Classical and Soft Computing based Congestion Control Protocols in WSNs: A Survey and Comparison

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ABSTRACT
Congestion in wireless sensor network (WSN) is one of the critical problems still from its evolution. Congestion in WSN can be a severe problem, as it causes plethora of malfunctions such as packet loss, lower throughput, energy efficiency, increase in collisions, increase in queuing delay and decreased network lifetime. As a result, the performance of the whole network is subject to undesirable and unpredictable changes. WSN performance control can be carried out by robust Congestion control approaches that aim to keep the network operational under varying network conditions. The potential paradigms of soft computing highly addressed their adaptability and compatibility to overwhelm the complex challenges in WSNs. This paper presents a comprehensive survey on classical and soft computing based congestion control mechanisms. In addition, a detailed comparison along with revealing their merits and demerits is presented. This work could bestow the researchers to come up with a broader and efficient approach to tackle the inherent problems of congestion in WSN.

1. INTRODUCTION
Wireless sensor network consist of multiple tiny, low powered, randomly distributed sensor nodes. It has the capability of sensing, processing, and communication over a wireless channel. In WSN, different types of data are generated and sent to the base station by nodes. These nodes may be stationary or moving. When large number of sensor nodes is active simultaneously transmitting the information, data traffic increases than the available capacity of network leading to congestion in the network. The main sources of congestion include buffer overflow, interference, channel contention, many to-one communication, etc. Congestion causes overall channel quality to degrade and loss rates to raise, leads to increased delays, and tends to be grossly unfair toward nodes whose data has to traverse a larger number of radio hops. In addition, congestion causes packet drops at buffer, increased queuing delay and increases packet retransmission. This consumes additional energy and wastage of communication resources. Congestion directly impact on energy efficiency, throughput, link utilization and network lifetime.

1.1 Reasons for Congestion
In WSNs, congestion occurs due to the following reasons when:

1) The offered traffic load exceeds the available capacity.
2) There is a increase in packet collision at the MAC layer due to sensors overhearing each other's radio transmissions.
3) The many-to-one communication creates a bottleneck when packets traverse towards the sink.
4) Delivery of myriad types of traffic, from simple periodic reports to unpredictable bursts of messages triggered by external events that are being sensed.
5) Radio channels vary in time and concurrent data transmissions over different radio links interact with each other.
6) The addition or removal of sensors, or a change in the report rate can cause previously decongested parts of the network to become under-provisioned and congested.
7) Lack of resources due to high reporting rates by numerous events.
8) Finally, when sensed events cause bursts of messages, congestion becomes even more likely.

1.2 Types of Congestion
There are two types of congestion in WSN, namely, node level and link-level.

1) Node-level congestion is occurred at a particular node when the packet inter arrival rate is greater than the scheduling rate, results in packet loss, increasing queuing.
2) Link-level congestion is occurred due to channel contention, interference, and packet collision due to accessing transmission medium simultaneously by multiple active sensor nodes.

1.3 Congestion Effects
The effects of congestion in WSN include:

1) The traffic from various parts of the network leads to congestion which in turn degrades the radio channel quality.
2) With a well-regulated traffic, the pitiable and time varying channel quality, asymmetric communication channels, and unseen terminals make the deliverance of the packets weaker.
3) When a packet traverses a large number of hops under traffic load, it gets penalized leading to large degrees of unfairness.
4) Buffer drop may occur due to degradation of overall channel quality. Delay can also be increased in the network due to this.
5) The link-level congestion causes increase in packet service time and decrease in link utilization. Energy efficiency and QoS is affected by both these congestions this decreases the network lifetime.

6) TCP congestion causes all segment losses. Due to this, window based flow control and congestion control are triggered.

7) Diverse data rate from very low rate periodic data to very high rate event data are generated by nodes. Hence, the capacity of the network is lesser than the aggregate traffic rate causing the bottleneck.

This paper presents a survey of soft computing based congestion detection, control and mitigating models that enriches the performance of the network and reviews classical congestion control models and compares them with soft computing models. Section 2 presents the classification of classical congestion control protocols. In Section 3, we compare several classical congestion control protocols. Some of the congestion control protocols based on soft computing paradigms are briefly described and a detailed comparison of congestion control based on soft computing paradigms with classical congestion control protocols is presented in Section 4. Section 5 concludes the paper and presents future work.

