WSN Routing Challenges: A Methodical Analysis

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Abstract— **A Multipath routing is an effectual method to direct data in wireless sensor networks (WSNs) for it can offer trustworthiness, sanctuary and load steadiness, which are definitely precarious in the resource controlled system such as WSNs. In this paper, analysis of anticipated multipath routing protocols for WSNs is presented, which are categorized into two types, protocol operation based and network structure based, founded on the extraordinary practices used in constructing multiple paths and distributing sensing data. For every kind, study the design of protocols, scrutinize the tradeoff of respectively design, and outline numerous demonstrating protocols. Further, provide a summary of design objectives, encounters, and assessment metrics for multipath routing protocols in resource inhibited systems in broad.**

Index Terms— **Wireless sensor network, Protocols, Sensor network services, Sensor network deployment, Survey**

1) INTRODUCTION

Wireless sensor networks (WSNs) have extended global courtesy in latest years, predominantly with the propagation in Micro-Electro-Mechanical Systems (MEMS) technology which has enabled the growth of clever sensors. These sensors are minor, with restricted handling and computing resources, and they are cheap compared to outdated sensors [1]. These sensor nodes can sense, measure, and collect facts from the surroundings and, based on some local judgment process, they can transfer the sensed data to the consumer. The accessibility of low-cost hardware such as CMOS cameras and microphones has adopted the progress of Wireless Multimedia Sensor Networks (WMSNs), i.e., networks of wirelessly connected devices that are capable to universally regain multimedia gratified such as movie and audio streams, still pictures, and scalar sensor information from the surroundings [2].

a. Wireless Senor Network Applications

Wireless multimedia sensor networks will not merely improve present sensor network applications such as stalking, home robotics, and ecological observing, but they will also allow numerous new applications such as:

1) Multimedia investigation sensor networks. Wireless movie sensor networks will be self-possessed of intersected, battery-powered tiny audiovisual cameras, respectively wrapped with a low-power wireless transceiver that is capable of processing,

sending, and receiving data. Video and audio sensors will be used to enhance and supplement present reconnaissance systems against offense and extremist attacks. Large-scale networks of audiovisual sensors can outspread the capability of rule implementation organizations to observer zones, community events, secretive stuffs and restrictions [3].

2) Record of hypothetically pertinent deeds. Multimedia sensors could surmise and store hypothetically appropriate accomplishments (robberies, car misfortunes, traffic defilements), and create video/audio torrents or information accessible for prospect inquiry [4].

3) Data prevention, implementation and governor. It will be conceivable to investigate road traffic in large metropolises or thoroughfares and use facilities that deal traffic routing guidance to evade overcrowding. In addition, keen parking guidance methods founded on WMSNs will permit observing obtainable parking spaces and deliver carters with automatic parking advice, consequently enlightening flexibility in metropolitan zones. Furthermore, multimedia sensors may observe the movement of vehicular circulation on roads and regain collective statistics such as average speed and quantity of cars. Devices could also identify defilements and communicate video streams to commandment implementation activities to recognize the violator, or safeguard pictures and streams in case of mishaps for succeeding fortune scene investigation [5].

4) Progressive health care conveyance. Telemedicine sensor networks can be combined with 3G interactive program networks to deliver omnipresent health care amenities. Patients will spread therapeutic sensors to observe factors such as body fever, blood density, pulse oximetry, ECG, inhalation action. Additionally, preoccupied remedial interiors will accomplish progressive faraway watching of their patients via video and audio sensors, site sensors, indication or movement sensors, which can also be entrenched in wrist devices [6].

5) Computerized support for the senior and personal investigators. Multimedia sensor networks can be recycled to investigate and study the deeds of mature persons as a means to recognize the reasons of diseases that disturb them such as dementia. Networks of wearable or video and audio devices

can deduce reserve situations and promptly acquaintance senior patients with distant support facilities or with families [7].

6) Environmental observing. Numerous developments on habitation checking that use sound and audiovisual feedstuffs are being imagined, in which statistics has to be carried in a time-critical manner. For example, collections of video sensors are previously used by oceanographers to decide the growth of ridges via image processing methods.

