Efficient Routing Protocol using Virtual connection and Load balancing for Network Mobility

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Abstract. Internet users are increasingly becoming more and more demanding, expecting Internet access anytime, anywhere, making ubiquitous, next generation networks a requirement. Uninterrupted connection, even in the case of moving networks, is expected. It is important for a vehicle network to reduce signaling traffic in wireless channels and have fast handover. To achieve these requirements, in this paper, a MRP based rouging scheme for network mobility, is proposed. In order to achieve fast handover, a candidate FA if found, which a mobile network is attached to, making an initial virtual connection to a Mobile Router (MR). In addition, the throughput of a wireless channel is upgraded, by reducing signaling traffic through load balancing. The performance of the proposed scheme is evaluated through a series of simulations using Network Simulator (ns-2).

Keywords: FA(Foreign Agent), HA(Home Agent), MNN(Mobile Network Node) and MR(Mobile Router)

1 Introduction

Wireless networks are evolving towards all-IP-based infrastructures, allowing seamless integration between wired and wireless networks [1]. In addition, the number of passengers, with a laptop, mobile phone or mobile notebook, demanding the use of the Internet at any location, is increasing. Even though these users may be in vehicles such, as a train and aircraft, continuous Internet use when using these devices is desired. In recent years, the IETF has developed protocols such as MIPv4(Mobile IPv4) and MIPv6(Mobile IPv6), for supporting seamless connectivity with mobile hosts[2][3]. However, MIPv4 and MIPv6 suffer from the problem that is difficult to support a moving mobile network. In order to cope with this problem, the IETF NEMO(NEtwork MObility) working group has proposed a NEMO Basic protocol, based on the Mobile Router (MR) for Network mobility. A MR acts on behalf of the nodes within its mobile network, performing routing operation and Home Agent function for Mobile Network [10]. The reasons of supporting a MR base for network mobility are as follows. First Mobile Network Nodes (MNNs) in mobile networks can reduce transmission power because the radio transmission distance from an on-board device to the MR is much shorter than to another Access Router on the Internet. Secondly, after MNNs establishment with MR, when the Mobile Network(MN) is moving, handover frequency MNNs can be reduced, as the MR only operates handover. In addition, once MNNs join the MN, they do not need to maintain their Internet address [4].

The NEMO Basic protocol, provides uninterrupted connectivity for MNNs, but, does not consider routing optimization. A routing scheme based on NEMO, uses MIPv6 for routing optimization and allows a MR to transmit a binding update message to each Correspondence Node (CN). This results in binding update implosion in large network, towards the MR .

To cope with this problem, the Ernst proposed Prefix Scope Binding Update(PSBU) method, was proposed. In this method, a MR obtains a Care of Address (CoA) from its attachment using MIPv6. The MR transmits this CoA to All CNs using PSBU. In this scheme, the MR overloads when transmitting a binding update message periodically to all CNs. Currently most schemes that provide network mobility are not sufficient in supporting fast handover. In addition, the MR suffers from overload, when performing a binding update and routing function. To cope with these problems, the proposed scheme is provided as follows. First, fast handover is provided, by using a candidate Foreign Agent (FA) for virtual connection. Second, a Mobile Router Proxy (MRP) for a MR is created. The MRP performs a binding update for each CNs as a substitute for the MR. Therefore, the MRP enables load balancing, to reduce the MR overload and upgrade performance of the mobile network, reducing traffic in the wireless zone between the MR and Access Router (AR).

