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A cross-layer mobility support protocol for wireless sensor networks ☆

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ABSTRACT

This paper proposes a cross-layer mobility support scheme for the IPv6 over low-power wireless personal area network (6LoWPAN) wireless sensor network (WSN). This scheme combines the handover in the network layer (L3) with the handover in the link layer (L2) so that the L3 handover and the L2 one can be performed simultaneously. During the L3 handover process, a sensor node neither needs a care-of address nor participates in the handover process. During the L2 handover process, a node uses the channel information to directly achieve the L2 handover without scanning all channels. Finally, this paper analyzes and evaluates the performance of this protocol, and the data results show that this protocol improves the mobility handover performance.

1. Introduction

The IPv6 over low-power wireless personal area network (6LoWPAN) is made up of low-power nodes with limited resources, and one typical example is 6LoWPAN wireless sensor network (WSN) where sensor nodes sense some physical parameters. 6LoWPAN WSN has mobility, so it can obtain more extensive application space only if it provides mobility support.

The fact that a sensor node works as both a router and a host results in differences between the IPv6 network architecture and the 6LoWPAN WSN one, so current mobility standards [1,2] cannot efficiently work in 6LoWPAN WSN. This poses considerable obstacles to the 6LoWPAN applications. At present, some mobility handover solutions for 6LoWPAN WSN [3–12] are proposed, and they improve the mobility handover performance to various extents. However, these solutions only focus on either the L2 handover or L3 handover, and they do not effectively combine these two kinds of handovers to improve the total handover performance. Moreover, in these handover solutions the L2 handover and the L3 handover are two independent processes and are performed in serial. That is, the L3 handover is started after the L2 handover is complete, so the total handover delay is the sum of the L2 handover latency and the L3 one. As a result, the handover performance is degraded to some extent.

In order to improve the handover performance, this paper proposes a cross-layer mobility support protocol for 6LoWPAN WSN. Compared with these previous works, this protocol has the following contributions:

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(1) This protocol proposes the 6LoWPAN WSN architecture. Based on this architecture, a distributed IPv6 addressing algorithm is presented. Through this algorithm, a node can acquire a unique address from its neighbor without duplicated address detection (DAD), and a routing backbone can be established. Via this routing backbone the routing can be achieved without route establishment.
(2) Based on this architecture, a cross-layer mobility handover algorithm is proposed. This algorithm combines the L3 handover with the L2 handover so that the L3 handover and the L2 one can be performed simultaneously. As a result, the handover delay and packet loss are reduced.
(3) In the L3 handover a node neither needs a care-of address (CoA) nor participates in the handover process, and in the L2 handover a node uses the channel information to directly achieve the L2 handover without scanning all channels, so the handover latency, cost and packet loss are lowered.

The following sections discuss this protocol in detail. In Section 2, the related work on the 6LoWPAN mobility support is discussed, and in Section 3 the 6LoWPAN architecture is presented. In Sections 4 and 5 the addressing algorithm and the handover algorithm are presented, respectively. In Section 6, the performance of this protocol is analyzed and evaluated, and in Section 7 the paper concludes with a summary.

2. Related work

Due to the differences between the IPv6 network architecture and the 6LoWPAN WSN one, the mobility support standards [1,2] cannot efficiently work in 6LoWPAN WSN. Therefore, the mobility support solutions for 6LoWPAN still remains an open issue and the further research is required [13].

2.1. Handover for 6LoWPAN

In [3], a mobile media access control (MAC) protocol for IP-based WSN is proposed. In order to save the energy and maximize the network lifetime, this protocol uses complex a duty cycle strategy to achieve the handover. In [4] the performance of mobile IPv6 (MIPv6) in WSNs is assessed and the data show that MIPv6 complexity leads to long handover time and high cost. The authors propose a proxy-based mobility approach in order to relieve sensor nodes from handover tasks. In [5], a mobile node depends on its location information to achieve the handover. Since the handover is achieved in the link layer, the cost is reduced. In [6], the mobility handover is achieved in the link layer, so the mobility handover delay and cost are reduced. In [7], a location-based mobility support for 6LoWPAN is proposed and it focuses on the intra-6LoWPAN mobility handover. In this scheme, an address includes the location information, so the routes are established based on this information. As a result, the handover performance is also improved. However, these protocols [3–7] do not discuss the inter-network handover.

In order to achieve the inter-network handover, some handover schemes based on proxy MIPv6 (PMIPv6) are presented. In [8], a handover scheme based on is proposed. This scheme presents the network architecture and control message formats, and also evaluates the handover cost and energy consumption. The results show that this scheme reduces the energy consumption significantly. In [9], another mobility support scheme based on PMIPv6 is proposed. This scheme also aims at improving the L3 handover performance. In [10], a mobility handover protocol for 6LoWPAN based on PMIPv6 is proposed. This protocol uses router solicitation and router advertisement messages to achieve the L3 handover. Performance results show that this scheme improves the performance of the L3 handover.

In [11], each mobile node has a partner node which maintains the information on neighbor personal area network (PAN) coordinators. Based on this information, the partner node of a mobile node performs the handover pre-configuration operation for the node in order to shorten the handover delay. If a node moves relatively fast or its mobile angle suddenly changes, then the pre-configuration process may fail. In [12], a seamless mobility handover scheme for 6LoWPAN is proposed in order to improve the L3 handover performance. This scheme presents the L3 handover algorithm and discusses the communication process during the L3 handover. Finally, the performance of this scheme is evaluated.

2.2. Our solution

From the above discussion, it can be seen that the existing handover solutions for 6LoWPAN WSN improve the mobility handover performance to various extents. However, these handover solutions only focus on either the L2 handover or L3 handover, and in these solutions the L2 handover and the L3 handover are two independent processes and are performed in serial. That is, the L3 handover is started after the L2 handover is complete. These solution do not effectively combine these two kinds of handovers to improve the total handover performance. As a result, the handover performance is degraded to some extent.

In order to improve the handover performance, this paper proposes a cross-layer mobility support protocol, and this protocol has the following novelties: