\left[E_j(l)\times\omega(l)+E_j(dist)\times\omega(dist)\right]}{N-G\left(r \bmod \frac{N}{G}\right)\times\frac{1}{N}\sum_{j=1}^{n} E_j(t)}, j \in i\} \quad (12)$$

Where, $P_j(E_j(t))$ means exchange probability, by residual energy of a node, $E_j(l)$ means energy by transmitting data, $E_j(dist)$ means the energy of the distance between nodes. $\omega(l)$ and

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ω(dist) mean weight of transmitting data and distance between nodes. Exchange probability of the cluster head node considering the direction and velocity of the node is as follow.

$$f_j\big(DV(t)\big) = \max\{P_j(DV(t)) | P_j\big(DV(t)\big) = \sum_{j\in CM_j} \frac{Dir_{ij}}{Dir_i^{rs}} \cdot \frac{V_{ij}}{\Delta V}\} \quad (13)$$

WHere, $f_j(DV(t))$ means exchange probability of cluster head node by velocity and direction. Using calculated exchange probabilities by equation (12) and equation (13), cluster member node calculates final probability. The method is expressed as an equation (14).

$$P_j\big(DDV(t)\big) = \max(f(E_j(t)) \times \omega_j(E_j(t)) \times f(DV(t)) \times \omega_j(DV(t))) \quad (14)$$

Where, $\omega(E_j(t))$ and $\omega(DV(t))$ mean weight of exchange probability by energy and exchange probability by velocity and direction.

Algorithm2: Exchange cluster head node of DDV

```
initialize CH' // initialize CH'
nextCH ← 0  // initialize nextCH
for a = 0 to G  // change cluster head node group
for b = 0 to G_m
if (CH[a] ∋ CM_CH[a][b] ) then
        // calculate probability of cluster member node for cluster head node change
        calculate f(E_b(t)) of CM_CH[a][b]
        calculate f(DV(t)) of CM_CH[a][b]
        P_b(DDV(t)) ← f(E_b(t)) x  f(DV(t))
        if (P_b(DDV(t)) of CM_CH[a][b] is max value) then
          nextCH ← CM_CH[a][b]
  end
  CH'[a] ← nextCH
end
for a = 0 to G // recast cluster member node group of all changed cluster head node
 for b = 0 to N-1
    if (Region including CH'[a] ≡ Region including V[b]) then
        // calculate between CH'[a] and V[b] about difference direction and velocity
        Dir_CH'[a]V[b] ← | Dir_CH'[a]  - Dir_V[b] |
        ν_CH'[a]V[b] ← | ν_CH'[a] – ν_V[b] |
        // if V[b] is similar direction and velocity with cluster head node CH'[a],
        // register cluster member node of CH'[a]
        if (0 ≤ (Dir_CH'[a] / |Dir_V[b]^rs|) ≤ 1) and (0 ≤ (ν_CH'[a] / |Δν|) ≤ 1) then
            CM'a ∋  V[b]
  end
end
output cluster head node group CH'
        all cluster member node group of cluster head node i CM'_i
end
```

As shown in Algorithm 2, for maintaining cluster formation, cluster head node calculates exchange probability of cluster member node that considers residual energy, velocity, direction in CMi. When A Cluster member node has a maximum exchange probability, the cluster member node becomes a next cluster head node. Exchanged cluster head node forms cluster formation.

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4. Simulation & Result

For comparing the efficiency of the proposed algorithm, we set up in a Java environment which is developed by us and use Random cluster algorithm. The random cluster algorithm is free from restraint of the network. The random cluster algorithm does not use the property of node such as energy, distance between nodes, direction, velocity, and *etc*. It forms cluster formation randomly. In this paper, we compose the simulation configuration as follows. Network area is 100 x 100 area, the nodes are arbitrarily arranged in the network area. The direction of node is divided four areas; the velocity of a node is assigned to receive optionally between 1 and 16. The number of clusters is 16 EA, the cluster is composed by direction of nodes and the number of dividing the network area. The total simulation time is 300 seconds, for measuring packet delivery ratio; we stopped simulation each 30 second. Moreover, we compare proposed algorithm and random cluster algorithm, Total of node is increased 100 to 400, and we have assumed that the base-station is located in center of network area, the network area is divided 4 regions by base-station. Table 1 shows the simulation configuration.

