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# Decisive Analysis of Current State of The Art in Congestion Aware and Control Routing Models In Ad Hoc Networks

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*Abstract -* An important aspect that portrays a crucial position in the ad hoc network routing is congestion. Almost every research analysis is en-route in adapting this key factor in addressing congestion. This problem cannot be totally addressed by the regular TCP protocol based networks, keeping in view the special assets which include multi hop sharing etc, which is difficult to ascertain in ad hoc networks. Many attempts have been made and are in progress by researchers to provide unique solutions to the above mentioned problems. This paper projects a vital study on jamming aware and different routing standards that have been dealt with in recent times.

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*Strictly as per the compliance and regulations of:*

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*Abstract* - An important aspect that portrays a crucial position in the ad hoc network routing is congestion. Almost every research analysis is en-route in adapting this key factor in addressing congestion. This problem cannot be totally addressed by the regular TCP protocol based networks, keeping in view the special assets which include multi hop sharing etc, which is difficult to ascertain in ad hoc networks. Many attempts have been made and are in progress by researchers to provide unique solutions to the above mentioned problems. This paper projects a vital study on jamming aware and different routing standards that have been dealt with in recent times.

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## I. Introduction

Wireless straits and node portability project a negative authority on data packet broadcasting which paves way to intrusion, which ultimately affect the load balancing. Similarly, the ever increasing claim on real time data broadcasting leads to failure in data transmission and bandwidth results in loss of valuable energy and time. Some provision can be made for congestion awareness which can ensure the broadcasting without any intricacies. Time-varying routes can be adapted to put up with through various wireless IEEE protocols and MANET transmission supports. IEEE 802.11 DCF assures extended equity data packets in a network which may face a working problem such as decrease in performance of the high pace nodes [22]. B. Awerbuch et a [23] insists on usage of multiple paths for data flow and data transmission. A multi-hop replica deems decrease in low pace nodes that ensure a rise in rate of data linkages. Diminishing the usage of excessive nodes with an overall low data rate ensures escalation in network performance. A medium metric time has been proposed by the B. Awerbuch et al[23], which enables us to select connections with low data rate, i.e, those links which involve the most number of data paths will be picked up ultimately ensuring soaring data velocity. This can be achieved only when the data packets are broadcasted through the chosen data routes [24].Increase in jamming of networks poses the problem of access conflicts [25]. Channel admission setback usage was boosted as a recommendation to the MTM affords routing avoiding restricted regions. The gain in the case of elevated data speed is that the links are basically petite and they can be easily accessed via any path of the network chosen. There is a possibility of over-crowding if there is a rise in the number of connections [26]. Then the channel access impediment, which took utmost care of avoiding jamming in severe areas of the network. Channel tenure, buffer loading and data packet loss velocity should furnish precise capacity of link jamming levels. Path possessing various links with a variety of data types will positively direct multiple networks of various rates.

If by chance, the paths which have low data pace pursues higher data pace links, data packets mount up leading to long tail. Link consistency also poses the issue of jamming, which causes in re-broadcasting.

## II. Taxonomy

### a) *What is Congestion?*

Data rate used by each dispatcher on the network is essential to regulate so as to avoid jamming of networks which involve shared resources. There are instances when data packets are declined access to traverse through networks and are left midway. As a result, circumstances may arise wherein extreme number of data packets arrive and are evidently plunged. These extreme number of data packets gobble up a considerable amount of shared utilities while travelling in a network and usually cause broadcasting to be done again, which ultimately indicates entry of even more number of packets than the ones already present in the network resulting in worsening of network throughput. If suitable jamming control method are not implemented then it may happen that the entire network gets jammed and no data is sent to the destination fully and successfully. TCP control jamming procedure was established when such a situation took place in the early Internet.

### b) *Congestion Factors:*

A network routing track can be jammed even if the actual load is reduced in the case of aggressive

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retransmissions of networks. Collapse occurs when throughput is reduced keeping in check the input load as stable and put. This happens due to some congestion factor and event termed as congestion collapse takes place. Some routers that act as mediators ensure packet decline in case of over-flooding hoping that the end points resurface the dropped packets back.

*c) Consequence factors in congestion aware and control routing models*

**Route failures:** Data packet and acknowledge-ment broadcast accounts for a substantial break because of loopholes in the paths of a network. This state forces a TCP sender to lessen his window volume resulting in jamming.

**Wireless losses:** There is a wrong elucidation that accidental packet losses due to other causes in a network excluding congestion is overcrowding which projects an unconstructive impact on jamming protocols.

**Shared medium:** The major confrontation faced by jamming control standards is recognizing real situations which involve dropping packets n a shared segment. The ultimate and essential regulation is compacting jamming at an early level that minimizes further damage to a network.

**Acknowledgement traffic:** This factor presents a situation where in a data packet and an ack packet ensure transmission in reverse directions which raises intra flow disputes. This factor also sometimes is responsible for deceiving jamming control standards.

## III. Predominant Citations

*a) Citations that deal with rout failure flaws:*

**TCP-Feedback (TCP-F)[1]:** Non jamming related fatalities and timeout states are resulted due to route failures which possibly immobilize TCP jamming control procedures.

**Explicit Link Failure Notification (ELFN)[2]:** This feature involves intimation via feedback through lower layers which takes the responsibility of notifying TCP procedures about any incidents of routing failures. Such a state enables a user to take to the stand-by mode which is similar to the snooze condition of the TCP protocols. In such a case, 2 options are available. The author attempts to make use of an ICMP host or resend the intimating signals back to the network. It is familiar with researchers and used in many of the approaches.

**TCP with Buffering Capability and Sequence Information (TCP-BuS) [3]:** Supplementary procedures are suggested that makes a point in escalating TCP performance, which helps in extending the ELFN. An unswerving liberation scheme is offered which makes certain the delivery of specific notices. Unequivocal warnings and probe data packets are scrutinized in order to establish and check re-established tracks.

**Fixed RTO scheme [4]:** This is in effect with the ELFN scheme and involves sending of data packets episodically, This scheme is intrinsically altered according to the requirements when compared to the ELFN scheme again.

**Enhanced Inter Layer Communication and Control (ENIC)[5]:** This scheme is a combination of ELFN-like route failure handling and the TCP SACK and DACK procedures. This does not involve separate notifications like ELFN but instead they are reused.

**TCP-ReComputation (TCP-RC)[6]:** This focuses on re-establishment of route altering route properties. This is an extension to ELFN which considers and deals with re-computation of TCP window size on the basis of the assets of the new track (cwnd) and slow start threshold (ssthresh) constraints.

**TCP for mobile ad hoc networks (ATCP)[7]:** This state makes use of TCP state procedures with the involvement of TCP-ELFN like packet probe procedure. In a case when no ECN message is obtained, the loss that occurs is considered to be non-jamming related. An additional layer called ATCP layer is built in below the transport layer that takes care of minimizing the dealings with respect to TCP.

