International Journal on Emerging Technologies **11**(2): 1013-1025(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

An Approach providing Congestion Control & Avoidance using Priority based Energy Efficient mechanism for Internet of Things (IoT)

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(Received 22 January 2020, Revised 16 March 2020, Accepted 18 March 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: The developing Internet of Things (IoT) is expanding wireless sensor network systems (WSNs) for various applications. Energy efficiency and reliability are key components for the root of various gets to the sink. Internet of Things (IoT) is an idea that covers various articles and techniques for correspondence for the trading of data. Today, the IoT is progressively an unmistakable term for a dream that everything ought to be associated with the Internet. The IoT will be urgent later on the grounds that the idea opens up open doors for new administrations and new developments. This document proposes a new technique of Collision Avoidance with Priority (CAP), which would be the most appropriate for transmission nodes during the transmission of data between the senders node and the receiver in IOT based on WSN (Internet of Things). The research challenges on energy efficiency and congestion control factors are analyzed in this research work. The proposed method first collects information on the relay node and the distance of all relay nodes between the sending node and the receiving IOT sink node. Every time the sender wishes to communicate with the receiving node, the position of the relay nodes changes dynamically according to number of hop counts, and packet sequence number. The relay node having the least number of hop along with the earliest packet sequence number would be selected to forward the data towards the IOT sink node. The contribution made to the study that CAP technique improves the way to select a higher energy level node between the relays nodes between the transmitters and the receiver so that the optimized path has high reliability and durability during data transmission. The CAP technique will be implemented using the Network Simulator 2 simulation tool and compared with the existing Bandwidth Aware Routing Scheme (BARS) method. Performance evaluation of both the proposed method and the existing method is done, based on performance metrics of packet delivery ratio, packet loss ratio, routing overhead, end to end delay and total energy consumption and throughput. The results of the simulation showed that the proposed CAP method exceeds the existing BARS method regarding total energy consumption with an improvement of about 10.41% for static topology and 8.8% for dynamic topology.

Keywords: WSN, Internet of Things, Congestion Control, Energy Efficient, Routing Protocols, NS-2, Packet Delivery Ratio, Throughput, End to End Delay.

Abbreviations: IoT, Internet of Things; *WSN*, Wireless Sensor Networks; ISO, International Standardization Organization; AODV, Ad-hoc On Demand Distance Vector; BS, Base Station; CAP, Congestion Avoidance with Priority; BARS, Bandwidth Aware Routing Scheme; MEMS, Micro Electrical Mechanical Systems; ARC, Adaptive Rate Control; AIMD, Adaptive Increase and Multiplicative Decrease; CODA, Congestion Detection and Avoidance; CCE, Congestion Control Equity; PCCP, Priority Based Upstream Congestion Control Protocol; PHTCCP ,Priority Heterogeneous Traffic Oriented Congestion Control Protocol; ESRT, Reliable Event to Sink Transport Protocol.

I. INTRODUCTION

In this section, it is mainly focusing on the background of wireless sensor network technologies and the general view of IoT, the structure of IoT and some important features that related to the wireless communication applications in IoT. With recent advances in micro electro mechanical system (MEMS) technology and processor design, the production of small, low-cost sensors has become technically and economically feasible. Each sensor node has detection, processing and communication capabilities. The sensor node implemented in a field of interest can detect specific environmental phenomena such as temperature, humidity, acoustics, vibration, pressure, light intensity, magnetic field, etc. WSNs can consists of various kinds of sensors, for example, seismic, attractive, warm, visual, infrared, and acoustic, fit for observing a wide assortment of ecological conditions. Be that as it may, the sensor hubs must have the option to withstand antagonistic natural conditions. Because of they are little size, the hubs have restricted battery power, handling speed, stockpiling limit and transfer speed. Because of the restricted battery charge, the life of a sensor hub relies upon its capacity to spare vitality. Accordingly, countless sensor hubs are conveyed. These nodes use wireless communication to perform their tasks by reporting the event itself or directly to the base station (BS). The base station acts as a gateway between the sensors node and the end user.

The Wireless Sensor Network (WSN) is defined as a collection of individual sensor nodes that are scattered in a physical space, organized in a cooperative network, able to interact with its environment by proactively detecting and controlling environmental and physical parameters. Proactive calculation helps the network sensor to access data from an inaccessible location; [1-4].

Wireless communication technology has made WSN conceivable in a wide scope of continuous ecological checking applications. The system engineering should be changed to meet the particular needs of the sensor nodes. There are many technical difficulties that must be overcome before WSN can be practically used. The nodes must meet the requirements deriving from the specific application, therefore they must be smaller, inexpensive and energy efficient must be equipped with the appropriate sensors, the necessary calculation and memory resources and must communicate correctly. In contrast to traditional system, sensor network organize are intended to adapt to different difficulties. WSN has a few challenges as depicted beneath:

•***Energy constrained:*** Sensor nodes are small, and conveyed in remote unmanned area. So nodes need to depend on a constrained battery power since probability of the substitution of batteries isn't pragmatic.

•***Application specific:*** WSN support diverse application that ranges from military to home and has shifting application prerequisite. Along these lines it is hard to plan a specific protocols design structure for various kinds of application situations.

•***Dynamic topology:*** Because of the idea of nodes being portable in WSN and also the node's failure because of draining energy the system is dynamic.

•***Multi-hop communication:*** Since sensor nodes are geologically put exceptionally near one another, multi-hop communication is increasingly appropriate for WSNs. Multi-hop communication requires lower transmission power than that of single-hop communication. This assists with signal propagation effected impacts experienced because of significant distance wireless communication in WSNs.

•***Fault tolerance:*** It is capacity to continue network functionalities with no interference because of sensor node failures because of physical harmed, breakdown or intruded on wireless communication. To endure such failures and to give dependability, quantities of repetitive nodes are conveyed in WSNs.

•***Scalability & Self-configuration:*** Scalability alludes to the capacity to suit the adjustment in network size. The utilized designs and protocols ought to have the option to withstand various sensor nodes. This should be possible in two, different ways, either by expanding the thickness of the system or by adding assets to solitary sensor nodes. Scalability depends on the application where the sensor nodes are conveyed. Sensor arranges design the greater part of its operational parameters autonomously.

•***Physical hindrance:*** The nature of signal gets debased because of hidden terminal crashes and numerous distant transmissions that interfere and degenerate packets.

The Internet of Things depends on the normal media transmission systems, and other data bearers. IoT is an augmentation of the standard Internet. The web terminal is the (PC, server); they run a good range of programs/projects. Internet is nothing progressively likes an information handling and transmission among PC and system. There's no other hardware (equipment) related to the web.

The main idea for IoT remains the web. Unlike the web, there aren't only PC and servers, but also there are embedded computer systems and its supporting sensors are often treating as terminals. It can connect all quite independent objects and form them function together, to realize a functional interconnection network.

This is the inevitable end in our computing and technology development. The pc has got to serve human in sort of forms, like environmental monitoring equipment, computer game equipment then on. As long as there's hardware or products hook up with the web, or the occurrence of knowledge exchange, we call it "Internet of Things."

IoT has evolved commencing the convergence of wireless technologies, micro-electromechanical systems (MEMS), micro services, and therefore the internet technology. The intermingling has helped level the feed storage dividers stuck between Operational Technology (OT) and knowledge Technology (IT), permitting undefined machine-created information to be broke down for experiences which will constrain enhancements.

Many methods have been developed by the Researchers to improve the energy efficiency of WSN but some methods uses un-necessary operations that affects system performance like Selection of Cluster Head node in each round and selecting lower energy node. Therefore Total Energy consumption from Source node, Relay Node and Sink Node should be considered, which is focused in this study and discussed in section IV and section V.

