An Overhearing Video Transmission for Wireless Sensor Networks

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Abstract - To transmit multimedia data on WMSNs (Wireless Multimedia Sensor Networks), it is required to use efficient protocols to reduce power consumption. This paper presents an efficient protocol to transfer multimedia data by overhearing messages of nodes and by transmitting next packets during the unused time interval. The proposed method is verified its performance by simulations and experiments. The results shows that the transmission rate of the proposed method 50% higher than that of End-to-end protocol. Also the transmission time is reduced up to 50%. The results of real measurement are very close to those of simulations. The proposed algorithm shows very good performance compared with the End-to-End transmission method. The transmission performance of the proposed method is double that of the End-to-End transmission. The experiment results show that average of the success rate is 93.78 %.

Keywords: WMSN, End-to-end, Hop-by-hop, Overhearing

1 Introduction

WSNs (Wireless Sensor Networks) are networks consisted of hundreds to thousands sensor nodes. Each node has a microprocessor with small memory, a communication device and sensors with an energy efficient power source. The power source may be batteries or solar cells to run a life time of several months to several years. Typically sensor networks are used to monitor environment events such as temperature, humidity, pollution level and so on. The rapid development of sensors and inexpensive CMOS cameras are allowed for the emergence of so called wireless multimedia sensor networks. WMSN (Wireless Multimedia Sensor Network) is a network of wirelessly interconnected sensor nodes equipped with multimedia devices, such as cameras and microphones, and capable to retrieve video, audio, images, as well as sensor data[1, 2].

2 Related Work

Many researches of WSNs are concentrated on MAC protocols to optimize operations of WSNs. Le, Guyennet and Felea have proposed an overhearing based MAC protocol for WSNs. By using overhearing, the MAC protocol reduces redundant transmissions and energy consumption[7]. This paper is not applied to multimedia transmission. Kanzaki and et al. have proposed an overhearing-based transmission to reduce traffics of WSNs. By using overhearing, each node autonomously determines the temporal redundancy of its reading by applying a lightweight interpolation based on the readings acquired by itself before determining the spatial redundancy [8]. This paper does not describe application area. Data of WSNs are transmitted form a source node to a destination node, which is called End-to-End transmission. When the destination node receives a packet, it replies back ACK control signals to the source node[9].

3 Proposed Algorithm

A new algorithm using packet overhearing is proposed. First of all, packet overhearing and its problem are discussed and a reliable transmission method is developed by removing transmission errors. This reliable transmission method is to transmit packets without using control messages signals at the MAC layer to transmit multimedia data for a short transmission time.

3.1 Overhearing collisions

In wireless sensor networks, the wireless signals of a transmitting node propagate all neighbors of the sender. Sometimes it may work as interference signals or make collisions. If the interval of the transmission is adjust, wireless signals work as overhear packets, which make unnecessary consumption of node energy. Packet overhearing is used in synchronous CSMA protocols such as SMAC and TMAC, in which all nodes in a neighborhood wake-up simultaneously to listen to in coming packets. As shown in Figure 1, Node S overhears packets of Node R1, when Node R1 transmits packets to Node R2. If Node R1 relays packets of Node S to Node R2, Node S uses packet overhearing as a reliable transmission signal instead using ACK signals. Unnecessary signals do not be used for reliable signal.

In order to implement the overhearing packets, all sensor nodes must process them as control signals to relay packets to a destination. It is required to change the packet handling algorithm of the MAC layer. When a node receives overhearing packets, the node must handle packets although they are not transmitted to the node.
After a packet is transmitted, the next packet is retransmitted sometime later. The time interval of packet transmission is important to prevent packet collision. Figure 2 and Figure 3 show examples of packet collision. Figure 2 shows that collision occurs in the middle of two nodes and Figure 3 shows that ambiguous collision occurs on Node R1 since Node R1 receives a new packet from the node S and receives overhearing packet from Node R2 at the same time. Therefore, appropriate time interval to transmit packets must be decided to avoid collision[9,10].

3.2 Time interval modeling

To avoid collision and to make efficient and reliable transmission, it is required to decide transmission time interval. At Figure 4, Node S transmits a packet to Node R1 during time $t_1$. When Node R1 receives the packet, it processes for time $\alpha$ and retransmit the received packet to its next node R2 for time $t_2$. And Node R2 transmits the packet to Node R3. To avoid collisions the total time interval is calculated as Equation (1). The transmission time is represented as $t_1 = t_2 = t_3 = t$ since all packets are the same size.

$$T_3 = t_1 + \alpha + t_2 + \alpha + t_3$$
$$= t_1 + t_2 + t_3 + 2\alpha$$
$$= 3t + 2\alpha$$ (1)

To use packet overhearing, it is required to transmit next packet after $T_i$ time later. It means that there is no collision or transmission fail after $T_i$ time later.