**Cross-layer information awareness[8]:** Two procedures have been introduced here, the first Early Packet Loss Notification (EPLN) and secondly Best-Effort ACK Delivery (BEAD). EPLN takes the responsibility of intimating TCP sender the series numbers of the lost data packets that were unable to be retrieved. The sender then immobilizes and the re-sends the respective data packets when the path is re-stacked again. Intermediate nodes receive BEAD loss warnings and then they are forwarded towards the TCP destination, thus thwarting BEAD loss.

**TCP with Detection of Out-of-Order and Response (TCPDOOR)[9]:** The TCP jamming control procedures may be suspended momentarily by the sender when dis-ordered packets are perceived. This involves a scheme called Instant Recovery where in effects of the jamming methods are recovered. The anticipated effect is parallel to that of the freezing technique after the reset changes to TCP and the connections operate as if no route change has occurred.

**Signal strength based link management [10]:** A record of node remoteness that is approximated RSSI values is kept in routing standards. The routing standard gets an intimation when the link breaks and a new track to the receiver is investigated. The author observes that 802.11 MAC fails to recognize break links accurately in connection to jamming. Two incidents are recognized where in links move out of the transmission arena and a jammed path does not grant access to successful RTS.

*b) The citations those deal with wireless losses in ad hoc networks:*

TCP/RCWE [11]: TCP with Restricted Congestion Window Enlargement is again formed on te basis of the ELFN procedure where the bond between nodes break and losses occur. A mechanism called RTO ie. Retransmission timeout is introduced which takes care of random losses. This value can be calculated on the basis of the observations that if the RTO value is higher, then the TCP window size is low and vice-versa.

ADTCP [12]: These showcase and throw light on the major issue of end-to-end transport standards in movable ad hoc networks is the unruliness of dimensions of indicators for some network occurrences. There are two metrics that are proposed to recognize network jamming. The inter-packet hindrance difference at the destination gets high when jamming occurs. Furthermore, the short-term throughput decreases. These two metrics join together to form a secure and strong jamming indicator. Route changes and channel errors are distinguished by the advent of out-of-order packets and packet loss proportions.

ADTFRC [13]: ADTFRC scheme is similar to TFRC, just as ADTCP is to TCP. An identical amalgamation of the metrics and general procedure are used for differentiating loss types and supply receiver-based feedback. ADTFRC contributes many of its advantages to ADTCP.

Edge based approach [14]: Medium loss detection triggers TCP jamming control response. When the destination fails to receive data packets after waiting for a long time and paves way to timeout, a track failure occurs. TCP gets into ELFN like "probe mode" where data packets are broadcasted at equal intervals of time which in turn senses a re-established track.

*c) The citations those deal with shared medium issues:*

Link RED (LRED) & adaptive pacing [15]: The most favorable TCP window size subsists for the given topology and traffic prototype other than the fact TCP fails to find it. Larger windows cause link-layer disputation which authorizes research in wireless multi-hop jamming control momentously. LRED makes sure that TCP flows normalize their window size closer to the best possible region of MANET's.

Neighborhood RED (NRED)[16]: In this scheme every node makes a guess as to how many nodes are lined up in succession in total. All the prevalent packets form an implicit and allotted queue. If the queue exceed the set protocol, then the data packets are dropped and lost with the maximum prospects.

Contention-based Path Selection (COPAS) [17]: This scheme mainly concentrates on the TCP issue in MANET known as the capture problem. Nodes can detain mediums unfairly and have an edge over others. The annex for reactive tracking standards is COPAS. When COPAS is in progress, all the links from the source to the receiver are taken into consideration. Then upstream TCP transfer and downstream acknowledgements are promoted by two of the selected tracks which then ignores after-effects when one of the directed medium gets arrested.

Congestion Aware Routing (CAR) [18]: This concentrates on TCP flows and jamming control procedures. There are few credentials that deal with Acknowledgement transfer problems:

Dynamic delayed ACK [19]: There is a blend of two conventional ACKS's, where in data packets are forwarded to the receiving end only after a predetermined timed-out sequence or when a specified number of segments are turned over.

Dynamic adaptive acknowledgment [20]: This scheme is taken care of by the application of TCP hypothesis of their jamming procedures to MANET's by a dynamic timeout ACK that is estimated on the basis of the arrival time of the data packet at the destination.

Preferred ACK retransmission [21]: This model amalgamates two schemes explained earlier mainly, ELFN messages and DACK for TCP present on Flexible Radio Network (FRN). This FRN is viable and easily accessible MANET system powered by FUJI ELECTRIC. What is noteworthy here is the fact that it is in no way connected to the IEEE standards and makes use of predetermined instances on the modes.

## IV. Current State of The Art

Elastic Routing Table with Provable Performance for congestion Control in DHT Networks [27]:In this proposal authors discussed the Elastic routing Table mechanism for query load balancing; this mechanism is based on the fact that high-degree nodes are more efficient in handling traffic loads in DHT networks which suffer from a serious drawback of load balancing problem. In the ERT mechanism each heterogeneous load has a routing table, the size of which is a function of corresponding node capacity.

The DHT network works by establishing a functional relationship between the nodes and utilizes a routing protocol to identify the node responsible for the key. When the network is heterogeneous comprising of time-variable popular files the problem of load handling turns even more serious. Moreover, this problem results in the phenomenon "Bottleneck" which is nothing but the engagement of a node with too many queries at a time. Even though the DHT networks have advantages of good lookup efficiency, robustness, scalability and deterministic data location but the inherent loading balancing problems as the continuous occurrence of hashing results into imbalance degree of keys between the networks nodes. Thus the design of such a DHT protocol which can overcome the congestion control is a challenge.

The paper proposes the strategy to cope with the node heterogeneity, skewed queries and churn in

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DHT networks which can overcome the flaws of past strategies, namely the requirement of same and constant DHT degrees. The ERT technique is fundamentally derived from the principle of power law networks.

The methodology adopted to resolve the issue of congestion control protocol, serving the rationale of avoiding bulky nodes in query routings and to allocate query loads among the nodes according to the capacities of the nodes is that the load share of every node is proportional to its "fair load share", which is denoted as $s_i$ and is defined as ,

$$S_i = \frac{(l_i / \sum_i l_i)}{(c_i / \sum_i c_i)}$$

Where the variables stands as, $c_i$ : capacity of the node i to handle number of queries in time T.

$L_i$: load of node i, i.e. the number of queries it receives and transmits to it neighborhood in time T.

