DynaMoNET: Dynamic Multi-homed IPv6 Mobile Networks with Multiple Mobile Routers

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Abstract. DynaMoNET is designed for a multihomed moving network which has various MANETs interconnected through WPAN interfaces. Each MANET has a mobile router, e.g. a cellular phone which can work as a root MR in DynaMoNET. The essential technologies for DynaMoNET include handover protocol in heterogeneous networks, network switchover algorithm considering multiple decision factors, root MR election process based on token-based algorithm, fast root MR discovery algorithm and fault avoidance mechanism to support reliable Internet connectivity. In addition DynaMoNET handles multiple HAs model, i.e. (n, n, n) model. Finally the system design of a mobile router is suggested in order to make relationship between the key components.

Key words: Network mobility, heterogeneous networks, fault tolerance.

1 Introduction

The evolution speed toward beyond third generation (B3G) network has been accelerated by the development of various advanced access technologies including infrastructure and ad hoc modes. The needs for seamless connectivity are issued by mobile users who want to enjoy ubiquitous computing and communication services, i.e. computing and communication at any time, in any place and with any devices.

In ubiquitous environment, fine grain services to support seamless mobility in complex heterogeneous networks will be the most essential issue. IETF Mobile IPv6 (MIPv6) will be a suitable solution for global mobility support of devices scattered around us. Network mobility, however, can not be enough served by MIPv6 because MIPv6 manage only terminal mobility [1-3]. IETF *NEMO* (Network Mobility) WG has made effort on network mobility with various scenarios [4][5]. As access networks evolve, moving networks and mobile terminals use multiple network interfaces. As a result, the network technologies related with multiple network interfaces come to be very critical issues which includes vertical handover based on multiple factors, load sharing or MR (Mobile Router) synchronization, fault detection and avoidance, and HA synchronization [5]. The issues will be actively investigated in *monami6* (Mobile Nodes and Multiple Interfaces in IPv6) WG in IETF as well as in *NEMO* WG. *Monami6* WG especially focuses on multihomed device and network support by extending MIPv6 and NEMO protocols.

Recently several researches on multihomed network mobility have been made to solve the issues mentioned above [6-10]. *Cho* proposes the authentication mechanism

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of neighbor MR and registration process in case of multiple MRs [11]. In addition load balancing can be achieved by adopting HA-based load sharing mechanism with latency-based approach. *Song* introduces a decision making process integrated with AHP (Analytic Hierarchy Process) and GRA (Grey Relation Analysis) [12]. *Paik* addresses many issues in multihomed NEMO and gives analysis of influence of network mobility with multiple MRs on load sharing and session preservation [13].

Our special interesting is concentrated on nested mobile ad hoc networks (MANET) dynamically composed of MANETs visiting a mobile network. Let's assume that MANETs in small size, e.g. WPAN (Wireless Personal Area Network) with a cellular phone as a MR, assemble and make a larger MANET moving together. They can elect one or multiple root MRs within the moving network in order to serve as egress network interfaces. The relationship between MANETs is not client/server but peer to peer, i.e. equivalent to each other. Any of the MRs in the moving network can be a root MR and the number of root MRs are not restricted to support the others by the reasons of load balancing and fault avoidance. As a result, the NEMO can be conceived as a mobile node which has dynamically changeable network capability. The architecture, therefore, proposed in this paper is named DynaMoNET (Dynamic Mobile Network). DynaMoNET will address vertical handover algorithm in heterogeneous network models, MR election algorithm among multiple MRs, fast MR discovery algorithm, fault avoidance and protocol for seamless Internet connectivity. However, route optimization for pinball routing of nested NEMO and ad hoc routing protocol itself are out of scope of this paper.

The organization of this paper is as follows: Section 2 designs the architecture of DynaMoNET including interworking model of heterogeneous mobile networks. And handover procedure based on 'NEMO basic support protocol' will be given for two networking model, e.g. (n, 1, 1) and (n, n, n) model. The notation of (n, n, n) model means the set of {multiple MRs, multiple HAs, multiple MNPs (Mobile Network Prefixes)}. One of the essential features of multihomed NEMO, fault avoidance mechanism based on token, will be introduced as well. In section 3, the detail development mechanisms will be described for the introduced features of DynaMoNET including the system architecture of a MR, network switchover algorithm, token-based MR selection algorithm and fast MR discovery algorithm. After evaluating the features of DynaMoNET, we will give the conclusive remarks.

2. DynaMoNET Architecture

2.1 Design Considerations

Some issues are discussed for the design of an efficient multihomed NEMO [14]. With considering the issues, key design requirements of DynaMoNET are extracted as follows:

(1) Mobility protocol should consider multiple HAs and multiple MNPs, i.e. (n, n, n) model including single HA and single MNP, i.e. (n, 1, 1) model.
(2) Network switchover algorithm must consider multi-optional preferences of users or service policies.

