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Traffic Control Mechanism Considering Packet Priority in Wireless Multimedia Sensor Network

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Abstract

Wireless Multimedia Sensor Networks should transfer a large quantity of multimedia data in a timely manner within a limited time; thus, it is very important to provide a low degree of delay and the maximum throughput. This paper proposes an efficient traffic control mechanism of multimedia data requiring real-time transmission in wireless multimedia sensor network with the path determination based on path cost. The proposed mechanism conducts routing by calculating path cost in accordance with the priority of packet by using the hop

count up to the sink, the information on residual energy quantity of neighbor nodes and the quality of wireless communication link.
The proposed traffic control mechanism can guarantee real-time of multimedia data and the quality of service required by users through performance analysis. Also, it enhances the network reliability and energy efficiency by minimizing the energy consumption.

Keywords: Traffic Control, Wireless Multimedia Sensor Network, QoS

1 Introduction

The miniature CMOS image sensor module has been recently developed. As a result, there are many studies currently in progress in relation to wireless multimedia sensor networks (WMSNs) that process not only numerical data such as temperature, humidity, etc. but also multimedia data such as voice or video [1] [2]. The previous studies on wireless multimedia sensor network have focused on energy retention in order to prolong the network lifetime. However, it is imperative to support for the quality of service (QoS) to transmit multimedia data promptly and reliably in wireless multimedia sensor networks [3] [4].
Multimedia data is uniquely sensitive to delay; the existing wireless sensor network will not be able to guarantee the requirement on QoS that is necessary for real-time transmission service and multimedia applications. On that account, it is required to have a traffic control mechanism to support for a high level of throughput and the minimum delay in order to minimize transmission delay and satisfy the stringent QoS requirement for serving streaming-type multimedia data in the existing wireless sensor network.
This paper proposes a traffic control mechanism to efficiently process the multimedia data requiring real-time transmission in wireless multimedia sensor networks. The proposed mechanism conducts routing by calculating path cost in accordance with the priority of packet by using the hop count up to the sink, the information on residual energy quantity of neighbor nodes and the quality of wireless communication link. Thus, it reduces end-to-end delay and possesses long network lifetime even while supporting for QoS in accordance with the priority of packet. Through performance evaluation, the proposed traffic control mechanism is able to guarantee the quality of service for real-time of multimedia data and user requirement. Also, it enhances the network reliability and energy efficiency as compared with the conventional methods by minimizing the energy consumption.

2 Related Works

Traffic control mechanism in wireless sensor networks is a technique to efficiently transmit the information of sensor nodes in wireless sensor networks to the destination. Those traffic control mechanisms of the early phase when the studies on wireless sensor network began heavily relied on the techniques to suppress the overflow of packets due to broadcasting, in other words, the number of messages. On the other hand, the recent traffic control mechanisms in wireless sensor network prevent the phenomenon that the available energy of nodes distributed in networks would be distributed unevenly through introducing an energy recognition technique to the conventional ways. The recent studies on traffic control mechanism have mainly focused on low power technologies to prolong the sensor network survival time by balancing the entire use of sensor node energy in wireless sensor networks [5] [6]. In this regard, there are many researches currently in progress as to the traffic control mechanism to allow users to select an uncongested path with a small hop count and low power consuming path. In addition, there are the other studies currently in progress in relation to the IP routing techniques, scalability, cross-layering routing, dynamic address assignment, network topology control, mobility support technology, etc. for connecting to IP network in sensor networks.

3 Proposed Technique

The proposed traffic control mechanism in this paper shall take into consideration the characteristics in accordance with the traffic pattern to which the packets to be transmitted belong. The reason why the packet traffic pattern should be considered is that transmitting promptly high priority data such as real-time multimedia traffic and pre-determined field monitoring allows for the support of service differentiation to guarantee QoS.

Packet priority transmits the level for quality of service by three steps of green, yellow and red in accordance with the data information to be transmitted by corresponding packets at a source node by using packet marking algorithm[7]. The level for quality of service is transmitted to a sink node after being saved in the priority field within packet. Wherein, green means the packet with the highest importance, whereas red means the packet with the lowest importance. Yellow packet possesses an intermediate level of importance between green and red.