The ideal situation is attained at $S_i=1$, at this stage the node is not overloaded and the distribution is fair. The paper suggests two methods to attain this ideal condition, they are:

- Periodical assessment of load $l_i$ and transmit the queries accordingly.
- Application of the principle that a high-degree node would be the most probable to experience the high query load.

The authors have utilized the second techniques out of the above mentioned, by describing a new variable $d_i$ which represents the indegree of a node. The authors have assumed that node and file queries are uniformly distributed and under this assumption it has been found that the $l_i$ is directly proportional to the $d_i$ . However, the authors have intelligently reversed the relationship for the determination of node's outdegree by choosing an appropriate value of indegree. Further, the authors have normalized the node capacity so that the mean of capacities is 1 i.e. $\Sigma_i c_i = n$. And if the churn is eliminated the load is directly proportional to indegree of node.

The fair load share $s_i$ *expression* transforms to

$$S_i = \frac{(d_i / \sum_i d_i)}{(c_i / \sum_i c_i)} \; and \; d_i \approx c_i \frac{\sum_i di}{n}$$

*Where* $d_i \approx c_i \frac{\sum_i di}{n}$ here the multiplier is a constant and is declared as $\alpha$ , which is a system parameter and is defined as a functions of different metrics in system experience. Experimentally, it has been found that the high-load system have small alpha whereas the low-load system have high alpha. For practical uses with initial degrees of nodes as €$d_i$ where € is predefined % of the application purpose which is defined in pursuance of actual system carrying load capacity. The authors have taken into consideration Gnutella network and have used the bidirectional links similar to the Gnutella network in the DHT network by maintaining a backward outlink for every inlink, in order to get the acquaintance with the nodes forwarding the queries to the later to reduce the load and non-uniform distribution tendency. As a result, of which a double link is maintained for each routing table neighborhood.

The initial indegree assignment is not strong enough to restrict the load which is a function of time. The authors have practically examined that the nodes join and leave DHT overlays consistently and the files in the system have non-uniform and time-dependent popularity. Hence the congestion control protocol should be designed in such a way that it controls the query flow towards the nodes with sufficient capacity and it can change the query rate and time-varying file popularity as well as network churn. The authors have designed a periodic indegree adaption algorithm which facilitate every node to fiddle it's indegree at regular frequencies pursuant with the peak load encountered by the node. To perform this task each node records its load in a specified time T at regular frequency and checks whether it is overloaded or unloaded, this efficiency is recorded by a constant ¥$_i$. However, even the in-degree of adaption may be impotent to deal with query load imbalance. The authors have proposed a complementary randomized query forwarding algorithms to help forward queries towards light nodes in order to further condense the lookup latency.

The authors conducted simulation tests for ERT over various aspects and describes the distinguished properties of the ERT based congestion control protocol. The parameters chosen by the authors to define the performance of the ERT mechanism are as follows:-

- Metric of $99^{th}$ percentile maximum congestion to measure the network congestion.
- Query distribution share $S_i$ which represents the fair load distribution. The paper has put light on the reasons of unfair load distribution in DHT networks, which are:-
  i. Difficult to record the data for loads and capacity.
  ii. DHT is a dynamic system with continuous joined and departure of nodes.
  iii. The load changes with the file popularity and churn.
- Query processing time which is determined by two factors lookup path and number of heavy nodes encountered.

**Observation**: Authors have conducted experiments on cycloid networks without congest control (base) and with ERT based congestion control. The results due to the virtual server are also included for better understanding. In the test representing the congestion control efficiency, it has been found that ERT leads to better efficiency and much lower congestion rates, apart from this in the test of lookup efficiency which is determined by two factors, namely, lookup path length and query processing time in each node along the path the test result proved that the ERT/AF leads to much higher lookup efficiency in comparisons with others. At last, the authors have described the effect of skewed lookup, effect of churn and adaption & query forwarding.

Unified Approach To Congestion Control And Node-Based Multipath Routing [28]: Fernando Paganini et al., takes into account a TCP/IP-style networking along with flow-control at end-systems based on Congestion feedback and routing decisions at network nodes on a per-destination basis. The key aspect is to allow the routers to split their traffic in a controlled way between the out-going links by instilling the global optimization criteria. A concrete implementation of various algorithms is presented, based on queuing delay as congestion price. In order to develop a multi-path variant of the RIP, we make use of a TCP-FAST, which is clearly demonstrated through the ns2-simulations.

It is already known that the amount of traffic by the transport layer and the routes chosen by the network layer greatly influences the congestion present in the packet-switched-network. But, adapting the TCP mechanism, which is slow to instantaneous congestion results in routing instabilities. So, this solution opts to Multi-path routing which can more easily attain the required equilibrium. In terms of Math, the basic difference between the single path and the multi-path is evident when the optimization of a convex congestion cost is considered to serve the matrix of end-to-end demands. The interpretation of the optimization particularly proves to be useful when the combination of multi-path routing and congestion control are mixed up. A multi-path proposal by Kelly, though is mathematically perfect, implies to transfer functionality from the network to transport layer, which needs to be aware of the network paths present in the anatomy. The work has come up with a more node-centric and scalable alter, i.e. to have routers in-charge of the multi-path function by monitoring the traffic speed to their destinations among their outgoing tasks.

As far as the formulation aspect of the problem is concerned, an N nodes network is considered which has L direct links. The network hare supports various flows between the source-destination pairs of nodes. For unique indications of flow, the traffics are allowed to follow multiple paths between source and destination. By calculating the incoming flow, the outgoing flow, the total flow in a link 'l' is formulated. But, in this thesis of formulation, optimization problems occur. These problems are further diluted into 1) Welfare Problems which outputs the maximum achievable utility over all sources if the traffic is allowed to follow multiple paths between source and destination and 2) Surplus problems. Also, by apt re-definition of variables, the equivalence of the above problems can be showed. In order to account for the reasons of scalability as well as preserving layer separation, a pre-defined set of variables is used. Another aspect that arises is the Feedback Signals. The primary feedback signal is a congestion measure for each individual link l out of the links L. it is well assumed that there is no 'service differentiation' between the commodities. Different paths from the source to the destination will have their own 'prices' at any time. To be aware of such paths, routers are not required in specific; rather they can work with the local and neighbor information in order to infer their price-to-destination. If the link prices are given, under mild conditions, the unique solutions can be obtained to the recursive equations.

Another important aspect of concern is the Anticipative Control of Traffic Splits and its Stability. All the limitations of multipath routing based on the gradient of congestion price are revealed. Just by slowing down the adaptation, oscillatory instabilities that appear cannot be overcome. If the feedback factor B is reduced, the frequency of the oscillations may be reduced but the oscillations remain. The key idea presented in the paper top introduce damping into the system is to use "proportional derivative control", i.e. to introduce some anticipation of future prices in the control of the routing splits.

