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A Cross-Layer Implementation and Efficiency Improvement Using Cross-Layer Detection and Allocation Algorithm

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Abstract- The IEEE 802.15.4 standard is designed to achieve low-power transmissions in low- rate and short distance wireless personal area networks (WPANs).In IEEE 802.15.4 CSMA/CA protocol is used. This protocol cannot avoid the hidden node collision. The hidden node collision is called as hidden device problem (HDP). Due to the hidden device problem, the inefficient data transmission and serious power consumption will occur in WPAN. In this paper, we propose a cross- layer detection and allocation (CL-DNA) scheme to solve the HDP in IEEE 802.15.4.The CL-DNA algorithm does not need extra control overhead in data transmissions. The proposed CL-DNA algorithm detects relationships of hidden devices based on the overlapped signals and then allocates the hidden devices into distinct sub periods for transmission[1]. This improves the throughput and reduces the power consumption.

Keywords : wireless sensor Network,Hidden Node Problem,Cross layer Detection

INTRODUCTION

Wireless sensor networking (WSN) is one of the most existing technology today.WSN is expected to be a low-cost and low-power solution for monitoring unsupervised devices in houses, factories and offices. IEEE 802.15.4 is originally designed for low-rate wireless personal networks (WPAN), has become one of the promising candidates for interconnections between wireless sensor devices.

In wireless networks, a device is not guaranteed to hear the signals from other devices. If signals transmitted from device A to device C cannot be sensed by device B, device B thinks that the channel is clear. As a result, device B might transmit data to device C at the same time. The overlapped signals cause the failure of device C to recognize either of the signals sent by device A and B. This is called the hidden device problem (HDP).

IEEE 802.15.4 OVERVIEW

PHYSICAL LAYER

The physical layer of the IEEE 802.15.4 standard is designed using direct sequence spread spectrum scheme. It supports three different data rates with transmission distance ranging from 10 to 100 meters. At the transmitter side, data bits are first divided into groups of four bits. Each four bit sequence is then mapped to one of the sixteen possible symbols and spread to the 32-chip sequence. The spread sequences are pseudorandom and orthogonal. The stream is offset quadrature phase shift keying (OQPSK) modulated with half-sine pulse-shaping[3].

MAC LAYER

The IEEE 802.15.4 MAC specifies two ways of medium access: the beacon –enabled mode and non- beacon-enabled modes[8]. The MAC constant a unit backoff period is (UBP) is used as a basic unit of the backoff period, which is of length 10 symbols. The devices starts sensing the channel when the backoff countdown process is complete. The contention free period composed of guaranteed time slots (GTS).

CROSS-LAYER DETECTION AND ALLOCATION ALGORITHM

The cross-layer detection and allocation algorithm (CL-DNA) algorithm is used in IEEE 802.15.4 to solve the hidden device problem[5]. CL-DNA consists of operations in both PHY and MAC layers. Based on the signal collision, device addresses are detected from the collided signals in the PHY layer to identify the hidden devices. In the MAC layer, the dubious hidden device addresses are checked twice through our HDP address verification procedure. The confirmed addresses of the hidden device address list (HDAL).A hidden device is arranged to access the channel by allocating time slots in different subperiods according to the number of hidden device pairs itt belongs to the size of HDAL, to eliminate its chance of causing the HDP[7].

HDP AND ADDRESS DETECTION IN THE PHYSICAL LAYER

The important feature of physical layer in IEEE802.15.4 is energy detection. The energy detection is used to monitor the received signal strength at the coordinator. The hidden device problem (HDP) is detected in physical layer by comparing the signal strength at the coordinator and the receiver[6]. When HDP is detected, the coordinator sends the NACK frame to the transmitting devices. The devices causes the HDP are detected by the coordinator by comparing the source address of the overlapped data at the coordinator and the source address of the receiver. The devices which cause the HDP are detected by the coordinator by comparing

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the source address of the overlapped data at the coordinator and the source address of the receiver.

TIME ALLOCATION ALGORITHM IN THE MAC LAYER

In MAC layer, the detected hidden device problem address is verified[4]. The hidden devices which receives NACK frame alone are allowed to transmit through guaranteed time slots(GTS).When the coordinator receives the frame in GTS the detected address is correct. The correct hidden device address are then added to hidden device address list (HDAL).The coordinator allocates the hidden devices in the HDAL to different sub periods for transmission to prevent the hidden device problem[9].