The routing table managed at a sensor node can be operated simply by including the path moving toward a sink node rather than the information on entire node. Moreover, it can be utilized usefully for conducting a variety of functions when including the information on adjacent neighboring sensor nodes additionally. The proposed traffic control mechanism utilizes the energy-efficient routing table building technique [7] that builds a routing table using broadcasting message to be periodically transmitted from a sink node. Table 1 shows the detailed fields of broadcasting message and table 2 shows the detailed fields of routing table.

Table 1. Detailed fields of broadcasting message

Field	Meaning
ID	Broadcast message identifier
Flag	Representing initial routing establishment message, requirement message for routing table modification or general broadcasting message
Node ID	Transmission node identifier
Location Information	Transmission node location information
Hops to Sink	Hop count up to sink node
Energy level	Residual energy quantity of transmission node
Path Costs	Path costs up to sink node for each packet priority

Table 2. Routing table

Field	Description
Node Position	Node number
Neighbor Nodes	List of neighboring nodes
Hops	Hop count of neighboring nodes up to sink node
Energy Level	Residual energy quantity level of neighboring nodes
LQIs	LQI values of neighboring nodes
Path Costs	Path cost up to sink node for each packet priority (green, yellow and red) of neighboring nodes
Next Node	Next node for each packet priority
Alternate Next Node	Next node for each alternate packet priority

The path cost in which Node *a* chooses Next Node *b* in order to transmit the packet whose priority is *pri* to a sink node is as shown in Formula 1 below.

$$C_a^{pri} = \min_{b \in N_a} \left\{ \alpha_{pri} \left(\frac{d_{by} + 1}{d_{ay} + 1} - 0.5 \right) \times \beta_{pri} \left(1 - \frac{LQI_b}{256} \right) \times \gamma_{pri} \left(1 - \frac{e_b^{res}}{e_b^{init}} \right) + C_b^{pri} \right\} \quad (1)$$

In represents the priority mark of packets to be transmitted to $pri \in$ {Green, Yellow, Red}, whereas N_a is the set of neighboring nodes of node *a*, d_{ay} is the distance of hop between node *a* and sink *y*. d_{by} is the distance of hop between node *b* and sink *y*. e_b^{init} is the initial energy level of node *b* and e_b^{res} is the residual energy quantity of node *b*. LQI_b is the value of link quality of node *b*; thereby, having a value between 0 and 255.
$\left(\frac{d_{by}+1}{d_{ay}+1} - 0.5\right)$, $\left(1 - \frac{LQI_b}{256}\right)$ and $\left(1 - \frac{e_b^{res}}{e_b^{init}}\right)$ have a value between 0 and 1. It means the cost in accordance with each distance of hop, link quality and residual energy quantity. α_{pri}, β_{pri} and γ_{pri} are the weighted values; thus, they should be assigned

a different value in accordance with the packet priority. Green packet has the highest priority; thus, hop count and link quality should be given a higher priority than residual energy quantity. When hop count is equivalent, a node with better link quality should be chosen. As a result, α_{Green} and β_{Green} hould be assigned a small value and set as a larger value than γ_{Green}.

Yellow packet has an intermediate level of priority and its value should be set at a level in which hop count, link quality and residual energy quantity are similar. Lastly, red packet has the lowest priority; thus, γ_{Red} should be assigned a small value and α_{Red} and β_{Red} are set as a large value in order to minimize the energy consumption in consideration of residual energy quantity rather than hop count and link quality.

Green packet conducts reliable transmission by a high quality link of the shortest distance since the packet loss rate and delay are reduced. Red packet does not consider a high quality link of the shortest distance; thus, it has a high degree of packet loss and delay. However, the quantity of packets to be lost on the way is small as the residual energy quantity is given a priority; thus, it is effective in terms of reliability. Yellow packet to use the intermediate path of green and red packets will have more capacity in terms of resource utilization; thus, the overall transmission rate will be enhanced. Figure 1 shows the routing algorithm of proposed traffic control mechanism.

