



A Review on Priority Based Congestion Control Protocols for Wireless Sensor Networks

Navashish Kaur¹, Dinesh Kumar²¹Student, Masters of Technology, ²Associate Professor^{1,2}Department of CSE, GZS-PTU Campus, Bathinda, Punjab, India

Abstract: *Wireless Sensor Networks consists of sensor nodes which are scattered to sense the environment, gather data and transmit it to a base station for processing. Energy conservation in the Wireless Sensor Networks (WSN) is a very important task because of their limited battery power. The related works so far have been done have tried to solve the problem keeping in the mind the constraints of WSNs. In this paper, a survey on various clustering techniques has been done. Also a priority based application specific congestion control clustering (PASCCC) protocol has been studied, which integrates the mobility and heterogeneity of the nodes to detect congestion in a network. PASCCC is an energy efficient application specific clustering protocol for detecting congestion in a network using a queuing model. But the survey shows that PASCCC does not work effectively alone. Therefore the paper ends with the future scope to enhance the working of PASCCC.*

Keywords: WSNs, PASCCC

I. INTRODUCTION

Wireless Sensor network are consists of many small distributed sensor nodes offering the reliable monitoring in several environments such as for instance military and civil applications. In WSN every sensor node contains specific hardware receiving hardware, memory, processing unit, which are required. With the aid of networking tiny sensor nodes, it becomes easy to get the info about physical phenomena that was quite difficult with conventional methods. These node process data and send it to base station called as sink. For communication of data between nodes and sink many routing technologies are used initially, such as for instance direct communication and multi hop data transmission. But due to limited battery life of nodes these techniques weren't so effective due to early death of some nodes in both techniques were fail to achieve the network suitability periods.

A WSN contains a wide array of nodes which can be tightly or arbitrarily deployed in a location by which they have interest. There is Base Stations (BS) situated to sensing area. The bottom station having major function in WSN as sink send queries to nodes while nodes sense the asked queries and send the sensed information in a joint way reverse to Base station. Base station also serves as an entrance for outer surface system i.e. Internet. And so the number of information and send only relevant data to customer via internet is performed by Base station. Because it is known nodes have little batteries which are hard to change or recharge. So to check out such structural design (having a lot less transfer and concentrated communication space) to improve power saving. You will find positive structural design like flat-network architecture and hierarchical network architecture.

II. APPLICATIONS OF WSN

WSN is usually motivated from the armed operation's gives improved outcome to in comparison with conventional wired network. In WSN nodes may be deployed in unmanned region. There are also a lot of fields of WSN application like farming, home study, location monitoring, structural health monitoring, heavy manufacturing monitoring, and security monitoring.

i) **Air pollution monitoring:-** Wireless sensor networks have already been deployed in many cities (Stockholm, London and Brisbane) to monitor the concentration of dangerous gases for citizens. These can make the most of the ad hoc wireless links rather than wired installations, which also cause them to become more mobile for testing readings in various areas.

ii) **Forest fire detection:-** A network of Sensor Nodes may be installed in a forest to detect whenever a fire has started. The nodes may be designed with sensors to measure temperature, humidity and gases which are created by fire in the trees or vegetation. Early detection is crucial for an effective action of the fire fighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know whenever a fire is started and how it's spreading.

iii) **Landslide detection:-** A landslide detection system utilizes a wireless sensor network to detect the slight movements of soil and changes in a variety of parameters that could occur before or within a landslide Through the data gathered it might be possible to learn the occurrence of landslides long before it actually happens.

iv) **Water quality monitoring:-** Water quality monitoring involves analyzing water properties in dams, rivers, lakes & oceans, as well as underground water reserves. The use of many wireless distributed sensors enables the creation of an

even more accurate map of the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, without the need of manual data retrieval.

v) Natural disaster prevention:- Wireless sensor networks can effectively act to prevent the effects of natural disasters, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time.

vi) Water/Waste water monitoring:-Monitoring the product quality and amount of water includes many activities such as checking the quality of underground or surface water and ensuring a country's water infrastructure for the main benefit of both human and animal.

