Load Balancing and stability based Quality of service routing in Ad-hoc networks: Software Agent based Approach

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***Abstract*— Mobile ad-hoc network is an Infrastructure-less, self organizing network. Due to the inbuilt uniqueness of MANET's such as frequent topology change, high mobility of nodes, Resource scarceness and lack of centralized controller like base station etc construct Quality of service (QoS) routing is a challenging task. Congestion occurs in Mobile ad-hoc network (MANET) with constrained resources. Traffic density which is unfairly distributed is one of the causes of congestion in the network. Designing a Reliable and stable routing for the uninterrupted communication is the most important issue for audio and video applications. To overcome these issues ,we design a load balancing and stability based QoS routing technique using software agent. Software agents collect and calculate queue length, link expiration time (LET) and Remaining battery power and delay of each nodes. Finally, route is calculated based on estimated parameters. In this research study; we provide a summary over existing proposal, their key ides, and our proposal.**

Keywords—Mobile agent (MA), Mobile Ad-hoc networks MANET,Quality of Service(QoS).

I. INTRODUCTION

Infrastructure less, mobile ad-hoc network (MANET) is composed of mobile nodes and wireless nodes are communicating with each other over radio links[1]. The large amount of real-time traffic involves high bandwidth and liable to congestion. Mobile Ad-hoc networks can be classified in three categories based on applications-MANET,WANET,WSN Network with no fixed infrastructure. Mobile nodes communicate directly within radio range. Node mobilityMANETs have several advantages over infrastructure networks like relatively low cost,On demand setup,Fault to tolerance etc[1].Based on the route discovery process MANET routing protocols are classified basically into two categoriesProactive routing and reactive routing [2]

A)AODV Routing

In AODV routing protocol routes are discovered on demand. like the DSDV routing protocol , AODV protocol is also uses the sequence n umber system to determine The freshness of the received information and uses the same method route discovery like the DSR protocol uses[2,3]. AODV routing protocol tires to find routes on the less congested routes and provide the route with the lowest hop count. *Route discovery*-When a source node has a data packet it searches its routing table for the destination entry If such an entry is not available in the routing table the source initiates a route discovery process by broadcasting the RREQ message in the network. The RREQ contains the following fields:<source _addr, source_ sequence_#, broadcast_ id, dest_ addr, dest_ sequence_#, hop _cnt>[3]

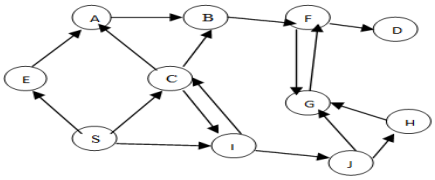

Fig-5 :Route Request mechanism in AODV Routing .

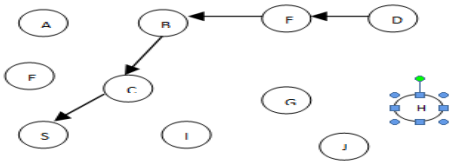

Fig-6: Route Request mechanism in AODV Routing. .

Data Forwarding- Once a route is found for the destination node in the network that route is used for the data transmission.

Route maintenance-To maintain the active routes in the network in MANETs the AODV uses two types of link connectivity checking mechanisms one with the use of link layer acknowledgements and other with the help of periodic HELLO messages. Advantage of AODV is lowest routing overhead when the network is underutilized and also in cases

where there is congestion in the network and AODV avoids the congested routes during the route discovery and provides routes that are less congested as well as with the lowest number of hops.

B)Software Agent

The paradigm of agent-oriented software engineering (AOSE) is argued to be well-matched for building complex software systems in distributed and dynamic environments [4]. The conventional programming paradigm utilizes functions, procedures, structures and objects to develop software for performing a given task. This paradigm does not maintain development of _Flexible, intelligent and adaptable softwares, and also does not make promising all the constraints of Component Based Software Engineering (CBSE) [4,5,6]. a software agent is a proactive software component that cooperates with its environment and other agents as a substitute for its user, and respond to component an agent.

C)Routing with Mobile agent

Solving routing problem in Mobile ad-hoc networks is a brutal task due to its dynamics as a effect of mobility and disconnection of mobile terminals, creates a number of troubles in designing proper routing scheme s for successful communication [4]. Mobile Agent technology is perfect solution with increase routing performance for such surroundings with reduce network traffic and load balancing[7,8]. For routing in MANETs their many routing protocols proposed by various researchers.