(3) Fault tolerant mechanism based on available multi-paths should be taken into consideration.
(4) Multiple MRs can be fairly used as an external connection interface in order to overcome the limitation of mobile devices, e.g. battery power.
(5) Fast MR discovery algorithm in a moving network should be independent to ad hoc routing protocol.

2.2 DynaMoNET Overview

The interconnection between heterogeneous networks with different technologies can be achieved by IP based protocol, e.g. MIPv6, NEMO and monami6. There can be various service models related with MRs and MNPs. In this paper, we have interesting on (n, 1, 1) and (n, n, n) models as an extended network model of (n, 1, 1). We don't, however, consider HA synchronization in (n, *, *) model [14]. MR synchronization can be performed by means of token-based root MR selection algorithm which will be explained in later sections.

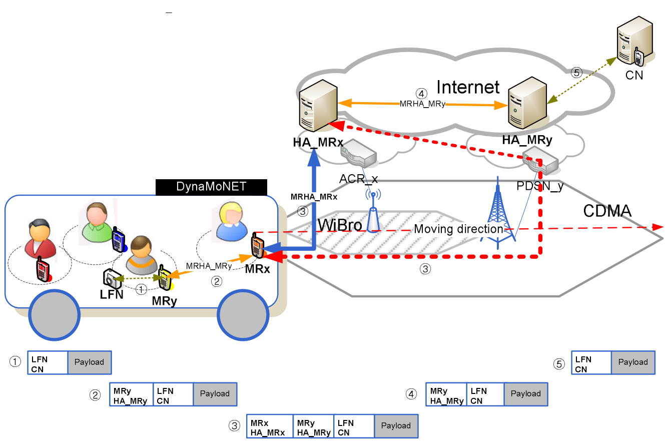

Fig. 1. DynaMoNET (n, 1, 1) model

Figure 1 shows (n, 1, 1) model which is a very simple architecture in terms of handover protocol. When mobile users with WPAN (Wireless Personal Area Network) get on a bus which has no network interfaces to the Internet, they will make a MANET in the vehicle and automatically elect root MR among them like figure 1. The elected MR will perform as a default router for the MANET to the Internet.

The packet formats for IP tunneling operation between LFN (Local Fixed Node), e.g. a digital camera with Bluetooth, and a corresponding node (CN) are shown at the bottom of figure 1. Since the depth of nested networks is 2 in this case, the tunnel header is encapsulated in double times. Figure 2 says the handover protocol in the scenario. When MRx detects availability of networks and makes decision of switching over to one of the networks, it performs MIPv6 binding update (BU) to its home agent (HA) which is the integrated mobility agent between CDMA and WiBro networks, i.e. (n, 1, 1) model. After the registration process is done, MRx releases the previous one. The support of simultaneous multiple paths on different network interfaces is out of scope of this research. Since MIPv6 can not support multiple CoAs at the same time, it is permitted that only one interface can be used as an egress interface in (n, 1, 1) model. However, *Wakikawa* suggests the modification on HA and caches to support multiple CoAs [15]. Since there are no changes of MNPs assigned to MRy, the nodes inside DynaMoNET do not need to update their CoAs (Care of Addresses). If the digital camera works as a VMN (Visiting Mobile Node) instead of a LFN, one more tunnel should be made between VMN and its HA or the CN.

