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A Study and Analysis of Congestion Control Wireless Sensor Networks

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Abstract

WSNs are becoming popular in real world uses. Due to resource-constrained and battery-aware features of the sensor; WSNs energy use in a major research topic was found to be interesting. WSNs contain battery powered nodes that for certain action or tasks are connected with the base station. The lifetime of battery-powered sensor nodes, after the consumption of the battery will be dead in WSNs. To prolong the lifetime of WSNs the energy has to be well organized. The cluster head selection and assignment, and construction of clusters require additional overhead. Cluster nodes distributed algorithms designed incorrectly can lead to isolation from cluster heads. Such isolated nodes waste large amount of energy to communicate with the sink. In this paper, energy conservation techniques related to WSNs are discussed. Also, the existing energy conservation algorithms are reviewed and the comparative analysis is also performed.

Index Terms: WSNs, Energy Consumption, Energy Aware Clustering, Congestion Control.

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1. Introduction

Wireless sensor networks with sensing, computing, and wireless communication capabilities consist of small nodes [1]. Many routing, energy management, and data dissemination protocols, especially where energy awareness is a necessary design issue is designed for WSNs. WSNs configuration includes a sensor network which contains various nodes. These nodes transfer data to the sink node or base station. Sink node is responsible for gathering the data from sensor nodes and transfer to the Internet. The user terminal sink node gets data via the Internet. The primary purposes of Wireless Sensor Networks consist of Medical Supervising, Associated with the Supervising, Normal Devastation Avoidance, Region Supervising and many others. Sensor Nodes can be used in several businesses, armed forces and also farming purposes, for instance travel visitors

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monitoring, environmentally friendly observation, smart office, frontline observation. In these kinds of purposes, these sensors usually are stationed in ad-hoc method and also work autonomously. In these kinds of alone situations, these kinds of sensors cannot be easily changed or perhaps energized, and also strength ingestion could be the most essential problem that need to be regarded [7].

Quite a few vitality effective relaying systems happen to be intended for WSNs, including [20]. Grouping of sensors is very convenient for exchange dependent sensor networks that want scalability to help hundreds possibly a large number of nodes. Some sort of clusters comprises at least a cluster head (CH) along with cluster members. CHs are responsible for managing the nodes within their clusters and also occasionally broadcast aggregated files to some remote control viewer (sink). In the course of routine re-clustering, nodes along with high left over vitality may assist as CHs. Network lifetime is prolonged utilizing overall performance files aggregation, involving merging the results by resource nodes into a small set of purposeful details, and also help make files indication to become much more vitality adequate. Nonetheless, most of these clustering algorithms exhibit negatives, for example extra over head in the course of CH choice and also job, and also in the cluster construction course of action.

Researchers have got planned numerous cluster-based practices recently intend to improve circle life-time. LEACH (Low Energy Adaptive Clustering Hierarchy) [9], [15] is usually a self-organizing adaptive standard protocol that will work on the dispersed clustering enhancement protocol. Within LEACH, CHs are selected determined by a new fixed likelihood; some other nodes go with a bunch to sign up by means of price which often with the selected CHs will be nearest thing. Even so, LEACH won't ensure a new even syndication involving CHs inside a circle. Within LEACH, CHs becomes overloaded, leading to the amount involving circle weight harmony in order to diminish. In addition, a new node can be selected as a CH intended for a couple of spherical of the functioning, hence taking in more energy than some other nodes. Throughout [18], the actual experts offered HEED (Hybrid Energy-Efficient Spread clustering), which usually works on the merged technique of one's as well as connection expense to get CHs. HEED generally prevents a couple of nodes from the same transmission range from growing to be CHs simply because electricity is consistently dispersed throughout most nodes. Also, the actual likelihood regarding CH assortment is variable, giving inter-CH connectivity within a sensor's transmission range. Throughout HEED, every node ought to communicate continuously with its border nodes for any established volume of iterations during CH assortment; hence, additional connection prices are expected. Consequently, HEED is improper with regard to large-scale WSNs. Distributed Energy Efficient Clustering (DEEC) [17] can be a clustering-based criteria where CHs tend to be chosen based on the possibility of the percentage of the extra energy for the common energy of the system. DEEC consists of assessing the optimal value regarding system life span, that's helpful to determine the mandatory electricity that every node needs to spend on a round. For that reason, each node is not necessary to have global expertise in the system. The main problem regarding DEEC may be the cost linked to running the common electricity of the system. Furthermore, the common electricity of the system cannot effectively characterize their state of the local system.