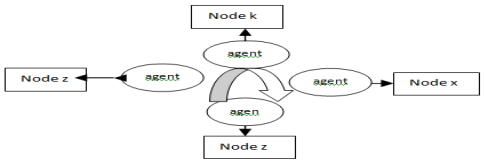

Fig-3: Mobile software agent paradigm in the mobile ad hoc network.

II QoS Routing in MANET

Due to high mobility of nodes in a network, Routing in MANET is a challenging task. It is more difficult to guarantee QoS in MANETs than in other type of networks[1]. To establish the routes and to secure the resources necessary to provide the QoS .The large amount of real-time traffic involves high bandwidth and liable to congestion. Due to high mobility of nodes in a network routing in MANET is a challenging task. It is more difficult to guarantee QoS in MANETs than in other type of networks.

A)Issues of QoS routing

1)Dynamic topology: In MANET, hanging the topology dynamically due to mobility of nodes[1] and resulting failing of a path. In[13] autors proposed a Agent based topology maintance based routing in manet

*2) Limited resource availability***:** Battery life, bandwidth, memory, processing capability and other resources in MANET affect the QoS aware routing.

*3)Bandwidth constraints & Variable capacity links***:** Wireless links have significant lower capacity than wired links . In [14] authors proposed bandwidth reservation technique for MANET based on mobile agent.

*4)Energy constrained operation***:** Battery power in manet is limited**.** The wireless nodes rely on batteries for proper operation [10]. In [15] authors proposed a novel energy consumption model using Residual Energy Based Mobile Agent selection scheme (REMA). *Lack of centralized control*: No central controller like Bases tation to coordinate the activities of mobile nodes[1]. This complicates .

5)Maintenance of route: Due to dynamic topology due to mobility of nodes in MANET, it is complicated to achieve a fast route maintenance scheme into QoS-aware routing. In [16]Authors proposed Ant-AODV hybrid protocol As a direct result of providing topology information to the nodes (using ants),

6)Security: In the lack of centralized control MANETs is more prone to security attacks such as eavesdropping,blackhole, wormhole, linkspoofing and denial of service . In [17] authors proposed Hybrid encryption technique (symmetric key encryption/public key encryption) for securing nodes.

7)Error-prone channel: In manet Radio waves travel in open medium and suffer from interference, attenuation and multipath propagation because of its broadcast nature.

Hidden and Exposed terminal problem: Hidden terminals are hidden wireless nodes to the sender, but are reachable to the receiver. It reduces the throughput of the QoS aware routing protocol. Exposed terminals are nodes in the transmission of the sender, but prevented from making a transmission.

B)Significant Parameters for QoS Routing in MANET

1. Throughput: It is defined as the maximum fraction of channel bandwidth used by successfully transmitted packets [18,19].

$$TH = \sum \text{Transmission of Routing Packets} \ldots\ldots(1)$$

2. Delay: It is defined as the time taken by a packet to travel from the source to the destination. Overall end-to-end delay is calculated as: [End-to-end delay = Propagation delay + Transmission delay + Packetizations delay + Congestion delay + Access delay + Queuing delay] [18,19] ……(2)

3. Jitter: It is defined as the variation in the delay of packets at the destination. Some time-sensitive applications may become affected by jitter.

4. Packet Delivery Ratio or Packet Delivery Fraction [18,19] This metric actually tells us how much reliable the protocol is. It describes the loss rate that will be seen by the transport protocol, which in turn affects the maximum throughput the ad hoc network can support.

$$PDF = \frac{\text{Packet recieved at Destination}}{\text{Sent Packet by Source}} \left(\frac{1}{n}\right) \ldots\ldots\ldots(3)$$

Here n is the number of devices in the network.

III Congestion and Route Stability in MANET

In MANET, Congestion occur with limited resources like Battery life, bandwidth, memory, processing capability and affects the QoS aware routing[20]. Congestion may occurs when the load on the network (number of packets send to the network) is greater than the capacity of the network (number of packets a network can handle). Or it is the condition when the existing load to the network exceeds the available

resources [20].Congestion leads to packet losses and bandwidth deficiency and waste time and energy on congestion recovery.

