Enhanced Mobility Support for Mobile Devices using Sensor Networks

V. Narayanaswamy, N. Thanthry, and R. Pendse

Department of Electrical and Computer Engineering, College of Engineering

1. Introduction

The Information Technology revolution, combined with people’s need to access information quickly, has resulted in the explosive growth of the Internet in the past decade. The need for internet has grown to such an extent that, internet is now available in airplanes. With the existing internet protocol, it is hard to support user mobility as the IP address is location dependent. The modified version of IP i.e. Mobile IP that was designed to support user mobility does not provide quality of service (QoS) and security for the user data. It was observed that when the mobile node moves from one foreign domain to the other, the delay involved in registering its new location and new identity with the home domain heavily affects the QoS. In addition to that, traditionally internet provides only best effort data delivery. The best effort cannot serve the bandwidth requirements of real time applications.

To achieve continued growth of mobile users and provide advanced services, it is important that a scalable QoS provisioning method be adopted. We propose a fast handoff method using wireless sensors as the location-tracking device. Networks of such sensors perform movement detection of mobile nodes in a particular direction and inform the mobility agent to which the mobile node is attached. The mobility agents predict the new point of attachment and inform the corresponding mobility agent about the requirements of the mobile node. This reduces the handoff time and improves the performance of the mobile nodes.

2. Reducing Handoff Time and Providing QoS using Wireless Sensors

Consider the network shown below, FA1 and FA2 are foreign agents, MN is the mobile node, HA is the MN’s home agent, CoN1 and CoN2 are the control nodes respectively. The procedure for the proposed method is as follows:

When MN moves from HA to FA1:
1. Wireless sensor network WSN1 detects the movement of MN and informs HA, CoN1 and FA1 about this movement.
2. HA immediately multicasts the information regarding the MN including the authentication information to a multicast group in which all the Control Nodes are members.
3. FA1 sends a request to the control nodes for the information regarding the MN and the control nodes send the required information to the FA1. The Control Nodes also ask the FA1 to join a multicast group in which the HA is already a member.
4. MN sends a registration request to FA1 and FA1 authenticates it.
5. FA1 then sends a message to HA saying that MN is now in its territory.

When MN moves from FA1 to FA2:
1. Wireless sensor network WSN2 detects the movement of MN and informs FA1, CoN2 and FA2 about this movement.
2. The FA2 sends a request to the control nodes for the information regarding the MN and the control nodes send it to the FA2. The Control Nodes also ask the FA2 to join a multicast group in which HA is already a member.
3. MN sends a registration request to FA2 and FA2 authenticates it.
4. FA2 then sends a message to HA saying that MN is now in its territory.
5. When HA permits FA2 to join the multicast group it relieves FA1 from that group.
3. Protocol Analysis

In this section we analyze the proposed handoff method based on an analytical model. Handoff time may be defined as the time difference between receiving the last packet from the oFA and the first packet from the nFA, assuming that the MN has an active traffic session during the handoff. MN detects that it has moved away from a mobility agent when the lifetime of that agent’s advertisement has expired and it has not received any new advertisements from it. Taking the worst case into consideration, assume that just before the MN receives the last packet from the oFA, it also received an agent advertisement with the lifetime set to TLifetime seconds. Let \( T_1 \) be the time when it received the last packet.

\[
\text{Figure 2: Proposed handoff mechanism}
\]

In the proposed method, wireless sensors perform movement detection. These wireless sensors can be installed in such a way that the L3 handoff process completes before L2 handoff takes place. We assume that wireless cells do not overlap always. Wireless sensors take a certain non-zero time to detect the movement of mobile devices. This time includes the time for sensing the mobility and passing the information to the corresponding data gathering nodes. Let this detection time be \( X \). We introduce a new component called control nodes. These Control Nodes (CoN) are placed between the FA and the HA and between FA’s. We assume the distance between the FA and the CoN and the distance between the HA and the CoN to be equal.

\[
T_{1WS-FA} = T_{1WS-HA} = T_{1WS-CoN}
\]

The wireless sensors then inform the HA, CoN and the FA about the node movement. The HA immediately sends all the information required for the MN registration and QoS provisioning to the CoN (\( T_{1HA-CoN} \)). The FA by this time would have sent a request to the CoN (\( T_{1FA-CoN} \)). CoN then sends the information it obtained from the HA to the FA (\( T_{1CoN-FA} \)). During this interval, the MN receives the information about the FA through its home agent. Then MN sends a registration request to FA and FA sends a registration reply to the MN. As soon as the MN receives the reply, it will try to force an L2 handoff. Since the MN is receiving packets during L3 handoff from oFA, total handoff latency during which packets are lost using wireless sensors is

\[
T_{(WS)Handoff} = L2 \text{ delay}.
\]

We now discuss an optimum distance at which these wireless sensors should be installed. The wireless sensors should start detection so that by the time L2 handoff occurs, MN should have received the registration reply forwarded by the nFA. Time taken for detection and L3 handoff is

\[
T_{Detection} = X + T_{1WS-HA} + T_{1HA-CoN} + T_{1FA-CoN} + T_{1CoN-FA} + T_{1(MN-FA)} + T_{1(FA-MN)}
\]

Assume a car moving at \( u \) m/s. The distance \( D \) at which the wireless sensors should be installed is

\[
D = T_{Detection} \times u \text{ meters}
\]

The time \( T_{Detection} \) in the above equation should be assumed slightly greater than the actual value to account for jitter, queuing delay and processing delay. Then it is assured that the registration reply will reach the MN before it moves to nFA. To determine packet loss during handoff, let us assume the source sends packets to the MN every \( Y \) seconds. Hence for the proposed method packet loss will be

\[
\text{Packet loss} = T_{WS \text{Handoff}} / Y
\]

While in traditional Mobile IP it is the time taken for the handoff which is \( T_{Handoff} \) (sum of movement detection delay, registration delay and L2 handoff delay). The handoff time for the wireless sensors is the L2 delay which is much lesser compared to the traditional Mobile IP handoff time.

4. References