II. RESEARCH OBJECTIVE

The principal goal of the current research work is to build up an effective congestion control convention for WSN. Congestion control assumes a significant job in improving system execution in any ideal condition. Congestion has direct effect on energy productivity and diminishes the lifetime of system. In this way upsets fair event discovery, and reliable data transmission. In this examination work, a Priority based energy efficient congestion control protocol is recommended that incorporate congestion control protocol and energy effective routing protocol. A decent congestion control protocol ought to give the accompanying facilities to empower reliable data information transmission during basic circumstances in wireless sensor network:

•Congestion avoidance algorithm is productive enough to distinguish Congestion and the mechanisms that keep away from congestion.

•There ought to be a productive congestion mitigating algorithm to recognize congestion and advice congestion data to rest of the system, when queue space isn't sufficient to oblige new packet.

•A congestion control strategy is utilized to relieve the impacts of congestion.

Then again, a great congestion control convention utilizing grouping for WSN should consider the accompanying settings:

•Congestion data ought not to be engaged in all the sensor nodes.

•Only chose nodes ought to be urged to keep up congestion data.

A decent energy efficient routing protocol for WSN should address the accompanying issues:

•Utilize the least energy to keep up neighborhood nodes availability data in WSN.

•Route information packets along the steady path.

This document proposes a new technique of Collision Avoidance with Priority (CAP), which would be the most appropriate for transmission nodes during the transmission of data between the senders node and the receiver in IOT based on WSN (Internet of Things). The research topic on energy efficiency and congestion control factors is analyzed in this research work.

III. RELATED WORKS

Internet In this section a literature survey pertaining to the current work has been presented. The general working principle and approaches for improving efficiency of the protocols have been studied here. It explains various congestion control protocols based on different mechanisms used for detecting, and controlling congestion. Next, the motivation of using energy efficient protocols in WSN is explained and congestion control protocols to mitigate congestion are concisely presented.

A. Related to Work on Congestion

The initial effort for controlling the network traffic in WSNs is Adaptive Rate Control (ARC) (Woo & Culler) [24]. It does not have any explicit congestion detection or notification mechanisms instead it uses additive increase and multiplicative decrease (AIMD) scheme to mitigate congestion. Using AIMD, intermediate nodes increase its sending rate by a constant value 6, if its parent node sends packets successfully. Otherwise, intermediate node multiplies its sending rate by a value þ, where 0 < þ < 1. It reduces the sending the rate of the node. ARC also handles both source and transit traffic to provide guaranteed fairness.

One of the first algorithms in the literature to directly address congestion in the WSN is the congestion detection and avoidance algorithm (CODA) (Wan et al.) [25]. It attempts to manage persistent and transient congestion by implementing three mechanisms distributed across the network and the MAC level: congestion detection, open-circuit hop-to-hop mechanism and closed-circuit end-to-end multi-source regulation. CODA detects congestion by monitoring buffer occupancy and load conditions of the current and past channel on each low cost receiver. Listening to the channel has a high cost. Therefore, CODA uses a sampling scheme to detect congestion. For transient congestion control, the congested node will notify its upstream neighbor to slow down through backpressure messages or released packets. So the ascending node reduces its exit speed using AIMD. The further propagation of the back pressure message in the upstream direction is based on your local network condition. This technique is called open circuit hop-to-hop back pressure. But the back pressure message can increase congestion due to the high load of the channel. The regulation of multiple end-to-end CCTV sources is used for persistent congestion control, but the response time increases in case of heavy congestion since ACK emitted from the sink will probably be lost. More ACK also causes extra energy consumption. CODA does not provide differentiated services to multiple traffic classes. It also does not take into account the fairness of the event and the reliability of the package.

Congestion Control Equity (CCE) (Ee & Bajcsy) [26] is a distributed and scalable mechanism implemented at the data link level; Ensures fair parcel delivery to the base station. It classifies WSN congestion into two types, namely transient congestion, caused by link variation, and persistent congestion, caused by the speed of sending the source data via explicit ACK. The use of the channel decreases, but the reduction of the sending speed is not applicable for some emergency applications, and the lost ACK, which continues to try to communicate again with the sender to re-transmit the packet that is correctly received. The two general approaches for control congestion is end-to-end and hop-by-hop. In the end-to-end approach, it is responsibility of the originating node to detect congestion, whether it is assisted by receiver-based leak detection or explicit network-based congestion notification to adjust its speed. At intermediate hop-by-hop nodes they detect congestion and warn the node of the source link to adjust its speed. Provides high performance and guarantees fair packet delivery.

WSN congestion control mitigation is called Fusion Hull *et al.*, [27]. As the name suggests, it combines three congestion control techniques, namely, hop-by-hop flow control, speed limitation and priority MAC for distributed congestion control in WSN. Each operates in several layers. Hop-by-hop flow control detects congestion by monitoring buffer occupancy and wireless channel load at fixed intervals. If it exceeds a certain threshold limit, a congestion bit is set in the data packet; otherwise, the congestion bit is discarded. The merger uses an implicit congestion notification called back pressure. Therefore, the absence of explicit control messages saves energy. Once the node detects congestion, set a congestion bit in the header of each outgoing packet, then neighboring nodes stop forwarding packets to the congested node until congestion is controlled. This mitigation technique controls the transmission rate to prevent tails from overflowing into the next hop node.

Enhanced Congestion Detection and Avoidance (ECODA) (Li & Feng) [28] is an energy efficient congestion control scheme for sensor networks. First, use the double buffer thresholds and the weighted buffer difference for congestion detection. The buffer is defined as three states, accept state, filter state and reject state. It could also differentiate the level of congestion and act accordingly. Next, a flexible queue scheduler is used to select the next packet to send based on channel load and packet priority. In addition, it also filters packets in case of congestion. Similar to CODA, it controls both transient and persistent congestion. For transient congestion, the implicit hop-by-hop back pressure method is used. For persistent congestion, the control of the speed of the origin traffic based on the congested node and the load balancing of multiple routes is proposed. With this method, you can identify congested nodes and adjust the speed of the originating traffic. Therefore, it leads to higher energy efficiency and better QoS regarding performance, correctness and delay compared to the CODA regulation of multiple closed-circuit sources. But it doesn't consider the traffic load along the way. Even, during extreme congestion when packets are dropped, priority is not given to transit packets. Each node has the additional overhead of calculating the weighted buffer difference to identify the high priority packet.

The Priority Based Upstream Congestion Control Protocol (PCCP) uses multilevel optimization and imposes a hop-by-hop approach to control congestion [29]. PCCP achieves efficient congestion control, and weighted equity for routing one or more routes; Solves node and link level congestion. PCCP refutes congestion control protocols that claim to provide fair equity to each sensor node in a multi-hop WSN by linking weighted equity to each node. PCCP offers different degrees of priority speed so that a sensor node with a higher priority speed achieves greater bandwidth and injects even more packets. PCCP determines the degree of congestion over time between the arrival of the packets and the service time of the packets by reflecting the level of activity on the node or link, and then applies the hop-by-hop congestion control according to the degree of congestion measured, and the priority index. A priority index reflects the importance of each sensor node. The PCCP uses implicit congestion notification by entering congestion information in the header of data packets, thus avoiding additional control packets. This results in less buffering, which can reduce packet drop. This allows for high link utilization and low packet delay.

PHTCCP (Priority Heterogeneous Traffic Oriented Congestion Control Protocol) takes advantage of the cross-layer approach. In PHTCCP, congestion control functionality is employed at the network level and works by interacting with the MAC level to perform congestion control. Perform the hop-by-hop speed adjustment to control congestion [30]. It ensures efficient traffic speed for diversified traffic with different priority queue priority. Then traffic priority was assigned to the weight of the queue. This protocol uses priorities within the queue and between queues. In priority between queues, BS assigns priorities for heterogeneous traffic, then the scheduler plans the queues based on their priority decides the service order of the data packet from the queue. This ensures the highest data priority for a higher service rate. With priority within the queue, the path through the data has a higher priority than generated data. The priority queue together with the fair weighted queue ensures feasible transmission speeds of heterogeneous data. It also ensures efficient use of the link through the use of dynamic transmission speed regulation.

