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THE CROSS-LAYER SCHEME FOR OPPORTUNISTIC ROUTING WITH MULTIPLE LAYER OPTIMIZATON IN MOBILE AD HOC NETWORK

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Abstract

In order to improve the effectiveness and dependability of opportunistic routing algorithms, we provide a cross-layer and reliable opportunistic routing algorithm (CBRT) for mobile ad hoc networks. This method integrates topology control and fuzzy logic in order to improve the efficiency it provides. The number of fuzzy rules in CBRT is greatly reduced when the relative variances (rv) of the measurements are used as inputs to the fuzzy logic system rather than the values of the measurements themselves. Additionally, the addition of additional inputs does not result in a bigger collection of fuzzy rules. When using CBRT, the relay node degree is not a fixed integer but rather a range. This allows for increased routing dependability while also lowering the cost of administration. In order to establish which, group the nodes belong to, the degree of their relay functions is taken into consideration. Nodes are able to alter their transmission power in accordance with their categorization categories. As an additional contribution, we provide a link lifetime prediction model that takes into account both the speed and the direction of movement in order to investigate the impact that node mobility has on the performance of routing. When it comes to CBRT, the source node makes its decision about the relaying priority by using the utilities of the prospective relay nodes. The most valuable relay node is responsible for assigning a priority to each data packet before sending it on to the next hop. As a result of these advancements, CBRT is able to exceed ExOR in terms of performance while maintaining the same degree of computational simplicity.

Keywords: - *Opportunistic routing, energy-efficient routing, end-to-end delay.*

INTRODUCTION

Microprocessors that are inexpensive and capable of wirelessly communicating, computing, storing data, and sensing their surroundings are the components that make up wireless sensor networks (WSNs). These platforms are showing a great deal of promise and have the potential to be used for a wide range of applications in a number of fields, such as smart cities, traffic management, public facility monitoring, human health, weather, animal protection, and military applications, amongst many others. Because of advancements in microprocessing technology, sensor nodes have become more powerful, smaller, and more affordable. Additionally, these sensor nodes have become more compact. As a consequence of this, the future of sensor nodes seems to be quite bright, with potential outcomes including the creation of an innovative edge computing and edge network architecture. In addition to this, they play a vital part in the Internet of items (IoT), which enables different items that are linked to the internet to exchange data with one another. In addition, it is feasible to use these sensors in combination with cloud networks in order to establish Sensor-

Cloud Networks, also known as SCNs. As an additional point of interest, there is a growing curiosity with the creation of social networks via the use of mobile sensing devices, such as smartphones, which have the potential to dramatically alter the existence of humans. Wireless sensor networks have the potential to self-organize into a dynamic topological network, which is advantageous for the purpose of collecting data from monitored objects. Once the data has been collected, it may be sent to a control center, also known as a "sink," via the use of multi-hop routing. After that, the sink will carry out the required control action on the things that are being monitored or controlled in order to complete the duties that have been assigned to it. In many well-known applications, having a high transmission reliability is absolutely necessary for the routing of data sources. It is very important for applications that have a high degree of mission criticality to have dependable transmission. This is especially true for applications such as home automation, tracking of chemical and explosive agents, monitoring of conflict, and monitoring of patients remotely. Due to the fact that these applications are sensitive to both loss and delay, it is of the highest significance that the data be sent in a reliable and rapidly efficient manner. Wireless sensor nodes are vulnerable to both loss and delay attributable to their tiny battery capacity. Additionally, energy economy is an additional factor that should be taken into consideration.

Because of factors such as weak radio power, background noise, multipath interference, and other types of interference, wireless communication links in wireless sensor networks (WSNs) are famously unstable, unpredictable, and inherently prone to mistakes. It is possible for data packets to be lost for no obvious cause if there are any broken connections along the path that the routing traffic is taking. The chance of the sink making erroneous conclusions because to a lack of data is far greater now than it was before. Furthermore, the installation of a retransmission technique may still result in higher end-to-end latency, which may in turn lead to system loss as a consequence of delayed reaction to crises, increased energy consumption, and a shorter lifetime for the network. All of these factors may contribute to the loss of the system.