III. CLUSTERING

Clustering techniques in wireless sensor networks aims at gathering data among sets of nodes, which elect leaders among themselves. The first choice or cluster-heads has got the role of aggregating the data and reporting the data to the BS. The advantages with this scheme is so it reduces energy usage of each node and communication cost. The clustering algorithms which can be made is founded on homogeneity and heterogeneity of nodes. One of many earliest work proposing this process in WSNs is LEACH (Low Energy Adaptive Clustering Hierarchy). Recently, there has been plenty of other clustering techniques which are mostly variants of LEACH protocol with slight improvement and different application scenarios. DEEC (Design of a distributed energy-efficient clustering), EDACH (Energy-Driven Adaptive Clustering Hierarchy) and EEUC (An Energy-Efficient Unequal Clustering Mechanism) are all clustering techniques proposed with the objective of minimizing energy usage, while extending network life time. Clustered sensor network could be classified into two main types: homogeneous and heterogeneous sensor network. While energy efficiency in WSNs remains a function of uniform distribution of energy among sensor nodes, classifying clustering techniques is dependent upon the objectives in mind. The Optimal clustering technique may be the technique for the heterogeneity nodes.

Clustering Objectives

Various objectives have been pursued by different literatures in designing clustering architecture for WSN. Most objectives are set to meet the application form constraints.

(i) Maximizing network Life-time

Unlike in cellular networks, where mobile gadgets (e.g. phones) can quickly be recharged constantly after battery drainage, thus power management in these networks remains a secondary issue. However, WSN is heavily constrained in this regard, apart from being infrastructure-less system their electric batteries is quite limited. All of the sensor nodes are equipped with minimal power source. Thus, power efficiency will remain of growing concern and will remain one of the main design objectives of WSN. To be able to cope with energy management in WSN, clustering scheme has been pursued, to extend network life-time and help ease the burden of each node transmitting straight to BS as in conventional protocols like Direct Transmission. When some nodes which are receiving less energy in the WSN then aim is to offer the vitality to that nodes before they declared to be fully dead nodes.

(ii) Fault-tolerance

The failure of an alarm node needs to have a small elect on the entire network system. The truth that sensor nodes will undoubtedly be deployed in harsh environmental conditions, there's tendency that some nodes may fail or be physically damaged. Some clustering techniques have been proposed to address the problem of node failure by using proxy cluster-heads, in case of failure of the original elected cluster-head or have minimal power for transmission. Various other literatures have employed adaptive clustering scheme, to deal with node failures such as for example rotating the cluster-head. Tolerating node failure is one of the other design goals of clustering protocols.

(iii) Load balancing

Load balancing technique might be another design goal of clustering schemes. It is always necessary to not over burden the cluster-heads as this could deplete their energies faster. So, it is important to have even distribution of nodes in each cluster. Especially in cases where cluster-heads are performing data aggregation and other signal processing task, an uneven characterization can extend the latency or communication delay to the base station.

IV. PASCCC: PRIORITY-BASED APPLICATION-SPECIFIC CONGESTION CONTROL CLUSTERING PROTOCOL

In this section, reveal description of distributed cluster-based routing protocol is given. To the most effective of knowledge, PASCCC is the very first protocol of its kind to take into account mobility, heterogeneity, and congestion detection and mitigation utilizing a cluster hierarchy. Many studies have addressed congestion detection and mitigation, but they're either generic or specifically linked to the transport layer. Following assumptions about the PASCCC are created:-

1. Nodes are deployed randomly in the field with a different group of energy values.
2. Nodes can handle adjusting their transmission power to be able to reach a very distant CH throughout a specific round.
3. The positioning of a BS isn't fixed and it may be either within or beyond your sensor field.
4. Nodes can handle moving across the field to cover vacant spaces utilizing the random waypoint mobility model with a rate V , where the value of V ranges between V_{min} and V_{max} . Hence, complete coverage of the sensor field is guaranteed.

