Mobility Aware Path Discovery for Efficient Routing in Wireless Multimedia Sensor Network

Rachana Borawake-Satao and Rajesh Prasad

Abstract This paper proposes effective solution for routing information in wireless multimedia sensor network using multipath and multi-objective routing scheme. The ubiquitous nature of the future Internet demands multi-objective routing for serving the dynamic applications and new technologies. Multimedia data and scalar data should be treated differently while routing through WMSN. This separation of data requires multiple paths for multiple objectives. Objectives can be the speed of communication, the energy efficiency of the network, the lifetime of the network, reliability of communication, or load balancing in the network. This paper discusses the advantages of multipath routing and proposed an effective solution for finding multiple paths depending upon the demand of quality of service from the network. The path discovery methodology is evaluated using a mathematical model and the results are compared for the mobility of the network which is a demand of ubiquitous future Internet.

Keywords WSN: Wireless Sensor Network · WMSN: Wireless Multimedia Sensor Network · Ubiquitous future Internet

1 Introduction

Dynamic applications of future Internet are promoting use of wireless multimedia sensor network due to availability of high-quality multimedia services. Since low-cost multimedia devices are easily available the use of these devices is in

Rachana Borawake-Satao (✉)
Smt Kashibai Navale COE, (Savitribai Phule Pune University), Vadgaon Bk, Pune 411041, Maharashtra, India
e-mail: rachana.borawake1@gmail.com

Rajesh Prasad
NBN Sinhgad School of Engineering, (Savitribai Phule Pune University), Ambegaon Bk, Pune, Maharashtra, India
e-mail: rajesh.prasad@sinhgad.edu

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demand. Application-specific QoS requirement, high bandwidth demand, multimedia source coding technique, power consumption, and multimedia in network processing are the factors which influence the design of routing algorithm [1]. Various algorithms are proposed and implemented for multipath routing in multimedia sensor network [2].

Wireless multimedia sensor network enhancing the capability of the wireless sensor network for modern applications such as smart home, smart city, advanced healthcare systems, and multimedia surveillance sensor networks [1].

1.1 Multipath Routing

Multipath routing provides better solution in terms of reliability, load balancing, high aggregate bandwidth, end-to-end delay, minimum energy consumption, and high throughput [2]. Performance evaluation of the various routing algorithms can be analyzed using parameters like routing load, average end-to-end delay, jitter, energy balancing, and average energy consumption. In [3] author compared multipath routing techniques based on energy efficiency, delay, fault tolerance, and data accuracy.

In [4] author proposes context aware routing which combines cluster formation algorithm with routing. During cluster formation algorithm the information required for routing is also preserved and later used for routing purpose. This definitely improves the lifetime of the network as remaining energy is considered for routing. This also resolves the energy hole problem in the network.

MEVI [5] is a multi-hop hierarchical routing protocol for efficient video communication (MEVI). This algorithm proposes cross-layer solution for the selection of the routes. Algorithm implemented two modes for video retrieval and transmission where it is event-based video transmission. The main addition of the paper is the cluster formation by sending a single beacon message, multi-hop communication between CHs and base station, and cross-layer scheme to acquire the network conditions for selecting the routes.

Multipath routing reduces delay in the network by processing delay estimation and finding alternate path if some paths or nodes are exhausted in the network. In wireless sensor network effective performance improvement is achieved through multipath routing [6, 7]. Similar approach can be applied in WMSN for dynamic protocols. Multimedia traffic can be classified into set of classes, and priorities can be assigned to each one for packet classification. Non-preemptive packet scheduling scheme gives improved results for routing multimedia data [8]. The DCM (Dynamic capacity multipath routing) algorithm uses anchor nodes for deciding duty cycle scheduling of the node in vicinity of the target and improves lifetime of the network [9].

Quality of service (QoS) is a key issue in WMSN, if packet classification will be based on QoS issues like delay, residual energy, and loss rate, targeting a particular application which will be effective. Cluster-based architecture is more suitable for

QoS-based routing [10]. Interference awareness, bandwidth awareness, congestion control schemes, and priority scheduling are some of the key aspects for design of routing protocols for application in future Internet [11–15].

The major communication challenges for QoS aware routing are energy consumption, application-specific requirements, resource constrains, variable link capacity and packet errors, dynamic network connectivity, and topologies [16]. Future Internet demands smart services in ubiquitous computing environment which introduces mobility awareness in basic architecture of wireless multimedia sensor network. In [17] author proposes mobile multimedia geographic routing (MGR) for QoS provisioning in MMSNs (Mobile multimedia sensor network). Mobility of nodes in the network and mobility of sink node in various applications are the challenges for researchers in MMSN.

2 Path Discovery Methodology

The important issue in communication is effective data dissemination and gathering. Various protocols are available for WSN and WMSN for routing the data efficiently. If we compare WSN with WMSN the multimedia data is a critical issue to address. The audio and video data transmissions require high data transmission rate and good quality of service. Hence, it is required that the design of routing protocol in WMSN must have effective methodology to handle multimedia data.