It is now possible to choose from a wide variety of trustworthy, low-latency, and energy-efficient routing algorithms for wireless sensor networks (WSNs). The term "one-hop transmission reliability" refers to the probability that the receiver of a sensor node will properly receive data packets that have been sent by a sender node via transmission. Due to the fact that data packets in wireless sensor networks (WSNs) generally go through a number of hops before arriving at the sink, end-to-end reliability is a measurement that determines the probability that the data packet arrives at the sink after all of those hops. To put it another way, it is the sum of all the one-hop transmission reliabilities that occur along the routing route. According to the one-hop transmission reliability, the end-to-end dependability decreases as the number of routing hops grows. This is the outcome of the situation. On the other hand, in order to achieve high dependability across lengthy routes, it is necessary to have a high one-hop transmission reliability. The following is a list of the several major methods that have been proposed for ensuring dependability: (1) The procedure regarding the retransmission of data... According to the send-wait protocol, which is the most common method, the verification of the packet's transport status is accomplished by the use of a second special message that is referred to as an acknowledgment (ACK). 2) A technique for routing over many paths. A node in this scenario publishes many copies of data and transmits them across a number of different channels; the failure of data routing occurs only when all of these pathways fail. When compared to a data retransmission system, multipath routing has the advantage of reducing delays, which is one of its benefits. (3) A method for the encoding of specific data. In order for this strategy to be successful, the data must first be encoded before it is routed. By using redundant coding, which enables the receiver to infer missing data from partly received information, it is possible to retain a degree of dependability in the unpredictable communication routes that are used between WSNs. It is true that encoding increases the volume of data, which is a disadvantage since it also raises the amount of energy that is used and reduces the lifetime of networks. a form of routing that capitalizes on opportunities is the fourth strategy. The sender nodes pick a selection of surrounding nodes with higher priorities and broadcast packets to them rather than explicitly naming the next hop node. This allows the sender nodes to avoid the need to identify the next hop node. The use of this particular routing method improves the dependability of transmission by reducing the loss of data as a result of unexpected abnormalities in the route.

OBJECTIVE

1. A cross-layer strategy for opportunistic routing in mobile ad hoc networks was studied.
2. Optimize routing efficiency and reliability by using opportunistic routing, which dynamically forwards data packets depending on network circumstances.

METHODS

One layer

How one layer interacts with other layers in order to enhance the performance of that layer is the primary focus of the majority of cross-layer techniques.

Physical Layer

In order to increase bandwidth while simultaneously reducing user disturbance, cross-layer techniques that focus on the physical layer use multi-element antenna systems to improve the antenna beamforming and space-time coding. This allows for the ultimate goal of cross-layer optimization. These algorithms make advantage of the information that is provided by the link layer as well as the network layer, which is information about data flows and nodes that are close.

Table 1. Cross-layer methods concentrated on physical layer.

Year	Citations	Layers	Goal	Type
2006	**98**	1,2	Bandwidth, interference	Multielement antenna systems
2007	**45**	1,2,3	Bandwidth	Multielement antenna systems

This study examines ad hoc networks using nodes with multiple antennas and MIMO technology. Additionally, channel layer protocol construction challenges are considered. Network nodes may create directed antenna patterns, filter interference, and code signals using MIMO space-time codes. With single omnidirectional antennas, nodes transmit packets to the target node requesting transmission, and the target node replies with broadcast authorization. All permitted and requested nodes will suspend the radio channel while the packet is transferred between the two nodes. If the receiving node can utilize the radio channel, it can receive packets. Multiple antennas with their own transceivers allow a node to receive many packets at once and use beamforming to avoid interference while sending. This is only achievable with enough physical distance between senders and recipients. Therefore, RTPs are advisory and used to identify data stream demands. Thus, the authors conclude that the physical and channel layers must interact.

Channel Layer

Cooperative transmission, random access, and resource reservation are channel-layer cross-layer strategies. Other methods involve random access. Channel layer resource reservations usually use network layer data rather than physical layer data. Information transferred between nodes is reported by the network layer. This data helps the channel layer reserve resources. Route data lets us divide the network into clusters and maximize communication channels inside each cluster. We may also allocate discontinuous channel resources across the tree's connections in a tree-shaped network where every node sends data to a single collector node. Channel layers may improve network capacity, route stability, and power consumption by saving resources using network layer data.

Table 2. Cross-layer methods concentrated on channel layer resource reservation.

