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A DYNAMIC TRAFFIC-AWARE ROUTING TO IMPROVE QOS IN WIRELESS SENSOR NETWORKS

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Abstract

With the enormous advancement in the field of embedded computer and sensor technology, Wireless Sensor Networks (WSNs) have made remarkable impact in today's world. These WSNs consist of several thousands of sensor nodes deployed randoml y, are capable of sensing, actuating, and communicating the collected information. Since wireless sensor networks are constrained by cost, scalability, topology change and power consumption, new technologies are being considered to overcome these and many other issues.Applications running on the same Wireless Sensor Network (WSN) platform usually have different Quality of Service (QoS) requirements. Two basic requirements are low delay and high data integrity. However, in most situations, these two requirements cannot be satisfied simultaneously. In this paper, based on the concept of potential in physics, we propose IDDR, a multi-path dynamic routing algorithm, to resolve this conflict. By constructing a virtual hybrid potential field, IDDR separates packets of applications with different QoS requirements according to the weight assigned to each packet, and routes them towards the sink through different paths to improve the data fidelity for integrity-sensitive applications as well as reduce the end-to-end delay for delay-sensitive ones. Using the Lyapunov drift technique, we prove that IDDR is stable. Simulation results demonstrate that IDDR provides data integrity and delay differentiated services.

Keywords: Wireless sensor networks, potential field, dynamic routing, data integrity, delay differentiated services.

I. INTRODUCTION

Wireless sensor networks (WSNs) have gained worldwide attention in recent years, particularly with the proliferation in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user. Smart sensor nodes are low power devices equipped with one or more sensors, a processor, memory, power supply, radio, and an actuator.

WSNS, which are used to sense the physical world, will play an important role in the next generation networks. Due to the diversity and complexity of applications running over WSNs, the QoS guarantee in such networks gains increasing attention in the research community. As a part of an information infrastructure, WSNs should be able to support various applications over the same platform. Different applications might have different QoS requirements. For instance, in a fire monitoring application, the event of a fire alarm should be reported to the sink as soon as possible. On the other hand, some applications require most of their packets to successfully arrive at the sink irrespective of when they arrive. For example, in habitat monitoring applications, the arrival of packets is allowed to have a delay, but the sink should receive most of the packets.

WSNs have two basic QoS requirements: low delay and high data integrity, leading to what are called delay sensitive applications and high-integrity applications, respectively.

Generally, in a network with light load, both requirements can be readily satisfied. However, a heavily loaded network will suffer congestion, which increases the end-to-end delay. This work aims to simultaneously improve the fidelity for high-integrity applications and decrease the end-to-end delay for delay-sensitive ones, even when the network is congested. We borrow the concept of potential field from the discipline of physics and design a novel potential based routing algorithm, which is called integrity and delay differentiated routing (IDDR). IDDR is able to provide the following two functions:

[1] Improve fidelity for high-integrity applications. The basic idea is to find as much buffer space as possible from the idle and/or under-loaded paths to cache the excessive packets that might be dropped on the shortest path. Therefore, the first task is to find these idle and/or under loaded paths, then the second task is to cache the packets efficiently for

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subsequent transmission. IDDR constructs a potential field according to the depth1 and queue length information to find the under-utilized paths. The packets with high integrity requirement will be forwarded to the next hop with smaller queue length. A mechanism called Implicit Hop-by-Hop Rate Control is designed to make packet caching more efficient.

[2] Decrease end-to-end delay for delay-sensitive applications. Each application is assigned a weight, which represents the degree of sensitivity to the delay. Through building local dynamic potential fields with different slopes according to the weight values carried by packets, IDDR allows the packets with larger weight to choose shorter paths. In addition, IDDR also employs the priority queue to further decrease the queuing delay of delay sensitive packets.

IDDR inherently avoids the conflict between high integrity and low delay: the high-integrity packets are cached on the under loaded paths along which packets will suffer large end-to-end delay because of more hops, and the delaysensitive packets travel along shorter paths to approach the sink as soon as possible. Using the Lyapunov drift theory, we prove that IDDR is stable. Furthermore, the results of a series of simulations conducted on the TOSSIM platform demonstrate the efficiency and feasibility of the IDDR scheme.