If Equation(1) is generalized for $n$ nodes, it is represent as Equation (2).

$$T_n = nt + (n-1)\alpha$$ (2)

3.3 Proposed Algorithm

Without using control protocols, packet overhearing is used for the multimedia data transmission. By adjusting time interval of the packet transmission, the proposed algorithm is developed. The algorithm is shown in Figure 5. The algorithm is divided into two parts. One is the transmission part and the other is receiving part. In Figure 5, each node will work a source node or a destination node depending upon received packets. To avoid collisions, it is required that the timer must work accurately.
1. Transmission
   if (source node)
      if (packet = image message)
         make packets from image or video data;
      do until (packet = the end of frame)
         Start Timer;
         Transmit packets;
         Change the receiving mode;
      }
   else if (relay node)
      transmit received packets to the next node;
      change to receiving mode;
   }

2. Reception
   receive packets;
   if (not source node)
      if (packet = image message)
         find the node position if the message;
         if (not destination node)
            increment message-relay-node count;
            transmit the message to the next node;
      if (destination node)
         transmit Ack;
      else
         change transmission mode;
   }
   else if (source node)
      if (packet overhearing)
         stop timer;
         calculate interval time;
         change transmission mode;
      else
         retransmit packets;
   }

4. Simulation and Experiment
   The proposed method is simulated using NS2 and its results are compared with the End-to-End transmission method. Also the algorithm is programmed on sensor network motes and measured its performance.

4.1.1 Simulation
   To setup simulation environment, the topology is shown in Figure 6. Five nodes are placed equally and the total distance from the source node to the destination is 100m. This configuration is good to find any problems to transmit packets continuously. Also it is fair condition to compare simulation results and the real measurement results. Table 1 shows simulation parameters.

![Network topology for simulation](image)

Table 1. Simulation parameters

<table>
<thead>
<tr>
<th>Parameters</th>
<th>End-to-End Transmission</th>
<th>Proposed algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routing protocols</td>
<td>AODV</td>
<td></td>
</tr>
<tr>
<td>MAC and PHY</td>
<td>IEEE 802.15.4</td>
<td></td>
</tr>
<tr>
<td>Packet size</td>
<td>127</td>
<td></td>
</tr>
<tr>
<td>Transmission Time</td>
<td>5 sec</td>
<td></td>
</tr>
</tbody>
</table>

CBR traffic is set to each transmission method and transmission time is 5seconds. The results of simulations are shown on Table 2. Transmission delay means that the interval time to transmit the next packet after a packet is transmitted. The transmission delay time of the proposed algorithm is the half of the End-to-End transmission. The number of transmitted packet is double of the End-to-End transmission. The reason is that the control signal, which is ACK, makes slow down packet transmission.

![Network topology for simulation](image)

Table 2. Simulation results for 5seconds

<table>
<thead>
<tr>
<th>Parameters</th>
<th>End-to-End Transmission</th>
<th>Proposed Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>No of Packets transmitted</td>
<td>52</td>
<td>104</td>
</tr>
<tr>
<td>No of failed packets</td>
<td>14</td>
<td>7</td>
</tr>
<tr>
<td>Average transmission time (msec)</td>
<td>28.08</td>
<td>24.2</td>
</tr>
<tr>
<td>Transmission delay (msec)</td>
<td>96.15</td>
<td>48</td>
</tr>
</tbody>
</table>
To apply to the multimedia sensor networks, JPEG image compression data is used for simulations. Three kinds of image size, which is 2KB(128 x 96), 8KB(320 X 240) and 16KB(640 x 480), are used for simulations. The simulation results are shown in Table 3.

<table>
<thead>
<tr>
<th>Image Size</th>
<th>End-to-End Transmission</th>
<th>Proposed Algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>2KB (19)</td>
<td>1.824 sec</td>
<td>0.78 sec</td>
</tr>
<tr>
<td>8KB (75)</td>
<td>7.2 sec</td>
<td>3.1 sec</td>
</tr>
<tr>
<td>16KB (149)</td>
<td>14.304 sec</td>
<td>6.2 sec</td>
</tr>
</tbody>
</table>

The overall performance of the proposed algorithm shows double of that of End-to-End transmission. The transmission time is shown in Figure 7. By using overhearing packets and proper transmission delay time, the proposed algorithm improves transmission performance compared with the End-to-End transmission method.

4.1.2 Experiments

The proposed algorithm is programmed and implemented on a sensor node, which is USS-2400 from Huins Co. TinyOS is the operating system of the sensor node. The firmware is modified to run the proposed algorithm. The timer of the nodes is set to 1msec to measure transmission interval. Experiment topology is set to the same as Figure 6. 100 packets are used to test the algorithm.

From Equation (2), $\alpha = 3$msec and transmission delay = 10msec are set to measure the transmission performance. As shown in Figure 8, average transmission delay time is 48msec, when 100 packets are transmitted from the source node to the destination node.

Figure 9 shows the success rate of the packets. To measure the success rate, 50 rounds of the 100 packets are transmitted and measured. Average of the success rate is 93.78%.

From simulation results and real measurements, the proposed algorithm shows very good performance compared with the End-to-End transmission. The transmission performance of the proposed method is double that of the End-to-End transmission method.
5 Conclusion

To transmit multimedia data on WMSNs, it is required to use efficient protocols to reduce power consumption. This paper presents a new approach by using packet overhearing and adjusting packet transmission delay time. Simulations and real measurements are implemented to prove the performance of the proposed algorithm.

The results of real measurement are very close to those of simulations. The proposed algorithm shows very good performance compared to the End-to-End transmission. The transmission performance of the proposed method is double that of the End-to-End transmission. The experiment results show that average of the success rate is 93.78%.

Please address any questions related to this paper to Byoungchul Agn by Email (b.ahn@yu.ac.kr).

6 References