MOVEMENT-AWARE MOBILE ROUTER ADVERTISEMENT FOR POWER SAVING IN VEHICULAR MOBILE NETWORKS

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Abstract

This paper proposes a power saving scheme for vehicular mobile networks, *Movement-aware Mobile Router Advertisement (MMRA)*. A mobile network moves as a single unit with one or more mobile routers that connect it to the global Internet. A node inside a mobile network is called Mobile Network Node (MNN). MNNs are fixed inside the mobile network, i.e. Local Fixed Node (LFN) or move freely inside the network, i.e. Local Mobile Node (LMN) or Visiting Mobile Node (VMN). Almost all mobile nodes have power restriction since they use batteries for their power. This paper proposes MMRA to reduce the power consumption at MNN by adjusting Router Advertisement (RA) interval in vehicular mobile networks. A Mobile Router (MR) uses information about whether the MR is moving or not. When a mobile network is moving, a new VMN cannot get into the mobile network. So by increasing the interval between RAs when it moves, MNNs can save their power to process frequent RAs.

1. Introduction

In ubiquitous computing, electronic appliances usually have wireless communication capability with their own IP addresses. MobileIP Working Group in Internet Engineering Task Force (IETF) [1] proposed Mobile IP [2] to support mobility in IP networks. Mobile IP aims at maintaining transport or higher layer Internet connectivity while a host is moving.

Not only devices but also vehicles can be connected to the Internet [3]. Mobile devices can be connected to Internet even in vehicles. In addition, they can move in groups, e.g. a radio, a Personal Digital Assistants (PDA), and a mobile phone that belong to the same person can be organized together to form a Personal Area Network (PAN). Network Mobility (NEMO) working group in IETF [4] investigated this issue and extended the existing Mobile IP to support network mobility.

In the mobile network, the mobility of the entire network is viewed and managed as a single unit, which changes its point of attachment to the Internet through a mobile router (MR) [5]. A mobile network includes one or more mobile routers (MRs) that connect it to the global Internet. A mobile network can contain both fixed and mobile nodes behind the MR. To support the network mobility, the binding cache in Mobile IP must have information about the mobile network prefix of MR's ingress interface.

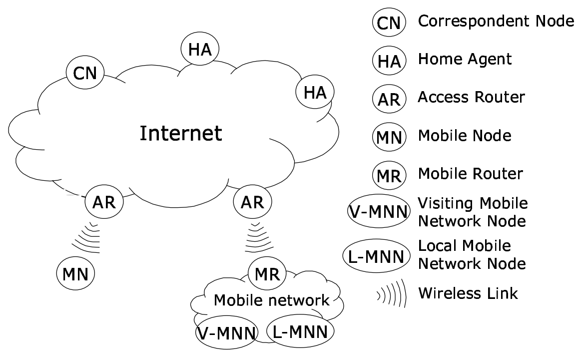

Figure 1: Host mobility and network mobility.

Host mobility and network mobility are illustrated in Fig. 1. We define two types of Mobile Network Node (MNN). One is Visiting MNN (V-MNN) and another is Local MNN (L-MNN). In the case of V-MNN, they can get on or off the vehicle while L-MNN is always staying inside the mobile network. Most V-MNNs usually use batteries for their power, so power saving is important for V-MNNs.

In MIPv6, Router Advertisement (RA) interval is important since the nodes can recognize the movement by listening to new RA. The router advertisement interval in IPv6 is restricted to minimum three seconds since the movement of node was not considered and the frequent RA is large overhead. In MIPv6, the RA interval is much shorter than that of IPv6. By frequent RA, the handoff latency is reduced but power consumption is increased.

This paper proposes a power saving scheme called Movement-aware Mobile Router Advertisement (MMRA) for vehicular mobile networks. In this scheme, an MR is aware of the vehicle's movement. When a mobile network is moving a new V-MNN cannot get into the mobile network, amd movement-detection is not necessary. By increasing RA interval while moving, Mobile Network Nodes (MNNs) can save power.

The rest of this paper is organized as follows. Section 2 introduces the movement detection in MIPv6 and section 3 describes MMRA. In section 4, we show simulation results. Finally, section 5 concludes this paper with future research issues.

2. Movement detection in MIPv6

In MIPv6, mobile nodes realize that they moved and are attached to new Access Router (AR) by listening to RA messages from the new AR. This process is called movement detection.

In Mobile IPv6-based protocols, handoff latency is composed of two main factors: one is the delay for the movement detection, and another is the delay for the registration. The delay for the registration is associated with the distance from the mobile node to its Home Agent (HA), and this delay is assumed to be constant. However in the case of the movement detection, the delay is associated with the interval between successive RAs. In MIPv6, the RA interval is set to be shorter to reduce the handoff latency.