Table 1. Simulation Configuration

Parameter	Value
Area	100 x 100
Velocity (m/s)	1 ~ 16
Number of cluster head nodes	16
Simulation time (Sec)	300

It was used Random network to compare the effectiveness of the algorithm DDV. Random network sets a routing path autonomously and clustering, the replacement of the head node. In addition, the ratio of packets reaching the destination node to the total packets generated at the source node. As shown Figure 5-7, the DDV algorithm and Random cluster shows the Packet Delivery Ratio due to pause time. The case of applying proposed algorithm, the Packet Delivery Ratio can look at the efficiency than Random network. In all cases, DDV shows better performance in packet delivery ratio. Result of the experiment, the node plays a very important role for the formation of a cluster using the direction and velocity. Figure 5 the simulator environment formed the cluster after arranging 100 nodes randomly. At this time, the number of cluster fixed with 16. Figure 6 the simulator environment formed the cluster after arranging 200 nodes randomly. At this time, the number of cluster fixed with 16. Figure 7 the simulator environment formed the cluster after arranging 300 nodes randomly. At this time, the number of cluster fixed with 16. Figure 8 the simulator environment formed the cluster after arranging 400 nodes randomly. At this time, the number of cluster fixed with 16.

Figure 5-8 is the simulation result that compares DDV algorithm and random cluster algorithm of packet delivery ratio. As shown in Figure 5-8, despite of the number of nodes is increased, proposed algorithm shows a high packet delivery ratio of up to 50% from 30% roughly. It means that the cluster is influenced by the direction and velocity of the node. In another ward, direction and velocity of node affects that cluster formation as forming cluster formation.

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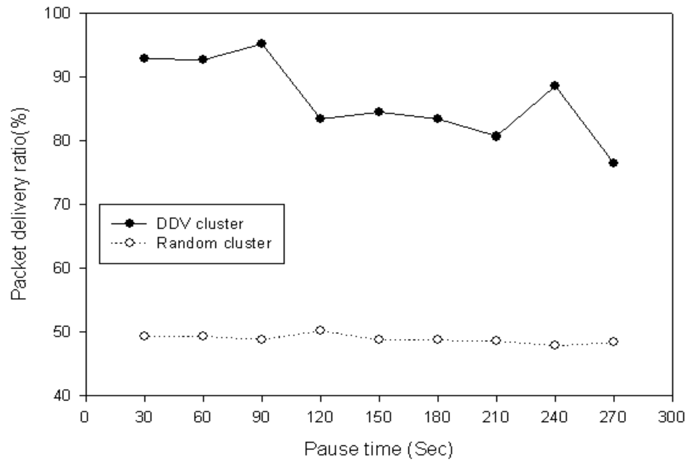