Common Metrices Used for Congestion Control in MANET
Therefore, the congestion condition of wireless ad hoc networks can not be only evaluated by packet loss. It should combine channel occupation[26], queue length[26,40], buffer load [40],Type of Service based queue length estimation [26] to measure the congestion exactly, and these parameters can be collected from the MAC Layer. It can take place during the routing process of packets from source node to destination node which ultimately leads to packet loss [21].

Stable routes: A route is selected based on the probability model of the path future availability.[30]
Efficient route repair: if the path duration estimate is available, service disruption due to route failure can be avoided by creating an alternative path breaks.[30]
Network connectivity: connectivity and topology characteristics determined by link dynamics are the fundamental issue to network design, as they support user communication and their reliability level.[30]
Stability based routing protocols tend to select paths that are long lasting. Relative speed differences, signal strength, pilot signals are the parameters used for the measuring the ink stability.

IV Related Work

A) *Agent Based Load Balancing Aware QoS Routing in MANET*
In [26] authors proposed an agent based congestion control technique. The information about network congestion is collected and distributed by mobile agents (MA).In this technique, the node is classified in one of the four categories depending on whether the traffic belongs to background, best effort, video or voice AC respectively. Then MA estimates the queue length of the various traffic classes and the channel contention of each path. Then this total congestion metric is applied to the routing protocol to select the minimum congested route in the network. , a mobile agent based congestion control AODV routing protocol reduces the end-to-end delay and the number of route discovery requests, balances the traffic load.
In [27]authors proposed a mobile agent based congestion aware routing(MACAR) protocol based on AODV routing , Network connectivity information is based on congestion state and disperse this information across the network. The congestion state is measured based on the interface queue size and MAC drops at each node. Two types of agents are used static and mobile agent . static agents are used to monitor therefore, the congestion condition of wireless ad hoc the nodes congestion status. Through simulation ns2.28 proved that MACAR provide robust routes compared than AODV.
In [28] authors integrated some mobile agents for carring routing information, and nodes congestion status in adhoc networks. When mobile agent travels through the network, it will prefer a low level of congestion for the next hop node. The Congestion level is calculated by the ratio which the current cache buffer queue length to the maximum length .

Congestion level = which the current cache buffer queue length /maximum length ……..(4).

A mobile agent based congestion control aodv routing protocol reduces the end to end delay, no of route discovery request and can get the dynamic network topology in time. Simulation using ns2 proves that MACC balances the traffic load, prolong the lifetime of network and reduces the end to end delay
In [29] authors propsed MAR-AODV (Mobile Agent-AODV) to enhance the AODV protocol based on mobile agent. Flow density which is unequally distributed is one of the causes of flow congestion in manet, To minimize this limitation authors integrated mobile agents into network nodes to update traffic density at each node.

CP(congestion level) is calculated by

CP= R1 / RA ……..(5)

Where R1 is total of routes passing the assessed node, RA the total of routes established in the network. When nodes receive an BA, they will select a route with the lowest congestion level basing on the value of CP fields in this agent.
Kazuya Nishimura et al [38] have proposed a multi-agents based routing protocol to reduce network congestion for a Mobile Ad hoc Network (MANET).Multiple MAs arrive at a node, they are held in the queue of the node. If the length of the queue is over the threshold, then congestion occurs.Proposed protocol performs better than traditionally DSR under different conditions of mobility and traffic patterns.

Route stability is most important matrices to meet the QoS requirements of mobile users. It focuses on the following aspects:

B)Agent based Routing protocol with combined matrices (Load balancing or Energy, stability) in MANET

In [30] a cross-layer based stable and energy-efficient routing technique in which QoS monitoring agents collect and calculate the link reliability metrics such as link expiration time (LET), probabilistic link reliable time (PLRT),link packet error rate (LPER) and link received signal strength (LRSS). In addition, residual battery power (RBP) is implemented to maintain the energy efficiency in the network.
In[32] authors proposed protocol SEQCDR multiple metrics of signal strength, queue length, drain rate and the delay in order to enhance the system performance. But here authors consided without consideration of mobile agent paradigm.
In [33] authors proposed a congestion and power control techniques based on mobile agent technology. The status of each and every node is collected and lastly it is delivered to destination node composed .according to this proposed scheme MA starts to forward data packets from source to destination with min cost and congestion with reduced power and congestion.
In[34] authors proposed a agent based model to discover the best path from source to destination by taking into consideration some concerns parameters for QoS routing like bandwidth, reliability, and congestion of the link. The simulation study proved that the proposed model is more feasible for providing reliable paths between the source and destination with the minimum control message packets over the network. The congestion can be measured with the help of current load among the neighbor nodes.