Framework of PASCCC

In PASCCC, the nodes can handle moving across the field if required to be able to cover vacant regions. Mobility ensures complete coverage and connectivity at all times. Hence, it is less likely that generated events should go unreported. In PASCCC, 10% of the nodes are advanced. These nodes have higher energy levels compared with normal nodes, thereby creating a heterogeneous number of nodes in the network. PASCCC is an application-specific protocol. In scheme, two application parameters are considered using PASCCC: temperature and humidity. PASCCC acts as a reactive protocol for temperature monitoring and as a proactive protocol for humidity. In reactive routing protocols, the nodes react immediately to sudden and drastic changes in the values of sensed events, and they're suited to time-critical applications. In proactive routing protocols, the nodes turn on their transmitters, sense the environmental surroundings, and report captured data periodically to the BS. These protocols are suited to applications that require periodic data transmission.

V. LITERATURE SURVEY

Zawodniok, Maciej, and Sarangapani Jagannathan et al. [1] presented a novel, decentralized, predictive congestion control for wireless sensor networks. The DPCC consists of an adaptive flow and adaptive back-off interval selection schemes that work in concert with energy efficient, distributed power control (DPC). The DPCC detects the onset of congestion using queue utilization and the embedded channel estimator algorithm in DPC that predicts the channel quality. Then, an adaptive flow control scheme selects suitable rate which is enforced by the newly proposed adaptive back off interval selection scheme. An optional adaptive scheduling scheme updates weights associated with each packet to guarantee the weighted fairness during congestion. Closed-loop stability of the proposed hop-by-hop congestion control is demonstrated by using the Lyapunov-based approach. Results after simulating reveal that the DPCC reduces congestion and improves performance over congestion detection and avoidance (CODA) [3] and IEEE 802.11 protocols. Wang, Chonggang et al. [2] proposed a novel upstream congestion control protocol for WSNs, called priority-based congestion control protocol (PCCP). Unlike existing work, PCCP innovatively measures congestion degree as the ratio of packet inter-arrival time along over packet service time. PCCP still introduced node priority index to reflect the importance of each sensor node. Based on the introduced congestion degree and node priority index, PCCP utilizes a cross-layer optimization and imposes a hop-by-hop approach to control congestion. They have demonstrated that PCCP achieves efficient congestion control and flexible weighted fairness for both single-path and multi-path routing, as a result this leads to raised energy efficiency and better QoS in terms of both packet loss rate and delay. Larsen, Carl et al. [3] presented a routing-aware predictive congestion control (RPCC) yet decentralized scheme for WSN that uses a combination of a hop by hop congestion control mechanism to maintain desired level of buffer occupancy, and a dynamic routing scheme that works in concert with the congestion control mechanism to forward the packets through less congested nodes. The proposed adaptive approach restricts the incoming traffic thus preventing buffer overflow while maintaining the rate through an adaptive back-off interval selection scheme. Furthermore, the suitable routing scheme diverts traffic from congested nodes through alternative paths in order to balance the load in the network, alleviating congestion. This load balancing of the routes will even out the congestion level throughout the network thus increasing throughput and reducing end to end delay. Closed-loop stability of the proposed hop-by-hop congestion control is demonstrated by using the Lyapunov-based approach. Results observed after simulating tells that the proposed scheme results in reduced end-to-end delays. Yaghmaee, Mohammad Hossein, and Donald Adjeroh et al. [4] presented a new queue based congestion control protocol with priority support (QCCP-PS), utilising the queue length being an indication of congestion degree. The rate assignment to each traffic source is based on its priority index along with its current congestion degree. Simulation results show that the proposed QCCP-PS protocol can detect congestion better than previous mechanisms. Furthermore it includes a good achieved priority close to the ideal and near-zero packet loss probability, which make it an efficient congestion control protocol for multimedia traffic in WMSNs. As congestion wastes the scarce energy as a result of large number of retransmissions and packet drops, the proposed QCCP-PS protocol can save energy at each node, given the reduced number of retransmissions and packet losses. Yaghmaee, Mohammad Hossein, and Donald Adjeroh [5] discussed that the available congestion control schemes, like transport control protocol (TCP), when applied to wireless networks results in a large number of packet drops, unfairness with an important number of wasted energy as an outcome of retransmissions. To totally utilize the hop by hop feedback information, a suite of novel, decentralized, predictive congestion control schemes are proposed for wireless sensor networks in concert with distributed power control (DPC). Besides providing energy efficient solution, embedded channel estimator in DPC predicts the channel quality. By using the channel quality and node queue utilizations, the onset of network congestion is predicted and congestion control is initiated. Stability of the hop by hop congestion control is demonstrated with a Lyapunov-based approach. Simulation results reveal that the proposed schemes lead to fewer dropped packets than a network with no hop-by-hop congestion control, better fairness index and network efficiency, higher aggregate throughput, and smaller end-to-end delays over one other available schemes like IEEE 802.11 protocol. Sheu, Jang-Ping, and Wei-Kai Hu [6] proposed a hybrid congestion control protocol that considers not only the packets delivery rate but also retains the buffer size of each node. The proposed protocol may avoid packets drop due to traffic congestion and improve the network throughput. The simulation results show that the performance of the proposed protocol is better than the previous works. Liu, Yong-Min, and Xin-hua Jiang [7] studied TCP's throughput issues in wireless sensor networks, and designs an improved congestion control algorithm on the basis of the characteristics of the wireless sensor networks. The protocol is made as extension to DCCP (datagram congestion control protocol) with a new congestion control component. They also implemented this congestion control algorithm in