II. RELATED WORK

2.1 Related Work

Most QoS provisioning protocols proposed for traditional ad hoc networks have large overhead caused by end-to-end path discovery and resource reservation. Thus, they are not suitable for resource-constrained WSNs. Some mechanisms have been designed to provide QoS services specifically for WSNs. Here we mainly focus on the metrics of delay and reliability.

2.1.1 Providing Real-Time Service

RAP exploits the notion of velocity and proposes a velocitymonotonic scheduling policy to minimize the ratio of missed deadlines. However, the global information of network topology is required. Implicit Earliest Deadline First (EDF) mainly utilizes a medium access control protocol to provide real-time service. The implicit prioritization is used instead of relying on control packets as most other protocols do. SPEED maintains a desired delivery speed across the network through a novel combination of feedback control and non-deterministic QoS-aware geographic forwarding .In a two-hop neighbor information-based gradient routing mechanism is proposed to enhance real-time performance. The routing decision is made based on the number of hops from a source to the sink and the two-hop information.

2.1.2 Providing Reliability Service

Adaptive Forwarding Scheme (AFS) employs the packet priority to determine the forwarding behavior to control the reliability. ReInforM uses the concept of dynamic packet states to control the number of paths required for the desired reliability . However, both of AFS and ReInforM require to know the global network topology. LIEMRO utilizes a dynamic path maintenance mechanism to monitor the quality of the active paths during network operation and regulates the injected traffic rate of the paths according to the latest perceived paths quality. However, it does not consider the effects of buffer capacity and service rate of the active nodes to estimate and adjust the traffic rate of the active paths.

2.1.3 Providing Real-Time and Reliability Services MMSPEED extends SPEED for service differentiation and probabilistic QoS guarantee. It uses the same mechanism as SPEED to satisfy the delay requirements for different types of traffic, and uses redundant paths to ensure reliability. The MAC layer function is modified to provide prioritized access and reliable multicast delivery of packets to multiple neighbors. However, when the network is congested, all the source nodes still continuously transmit packets to the sink along multipaths without taking some other mechanisms, such as caching packets for some time. This not only deteriorates reliability but also retards the delay-sensitive packets. Energy-Efficient and QoS-based Multipath Routing Protocol (EQSR) improves reliability through using a lightweight XOR-based Forward Error Correction (FEC) mechanism, which introduces data redundancy in the data transmission process. Furthermore, in order to meet the delay requirements of various applications, EQSR employs a queuing model to manage real-time and non-real-time traffic. DARA considers reliability, delay and residual energy.

2.2 Motivation

A small part of a WSN. Suppose node 1 is a hotspot and there are both high integrity packets (hollow rectangles) and delay-sensitive packets (solid rectangles) from source nodes A, B and C. A commonly used routing algorithm will choose the optimal path for all the packets. For example, the standard shortest path tree (SPT) routing will forward all of them to node 1 as shown in Fig. 1a. This will cause congestion and thus lead to many high integrity packets loss and large end-to-end delay for delay sensitive packets. A multipath routing algorithm. It can utilize more paths to avoid hotspots. However, the low delay and high throughput are hardly met simultaneously. The reasons are:

Delay-sensitive packets occupy the limited bandwidth and buffers, worsening drops of high-integrity ones.

High-integrity packets block the shortest paths, compelling the delay-sensitive packets to travel more hops before reaching the sink, which increases the delay.

High-integrity packets occupy the buffers, which also increases the queuing delay of delay-sensitive packets. To overcome the above drawbacks, we intend to design a mechanism which allows the delay-sensitive packets to move along the shortest path and the packets with fidelity requirements to detour to avoid possible dropping on the hotspots. In this way, the data integrity and delay differentiated services can be provided in the same network. Motivated by this understanding, we propose the IDDR scheme, a potential-based multi-path dynamic routing algorithm. The high-integrity packets do not choose node 1 due to its large queue length. Some other idle and/or under loaded paths. On the other hand, IDDR gives delay-sensitive packets priority to go ahead in the shortest path to achieve low delay. Furthermore, if the traffic on the shortest path is heavy, IDDR can also select other paths for the delay sensitive packets. IDDR distinguishes different types of packets using the weight values inserted into the header of packets,

and then performs different actions on them. Its cornerstone is to construct proper potential fields to make right routing decisions for different types of packets. Next the potential based IDDR algorithm will be described in detail. attract widespread attention because of its huge management overhead. It is quite expensive to build an exclusive virtual field for each destination in traditional networks where numerous destinations might be distributed arbitrarily. On the contrary, the potential-based routing algorithm is much suitable for the many-to-one traffic pattern in WSNs.