The subsequent sections of this paper are organized as follows. Section 2 provides related work. Then the MRP based routing scheme is described in Section 3. The evaluation of the proposed scheme is presented in Section 4, and some concluding remarks are provided in Section 5

2 Related Work

In this section, various schemes regarding most recent network mobility developments are introduced, and their characteristics are discussed. In the case of using MIPv4 for network mobility, the MR acts as a FA, it provides MNNs with CoA. The packets, destined for MNNs within a MN, are transmitted through the HA. For global connectivity of fixed nodes within a MN, the MR permanently registers the Home of Address (HoA) of the MR to the Home Agent (HA), as a CoA of the MR. MIPv4 supports MNNs within a MN as a single mobile node for network mobility. Whenever network mobility occurs, each MNN obtains a CoA from the MR and then performs a binding update to HA. Therefore this scheme makes it difficult for a MNN to maintain an address, as well as resulting in binding update implosion of the MR. In this case, using MIPv6 for network mobility, the MR must operate a binding update to CNs

NEMO was designed to provide uninterrupted connectivity for MNNs within MN, without considering routing optimization. The MR in NEMO acts on behalf of MNNs within MN. That is, the MIPv4/v6 performs a binding update only for the MR but NEMO performs it for all mobile networks to the HA. The follow details NEMO Basic protocol operation principles. When a mobile network is moving, the MR registers the mobile network prefix to the HA. This prefix is used by the HA, which intercepts packets destined to MNNs and forwards them to the MR. The MR decapsulates the packets in turn, and then transmits them to the MNNs. In the case where the packets destined to egress, the HA decapsulates the packets and forwards them to the CNs.

The scheme using MIPv6 routing optimization for network mobility has binding update implosions because the MR performs a binding update for all CNs. To solve these problems, the PSBU method, together with the Optimized Route Cache (ORC) Management protocol, exists.

The PSBU uses MIPv6 extension to broadcast the mobile network prefix to the HA and all CNs. When the PSBU performs a binding update, it initially registers all mobile networks to the HA. At this point, the MR uses MIPv6, obtaining the CoA from its attachment point. This CoA is transmitted to all CNs in the mobile network using PSBU. The PSBU performs binding, and this binding relates to the mobile network prefix CoA of the MR. Before transmitting packets, the CN verifies accordance with the destination prefix and mobile network prefix in the binding cache. If it is matched, the packets are transmitted through the CoA of the MR, using a routing extension header. Therefore the PSBU provides optimal routing between CNs and MNNs.

However, the MR has overload when processing everything. In addition, when there are lots of CNs, the MR has a problem of transmitting periodic PSBU to all CNs.

3 Efficient Routing Protocol(ERP)

3.1 Preliminaries

The following scenarios must be considered for network mobility. Network mobility moves pre-defined low & high speeds, and stops at pre-defined stations, MNNs within MNs can move randomly. Currently, most routing schemes for network mobility have problems as follows.

(1) No routing optimization: NEMO has a problem that All packets of a MN can communicate to CNs only via the HA

(2) The MR's binding update implosion: when providing routing optimization using MIPv4/v6, the MR has a problem that MR transmits periodic binding update messages to a number of CNs

(3) Signaling overload: high error rate and bursty errors in a wireless channel zone between MR and AR(like a FA) exist. Therefore, it is import for this network to reduce signaling overload.

In order to solve the above problems, the ERP based routing scheme is proposed as follows.

(4) Fast Handover: Since the MR makes temporary tunneling using a candidate, prior to the FA mechanism, when the MR reaches a foreign network, it can minimize registration delay time.
(5) MR's Load Balancing: Since the MRP performs binding a update function for the CN, the MRP can reduce the overload of the MR, as well as signal the traffic of a wireless channel zone.

New concepts regarding candidate FA and MRP are defined, for the proposed scheme
Definition 1: The candidate FA is set of foreign agents which the mobile network will move into. The candidate FA provides a minimizing registration delay time, in order to support fast handover when a MN moves. That is, the candidate FA is registered, prior to temporary tunneling to the HA. The current FA or HA searches the candidate FA, based on $P_t(x_t, y_t)$, in Section 3.3.1, using a predicted traveling distance.
Definition 2: The MRP(Mobile Router Proxy) performs proxy function of the MR. The *MRP on behalf of the MR operates a binding update to the CNs for the MNNs within the MN.* The MRP is the root router in one domain and its function can add a traditional router easily.