All the theory thus described, can further be installed into a more than one implementation, depending on the choice of the link congestion price, the source utility function, and the methodology for sharing congestion information between the routers and with traffic sources.

1. Routing Protocol and Node Price Formation: unlike the prevailing computation methods, routers disseminate metric information for computation, either globally or to neighbors'.
2. Update of Split Ratios, Blocking and Forwarding: the methodology for avoiding the formation of routing loops is discussed here.
3. Communication of Prices from routers to Sources: Considering the time-scales involved, the issues pertaining to the multipath algorithm is discussed here

Another major part discussed in the paper is of Simulations. This part elaborates and contrasts about the Gradient and Anticipatory control with a dynamic example of the 4 Node Topology. The simulation results thus depicted contain split ratios and metrics (prices) for the denoted nodes. The various processes such as the initialization process wherein all nodes first discover the direct route to the destination. The default route is highlighted here in this process. The TCP-FAST sources react to the lowering in the average queuing delay by increasing the rate. It is noted that as the traffic increases, the congestion increases, thereby the traffic is reduced through the route. Each of the nodes used have a number of routing links through which they send the traffic.

By and large, a framework has been successfully designed and proposed by the authors, containing details about multipath routing and congestion control which together are helpful in pursuing a common objective: the maximization of aggregate utility or surplus over the network. It is also noted that the control of input rates and routing splits is purely decentralized, completely relying on the sole factor of a common congestion "currency" for enhancing its decisions. A detailed mathematical study has been done on the equilibrium and dynamic properties of various control laws, in particular, a new anticipatory control of traffic splits has been proposed that stabilizes the maximum welfare allocation when it is combined with the dual congestion control. The persistent TCP flows have been assumed in the theory. Provided the relatively slow dynamics of the routing is given, it becomes very important to drag on the work to take into account the effect of finite TCP flows that come in and out of the network. This concept is kept open for the future research. Another key topic that has been presented is combining the network control and transport layers with the lower layers, particularly for the wireless networks, possibly offering alternatives to the back-pressure scheduling approach.

**Observation:** A detailed packet implementation based on queuing delay has been presented in the work. The delay pertains to congestion price wherein the routers measure local prices exchange information with neighbors', thereby following a multipath variant of a distance vector routing protocol. FAST TCP sources clearly estimate this particular delay from their RTT measurements in real time, calibrating their propagation delay through regular periodic interactions with the respective IP layer. The expected behavior from the theory is verified from the ns2 simulations. An alternate consideration is that one can as well consider implementations based on the loss of the marking as a congestion price.

**Congestion-Constrained Layer Assignment For Via Minimization In Global Routing [29]:** Multi layer Routing, which is one of the advanced technologies is usually done in two methods one being Detailed Routing and other global routing. The Present Paper focused on global routing. This Methodology uses full- fledged one layer routers and produces one layer routing result. Though this is an effective method, an advanced assignment algorithm is still required to bring in effective routing . Though the layer assignment the wire length and topology of the initial one layer routing result can be saved and delay, cross talk and vias can be reduced.

In Multilayer routing, of the net different layers are connected through the technology 'via'. But extensive usage of the via degrades the effectiveness of Routing. As such to minimize the via cost several new bench marks were released by ISPD '07. This paper also projects a new algorithm for via cost Minimization in layer assignment.

To minimize the via cost in the layer assignment two problems must be resolved. One is to see that the same routing topology is maintained and the other is total overflow constraint and maximum overflow Constraints are resolved. The present paper presents a layer assignment algorithm which can bring a solution for these congestion constraints.

The algorithm introduced is known as Congestion – Constrained Layer Assignment (COLA). COLA has two major procedures one is net order determination and the other is Single – Net layer assignment notifying congestion problems.

Net order determination is very important and decides the routing resources. These resources are very few as such net order is required for the maximum usage of the given resources. As such a new method is introduced by COLA to achieve the best utilization. Here in this methodology, for each one layer routed net, three factor are utilized to calculate score so as to decide the net order. The use specified parameters in the net order after the calculations of the score will be &,B and Y. In the new method proposed & and B are set equal and Y will be lesser than & and B. This produced a better layer assignment result.

For the single-Net layer assignment considering congestion problems a new algorithm which combines SOLA and APEC is newly presented in this paper. The proposed algorithm removes a group of edges from each cycle to simplify the procedure. SOLA which is a programming based algorithm is very effective in resolving the layer assignment problem where congestion problems are not taken into account. And APEC (Accurate and Predictable Examination of Congestion Constraints) is very useful in reproducing an edge during the layer assignment for a net. Which congestion constraint violation does not happen? COLA a new algorithm presenter in this paper combines the two, SOLA and APEC to resolve Single-net layer assignment problems.

COLA was experimented with standard ANSI C++ and tested on a Linux work station with AMD Dual Core Opteron Processor 2. 2 – GHZ CPU and 8-GB Memory. The first published multilayer global routing benchmarks, ISPD 07 were used in the experiments. COLA was tested to see if it could be improve the results of Maize Router, Box Router, and FGR and was implemented on a straight forward greedy algorithm to see the effectiveness of the COLA algorithm. Though the greedy algorithm a feasible layer assignment result for each benchmark is possible but the total wire length

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results will be worst. Whereas COLA was able to bring down the total wire lengths and improved the Via wire lengths more than Maize Router, Box Router and FGR Router could do.

From the experiments it was found that COLA did not take more than 2 min for each benchmark which is as good as greedy algorithm. Whereas CPU time taken by COLA is much lesser when compared to greedy algorithm.

Net order Determination method introduced by COLA was also experimented. The Via wave length results by COLA are much better when compared to the existing methodologies. From these experiments it was found that net order determination method and single-net layer assignment method are equally important for the success of COLA algorithm.

COLA was also tested on the compressed one-layer results of Box Router. And results show that COLA was still able to improve the results of Via wave length and the total wire length on each benchmark for Box Router 2. 0. The other note worthy point is that it does not give raise any parallel edges. In the case of Net with parallel edges, COLA was able to produce either better or worse layer assignment results in terms of the Via wire length.

In the case of layer assignment also COLA was able to achieve better results. in the Layer assignment situation where the parallel edges were not allowed COLA decreased the via wire length. But when the parallel edges were disallowed COLA could not perform well and rose the via wire length. The success of COLA was seen in the improvement of total wire length results and reduction of total overflow results. The advance step of COLA is COLA_R which can be used to iteratively refine a multilayer global routing solution in a net-by-net manner. COLA_R was tested and found that it was able to improve Via wire length total wire length results. And it was able to reduce total overflow.

**Observations:** The VIA capacity constraint must be considered in a better practical layer assignment problem so that a routable result can be given to the detailed router. But this paper does not produce any solution to Via capacity constraint and limits itself to the layer assignment problem.