2. CLASSICAL CONGESTION CONTROL PROTOCOLS

Several classical congestion control protocols are found in the literature. They can be classified based on i. Rate, ii. Buffer, iii. Hybrid or Rate and buffer, iv. Priority, v. Cluster and vi. Multi-path routing and are briefed below:

2.1 Rate Control Based Protocols

In rate based congestion control protocols, each node estimates the number of flows derived from upstream nodes, and based on this it modulates the rate when congestion is detected. The mechanisms used by these protocols are reactive; in that, congestion is not estimated but reduced. In congestion mitigating protocols, nodes must continuously monitor their parents this consumes more energy and network resources. In these protocols, there is a chance that transmission frequency in non-congested source-sink path is reduced, if congestion is detected. Rate control approaches are considered to be the most appropriate when dealing with streaming applications. The protocols that follow this approach are as follows:

1) Congestion Detection and Avoidance (CODA) [26]: It is a typical congestion control mechanism in WSNs. It comprises of three mechanisms: i. Receiver-based congestion detection; ii. Open - loop hop-by-hop back pressure; and iii. Closed loop multi-source regulation. CODA guarantees that throughput satisfies the accurate request by adjusting rate in closed loop way.

2) Event-to-Sink Reliable Transport (ESRT) [25]: It is a transport solution developed to achieve reliable event detection in WSN with minimum energy expenditure. It includes a congestion control component that serves the dual purpose of achieving reliability and conserving energy. The protocol operation is determined by the current network state based on the reliability achieved and congestion condition in the network.

3) Pump Slowly, Fetch Quickly (PSFQ) [24]: The aim of PSFQ is to distribute data from a source node by pacing data at a relatively slow speed (“pump slowly”), but allowing nodes that experience data loss to fetch (i.e., recover) any missing segments from their local immediate neighbors aggressively(“fetch quickly”). It slowly injects packets into the network, but performing aggressive hop-by-hop recovery in case of packet losses. The pump operation in PSFQ simply performs controlled flooding and requires each intermediate node to create and maintain a data cache to be used for local loss recovery and in-sequence data delivery.

4) Interface Aware Fair Rate Control (IFRC) [20]: This protocol uses static queue thresholds to determine congestion level where as IFRC exercise congestion control by adjusting outgoing rate on each link based on AIMD scheme. Consequently the IFRC reduces the number of dropped packets by reducing the throughput. By contrast, the proposed scheme varies the rate adaptively based on the current and predicted congestion level. IFRC has high processing overhead and energy consumption.

5) Adaptive Rate Control (ARC) [30]: This protocol monitors the injection of packets into the traffic stream as well as route-through traffic. Each node estimates the number of upstream node and the bandwidth is split proportionally between route-through and locally generated traffic with preference given to the former. The resulting bandwidth allocated to each node is thus approximately fair. Also reduction in transmission rate of route-through traffic has a back pressure effect on upstream nodes, which in turn can reduce their transmission rates.

2.2 Buffer Based Protocols

Buffer based protocols forward their packets to their upstream neighbors, only when buffer has enough space to hold the packets. It does not consider the data rate of upstream and downstream neighbors. It eliminates the complicated rate based signaling. This scheme, unlike the rate based approaches does not drop the packets. The aftermath of these protocols is that, the congestion is alleviated earlier. These methods give the faster detection, and feedback action taken place at right time and they are best suited as reliable methods. Some of the buffer based congestion control protocols for WSN are briefly explained below:

1) Congestion Avoidance Based on Lightweight Buffer Management [21]: This mechanism prevents data packets from overflowing the buffer space of the intermediate sensors. These approaches automatically adapt the sensors’ forwarding rates to nearly optimal without causing congestion. The mechanisms are introduced with responsibility for precise congestion discovery and weighted fair congestion control.

2) Buffer based Media Access and Greedy Routing Scheme [10]: This scheme proposes a buffer based media access control combined with greedy routing scheme in WSN. The scheme provides highest priority for the node with maximum occupied buffers (containing event information) for media access. The routing is carried out through greedy algorithm; this makes an optimal choice of next hop for forwarding.

3) RMST: Reliable Data Transport in Sensor Networks [27]: RMST (Reliable Multi-Segment Transport), is a new transport layer for Directed Diffusion. RMST provides guaranteed delivery and fragmentation / reassembly for applications that require them. RMST is a selective NACK-based protocol that can be configured for in-network caching and repair.