III. EXISTING SYSTEM

1) Most QoS provisioning protocols proposed for traditional ad hoc networks have large overhead caused by end-to-end path discovery and resource reservation.

Thus, they are not suitable for resource-constrained WSNs. Some mechanisms

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have been designed to provide QoS services specifically for WSNs.

2) Adaptive Forwarding Scheme (AFS) employs the packet priority to determine the forwarding behavior to control the reliability

3) LIEMRO utilizes a dynamic path maintenance
mechanism to monitor the quality of the active paths during network operation and regulates the injected traffic rate of the paths according to the latest perceived paths quality.

3.1 Disadvantages of Existing System

1) It does not consider the effects of buffer capacity and service rate of the active nodes to estimate and adjust the traffic rate of the active paths.

2) This will cause congestion and thus lead to many high integrity packets loss and large end-to-end delay for delay sensitive packets.

3) Delay-sensitive packets occupy the limited bandwidth and buffers, worsening drops of high-integrity ones.

4) High-integrity packets block the shortest paths, compelling the delay-sensitive packets to travel more hops before reaching the sink, which increases the delay.

5) High-integrity packets occupy the buffers, which also increases the queuing delay of delay-sensitive packets.

IV. PROPOSED SYSTEM

This work aims to simultaneously improve the fidelity for high-integrity applications and decrease the end-to-end delay for delay-sensitive ones, even when the network is congested. We borrow the concept of potential field from the discipline of physics and design a novel potential based.some special applications and environments, more than one sink may exist. However, generally the data-centric WSNs only require nodes to transmit their sampling data to one of them. Therefore, in this work, we build a unique virtual potential field to customize a multipath dynamic routing algorithm, which finds proper paths to the sink for the packets with high integrity and delay requirements. Next, the potential-based routing algorithm for WSNs with one sink is described. It is straightforward to extend the algorithm to work in WSNs with multiple sinks.
routing algorithm, which is called integrity and delay differentiated routing (IDDR). IDDR is able to provide the following two functions: Improve fidelity for high-integrity applications. The basic idea is to find as much buffer space as possible from the idle and/or under-loaded paths to cache

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the excessive packets that might be dropped on the shortest path. Therefore, the first task is to find these idle and/or under loaded paths, then the second task is to cache the packets efficiently for subsequent transmission. IDDR constructs a potential field according to the depth1 and queue length information to find the under-utilized paths. The packets with high integrity requirement will be forwarded to the next hop with smaller queue length. A mechanism called Implicit Hop-by-Hop Rate Control is designed to make packet caching more efficient. Decrease end-to-end delay for delay-sensitive applications. Each application is assigned a weight, which represents the degree of sensitivity to the delay. Through building local dynamic potential fields with different slopes according to the weight values carried by packets, IDDR allows the packets with larger weight to choose shorter paths. In addition, IDDR also employs the priority queue to further decrease the queuing delay of delay-sensitive packets.

4.1 Advantages of Proposed System

1) IDDR inherently avoids the conflict between high integrity and low delay: the high-integrity packets are cached on the under loaded paths along which packets will suffer a large end-to-end delay because of more hops, and the delay-sensitive packets travel along shorter paths to approach the sink as soon as possible.

2) Using the Lyapunov drift theory, we prove that IDDR is stable.