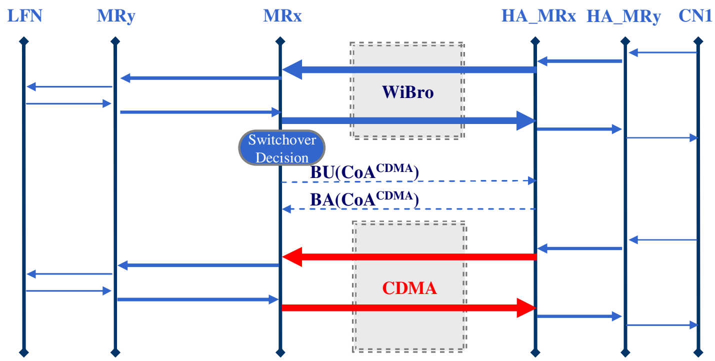

Fig. 2. Handover protocol in (n, 1, 1) model

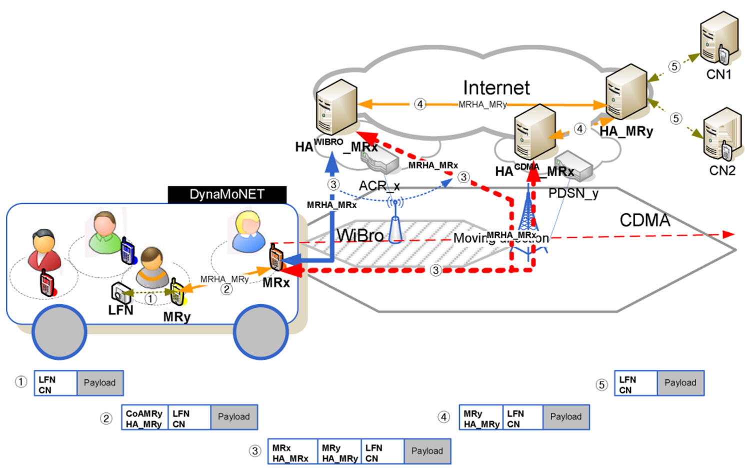

Fig. 3. DynaMoNET (n, n, n) model

Figure 3 and figure 4 show the service scenario and handover protocol of (n, n, n) model respectively. Let's assume that HAs of a MR are independent to each other and MNPs under control of each HA are different in our (n, n, n) model. As mentioned above, HA synchronization for the same MNP is out of our research scope in this paper. Multiple HAs assigns a HoA (Home Address) per interface in a MR and each HoA is registered with each authorized HA respectively. In DynaMoNET architecture, HoA of one network interface should be able to be assigned to the other network interface so that seamless connectivity can be achieved on handover process. Since the protocol, i.e. MIPv6, allows the operation in which multiple HoAs can be assigned to a network interface, this mechanism can be fallen into implementation issue.

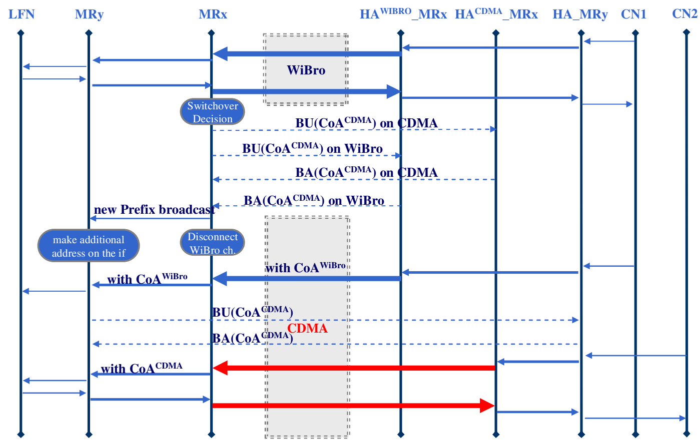

Fig. 4. Handover protocol in (n, n, n) model

When MRx decides to switch over to the new network, it sends BU (CoA^{CDMA}) messages to both HA^{CDMA}_MRx and HA^{WIBRO}_MRx before it releases the connection of the previous network, i.e. WiBro. By this operation, HA^{WIBRO}_MRx forwards all traffic for MRx toward the new CoA, i.e. CoA^{CDMA} over CDMA networks not over WiBro. The CDMA interface of MRx should be able to have the HoA from HA^{WIBRO}_MRx so as to permit the tunneled packets from CoA^{CDMA} with HA^{WIBRO}_MRx. After MRx disconnects WiBro connection, the existing connection between LFN and CN1 will continue to flow over CDMA networks as shown in figure 4. On receiving router advertisement with a new MNP, MRy generates a new CoA and tries to register the new CoA with HA_MRy. If a new CN2 tries to communicate with LFN, the new path will pass through HA^{CDMA}_MRx with CoA^{CDMA}.

2.3 Network Switchover Mechanism

The network switchover or handover of a root MR is an important feature of DynaMoNET for seamless Internet connectivity. The existing research suggested an intelligent multi-optional network decision algorithm based on AHP (Analytic Hierarchy Process) and GRA (Grey Relational Analysis) [12]. It analyses the relationship between multiple factors which affects the decision of an optimal network and evaluates each options, e.g. UMTS and WLAN, in terms of GRC (Gray Relational Coefficient). It neither considers the ping-pong problem or back-and-forth problem of mobile nodes nor takes RSS factor into the multiple factors of AHP, such as throughput, BER (Bit Error Rate), security level, and cost per packet. The algorithm simply decides if WLAN is available or not because of ubiquity of CDMA networks. If WLAN is available, it calculates GRC for the available options. However, RSS should be included to make decision of an optimal network. And hysteresis function (terminal_speed) is especially adopted for ping-pong problem. The solution will be introduced in the other paper in detail. Since the solution was developed and validated for a key component of dual-mode terminal software platform, i.e. CDMA-WiBro dual-mode platform in our research, this paper uses the result of the research as shown in figure 5 and figure 6.