3.2 ERP Architecture

In this section, the search method of the candidate FA using predicted traveling distance, and how it forms an establishment between MR and MRP, is presented.

3.2.1 MRP establishment

The following represents the process of MRP establishment
(1) Handover Initialization
When the MN is a home network, the MR registers its own home address and mobile network prefix to the HA and then the MR transmits its own speed periodically, together with location information to the HA. Like Fig 1, the HA calculates the $P_t(x_t, y_t)$ in 3.3.1
(2) After the MN searches the FA, which the MN moves into, the HA transmits the network prefix of the MN to the FA of AS2.
(3) Temporary tunneling setup
The FA creates temporary tunneling with the HA, which is the MR-CoA uses to assign to the MR. At that time the FA creates an initial connection descriptor for the session.
(4) Mobile network moving
Mobile network is attached into the FA of AS2.
(5) HA Registration

After the MR receives the connection descriptor, the MR connects the session using the connection descriptor, to the FA. The MR transmits the binding update message to the HA.
(6) MRP establishment
The MR selects the domain root router in the new foreign network as the MRP. The MR transmits information, which is the address of the CNs for the MNNs within the MN, to the MRP1 using IPv6 address extension.
(7) CN updating
On behalf of the MR, the MRP1transmits a periodic binding update message to each of the CNs. After each of the CNs receives this message, They transmit packets destined to the MNN to MRP1. Packets destined to the MRP1 are transmitted to the FA, and then to the MR, then the MR transmits the packet MNNs within the MN. The MRP1 transmits a periodic binding update message to indicate the lifetime of the binding cache to the CNs.

3.2.2. Handover processing

Followings are procedures about virtual connection for L3, handover process for L2.

Virtual connection for L3 Handover
(1) The oFA requests periodically a MR's velocity & location information to the MR.
(2) The MR responses with current velocity & location information to oFA
(3) The oFA calculates the MR's predicted traveling distance based on formula (5)
(4) The oFA requests MR's handover with MR's HoA, oFA's IP addr, MNP(Mobile Network Prefix), estimated time to handover.
(5) If there are candidate FAs (1 or more FA), which can satisfy the condition of Step 4, go to next step. Otherwise this operation is finished.
(6) The candidate FA responses the oFA for handover confirmation
(7) The oFA sends candidate FA's IP address to the MR.
(8) The candidate FA requests virtual connection to HA.
(9) The HA responses to the candidate FA
(10) The candidate FA sends connection descriptor to the MR.
(11) Setups virtual connection for the MR

Handover procedure for L2

(1) The MR is moving into new FA.
(2) The MR performs scanning procedure.
(3) The MR sends MR's connection descriptor to new FA.
(4) If nFA had MR's connection descriptor, response confirmation message to the MR. Otherwise this operation is closed here for virtual connection and MR performs general L3 Handover procedure.
(5) Setups complete tunneling between L2 and L3

4 Performance Evaluation

The performance evaluation of the proposed scheme has been tested and evaluated using temporary tunneling, through simulations of CMU's wireless extensions for Network Simulator (ns-2). Also we developed MR and candidate FA by modifying MobiWan[12]. For load balancing, we modified function of MIPv6 at domain root router to perform binding update for CNs among function of MR. Also we added this function of virtual connection to FA. The nodes use an 802.11 radio and MAC model provided by CMU extensions. The radio propagation range for each node is 100 meters. The wired network capacity is 10/50/100Mbps(Base station, Site Router, Border Router, respectively) and mobile node's speed is 2M/s. The simulation time is 100sec and the mobility model is GNMM. In simulation, we simulated that domain are 2, sites are 8, total number of wired-nodes are 28 and MR is 1.

4.1 Network Mobility Model

The design for mobility is important in correcting the evaluation of the routing algorithm. The Random Waypoint Mobility Model(RWMM) and Gauss-Markov Mobility Model(GNMM) is used as independent mobility for each node.