Based on the thought of LEACH, REAC-IN [19] permits every single node to consume electricity uniformly through revolving the CH role between many nodes. REAC-IN chooses your CHs while using limit involving the left over energy regarding particular individual sensor plus the regional regular electricity of every sensor inside every single bunch to try and uniformly spread CHs, in contrast to LEACH chooses the CHs while using limit contemplating a predetermined likelihood merely. REAC-IN entails having your revolving epoch of every node to the energy and also indicates the condition regarding node remote location. Incorrectly designed distributed clustering algorithms can lead nodes to isolation from CHs. Such isolated nodes interconnect with the sink by consuming surplus energy. Furthermore, the isolated nodes sent its data to CH node or to the sink depending on the distance and regional average energy amongst sensors and the sink.

This paper has compared existing energy conservation algorithms and found that each technique has its own benefits and limitations over each other. However this work has found that the effect of congestion is ignored in majority of existing protocols. Therefore in near future congestion control strategies based clustering

protocols will be proposed. This can improve the energy conservation rate and also decrease the packet dropping problem with existing networks.

2. Clustering

As wireless sensor network can be an accumulation sensor nodes and so these kind of sensor nodes usually are clustered in to groupings. Each and every group can be assigned having a leader, known as the actual cluster head (CH) as well as performs the actual specific tasks similar to files aggregation, pass files for you to starting base station.

Following the cluster formation course of action, CH nodes form the higher level hierarchy plus the member nodes involving cluster form the lower level hierarchy. The particular sensor nodes routinely mail their files for the comparable CH nodes. CH nodes mix the information and present that for the base station (BS) often straight or throughout the intermediary communication. However, the CH nodes sends files to higher distances compared to the typical nodes on a regular basis, these people commit power on increased rates. To balance the vitality ingestion, a typical alternative is to routinely re-elect fresh node with each and every cluster amongst the many system nodes.

2.1. Clustering Factors

These factors serve as the simple means for additional analysis and class on the current clustering methods during this segment.

- *Total clusters:* Latest probabilistic along with randomized clustering algorithms result in adjustable amount of groups pertaining to CH election along with enhancement practice. The actual group of CHs is usually prearranged and so the actual amounts of groups are usually fixed. Critical parameters with respect to the effectiveness of the entire routing protocol are the number of clusters.
- *Intra Cluster Communication:* The communication amidst a new sensor and its particular elected CH is actually assumed to be one-hop communication. Though, multi-hop intra cluster communication can often be necessary, i.e., once the selection of communication of the sensor nodes is actually filter or the actual sensor nodes are generally significant within range and also the amount of CHs is limited.
- *CH and Nodes mobility:* Immobile sensor nodes in addition to standing CHs are triggered firm clusters together with permitted intra cluster in addition to inter cluster system managing. Should the nodes or even CHs themselves are usually allowed to be moving, the regular membership associated with cluster for each node really should change dynamically; engaging clusters to progress with time and maybe should be constantly preserved.
- *Types of Nodes and its roles:* Within heterogeneous conditions, this CHs are assumed to become network using significantly more communication along with calculation than the rest. Within homogeneous conditions, each node contains the identical skills and is particularly simply a subgroup in the used devices and is particularly chosen as CHs.
- *Cluster formation approach:* In many current strategies, while CHs are only frequent receptors nodes along with time effectiveness is often a key design and style qualification, clustering is conducted inside a allocated method without coordination. In several earlier strategies, both centralized as well as hybrid car approach is surveyed; one or more sponsor nodes handle the actual group membership along with break down then entire multilevel off-line.
- *Cluster Head Selection:* The particular CHs throughout heterogeneous surroundings can be allocated in the beginning. Even so, throughout homogeneous surroundings, the actual CHs are chosen from your put set of nodes both in a fully arbitrary means or perhaps probabilistic or perhaps determined by different more descriptive standards just like extra strength, online connectivity and so forth.

- *Algorithm intricacy:* Contemporary algorithms have the fast cessation of the implemented protocol as one of the chief design goals. Hence, in most cluster formation procedures proposed nowadays, the time complexity or convergence rate is constant. In former protocols, the overall sensors in a network were used to calculate the complexity time, concentrating on additional conditions first.
- *Multiple stages:* To attain even better total energy consumption and energy distribution, the idea of a multi-level cluster hierarchy is offered. The multi-level clustering offered improvements that are to be further calculated, particularly when inter-CH communication efficiency is of great significance when there is a very large network.
- *Overlapping:* For quicker cluster creation protocol execution or for superior routing efficiency, numerous protocols also give great significance on the theory of node overlapping in different clusters. Most protocols still try to overlap only minimum or not at all support overlapping.