7) Individual detector facilities. Multimedia data such as audiovisual streams and still pictures, along with innovative signal processing methods, can be used to discover misplaced people, or recognize offenders or extremists [8].

8) Manufacturing process governor. Multimedia data such as imaging, heat, or compression between others, may be used for time-critical manufacturing process governor. Machine visualization is the use of computer vision methods to manufacturing and engineering, where statistics can be mined and scrutinized by WMSNs to upkeep a engineering process such as those used in semiconductor chips, automobiles, food or pharmacological goods. For example, in quality control of engineering procedures, details or absolute goods are robotically scrutinized to discover faults [9].

b. Limitations in Single Path Routing

Single path routing is artless and accessible, but does not professionally fulfill the requests of resource constrained WSNs. It is guileless since the route among the source node and the endpoint node can be recognized in a particular epoch of time. It is accessible because, even if the network variations from ten nodes to ten thousand nodes, the intricacy and the methodology to determine the track residues the similar. Whereas seeing the individualities of WSNs, single path routing is not well-organized for the subsequent details [10] [11] [[12].

1) In single path routing, it is calm for the source node to choice the middle data routing nodes from the identical part of the system over and over again. This may reason reduction of power of those sensor nodes and network partition, which reduces the lifespan of WSNs.

2) In WSNs, catastrophes are communal because of inadequate power, inadequate storage space, untrustworthy wireless message, or impulsive conservation interloping. If any failure happens, most single path routing protocols could not effectively distribute sensed data to the sink due to a deficiency of fault-tolerance devices.

3) In single path routing, the existence of a malevolent node on the path can operate and debase the data deprived of gathering the thoughtfulness of the descend node.

Multipath routing is a substitute routing method, which chooses numerous tracks to distribute information from source to target. Because of the nature of multipath routing that usages terminated tracks, multipath routing can fundamentally report the trustworthiness, sanctuary and load harmonizing problems of single path routing protocols. Consequently, multipath routing shows a noteworthy character in WSNs and several multipath routing protocols have been projected in the legendary of WSNs research [13]. In this paper, take a primary stage to encapsulate all multipath routing techniques suggested in the WSN investigation legendary. On the basis of the protocol article and its requirement.

c. Benefits of Multi path routing

Subsequent, seeing the individualities of WSN, reckon the main rewards of multipath routing protocol over single path routing [10] [12] [14] [15] [16].

1. Data Trustworthiness. Data Trustworthiness can be described as the relationship of the quantity of data acknowledged by the target node to the quantity of data sent by the source node. Protocols using a single path to handover the data from source to target have low data steadfastness. This is due to numerous aspects containing environmental disruption, defective nodes, and reserve restraint.

2. Data Sanctuary. In single path routing, if any sensor node on the track is bargained into malevolent action, then the network is not anodyne to convey the data. Single path routing is disposed to numerous categories of assaults. For example, a sink hole occurrence can be propelled to single path routing in which the invader attempts to distract the network traffic from a definite zone through a malevolent node.

3. Energy-Efficient. Wireless sensor nodes have inadequate energy stock, consequently well-organized use of energy is compulsory to exploit the network lifespan. In the single path routing protocol the usage of the same optimal path over and over again may reason definite nodes to reduce their energy at an earlier speed, which might reason network barrier.

2) RESEARCH METHODOLOGY

a. Research Questions

Innovative network protocols that reason for the important realisms in wireless message are compulsory [14] [24] [25]. New research is needed to:

3) Measure and evaluate how the imaginary assets of wireless communication are demonstrated in present's and future's sensing and message maneuvers,

4) Inaugurate improved models of message authenticities to nourish back into amended replication tools,

5) Formulate new network protocols that responsible for the message authenticities of real world surroundings,

6) Examination the distinct resolutions on real platforms in real world situations, and amalgamate innovative resolutions into a comprehensive system-wide protocol heap for an actual application.

a. Source of Information

The following are source of all the information regarding WSN discussed in this paper:

7) ACM Digital Library (<www.acm.org/dl>)
8) IEEE eXplore (<www.ieeexplore.ieee.org>)
9) ScienceDirect (<www.sciencedirect.com>)
10) Google Scholar (<www.scholar.google.co.in>)

a. Research Keywords

Table 1 shows the Search Keywords and Synonyms used to collect the information presented in this research.