In[35], authors proposed a a new QoS (Quality of Service) routing protocol collective with the flow control mechanism. In express to support the congestion avoidance, a flow control mechanism is in use to adapt the transmission rate for each route with stable route with energy efficient and less delay . ant systems is used to model the proposed routing solution .
In [36] authors proposed a cluster-based mechanism to the AODV routing protocol with congestion control in mechanism in MANET which provides a QoS aware path. The selection of cluster - head is done on the basis of the congestion status of the nodes. This protocol is highly efficient in dealing congestion by achieving QoS constraints (good packet delivery fraction, low delay and reduces packet drop) with less energy consumption due to clustering of the nodes.
Congestion status of each node is calculated by using

$$\text{Status} = = (1-(\sum qi/\sum bi)) \ldots\ldots\ldots\ldots(6).$$

Where, q is a length of the queue (number of packets there in a queue) ,b is a buffer size of a node i.

V Our Proposed Work

Problem Indentification
Existing Tradional routing protocol such as AODV , DSR etc route data packet with min hop count without considering explicit QoS constraints . These algorithms are not suitable for applications requiring a quality of service. Real- time audio and video applications require the underlying network to provide certain guarantees that are manifested in support of several important QoS parameters such as delay, throughput, link stability, PDF (Packet delivery fraction),node buffer space, energy consumption.
The link breakdown due to node mobility and the energy depletion is the key issue which makes it complex to develop QoS routing in wireless ad hoc networks. This leads to network partition and performance degradation. So, there is a need of stable route from source to destination.
Due to unbalanced distribution of traffic may inurn lead to higher packet losses, faster battery power and more delay . so, routing should be congestion free.
Motivation
Flow density which is unevenly distributed is one of the causes of flow congestion in MANET network.
In order to balance network load and maintain network continuous, efficient and stable operation, it is necessary to take in to account the routing nodes load and congestion in network. Stability – based routing protocol tend to select paths that are long lasting. However many critical parameters like link life time and load balancing and energy and delay is not considered together Or are taken with insufficient details. In The number of links that compose the route and stability of each link in the route determine stability or life time of a route. Hence , For solving these major issue multiple metrics of LET(link expiration time, Queue length, drain rate, and delay) can be integrated.
But taking into consideration multiple parameters in routing is an NP- Complete problem. To reduce this complexity we used the concept of software Agent paradigm for calculating and updating in formation in the network.

A)Designing Agent Based Load Balancing and Stability based QoS routing in MANET

In this section we proposed to design and develop a software agent paradigm based Load Balancing and stability based Quality of service routing architecture with new combination of critical parameters queue length, Link Expiration Time(LET), Remaining battery power and delay for Real-time audio and video applications.
Our objective is to Increasing network performance with combination of multiple matrices taking advantage of use of agent technology paradigm with Reduced *complexity of our proposed routing algorithm
Before presenting our proposed Mobile agent based routing we want to discuss used matrices in this proposed routing algorithm.

B)Estimation of used multiple metrices are as follows:
1) Estimation of stability using Link Expiration Time (LET)[31]
LET metric is related for selecting a reliable route .For calculating LET between the nodes, speed parameters of two neighbouring nodes and the free space propogation are required. Consider (a_1,b_1) and (a_2,b_2) denotes the positions of the nodes and (s_1 ,s_2) denotes the speed of the nodes along with θ_1 and θ_2 as directions, respectively.
Then LET is calculated by the following equation given below

$$LET = \frac{-(ab+cd) + \sqrt{(a^2+b^2)\, r^2-(ad-cb)^2}}{(a^2+c^2)} \ldots\ldots\ldots(7)$$

2)Estimation of battery power [37]
Estimation of battery power
The battery power consumed by a node after time t can be calculated as

$$Pc(t) = \alpha \cdot Ndp + \beta \cdot Nd \ldots\ldots\ldots\ldots\ldots\ldots(8)$$

where: *N*dp – number of data packets transmitted by the node after time t;
*N*dr – number of data packets received after time t;
α, β– constants having values between 0 and 1.
If *P*1 is the initial power of the node, then the remaining power of the node *P*R at time *t* can be calculated as:

$$PR(t) = Pc(t) - P \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9)$$

3)Congestion estimation by queue length [36]
Congestion status of each node is calculated by using

Congestion Status(CSi) = No of Packets in the Queue/buffer size ….(10).