The Reliable Event to Sink Transport Protocol (ESRT) is a new transport protocol that attempts to achieve reliable event detection and congestion control with minimal energy for WSN [31]. It uses a centralized congestion control mechanism in which the base station periodically counts the number of packets received. Based on this counting rate, the source allocation is calculated and passed on to the sources. So the source sets the congestion bit on it's outgoing packets when its buffer overflows. However, ESRT uses high energy signals to transmit the state of the network to the sensor nodes at regular intervals, which consumes a lot of energies. Even in the event of congestion, it regulates the sending speed of all sources, regardless of where the congestion access point is located. However, heterogeneous sources need to be supported and only the source responsible for congestion should be regulated. Significant efforts have been made to develop congestion control schemes that place importance on high priority data or data with specific delay or quality of life requirements in case of congestion. This method is only suitable for homogeneous applications because all the source nodes on the network have the same reporting speed.

The Sensor Congestion Control Protocol (CONSISE) manages the problem of congestion in the downstream direction [32]. In CONSISE, sensor nodes can detect congestion based on the level of congestion around your location and adjust the shipping speed at the end of each epoch. The actual functionality is the downstream nodes report their sending speed to the preferred upstream node through explicit control messages and inform you that you can send data at a higher speed so that the upstream node can adapt their shipping speed; while the rest of the unselected network has a reduced shipping rate.

Topology Aware Resource Adaptation (TARA) is a resource control protocol for controlling congestion [33]. Use a capacity analysis model to determine the required topology. This model is formulated using a graphical coloring problem for the resource adaptation strategy. TARA detects congestion using buffer occupancy and wireless channel load. As soon as the level of congestion reaches the specified threshold, it declares congestion. The congested nodes immediately locate two nodes called the distributor and joined. An alternative route is a then called the diversion route between the distributors and the merger. The distributor distributes the incoming traffic between the original route and the detour route, while the union unites these two flows. Once congestion is controlled, the network stops using the bypass route, so, it is highly energy efficient. But it requires prior knowledge of the network topology, which is not practical for large-scale networks.

The dynamic alternative path selection algorithm (DAlPaS) is a hop-by-hop congestion control protocol. Use a resource control method to avoid congestion [34]. Detect congestion based on buffer occupancy and channel interference; during congestion try to take an alternative route. It works in two stages, i.e. soft and hard. During the software phase, the node receives packets from more than one stream and serves at a higher speed and informs the neighboring nodes from which the other streams arrive to change the destination.

Table 1: Summary of congestion control protocols.

Protocol / Mechanism	Congestion Detection	Congestion Notification	Congestion Control
ARC	Packet Loss	Implicit	Phase Shifting, AIMD Control
CODA	Buffer Occupancy, Wireless Channel load	Implicit, Explicit	Open Loop hop-by-hop pressure, Closed Loop multi Source regulation
CCE	Packet Service Time, Buffer Occupancy	Implicit	Rate Adjustment by dividing data rate amongst child nodes
Fusion	Buffer Occupancy, wireless channel load	Implicit	Rate Limit, Prioritized MAC
ECODA	Weighted queue length	Implicit	Rate Adaptation
PCCP	Packet inter arrival time and packet service time	Implicit	Priority based exact rate control
PHTCCP	Packet Service Ratio	Information in header	Rate Adjustment
ESRT	Buffer Occupancy	Implicit	Rate Adjustment
UHCC	Buffer Occupancy	Implicit	Traffic Control
CONSISE	Wireless Channel Load	Implicit	Traffic Control (Sink to sensors)
TARA	Buffer Occupancy, Wireless Channel load	Explicit	Resource Control
DAIPas	Buffer Occupancy, Wireless Channel load	Implicit	Resource Control

B. Related Work to Energy Efficient Protocols

Internet The area portrays the review of existing, and later looks into in WSN, directing convention, security and vitality productivity.

Rahman *et al*. [11] have exhibited the vitality effective crisscross steering convention for WSN. In this investigation creator has skilled the problems of sensor hubs i.e. constrained power and built up a steering convention to enhance the vitality utilization.

An exploration consideration was completed by Li *et al.* [12] on security systems for WSN. The creator has comprehensively clarified various steering conventions and basically centered on the SPIN steering convention. Creator has considered each steering convention by playing out the recreation over NS2 Simulator and through examination reasoned that the SPIN calculation is secure what's more, keeps up greater secrecy.

The consolidated investigation of Tarabovs and Zagursky [13] gave the effective correspondence reasons medium access convention for grouped WSN. In WSN, the asset designation and vitality effectiveness is the testing issues as its SN have low power battery. Thus, creator has displayed the bunch based MAC convention for WSN to bring productivity.

The low power versatile RP for WSN is displayed in Ji *et al.* [14]. To bring the vitality proficiency and resolve, the knowledge conglomeration issue creator has exhibited the versatile steering calculation for grouping. During this grouping, head was chosen in sight of hub thickness within the estimating region. The results of versatile steering calculation are contrasted and LEECH calculation and presumed that the calculation brings vitality enhancement and enhanced correspondence quality in conveyance circumstances.

Crafted by Hu and Li [15] introduced the geology locale based bunching calculation in WSN. In this, each district picks its individual bunch head. To decrease the vitality use what's more, appropriate asset designation, multi-jump and single bounce blend is employed. The recreation the consequence of the geographic locale calculation fulfills the above necessity.

An instrument of load adjusts in WSN utilizing compressive detecting is depicted in Cao and Yu [16]. During this work the vitality utilization of SNs is taken into account. The heap is adjusted by utilizing compressive detecting, and therefore, the execution is assessed by Tiny OS and reproduction comes about speak to the critical outcomes.

The multipath steering for group tree WSN (ZigBee) was presented in Bidai *et al*. [17]. The examination is additionally worried about effectiveness, throughput, and knowledge transmission at low and high information rates.

Thaskani *et al.* [18] have presented a cross-layer plan convention for WSN to bring the vitality effectiveness utilizing token passing component. To beat the problems of conventional vitality productive WSN technique, the outline, and improvement layer of WSN is exhibited. The component gives effective comes (about) than another directing components.

Othman *et al.* [19] have actualized the self stabilizing calculation to limit the vitality use in WSN. In this, the guess calculation is introduced to construct the spine for a sensor that brings the productive directing. The creator has accomplished the productivity in their strategy by reenactment comes about.

Keeping in mind the top goal to regulate the heap in WSN, a multipath steering convention is displayed in [20]. A heap adjust calculation is meant to regulate the system over the built-up ways. The knowledge parcels are conveyed over additional number of SNs and help in vitality improvement. The reenactment is performed and contrasted the outcomes, and a special steering convention. The system brings the vitality enhancement in WSN.

For the uneven hub sending of WSN, a bunching steering calculation is exhibited [21]. In this, the detecting zone was isolated as different hubs and concentric annuli which are dispersed over uneven territory. The strategy results with better load adjusting system and vitality streamlining. The summary of the survey is given in Table 2.

Table 2: Comparison of Energy Efficient techniques

Authors	Mechanism	Method	Purpose
Rahman *et al* [13]	Energy Efficient Zig Zag Routing Protocol	Zig Zag Routing Protocol	To get energy efficiency in WSN
Li *et al* [14]	Security Mechanisms	SPIN routing Protocol	Comparison of SPIN algorithm with other algorithm
Tarabovs and Zagursky [15]	Efficient Communication purpose medium access protocols for clustered WSN	MAC Protocol	To bring efficiency
Ji *et al.* [16]	Low power adaptive RP for WSN	Low power Adaptive RP	To brings energy optimization & Improved communication quality in distribution situation
Hu and Li [17]	Geography region based clustering algorithm for WSN	clustering algorithm	to reduce the energy usage and proper resource allocation
Cao and Yu [18]	A mechanism of load balance for WSN	Compressive sensing	Energy consumption minimization
Bidai *et al.* [19]	Multipath routing for cluster tree WSN (ZigBee)	multipath routing protocol	efficiency, throughput and data transmission at low and high data rates
Thaskani *et al.* [20]	A cross layer design protocol for WSN to bring the energy efficiency using token passing mechanism	A cross layer design protocol	Energy consumption Minimization.
Othman *et al.* [21]	Self stabilizing algorithm to minimize the energy usage in WSN	self stabilizing algorithm	minimize the energy usage
Ming-hao *et al.* [22]	designed to balance the network over the established paths	Load balance algorithm	balance the network over the established paths

IV. PROBLEM IDENTIFICATION

Some Problems can be formalized according to exist work are follows:

1. Energy Efficiency and Congestion Factors directly affects on

i. Interference between data packets send/receive.

ii. Architecture/ Topology uses for WSN.