**Interference Minimized Multipath Routing with Congestion Control in Wireless Sensor Network for High Rate Streaming [30]:** Focuses on dealing with and providing solutions for estimating the track attributes and appropriate resolution for multi track load complimenting. Jenn-Yue Teo, Yajun Ha, and Chen-Khong Tham recommended an Interference-Minimized Multipath Routing (I2MR) protocol that concentrates on mounting throughputs by ascertaining zone disjoint tracks for harmonizing weight. Handling and directing overcrowding proposals is also another feature that is performed and supposedly done. Basically of importance mainly in armed services wherein wireless intersection joints of minimal control are involved which prepares a base for underground WSNs. These underground WSNs mostly help in transmitting data of sharp bandwidth with the employment of Unmanned Aerial Vehicles (UAVs).

Harmonizing load in several tracks is fundamentally elucidated with stationary wireless systems in which a network can be represented with the help of a connectivity grid. Illustration of interfering procedure copy or rather a substantial copy of interfering networks can reproduce wireless intrusions in wireless arrangement. The basic number of linkages that aids in linking two paths can be traced with the correlation factor concerning two node-disjoint tracks. This correlation factor metric effectively depicts the quantity of wireless intrusions, thereby stating that the two connections are correlated and if in case where there is an absence of connections, it is reasoned that the two mentioned tracks are distinct. There is also the involvement of a conflict graph whose vertices conflict directly to a series of intended links. To ascertain this, various notions are made up that proposes few beliefs such as network concerned is wireless and stationary, a consistent broadcast and intrusion series for all connections, distinct basis and target connection and so on.

The instant end information is constantly confined via the antenna by means of EO through a solitary path along with controlled energy WSNs which provide associations to the UAV resilient scheme concerning the adjoining access nodes, hence concentrating on the competent multihop dispatching of information. The crisis is basically addressed as multipath and multihop steering wherein the foundation node endeavors assembling of three sector disjoint trails namely primary, secondary and backup lanes to the end node which are termed as primary, secondary and backup destinations correspondingly. The primary and the secondary trails are mostly in parallel use for harmonizing load and swaps itself to the backup state whenever a failure occurs, hence ensuring trail unearthing slide reduction. The underlying principle in usage of two trails is that there is literally little or no expansion in terms of cumulative throughput while using more than two trails. There are some suppositions supposedly made which state that the WSN connections are stationary, recognized sites for the basis and the entryway, basis and entryway sites are quite less energy-controlled, the start-target duo are duly placed at equal intervals, provision of sharp competence and non-intrusive data linkages to bond several entryway sites to the resilient intersection point etc. There is commencement of the track detection process from the basis to the ultimate target site. The process of track detection covers three fundamental measures, Primary path discovery, Interference-zone marking and Secondary and backup path discovery. Primary path discovery aids in building unswerving tracks which reduces intrusion with respect to tracks present in the interiors starting from the basis and ending at the primary target. Interference-zone marking grades one and two hop neighbors of primary tracks involving transitional intersections of least possible transparency. A maximum number of two hop neighbors are taken into consideration due to the base of the meddling scope measured twice the number of the communication scope. Interference-zone marking marks involvement of three undemanding moves, i.e. Sector marking, Broadcast Zone-marker Potential (BZP) assignment and Zone marking. Sector marking engages nodes the length of the primary tracks and aids in categorizing the corresponding neighbors into individual divisions. Broadcast Zone-marker Potential (BZP) assignment takes charge of allocating various BZPs to distinct areas concerning distinct sections. Zone marking in scripts a maximum of two-hop neighbors of respective Sector Heads (SHs) into Interference-Zone1 or Interference-Zone2.

Jamming Control schemes basically for I2MR (Interference Minimized Multipath Routing) consigns tracks at pre-defined pace which necessitates the need of three essential steps. Firstly, it engrosses in perceiving extended tenures of track jamming arenas. Secondly, there is a requirement of notifying basis about track jamming areas. Lastly, there is a want for plummeting the basis's loading velocity. Tentative intentions are firstly, I2MR for dissimilar network concentrations and the pace at which packet failures occur by making a contrast between track detection proposals compared with the other respective track detection proposals. Four different plans are made use of for analyzing performance of various track-sets mainly Aggregate throughput, Average end-to-end delay, Total energy consumed and Packet delivery ratio. The trials performed are based on the researches carried out making usage of GloMoSim network simulator. Stationary nodes are positioned homogeneously wherein the region is partitioned into a considerable number of chambers.

**Observation:** It is proved that I2MR is comparatively efficient in terms of the total track detection time, total control bytes broadcasted and the sum of the intact energy devotedly used up during the process of track detection, but NDMR seemingly devours more amount of energy due to the considerable dimension of the control packet as compared to I2MR. Even if the track-set performances for managing and organizing jamming are taken into consideration, I2MR plays a remarkable role with maximum throughput and significant gains when compared with I2MR, I2MR50, NDMR, and AODV. Another substantial finding worth mentioning is that I2MR consumes lowest amount of energy when compared with other multiple track proposals which makes it even more appealing. It can hence, be deduced as the modus operandi used for multiple track load balancing is effective enough to encapsulate the consequences of both intra and inter wireless intrusions, the projected I2MR procedure can showcase a considerable gain in throughput and the projected jamming control plan can increase throughput by loading effective tracks at the peak rate which in turn helps in reducing long-term overcrowding of tracks. The most probable restraint caused by I2MR protocol is that there is a vital need for spacing the source and the target that is required to be done by the wireless intrusions present between various adjoining track-sets. Future work has a proposal for an extension of the projected I2MR protocol which considers the outcome of inter-path set intrusions, with the sole viewpoint of deployment of WSN.

**A Low-Complexity Message-Passing Algorithm for Reduced Routing Congestion in LDPC Decoders** [31]: An LDPC (low density parity check) is generally used and got famous for error correction and real channel capacity performances, and also generates very low errors, for which its being suggested and possess a good error performance with large code lengths. Hence, these are widely used in Wi-max and 10GBASE-T. Every LDPC is implemented with a split row threshold algorithm that improves error performance and reduces routing congestion.

There are many iterative message algorithms for an LDPC decoder. A Min-sum decoding algorithm is an iterative message passing algorithm which is very vastly used for practical decoding. A fully parallel decoder maps every row and every column of parity check to different processing units which operate parallel in the same. These have larger area and a very good capacitance and a low operating frequency and are highly energy efficient. Fully serial and partially parallel decoders have a processing core and a memory block having lower throughputs and high latencies. And finally, an early terminator for message passing algorithm, simulations are used to determine predefined set for range of SNRs and as the condition gets satisfied early termination happens and is considered error free.