4) GARUDA: Achieving Effective Reliability for downstream Communication in Wireless Sensor Networks [26]: In this paper, the problem of reliable sink-to-sensors data delivery is considered. A scalable framework for reliable downstream data delivery that is specifically designed to both address and leverages the characteristics of the wireless sensor networks while achieving the reliability in an efficient manner is proposed.

2.3 Priority based protocols

In WSNs, different packets may be of different importance in the serving of event detection. Since the precision of sensors decreases when the distance grows, the data collected by the nodes closer to the event are usually more precise than those collected by nodes farther away, and therefore more critical to the application when the network fails to transmit all packets to sink, it should try its best to transmit the packets which are more important. Priority can be utilized to describe the importance of the packet, node, congestion control mechanisms include the following link or application. Some of the priority based congestion control mechanisms include the following:

1) Priority-based Congestion control in wireless Sensor Networks (PCCP) [7]: In PCCP, packet inter-arrival time and packet service time are calculated in order to produce a measure of congestion. By incorporating information about packet inter-arrival time and the packet service time, congestion at the node level or at the link level are captured. PCCP realizes priority-dependent weighted fairness which allows sensor nodes to receive priority-dependent throughput. This protocol results in low buffer occupancy. As a result, it can avoid and/or reduce packet loss and therefore improve energy efficiency. It achieves high link utilization and low packet delay.

2) Priority based Queue Management (PBQM) [32]: In PBQM, priority to each packet is assigned and priority to the packets is assigned in three ways. Packets are ordered in the queue according to their priority. Packets with higher priority will be serviced before those with lower priority. This method will not increase the throughput of the network because there will be dropping of low priority packets.

2.4 Cluster based Protocols

Cluster based congestion control techniques are developed keeping in mind the following aspects: i. Provision for distributed mechanisms for congestion control and ii. Management of flows from multiple classes of traffic. In the existing methods, congestion is estimated and action is taken on a per node basis where as in cluster based techniques congestion is monitored in its localized scope. In cluster approach the nodes are divided into various cluster groups and in each group there is one cluster head.

1) Cluster-Based Congestion Control for Supporting Multiple Classes of Traffic (CMOUT) [8]: CMOUT is a scalable and distributed framework for eliminating congestion and supporting multiple classes of flows in event-based sensor networks. It is based on self organization of the network into clusters each of which autonomously and proactively monitors congestion within its localized scope. The clusters then exchange appropriate information to facilitate system wide rate control where, each data source, depending on the relative importance of its data flow and the experienced congestion en route the sink, is coerced into controlling its rate.
2) Clustering based Energy Efficient Congestion Aware Protocol [6]: This protocol investigates the cluster head election problem and congestion management problem. It deals on applications where the energy of full network is the main requirement, and proposes a new approach to exploit efficiently the network energy, by reducing the energy consumed for cluster forming and reducing the congestion to provide the better efficiency for the high priority data.
3) Cluster Based Congestion Control Protocol (CBCC) [14]: This protocol consists of scalable and distributed cluster based mechanisms for supporting congestion control in WSN. Nodes were grouped into clusters and messages are exchanged between cluster head and their associated nodes, while nodes perform local computations of estimated traffic load the estimated information is processed by the cluster head and a collective cluster level load estimate is transmitted to the cluster heads towards the source clusters. This allows source nodes to regulate their sending rate based on the congestion level in traffic path. This protocol is highly efficient in dealing with multiple flows by achieving good packet delivery ratio, high throughput and low delay.

2.5 Congestion Control by Multi-path Routing

In these protocols, the traffic is transmitted using multiple paths to reach the destination and high priority packets are transmitted prior in the presence of congestion. Hence, these protocols achieve a high degree of reliability.

1) Congestion Aware Routing (CAR) [23]: This mechanism enforces a differentiated routing approach to discover the congested zone of the network that exists between high priority data source and data sink and to dedicate this portion of network to forward primarily high priority traffic.

2) Traffic Aware Dynamic Routing (TADR) [12]: This protocol is proposed to route packets around the congestion areas and scatter the excessive packets along multiple paths consisting of idle and under loaded nodes.

3) Biased Geographic Routing (BGR) [9]: It is a light weight stateless, geographical forwarding protocol. It is a cost effective complement to greedy routing. BGR routes packets on curved trajectories by forwarding packets along curves, instead of shortest path.

