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A Survey on various Multipath Routing protocols in Wireless Sensor Networks

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Abstract

There has been a huge development in the field of Wireless Sensor Networks (WSN) in the recent years. The development is mainly due to the availability of small size sensor cameras and microphones. Such devices capture the multimedia data from the environment and effectively transmit them. Wireless Multimedia Sensor Networks (WSMN) is also the current topic of discussion due to its application in various fields. In order to improve the channel utilization rate, reduce transmission delay and balance the transmission load in WMSN multipath routing is a promising solution. Multipath routing helps to transfer data simultaneously thus by reducing delay and congestion in WMSN. In this paper, various protocols and schemes are being discussed on multipath routing strategy which will identify the areas of further development for WMSN.

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Keywords: Wireless Sensor Networks (WSN); Wireless Multimedia Sensor Networks (WMSN)

1. Introduction

Since the past years many Research Community has been working on Wireless sensor networks (WSN) because of its theoretical and practical challenges. It includes the applications for large-scale networks having small devices which are capable of extracting information from the real environment then performing simple processing

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on the extracted data and transmitting it to remote locations. Significant result in this area has help in the development of civil and military applications. Till today the developed system using WSN are used to measure temperature, pressure, humidity or the location of objects. The various applications of WMSN include battlefield visual monitoring, traffic monitoring, environment monitoring, safety monitoring, medical treatment, intelligent home, public healthcare and various other applications.

Transmission of mass data and processing the data requires lots of energy in WMSN. The necessary thing is to provide the required quality of service and to have minimum end delay while meeting the bandwidth requirements in the system. The main factor which need to be considered for real-time multimedia transmission are low transmission delay, balanced energy distribution and duplicated paths which are explained below.

1. Low transmission delay: The transmission delay should be as small as possible as the delayed data become useless from the view of real time application.
2. Balanced energy distribution: The sensor nodes are battery powered and get exhaust with time thus to have balanced energy distribution the load must be distributed equally on all the sensor nodes in the environment.
3. Duplicated paths: When the small sensor nodes are affected by disturbances in the path the try to reconstruct a new path for retransmission which may result in formation of new paths which we can say duplicated paths which are supposed to be avoided in the network system.

As a result, multi-path is an important feature for the development of WMSN. The multiple path schemes will construct multiple transmission paths from each source to sink pair and send the data packets through these multiple paths. In wireless communication, bandwidth is usually shared among neighbor nodes and a node may interfere with its geographically close nodes thus reducing the throughput of the network. Thus to ensure effective real-time transmission for WMSN it is therefore required to transmit the data through paths that will not interfere with each other. Other important factor for consideration also includes reliability, fault tolerance, load balance and bandwidth improvement which are explained below.

1. Reliability and fault tolerance: The reliability can be increased by sending the data through multiple paths such that if one path fails then it can be recovers by another path. In fault tolerance some additional information is transmitted along with the data and then the data is transmitted through multi-path such that if the receiver node receives a part of the data the whole data can be recovers.
2. Load Balance and Bandwidth Improvement: Multipath routing can support different applications and can solve the network congestion problem by distributing the traffic equally through multi-paths and also can obtained equal load balancing for traffic.

This paper is organized in the following way as follows. Section 2 provides a significant survey on various protocols and schemes in Multipath WMSN, including their working mechanism, advantages and drawbacks so as to consider them as a source of future work. Section 3 concludes the paper with providing a glance on various issues to be considered as a topic of research.

2. Literature Survey

It includes the brief overview of existing work of various protocols in Multipath WMSN:

The Greedy Perimeter Stateless Routing (GPSR[1]) scheme uses the positions of routers and a packet's destination to make packet forwarding decisions. It makes greedy forwarding decisions when it is impossible and it uses routing around the perimeter of the region. GPSR simply sends a packet to a neighbouring node which sits nearest to the sink instead of constructing and maintaining a routing table. It can reduce a large amount of memory required for maintaining a routing table and can react easily to topology changes. The major drawback of GPSR is that it sends a packet only to the node closest to the sink and allows a node to change its next hop only when the original next hop is dead. Besides GPSR, there are also protocols that take both the angle and distance into consideration.

The Two-Phase geographical Greedy Forwarding (TPGF[2]) scheme builds multiple node-disjoint paths to

increase the node utilization. It does not adopt face routing to bypass holes which makes it different from other algorithms. It uses greedy algorithm, where one node is assigned to only one path. It is fast and simple but it suffers from the inter-path interference.

Ni's On-demand geographic routing scheme (briefed as NI[3]) enables a source to route data along two paths without any routing messages. The routing scheme is based on the assumption that the sensor nodes are aware of their geographic position. It first sets a fixed rectangular forbidden zone between the source and the sink, its width being twice the transmission range and length less than the distance between the source and the sink. It can successfully set up two non-interfering paths but the nodes in the paths are fixed they will not change until some are dead.