Iii. Battery Energy of nodes.

iv. Transmission Power on relay nodes.

v. Memory size for data gathering.

2. Basically Relay node energy consumption directly depends on Work Load as well as Transmission Power.

3. Many methods have been developed by the Researchers, but some methods uses unnecessary operations that affect system performance like Selection of Cluster Head node in each round and select lower energy node. Therefore, Total Energy consumption from Source node+ Relay Node + Sink Node should be considered.

4. Most of the method utilizes single hop data transmission which utilizes more energy. So, there is problem identified as; since single hop utilizes more energy so we can prefer Multi-Hop transmission method.

5. The previous research (existing work) performed on network which depends upon network topology, and different data-traffic load.

As per future work is concerned the research issues; Energy Efficiency and Congestion control could be performed on mobility based IOT (Internet of Things) WSN in real world applications, such as home appliances, grids, and health care.

So a new mechanism namely Collision Avoidance with Priority (CAP) is being developed to overcome this above problem and make the best use of energy efficiency & congestion control which may best fits for IOT applications.

V. RESEARCH METHODOLOGY

Internet Following Fig. 1 show the hypothesis made to accomplish this research work. As shown in Flowchart of hypothesis of proposed work, following points are included:

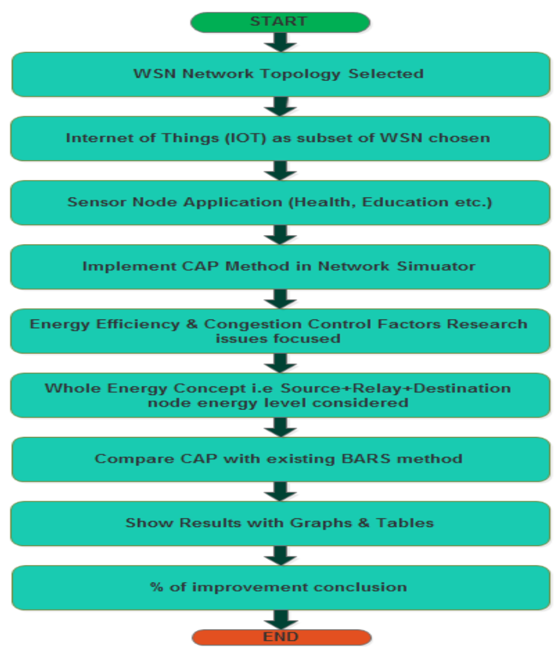

Fig. 1. Hypothesis for Proposed Work.

1. Wireless Sensor Network (WSN) Topology is being selected.

2. Internet of Things (IOT) as specific application is focused as a subset of WSN.

3. Sensor node application area may be focused like Education, Health Systems, etc.

4. The proposed CAP technique would be designed in Network Simulator 2.
5. CAP technique should consider Energy Efficiency and Congestion Control Factor Research issues.
6. Whole Energy concept is utilized i.e. in a communication path the whole energy of the communication link would be considered including Source Node, Relay Node and Destination Node Energy Levels.
7. The CAP technique would be compared with existing EDRS Method.
8. The evaluation of proposed method versus existing method would be shown using Graphs & Tables.
9. Percentage of Improvement of Proposed work would be concluded.

A. Proposed Congestion Avoidance with Priority (CAP)

The CAP method is proposed in this research work keeping two research issues in mind; one is reliability factor and other is energy consumption. Both issues are boomed in today's era of wireless sensor network research. To work on in this method becomes more interesting since a new concept of IoT is been also studied. The CAP method is the enhancement of the previous BARS method including some more features on it, which was not included on the existing system in a multi-hop sensor networks [37].

In WSN, due to retransmission of data packets, the sensor node utilizes more energy than other normal nodes. If the node energy depleted faster, then the node will no longer available for compunction and can't acts as relay node or router. In such a situation the lifetime of the sensor network would be affected. The CAP method tries to resolve this issue by picking that node as relay node which has higher energy level and changes the position of relay node periodically. The reason to change the relay node periodically means, the relay node would be different when the sender node tries to retransmit the packet. This process is iterated for other relay nodes and appropriates other sensor nodes of the network.

Therefore, the proposed technique of Collision Avoidance with Priority (CAP) would be more appropriate for transmission nodes during the transmission of data between the senders node and the receiver in IOT based on WSN (Internet of Things). The proposed method first collects information on the relay node and the distance of all relays nodes between the sending node and the receiving IOT sink node. Every time the sender wishes to communicate with the receiving node, the position of the relay nodes changes dynamically according to number of hop counts, and packet sequence number. The relay node having the least number of hops alongwith the earliest packet sequence number would be selected to forward the data towards the IOT sink node. The CAP technique improves the way to select a higher energy level node between the relays nodes between the transmitters and the receiver so that the optimized path has high reliability and durability during data transmission.

The CAP technique will be implemented using the Network Simulator 2 simulation tool and compared with the existing Bandwidth Aware Routing Strategy (BARS) method. The flowchart of proposed work is shown in Fig. 2.

The IoT based network scenario is designed using Network Simulator 2. The scenario is chosen in such a fashion that it should be multi-hop; it means there would be more than relay node or router in between sender node and IoT sink node. Whenever a sender node wants to send data, it checks for two conditions first.

If it is found that the recipient node is the IoT sink node, then sender node starts communicating without checking the relay node positions. This is reliability factor included in the CAP method, since there is no need of searching for relay node and no need to waste the energy to find them.

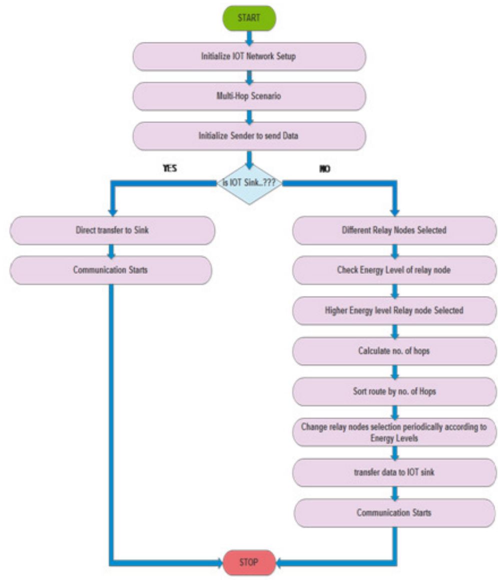

Fig. 2. CAP Methodology Flowchart.

If it is found that the recipient node is the IoT sink node, then sender node starts select different relay node as multi-hop scenario is picked up. The CAP method checks the energy level of all relays nodes, and forwards the data appropriately by choosing high energy level of relay nodes. This step includes one more step which is the CAP method also calculates the no. of hops required to reach at sink node, then the relay node which has minimal hop count is selected. Hence, an optimized path is obtained which has higher level of energy and minimum hops count.

In addition, the selection of relay node is changed i.e. the same relay node is not available whenever the same sender node wants to retransmit the data towards the IoT sink node. The reason for this is the different relay node utilized according to energy levels and the work load would not be increased on the relay node also which saves energy for them. This process is iterated for other sender nodes also and the transferring of data started towards IoT sink node.

