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Modeling and performance analysis of power efficient multi-tier location management in interworked WLAN and cellular network

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ABSTRACT

In multi-radio access networks, it is essential to support multi-tier location management to mobile stations (MSs) with multi-radio interfaces, in order to deliver incoming calls to appropriate radio access networks. In multi-tier location management, the location information of MSs at multi-radio access networks should be managed in an integrated way, and single registration (SR) and multi registration (MR) are widely used multi-tier location management schemes. In SR, MSs register at the registration area (RA) of only one of available access networks. In MR, on the other hand, MSs register at the RAs of all available access networks simultaneously. However, battery power consumption is significant in both SR and MR, since multiple radio interfaces operate simultaneously. Recently, works on efficient power management (EPM) have been carried out in interworked WLAN and cellular network by turning off the WLAN interface when it is not active because the idle state power consumption of WLAN interface is significant. In EPM, if a voice over IP (VoIP) call arrives at WLAN, it is notified through a less power-consuming cellular interface. The paging via cellular interface, however, generates significant signaling load at radio interface because paging has to be performed to all cells within a registration area (RA) of cellular network. In this paper, we propose power efficient multi-tier location management schemes, i.e., power efficient SR (PSR) and power efficient MR (PMR), based on the tradeoff between SR/MR and EPM. The performance of the proposed schemes is analyzed in terms of signaling load and energy consumption. The results show that PSR and PMR have significantly lower signaling load than EPM and have significantly smaller energy consumption than SR/MR.

1. Introduction

1.1. Background

Next generation mobile communication networks consist of multi-radio access networks, such as cellular network, WiMAX, and wireless local area network (WLAN). Each access network is complementary to each other from the aspect of service coverage area, mobility support, transmission bandwidth, etc. For example, high mobility support and large service coverage area are provided in cellular network. On the other hand, high bandwidth is provided with a cheap price in WLAN, although mobility is limited. Therefore, it is possible to select an appropriate access network via mobile stations (MSs) with multi-radio interfaces.

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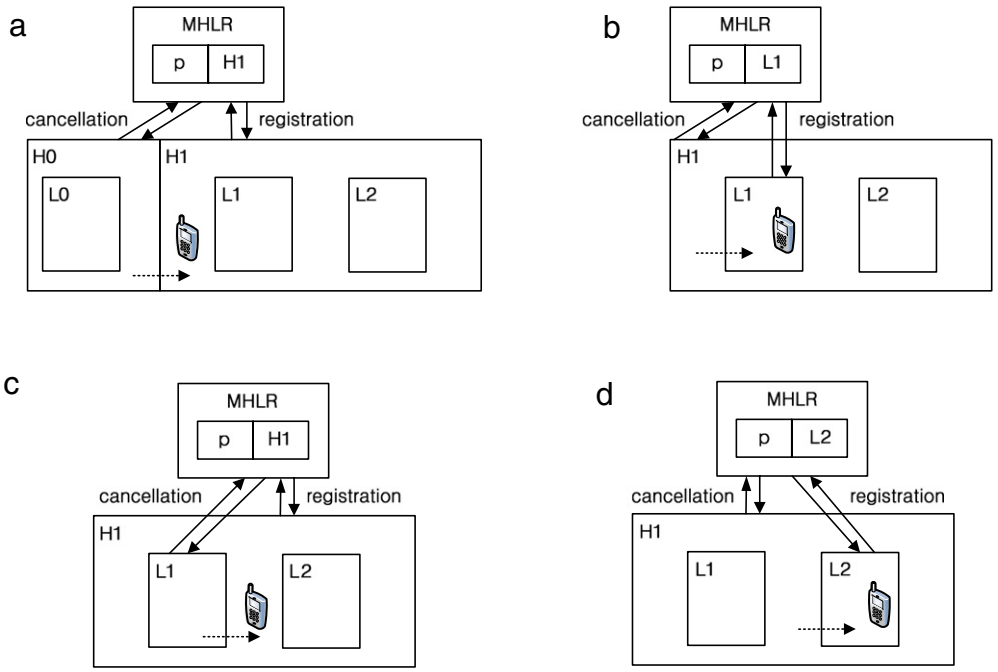

Fig. 1. Single registration (SR) scheme.

In multi-radio access networks, it is essential to support multi-tier location management to MSs with multi-radio interfaces, in order to deliver an incoming call to an appropriate radio access network. In multi-tier location management, the location information of MSs at multi-radio access networks should be managed in an integrated way.

1.2. Multi-tier location management

Single registration (SR) and multi registration (MR) are widely used multi-tier location management schemes [1–3]. In SR, MSs register at the registration area (RA) of only one of available access networks. In MR, on the other hand, MSs register at the RAs of all available access networks simultaneously. Fig. 1 shows SR in multi-tier network architecture, which consists of low-tier network L and high-tier network H. Low-tier network has small coverage area and does not cover the whole area continuously. On the other hand, high-tier network covers large area and overlays low-tier network. For example, if we consider interworked WLAN and cellular network, low-tier network corresponds to WLAN and high-tier network corresponds to cellular network. Multi-tier home location register (MHLR) manages the RA information at which MSs are currently registered.

In SR, if an MS is located at high-tier network initially, it registers the high-tier network RA at MHLR. On the other hand, if an MS is located at low-tier network initially, it registers the low-tier network RA at MHLR, although the MS is also located at overlaid high-tier network. This is because it is generally assumed that low-tier network provides cheaper services than high-tier network. If an MS p moves into high-tier RA H1 from another high-tier RA H0, it registers H1 at MHLR and H0 is deregistered (Step a). Then, if the MS moves to L1, it registers L1 at MHLR and deregisters H1 at MHLR (Step b). If the MS moves back to H1, it registers H1 at MHLR again and deregisters L1 (Step c). If the MS moves to new low-tier L2, it registers L2 at MHLR and H1 is deregistered (Step d).

In MR, an MS registers at the RAs of all available networks at MHLR simultaneously, as shown in Fig. 2 [1–3], where high-tier RA H0 and low-tier RA L0 are registered at MHLR initially. If an MS p moves into high-tier RA H1 from another high-tier RA H0, it registers H1 at MHLR and low-tier location information L0 is still registered at MHLR (Step a). Then, if it moves to L1, it registers L1 at MHLR and L0 is deregistered (Step b). In Step b, it is noted that no deregistration for H1 is performed. If the MS moves back to H1, there is no registration and deregistration since there is no need of location information change at MHLR (Step c). If it enters into L2, it registers L2 and deregisters L1 at MHLR, and both H1 and L2 are registered at MHLR (Step d). In MR, either registration or deregistration is performed only when an MS moves to a new low-tier or high-tier network RA.

In quality of service (QoS)-aware multi-tier location management [4], SR and MR were extended to accommodate QoS requirement of both voice and data calls. In [4], a voice call is delivered to cellular network and a data call is delivered to WLAN as much as possible in interworked WLAN and cellular network. Thus, when a voice call arrives at an MS which is located in low-tier RA in MR, the call is delivered via high-tier cellular network, instead of being delivered via low-tier WLAN.