Performance Evaluation of IP Paging with Power Save Mechanism *

Ved Kafle, Sangheon Pack and Yanghee Choi
School of Computer Science & Engineering
Seoul National University, Seoul, Korea
{kafle,shpack}@mmlab.snu.ac.kr, yhchoi@snu.ac.kr

Abstract

We evaluate the performance of IP paging with power save mechanism by formulating an analytical model and carrying out simulation study of Integrated IP Paging Protocol (IIPP) that integrates both the paging and power save functionality in IP layer. The results show that, compared to the Mobile IP regional registration, the IIPP significantly reduces the average power consumption of a mobile node and the signaling load in the access networks, while providing link layer independent mobility and power management functions.

1. Introduction

The future IP mobile nodes are expected to change their points of attachment to the network very frequently as the cell coverage reduces with increasing bandwidth service for multimedia applications. Although, the mobile nodes seem very mobile to the network, most of them remain idle i.e. do not transmit or receive data most of the time. Registering the location of an idle mobile node every time it moves to the coverage of new access router has no significant advantage to the network and mobile node. It is just wastage of network resource and the battery power of the mobile node. To eliminate these problems, therefore, we develop an link-layer independent Integrated IP Paging Protocol (IIPP) by integrating the paging and power save mechanisms in IP layer.

In the existing cellular network, both the paging and power management functions are implemented in link layer. However, we believe the forthcoming all IP networks use wide varieties of link-access technologies, therefore, the need for an integrated IP layer paging and power save mechanism for all devices is imminent.

Though in brief, this paper explores the possibility of using an unified paging and power save protocol in IP layer that can extend the network scalability and the battery life.

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2. IIPP Overview

We take the Mobile IP regional registration [1] as the reference architecture for IIPP, in which the foreign agents are configured in hierarchical order, with the gateway foreign agent (GFA) at the top and the access routers (ARs) at the bottom level of hierarchy. In between the GFA and AR there may be some or none regional foreign agents (RFAs).

2.1. Regional Registration

To reduce signaling load in the IIPP, idle mobile nodes do not register their locations with the GFA every time they move from a cell to another. Instead, they register only when they cross a paging area (PA) that consists of a number of cells. To register the location a mobile node sends regional registration request to the GFA through AR and receives back the reply from the GFA.

After registration, the GFA and other FAs maintain entry for the mobile node in their visitor lists, and start active timer. The active timer is reset by every data packet, destined for or originated from the mobile node, traversing the FA. If the mobile node does not send or receive data for an active timeout, the GFA sets the mode of mobile node as dormant and all other FAs below the GFA delete the entry for mobile node from their visitor lists. Only the GFA maintains the location of an idle mobile node in terms of a PA.

2.2. Paging Functional Architecture

As explained in RFC 3154 [3], a paging functional architecture consists of three logical entities: *dormant monitoring agent* (DMA), *tracking agent* and *paging agent*. We consider all these entities colocate in the GFA. When the DMA receives data packet addressed to a dormant mobile node, it buffers the packet, and inquires the tracking agent about the paging area of mobile node. The tracking agent is informed by a mobile node when the later changes paging area, therefore, the tracking agent maintains the up-to-date location of mobile nodes defined by a PA. The DMA forwards this information to the paging agent that pages the mobile node by sending paging request to all ARs belonging of the paging area. If an AR receives multiple paging requests for different mobile nodes, it forms a queue of requests and broadcasts in its cell at once.

To implement the dormant monitoring agent and tracking agent in GFA we add three more fields in the entry for a mobile node: the mode, *Paging Area Identifier* (PAI), and *Maximum Paging Interval* (MPI). All of these fields are updated through regional registration performed by a mobile node. The mode field has either active or dormant value.

2.3. Power Save Mechanism

To reduce the energy consumption, IIPP employs power saving mechanism to allow the idle mobile nodes enter power save mode (PSM) or dormant mode. An IIPP mobile node in active mode, i.e. when communicating with network, behaves in the same way as a node does in Mobile IP regional registration (MIPRR).

We add a few time-related fields in agent advertisement and registration messages. The unsolicited agent advertisement message has an *Advertisement Interval* extension that has two fields: the *Agent Advertisement Interval* (AAI), and *Advertisement Slot Length* (ASL). The AAI field is used to specify the time interval between two successive unsolicited agent advertisements; and the ASL is used to specify the duration of time in which an AR may send agent advertisement message in its cell. We assume that by any way the ARs under a GFA are synchronized, so that the mobile node once synchronized with an AR in any cell can remained synchronized in all cells in the networks.

A dormant mobile node may wake at every AAI for a duration of ASL, and may go to sleep in the remaining time between two advertisements. However, to save more power a dormant mobile node may skip a number of advertisements, and wake up less frequently. We add *Maximum Paging Interval* (κ) field that indicates the number of skipped advertisements, in the extension of regional registration. While paging, the GFA includes κ in the paging request message and the ARs use κ to decide when they need to broadcast the paging alert in their cells. However, skipping an advertisement with paging message to the mobile node may delay a session set up process and increase the possibility of blocking the arrival session. We have addressed a case of this issue in [4].

3. Results and Future Works

We formulated an analytical model using fluid flow mobility model to evaluate the average power consumption of a mobile node and the average signaling load in the access network. The mobility related parameters used for evaluation are taken form P-MIP [2] and other published literature, and the power related parameters are set as follows. Mobile node consumes maximum power at active mode whereas it consumes $\frac{2}{3}$ and $\frac{1}{20}$ of active power in idle and sleep modes, respectively.

Table 1. Average power consumption of a mobile node as a fraction of active power

MIPRR	IIPP without PSM	IIPP
0.78	0.72	0.12

We found that the optimal range of PA is 10-35 cells. Table 1 shows the analytical result for the average power consumption of a MIPRR node and an IIPP node for the optimal PA. As IIPP mobile nodes do not register their location on changing every cell, they remain in idle mode for longer time and consume less power, even when the power save mode is not used. Moreover, the use of PSM significantly reduces the power consumption. Similarly, we found that within the optimal PA, compared to MIPRR, the IIPP reduces the signaling load in network by about 18-42%. We also carried out simulation study and found the same sorts of results as found in analytical modeling. More detail results can be found in [5].

In current version of IIPP we simply consider a case of static paging in which the GFA sends unicast paging request to all ARs of current paging area. Our future work will focus on studying the dynamic paging methods to efficiently transmit paging request from the GFA to the selected ARs of current paging areas, so that the paging delay and signaling overhead could be reduced.

References

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