2.2. Isolated Nodes

Every single sensor node inside a WSN uses energy to sense the environment and convey or maybe exchange its sensed data to some sink node. WSN shaped simply by inaccurately intended spread clustering algorithms, nodes can be remote due to at random chosen CHs.

The vitality consumption trouble of the separated node communicating while using the sink would certainly are more noticeable once the length in between all of them is fairly considerable. Even worse, it's at risk of strain its energy, producing a good imperfect realizing protection. To help extend community life span, the length in between receptors and the sink and also regional common energy and also were being analysed to discover perhaps the separated node need to send their facts to the sink or the CH node in the last around.

2.3. Global Average Energy and Local Average Energy

With regard to large-scale networks, the average energy in the network cannot precisely characterize the state in the entire network. The first scheme within [17] would not think about regional average energy (or local energy). A node must evaluate the action higher level of community nodes whenever picking out a CH to save lots of more strength.

3. Taxonomy of WSN Applications

The taxonomy that characterizes numerous properties of sensor systems is-

3.1. Goal

Throughout first reports, WSN purposes target is to accumulate the environmental facts regarding search. This can be known as perception only. The particular subject regarding sensor-equipped nodes which directs their facts are capable of doing this likely coupled many hops, to solitary foundation place which often centrally gathers the info. However, much behaviour must conduct with the purposes about the sensed facts. This particular sensation is termed perception and reply.

3.2. Interaction pattern

Interaction pattern refer to the methods where sensor nodes interchange the data with one another. When data is send from each node in the network to a principal collection point then it is the interaction pattern many-to-one. When one node transfers data to all or more than node then it is One- to-many interaction pattern. And many nodes pass on data many other nodes in many-to-many interactions.

3.3. Mobility

The key property is Mobility. Immediately after preliminary deployment, the actual sensor nodes may well alter the position. It could be put on most nodes within a network or perhaps just to subdivisions connected with nodes. A few instruction connected with flexibility are generally static, cell phone nodes along with cell phone sinks. It can lead to via ecological consequences including breeze or perhaps mineral water; sensor nodes may very well be placed on or perhaps helped by simply cell phone entities – passive mobility. Sensor nodes could have motorized features – active mobility. The degree connected with flexibility could also vary from hit-or-miss movements together with extensive stages connected with immobility among, to help continual travel.

3.4. Space

Different parts of the physical location of the different applications may require distributed processing. The processing involves in principle where the space can be global in the whole network because of interest span the entire geographic region where the WSN is positioned where the bulk of the dispensation happens only in some narrow range of concern.

3.5. Time

The definition of time period is related to the system use of nodes, possesses a great effect on the required amount of energy proficiency and also connection. Nonetheless, the phrase time period may typify the approach the way to carry out the distributed processing. The application can accomplish sporadic jobs to collect sensor analyses if the network is used to observe some well-thought-out area. The collected data may possibly be used in auxiliary exploration but this elucidation is not energy efficient. Another solution is event triggered solution – the application is categorized as two stages:

- During event detection, the device is often slower, with each and every node seeing the prices this tester on the surroundings with less or perhaps absolutely no communication;
- If the event condition is come across, the WSN commences its distributed processing.

4. Sensor Positioning

Nodes in a sensor network status are a basic factor. Deployment of nodes and localization in the research are key issues. A number of key aims pertaining to sensor deployment, those are generally: network connection, network durability, area coverage, in addition to data fidelity.

4.1. Coverage

Generally thought to be hitches tend to point/target coverage, area coverage, k-coverage problem and energy-efficient coverage. When estimating the coverage of each sensor sector collective coverage of the underlying model and deploy sensors vary depending on the metric used to measure. Sensor disk model is the sensor coverage model that is most generally used. All factors within a disk centered on the actual sensor being included in the actual sensor are considered.

4.2. Distinguished Detection Levels

Distinguished sensor network deployment is also a significant concern. High detection probabilities are

required at certain sensitive areas like surveillance applications or underwater sensor deployment. Conversely, to decrease the cost, comparatively low detection probabilities are necessary for some not so sensitive areas.

4.3. Network Connectivity

In the event virtually any effective node could interconnect using any further effective nodes then the system is actually linked. Network connectivity is needed to ensure which emails are usually circulated towards the proper foundation train station and also system life finishes individuals lack of online connectivity. It really is strongly linked to vitality proficiency and also coverage. Transmission stages and also realizing ascertains their bond concerning connectivity and also coverage. Network connectivity is actually easy if the realizing selection of any node is a lot lower than this transmission selection.

4.4. Network Lifetime

Limited energy resources are one of the foremost challenges in the design of WSNs. The difficulty lies in the replacing or recharging of the battery of sensors. Function of WSNs cannot be harmed by failure of regular sensors, as adjoining sensors will take their place, on condition that the density of WSN is high.