Table 1: Search Keywords and Synonyms

Keywords	Synonyms
WSN	Wireless sensor network
WSN Protocols	Wireless sensor network protocols
SNS	Sensor network services
SND	Sensor network deployment
Survey	Review and Issues

b. Study Selection

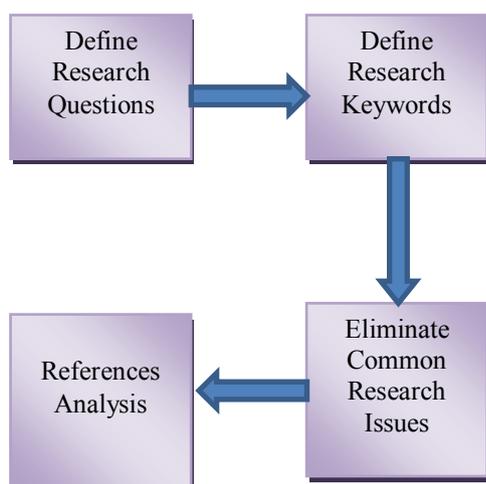Figure 1 show the research procedure used to find the research issues.

Figure 1: Research Procedure

11) ANALYSIS AND DISCUSSION

Limited investigative consequences happen for WSN. Meanwhile WSN are in the initial phase of progress it is not astonishing that rare investigative consequences occur. Researchers are hectic discovering new protocols and new requests for WSN. The resolutions are constructed, verified and appraised either by replication or test beds; occasionally an authentic system has been organized. Pragmatic indication is opening to collect. Though, a more methodical method is mandatory where a system can be intended and investigated before it is organized. The examination desires to deliver self-assurance that the system will encounter its desires and to designate the effectiveness and enactment of the system. Deliberate the following motivating investigation problems.

12) What compactness of nodes is mandatory to encounter the lifespan desires of the system?
13) What detecting and message ranges are desirable to discover, categorize and report an aim to an immoral location by a limit?

14) What sensing scope and what nodes requirement to be aware in order to assurance a convinced amount of sensing attention for a system?
15) Given n streams of intermittent sensing traffic categorized by a start time, old-fashioned, communication scope, time limit, source situation and target situation for a given WSN will all the traffic encounter their time limit?

To response this last query, the intervention designs of wireless communication must be taken into account. When investigation procedures and resolutions are industrialized for these kinds of queries, they must also be authorized with factual systems [8] [10] [13] [14] [15] [16].

a. Challenges in Constructing Multipath Routing Protocols

In WSNs, due to the little transmission scope among the nodes, multi-hop routing is recycled to handover the information to the descend. Consequently to track the data packet from source to target, it uses numerous middle nodes which act as data routers [17]. Routing in WSN is an enormous encounter because of obtainability of littler resources at respectively node, distribution of network in interesting and intimidating surroundings, recurrent variation in network topology and fault-tolerance [1]. To endure disappointment, in single path routing, an optimum path is particular to route the data from source to target, and a substitute path is used when an optimum path nosedives. In multipath routing, multiple paths are exposed to allocate the network traffic and extend network lifespan; though, there are numerous main interrogations to be lectured in the enterprise of multipath routing protocol. These problems are like follows [10] [16]:

16) How many paths are optimums?
17) How does one determine those optimum tracks?
18) How does one uphold exposed tracks and allocate the data amongst those tracks?