V. IMPLEMENTATION

Design of Potential Fields

A potential-based routing paradigm has been designed for ancient wire line networks. However, it didn't attract widespread attention attributable to its immense management overhead. it's quite pricy to create Associate in Nursing exclusive virtual field for every destination in ancient networks wherever various destinations can be distributed randomly. On the contrary, the potential-based routing rule is way appropriate for the many-to-one route in WSNs. In some special applications and environments, quite one sink could exist. However, typically the information-centric WSNs solely need nodes to transmit their sampling data to 1 of them. Therefore, during this work, we tend to build a singular virtual potential field to customise a multipath dynamic routing rule, that finds correct ways to the sink for the packets with high integrity and delay necessities. Next, the potential-based routing rule for WSNs with one sink is

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delineate. it's easy to increase the rule to figure in WSNs with multiple sinks.

High-Integrity Services

The basic plan of IDDR is to think about the total network as an enormous buffer to cache the excessive packets before they gain the sink. There are 2 key steps: (1) Finding enough buffer areas from the idle or beneath loaded nodes, that is truly resource discovery. (2) Caching the excessive packets in these idle buffers expeditiously for resulting transmissions, which suggests Associate in Nursing implicit hop-by-hop rate management.

In a under-utilized WSN, the queue length is extremely little, the hybrid potential field is ruled by the depth potential field. IDDR performs just like the shortest path rule, that is, a node forever chooses one neighbor with lower depth as its next hop. However, in an exceedingly over-utilized WSN, the shortest ways ar doubtless be filled with packets. Therefore, new returning packets are driven out of the shortest ways to seek out different out there resource. If a node is aware of the queue length data of its neighbors, it will forward packets to the under loaded neighbors to square against doable dropping.

Delay-Differentiated Services

There are principally four factors that have an effect on the end-to-end delay in WSNs: (1) Transmission delay. it's restricted by the link bandwidth; (2) Competition of the radio channel. particularly beneath a rivalry primarily based mackintosh, a packet needs to contend for the access of the channel and sit up for transmission till the channel is idle; (3) Queuing delay. an outsized queue can seriously delay packets; (4) Path length. Generally, the additional hops a packet travels, the big propagation delay it'll suffer. The physical limitation determines the transmission delay, and also the mackintosh affects the competition of the radio channel. they're each on the far side the scope of this paper. The IDDR aims to decrease the queuing delay and shorten the trail length for delay sensitive packets. Before describing however IDDR provides the delay-differentiated services, we tend to initial observe some fascinating properties of the hybrid potential field. Then, we tend to propose 2 effective mechanisms to decrease the end-to-end delay of delay-sensitive packets.

Design of IDDR Algorithm

Consider a WSN with totally different high-integrity or delay-sensitive applications. The depth potential field is very important as a result of it provides the fundamental routing operate. it's created supported the depth worth of every node. At the start, the depth values of all the nodes ar initialized to zero, except that the default depth of the sink is zero. The sink initial sends a depth update message, the nodes one hop far away from the sink obtain their own depth by adding one to the depth worth within the update message then send new update messages with their own depth values. Similarly, all the opposite nodes will get their own depth by receiving update messages from their neighbors UN agency already apprehend the depth worth. Multiple sinks could exist in giant scale WSNs. per the procedure of the depth potential field construction, these sinks can sporadically broadcast their update messages of depth. The nodes receive these update messages, compare the various depth values from different sinks, then opt for the closest sink as its destination. If the littlest depth worth isn't distinctive, the node will opt for one among them willy-nilly. Actually, once multiple sinks exist in an exceedingly giant scale WSN, IDDR can naturally partition the total networks into sub regions managed by totally different sinks. Therefore, IDDR will add giant scale WSNs with multiple sinks.

VI. CONCLUSION

In this paper, a dynamic multipath routing algorithm IDDR is proposed based on the concept of potential in physics to satisfy the two different QoS requirements, high data fidelity and low end-to-end delay, over the same WSN simultaneously. The IDDR algorithm is proved stable using the Lyapunov drift theory. Moreover, that IDDR can significantly improve the throughput of the high-integrity applications and decrease the end-to-end delay of delay sensitive applications through scattering different packets from different applications spatially and temporally. IDDR can also provide good scalability because only local information is required, which simplifies the implementation. In addition, IDDR has acceptable communication overhead.

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