In overall, the CAP method is very much enhanced in a way the existing system BARS method selects the relay node. The existing system select the relay node based on relay node energy level, whereas the proposed method selects the relay node in reliable and energy efficient manner. The pseudo code algorithm for CAP method is shown in Fig. 3.

```
INPUT: MFEE Method
OUTPUT: Min. Energy Consumption of Sensor Nodes
Step 1: Initiate all sensor nodes along with IOT Sink Node.
Step 2: IOT sink node sends Hello packets to all sensor nodes.
Step 3: Sender node receives hello request and do reply.
Step 4: Check whether it is IOT Sink Node...?
Step 5: If Yes;
    >>>direct transfer to IOT sink node.
    >>>communication started.
    >>> goto step 8.
Step 6: If No;
    >>>different relay node selected which forms minimal distance path to IOT sink.
    >>>Check Energy level of Relay Nodes.
    >>>Calculate no. of Hops and sort route by minimal hops.
    >>>Change relay nodes periodically according to Energy Level.
    >>> transfer data to IOT sink.
    >>> goto step 8.
Step 7:Communication started...
Step 8: Stop.
```

Fig. 3. Pseudo code algorithm for CAP Method.

B. CAP Estimates

1. Hop Distance: The first parameter for the congestion estimate to be considered is hop distance. It is an important metric required to route packets. Hop distance is defined as the distance of the node Node (i) with respect to Sink. As per approach, the hop distance of any node is calculated from its sender (source) through other nodes towards Sink node.

2. Path Residual Energy: The last parameter used for congestion estimate is path residual energy. The energy needed for the path to route packets depends on the residual energy at the node Ni which is Er (Ni). Initially the energy present in the node is assumed to be 1. Energy spent for routing a packet is Es (Ni). Therefore, the residual energy at node Er (Ni) is computed as in Equation 1

$$Er\ (Ni) = 1 - Es\ (Ni) \quad (1)$$

Consider there are n numbers of forwarder nodes along the path from Ni to Sink. Then we define Path residual energy over as summation of residual energy of individual node along the path. Equation (2) gives the path residual energy PEr.

$$PEr = \sum Er\ (Ni) \quad (2)$$

Once a node Ni has a packet to send to Sink node, it calculates the congestion estimate of various paths to reach Sink node which is given in the following Equation (3).

$$\text{Congestion estimate (PK)} = w1 * HC + w2 * PTL + w3 * PEr \quad (3)$$

Where

w1, w2 and w3 are non negative weight coefficients

PTL= Path Traffic Load and

HC= Hop count

Once Ni receives congestion estimate of all the paths, it selects the best path to route the packet, which is denoted in the following Equation (4).

$$\text{Best path (Pb)} = \min(\text{congestion estimate (Pk)}) \quad (4)$$

3. Energy Consumption Model: Energy consumption can be defined as the average energy consumed by each node during the given simulation time and is expressed in Joules (J). The energy model for WSN is different from energy consumption model.

The energy consumption for sensing, receiving and updating for a packet size k in bits is the same for both topology but it is different during transmission. Hence, the total energy consumption of a node differs from that of a relay node which is given below Equation (5).

Therefore the total energy spent of a node Ni is the summation of energy consumptions during sensing, transmitting, receiving, and updating the packet size k in bits could be calculated by Equation (5).

$$Es\ (Ni) = ETX\ (k,d) + ERX\ (k,d) + Eu\ (k,d) \quad (5)$$

Where; Es (Ni) is Estimated Energy at ith Node.

ETX (k,d) = Transmitted Energy at k node.

ERX (k,d) = Receiving Energy at k node and

Eu (k,d) = Updating Energy at k node.

VI. SIMULATION TOPOLOGY

This section describes about the simulation scenario designed in network simulator 2. The scenario depicts the IoT based wireless sensor networks. There is one IoT sink and some sender node which send data packets to sink node. There are sensors node between sender and sink node which would act as relay or router node. The network topology varies with 50 numbers of nodes for Static and Dynamic Topology. The simulation is carried for both BARS method, and CAP method and results are extracted using AWK scripts. From Fig. 4 to 5, shows the snapshot of simulation scenarios for different number of nodes with IoT sink node in a wireless sensor networks.

Fig. 4 and Fig. 5, shows the simulation topology for static nodes and dynamic nodes with 5-10 sender and receiver nodes respectively.

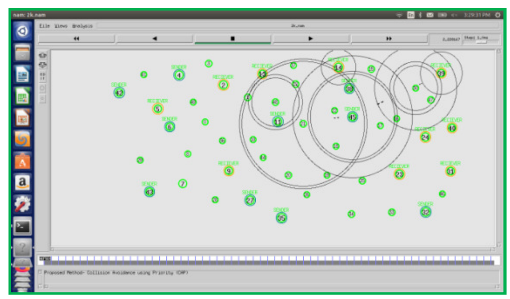

Fig. 4. Simulation topology for static nodes.

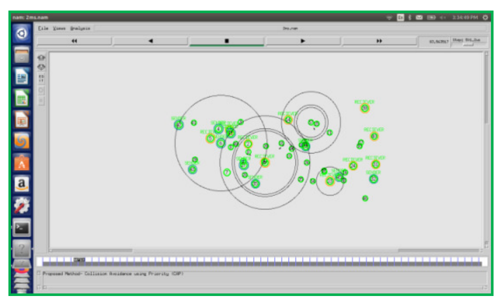

Fig. 5. Simulation topology for dynamic nodes.

For simulation and result analysis, it must require setting of simulation parameters, and mobility models. The summarized simulation parameter is depicted in Table 3.

In this research Random Waypoint Model is used, where mobile node is allowed to move at random in any direction .Constant Bit Rate (CBR) traffic with a transmission rate of 4 packets per second is used. Nodes in experimental scenario select any arbitrary destination in 1000 X 1000 M^2 area and moves with the speed of 2 m/s, 4 m/s, 6 m/s, 8 m/s and 10 m/s. 50 nodes are used in scenarios with change in pause times and data rate for packets with 2000 bits/sec, 4000 bits/sec, 6000 bits/sec, 8000 bits/sec and 1000 bits/sec with simulation times of 1000 seconds to compare the performance of the protocols for low as well as high density environment and for low mobility of the nodes to high mobility.

Table 3: Simulation Parameters.

Parameters	Value
Simulator	NS-2.35
Routing Protocol	CAP, BARS, DRA
Simulation Time	1000 seconds
Number of Nodes	50
Traffic Model	Constant Bit Rate (CBR)
Packet Size	512 Bits
Node Velocities	2 m/s, 4 m/s, 6 m/s, 8 m/s and 10 m/s
Simulation Area	1000 * 1000 meter square
Data Rate	2000 bits/sec, 4000 bits/sec, 6000 bits/sec, 8000 bits/sec and 10000 bits/sec
Mobility Model	Random Way Point
Mac Layer Protocol	IEEE 802.11

VII. RESULTS AND DISCUSSION

A. Results Graph for Static Topology

1. Packet Delivery Ratio: Following Fig. 6, shows the packet delivery ratio results for static topology obtained for CAP, BARS and DRA method. For effective method the PDR value should be higher. The values of PDR for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 84.03 %, 80.97% and 77.97% for CAP, BARS and DRA methods respectively. Also, for data rate of 10000 bits/sec the values are 85.02 %, 79.99 % and 76.99% for CAP, BARS and DRA methods respectively. The graph also shows there is very little impact of rate of change of data rate values for all methods.

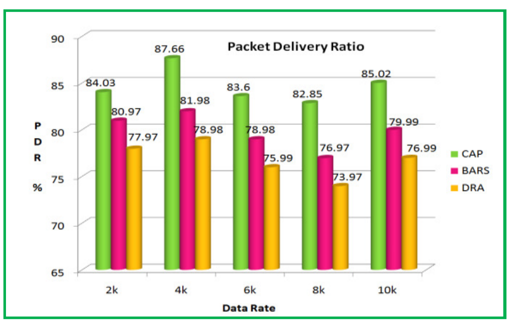

Fig. 6. PDR Graph- Static Topology.