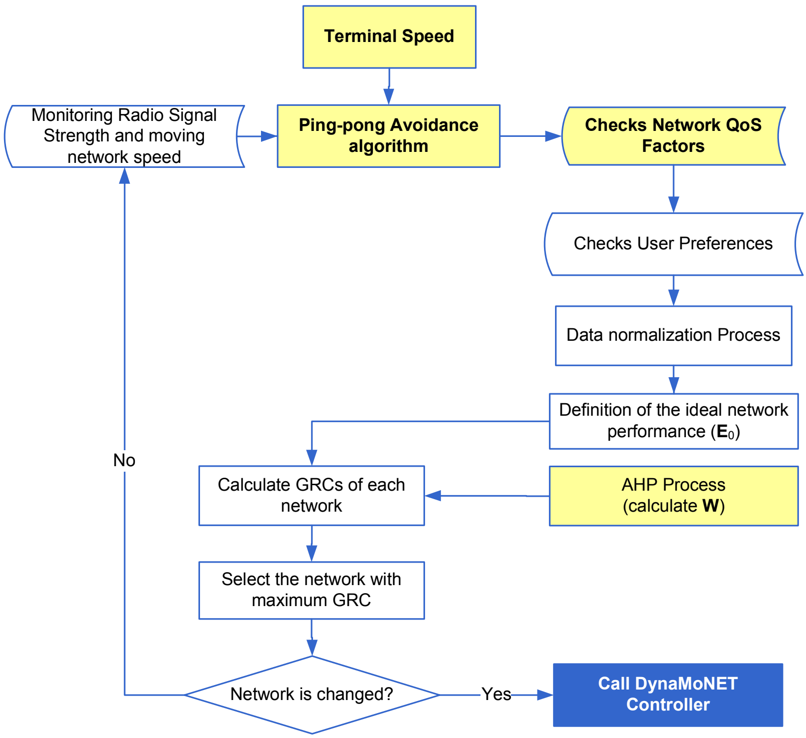

Fig. 5. Network Switchover algorithm with multi-optional preferences

2.4 DynaMoNET MR System

A MR system of DynaMoNET consists of 5 modules as shown in figure 5 which includes DynaMoNET controller, MR Election Module (MEM), Fast Route Discovery (FRD), Network Switchover Decision module (NSD) and DynaMoNET handover protocol. In network convergence layer it has network status monitor module (NSM), tunnel interface manager (TIM), network device manager (NDM) and multiple HoA manager (MHM).

```
1. Initial selected network (1: CDMA, 2:WiBro, 3: NONE) : )1
2-1. Normalized Radio Signal strength of CDMA (0 - 7) = 5
2-2. Normalized Radio Signal strength of WiBro (0 - 7) = 2
3. The Speed of Mobile Terminal : (1)10 (2)60 (3)120 (4)250 (5
4.Which network selection service do you want?
==============================================================
(1) Only RSS(Radio Signal Strenth) based Network selection
(2) Cost based Network selection
(3) Throughput based Network selection
(4) Security based Network selection
(5) Channel Reliability
==============================================================
 Select service which you want (1-5): 1
################## GRC on CDMA and WiBro ##################

  GRC of CDMA:          1
  GRC of WiBro:       0.5

 Multi-demensional parameters of CDMA and WiBro
|=====================|=============|=============|
|                     |        CDMA |       WiBro |
|---------------------|-------------|-------------|
|Normalized RSS       |        5.00 |        2.00 |
|Bandwidth (Mbps)     |        0.70 |        1.50 |
|Delay (msec)         |      100.00 |       10.00 |
|Radio BER            |    1.00e-03 |    1.00e-04 |
|Security Level       |        1.00 |        3.00 |
|Packet Cost (Won)    |       30.00 |       10.00 |
|=====================|=============|=============|
Keep CDMA network interface
############################################################
```

(a) RSS-weighted selection

```
1. Initial selected network (1: CDMA, 2:WiBro, 3: NONE) : )1
2-1. Normalized Radio Signal strength of CDMA (0 - 7) = 7
2-2. Normalized Radio Signal strength of WiBro (0 - 7) = 3
3. The Speed of Mobile Terminal : (1)10 (2)60 (3)120 (4)250 (5
4.Which network selection service do you want?
==============================================================
(1) Only RSS(Radio Signal Strenth) based Network selection
(2) Cost based Network selection
(3) Throughput based Network selection
(4) Security based Network selection
(5) Channel Reliability
==============================================================
 Select service which you want (1-5): 2
################## GRC on CDMA and WiBro ##################

  GRC of CDMA:      0.5155
  GRC of WiBro:     0.8065

 Multi-demensional parameters of CDMA and WiBro
|=====================|=============|=============|
|                     |        CDMA |       WiBro |
|---------------------|-------------|-------------|
|Normalized RSS       |        7.00 |        3.00 |
|Bandwidth (Mbps)     |        1.50 |        1.50 |
|Delay (msec)         |       10.00 |       20.00 |
|Radio BER            |    1.00e-05 |    1.00e-04 |
|Security Level       |        1.00 |        3.00 |
|Packet Cost (Won)    |       30.00 |       10.00 |
|=====================|=============|=============|
WiBro Network is selected and change to WiBro
############################################################
```