NS2. Simulation results show improvements on throughput accomplished by using Extended congestion control algorithm. Liu, Yong-Min et al. [8] studied TCP psilas throughput issues in Wireless Sensor Networks, and designs a better congestion control algorithm on the basis of the characteristics of the Wireless Sensor Networks. The protocol is made as improvement to DCCP (Datagram Congestion Control Protocol) with a new congestion control component. They have also implemented this congestion control algorithm in NS2. Their simulation results demonstrate that the improved DCCP techniques are highly throughput in dealing with data transfer process. Liang, Lulu et al. [9] proposed a congestion-aware mac protocol (C-MAC) for wireless sensor networks. In C-MAC, cool off delay of the nodes around contention area is adopted as a congestion indication. In normal state, the CSMA/CA is working well at sensor nodes. And when the congestion occurs, localized TDMA replaces the CSMA/CA in the congestion nodes. With the aforementioned mechanism, the congestion nodes only deliver their data during its assigned slots to control the contention overhead. Finally, they implemented the C-MAC in their sensor network test bed. The experiment results reveal that the proposed MAC protocol could effectively operate on the congestion caused by burst information, and reduce both the delay and packet loss rate significantly. Alikhanzadeh, Samaneh, and Mohammad Hossein Yaghmaee et al. [10] discussed that the most important challenges in WSNs is how to address congestion problem in such environments. The nature of WSN applications such as for instance data centric and many to one data flow and infrastructure of sensors offers different solutions. In a few particular applications of WSN such as reprogramming nodes or sending commands to them it is necessary that the sink has the capacity send data to the sensors in the least possible time. So in such stats, in addition to solving congestion in upstream direction, downstream congestion control can also be needed. Although you will find approaches that work on congestion in sensor to sink traffic but there is no protocol that control bidirectional congestion. In this paper, an approach based on learning automata is proposed. Each intermediate node possesses an automaton and makes decision to increase or decrease upstream and downstream data rate in accordance with feedback signal, which received from environment that sensor, works on it. Michopoulos, Vasilis et al. [11] argued that the presence (or lack) of RDC can drastically influence the performance of congestion detection. Furthermore, most WSN CC mechanisms are evaluated under traditional sensor network topologies and protocols (e.g. trickle data dissemination, tree data collection). The emerging IPv6 over Low power Wireless Personal Area Networks (6LoWPAN) and related standards pose a new requirement: they now need to investigate if previous findings regarding congestion control are still applicable. In this context, this paper contributes a thorough evaluation of existing congestion detection mechanisms in a simulated, multi-node 6LoWPAN sensor network. They presented results from two sets of experiments, differentiated by the presence or lack of RDC. Li, Mingwei, and Yuanwei Jing et al. [12] proposed innovative model and congestion control algorithm for wireless sensor networks based on feedback control, which will be referred to as Feedback Congestion Control (FBCC). The algorithm has been created by exploiting linear discrete time control theory. A feedback control scheme is established between