The path discovery process is achieved through multipath routing. There are many goals of multipath routing protocols to achieve such as reliability, load balancing, high aggregate bandwidth, minimum end-to-end delay, minimum energy consumption, and high throughput.

The proposed system uses multiple paths for routing. The captured data is divided into parts and forward through multiple paths. This will increase speed of data transmission as well as priorities can be assigned to the respective paths depending upon the parameter.

Following parameters are used for path discovery process:

(a) Link quality index (LQI)
(b) Remaining energy (Er)
(c) Hop count (HC)
(d) Speed of mobility (Mf)
(e) Location of node
(f) Movement direction of node

As shown in Fig. 1 the path discovery process starts after deployment of sensor network. After deployment the initiation process takes place which includes location awareness about the neighboring node, sink node, and the node itself. Once all locations are known the next hop is checked for whether it is a sink node or not. If next node is a sink node, the algorithm stops; otherwise path discovery takes place.

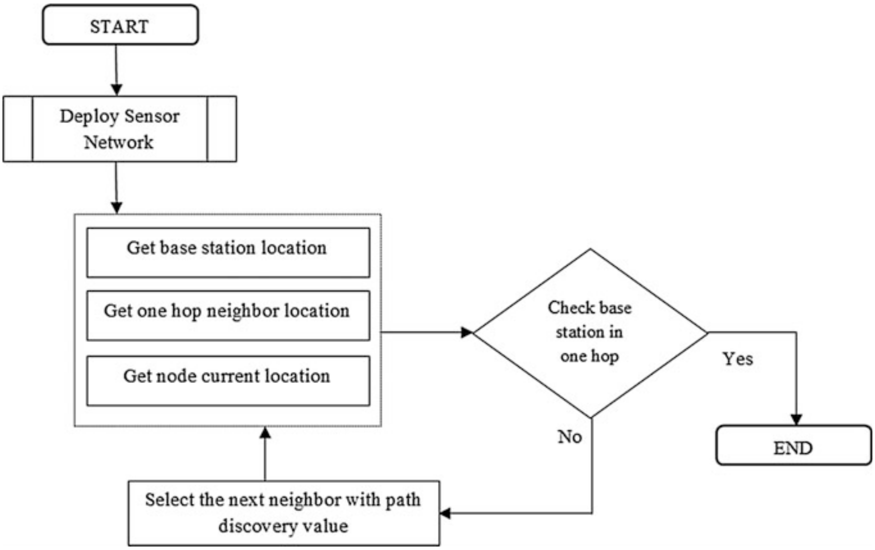

Fig. 1 Path discovery methodology

The path discovery process includes analysis of different parameters like remaining energy, hop count, LQI, and mobility value of neighboring node. Depending on these values the weight for multiple paths is calculated. One of the best solutions is used or multiple solutions are used for efficient routing.

The path discovery process makes use of formulae (I) in Sect. 3 for calculation of the $Node_{val}$. Various methods can be adapted to calculate the $Node_{val}$, but for this paper we are considering mobility as important factor as it is useful for ubiquitous computing in future network.

3 Mathematical Model for Performance Evaluation

As given in Eq. (1) the $Node_{val}$ is calculated using three terms: remaining energy (*Er*), current link quality (*LQ*), and current hop count (*HC*). The $Node_{val}$ ranges between 0 and 1. The multiplication factors α, β, and γ are used to assign priorities to the parameters respectively.

The equation *Er*/*Ei* gives value of remaining energy between 0 and 1 [5]. If application gives priority to energy saving, the value of the α will be more than β and γ. Possible values for α, β, and γ are {0.2, 0.3, 0.5}.

Similarly, the equation *curLQ/maxLQ* gives values for link quality ranges between 0 and 1 and equation *(totHC-curHC)/totHC* gives value for remaining traveling distance. As per the requirement of the application, three different paths

Table 1 Parameter description

Ei	Initial energy of node
Er	Residual energy of node
curLQ	Current link quality of node
maxLQ	Maximum link quality of node
totHC	Total hope count
curHC	Current hope count of node
M_f	Mobility factor
PT_r	Remaining pause time duration in milliseconds
totPT	Total pause time duration in milliseconds
Node_{val}	Node value for data transmission
PD_{val}	Path discovery value with mobility added to Node_{val}
Node with highest PD_{val} has better conditions to transmit packet	

are estimated and packet allocation is done according to the priorities assigned by the variables α, β, and γ:

$$\text{Node}_{\text{val}} = [(\alpha * Er/Ei) + (\beta * curLQ/maxLQ) + (\gamma * (totHC - curHC)/totHC))] \quad (1)$$

where α + β + γ = 1.