Year	Citations	Layers	Goal	Type
2005	69	2,3	Bandwidth	Resource reservation
2006	58	2,3	Bandwidth	Resource reservation
2007	94	2,3	Bandwidth	Resource reservation
2018	34	1,2,3	Bandwidth, route stability	Resource reservation
2022	25	2,3	Energy, power consumption	Resource reservation

Allocating node channels via the use of a routing protocol is something that the authors recommend doing in order to prevent interference from other nodes along the way. A comparison between the suggested channel allocation technique and the channel allocation based on local node information reveals that the proposed approach results in an increase in bandwidth.

RESULT

In situations in which many layers are independent of one another but nevertheless share information with one another, or when an external entity optimizes and regulates multiple levels, we have cross-layer processes that optimize the operation of those layers.

External entity multiple layers control and optimisation

An external entity has the ability to govern and optimize several levels when it is present. There is compatibility between this approach and the "CrossTalk" implementation. A subsection within the study of external entity control is comprised of approaches that are based on fuzzy logic as well as techniques that are based on dual decomposition optimization. The use of fuzzy logic for the purpose of optimizing and managing the multiple layers of an external object Fuzzy logic-based cross-layer techniques make use of a set of rules that are developed for the purpose of changing a collection of input measurements from different layers into output metrics for the purpose of layer enhancement. The transformation of the input measurements into classes is determined by the ranges that are used in the process of dividing the value space of the metrics. As a consequence of the system that is based on fuzzy logic, the metrics classes that are turned into parameter values are the outcome. When it comes to choosing the conversion criteria for their papers, the authors often depend on empirical facts.

Table 3. Cross-layer methods concentrated on multiple layer optimisation with fuzzy logic.

Year	Citations	Layers	Coal	Type
2006	31	1,2,5	Delay, bandwidth, energy consumption	Fuzzy logic
2018	22	1,2,3,4,5	Packet successful delivery	Fuzzy logic
2022	10	1,2,3,4,5	Bandwidth, packet successful delivery, delay	Fuzzy logic

The essay recommended feeding the fuzzy logic system data from the physical, channel, and application layers. This statistics would comprise average line transmission time, packet delivery probability, and vehicle traffic speed. This information accounts for Doppler-induced signal fading. Correction factors control application layer packet stream creation, maximum retransmissions, transmission power, error correcting code type, and modulation.

A general method is suggested for evaluating nodes' utility while choosing the next node to send data to. Authors employ fuzzy logic for analysis. A node may have several metrics, however the metrics utilized to pick which node to forward may differ. If nodes vary little, a metric may be assigned less weight. Fuzzy logic evaluators weight measurements that have been adjusted to the mathematical expectation of their variance. After this, weighted metrics may be used to calculate the forwarding node's utility value. Following this node, the highest forwarding value node is chosen. With all layer metrics, the suggested technique works well.

One way is to use fuzzy logic in a multi-layer strategy. Fuzzy logic evaluator inputs include end-to-end transport layer latency, application layer packet delivery probability, and physical layer transmission speed. It then calculates application layer transmission rate, network route hops, channel layer retransmissions, physical layer transmission power, and signal-code constructions. It uses fuzzy logic to assign low, medium, and high values to the three input parameters. After this method, nine parameter permutations are obtained. These permutations are matched with criteria that determine output parameter ranges throughout those nine options.

Dual decomposition is a multi-layer control and optimization mechanism utilized by an external entity. Dual decomposition may help determine network designs. Data flow volumes between node pairs, transceiver signal-code architectures, transmission rates, and MIMO antenna features constrain optimization. Route selection, flow distribution, transmission power and rate, transmitter signal-code structures, MIMO space-time coding parameters, and channel access time must be optimized.

Table 4. The focus of cross-layer approaches was on optimizing many layers via dual decomposition.

Year	Citations	Layers	Coal	'type
2008	55	1,2,3	Bandwidth	Dual decomposition
2015	35	1,2,3,4	Bandwidth	Dual decomposition
2017	21	1,2,3,4,5	Not specified	Dual decomposition

Implementing ad hoc MIMO networks with many degrees of throughput optimization is suggested. Each MIMO complex-matrix channel tunes its route selection, packet transmission bandwidth, and transmission power concurrently. This optimizes efficacy. Optimization occurs at the physical, channel, and network levels. Combining network, physical, and link layer subproblems creates the optimization challenge. The two optimization issues are subsequently addressed using subgradient and plane dissection methods.