(b) Cost-weighted selection

Fig. 6. Experiments of Network Switchover algorithm

DynaMoNET controller manages all the control modules and receives L2 triggering events from NSM. The triggering can be implemented as polling based mechanism for NSM, however event-based or interrupt-based mechanism is much more efficient in terms of computing power efficiency. After receiving events, it notifies NSD which performs the network selection algorithm as described in section 2.3. If the result of the calculation says change of network attachment, NSD calls DynaMoNET controller to switchover to the triggered network. From this point, handover protocol can be performed under the control of DynaMoNET controller as shown in figure 2 and figure 4. The management of DynaMoNET covers dynamic tunnel interfaces, network device management and multiple HoAs control on each network interfaces.

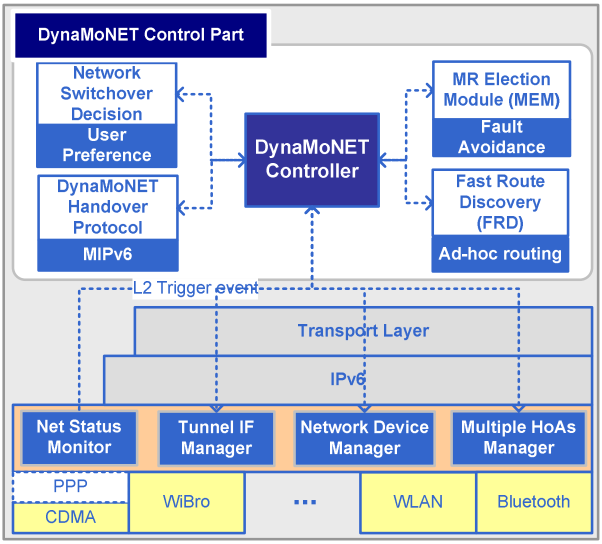

Fig. 7. DynaMoNET MR System Architecture

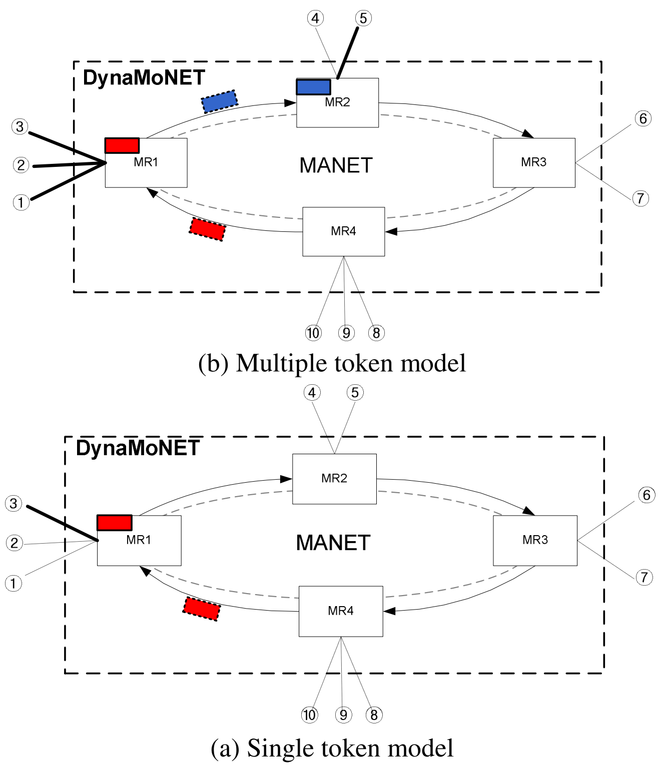

Fig. 8. Token-based control model

3 Fault Tolerance Mechanisms

3.1 Logical Ring Topology for Root MR Selection

This section explains a logical ring mechanism for management of root MR candidates which can be a root MR or multiple root MRs in DynaMoNET. There are two types of token models as shown in figure 8. Token means the right to work as a root MR in a DynaMoNET domain. If there is single token in a logical ring as shown figure 8 (a), only one MR, i.e. MR1 can be a root MR in the network. In this case MR1 comes to be a primary MR which can generate tokens in order to support QoS and fault tolerance. If there are multiple tokens in the ring as shown in figure 8 (b), there are the same numbers of root MRs. In this case MR1 works as the primary MR as well. Figure 9 shows the algorithm of establishment of a logical ring for DynaMoNET.