children node and father node. The FBCC detects the onset of congestion using queue length. Then, a dynamic flow control scheme selects suitable incoming traffic, which is enforced by the newly proposed active scheme. Closed-loop stability of the proposed hop-by-hop congestion control is demonstrated by using the Lyapunov-based approach. The scheme makes congestion control in WSN rise to theoretical height. Simulation results show that the FBCC reduces congestion and improves performance over Congestion Detection and Avoidance (CODA). The results of simulations validate FBCC can avoid and alleviate congestion, and has reasonable effects of reliability, low energy consumption and high throughput. Sridevi, S., M. Usha, and G. Pauline Amertha Lithurin [13] proposed a priority based congestion control for heterogeneous traffic in multi path wireless sensor network. The proposed protocol allocates bandwidth proportional to the priority of several applications simultaneously running in the sensor nodes. Each sensor node route is own data as well as the information generated from other sensor nodes. The parent node of each sensor node allocates the bandwidth based on the source traffic priority and transit traffic priority of the information from heterogeneous applications in the little one node. Congestion is detected based on the packet service ratio and congestion notification is implicit. The normalized throughput comparison for simple fairness and weighted fairness is shown in the results. Lee, Joahyoung, and Byungtae Jang [14] proposed a new congestion control method based on a generalization algorithm is proposed. The proposed method selects data forwarding nodes that distribute the congested traffic over other sensor nodes and is available to guide data traffic between all sensor nodes fairly. This prevents biased energy consumption by some sensor nodes, and the total duration of the sensor nodes is prolonged by almost the total amount of saved battery energy. Kafi, M. et al. [15] discussed that the performance of wireless sensor networks (WSN) is affected by the loss communication medium, application diversity, dense deployment, limited processing power and storage capacity, frequent topology change. All these limitations provide significant and unique design challenges to data transport control in wireless sensor networks. A successful transport protocol should consider reliable message delivery, energy-efficiency, and quality of service and congestion control. The latter is essential for achieving a high throughput and a long network lifetime. Despite the huge number of protocols proposed in the literature, congestion control in WSN remains challenging. A review and taxonomy of the state-of-the-art protocols from the literature up to 2013 is provided in this paper. First, depending on the control policy, the protocols are split into resource control vs. traffic control. Traffic control protocols are either reactive or preventive (avoiding). Reactive solutions are classified following the reaction scale, while preventive solutions are split up into buffer limitation vs. interference control. Resource control protocols are classified according to the type of resource to be tuned. Farzaneh, Nazbanoo et al. [16] proposed a Dynamic Resource Control Protocol (DRCP) to control congestion in wireless sensor networks. DRCP utilizes multiple resources to control congestion. DRCP alleviates congestion by controlling transmission power. Simulation results show the performance of the proposed protocol that improves system throughput, and decreases packet dropping, while saving energy.