Algorithm 1. Routing algorithm

Input: Packet
Output: NextNode
Procedure Routing(Packet *p*)
    pri = traffice of *p*
    if *pri* = "Green" **then**
        Set $\alpha_{pri} = \beta_{pri} < \gamma_{pri}$
    else if *pri* = "Red" **then**
        Set $\alpha_{pri} = \beta_{pri} > \gamma_{pri}$
    else
        Set $\alpha_{pri} = \beta_{pri} = \gamma_{pri}$
    end if
    Calculate C_a^{pri} by equation(1).
    Select node *b* which has minimum path cost C_b^{pri}in neighbor nodes
    NextNode = *b*
return *NextNode*

Figure 1. Routing algorithm of proposed traffic control mechanism

4 Performance Evaluation

For performance evaluation, the simulation was conducted on the min hop routing technique, CR-WMSN QoS routing protocol [4], the mean throughput of proposed traffic control mechanism, delay between terminations and network lifetime. The network environment used in the simulation is as shown in Table 3 below.

Table 3. Variables and set values used in the simulation

Parameter	Set value
Network size	(0m, 0m) ~ (200m, 200m)
Sink	(0m, 0m)
Number of nodes	100
Transmission scope	30m
Packet size	125bytes
Initial node energy	1J
Transmission energy consumption	0.021mJ/bit
Reception energy consumption	0.014mJ/bit
Atmosphere energy consumption	64μJ
Wireless bandwidth	250kbps
Data transmission cycle	0.3s
Simulation time	300s
MAC protocol	IEEE 802.15.4

A source node and intermediate node were selected randomly with the exception of sink in the simulation and the generation for each packet priority was incurred randomly. LQI value was set as a value between 60 and 110 randomly at a sensor node.

The throughput was defined as the number of bits per second of received data from the destination (sink). Figure 2 is the simulation result as to the mean throughput of min hop, CR-WMSN and proposed technique. When the number of source nodes is small, the throughput of min hop and CR-WMSN is similar to the one of proposed technique. However, the larger the number of source nodes is, the higher the throughput of proposed technique is. As a result of the experiment, the proposed mechanism was found to have an improved performance by 27 percent as compared with the min hop and 14 percent as compared with CR-WMSN.

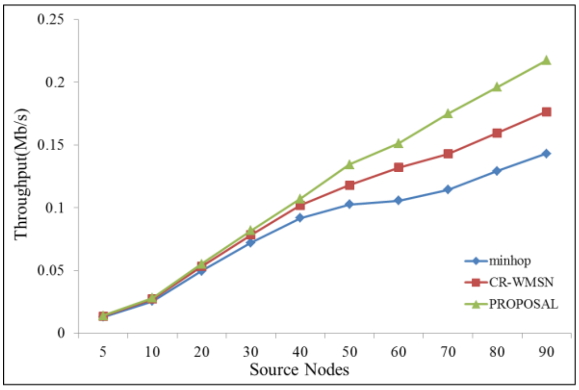

Figure 2. Average throughput in accordance with an increase in traffic load

Network lifetime means the time until the first appearing time of energy-depleted nodes. Figure 3 shows the results of comparison on network lifetime between the min hop, CR-WMSN and the proposed technique. The proposed mechanism is able to reduce energy consumption by setting the packet transmission path as the minimum path cost using traffic priority, link quality, residual energy quantity of neighboring nodes and distance between nodes.
As a result of the simulation, the network lifetime of CR-WMSN is long when the number of source nodes is small. However, it is possible to know that the network lifetime of proposed technique become much longer with an increasing number of source nodes. The network lifetime of proposed technique was found to be enhanced by 66 percent and 45 percent as compared with the min hop and CR-WMSN, respectively. It was not affected significantly by the network size and number of source nodes. Instead, it showed a stable performance.