Figure 5. Packet Delivery Ratio with 100 Nodes

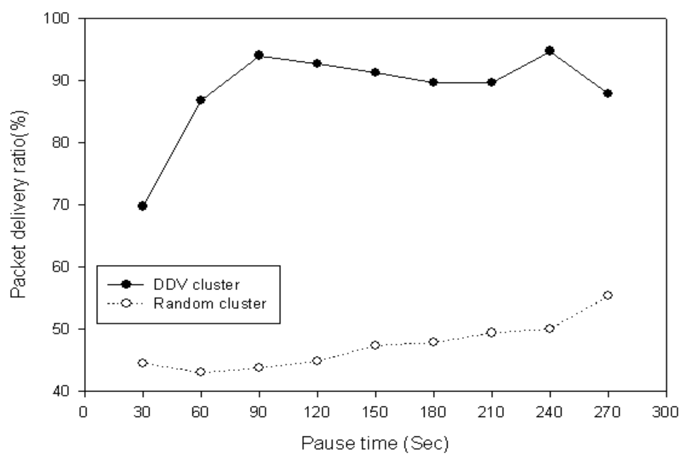

Figure 6. Packet Delivery Ratio with 200 Nodes

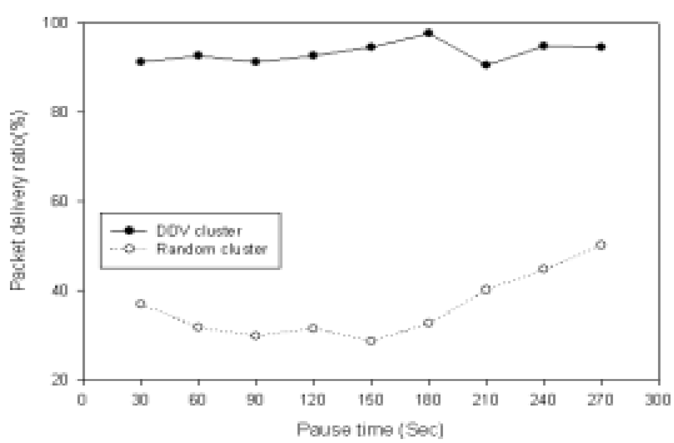

Figure 7. Packet Delivery Ratio with 300 Nodes

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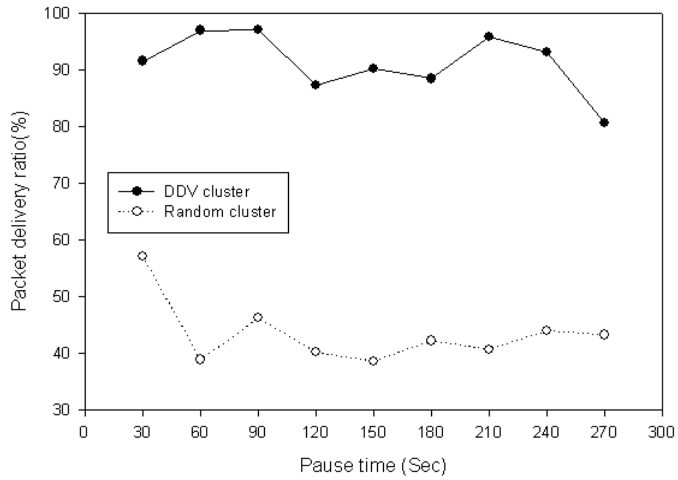

Figure 8. Packet Delivery Ratio with 400 Nodes

5. Conclusion

MANET consists of nodes that have mobility property such as direction and velocity. Due to the characteristic of a node, MANET frequently exchanges topology. According to exchange topology, MANET happens overhead and uses inefficient energy consumption. To solve these problems, we proposed Dynamic Distance Vector (DDV) algorithm. DDV algorithm is cluster algorithm that uses direction and velocity as the components of cluster formation. Proposed algorithm, for forming cluster formation, base-station establishes a standard about direction and velocity. Cluster head node is determined by these standards. The Cluster head node joins cluster members that have similar velocity and direction of the cluster head node. Since then, for maintaining cluster formation, cluster head node exchanged periodically. For exchanging cluster head node, cluster member node calculates a probability using distance between cluster head node and cluster member node, direction, velocity. The calculated probability of cluster members, cluster head node choices cluster member node that has maximum probability and update cluster information. For proving an efficient connection of proposed algorithm, we measured random cluster algorithm against the proposed algorithm. The simulation result, DDV algorithm is higher than random cluster algorithm about packet delivery ratio. However, different results depending on the nature of the network will be able to show the future compared with other property information that is necessary to study.

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