We will now be discussing about split row algorithm and ability to reduce routing congestion in layout, a split row decoding algorithm reduces the interconnect complexity. Here the total congestion is minimized and is used with SPA and minsum algorithm and a routing congestion reduction in this split row algorithm reduces routing congestion by a factor. And it is to note that splitting reduces routing congestion affecting global interconnects caused by message passing.

There is also a split row threshold decoding method in which we have a split row error performance that suffers 0.4 to 0.7 dB error proportional to spn as every split row has no information about minimum value and a split row threshold algorithm increases the error performance without reduction of effect of split row algorithm which creates a negligible hardware to check node processor and the kernel of split row algorithm is in four conditions, they are an Origin Block i.e., reg2out delay in which the path where threshold_en signal is generated in a block. This path has comparators to generate min1 and min2 , in addition to a comparison with threshold(T) , and an OR gate to generate threshold_en_out the signal going to the next partition and middle blocks i.e., in2out delay This path has middle blocks where threshold_en signal is passing through. Assuming that local min1 and min2 in all blocks are generated simultaneously, the delay in a middle block is one OR gate which generates the signal.

And finally in, destination block i.e., in2reg delay this is the path that a block updates the final check node output and is using threshold_en signal from neighboring partitions. The path which goes through the variable processor and ends at the register will be discussed in detail. The error value depends only on the threshold values and the benefit of split row threshold is partitioning of check node processing is arbitrary.

The architecture of this whole design consists of a check node processor, variable node processor and then we implement a fully parallel decoder, which check the logic gates, compared values and correction factors and its implementations while the equations of variable node processor remain unchanged for a both min-sum and a split row threshold decoder this implementation uses a 5-bit data path and finally, and in fully parallel implementations, all check and variable processor. Outputs are updated in parallel, and as in the timing.

In the C'MOS design of decoders the design flow and its implementation use standard cell based automatic place and a routine place decoder which stresses on the working, and in the delay analysis we discuss about the interconnect variable delays and delays in various blocks and methods to reduce it. And analysis about area after synthesis and layout and before synthesis and layout and its wiring and exponential problems, power and energy analysis deals with energy consumed by decoders, capacitances partitioning and its variations and methods to yield higher output and the variations on capacitances on different kinds of fabrications.

**Observation:** The various disadvantages of this are it requires a high performance and low power with a large number of nodes having high degree of interconnectedness and a large memory capacity with high memory bandwidth. These necessities are still due, to the message-passing algorithm which are used by the LDPC decoder. Actually, this was done with the sum–product algorithm (SPA) or min-sum algorithm. Our previous work introduced two nonstandard LDPC decoding algorithms dependant on min sum, called "Split-Row" and "multi-split" algorithms that were proven to the increase throughput up to five times, and reduce wiring and area up to three times. Split-row algorithm achieves this through the partitioning of min-sum algorithms global operation into semiautonomous localized operations. Hence, the reduction in message passing, there is a 0.3- to 0.7-dB reduction in performance, depending on the level of partitioning.

**Multipath routing algorithm for congestion minimization [32]:** Various track routing policies can relieve jamming of systems when divided among a number of trails. Routing proposals that are presently in use throw light on ascertaining a best possible path for routing purpose which results in a generous loss of network means. A varying methodology called multipath routing is a favorable solution which makes use of a number of superior tracks instead of a lone track. Crowded systems bring with them the issues of deprived presentation and high discrepancies which can be evaded using multipath routing. These issues have been addressed competently with the aid of two problems specified below which are first screened meticulously with calculations to find out whether there are any discrepancies involved in the process. The jamming issue is addressed with the aid of two problems that are taken into view to prove the facts mentioned in this paper, Problem RMP (Restricted Multipath) and Problem KPR (K-Path Routing). Problem RMP (Restricted Multipath) deals with reducing the network overcrowding issue with respect to the constraint set on the span of the track selected for networking. Problem KPR (K-Path Routing) steers clear the obligation of bounding the various tracks, at the same time taking into consideration reduction of network jamming issue. Problem RMP (Restricted Multipath) as stated before focuses on reducing overcrowding of networks under track quality limitations. It is statistically proved that this problem can be solved dutifully with the help of respective calculations. A pseudo-polynomial result comes into existence and an optimal estimation proposal is devised for the same. On the same lines, this problem paves a way to two additional logics, Multi commodity Extensions and End-to-End Reliability Constraints. There is a presumption in Multi commodity Extensions that only a lone source target pair is present in all occurrences of the given problem. End-to-End Reliability Constraints explains and provides an explanation to the instance which states that any kind of breakdown in any track in case of multiple tracks will ultimately affect the entire broadcast.
Problem KPR (K-Path Routing) is also explored which while routing passage along K number of various paths, reduces overcrowding of networks. A clear polynomial solution is presented as the problem is NP-Hard and happens only when the limitation on the number of tracks is more than the number of connections. Accordingly, in case of the number of tracks being less than the number of connection links, a two point estimation format is invented. Similarly, Problem Integral

Routing is proposed on the basis of provision of a supplementary state which handles network jamming all the while limiting access along each path present in the network.

It is proved through thorough simulations that multipath routing proposal results acquired by the most favorable jamming reduction schemes are comparatively well-organized than single path routing proposals. Hence, two classes of arbitrary networks are created, Power-Law topologies and Waxman topologies. This is done ensuring that the link competence, bandwidth demands and the span of each connection is spread maintaining the consistency factor. There is an assessment prepared on the basis of the contrast in the jamming caused by multipath routing and jamming caused by well-known single track routing protocol.

**Observation:** It is syntactically verified that feasible overcrowding reduction proposals are noteworthy as compared to single path routing proposals. What is important to note here is that both the problems discussed present a distinct series of reasonable explanations. Problem KPR (K-Path Routing) limits the stream of data along every track whereas Problem RMP (Restricted Multipath) sets itself up by applying constraints to the span of the network tracks. As every coin has two sides to consider, similarly, this proposal also has some shortcomings. There is no proposition that allows the two problems i.e. Problem RMP (Restricted Multipath) and Problem KPR (K-Path Routing) to merge and provide a competent and fused result. This drawback if taken care of can result in a sophisticated and systematic manner for data transmission and also jamming concerns can be addressed proficiently. Another issue of concern is the circulated execution of algorithm RMP which can be experimented with in future and favorable solutions can be found out. It is also stated that multipath routing also grants other areas for cumulative investigation such as network safety issues, energy competence etc and extensive studies for the same are in progress.

**Towards Robust Multi-Layer Traffic Engineering: Optimization of Congestion Control and Routing [33]:** This after some justification is further being resolved by Jiayue He, Bresler, Mung Chiang, and Jennifer and mainly discusses about traffic engineering and how to effectively control the congestion by TCP (transmission control protocol). Traffic engineering is a method of optimizing the performance of a telecommunications network by dynamically analyzing, predicting and regulating the behavior of data transmitted over that network. The hosts increase or decrease the data sending depending on the network congestion. The study of traffic engineering is done using two approaches. First is the bottom-up approach that compares interaction between TCP congestion control and conventional traffic engineering practices and top down approach which creates a new multi layered dynamic distributed algorithm based on the following points.