3. COMPARISON OF CLASSICAL CONGESTION CONTROL PROTOCOLS

Table 1 presents the comparison of rate and buffer based congestion control protocols. In Table 2, the five types of classical congestion control protocols are compared in detail. The protocols are compared based on how the congestion is detected, notified and avoided. They are also compared based on energy efficiency, QoS, nature of data flow, delay, type of routing, number of paths and link utilization.

4. CONGESTION CONTROL PROTOCOLS BASED ON SOFT COMPUTING (SC)

SC techniques are smart and intellectual techniques that enhance the effectiveness of WSNs. SC techniques optimize power consumption, network challenges and design and deployment aspects. The European Centre for Soft Computing defines it as “A set of computational techniques to solve problems by imitating nature’s approaches”. The soft computing paradigms such as Swarm Intelligence (SI), Fuzzy Logic (FL), Game Theory (GT) have been applied to different WSN applications and deployment based on their dynamic and heterogeneous characteristics.

4.1 Swarm Intelligence

This soft computing paradigm is an evolved system of collective intelligent groups of simple agents that interacts with each other’s and the environment around. It is characterized with decentralization. Individual agents act by following simple rules that accumulatively lead to global system behavior.

1) Congestion Control in Wireless Sensor Networks based on Bird Flocking Behavior (FLOCK-CC)[2]: In this approach packets are modeled as birds flying over a topological space (sensor network), packets are modeled as bird flocks and fly towards a global attractor (sink), whilst trying to avoid obstacles (congested regions). The direction of motion is influenced by repulsion and attraction forces and the gravitational force in the direction of the sink. The performance is measured using energy tax metric.

2) A Swarm Intelligence Congestion Control Approach for Autonomous Decentralized Communication Networks [3]: In this method swarm approach of the work in [2] is reformulated from a metrical space to a topological one (graph of nodes). To provide the direction of motion of packets, limited visual perception of birds is used, each packet moves within finite field of perception.

Table 1. Comparison of rate and buffer based congestion protocols

Congestion Control Technique	ESRT[25]	PSFQ[24]	RMST[27]	GARUDA[15]
Direction	Upstream	Downstream	Upstream	Downstream
Type of Reliability	Event-Driven	Packet-Driven	Packet-Driven	Packet/Destination -Driven
Loss Detection and Notification	Implicit	NACK	NACK	NACK
Loss Recovery	End-to-End	Hop-by-Hop	Hop-by-Hop	Two-tier Two-stage
Loss Recovery Control	Sink establishes update frequency	Receiver Node	Receiver Node	Receiver Node
Application	Signal estimation/	Reliability Applications	Multimedia Applications	Reliability Applications
Sensor Deployment	Ad-hoc	Linear	Grid	Grid

Table 2. Comparison of classical congestion protocols

Type	Congestion Detection	Congestion Notification	Congestion Avoidance	Energy Efficiency	QoS	Data Flow Nature	Dela y	Reactive/ Proactive	Single / Multi path	Link utilization
Rate [26],[25] [24] [20],[30]	Channel l status & buffer occupancy	Implicit piggyback	Rate adjustment	Energy Efficient	Not Conce rned	Not Classified	High	Reactive	Single	Low
Buffer [21],[10] [27],[15]	Buffer occupancy	Implicit Piggyback	Rate adjustment	Energy Efficient	Not QoS Conce rned	Not Classified	High	Reactive	Single	Low
Priority [22],[18] [17] [11],[4]	Packet interarrival & service time	Explicit Notification	Rate adjustment	Energy Efficient	Few QoS param eters	High & Low Priority packets	Low for HP High for LP	Both	Both	High
Cluster [23],[12] [5]	Traffic intensity @ cluster level & packet rate at node level	Explicit Notification	Redirect traffic from hot spot	Energy Efficient	Not QoS Conce rned	Multiple interfering node	Low	Proactive	Both	High
Multipath [23],[12] [9]	Buffer Occupancy	Explicit Notification	Utilization of unused path & uncongested nodes	Energy Efficient	Few QoS param eters	High & Low Priority packets	High	Proactive	Multip ath	High

3) Employing the Flocking Beh ior of Birds for Controlling Congestion in Autonomous Decentralized av Networks [15]: In this mechanism a bio-inspired, scalable and self-adaptive congestion control approach is proposed. This approach prevents congestion in WSNs by regulating the rate of each traffic flow based on the Lotka-Volterra [LV] hop-by-hop population model. Table 3 provides the comparison of some of the swarm intelligence based congestion control protocols with classical congestion control protocols presented in Section 2.