Establishment of Logical Ring

MEM initializes data structures for DynaMoNET;
MEM of the primary MR makes logical ring map based on link local addresses;
Sets the first root MT as the primary MR ;
Sets τ_{MR} *to a fixed period;*
while(TRUE) {
  MEM broadcasts solicit_root_MR over ad hoc network;
  Receives candidate_root_MR messages;
  Set $N_{candicates}$ *to the number of messages;*
  Registers the link local addresses with candidate root MR table;
  if ($N_{candicates}$ *is changed) {*
  for (i =0; i < $N_{candicates}$ *; i++){*
    Sorts candidate root MR table by addressing order;
   Makes unidirectional linked list in candidate root MR table;
    }
  MEM reliably sends the updated map to all candidates' link local addresses ;
  }
}

Fig. 9. The algorithm for establishment of logical ring

where $N_{candicates}$ means the number of candidate MRs which want to be root MRs

3.2 Token-Based MR Selection Algorithm

The token-based MR selection algorithm can solve some fault states. Let's assume that MR1 detects the lack of egress network bandwidth. The best way for this is to make another paths which can do load sharing with the existing path. The primary MR generates multiple tokens until the congestion is solved. The primary MR has the right to delete tokens which was released by a root MR. A root MR with a token can release the token when the traffic level goes down under a threshold level within some period. The released token goes around along the logical ring and arrives at MR1 which decides to delete the token or not. Figure 10 gives the algorithm implementing the above operations. We define three possible fault states as follows:

1) Traffic overload makes packet overflow or packet loss
2) The shortage of battery capacity
3) The breakdown of network devices

Token Control Algorithm for Fault Avoidance

while(TRUE) {
Monitors fault conditions;
if ($\Delta_i < \lambda_i$ *or* $C_{MR} < T_{MR}$ *or* $RSS_{active\_if} = 0$ *) set fault_state to TRUE;*
if(fault_state == TRUE) {
switch(policy) {
case SINGLE_ROOTMR:
Sends token to P_{next} *node;*
Waits for response from P_{next} *until the reserved time;*
if no response within the timer) retransmits 3 times;
else received positive response from P_{next} *or others next to* P_{next} *& prefix broadcast from the answerer then break;*
case MULTI_ROOTMR:
switch(fault_option){
case ***TRAFFIC_OVERLOAD:***
Generates a new token & N_{token}++;
Sends the token to P_{next} *node;*
Waits for response from P_{next} *until the reserved time;*
if(no response within the timer) retransmits 3 times;
else received positive response from P_{next} *or others next to* P_{next} *& prefix broadcast from the answerer then break;*
case ***BREAKDOWN_NETIF****:*
case ***SHORTAGE_BATTERY****:*
Sends token to P_{next} *node;*
Waits for response from P_{next} *until the reserved time;*
if(no response within the timer) retransmits 3 times;
else received positive response from P_{next} *or others next to* P_{next} *& prefix broadcast from the answerer then close all egress network interfaces;*
break;
}
}
}

Fig. 10. Token Control Algorithm for Fault Avoidance

where, N_{token} : The number of generated tokens by the primary MR which is a root MR, and the default value of N_{token} is 1

P_{next} : The pointer (link local address) for the next node in a logical ring topology

$P_{previous}$: The pointer (link local address) for the previous node in a logical ring topology

λ_i : Incoming traffic rate on i^{th} network interface

Δ_i : The threshold bandwidth of i^{th} network interface on a root MR

C_{MR} : Available Battery capacity of root MR

T_{MR} : The threshold battery capacity

RSS_{active_if} : Radio signal strength of active interfaces

3.3 Fast Root MR Discovery Algorithm

There are very interesting phenomena in which specific some nodes have the traffic favoritism, i.e. taking almost chances to serve requests from others. Through analyzing the patterns of network traffic, it is generally known that most traffic of a node is concentrated on a few particular nodes [16]. FRD (Fast Route Discovery) algorithm is devised to fast find the route to root MRs which have the traffic favoritism in DynaMoNET.

FRD can be combined with reactive ad hoc routing protocol, e.g. Ad-hoc On-Demand Distance Vector (AODV) or Dynamic Source Routing (DSR) since this algorithm is not a fundamental routing protocol but a supplementary algorithm to improve the base routing algorithm. The essential difference from native ad hoc routing mode is that the additional RREQ (Route Request) message is added to the ad hoc routing protocol in order to fast explore path for nodes with traffic favoritism. There are two additional fields in each destination entry in the routing table: the *Counter* and the *Is_Sel_RREQ*. Each node examines the packet type when transmitting the packet. If it is the data packet, the *Counter* value for the destination increases. Therefore, the number of packets transmitted to a destination is easily grasped. Note that the *Counter* value does not increase for control messages such as RREQ or RREP. Increasing the *Counter* value for the control packet disturbs the analysis of the traffic pattern. The maximum number of selected nodes with traffic favoritism is controlled by a variable, *MAX_NUM_FRD*.