VI. COMPARISON LIST

Table 1 shows the comparison of the various techniques.

Table 1: Comparison of various techniques

REF	AUTHORS	YEAR	TECHNIQUE	FEATURES	LIMITATIONS
[1]	Zawodniok, Maciej, and Sarangapani Jagannathan	2007	Predictive congestion control protocol	reduces congestion and improves performance over congestion detection and avoidance	The use of congestion prevention has been neglected
[2]	Wang, Chonggang, Bo Li, Kazem Sohraby, Mahmoud Daneshmand, and Yueming Hu.	2007	Upstream congestion control through cross-layer optimization	leads to raised energy efficiency and better QoS in terms of both packet loss rate and delay	The use of Quality of Service (QoS) algorithm has also ignored in congestion control in WSNs.
[3]	Larsen, Carl, Maciej Zawodniok, and Sarangapani Jagannathan	2007	Route aware predictive congestion control protocol	reduced end-to-end delays	the use of genetic algorithm based multipath has been ignored
[4]	Yaghmaee, Mohammad Hossein, and Donald Adjeroh	2008	priority based congestion control protocol	reduced number of retransmissions and packet losses	The use of congestion prevention has been neglected
[6]	Sheu, Jang-Ping, and Wei-Kai Hu	2008	Hybrid congestion control protocol	avoid packets drop due to traffic congestion and improve the network throughput.	the use of genetic algorithm based multipath has been ignored
[7]	Liu, Yong-Min, and Xin-hua Jiang	2009	AN extended DCCP congestion control	improvements on throughput accomplished by using Extended congestion control algorithm	The use of congestion prevention has been neglected
[8]	Liu, Yong-Min, Xin-hua Jiang, Xiao-Hong Nian, and Wu-Yi Lu	2009	Improved DCCP congestion control	highly throughput in dealing with data transfer process	The use of Quality of Service (QoS) algorithm has also ignored in congestion control in WSNs.
[9]	Liang, Lulu, Deyun Gao, Yajuan Qin, and Hongke Zhang	2010	An adaptive congestion-aware MAC protocol	reduce both the delay and packet loss rate	the use of genetic algorithm based multipath has been ignored
[10]	Alikhanzadeh, Samaneh, and Mohammad Hossein Yaghmaee.	2010	A learning based protocol for bidirectional congestion control	control bidirectional congestion	The use of congestion prevention has been neglected
[11]	Michopoulos, Vasilis, Lin Guan, George Oikonomou, and Iain Phillips	2011	congestion control algorithms	drastically influence the performance of congestion detection	The use of Quality of Service (QoS) algorithm has also ignored in congestion control in WSNs.
[12]	Li, Mingwei, and Yuanwei Jing.	2012	Feedback congestion control protocol	avoid and alleviate congestion, and has reasonable effects of reliability, low energy consumption and high throughput	the use of genetic algorithm based multipath has been ignored

[13]	Sridevi, S., M. Usha, and G. Pauline Amertha Lithurin.	2012	Priority based congestion control	simple fairness and weighted fairness	The use of congestion prevention has been neglected
[14]	Lee, Joahyoung, and Byungtae Jang.	2013	Generalization-based congestion control protocol	prevents biased energy consumption	The use of Quality of Service (QoS) algorithm has also ignored in congestion control in WSNs.
[15]	Kafi, M., Djamel Djenouri, Jalel Ben-Othman, and Nadjib Badache.	2014	Congestion control protocols	consider reliable message delivery, energy-efficiency, and quality of service and congestion control	the use of genetic algorithm based multipath has been ignored
[16]	Farzaneh, Nazbanoo, Mohammad Hossein Yaghmaee, and Mehdi Dehghan Takht Fooladi.	2014	DRCP: A Dynamic Resource Control Protocol	improves system throughput, and decreases packet dropping, while saving energy	The use of congestion prevention has been neglected

VII. CONCLUSION AND FUTURE SCOPE

In this paper, the survey has shown that the use of congestion prevention has been neglected in majority of existing research of WSN. Moreover the use of Quality of Service (QoS) algorithm has also ignored in congestion control in WSNs. Also most of the existing congestion control protocols are based on single path, the use of genetic algorithm based multipath has been ignored. In near future, to overcome these issues, a new QoS and genetic algorithm based PASCCC protocol may be proposed. The QoS parameters will be used to improve the cluster head selection to balance the energy consumption in more proficient manner.