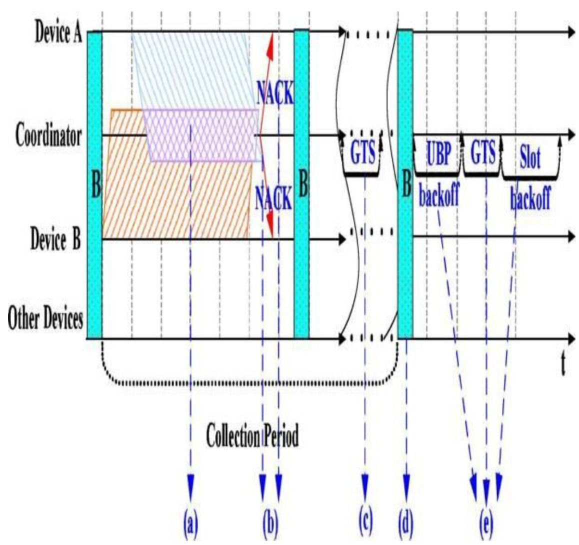

Fig 1. A cross-layer detection and allocation

PERFORMANCE OF CL-DNA

The time allocation algorithm of CL-DNA is performed by comparing HDALsize and HDALsevereness. HDALsize denotes the number of devices listed in the HDAL, whereas HDsevereness is the number of devices that device can cause the HDP. Both can be extracted from the HDAL. In addition, two threshold values, Sizethreshold and Severenessthreshold are taken for comparison. By comparing HDALsize to Sizethreshold and HDsevereness to Severenessthreshold, thee are four possible cases.

1. If HDALsize < Sizethreshold and Max{HDsevereness < Severenessthreshold, the coordinator concludes that the HDP is not severe. The coordinator allocates the hidden devices to transmit in the inactive period. No need to use GTS in this case.

2. If HDALsize < Sizethreshold and HDsevereness ≥ Severenessthreshold for some devices, the coordinator concludes that these hidden devices cause more serious HDP. Such devices are allocated to transmit using GTS while the rest of the hidden devices in the HDAL are allocated to the inactive period for transmissions.

3. If HDALsize ≥ Sizethreshold and MAX{HDsevereness} < Severenessthreshold, it indicates that the most of the hidden devices are only causing the HDP to a few devices. The coordinator chooses the device with the largest HDsevereness value and allocate it to transmit using GTS. All of the hidden devices in the HDAL with the HDP relation are allocated to the inactive period.

4. If HDALsize ≥ Sizethreshold and HDsevereness ≥ Severenesstheshold for some devices, this indicates that the HDP problem is severe and device is causing the HDP to many devices. We should allocate at most seven of such devices with largest HDsevereness values to transmit using GTS, while the remaining hidden devices are allocate to transmit in the inactive period.

Hence, the CL-DNA solves the HDP without disturbing the transmission of non-hidden devices.

PORT ADDRESS TANSLATION ALGORITHM

In our proposed system to solve the hidden device problem in personal area network without changing the infrastructure we use PAT (PORT ADDRESS TRANSLATION).It serves best communication in personal area network and reduces the IP usage in all users. It uses the port address for the PAN connection. It can be easily find the hidden devices and allow the device properly using port address. For high level priority Port address translation verify the hidden devices and allow the hidden devices with proper allocation of the system without congestion and collision. It can improve the reliable communication and reduces the routing overhead and router drops. It has two level of the system, Outlet communication and Inlet communication, during the inlet communication all connection address changed into port address and to translate to the all communication member nodes.