Table 1: Router advertisement interval in IPv6 and MIPv6.

Drafts	Router Advertisement interval (msec)	
	Min.	Max.
IPv6	3000	600000
MIPv6-13	500	1500
MIPv6-19	50	1500
MIPv6-24	30	70

Table 1 shows the historical changes of the RA interval by the version of the draft. We can choose the RA interval between maximum and minimum value. If a node is moved and attached to the AR, the node can make its address after receiving RA from AR. In the case of IPv6, though the interval is set to minimum value, the node should wait 3 seconds in worst case. But in the case of the latest version of MIPv6, the node can recognize its movement within 30ms.

3. Movement-aware mobile router advertisement

Short RA interval reduces the delay of movement detection but the frequent RA is serious overhead in the view of the power consumption of MNNs since every MNNs should process every unnecessary RAs. Fig. 2 shows the relation between movement detection and power consumption by RA interval. According to [6], nodes are idle most of the time. So even though a node is idle, the node must listen to the periodical RA and perform a process on that RA. RA processing is also a power consuming work.

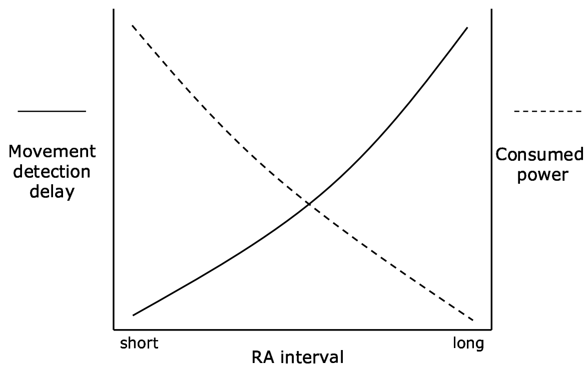

Figure 2: The relation between movement detection and power consumption by route advertisement interval.

NEMO basic support protocol [7] is based on MIPv6, so it also has the frequent RA interval like MIPv6. However we can make use of the mobility pattern of vehicles for saving the power of MNNs. MNNs are classified into two modes: local and visiting [8]. L-MNNs do not need movement detection since they do not move from a network to the other network. V-MNNs need an RA for movement detection. But when a mobile network is moving, new visiting nodes cannot get into the network and existing visiting nodes cannot get off from the network. So we can have classified two modes of occurrence of new V-MNNs:

- The first case is when a V-MNN gets into the network while the power is on. This occurrence of a V-MNN is happen only when the vehicle is stopped.
- The second case is when a V-MNN is turned on inside the mobile network. In this case the V-MNN broadcasts Router Solicitation (RS) to get RA from a MR [9].

In MMRA, the RA interval of MR can be varied by the status of MR. We assume that an MR knows its movement by in-vehicle sensors. So when a vehicle is moving, the MR reduces the frequency of RA. And when the vehicle is stopped, the MR reduces the interval of RA so new V-MNN from outside of the network can recognize its movement immediately. Doors of a vehicle also can have sensors. If a MR knows whether the doors are opened or not, the MR can adjust the RA interval more precisely. The MR collects the information from in-vehicle sensors that are a sort of L-MNNs, and using that information the MR tunes the RA interval for new V-MNNs in vehicular mobile network.

Table 2 shows the movement pattern of vehicles. These patterns of vehicles are based on the real vehicle movement. In the case of subway in Korea, average distances between stations are about 150 seconds. And when they stopped at a station, they stay for 20 seconds. If the period of moving is long, the advantage of MMRA is bigger since MNNs do not waste their power when the network is moving.

Table 2: Movement pattern of vehicles.

Vehicle type	Moving period (sec)	Stopped period (sec)
Subway	150	20
Bus	900	30
Train	1500	120

4. Performance evaluation

We simulated MMRA using Network Simulator 2 (NS2) [10] and MobiWan [11] extension for MIPv6. We measured the connectivity from CN to MNN and the power consumption of MNNs.

4.1 Handoff latency

The handoff latency is composed of the movement-detection delay and the location registration delay. We measured the handoff latency on each router advertisement interval when a mobile node is moving between access routers by the speed of 20m/s (72Km/h). Fig. 3 shows the average handoff latency for a mobile node. Short handoff latency means that the mobile node can detect its movement quickly using frequent router advertisement message.

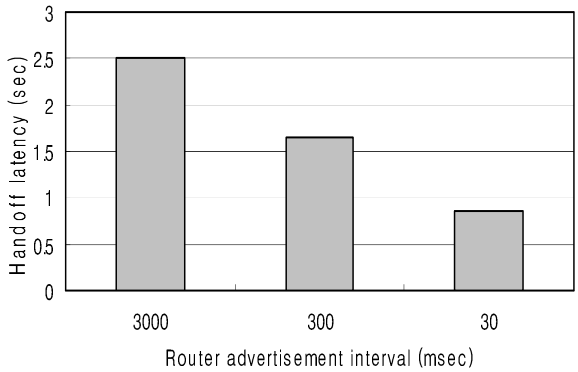

Figure 3: Handoff latency according to RA interval.

4.2 Power consumption

Frequent RA is helpful for movement detection. However mobile nodes have restrictions of power since they use batteries. Processing frequent RA is significant overhead for local nodes in the view of power.

Fig. 4 shows the power consumption of a mobile node when the interval of RA is varied. The background traffic is set to 10Kbps and the simulation is performed for an hour. The initial energy of the mobile node is 50J and it consumes its energy when it receives or sends packets. The difference between long and short RA interval is the overhead of frequent RA in the view of power consumption.

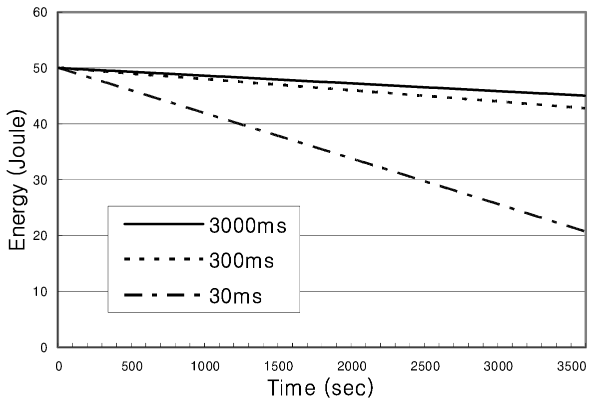

Figure 4: Power consumption according to RA interval.

4.3 Movement-aware mobile router advertisement

Vehicular mobile networks have a regular movement patterns for the kind of vehicle. Those patterns are described in Table 2. The MR in a vehicular mobile network can know whether the network is moving or not and adjusts the RA interval by the current state of the network.

MMRA uses the characteristic that new V-MNN cannot occur when the network is moving. So the MR broadcasts its RA frequently only when the vehicle is stopped and passengers get in or off. Fig. 5 shows the effect of MMRA. The simulation is performed for each vehicle type in Table 2. The RA interval is set to 30ms for fast movement detection and the background traffic is 10Kbps CBR. The condition of initial and consuming energy is the same for the simulation of section 4.2.

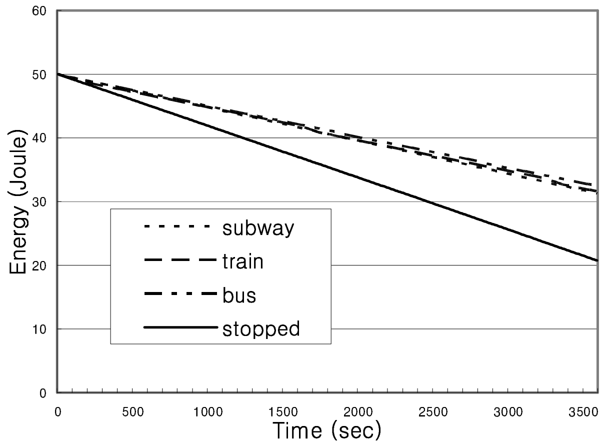

Figure 5: Power consumption with MMRA

Slight differences between vehicle types are since each vehicle represents different movement pattern. The MMRA is more effective especially when the moving period is much longer than the stopped period in movement patterns.

5. Conclusion

Reducing the RA interval in MIPv6 is helpful for the movement detection and it causes shorter handoff latency. However processing frequent RA is significant overhead for power-constrained mobile nodes. This paper proposes a power saving scheme, MMRA, for vehicular mobile networks. According to the characteristic of vehicles, new V-MNNs can appear only when the vehicle is stopped. Using this characteristic, MRs increase its RA interval when the vehicular mobile network is moving so MNNs inside the mobile network do not need to waste their power during the vehicle is moving.

We are further generalizing the scheme for common mobile networks and improving the scheme for the multi-homed vehicular mobile network. If a mobile network has two or more MRs, handoffs can occur inside the mobile network during it is moving. In this case, we need more intelligent method for power saving and seamless handoff.

Acknowledgement

This work was supported in part by the Brain Korea 21 project of the Ministry of Education, and in part by the National Research Laboratory project of the Ministry of Science and Technology, 2004, Korea.

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