- Stability – Are congestion control and routing in equilibrium?
- Optimality – does the equilibrium maximize the aggregate user utility, over the routing parameters and source rates?

For having both performance and robustness top- down approach is preferred with the following goals

- Distributed
- Robust
- Implementable
- Efficient

The TE model (traffic engineering model) and DATE algorithm (Distributed Adaptive)

Traffic Engineering are used in implementing traffic engineering.

The paper also discusses about network model which deals with focus on routing and congestion control.

A network can be taken as a set of $L$ bidirectional links with finite capacities $c = (cl, l = 1, . . . , L)$, which are shared by a set of $N$ source-destination pairs, indexed by $i$. a source destination pair can be represented as "source $i$." . The traffic engineering practices can be known by given routing configuration as follows using $ul = Rlixi/cl$. Where matrix $Rli$ represent the current routing that captures the fraction of $i$'s flow that traverses each link $l$. TCP congestion control based on reverse engineering was also discussed with a goal of maximize aggregate user utility by varying $x$. Simulation of the TE model can be done by using a combination of the Matlab and MOSEK environments. Different experiments were conducted by the authors by evaluating two variants of TCP congestion control: $\alpha = 2$ (*e.g.*, TCP Reno) and $\alpha = 1$ (*e.g.*, TCP Vegas) for the cost function $f(ul)$. Initial experiments evaluate a simple $N$ - node ring topology. The experiments were done using $N$ nodes, $N$ sources and $N$ nodes, 1 destination, Access-Core topology and Abilene topology.

In the first experiment the capacity of link 1 was varied and plots the gap in aggregate utility for ring topologies with three, five, and ten nodes, where each node communicates with its clockwise neighbor. The two graphs were plotted for $\alpha = 1$ and $\alpha = 2$. In the second experiment graphs were plotted for Aggregate utility gap for the $N$ - node, 1-destination ring and the results were noted as Traffic pattern can have a significant effect and TCP variants give the same trend in both the experiments with $\alpha = 1$. This paper also discusses analysis of TE model with theorems. The design goals for multi layered traffic engineering are

- *Satisfying User and Operator Objectives*
- *Adapting Routing on a Smaller Timescale*

To conclude distributed adaptive traffic engineering was discussed with DATE algorithm and stability and optimum results. There are also some cross layer studies which resembles TE model which share congestion control model or routing model. The DATE algorithm bears similarity to MATE [10], TeXCP [11] and REPLEX [14]. The difference is that other schemes do not consider congestion control explicitly.

## V. Conclusion

A decisive analysis has been conducted on current state of the art. It is clear from our discussions that the algorithms stated are aiming to handle the congestion raised due to vast payloads on network, which may be due to flooding of packets or may be due to repeat requests on the basis of error correction techniques. Based on on the decisive analysis conducted in this paper we can state that congestion control models must handle the negative influences raised because of one or more factors like link failures, wireless losses, shared media issues and ACK packet load issues. This is clear from the investigations that all of the existing solutions are not robust to handle congestion raised, since the negative impact of above stated factors are vary from one to other network topologies. This leads us to conclude that new set of solutions are needed to overcome the limits in existing models in the view of robustness and adaptation.

## References Références Referencias

1. K. Chandran, S. Raghunathan, S. Venkatesan, and R. Prakash. A Feedback Based Scheme for Improving TCP Performance in Ad-Hoc Wireless Networks. In ICDCS '98: Proceedings of the 18th International Conference on Distributed Computing Systems, pages 472–479, May 1998.
2. G. Holland and N. H. Vaidya. Analysis of TCP Performance over Mobile Ad Hoc Networks. In MobiCom '99: Proceedings of the 5th Annual ACM/IEEE International Conference on Mobile Computing and Networking, pages 219–230, Aug. 1999. DOI: http://doi.acm.org/10.1145/313451.313540.
3. D. Kim, C.-K. Toh, and Y. Choi. TCP-Bus: Improving TCP Performance in Wireless Ad-Hoc Networks. In ICC '00: Proceedings of the IEEE International Conference on Communications, volume 3, pages 1707–1713, June 2000. DOI: 10.1109/ICC.2000.853785.
4. T. D. Dyer and R. V. Boppana. A Comparison of TCP Performance over Three Routing Protocols for Mobile Ad Hoc Networks. In MobiHoc '01: Proceedings of the 2nd ACM International Symposium on Mobile Ad Hoc Networking & Computing, pages 56–66, 2001. DOI: 10.1145/501422.501425.
5. D. Sun and H. Man. ENIC – An Improved Reliable Transport Scheme for Mobile Ad Hoc Networks. In GLOBECOM '01: Proceedings of the IEEE Global Telecommunications Conference, volume 5, pages 2852–2856, Nov. 2001. DOI: 10.1109/GLOCOM.2001.965950.
6. J. Zhou, B. Shi, and L. Zou. Improve TCP performance in Ad hoc network by TCP-RC. In PIMRC '03: Proceedings of the 14th IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, volume 1, pages 216–220, Sept. 2003. DOI: 10.1109/PIMRC. 2003. 1264264.
7. J. Liu and S. Singh. ATCP: TCP for Mobile Ad Hoc Networks. IEEE Journal on Selceted Areas in Communications (J-SAC), 19(7):1300–1315, July 2001. DOI: 10.1109/49.932698.
8. X. Yu. Improving TCP Performance over Mobile Ad Hoc Networks by Exploiting Cross-Layer Information Awareness. In MobiCom '04: Proceedings of the 10th annual international conference on Mobile computing and networking, pages 231–244, New York, NY, USA, 2004. ACM Press. DOI: http://doi.acm.org/10.1145/1023720.1023743.
9. F.Wang and Y. Zhang. Improving TCP Performance over Mobile Ad-Hoc Networks with Out-of-Order Detection and Response. In MobiHoc '02: Proceedings of the 3rd ACM International Symposium on Mobile Ad Hoc Networking & Computing, pages 217–225, 2002. DOI: http://doi.acm.org/10. 1145/513800. 513827.
10. F. Klemm, Z. Ye, S. V. Krishnamurthy, and S. K. Tripathi. Improving TCP Performance in Ad Hoc Networks using Signal Strength based Link Management. Elsevier Ad Hoc Networks, 3(2):175–191, 2005. DOI: 10.1016/j.adhoc.2004.07.005.
11. M. G¨unes¸ and D. Vlahovic. The Performance of the TCP/RCWE Enhancement for Ad-Hoc Networks. In ISCC '02: Proceedings of the 7th IEEE International Symposium on Computers and Communication, pages 43–48, 2002. DOI: 10.1109/ISCC.2002.1021656.
12. Z. Fu, B. Greenstein, X. Meng, and S. Lu. Design and Implementation of a TCP-Friendly Transport Protocol for Ad Hoc Wireless Networks. In ICNP '02: Proceedings of the 10th IEEE International Conference on Network Protocols, pages 216–225, Nov. 2002.
13. Z. Fu, X. Meng, and S. Lu. A Transport Protocol for Supporting Multimedia Streaming in Mobile Adhoc Networks. IEEE Journal on Selected Areas in Communications, 21(10):1615–1626, Dec. 2003. DOI: 10.1109/JSAC.2003.816461.
14. R. de Oliveira, T. Braun, and M. Heissenb¨uttel. An Edge-based Approach for Improving TCP in Wireless Mobile Ad Hoc Networks. In DADS '03: Proceedings of the Conference on Design, Analysis and Simulation of Distributed Systems, Orlando, USA, Mar. 2003.