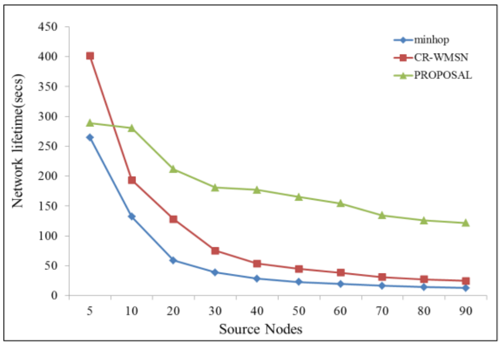

Figure 3. Network lifetime

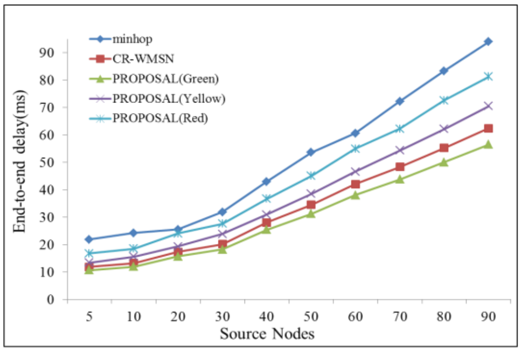

Figure 4. Average end-to-end delay

Figure 4 shows the results of simulation as to the mean end-to-end delay time of packet. As a result of the experiment, the mean end-to-end delay for the min hop routing protocol has increased rapidly with an increase in the number of sources.

On the other hand, the mean delay time will gradually increase with an increase in the number of source nodes in the case of CR-WMSN routing technique. The proposed mechanism showed the result that the mean end-to-end delay time was more different for each packet priority than CR-WMSN routing technique. In the case of yellow and red packets, the mean end-to-end delay is less serious than the min hop routing technique. However, the delay has increased by more than CR-WMSN routing protocol. Green packet has the highest priority and its packet loss rate and delay were reduced by transmitting with a high quality link of the shortest distance rather than the residual energy quantity. As a result, it showed the low mean end-to-end delay time, which was improved by 11 percent as compared with CR-WMSN routing technique. It is imperative to support for a high degree of throughput and the minimum delay in order to minimize transmission delay and satisfy stringent QoS requirements when servicing multimedia data in wireless multimedia sensor networks. As a result of the experiment, red packet had an improved performance by 16 percent as compared with min hop, whereas green packet had an improved performance by 11 percent as compared with CR-WMSN in the proposed mechanism.

5. Conclusion

This paper proposed a traffic control mechanism to efficiently process multimedia data requiring real-time transmission in wireless multimedia sensor networks. The proposed traffic control mechanism reduced the end-to-end delay and improved the network lifetime while supporting for QoS in accordance with the packet priority by setting the path in consideration of LQI value that could identify the hop count up to a sink, information on residual energy quantity of neighboring nodes and link quality depending on the packet priority.

Through the simulation, the proposed traffic control mechanism was found to guarantee the quality of service for real-time of multimedia data and user requirements. Also, it improved the network reliability and energy efficiency as compared with the conventional methods by minimizing the energy consumption.

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References

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, Wireless sensor networks: a survey, *Computer networks*, **38.4** (2002), 393-422.

[2] I.F. Akyildiz, T. Melodia and K.R. Chowdhury, A survey on wireless multimedia sensor networks, *Computer networks*, **51.4** (2007), 921-960.

[3] G.A. Shah, W. Liang and O.B. Akan, Cross-Layer Framework for QoS Support in Wireless Multimedia Sensor Netwoks, *Multimedia*, *IEEE Transactions on*, **14.5** (2012), 1442-1455.

[4] Z. Hamid, F. Bashir and J.Y. Pyun, Cross-Layer QoS Routing Protocol for Multimedia Communications in Sensor Networks, *Ubiquitous and future networks(ICUFN), 2012 fourth international conference on*, IEEE (2012), 498-502.

[5] H.S. Aghdasi, M. Abbaspour, M.E. Moghadam and Y. Samei, An energy-Efficient and high-quality video transmission architecture in wireless video-based sensor networks, *Sensors*, **8** (2008), 4529-4559.

[6] R.C. Shah and J.M. Rabaey, Energy aware routing for low energy ad hoc sensor networks, *Wireless Communications and Networking Conference(WCNC2002)*, IEEE (2002), 350-355.

[7] Y.J. Jang, S.Y. Bae and S.K. Lee, An Energy-Efficient Routing Algorithm in Wireless Sensor Networks, *Future Generation Information Technology*, *Lecture Notes in Computer Science*, **7105** (2011), 183-189.

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