Cognitive radio is suggested for optimizing ad hoc network operating settings to maximize dual decomposition throughput. To maximize network throughput, combine transport layer transmission rate, network layer routes, and channel layer channel access time.

The study suggests reducing the optimization challenge vertically and improving network performance across all five levels. This research uses the Lagrange multiplier approach to create a partial Lagrangian formula that includes the network's goal function and restrictions from all five levels. Dual decomposition divides the complicated optimization problem into three smaller problems, and control parameters are swapped between them. The authors devised a simpler heuristic since solving all three optimization issues would be computationally difficult.

Independent layers and information sharing

Through the use of the data that is transferred across the layers, each layer is able to preserve its independence while simultaneously enhancing its performance. To maintain the integrity of the "Mobile Man" design, this approach takes

Table 5. Optimization techniques using cross-layer procedures with separate layers

Year	Citations	Layers	Goal	Type
2002	157	1,2,3	Bandwidth	Independent layers
2005	331	1,2,3	Bandwidth, energy consumption	Independent layers

2005	466	1,2,3,4,5	Bandwidth, delay	Independent layers
2007	27	2,3	Interference	Independent layers
2007	78	1,204,5	Bandwidth, interference	Independent layers
2007	183	1,2,3	Bandwidth, delay, route stability	Independent layers
2008	71	2,4	Bandwidth	Independent layers
2010	100	1,2,3	Bandwidth	Independent layers
2015	25	4,2,1	Delay, energy consumption	Independent layers
2017	1	1,2,3	Bandwidth, interference	Independent layers
2021	4	2,3,4	Bandwidth, delay	Independent layers

Using resource reservation packets from the channel layer, the physical layer is supposed to make an assessment of the status of the channel and then provide a response to the channel layer. It is possible for the sender to choose the optimal signal-code architecture by taking into account the channel estimation in this manner. It is the responsibility of the network layer to acquire information from the appropriate layers about reserved resources and signal-code structures in order to select the most optimal pathways.

The problem of allocating resources at the physical and channel layers is addressed in in order to achieve the goal of maximizing the throughput for multicast data streams. A list of feasible compromises between energy efficiency and throughput is the final product that it is possible to achieve. Time slots are resources that are associated with the channel layer, while transmission speed is a resource that is associated with the physical layer. The network layer is responsible for converting the requirements for the data flow of the sender and receiver into the resources that are required for the connection. With limited bandwidth and energy, the objective of this work is to lessen the amount of energy that is used and the amount of congestion that occurs on the lines.

Discussion

67 distinct publications were examined by our team in total. Figure 6 displays a histogram that illustrates the yearly publishing activity in a graphical format. The histogram makes it quite evident that the overall quantity of articles is decreasing. There are four peaks that may be recognized in relation to the increases and decreases in publication activity. These peaks are as follows: from 2002 to 2009, from 2009 to 2014, from 2014 to 2020, and from 2020 to 2022.

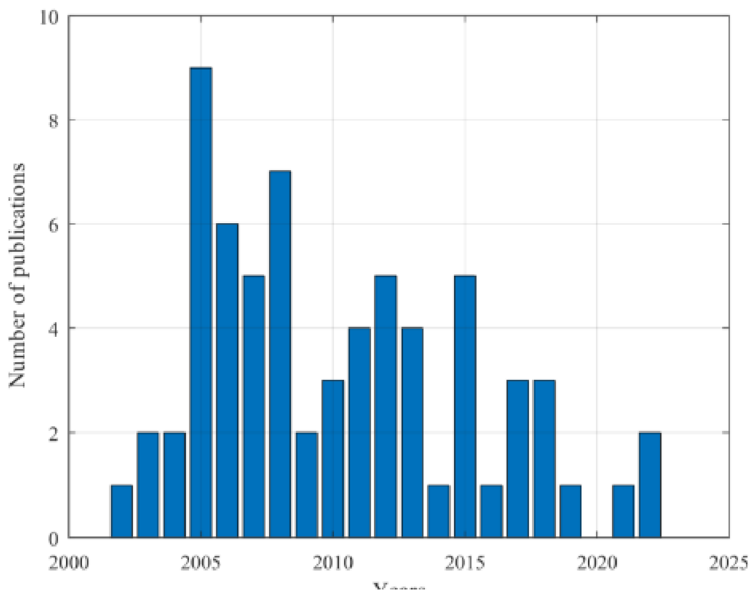

Figure 6. Interlayer approaches to publishing activity in ad hoc networks.

