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Analysis of Storage Congestion Control Techniques in Mobile Opportunistic Networks: A Review

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Abstract: Opportunistic Networks are type of MANET's where contacts between mobile nodes are unpredictable and source to destination path rarely exists. Due to irregular contacts between mobile nodes, data dissemination is taking place hop-by-hop of message transfer in communication networks. Data replication and unpredictable contact times leads to congestion at nodes which necessitate buffer management control mechanisms between mobile nodes. The congestion control may be single copy and multi copy, whereas single copy congestion control uses local information at the node for decision making about the hop by hop custody transfer of message, which is liable to fail due to disconnection or change in latency of signal. Multi copy is replication based mechanism which achieves large delivery performance at the expense of high transmission cost in terms of extra overhead, energy and resource usage. The need arises to measure the congestion locally and how it can be further effectively considered by routing mechanisms. The congestion control can be regarded complimentary component of routing in mobile opportunistic networks, as both shares the common challenge of inadequate network information. In future work, self learning algorithms ought to be designed and integrated and for buffer management to enhance latency.

Keywords: Mobile Opportunistic Network, Storage congestion control, Buffer Management, efficient delivery, Replication Management

I. INTRODUCTION

The overall delivery ratio of messages can be improved by optimizing the buffer at a node by considering various properties of a message like message lifetime, size and the likelihood by which the massage can be further forwarded. The congestion can be categorized as link congestion and node buffer congestion in communication network. The link congestion is rarely occur in mobile opportunistic networks as link or channel is broadcast in nature and no node is facing challenge to transmit the message between two or more nodes when they are within the communication range of network. While, on the other hand the buffer congestion occur at node when multiple messages compete for the use of amount of free space available at node. The procedure for Congestion control in mobile opportunistic networks relies on the quantity of message duplicates disseminated in mobile opportunistic network. The Routing mechanisms can utilize flooding or replication of messages (multiple copies of massage) out of which atleast one message will reach at the destination which increases the message delivery ratio and reduces the source to destination delay. In this strategy a numbers of message duplicates are accessible in the communication network. Because of high repetition of messages in the network the custody transfer of message is not making any rationale in the system, and controlling the congestion appear as dropping a message in communication network. In mobile opportunistic networks, the high round trip time (RTT) makes the source to destination messaging mechanism very slow and furthermore the dropped messages are difficult to be identified by the source node as there is no provision of acknowledgement exists in the system. In mobile opportunistic network, a message has to be dropped at node whenever some congestion occur, While considering the network delivery performance, those messages must be dropped having low impact on source to destination delivery of messages.

On the other hand, in single copy routing mechanism, message dropping at the instance of congestion can significantly decrease the delivery ratio in the system. The storage congestion management mechanism should carefully decide and select about the massages so that it should not cause any congestion at node in future.
Figure 1 illustrates the classification of congestion control mechanisms for mobile opportunistic networks.

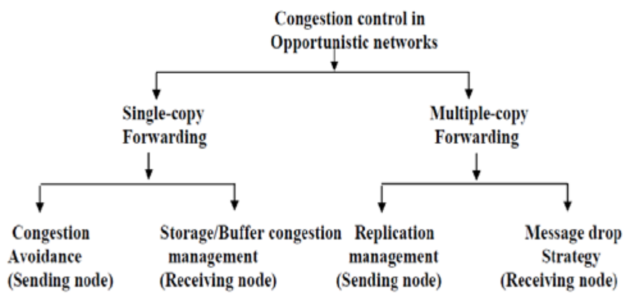

Figure 1 Congestion control strategies for opportunistic networks.

II. Congestion control in Single Copy message forwarding

In this section the focus is on making decision for custody acceptance/rejection of message for a single node. The system uses hop by hop reliable, delivery responsibility transfer in the communication network. Message acceptance with custody transfer keeps the promise for not to erase the message until it ultimately reaches to other node reliably.

Single copy message forwarding

In this messaging technique the node has to decide every time how successfully handover a message to enhance end to end reliability in network and moving the responsibility towards the destination. The important issue here is how to select the next hop on the basis of current connectivity status of network. As there is only one message copy in the network and its custody should be reliably to be delivered to the next node. While accepting the custody of message at node it must not to delete the message until its custody is transferred reliably or the message is reached at destination. The main advantage of custody transfer is the node can be allowed to delete the message quickly as the custody transfer acknowledgement is received. This makes the network to offer an effective message guardianship message transfer service in the network. The buffer congestion mechanism in single copy message forwarding can be classified into two categories, namely financial models which determine the strength of custody transfer of message to new node and traffic distribution analyzer which determine the traffic levels in the network and then makes the decision of message transfer.