Where, q is a length of the queue (number of packets there in a queue) ,b is a buffer size of a node i.
.
4) Delay estimation
This metric is considered by taking total sum of processing delay, queuing delay, transmission delay and propagation delay etc when they travel from one node to another node along a path in networks.

delaytotal (DEL)= Dproc + Dqueue + Dtrans + Dprop …..(11)

So, total Path selection index(PSI) is calculated by

$$PSI\ max = 1/N \sum_{i=1}^{N} (LETi \times (1-CSi) \times (1-DELi) \times PRi) \ldots\ldots.(12)$$

Where , N=total number of nodes in selected route.

C) *Agent Based load balancing and stability aware routing architecture can be explained from the following figures*:

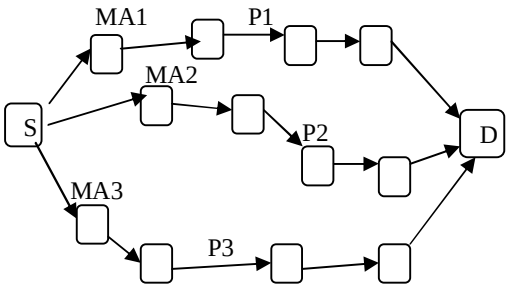

Fig-Agent working for selecting of QoS based path

In fig-4 MA1, MA2, and MA3 denotes the clone of Mobile Agent (MA) and P1, P2, P3 denotes the path 1, path2, path3 respectively.

Step1 : The source node SN checks the number of existing one hop neighbors and clones the Mobile agent to that neighbor. Step 2 : The Mobile agent(MA) select the shortest path of the route to travel towards the destination node D.

Step 3 :The MA1 (Mobile agent) moves towards path P1 in hope by hop manner, MA2 in path P2 and MA3 in path P3. Mobile agents carry its own history of movements and calculate and update routing table entiries (LET, *PR* , CS , DEL) of the node it is visiting.

Step 4 :Now the Desination node D send total Path selection Index() PSI using eq12 of path P1, P2,P3 respectively to the source node.

Step 5 : Now, the source node S select the path with max PSI.

VI Conclusion

Designing a QoS routing with multiple metrices is a complex problem . we integrated mobile agent technology in the network for increasing the performance of routing and collecting and updating routing information in the network. Many QoS routing has been developed with the integration of one or two metrices or based on hop count only but this type of routing is not provide performance with respect to real time applications. We design a load balancing and stability based QoS routing technique with combined multiple metrices queue length, link expiration time (LET) and Remaining battery power and delay of each nodes. we also provide a summary over existing proposal, their key ides.