2. Packet Loss Ratio: Following Fig. 7, shows the packet loss ratio results for static topology obtained for CAP, BARS and DRA method. For effective method the PLR value should be lowered. The values of PLR for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 15.96 %, 19.02% and 22.03% for CAP, BARS and DRA methods respectively. Also, for data rate of 10000 bits/sec the values are 14.97 %, 20.01 % and 23.01% for CAP, BARS and DRA methods respectively. The graph also shows there is very little impact of rate of a change of data rate values for all methods.

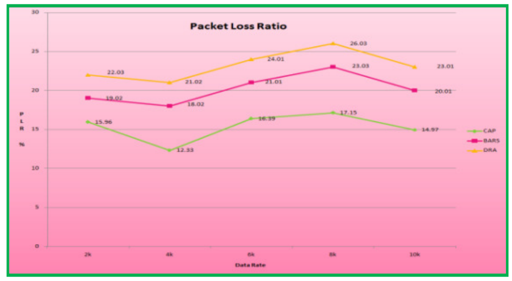

Fig. 7. PLR Graph- Static Topology.

3. End to End Delay: Following Fig. 8 shows the end to end delay results for static topology obtained for CAP, BARS and DRA method. For effective method the E2E Delay value should be lower. The values of E2E Delay for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 11.79 %, 13.8% and 14.49 % for CAP, BARS and DRA methods respectively. Also for data rate of 10000 bits/sec the values are 11.68 %, 12.61 % and 13.24 % for CAP, BARS and DRA methods respectively. The graph also shows there is very little impact of rate of change of data rate values for all methods.

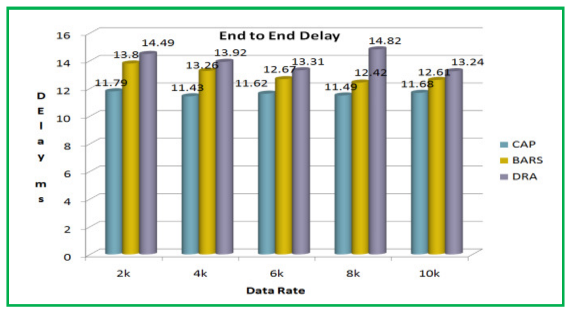

Fig. 8. E2E Delay Graph- Static Topology.

4. Throughput: Following Fig. 9 shows the throughput results for static topology obtained for CAP, BARS and DRA method. For effective method the throughput value should be higher. The values of throughput for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 494.83 kbps, 445.56 kbps and 401 kbps for CAP, BARS and DRA methods respectively.

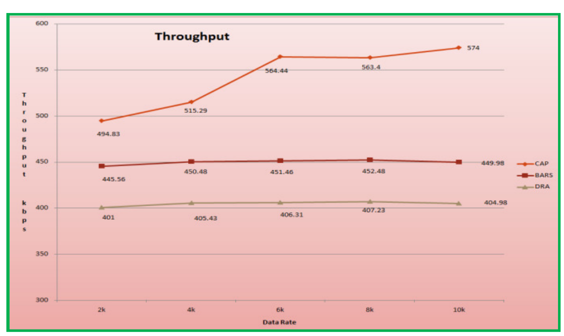

Fig. 9. Throughput Graph- Static Topology.

Also, for data rate of 10000 bits/sec the values are 574 kbps, 449.98 kbps and 404.98 kbps for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of a change of data rate values for all methods.

5. Energy Consumption: Following Fig. 10 shows the energy consumption results for static topology obtained for CAP, BARS and DRA method. For effective method the energy consumption value should be lowered. The values of energy consumption for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 14.11 joules, 16.18 joules and 17.63 joules for CAP, BARS and DRA methods respectively. Also for data rate of 10000 bits/sec the values are 13.24 joules, 14.26 joules and 15.55 joules for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of data rate values for all methods.

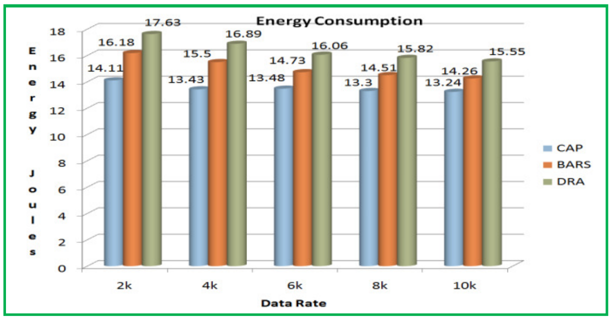

Fig. 10. Energy consumption- Static Topology.

6. Routing Overhead: Following Fig. 11 shows the routing overhead results for static topology obtained for CAP, BARS and DRA method. For effective method the routing overhead value should be lowered. The values of routing overhead for all three methods show that CAP method achieves better performance as compared to other two methods. For data rate of 2000 bits/sec the values are 39732, 45910 and 46955 for CAP, BARS and DRA methods respectively. Also for data rate of 10000 bits/sec the values are 43225, 46960 and 47006 for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of data rate values for all methods.

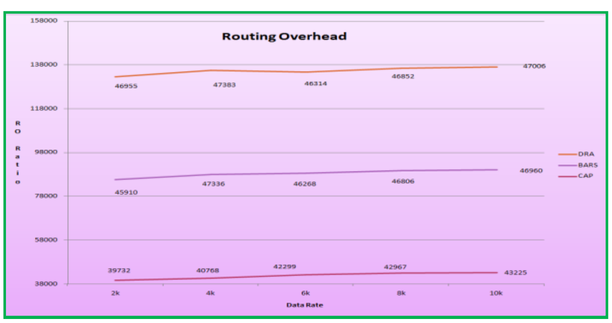

Fig. 11. Routing overhead Graph- Static Topology.

B. Results Graphs for Dynamic Topology

1. Packet Delivery Ratio: Following Fig. 12 shows the packet delivery ratio results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the PDR value should be higher. The values of PDR for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 94.4 %, 89.68% and 84.96% for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 97.8 %, 91.16 % and 88% for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

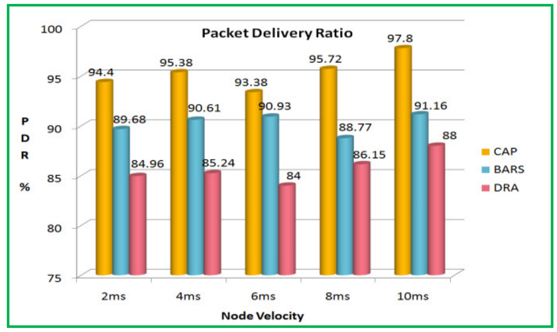

Fig. 12. PDR Graph- Dynamic Topology.

2. Packet Loss Ratio: Following Fig. 13 shows the packet loss ratio results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the PLR value should be lowered. The values of PLR for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 5.6 %, 10.31% and 15.03% for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 2.19 %, 8.83 % and 11.97% for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

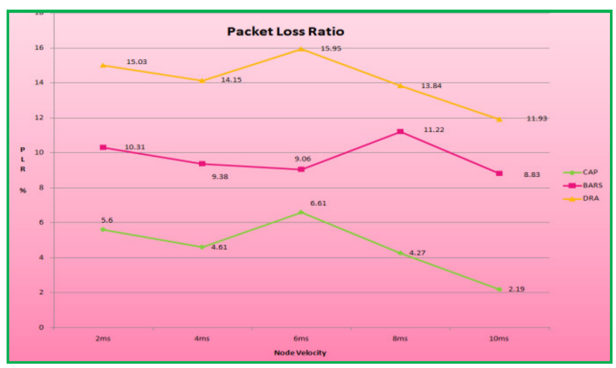

Fig. 13. PLR Graph- Dynamic Topology.