Several procedures consuming intellectual methods and altered strategy ideologies have been anticipated in the exploration for responses to these queries. Though, it remainders an inspiring mission. Therefore, multipath routing has numerous rewards in WSN as mentioned nonetheless these compensations come with some encounters as enumerated as follows [14] [15] [16] [17] [18] [19] [20]:

19) *Number of Routes.* In multipath routing, trustworthiness and sanctuary are functions of the number of paths designated for transmitting data from source to target. If there is not an adequate number of paths accessible between source and target, attaining the objective of multipath routing is not conceivable. Detection of multiple paths from dissimilar servings of network assistances in allocating the network traffic consistently. This will upturn network lifespan but at the price of additional route creation period.

20) *Route Detection.* The nodes in the WSN act as data dispatcher as well as data router. When the data packet has attained at a middle routing node, it must choice the subsequent node having the proficiency of passing the data packet in the direction of the

sink. The choice of the subsequent node is based on ascent information comprising signal power, residual energy and others. Lengthways with the ascent information, the source node has to authenticate that the designated node is not a mischievous node, which reasons additional message above and broadcast deferral [4]. The designated data routing nodes straight affect the Quality of Service (QoS), while it is problematic to treasure a set of optimum multiple paths complementary the energy ingestion and the quality of routing. In the case of an extraordinary vibrant sensor network the route detection process is even more inspiring because of persistent topological deviations.

21) *Ingestion of Resources.* In WSN the effectual resource ingestion at each node is compulsory in order to upturn the network lifespan. In multipath routing many messages are swapped amongst nodes in order to determine the optimum paths between source and target. Once the multiple paths are revealed, the data packet will be transmitted from source to target using those multiple paths. Transmitting data packets from dissimilar shares of the network benefits in allocating the traffic to the entire network, while it is a encounter to scheme an intellectual procedure to allocate the traffic consistently to the entire network. To stunned the problem of directing the similar data packet from dissimilar discovered paths, numerous coding patterns can be used. Furthermore, stoutness and density proficiency of the coding procedure are also of main anxiety when using coding procedures. Consequently a tradeoff occurs among trustworthiness and energy proficiency.

22) *Path Preservation.* In multipath routing, the procedure of multiple paths from source to target desires to be preserved occasionally in order to attain high data trustworthiness as well as load balance among many paths. If the path is wrecked, then the source node has to select alternative optimum path. The assortment of the greatest next hop is based on investigative material. Group of all experiential statistics is thought-provoking and can reason deferral in data packet broadcast. The judgment of path preservation can be completed by the target node or it is set up in the application itself. In some cases merely limited optimum paths are used from numerous revealed multiple paths.

a. Foremost Performance Metrics

This section presenting the metrics on the basis of which can find the enactment of protocols using a multipath routing method in a WSN. Metrics used to measure the compensations and disbursements of those protocols [21] [22] [23] [24] [25].

23) Energy Effectiveness. Energy proficiency should be one of the foremost enterprise objectives of any routing protocol in WSN. Network lifespan participating energy ingestion in sensing, reckoning and message, as well as network handling and connectivity can be used to appraise energy proficiency of multipath routing protocols. On the other hand, since the most noteworthy energy ingesting of sensors is in communication, the total number of communications transferred in multi path protocols can also be a respectable metric to assess energy proficiency.

24) Data Trustworthiness. Steadfastness is one of the furthermost imperative compensations of multipath routing protocol over single path routing protocol. Data dependability is calculated as the total amount of messages acknowledged at the target node alienated by the total number of messages originated from the source node. In other words it can describe data trustworthiness as the proportion of data packet efficaciously established by the target node. The trustworthiness of a protocol is also exaggerated by the number of paths revealed, because this disturbs the amount of data transferred. Consequently, the more paths revealed, the superior the data trustworthiness.

25) Route Outfit Period. Associated to single path routing protocols, path finding is more stimulating in multipath routing protocols. The metric, route outfit period, is typically used to appraise the overhead of multipath routing protocol. The route outfit period can be well-defined as the total amount of time occupied by the sink or source node to determine the paths from the source to the target node. The superior the protocol design, the smaller the route outfit period.