Proposed routing scheme is a group mobility model, in which mobile nodes move together. In this paper, the Group Network Mobility Model(GNMM) is developed, to evaluate the proposed routing scheme. The Reference Point Group Mobility Model(RPGM), is used widely, to express the random motion of each mobile node within a group, in addition to the random motion of one group[11]. The RPGM demonstrates that group movement is based on the path traveled by the logical center for the group. The motion of the group center completely characterizes the movement of its corresponding group of mobile nodes, including their direction and speed. The individual mobile nodes randomly move around their pre-defined reference points, with movements depending on the group movement.

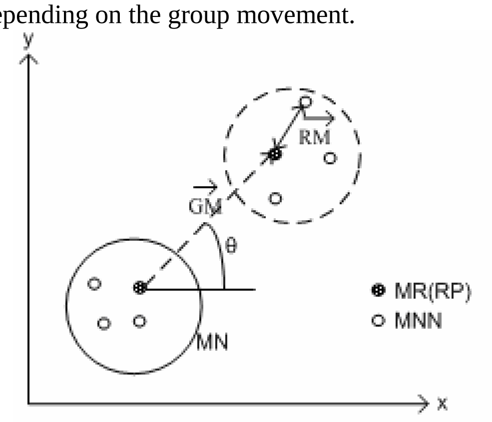

Fig. 1. Network Mobility using the GNMM model

Fig 1 presents the MN motion composed of one MR and three MNNs, using the GNMM Model, which is modified by the RPGM.

At time t, the MR acts as a Reference Point((RP_{t-1}) for three MNNs. The GNMM uses Group motion vector $\overrightarrow{GM}$, in order to calculate Reference Point RP_t at time instant t. $\overrightarrow{GM}$ is composed of velocity vector V_t = (v, θ) and position $P_t(x_t, y_t)$ of the MN. Therefore candidate FA can be found using $\overrightarrow{GM}$. Velocity vector and position can be written, following at time instant t.

$$V_t = \min[\max(V_{t-1} + \overline{V}, 0), V^{\max}] \quad (1)$$

$$\theta_t = \theta_{t-1} + \overline{\theta} \quad (2)$$

Here $\overline{V}$, is the variation of speed, uniformly distributed at $[-S_t^{\max} * \overline{V}, S_t^{\max} * \overline{V}]$. $S_t^{\max}$ represents maximum acceleration. In addition, $V^{\max}$ is the maximum speed of the MN. In formula (2), $\overline{\theta}$ is the variation of direction, and is uniformly distributed at $[-\gamma * \overline{V}, \gamma * \overline{V}]$. γ is the maximum angular, as a MN motion.

$$x_t = x_{t-1} + V_t * \cos\theta_t \quad (3)$$

$$y_t = y_{t-1} + V_t * \sin\theta_t \quad (4)$$

The new position of each MNN is calculated by summing the random motion vectors $\overrightarrow{RM}$ and RP_t.

At RP_t, distance of $\overrightarrow{RM}$, the distance between MNNs and MR, is uniformly distributed within a predefined radius center. Each MNN within MN is implemented using the Random Waypoint Mobility Model. Based on formula (3), (4)

$$P_t(x_t, y_t). \quad (5)$$

(5) is New position of Network Mobility.

4.2 MR's Load Balancing

We simulate to know how many MR generates binding update messages for CNs and Simulation is increasing the number of CNs. Binding updates are composed of HA and CN at MR. In real world, MR performs binding update to CNs for MNNs within MN. In this simulation, one MR means one mobile network. What it is increasing CNs means that MNNs within MN send and receive packets with CNs. Therefore, it is significant to measure the number of binding update to evaluate overload of MR owing to binding update according to increasing CNs. We generate traffics between CNs and MR to measure this. The traffic is generated ping per second. When MR receives new CoA, MR sends binding update CNs per seconds and per 10 seconds to refresh binding cache of CNs. We find influence on wireless channel between MR and AR(Access Router, like a FA) through simulation.