4.5. Data Reliability

Confirming the integrity of the congregated data is evidently an imperative design aim of WSNs. A sensor network is basically consisting of independent sensor readings detected by fusing the event, provides a collective assessment. By lowering the false alarms probability and of object being missing, the reliability of the data is boosted. By some increase in the number of sensors broadcasting in a specific area related to the course will boost the accuracy of data.

4.6. Energy Efficiency

Each sensor node due to limited energy resources, we need an efficient way to use the sensor to increase the lifetime of the network. Relating to optimal placement of the problems associated with sensor networks for energy conservation, there are at least two approaches. The first approach is to use a paste-over between the sensing ranges for other sensors to go to a sleep method that enables to plan a program of active sensors. The second approach includes adjusting of sensing range for energy conservation.

4.7. Number of Nodes

Higher the number of nodes, higher will be the cost. Thus optimum node deployment is considered to attain the stated goals.

4.8. Fault Tolerance and Load Balancing

Fault-tolerant design to shorten the lifetime of the network is essential to prevent individual failures. The k-connected theory is the main focus of many authors. K-connectivity infers that there are k autonomous routes among every couple of nodes.

5. Related Works

A brief summation of the related literature is listed below-

Leu et al. (2015) [19] offered the latest local vitality aware clustering process termed REAC-IN (Regional Energy Aware Clustering using Isolated Nodes) applying singled out nodes intended for WSNs. Throughout REACH-IN, Cluster Heads (CH) will be selected based on weight. The receptors within each and every cluster along with the weight of the staying vitality of each and every sensor and is also established according to the local typical vitality. Inaccurately developed allocated clustering algorithms may lead nodes to be able to remoteness through CHs. Such singled out nodes takes in excessive amount of vitality to be able to get in touch with Sink. The length as well as local typical vitality between the receptors along with the drain is utilized to determine if the singled out node deliver its information to your CH node so they can your Sink to increase network life time. The simulation effects discovered in which REAC-IN may greater than additional clustering algorithms.

Wang et al. (2014) [4] suggested the fuzzy-based WSN simulation method, to research the actual sensor life time by means of considering the sleeping period rate, transmitting period rate along with remaining battery. MATLAB has been helpful to measure the simulations along with display it has a excellent efficiency for identifying sensor life time. In the simulation final results, these people figured the actual Sleep Time Rate (STR) is specifically proportional to life time and a sensor together with excessive Remaining Electric batteries of Sensor (RPS) can have a prolonged life time.

Wagh et al. (2014) [6] centred on picking the particular cluster head wisely applying retail info involving node i.e. it's nearby battery, outside battery power support along with topology power. This time of system can be stressed on this exploration papers which in turn explores intelligent collection of cluster head by utilizing retail centred strategy. This multi-objective aspects applying genetic algorithm are believed to unravel the issue. This proposed algorithm proves which the average fitness value to increase the particular time of the particular system and get estimated finest vitality option.

Sharma et al. [3] offered a structure a bunch structured process through which respected cluster head are picked at random. Instead of a supplementary expense regarding choosing intermediate nodes, offered criteria can give finest leads to simulations. The offered criteria has been balanced with your overall performance regarding LEACH (Low Vitality Adaptive Clustering Hierarchy) method along with simulation outcomes of your offered method regarding successful strength utilizations along with increased community lifetime provides optimized alternatives.

Ruperee et al. (2014) [5] planned the protocol of which procedures the data for the node on it's own as well as lowers the capacity of the supply by making use of Delta Modulation. The particular planned technique analyses the previous files importance and also the present files importance. It lowers the force use by means of reducing the dimensions of the supply. They discovered, with actually cluster dimension, the reduction in strength use can be 28% as well as for unequal cluster it can be 34%. The life on the sensor circle might be improved together with reduction in strength use.

Li et al. (2013) [20] suggested a new energy-efficient metric in multi-hop random wireless sensor networks (WSN) for relay node selection where the sensor nodes are dispersed unsystematically and the node circuit energy depletion is also considered. Under the guide of new metric, by picking the appropriate forwarding area radius and angle, they maximized the effective communicating distance per unit energy depletion. The proposed metric can be applied in multi-hop routing transmission.

Arbab et al. (2012) [9] planned an energy efficient clustering algorithm with regard to WSNs in line with the LEACH algorithm. The planned algorithm resolves any additional transmission difficulty that will take place in LEACH algorithm. Simulation final results ensures that this planned algorithm may reduce the vitality consumption of this circle and considerably improve the circle life with regard to LND (Last Node Dies) metric in the matter of the Base Sink.