4.2 Fuzzy Congestion Control Techniques

Fuzzy logic methodology helps to have a proactive approach to solve QoS related issues. Fuzzy logic is very effective to manage the performance of WSN, without requiring a mathematical model. Fuzzy control theory provides formal techniques to represent manipulate and implement human expert's heuristic knowledge for controlling WSN. Some of the congestion control protocols based on fuzzy logic are as follows:

1) Efficient Fuzzy based Congestion Control Technique [31]: This technique takes into consideration the node degree, queue length and the data arrival rate as parameters for congestion detection. The fuzzy logic table accepts the values of data arrival rate, node degree and the queue length as input and the output is given in the form of fuzzy variables which indicates the level of congestion.

2) Fuzzy Logic based Congestion Estimation for QoS [29]: A congestion estimation model for QoS in WSN was proposed, and implemented using fuzzy logic with fuzzy set variables. For the purpose of QoS administration, both at the node level and the sink, the QoS management and control module is essential. Here, the resource constrained WSN will not be impeded since the the QoS module implemented at sensor node forms a subset of the larger QoS Management and control module so that system has a wider information.

Table 3. Summary of fuzzy congestion control protocols

Fuzzy Technique	Input parameter	Output parameter	Merits	Demerits
Fuzzy based congestion estimation [23]	• Net packet arrival rate • Current buffer occupancy	Congestion estimation	• Enhances QoS mechanisms	Not energy efficient
Fuzzy based rate control [12]	• Queue length • Outgoing flow rate	Congestion detection	• Simple, Low complexity • Energy efficient	Increased delay per packet
Fuzzy based trust estimation [8]	• No. of forward packets • Delay of forward packets • Validity of forward packets Buffer capacity	Trust value	• Increased packet delivery • Reduced packet ratio loss	More no. of inputs Not energy efficient
FEEPRP [13]	• Energy • Hop count • Packet Dropped	Appropriate choice of route	• Provides secure route by avoiding malicious nodes • Energy efficient	Low packet delivery ratio

Table 4. Comparison of priority and fuzzy based protocols with data flow and rate parameters

Metric	Parameter	PCCP[7] / FLC[8] / PHTCCP[17]
Network Efficiency	Data Flow	PCCP > FLC > PHTCCP
Delivery Ratio	Data Flow	PCCP < FLC < PHTCCP
Drop of packets	Data Flow	PCCP > FLC > PHTCCP
Throughput	Data Flow	PCCP < FLC < PHTCCP
Network Efficiency	Rate	PCCP > FLC > PHTCCP
Delivery Ratio	Rate	PCCP < FLC < PHTCCP
Drop of packets	Rate	PCCP > FLC > PHTCCP
Throughput	Rate	PCCP < FLC < PHTCCP

3) Fuzzy logic control based QoS management (FLCQM) [11]: This is a scheme for WSNs with constrained resources and in dynamic and unpredictable environments. In WSNs, the feedback control technology is used in order to deal with the impulsive changes of traffic load. The sampling period to the deadline miss ratio coupled with the data transmission can be adapted using a fuzzy logic controller in the sensor node. In order to achieve the required QoS, the deadlines miss ratio needs to be sustained at a pre-determined desired level. The FLC-QM has the advantages of generality, scalability, and simplicity.

4) Rate Control in Wireless Sensor Networks for Mitigating Congestion [5]: In this protocol, to mitigate congestion, the buffer length of the sensor node is continuously monitored using the congestion headers br-stamp, delay-stamp and rate stamp fields in the packet header. Fuzzy logic congestion detection system will calculate the probability of congestion using congestion header of packets.

5) Congestion control in Heterogeneous Resources using Fuzzy logic [18]: In this mechanism to detect and control the congestion buffer occupancy is considered. Using fuzzy logic

theory periodically congestion degree is calculated at node level at the same time each upstream traffic rate is emphasized according to the value of the congestion degree. This scheme can quickly solve the status and trends of the network.