As mentioned in Sect. 1 the mobility is a critical issue in design of routing path in case majority nodes in the network are mobile node. Here we introduce mobility factor (M_f) as ratio of remaining pause time (*PTr*) and total pause time of the node (*totPT*). This ratio gives prediction regarding mobility of the node. If the node is having possibility of changing its position from the current place within very short time, then possibility of the selection of that node is reduced using mobility factor (M_f) (Table 1).

$$\text{Mobility factor}\,(M_f) = (PTr/totPT) \quad (2)$$

$$\text{Path Discovery value}\,(PD_{val}) = \text{Node}_{\text{val}} * M_f \quad (3)$$

3.1 Experimental Setup

Multiply mobility factor (M_f) with Node_{val} to get an exact value of every node with respect to the mobility prediction of the current node.

Figure 2 shows the experimental setup with total four nodes where node 1 is willing to transmit data, and various values related to all nodes in the scenario are describe in Table 2. Table 2 also describes the scenario if priority is assigned to a certain parameter which node is selected for transmission.

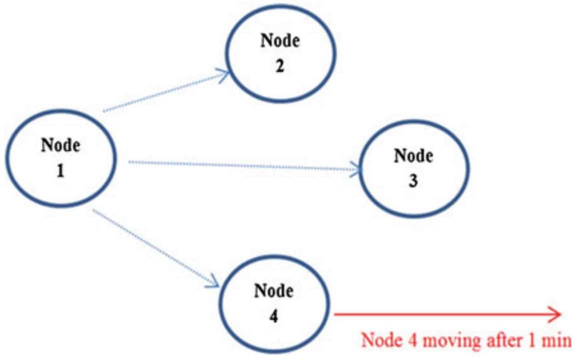

Fig. 2 Experimental setup for node mobility

3.1.1 Case 1: No Mobility Considered

As shown in Fig. 2 consider case 1 where the node 1 trying to select one node for transmission of data (either node 2 or node 3 or node 4). The decision depends on the values of remaining energy (*Er*), link quality (*LQ*), and hope count (*HC*) as shown in Table 2.

If energy saving is a priority, then value for α in Eq. 1 is selected as highest value and the node 4 is selected for transmission. Naturally, the node with highest remaining energy is selected which in this case is node 4.

If priority is high data accuracy (less packet loss) then Link Quality is important then value for β in Eq. 1 is selected as highest value and the result will be selection of node 3 for next data forward.

Similarly, if minimum delay is the requirement then value for γ in Eq. 1 is selected as highest value and result will be the selection of node 2 for next data forward.

Table 2 Values for no mobility in the network

Node Id	Remaining energy (*Er/Ei*)	Link quality (*LQ/maxLQ*)	(*maxHC* – *HC*)/*totHC* (distance to travel)
2	0.5	0.59	0.9
3	0.75	0.63	0.7
4	0.9	0.55	0.6
After applying Eq. 1			
If α is greater (priority = energy)		Node 4 is selected	
If β is greater (priority = LQI)		Node 3 is selected	
If γ is greater (priority = HC)		Node 2 is selected	

Table 3 Values for mobility in the network

Node Id	Remaining energy (Er/Ei)	Link quality (LQ/Mac LQ)	(Max_HC – HC)/tot_HC (distance to travel)	Mobility factor (PTr/tot_PT)
2	0.5	0.59	0.9	0.50 (moving after 5 min)
3	0.75	0.63	0.7	0.50 (moving after 5 min)
4	0.85	0.55	0.6	0.10 (moving after 1 min)
After applying Eq. 3				
If α is greater (priority = energy)			Node 3 is selected	
If β is greater (priority = LQI)			Node 3 is selected	
If γ is greater (priority = HC)			Node 2 is selected	

3.1.2 Case 2: Mobility Considered

As shown in Fig. 2, consider case 2 where the node 1 trying to select one node for transmission of data (either node 2 or node 3 or node 4). The decision depends on the values of remaining energy (*Er*), link quality (*LQ*), hope count (*HC*), and mobility factor (M_f) as shown in Table 3.

If energy saving is a priority then value for α in Eq. 1 is selected as highest value and the node 4 is selected for transmission. But if we are using Eq. 3 then as per the mobility factor of node 4, it will not be selected; instead node 3 will be selected as node 4 is moving early as compared to node 4. Hence, connection loss and data reliability will be increased.

Similarly, while giving priority to link quality (LQ) and hop count (HC) the mobility factor is considered and accordingly decision takes place and increases reliability of data transmission.

4 Conclusion

This paper has addressed issue of multipath and multi-objective routing in wireless multimedia sensor network (WMSN). In Sect. 1 we discussed various multipath routing schemes. Section 2 describes our proposal for path discovery mechanism which not only takes care of multiple objectives like remaining energy, link quality, and hop count for routing but also considers mobility factor of the node. Path discovery value makes this algorithm compatible for future Internet applications. Section 3 supports the algorithm by implementation of mathematical model. This section also describes in detail about the functionality of model in two different cases. We proposed effective mechanism for routing using path discovery algorithm.

Future studies in this research can be enhancement of the path discovery algorithm using packet classification and dynamic hole healing mechanism for expanding the application areas for the algorithm. Various duties scheduling mechanism can be applied to path discovery to improve the lifetime of the network.

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