26) Average Deferral. Since of the deliberation of load balance and trustworthiness, multipath routing could take a time-consuming path than single path routing. As a result, it may proceeds longer for a packet is transmitted from source to target. The average deferral is used to estimate the deferral produced by multipath routing. Average deferral can be demarcated as the total quantity of time taken by the data packet to foldaway from source to target.

a. Routing Encounters and Design Problems in WSNs

Notwithstanding the incalculable applications of WSNs, these networks have numerous constraints, such as restricted energy stock, restricted computing power, and restricted bandwidth of the wireless associates joining sensor nodes. One of the key design objectives of WSNs is to carry out data communication while annoying to extend the lifespan of the network and preclude connectivity dilapidation by retaining aggressive energy management procedures. The design of

routing protocols in WSNs is prejudiced by many interesting issues. These influences must be overwhelmed before effectual communication can be attained in WSNs. In the following, succinct some of the routing encounters and design problems that disturb the routing process in WSNs [4] [6] [9] [12] [13] [18] [21] [24] [25].

27) Node placement: Node placement in WSNs is application-dependent and can be either physical (deterministic) or randomized. In physical placement, the sensors are physically located and data is routed done prearranged paths. Though, in random node deployment, the sensor nodes are dispersed haphazardly, generating an ad hoc routing infrastructure. If the subsequent dissemination of nodes is not unvarying, optimum grouping becomes obligatory to permit connectivity and empower energy-efficient network procedure. Inter sensor communication is customarily within little broadcast varieties due to energy and bandwidth confines. Consequently, it is most expected that a direction will consist of many wireless hops.

28) Data broadcasting technique: Data broadcasting in WSNs is application-dependent and also be influenced by time criticality of the data. Data broadcasting can be characterized as either period-driven, occurrence driven, query-driven, or a mixture of all these approaches.

29) Connection heterogeneity: In many studies, all sensor nodes were presumed to be identical (i.e., has identical ability in terms of calculation, communication, and power). Though, contingent on the request a sensor node can have a dissimilar character or ability. The presence of a heterogeneous set of sensors raises numerous official problems associated to data routing.

30) Fault acceptance: Some sensor nodes may miscarry or be congested due to deficiency of power, physical impairment, or environmental intervention. The disappointment of sensor nodes should not disturb the complete assignment of the sensor network. If many nodes flop, medium access control (MAC) and routing protocols must provide somewhere to stay realization of new links and ways to the data collection BSs.

31) Scalability: The number of sensor nodes deployed in the sensing zone may be on the order of hundreds or thousands, or more. Any routing pattern must be capable to work with this enormous number of sensor nodes. In addition, sensor network routing protocols should be scalable adequate to reply to events in the environment. Till an incident happens, most sensors can endure in the snooze state, with data from the few enduring sensors providing abrasive excellence.

32) Network crescendos: In many studies, sensor nodes are presumed stable. Though, in many applications both the BS or sensor nodes can be movable [6]. As such, routing messages from or to poignant nodes is more inspiring since route and topology immovability become vital problems, in addition to energy, bandwidth, and so onward. Furthermore, the occurrence can be moveable (e.g., target recognition/ stalking application).

33) Communication broadcasting: In a multi hop sensor network, collaborating nodes are interconnected by a wireless standard. The outdated difficulties connected with a wireless frequency may also disturb the maneuver of the sensor network. In overall, the compulsory bandwidth of sensor data will be little, on the order of 1–100 kb/s.

34) Connectivity: Extraordinary node compactness in sensor networks impedes them from being entirely insulated from each other. Consequently, sensor nodes are anticipated to be extremely associated. This, nonetheless, may not avoid the network topology from being flexible and the network magnitude from attenuation due to sensor node catastrophes. In addition, connectivity is determined by conceivably random dissemination of nodes.

35) Attention: In WSNs, each sensor node attains a definite vision of the surroundings. An assumed sensor's interpretation of the environment is inadequate in both assortment and accurateness; it can only shield a inadequate physical area of the surroundings. Therefore, area attention is also an imperative design parameter in WSNs.

36) Data accumulation: Subsequently sensor nodes may spawn noteworthy redundant data; comparable packets from numerous nodes can be amassed to decrease the number of diffusions. Data accumulation is the amalgamation of data from dissimilar sources agreeing to a convinced accumulation. This procedure has been used to attain energy effectiveness and data transfer optimization in a number of routing protocols. Signal processing approaches can also be used for data accumulation.