In Ge et al. (Ge et al[4]) scheme to improve path efficiency, the scheme lets each node store the two-hop neighbour information and divides the area between the source–sink pair into various zones. The source can send data to the sink through different zones to achieve node disjoint paths. Zone uses a multiple zoning method based on location to guarantee that the nodes in multiple routes are different apart from the source and the destination. There are two approaches to maintain the routes: one is local route maintenance and the other is global route maintenance. It works well when the nodes are uniformly distributed in the network with comparatively high density. When there are holes in the network protocol it is not so adaptive. It consumes more memory and also the inter-path interference problem is left out unconsidered.

The Non-Interfering Multipath Geographic Routing (NIMGR[5]) protocol by generating a deviation angle, the source sends packets along two paths deviate from the straight line between source and sink. The two paths are non-interfering exception in proximity to the source and the sink. The nodes have more chance to relay data. It considers only nodes within less than 2R distance from the line of the source and sinks pair. It reduces the average end-to-end packet delay. Besides, it does not take the remaining energy of nodes into account and has at most two paths at the same time and the nodes close to source and sink are interfering.

AOMDV[6a] guarantees loop freedom and disjointness of alternate paths. It is able to find multiple paths without geographical information. But it fails to solve the route coupling problem. Also the protocol can be improved to compute more disjoint paths when source-destination pairs are far apart. We need to carefully study the interaction between timeout settings.

BeeSensor[6b] is designed with the so-called ''bottom-up approach'' in which ''the design starts with the definition of the behaviour and interaction modalities of the individual node in the perspective of obtaining the wanted global behaviour as the result of the joint actions of all nodes interacting with one another and with the environment at the local level". It uses Swarm Intelligence to find the paths. It is able to find multiple paths without geographical information but fail to solve the route coupling problem.

SDMR[6c] is capable of finding multiple paths assisted by the global location information of the whole network in one route discovery, measuring the distance between them and choosing paths with most separation. It does not fit to error-prone and energy-limited wireless networks.

Geographic Energy-Aware non-interfering Multipath (GEAM[7]) scheme divides the whole topology into various districts and the districts into different groups. The distance between any two districts of a group will be set more than twice the transmission radius to avoid interference. To send a packet to the sink it uses the greedy algorithm. It achieves a non-interfering multipath transmission by using district. It fits well in the error-prone areas and maintain high performance even when the network topology changes. Sink report the energy and location information of node and reduce the transmission burden and increases the lifetime of node and network. It is implemented only for the single source-sink area network.

The fact for using the Energy Constrained Multipath Routing (ECMP[8]) protocol model in the wireless sensor networks is to have efficient bandwidth utilization along with minimal usage of energy. The strength of the ECMP model is that it selects minimum number of hops and minimum energy by selecting a path with minimum number of hops only when it is the path with minimum energy or a longer path with minimum energy satisfying the constraints. It shows that the QoS should be based on well-defined constraints to avoid unnecessary energy consumption when delivering data. It has a designing challenge for such an energy constrained network.

Reliable Information Forwarding Using Multiple Paths in Sensor Networks (ReInForM[9]) deliver packets at required reliability at a proper communication cost. It sends multiple copies of each packet along multiple paths from source to sink, such that data is delivered at the desired reliability. It uses the concept of dynamic packet state and uses the local knowledge of channel error rates and topology. As a result it uses all possible paths and efficient load balancing. The network topology related issues also needs to be dealt with to compute the reliability desired by

each node to deliver its packets to the sink.

Directional geographical routing for real-time video communications in wireless sensor networks DGR[10]) scheme is used for efficient multipath routing of parallel sub-streams from the source to the sink. It solves the route coupling problem caused by interference between packets transmitted over different paths between the same source–destination pair. It increases source-to-sink bandwidth and better load balancing. It achieves reliability, energy efficiency and timely packet delivery to support real-time video service over WSNs. But it suffers from the energy bottleneck problem.

Interference-Minimized Multipath Routing (I2MR[11]) scheme is able to significantly increase throughput by discovering and using maximally zone-disjoint shortest paths for load balancing, while requiring minimal localization support and incurring low overheads. It does not use the directional antennas. It needs to take into account the effects of inter-path set interferences, so as to ease the deployment of the WSN.

On the lifetime of large scale sensor networks (OLWSN[12]) scheme consist of a large scale sensor network with n randomly deployed sensors communicating with a base station (BS), where each sensor node has the same probability to sense and report its data to the BS. Due to factors depending on the path loss, radio transceiver parameters and network density, these optimal cell sizes are not always achievable. The hybrid schemes can significantly improve the network lifetime over uniform forwarding scheme as the hybrid schemes do not require any additional route maintenance, they are suitable for optimizing the lifetime of location aware sensor networks. The lifetime of such kind of sensor networks depends on transmission schemes, network density and transceiver parameters with different constraints on network mobility, position awareness and maximum transmission range which need to be taken into consideration.