According on the combinations of layers that were deployed, cross-layer techniques have been characterized in previous research. In addition to being very extensive, it does not adequately represent the essence of cross-layer techniques. On the basis of the goals to use the cross-layer approach (Figure 7), which are based on the purpose to use many layers, our new classification of cross-layer techniques in ad hoc networks is based on the purposes to use the cross-layer approach. It is possible that the classification that was provided will make the process of developing goal-oriented cross-layer protocols simpler.

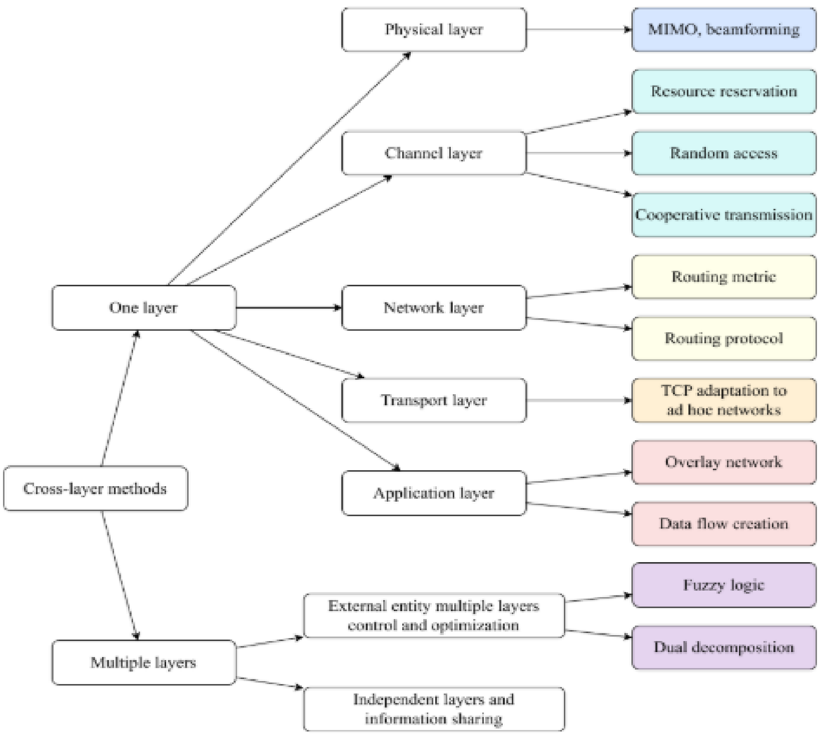

Figure 7. Ad hoc network categorization using cross-layer techniques.

Developers create new cross-layer protocols with a purpose in mind. This might be a routing, channel access, or other protocol. Figure 7 helps choose articles for new cross-layer protocol research. This is because the publications' procedures were previously classified using the suggested taxonomy. Goal-based classifications are provided instead of combination-based ones. Claims utilizing combinational criteria may be unclear. A single cross-layer method using physical, channel, and network layers may be helpful. This technique is equally comfortable as a routing protocol, channel access protocol, or system with shared and independent layers. The category gives good rationale for the researched technique. The suggested categorization is better because of this.

CONCLUSION

It is not necessary for us to depend on the many potential permutations of OSI levels in order to categorize ad hoc network cross-layer techniques for our revolutionary method. Instead, it is depending on the principal purpose of the strategy that involves several layers. There are two primary categories that cross-layer methods fall into: strategies for the collaborative optimization of numerous layers and techniques for optimizing tasks of a single layer with information utilization from other levels. Both of these techniques are examples of cross-layer approaches. Different layers of one-layer optimization methodologies are equal to one another. These levels include physical, channel, network, transport, and application. In the context of multiple layer optimization, one kind of optimization includes having each layer optimized by a separate entity; this is comparable to the "Crosstalk" design principle. In a different sort of optimization, each layer is optimized individually, but information is transferred between them; this style of optimization is comparable to the "Mobile Man" concept.

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