37) Quality of service: In some applications, data should be distributed within a convinced period of time from the instant it is sensed, or it will be impractical. Consequently, constrained expectancy for data distribution is another circumstance for time-constrained applications. Nevertheless, in numerous applications, preservation of energy, which is openly related to network lifespan, is deliberated reasonably more significant than the quality of data referred.

a. Routing Protocols in WSNs

In this section routing protocols for WSNs are presenting. In overall, routing in WSNs can be alienated into flat-based

routing, hierarchical-based routing, and location-based routing reliant on the network organization. In flat-based routing, all nodes are characteristically allocated equivalent roles or functionality. In hierarchical- based routing, nodes will tragedy dissimilar roles in the network. In location-based routing, sensor nodes' locations are subjugated to route data in the network. A routing protocol is deliberated adaptive if convinced system parameters can be organized in order to acclimatize to present network conditions and accessible energy levels. Additionally, these protocols can be categorized into multipath-based, query-based, and negotiation-based, QoS-based, or coherent-based routing methods reliant on the protocol procedure. In addition to the above, routing protocols can be categorized into three classifications, active, oversensitive, and mixture, depending on how the source discoveries a route to the target. In preemptive protocols, all routes are calculated before they are actually wanted, while in oversensitive protocols, routes are calculated on demand. Mix protocols use an amalgamation of these two designs. When sensor nodes are immovable, it is required to have table-driven routing protocols rather than oversensitive protocols. A significant amount of energy is used in route detection and arrangement of oversensitive protocols [11] [12] [17] [18] [21] [24] [25]. The classification of Routing Protocols in WSNs is shown in Fig. 2.
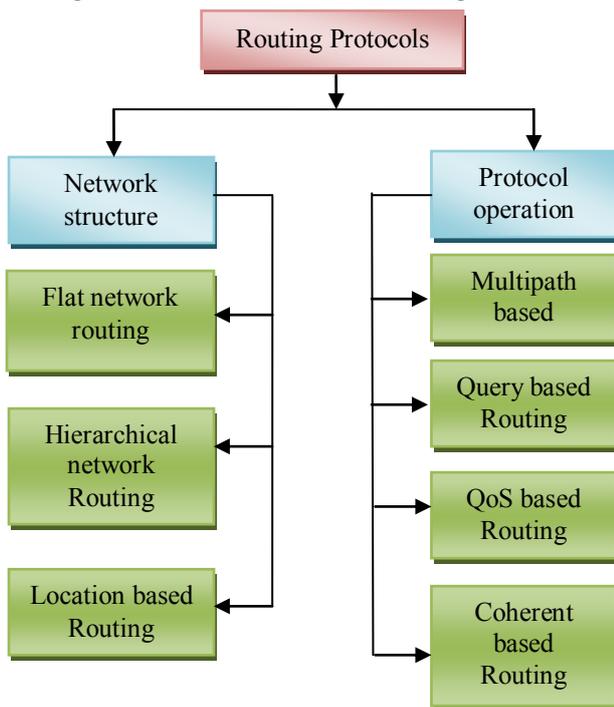

Figure 2: Classification of Routing Protocols in WSNs

38) THREATS TO VALIDITY

The research articles were acquired by keyword probing and reference investigation. Eliminations were made by understanding the title, abstract and inferences. Though, there is a risk that there exist papers that were neglected due to the beyond searching and elimination technique.

39) CONCLUSION AND FUTURE SCOPE

In this paper, primary stage to outline the proposed multipath routing protocols, issues and metrics in WSNs has been taken. Multipath routing protocols primarily constructed on whether the proposed routing protocol produces multiple path infrastructures or not. Furthermore, because of the special importance of coding techniques in multipath routing, a set of coding method based multipath routing protocols in depth is discussed. In addition, a collection of multipath routing protocol design problems such as major design objectives, encounters and appraisal metrics are presented in this paper.

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