3. End to End Delay: Following Fig. 14 shows the end to end delay results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the E2E delay value should be lowered. The values of E2E delay for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 10.77 ms, 12.93 ms and 14.98 ms for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 12.33 ms, 13.29 ms and 17.14 ms for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

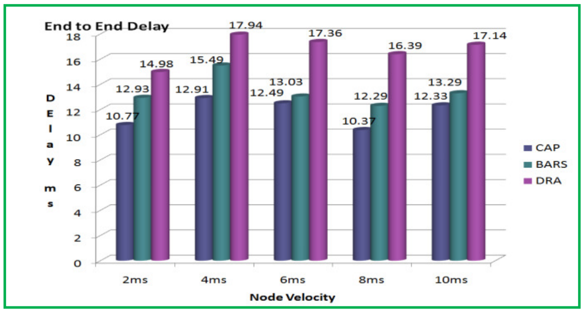

Fig. 14. E2E Delay Graph- Dynamic Topology.

4. Throughput: Following Fig. 15 shows the throughput results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the throughput value should be higher. The values of throughput for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 638.11 kbps, 425.11 kbps and 382.87 kbps for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 663.36 kbps, 435.28 kbps and 398 kbps for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

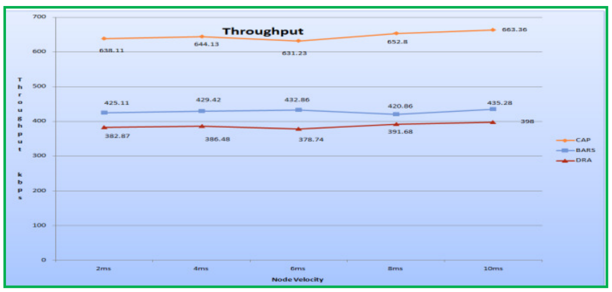

Fig. 15. Throughput Graph- Dynamic Topology.

5. Energy Consumption: Following Fig. 16 shows the energy consumption results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the energy consumption value should be lowered. The values of energy consumption for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 13.82 joules, 14.98 joules and 15.94 joules for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 10.89 joules, 12.09 joules and 12.74 joules for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

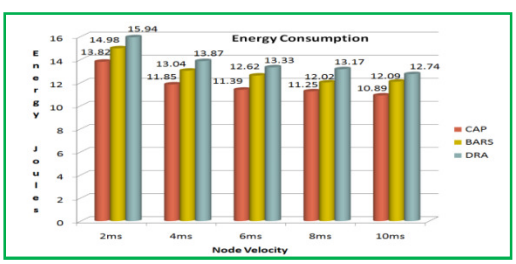

Fig. 16. Energy consumption Graph- Dynamic Topology.

6. Routing Overhead: Following Fig. 17 shows the routing overhead results for dynamic topology obtained for CAP, BARS and DRA method. For effective method the routing overhead value should be lowered. The values of routing overhead for all three methods show that CAP method achieves better performance as compared to other two methods. For node velocity of 2 m/sec the values are 39732, 45910 and 46955 for CAP, BARS and DRA methods respectively. Also for node velocity of 10 m/sec the values are 43225, 46960 and 47006 for CAP, BARS and DRA methods respectively. The graph also shows there is higher impact of rate of change of node velocity values for all methods.

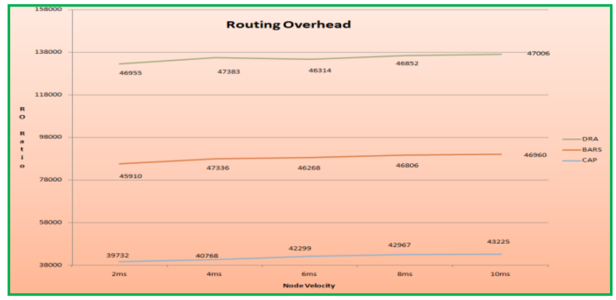

Fig. 17. Routing Overhead Graph- Dynamic Topology.

VIII. CONCLUSION AND FUTURE SCOPE

The In this experiment, two set of experiments; static and dynamic for Wireless Sensor Networks based on Internet of Things (IoT) is analyzed. Two methods are considered namely CAP and BARS methods.

By considering the existing system performance and performance issues of routing protocols, some points are drawn. Energy Efficiency and Congestion control Factors directly affects on Interference between data packets send/receive, Architecture/ Topology uses for WSN, Battery Energy of nodes, and Transmission Power on relay nodes and Memory size for data gathering. Basically Relay node energy consumption directly depends on Work Load as well as Transmission Power. Many methods have been developed by the Researchers, but some methods uses unnecessary operations that affect system performance like Selection of Cluster Head node in each round and select lower energy node. Most of the method utilizes single hop data transmission which utilizes more energy since single hop utilizes more energy, so we can prefer Multi-Hop transmission method. The previous research performed on static network which depends upon network topology, and different data-traffic load.

The CAP method is proposed in this research work keeping two research issues in mind; one is congestion control factor and other is energy consumption. Both issues are boomed in today's era of wireless sensor network research. To work on in this method becomes more interesting since a new concept of IoT is been also studied. The CAP method is the enhancement of the previous BARS method including some more features on it, which was not included on the existing system in a multi-hop sensor networks.

In WSN, due to retransmission of data packets, the sensor node utilizes more energy than other normal nodes. If the node energy depleted faster, then the node will no longer available for compunction and can't acts as relay node or router. In such a situation the lifetime of the sensor network would be affected. The CAP method tries to resolve this issue by picking that node as relay node which has higher energy level and changes the position of relay node periodically. The reason to change the relay node periodically means, the relay node would be different when the sender node tries to retransmit the packet. This process is iterated for other relay nodes and appropriates other sensor nodes of the network.

Therefore, the proposed technique of Collision Avoidance with Priority (CAP) would be more appropriate for transmission nodes during the transmission of data between the senders node and the receiver in IOT based on WSN (Internet of Things). The proposed method first collects information on the relay node and the distance of all relays nodes between the sending node and the receiving IOT sink node. Every time the sender wishes to communicate with the receiving node, the position of the relay nodes changes dynamically according to number of hop counts, and packet sequence number. The relay node having least number of hops along with the earliest packet sequence number would be selected to forward the data towards the IOT sink node. The CAP technique improves the way to select a higher energy level node between the relay nodes between the transmitters and the receiver so that the optimized path has high reliability and durability during data transmission.

Both methods are simulated using simulation tool NS-2. The CAP method outperforms than existing BARS method. The percentage of improvement of proposed work is shown in table 4 and 5 for Static and Dynamic topologies respectively.

Table 4: Percentage of Improvement- Static Topology.

Parameter	BARS Method	CAP Method	Percentage of Improvement
Packet Delivery Ratio	79.78 %	84.632 %	**6.08 %**
Packet Loss Ratio	20.21 %	15.36 %	**23.99 %**
End to End Delay	12.95 ms	11.6 ms	**10.42 %**
Throughput	449.992 kbps	542.39 kbps	**20.53 %**
Energy Consumption	15.036 joules	13.51 joules	**10.41 %**
Routing Overhead	46656	41798	**10.31 %**

Table 5: Percentage of Improvement- Dynamic Topology.

Parameter	BARS Method	CAP Method	Percentage of Improvement
Packet Delivery Ratio	90.23 %	95.336 %	**5.65 %**
Packet Loss Ratio	9.76 %	4.656 %	**52.29 %**
End to End Delay	13.406 ms	11.774 ms	**12.17 %**
Throughput	428.706 kbps	645.926 kbps	**50.66 %**
Energy Consumption	12.95 joules	11.8 joules	**8.88 %**
Routing Overhead	39433	38423	**2.56 %**

The future work relies on improving CAP method in terms of Quality of Service (QoS) and security feature. The key considerations could include; (a) Enhancement of congestion control with different mobility models (b) Taking advantage of features that are offered on distributed networking / services in cloud computing space. It would be tested for larger number of nodes deployed against different simulation area.