A. Financial Model of buffer management

The nodes in mobile opportunistic networks are often have restricted resources, particularly limited storage at node to accomplish message forwarding in mobile opportunistic networks.

Spyropoulos T et al. [1] have introduced hybrid single copy message forwarding in opportunistic network on the basis of hop by hop routing model. The main issue is of deciding about the next hop to carry the message forward towards destination. Every node must be careful while accepting a message from another node as it substantially consumes local node resources. Buffer management in mobile opportunistic networks is modeled as a financial activity where a choice to accept message custody, is made self sufficiently based only on accessible neighbourhood information, as information related to entire network is readily not available because of the dynamic nature of communication network.

Fall et al. [2] introduced while accepting the custody of message at node it must not to delete the message until its custody is transferred reliably or the message is reached at destination. The main advantage of custody transfer is the node can be allowed to delete the message quickly as the custody transfer acknowledgement is received. A node must be care full while agree to accept custody of message as it appears the storage resources are managed properly. Local decision to accept message is similar to purchasing a perishable commodity whereas larger message is similar to high price and time for next contact corresponds to liquidity.

Burleigh and Jennings [3] introduced the concept of congestion control mechanism where a decision is taken autonomously with local information available with node like available buffer and the value of risk of associated with acknowledging the message. The custody acknowledgement is on the basis of financial model. The merit of this technique is that every node needs only local information to make message custody transfer decision. It is not adding any communication overhead for gathering local information and for making decisions and it does not fail due to disconnections or large variations in signal propagation latency. The sender and receiver of message will have to pay the conveyance charges to get the message delivered and the relay node will get the commission for forwarding the biggest possible message and as fast as possible. The node can acknowledge a new message only if the space needed for the message is smaller than the accessible space of buffer and furthermore the risk of accepting the message is acceptable.

Zhang and Liu [4] implemented incentive management and employ dynamic programming to design congestion management technique in mobile opportunistic networks. In case the receiving node accepting too many messages and setting aside excessive storage and preventing itself from receiving important messages. The algorithm aims to improve source to destination reliability and custody transfer is proposed where responsibility for reliable delivery of a message is moved hop by hop towards its destination. The approach is proactive, where each node makes decision whether to accept custody request to avoid congestion. The network utilization can be enhanced by balancing opportunity cost and benefits function during message custody transfer. The performance metrics of congestion management in simulation are throughput of network and buffer utilization in each node. As relying on the information of local storage space, the scheme can readily applied on dynamic and unpredictable environments.

B. Congestion Management Traffic Distribution analyzer

In mobile opportunistic networks instead of exchanging control traffic to create unreliable routing structures, it has been tried to search for such characteristics which are less volatile than mobility. The focus is on two parts of network scenario; community and centrality. Community is very important characteristic of PSN's. Pan Hui et al. [7] shows that correlated interaction concept can be exploited to select forwarding paths. The algorithm selects high centrality nodes and community members for message forwarding to destination or relays.

E. Daly et al. [6] presented that the centrality metric measure the significance of a node in the network.

a) Centrality: centrality measure in graph theory is relative significance of a vertex within the graph. A more significant node or individual will always have higher centrality in the network.

b) Degree centrality of a node: Measured as the quantity of direct ties that involve a given node.

c) Betweeness centrality: it measures the degree to which a node lying on the way connecting different nodes. It can be viewed as measure of the degree to which a node has a control over data streaming between others.

d) Ego network: It can be characterized as network comprising of a actor together with the on-screen actors they are associated with and every one of the connections among every one of these on-screen actors.

e) Ego betweeness centrality: Degree centrality can be effortlessly measured for an ego network. It is a basic tally of the quantity of contacts.

T. Hossmann et al. [5] presented that social organizations have a non-irregular structure, though few nodes are developed as centre points for communication in the network and carrying a high extent of total traffic of the network. These centre nodes (with most elevated centrality) have numerous relations with different nodes in the system and henceforth are very well known in the society.

E. Daly et al. [6] Social network based routing protocols like SimBet showing the small world domain where individuals are linked with short distance through some bridge nodes on the basis of centrality characteristics. These extension nodes go about as hand-off and encourage information exchange among separated hubs. Because of the complexity of centrality metrics the idea of ego network is exploited where nodes not required exchanging information about whole network topology and just locally accessible information is considered. These extension hubs go about as hand-off and encourage data trade among separated hubs. Because of the intricacy of centrality measurements the idea of inner self system is misused where hubs not required trading data about whole system topology and just locally accessible data is considered

P. Hui et al. [7] proposed that the Social structures can be used in design of forwarding algorithms for pocket switched networks (PSN's). It is implemented and demonstrated and is applicable in the decentralized environment of PSN's.