6) Fuzzy logic-based Energy Efficient Packet Loss Preventive Routing (FEEPLPRP) [22]: This protocol adopts a routing protocol which imparts security in terms of avoiding malicious nodes and prevents data loss as well as constrains the utilization of excess energy. It exploits the fuzzy decision making model to avail an energy-efficient secure route to the destination.

Table 3 summarizes several fuzzy congestion control protocols along with their merits and demerits and in Table 4, we compare priority and fuzzy based protocols using data flow and rate parameters.

4.3 Game Theory (GT)

Intelligent rational decision-makers. In particular, the theory has been proven very useful in the design of WSNs. GT has been successfully applied in routing protocol design, topology control, power control and energy saving, packet forwarding, data collection, spectrum allocation, bandwidth allocation, quality of service control, coverage optimization, security, and other sensor management tasks in wireless sensor networks. Some of the GT based congestion control protocols for WSN are briefed in the following:

1) A Game-theoretic Framework for Congestion Control in General Topology Networks Decision and Control [2]: In this approach a game-theoretic framework is designed for congestion control in general topology networks along with varying behavior and preferences for individual users. A distributed, market-based, end-to-end framework that addresses congestion control, problems for a large class of communication networks at Nash equilibrium is designed.

Table 5. Comparison of swarm intelligence based congestion Control Protocols with Classical Congestion Control Protocols

Criteria	Swarm intelligence	Classical
Dynamic	Not sensitive, handles efficiently	Sensitive
Self-organizing	Applied globally	Applied individually
Congestion Detection	End-to-end	Buffer drops
CC mechanism	Nature-inspired	throttle injecting traffic
QoS	More QoS parameters	Trade off with QoS
Optimization	From sub-optimal paths	Mathematical models
Energy Consumption	Energy efficient	Not all protocols
Packet Delivery Ratio	High for all low, mid high load network type	Not for all network types
End-to-End delay	Low for all low, mid & high load network type	Not for all network types

Table 6. Comparison of classical and swarm intelligence congestion control protocols

Congestion	Computation	Flexibility	Security	Energy Efficiency
Swarm intelligence	Low	High	Low	High
Fuzzy Logic	Medium	High	High	Medium
Classical	High	Low	Low	Medium

2) A Game Theory-Based Obstacle Avoidance Routing Protocol for Wireless Sensor Network [1]: In this approach, a novel protocol is proposed to handle the obstacle problem based on forwarding mechanisms in sensor networks. This protocol first computes the connectivity degree set for every node and separates the degree set into out-degree and in-degree sets. A concave region in the sensor network is established. Packets cannot be forwarded to the concave region and this approach can avoid lost packets and reduce the transmission delay. Furthermore, a game theory model based on the forwarding probability of forwarding participants is provided and proven that in the game model a Nash equilibrium exists.

3) A Game-theoretic Approach towards Congestion Control in Communication Networks [30]: In this paper, a game theoretic approach towards congestion control is proposed. The crux of the approach is to deploy schedulers and/or buffer management policies at intermediate switches and routers that punish misbehaving flows by cutting down their rates thereby encouraging well behaved flows. A class of scheduling protocols called Diminishing Weight Scheduling (DWS) is proposed that punish misbehaving flows in such a way that. the resulting game-theoretic equilibrium results in fair resource allocations.

5. CONCLUSION AND FUTURE WORK

From the review and comparisons, it is clearly seen that, significant efforts have been made in addressing the congestion control techniques to design effective and efficient congestion control protocols for WSNs. This paper presents a comprehensive survey of the most updated techniques for congestion control in WSNs based on classical congestion control and soft computing paradigms. A soft computing paradigm has less computational overhead and more flexibility than classical methods because the SC techniques computations are not applied individually but applied globally. In fuzzy logic approaches, rules can be modified and more variables can be considered to represent the dynamic nature of WSN. Moreover, additional QoS parameters can be considered in soft computing paradigms for all type of traffic loads in the network and said to be are energy efficient. Further research would be needed to address issues such as QoS posed by video and imaging sensors and real-time applications in congestion control protocols. This paper shall encourage researchers working in the area of congestion control to take into account the various protocol characteristics when designing an efficient congestion control protocol, QoS awareness, energy efficiency, mathematical models, simulation environment and settings, finally real time implementation and finally using the potential benefits of soft computing. This will then enable and facilitate more research on the set goals as well as allow researchers to perform fair comparison.

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