Let *RREQ_Entry_Selection_Time* and *Sel_RREQ_Time* be the periods to select the frequently accessed nodes and to send the additional RREQ messages, respectively. Each host searches the *Counter* values in its routing table entries and determines the *RREQ_Entry_Number* nodes with the largest values. The *Is_Sel_RREQ* values of these nodes are set to one. Each node sends additional RREQ messages to the destination nodes every *Sel_RREQ_Time* if the *Is_Sel_RREQ*s corresponding to those nodes are one. Then, the *Counter* values in the routing entries are initialized to zero in order to rapidly adapt to the changes of network. These procedures are consecutively repeated every *RREQ_Entry_ Selection_Time*. By doing so, the packet is sent faster and is more stable for most frequently accessed destinations.

Since root MRs, as mentioned above, natively have traffic favoritism in a DynaMoNET, they have the highest priority as selected nodes in this algorithm. When an elected MR broadcast router advertisement into the network, each MR makes an entry for the MR, if necessary, and sets *Is_Sel_RREQ* flag without concerns of *Counter value*. Of course, the number of the root MRs should be counted in *MAX_NUM_FRD*. If there is a late selected root MR and slot for the root MR is occupied, then *Is_Sel_RREQ* flag of a normal MR or a node with lowest *Counter value* should be reset instead of the late joined root MR.

4 Simulation Study

In section 3, the token-based MR selection algorithm was proposed to support fault tolerance to a DynaMoNET domain. If a DynaMoNET suffers from buffer overflow or packet loss caused by traffic overload in a root MR, additional new root MRs must be selected as the algorithm. In case of traffic overload condition, the optimum number of root MRs is so important factors in order to save entire network energy and keep the network reliability as well. Root MRs forward the packets from its DynaMoNET toward the Internet via theirs own infrastructure network interfaces. While internal MRs in a DynaMoNET are interconnected with WPAN and establish MANET domain, root MRs use infrastructure network interfaces, e.g. CDMA or WiBro. As a result, there is asymmetric energy consumption between root MRs and internal MRs in a DynaMoNET [17]. Therefore, the network total energy consumption must be considered for selecting additional MRs in order to avoid the traffic overload. In this section, the simulation about selecting optimum number of root MR is considered for reducing packet loss and packet overflow and minimizing network total energy consumption.

Table 1. The simulation environment

ITEMS	VALUE
Simulation tool	NS-2
MANET MAC	IEEE 802.11
Bandwidth of external network interface	2Mbps
Packet size	1024 bytes
Radio coverage range of MANET	50m
Simulation Area	500m x 500m
Traffic pattern	Constant bit rate
Number of nodes	30
Number of network interfaces	2

Table 1 shows the network simulation environment for a DynaMoNET. The total number of nodes in the network and the number of nodes selected as root MR is determined to meet the optimum ratio considering packet loss and energy consumption. It is necessary that the total number of node and the number of node selected as root MR are constituted to optimum rate for reducing packet loss and energy consumption. We define ρ factor to show simulation results according to the ratio of the number of root MRs to the number of the internal MRs.

$$\rho = \frac{\text{The number of selected root MRs}}{\text{The number of other MRs excluding the root MRs}} \times 100(\%) \qquad (1)$$

In order to find the optimum number of root MRs, energy consumption and packet loss are under consideration with various ρ rates, e.g. 5%, 20%, 40% and 60% respectively. Figure 11 shows the simulation results of total energy consumption according to the ρ values. As the root MRs need more energy consumption than other MRs to interconnect the moving network with the Internet, the cases with higher ρ value consumes much more energy level than the ones with lower ρ rate. In terms of network lifetime, high energy consumption has an effect on the network lifetime.

Figure 12 gives the simulation result of packet loss amount in terms of network reliability according to the ρ rates. With higher ρ rate, because traffic processed by root MR is reduced, possibility to be in fault state gets lower. Therefore network reliability is enhanced with higher ρ rate. As a result of the simulations, all of network energy consumption and network reliability can be considered in terms of the number of root MRs. If many root MRs are elected in order to increase the reliability as designed in the fault tolerant algorithm, the energy