MR performs many and frequently binding update according to increasing the number of CNs. Like fig 2, the number of binding update of MR is increased rapidly according to increasing CNs.

In proposed scheme, the number of binding update of MR is increased linearly according to increasing CNs. We find that MRP can reduce overload of MR as MRP performs binding update for CN instead of MR and MRP upgrade mobile network efficiency as it reduce signaling traffic over wireless channel zone.

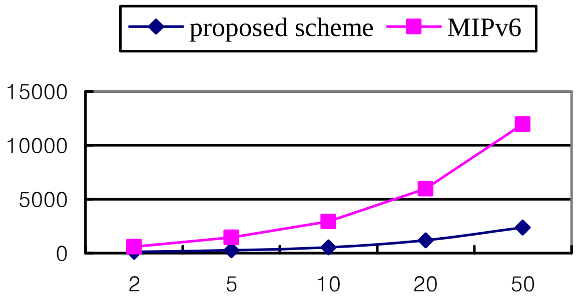

Fig. 2. MR's # of Binding Update

In Fig 2, X axis is the number of CNs and Y axis is all Binding update of MR. The number of Binding Update is that MR performs binding updates for HA and CNs. As you see like a Fig 2, the number of Binding update of proposed scheme is smaller than MIPv6. Fig 2 illustrates that proposed scheme uses efficiently bandwidth in wireless channel because MR does not send signaling messages. Also in MIPv6, we find that Binding Update is increasing rapidly according to increasing the number of CNs. Which presents that overload of MR is increasing rapidly according to increasing the number of CNs of MNNs within MN.

4.3 Fast Handover

Fig 3 shows handover latency time according to speed variation of MR. X axis is speed of MR, Y axis is handover latency time. Also we have tested that the number of CNs is set 10. We assumed that moving path of mobile network moves pre-defined path. Proposed scheme can minimize handover latency time because the current FA or HA searches the candidate FA using a predicted traveling distance and the candidate FA is registered, prior to temporary tunneling to the HA.

Fig 3 illustrates that proposed scheme can maintain small & regular handover latency time and it can support seamless handover

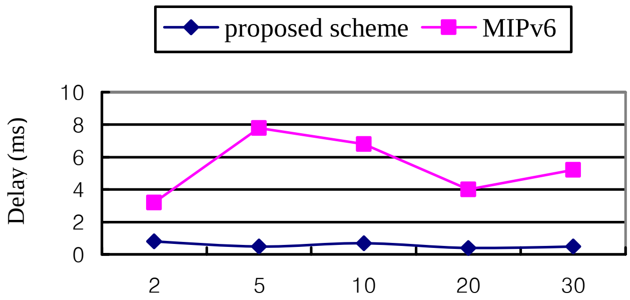

Fig. 3. Handover latency time

5 Concluding Remarks

In this paper, we described that our scheme uses virtual connection for fast handover and it develop load balancing of MR using MRP when In-vehicle mobile network moves.

According to increasingly becoming more and more mobile communication, we expect increasing technical demands of in-vehicle mobile network. When in-vehicle mobile network moves, the function of MR is important to use internet for nodes within mobile network. Also efficiency of wireless channel between MR and AR is very important. Therefore, in this area, in order to reduce signaling traffic, we proposed MRP mechanism.

Like simulation, as the MRP on behalf of the MR operates a binding update to the CNs for the MNNs within the MN, even increasing the number of CNs, proposed scheme can maximize efficiency of bandwidth and provide load balancing of MR as reducing signaling traffics in wireless channels. Also when mobile network moves, proposed scheme can minimize handover latency time because the current FA or HA searches the candidate FA using a predicted traveling distance and the candidate FA is registered, prior to temporary tunneling to the HA. In this simulation, we find that how many binding update for CNs has influence on wireless channels and if reduction of signaling traffic in wireless channels has influence on all mobile network.

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