15. Z. Fu, P. Zerfos, H. Luo, S. Lu, L. Zhang, and M. Gerla. The Impact of Multihop Wireless Channel on TCP Throughput and Loss. In INFOCOM '03: Proceedings of the 22nd Annual Joint Conference of the IEEE Computer and Communications Societies, volume 3, pages 1744–1753, Apr. 2003.
16. S. Xu and T. Saadawi. Does the IEEE 802.11 MAC protocol work well in multihop wireless ad hoc network. IEEE Communications Magazine, 39(6):130–137, June 2001. DOI: 10.1109/35.925681.
17. C. de M. Cordeiro, S. R. Das, and D. P. Agrawal. COPAS: Dynamic Contention-Balancing to Enhance the Performance of TCP over Multi-hop Wireless Networks. In Proceedings of the 10th International Conference on Computer Communication and Networks (IC3N), pages 382–387, Miami, FL, USA, Oct. 2002.
18. Z. Ye, S. Krishnamurthy, and S. Tripathi. Use of Congestion-Aware Routing to Spatially Separate TCP Connections in Wireless Ad Hoc Networks. In Proceedings of the 1st International Conference on Mobile Ad hoc and Sensor Systems (MASS), Fort Lauderdale, FL, USA, Oct. 2004.
19. E. Altman and T. Jim´enez. Novel Delayed ACK Techniques for Improving TCP Performance in Multihop Wireless Networks. In PWC '03: Proceedings of the IFIP-TC6 8th International Conference on Personal Wireless Communications, pages 237–250, Sept. 2003. DOI: 10.1007/b12004.
20. R. de Oliveira and T. Braun. A Dynamic Adaptive Acknowledgment Strategy for TCP over Multihop Wireless Networks. In INFOCOM '05: Proceedings of the 24th Annual Joint Conference of the IEEE Computer and Communications Societies, volume 3, pages 1863–1874, Mar. 2005. DOI: 10.1109/INFCOM.2005.1498465.
21. M. Sugano and M. Murata. Performance Improvement of TCP on a Wireless Ad Hoc Network. In VTC '03-Spring: Proceedings of the 57th IEEE Vehicular Technology Conference, volume 4, pages 2276–2280, Apr. 2003. DOI: 10.1109/VETECS.2003. 1208794.
22. M. Heusse, F. Rousseau, G. Berger-Sabbatel, and A. Duda, "Performance anomaly of 802.11b," Proc. of INFOCOM, vol. 2, pp. 836–843, 2003.
23. B. Awerbuch, D. Holer, and H. Rubens, "High throughput route selection in multi-rate ad hoc wireless networks," Proc. of the First working conference on wireless on-demand network systems, pp. 251–269, 2004.
24. S. Zhao, Z. Wu, A. Acharya, and D. Raychaudhuri, "PARMA: a PHY / MAC aware routing metric for ad-hoc wireless networks with multi-rate radios," Proc. of WoWMoM 2005, pp. 286–292, Jun. 2005.
25. J. Kang, Y. Zhang, and B. Nath, "Accurate and energy-efficient congestion level measurement in ad hoc networks," Proc. of WCNC, vol. 4, pp. 2258–2263, Mar. 2005.
26. Y. J. Lee and G. F. Riley, "A workload-based adaptive loadbalancing technique for mobile ad hoc networks," Proc. of WCNC, vol. 4, pp. 2002–2007, Mar. 2005.
27. Haiying Shen; Cheng-Zhong Xu; , "Elastic Routing Table with Provable Performance for Congestion Control in DHT Networks," Parallel and Distributed Systems, IEEE Transactions on , vol.21, no.2, pp.242-256, Feb. 2010 doi: 10.1109/TPDS.2009.51 URL : http://ieeexplore.ieee.org/stamp/stamp.jsp?tp =&arnumber=4815223&isnumber=5372118
28. Fernando Paganini, Enrique Mallada: A unified approach to congestion control and node-based multipath routing. IEEE/ACM Trans. Netw. 17(5): 1413-1426 (2009).
29. Tsung-Hsien Lee; Ting-Chi Wang; , "Congestion-Constrained Layer Assignment for Via Minimization in Global Routing," Computer-Aided Design of Integrated Circuits and Systems, IEEE Transactions on , vol.27, no.9, pp.1643-1656, Sept. 2008 doi: 10.1109/TCAD.2008.927733. URL: http://ieeexplore.ieee.org/stamp/stamp.jsp? tp=&arnumber=4603083&isnumber=4603069
30. Jenn-Yue Teo; Yajun Ha; Chen-Khong Tham; , "Interference-Minimized Multipath Routing with Congestion Control in Wireless Sensor Network for High-Rate Streaming," Mobile Computing, IEEE Transactions on , vol.7, no.9, pp.1124-1137, Sept. 2008 doi: 10.1109/TMC.2008.24. URL:http://ieeexplore.ieee.org/stamp/stamp.jsp?tp =&arnumber=4453827&isnumber=4573014
31. Tinoosh Mohsenin, Dean N. Truong, and Bevan M. Baas. 2010. A low-complexity message-passing algorithm for reduced routing congestion in LDPC decoders. Trans. Cir. Sys. Part I 57, 5 (May 2010), 1048-1061.DOI=10.1109/TCSI.2010.2046957 http://dx.doi.org/10.1109/TCSI.2010.2046957
32. Banner, R.; Orda, A.; , "Multipath Routing Algorithms for Congestion Minimization," Networking, IEEE/ACM Transactions on, vol.15, no.2, pp.413-424, April 2007 doi: 10.1109/TNET.2007.892850 URL:http://ieeexplore.ieee.org/stamp/stamp.jsp?tp =&arnumber=4154742&isnumber=4154740