FLOW CHART

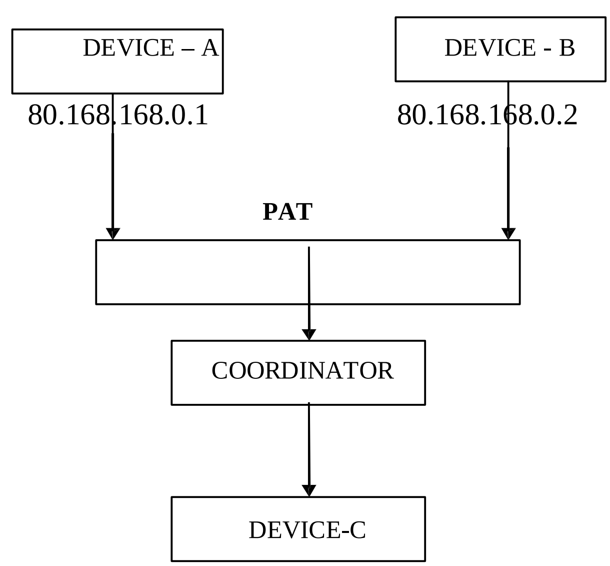

Fig 2. Flowchart of Port address translation algorithm

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SIMULATION RESULTS

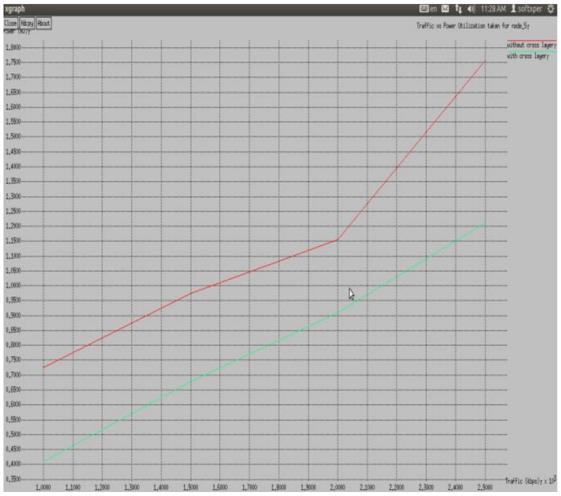

Fig 3. Traffic vs Power utilization

From the above graph, the power utilization is very low in cross-layer when compared to the general layer. In cross-layer, by using low power it will transmit large amount of data. Thus the efficiency can be improved.

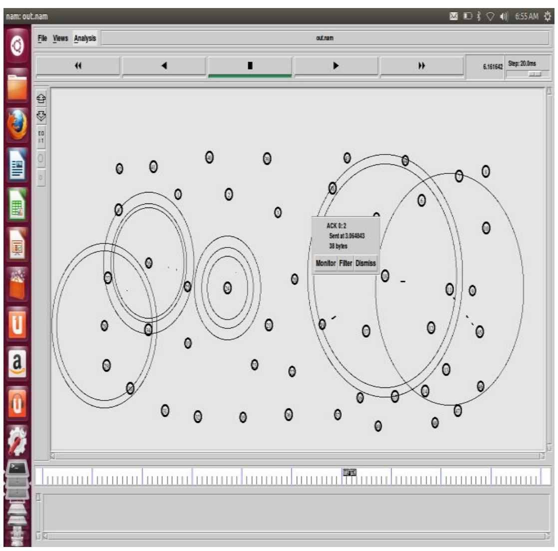

Fig 4. Simulation result of cross-layer

The cross-layer algorithm reduces the packet losses while transmitting the data. This will reduce the power consumption and increases the throughput when compared to the general layer. The time consuming is also very less and it does not need any extra control overhead.

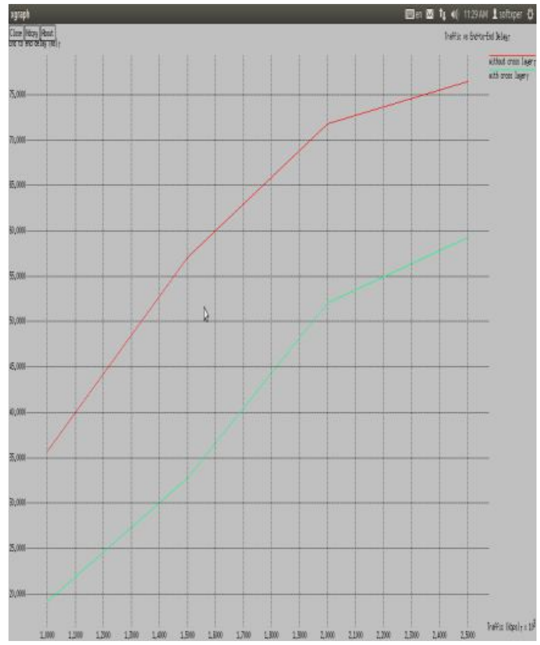

Fig 5. Traffic vs End-to-End delay

From the above graph, end-to-end delay is very low in cross-layer when compared to the end-to-end delay in general layer. The efficiency can be improved.

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