ACKNOWLWDGEMENTS

The author thanks to the other professors and friends of the college who help in planning, implementing and developing the research work on wireless senor network based internet of things.

Conflict of Interest. No.

REFERENCES

[1]. Vidyasagar Potdar; Atif Sharif; Elizabeth Chang, (2009). Wireless Sensor Networks: A Survey. IEEE transactions on International Conference on Advanced Information Networking and Applications Workshops, Bradford, pp. 636-641.

[2]. Kruger, C.P. & Hancke, G.P. (2014). Implementing the Internet of Things vision in industrial wireless sensor networks.12th IEEE International Conference on Industrial Informatics, INDIA 2014, pp-627-632.

[3]. Hu, Fang & Xie, Dan & Shen, Shaowu. (2013). On the Application of the Internet of Things in the Field of Medical and Health Care, IEEE International Conference on Cyber, Physical and Social Computing, pp-2053-2058.

[4]. Zhang, F (2013). Research on applications of Internet of Things in agriculture. In Informatics and Management Science VI; Springer: London, UK, pp. 69–75.

[5]. Zhang, Junqi & Varadharajan, Vijay (2008). A New Security Scheme for Wireless Sensor Networks. IEEE Proceedings of the Global Communications Conference, Globecom, pp-128-132.

[6]. "WSN Security Project Overview and Scope-Internal Statoil Document " Statoil 2009.

[7]. “Recommendation ITU-T Y.2060 (06/2012),” 2012.

[8]. Du, Wenliang & Deng, Jing & Han, Young-Soo & Chen, Shigang & Varshney, P.K. (2004).A key management scheme for wireless sensor networks using deployment knowledge. Twenty-third Annual Joint Conference of the IEEE Computer and Communications Societies, INFOCOM, *1*, pp-597.

[9]. Lennvall, T., Svensson, S., and Hekl and, F. (2008) A comparison of Wireless HART and Zig-Bee for industrial applications. Proceedings of the IEEE International Workshop Factory Communication Systems, pp. 85-88.

[10]. "HART Communication Foundation," https://fieldcommgroup.org/

[11]. "The Components of Wireless HART Technology": https://fieldcommgroup.org/technologies/hart/hart-technology

[12]. Song, Tian-Wen & Yang, Chu-Sing, (2008).A Connectivity Improving Mechanism for ZigBee Wireless Sensor Networks. IEEE/IPIP International Conference on Embedded and Ubiquitous Computing (EUC 2008), Shanghai, China, December 17-20, 2008, *2*, pp- 495-500.
[13]. "Getting Started with ZigBee and IEEE 802.15.4," Daintree Networks, Feb 2008.
[14]. Sun, Jing & Zhang, Xiaofen, (2009). Study of ZigBee Wireless Mesh Networks. DBLP Proceedings, 9th International Conference on Hybrid Intelligent Systems, HIS, pp- 264-267.
[15]. "ISA 100: Wireless Systems for Industrial Automation-Developing a Reliable, Universal Family of Wireless Standards," ISA, Standard 2007.
[16]. "ISA I 00.11 a Release I Status," ISA 2008.
[17]. "ISA-I 00.11 a-2009 Wireless systems for industrial automation: Process control and related applications," ISA, 2009.
[18]. D. Sexton, "Understanding the unique nature of the universal family of ISAIOO Wireless Standards," ISA Aug. 28 2007.
[19]. Borgia, E. (2014). The Internet of Things vision: Key features, applications and open issues. *Science Direct (Elsevier), Computer Communications, 54*, pp-1-31.
[20]. R. Roman, C. Alcaraz, J. Lopez, and N. Sklavos, (2011).Key management systems for sensor networks in the context of the Internet of Things.NICS Lab Publications, Computers & Electrical Engineering, *37*, pp-147-159.
[21]. S. Sebastian, P. P. Ray, (2015).Development of IoT invasive architecture for complying with health of home. In Proceedings of I3CS, Shillong, pp-79–83.
[22]. P.P. Ray, (2016). A survey on Internet of Things architectures. Journal of King Saud University, Computer and Information Sciences, pp-1-29.
[23]. J. Granjal, E. Monteiro and J. Sá Silva, (2015).Security for the Internet of Things: A Survey of Existing Protocols and Open Research Issues. *Proceedings in IEEE Communications Surveys & Tutorials*, *17*, no. 3, pp. 1294-1312.
[24]. Yang, Geng & Xie, Li & Mäntysalo, Matti & Zhou, Xiaolin & Pang, Zhibo & Xu, Li & Kao-Walter, Sharon & Chen, Qiang & Zheng, Li-Rong. (2014). A Health-IoT Platform Based on the Integration of Intelligent Packaging, Unobtrusive Bio-Sensor and Intelligent Medicine Box. *IEEE Transactions on Industrial Informatics*, *10* (4). 1-1.
[25]. D. Trˇcek,(2013). Lightweight protocols and privacy for all-in-silicon objects. Science Direct (Elsevier) Ad Hoc Networks, *11*, issue 5, pp. 1619–1628.
[26]. J. A. Manrique, J. S. Rueda-Rueda and J. M. T. Portocarrero (2016). Contrasting Internet of Things and Wireless Sensor Network from a Conceptual Overview. IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Chengdu, pp. 252-257.
[27]. M. R. Abid, R. Lghoul and D. Benhaddou, (2017). ICT for renewable energy integration into smart buildings: IoT and big data approach. IEEE AFRICON, Cape Town, pp. 856-861.
[28]. A. Zanella, N. Bui, A. Castellani, L. Vangelista and M. Zorzi, (2014). Internet of Things for Smart Cities. *Proceedings in IEEE Internet of Things Journal, 1*, issue 1, pp. 22-32.
[29]. A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari and M. Ayyash, (2015). Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications. *Proceedings in IEEE Communications Surveys & Tutorials*, *17*, no. 4, pp. 2347-2376.
[30]. J. A. Stankovic, (2014). Research Directions for the Internet of Things. *Proceedings in IEEE Internet of Things Journal*, *1*, no. 1, pp. 3-9.
[31]. W. He, G. Yan and L. D. Xu, (2014). Developing Vehicular Data Cloud Services in the IoT Environment. *Proceedings in IEEE Transactions on Industrial Informatics*, *10*, no. 2, pp. 1587-1595.
[32]. M. Abrar, R. Masroor, I. Masroor and A. Hussain, (2018). IOT based efficient D2D communication. Moscow Workshop on Electronic and Networking Technologies (MWENT), Moscow, pp. 1-7.
[33]. P. Agrawal and G. Chitranshi, (2016). Internet of Things for monitoring the environmental parameters. IEEE International Conference on Information Technology (InCITe) - The Next Generation IT Summit on the Theme - Internet of Things: Connect your Worlds, Noida, pp. 48-52.
[34]. R. Koshy, N. Shah, M. Dhodi and A. Desai, (2017). Iot based information dissemination system in the field of education. *IEEE 2nd International Conference for Convergence in Technology (I2CT), Mumbai*, 2017, pp. 217-221.
[35]. A. C. Swastika, R. Pramudita and R. Hakimi, (2017). IoT-based smart grid system design for smart home. IEEE 3rd International Conference on Wireless and Telematics (ICWT), Palembang, pp. 49-53.
[36]. S. T. Bakhsh, (2017). Energy-efficient distributed relay selection in wireless sensor network for Internet of Things. IEEE 13th International Wireless Communications and Mobile Computing Conference (IWCMC), Valencia, pp. 1802-1807.
[37]. N. Akhtar, M. A. Khan, A. Ullah and M. Y. Javed, (2019). Congestion Avoidance for Smart Devices by Caching Information in MANETS and IoT. Proceedings in IEEE Access, *7*, pp. 71459-71471.

How to cite this article: Sarad, A., Verma, A. and Badholia, A. (2020). An Approach providing Congestion Control & Avoidance using Priority based Energy Efficient mechanism for Internet of Things (IoT). *International Journal on Emerging Technologies*, *11*(2): 1013–1025.