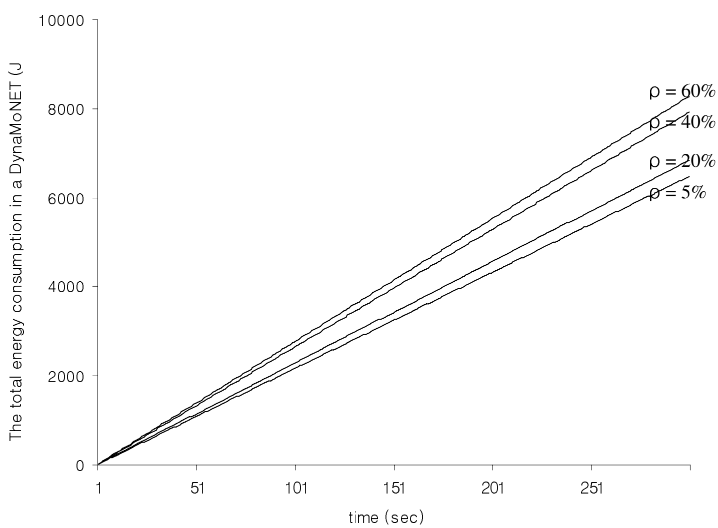

Fig. 11. Total energy consumption of DynaMoNET

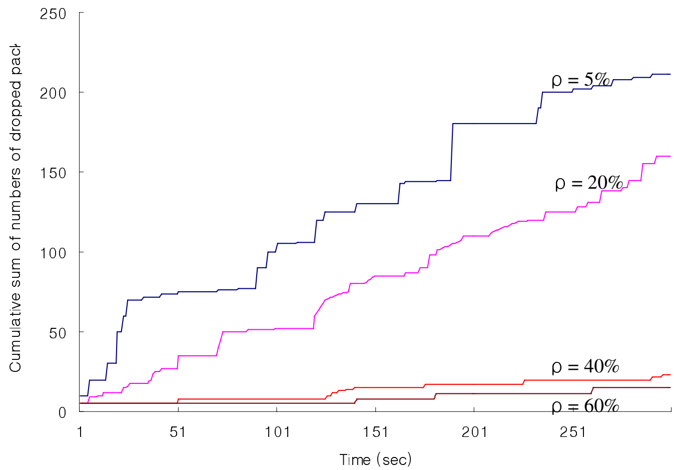

Fig. 12. Packet loss amount in terms of ρ

consumption will increase and the lifetime of the entire network will linearly decrease as the number of the root MRs selected in a DynaMoNET. Meanwhile, the network reliability does not increase as the number of root MRs. In case of this simulation, the network reliability or packet loss rate comes to be stable as the value of ρ approaches to 40%. Therefore, the optimum rate of ρ for network reliability is around 40% at the expense of entire network energy.

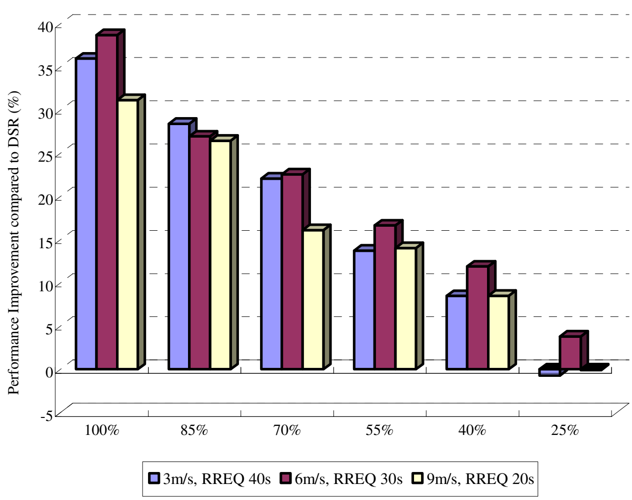

Fig. 13. The performance enhancement in terms of delivery delay(%)

Table 2. The performance comparison between FRD-AODV and FRD-DSR

	100%	80%	70%	55%	40%	25%	Average
3m/sec 40s	0.34	0.32	0.82	1.08	-0.95	3.02	0.771667
6m/sec 30s	0.98	0.58	0.84	0.84	-0.26	0.8	0.63
Average	0.66	0.45	0.83	0.96	-0.605	1.91	0.700833

As mentioned in section 3.3, the effect of FRD needs to be proved in a DynaMoNET domain. Figure 13 and table 2 show the performance enhancement by FRD and the performance comparison between FRD-AODV and FRD-DSR, respectively. As a result the adoption of FRD can enhance the delivery delay time in DynaMoNET with independent to ad hoc routing algorithm.

5 Conclusion

In this paper we proposed a novel moving network architecture, DynaMoNET, which aims to solve the problems of moving ad hoc networks with multiple network interfaces. There are some key issues in DynaMoNET in order to support seamless Internet connectivity: handover protocol in heterogeneous networks, vertical handover algorithm considering multiple decision factors, root MR election algorithm, fast root MR discovery algorithm and fault avoidance mechanism.

Handover protocol is designed based on NEMO basic support protocol, which does not consider multiple network interfaces and multiple HAs environment. DynaMoNET addresses the problems by adopting multiple CoAs registration mechanism. The handover protocol is triggered by the decision from network switchover module which takes account of multiple decision factors, such as RSS, bandwidth, BER, Cost per packet and etc. In addition terminal speed-based hysteresis value is used for ping-pong problem. There are always reliability problem in unreliable networks like ours. Therefore, token-based logical ring mechanism is adopted in order to improve fault states and elect root MRs. Finally FRD algorithm was introduced so that normal MRs can seek for the route to root MRs as fast as possible.

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