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TABLE-1 : SOFTWARE AGENT BASED LOAD BALANCING MECHANISM IN MANET

Approach with Reference	functioning of Mobile agent(MA)	strength/Limitation	Used performance metrics with Type of study
An agent based congestion control technique, [26]	Congestion Metric (TCM) can be estimated using Mobile Agent from the obtained queue length and the channel contention. The MA updates the routing table of the node it is visiting	MA can select a less-loaded neighbor node as its next hop and update the routing table according to the node's congestion status. With the support of mobile agents, the nodes can get the dynamic network topology in time. MAs consume more power.	High Packet delivery ratio and throughput than AODV using ns2 simulator
Mobile Agent based congestion Aware in MANETs, the communication protocols such as transport Routing (MACAR), [27]	The congestion state is measured based on the interface queue size and MAC drops at each node.	It provide both congestion control and avoidance due to data traffic to be spatially distributed .	It provides roust route with reduced end to end delay and higher throughput when compared to traditional aodv using ns2.28 simulator.
A mobile agent based congestion control AODV Routing, [28]	integrated some mobile agents for carring routing information, and nodes congestion status in adhoc networks so that through mobile agent , the node can get the dynamic network topogoly timely. The Congestion level is calculated by the ratio which the current cache buffer queue length to the maximum length .	With the aid of mobile agents, the nodes can get the dynamic network topology in time. The low level of cumulative congestion node is used to update route table of a new node to avoid congestion in network.	Reduces the end-to-end delay and the number of route discovery requests, balances the traffic load than AODV using ns2 simulator
An agent based Congestion and Power Control Technique, [33]	Congestion Metric (TCM) can be estimated from the obtained queue length and the channel contention with power control(Listening and non listening mode)	mobile agents reduce the congestion and power by *forwarding the data packets through the path which has minimum cost and congestion.* It provides most proficient congestion and power controls	HighPDF, throughtput, reduced delay and less energy consumption using ns2 simulator.
QOS-AODV, [35]	Ant Contains the minimum transmission rate on the found route. The use of ant systems also reduces congestion by selecting routes in an intelligent manner instead of diffusion.	Flow control is a good mechanism to avoid the congestion problem authors combile a QoS routing protocolwith an explicit flow control mechanism. QoS routing protocol selects routes having more resources (bandwidth and energy), less delay and better stability	Increased network performance with larger bandwidth, smaller delay and better stability.In order to assess the link stability. Using ns2.31
Mobile Agent based congestion Aware in MANETs, the communication protocols such as transport Routing	The congestion state is measured based on the interface queue size and MAC drops at each node.	It provide both congestion control and avoidance due to data traffic to be spatially distributed .	It provides roust route with reduced end to end delay and higher throughput when compared to traditional aodv using

(MACAR), [27]			ns2.28 simulator.
A mobile agent based congestion control AODV Routing, [28]	integrated some mobile agents for carring routing information, and nodes congestion status in adhoc networks so that through mobile agent , the node can get the dynamic network topogoly timely. The Congestion level is calculated by the ratio which the current cache buffer queue length to the maximum length .	With the aid of mobile agents, the nodes can get the dynamic network topology in time. The low level of cumulative congestion node is used to update route table of a new node to avoid congestion in network.	Reduces the end-to-end delay and the number of route discovery requests, balances the traffic load than AODV using ns2 simulator
MAR-AODV (Mobile Agent – AODV), 29]	Idea of this algo in based on flow density which is unequally distributed is one of the causes of flow congestion. mobile agent s into network nodes to update traffic density at each node. The value of congestion is estimated with the rate of the total of routes passing the assessed node and the total of routes established in the network.	MAR-AODV,improved network flow density and improved the probability of packet congestion at intermediate nodes by integrating MA in the network.MAR-AODV does not considerably increase average packet delay.	For blocking probability, MAR-AODV performs more effective than AODV but does not considerably increase average packet delay using OMNet++ simulator.
Multi-agents based congestion control, [38]	. multiple MAs arrive at a node, they are held in the queue of the node. If the length of the queue is over the threshold, then congestion occurs.	It follow minar's model & To evaluate the best route, authors developed a function based on the reliability of links. Two kinds of agents are engaged in routing. One is a Routing Agent that collects information about network congestion as well as link failure. The other is a Message Agent that uses this information to get to their destination nodes.	Less packet loss in mobility senarion,Increased PDF lower congested node compared than AODV Using JAVA as a simulation tool.
Stability routing model of DSR, [34]	The congestion can be measured with the help of current load among the neighbor nodes. If there is congestion on the primary path, then all future packets can be sent through new routes. This way the congestion can be handled without much overhead.	The metrics like bandwidth,reliability, and congestion of the path are used to route the data packets from the source to destination. The proposed system has not considered packet loss over the network.	Improved performance in terms of Packet delivery ratio, Number of path reconstructions, Control message packets compared with traditional model AODV & DSR.
QoS Aware Routing based on AODV, [36].	cluster-based mechanism for supporting congestion control in MANET which provides a QoS aware path. Congestion is controlled by selecting the cluster-head on the basis of congestion level.	The main feature of this approach is clustering and the selection of the cluster - head is on the basis of the congestion status of the nodes and avoids congestion by making cluster - head to cluster - head communication .	This proposed approach is highly energy efficient as compared to AODV routing protocol in dealing congestion by achieving a good delivery ratio, low delay and reduced packet drop.