Peng et al. (2012) [8] proposed an algorithm devised from LEACH, and research parameters considered were energy efficiency and latency. The overlap to go over regions seemed to be outlined plus a nodes-adaptive routine seemed to lower the volume of files along with LEACH protocol. The planned protocol seemed to be examined using the regular LEACH along with the performance of the planned protocol seemed to be verified being successful as well as competent.

Lee et al. (2012) [10] proposed a fuzzy logic primarily based clustering way of expand the lifetime of WSNs by consistently circulating this workload with the expansion towards strength predication. The actual simulation final results showed which the advised process is extremely effective versus additional dispersed algorithms. This specific report reveals this tactics that may be put on these large-scale instant sensor systems.

Xu et al. (2014) [21] proposed a fresh criteria according to HEED, called the Balanced Energy Efficiency (BEE) clustering criteria. Experimental final results demonstrated that the BEE surpassed HEED and also LEACH coming from extended life and also healthy sensor syndication views. In addition, they created the multi-hop edition of BEE, referred to as the Balanced Energy Efficiency Multi-hop (BEEM) clustering criteria, which often can further enhance the effectiveness of BEE.

Misbahuddin et al. (2014) [22] suggested a lossless data reduction algorithm that tests the data samples composed by sensor nodes of their non-variability. The advanced algorithm brings global positive improvement on energy depletion due to compact WSN package bulk. The presentation of the offered Data Reduction (DR) algorithm has been evaluated in the term of compression ratio.

Hoang et al. (2014) [2] presented a novel cluster head selection approach that takes obstacle aware criteria into consideration to prolong network lifetime and reliability. This method will allow deciding on the most likely sensor to become cluster head. Simulation benefits shows considerable benefits by means of decreasing 93% connected with misplaced packets inside circle, consequently refining the actual circle throughput around 53%. The option furthermore stretches the actual circle life time to 11%.

6. Limitations in Earlier Works

Listed below are the limits in prior works-

- The prevention of congestion has been neglected in the majority of existing research of WSNs.
- Token bucket algorithm has also been ignored in congestion control in WSNs.
- Multiplexing has not been used in current congestion control protocols to prevent congestion further.

7. Comparative Study

Table 1. Comparative study of Congestion Control in WSNs

Reference No.	Technique	Year	Centralized	Multi-hop	Reactivity	Node Distribution	Sink Location	Heterogeneous	Congestion Protocol
[15]	LEACH	2008	Yes	No	No	Uniform	Static	No	No
[21]	BEE	2014	Yes	No	No	Random/Uniform	Static	No	No
[21]	BEEM	2014	Yes	Yes	No	Random/Uniform	Static	No	No
[17]	DEEC	2006	Yes	No	No	Random	Static	No	No
[19]	REAC	2015	Yes	No	No	Uniform	Static	No	No
[19]	REAC-IN	2015	Yes	No	No	Uniform	Static	No	No
[5]	Delta Modulation	2014	No	Yes	Yes	Random/Uniform	Static	No	Yes
[3]	ACO	2014	Yes	No	Yes	Uniform	Static	Yes	Yes
[4]	Fuzzy-based	2014	No	No	No	Uniform	Static	No	No
[6]	Genetic Approach	2014	Yes	Yes	Yes	Uniform	Static	Yes	Yes
[10]	Fuzzy-based	2012	No	Yes	Yes	Uniform	Static	No	No
[9]	LEACH-based Relay	2012	Yes	No	Yes	Random	Static	No	No
[20]	Node Selection	2013	Yes	Yes	Yes	Random	Static	No	Yes
[8]	LEACH based	2012	No	No	No	Random	Static	Yes	No
[2]	LEACH based	2014	Yes	Yes	Yes	Uniform	Static	No	No
[14]	EEHC	2008	No	No	Yes	Random	Static	Yes	No
[16]	HEED	2007	No	Yes	No	Random/Uniform	Static	No	No

8. Conclusions

WSNs can increase the energy efficiency by using an appropriate clustering algorithm for combination of sensor nodes. However, the cluster head selection and assignment, and construction of clusters require additional overhead. Cluster nodes distributed algorithms designed incorrectly can lead to isolation from cluster heads. Such isolated nodes waste large amount of energy to communicate with sink. This paper has compared existing energy conservation algorithms and found that each technique has its own benefits and limitations over each other. However this work has found that the effect of congestion is ignored in majority of existing protocols. Therefore in near future congestion control strategies based clustering protocols will be proposed. This can improve the energy conservation rate and also decrease the packet dropping problem with existing networks.

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