In Pair-Wise Directional Geographical Routing (PWDGR[13]) the neighbour nodes of the source first send data to the pair-wise node around sink using DGR algorithm and then transfer data to the sink node by GPSR[1] algorithm. Therefore, it can effectively relieve the serious energy burden around Sink and also make a balance between energy consumption and end-to-end delay. PWDGR is used to solve the energy bottleneck problem. It is able to prolong 70% network life. When the node density is too small to find enough pair-wise nodes, the performance will be affected. The delay time is also increased by 8.1%. So it causes some extra delay in the system.

The above schemes has been briefly summarized in the below table with their working mechanism, advantages and disadvantages. So it becomes easy to understand the various schemes by simply following the table. It also provides an outlook to other people to work on those domains which are still left unnoticed.

Table 1. A comparison of various multipath routing schemes.

Sr.No.	Scheme	Working	Advantages	Disadvantages
1	GPSR[1]	Simply sends packet to a neighbouring node which sits nearest to the sink	It can reduce a large amount, fit in the memory- Limited sensor networks and reacts easily to topology changes.	It sends a packet only to the node closest to the Sink and allows a node to change its next hop only when the original next hop is dead.
2	TPGF[2]	Builds multiple node-disjoint paths by the greedy algorithm, with each node being assigned to one path only.	It is fast and simple	suffer from the inter-path interference problem
3	NI[3]	constructs two non-interfering paths to cope with the route coupling problem	Can successfully set up two non-interfering paths	But the nodes in the paths are fixed – they will not change until some are dead, just like GPSR[1]
4	Ge et al[4]	lets each node store the two-hop neighbour information and divides the area between the source–sink pair into various zones	using the two-hop neighbour information may help nodes relay data more efficiently	consume more memory the inter-path interference problem is also left out, unconsidered
5	NIMGR[5]	changes the location of the forbidden zone periodically so that nodes have more chance to relay data	is more efficient	it does not take the remaining energy of nodes into account and has at most two paths at the same time
6	AOMDV[6a], Bee Sensor[6b]	AOMDV attain multiple node-disjoint paths. Bee Sensor uses Swarm Intelligence to	all are able to find multiple paths without geographical information	performance not fit the error-prone, energy-limited wireless networks & fail to solve the route coupling

	& SDMR[6c]	find the path. SDMR computes optimized multiple paths assisted by the global location information of the whole network.		problem
7	GEAM[7]	to send a packet, it first assigns a district boundary to the packet and sends it through the district by the greedy algorithm to the sink.	fits well in the error-prone sensor environments and can maintain high performance even when the network topology undergoes rapid changes.	able to achieve balanced energy consumption and load distribution for nodes only in certain situations and has more number of hop counts
8	ECMP[8]	select a path with minimum number of hops only when it is the path with minimum energy.	it takes smaller neighbour point set considering energy efficiency of link.	there is a designing challenge for a energy constrained network
9	ReinForm[9]	sends multiple copies of each packet along multiple paths from source to sink, such that data is delivered at the desired reliability.	use of all possible paths and efficient load Balancing.	network topology related issues also needs to be dealt with to compute the reliability desired by each Node to deliver its packets to the sink.
10	DGR[10]	network topology related issues also needs to be dealt with to compute the reliability desired by each node to deliver its packets to the sink.	lower delay, longer network lifetime, a better received video quality and PSNR by up to 3dB	It has an energy bottleneck problem.
11	I2MR[11]	source initiates path discovery to destination by 3 basic steps i. Primary path discovery ii. Interference-zone marking iii. Secondary and backup path discovery.	increases throughput by discovering zone-disjoint paths for load balancing, require minimal localization support.	does not take into account the effects of inter path set Interferences
12	OLWSN [12]	n randomly deployed sensors communicating with a BS, where each sensor node has the same probability to sense and report its data to the BS.	optimize the network lifetime	Many network parameters need to be taken into consideration for large sensor network.
13	PWDGR [13]	Source node sends the data to the pair wise node around the destination node with 3 hop counts	Selection of pair wise node allows the system to remove the problem of energy bottleneck	Cause some extra delay in the system

Conclusion

This paper has presented an effective analysis of various protocols and schemes related to multipath routing in Wireless Sensor Networks (WSN). It has also provided a tabular format containing all the multipath schemes to refer it for quick overview to identify the areas of further development for WMSN. The future research can be conducted on reducing the transmission delay in the network, increasing the efficiency and thus the throughput of the system, to implement the system with multiple source-sink pairs, to solve the energy bottleneck problem of sensor nodes and many more.

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