REFERENCES

- [1] Zawodniok, Maciej, and Sarangapani Jagannathan. "Predictive congestion control protocol for wireless sensor networks." *Wireless Communications, IEEE Transactions on* 6, no. 11 (2007): 3955-3963.
- [2] Wang, Chonggang, Bo Li, Kazem Sohraby, Mahmoud Daneshmand, and Yueming Hu. "Upstream congestion control in wireless sensor networks through cross-layer optimization." *Selected Areas in Communications, IEEE Journal on* 25, no. 4 (2007): 786-795.
- [3] Larsen, Carl, Maciej Zawodniok, and Sarangapani Jagannathan. "Route aware predictive congestion control protocol for wireless sensor networks." In *Intelligent Control, 2007. ISIC 2007. IEEE 22nd International Symposium on*, pp. 13-18. IEEE, 2007.
- [4] Yaghmaee, Mohammad Hossein, and Donald Adjeroh. "A new priority based congestion control protocol for wireless multimedia sensor networks." In *World of Wireless, Mobile and Multimedia Networks, 2008. WoWMoM 2008. 2008 International Symposium on a*, pp. 1-8. IEEE, 2008.
- [5] Yaghmaee, Mohammad Hossein, and Donald Adjeroh. "A new priority based congestion control protocol for wireless multimedia sensor networks." In *World of Wireless, Mobile and Multimedia Networks, 2008. WoWMoM 2008. 2008 International Symposium on a*, pp. 1-8. IEEE, 2009.
- [6] Sheu, Jang-Ping, and Wei-Kai Hu. "Hybrid congestion control protocol in wireless sensor networks." In *Vehicular Technology Conference, 2008. VTC Spring 2008. IEEE*, pp. 213-217. IEEE, 2008.
- [7] Liu, Yong-Min, and Xin-hua Jiang. "A extended dccp congestion control in wireless sensor networks." In *Intelligent Systems and Applications, 2009. ISA 2009. International Workshop on*, pp. 1-4. IEEE, 2009.
- [8] Liu, Yong-Min, Xin-hua Jiang, Xiao-Hong Nian, and Wu-Yi Lu. "Improved dccp congestion control for wireless sensor networks." In *Computer and Information Science, 2009. ICIS 2009. Eighth IEEE/ACIS International Conference on*, pp. 194-198. IEEE, 2009.
- [9] Liang, Lulu, Deyun Gao, Yajuan Qin, and Hongke Zhang. "An adaptive congestion-aware MAC protocol for wireless sensor networks." In *Broadband Network and Multimedia Technology (IC-BNMT), 2010 3rd IEEE International Conference on*, pp. 1074-1078. IEEE, 2010.
- [10] Alikhanzadeh, Samaneh, and Mohammad Hossein Yaghmaee. "A learning based protocol for bidirectional congestion control in wireless sensor network." In *2010 International Conference on Information, Networking and Automation (ICINA)*. 2010.
- [11] Michopoulos, Vasilis, Lin Guan, George Oikonomou, and Iain Phillips. "A comparative study of congestion control algorithms in IPv6 wireless sensor networks." In *Distributed Computing in Sensor Systems and Workshops (DCOSS), 2011 International Conference on*, pp. 1-6. IEEE, 2011.
- [12] Li, Mingwei, and Yuanwei Jing. "Feedback congestion control protocol for wireless sensor networks." In *Control and Decision Conference (CCDC), 2012 24th Chinese*, pp. 4217-4220. IEEE, 2012.

- [13] Sridevi, S., M. Usha, and G. Pauline Amertha Lithurin. "Priority based congestion control for heterogeneous traffic in multipath wireless sensor networks." In *Computer Communication and Informatics (ICCCI), 2012 International Conference on*, pp. 1-5. IEEE, 2012.
- [14] Lee, Joahyoung, and Byungtae Jang. "Generalization-based congestion control protocol in wireless sensor network." In *ICT Convergence (ICTC), 2013 International Conference on*, pp. 865-870. IEEE, 2013.
- [15] Kafi, M., Djamel Djenouri, Jalel Ben-Othman, and Nadjib Badache. "Congestion control protocols in wireless sensor networks: A survey." (2014): 1-22.
- [16] Farzaneh, Nazbanoo, Mohammad Hossein Yaghmaee, and Mehdi Dehghan Takht Fooladi. "DRCP: A Dynamic Resource Control Protocol for alleviating congestion in Wireless Sensor Networks." In *Telecommunications (IST), 2014 7th International Symposium on*, pp. 1088-1093. IEEE, 2014.