J.M. Pujol et al. [8] introduced the concept of Social networks which leads the routing through some key nodes in the network. The algorithm achieves more than 33% of more efficiency than existing algorithms. It improves performance by favouring those peers that appears to carry forward the message successfully to the target node. A fair route routing algorithm is outperforms existing algorithm and distribute the load where top 10% of nodes performs 26% of all advances and 28% of the considerable number of handovers with no loss of performance.

Kathiravelu et al. [9] presented the Adaptive Routing protocol that uses the predictability and associated connection information to route messages effectively towards their destination. Simulation based similar reviews demonstrate that the proposed routing protocol beats existing Epidemic and probabilistic routing protocols to carry forward messages.

M. Radenkovic et al. [10] presented Congestion Aware Adaptive (CAA) algorithm for opportunistic forwarding that supports improves multipoint high volume information stream while keeping up high buffer accessibility and low delays. It investigates various social, buffer and delay heuristics to offload the traffic from congested parts of the network and spread it over less congested parts of the network with specific end goal to keep low delays, high success ratios and high accessibility of nodes.

C. Congestion Avoidance

D. Hua et al. [11] proposed a new congestion avoidance mechanism which is on the basis of path avoidance for mobile opportunistic network. This mechanism upgrades the management of node buffer and characterize following states for nodes:

i) Normal state (NS)
ii) Congestion adjacent state (CAS)
iii) Congestion state (CS).

On the basis of state of node a different technique is used for avoiding congestion.

The CAS and CS required deciding the rate of use of node buffer and the message forwarding speed. If the use of rate of node storage comes to an edge value with little storage unused and the rate doesn't diminish beneath as far as possible for a period than the node is said to be in CAS. The node storage management divided the storage into custody storage, temporary storage and direct transmission storage. This empowers the utilization of storage to be more adaptable and fulfils the network requirements for custody storage and temporary storage.

E. Coe and C. Raghavendra [12] proposed Token Based Congestion Control (TBCC) which attempts to address the challenges of congestion control and implemented a novel congestion control mechanism by using tokens. Utilizing discrete event simulator, it demonstrate measure of dropped messages are diminished because of the network congestion. Network nodes must have a token so as infuse messages into the network. Here the aggregate transit time, the time from message generation to until delivery to the destination is decreased by 20% and furthermore 36% reductions in the measure of intermediate network storage. It shows a decrease in both space and time. A token based congestion control is utilized where nodes see each other regularly but yet because of high mobility source to destination paths cannot be kept up.

III. CONGESTION CONTROL IN MULTI COPY MESSAGE FORWARDING

In this section the congestion control is extended to multi copy case, in which each node communicates the received packet to every one of its neighbors. However few nodes won't have capacity to get communicate packets due to partition of network. Henceforth, every node stores the message until the message at long last arrive the destination.

Multi Copy message forwarding

A number of message copies are effective but limited resources available at node can easily overwhelm as compared to single-copy strategy. To avoid excessive dissemination of message copies into the network, controlled replication management algorithms are proposed. Uncontrolled replication will exhaust network resources. The message replication is commonly used as forwarding technique to improve message delivery. The goal of replication management is to maximize message delivery by avoiding congestion. Epidemic routing protocol is one such protocol work on the basis of replication based routing in the networks and it performs well with unlimited resources in the network.

A. Replication Based Management

The efficient replication management needs restricting the amount of replications allowed. Imposing a limit on maximum number of message copies to save the network resources.

S.C. Nelson [13] presented there are many replication based protocols to obtain correspondingly high delivery performance. But it is available at the expense of overwhelming network resources. Encounter Based Routing in networks provides high message forward performance than current replication based protocols while minimizing overhead and delay. It achieves up to 40% enhancement in message forward performance than the currently available novel protocols.

N. Thompson et al. [14] proposed node based replication management mechanism that addresses the storage congestion through variably restricting the message replication at node during every encounter. The delivery is improved with restricted resources available to the mobile node. The main objective is to acquire knowledge of global nature of congestion and implement congestion control locally, subsequently improving message delivery performance. The aim is set to search parameters which can track the variation in rate of delivery because of buffer congestion at node. The model determine the rate of delivery on the basis of replication of messages in the entire mobile opportunistic network in respect of parameters like size of buffer, rate of generating message, replication rate etc.. The relation of delivery rate relies on interaction of different parameters of network.

Y.K. Ip et al. [15] studied the effect of resource conflict of delivery delay performance for multi copy message forwarding. It demonstrates the performance improvement of delivery delay with multi copy routing can be inspite of by resource conflicts during high load. A possible future work can incorporate determining the results of analysis that interpret the ideal count of message replication under little transmission capacity and node buffer supporting requirements.

B. Message Drop Strategy

In multi copy routing mechanism the storage space at node's buffer is being still remains in use even after the message is forwarded. So, it is important to design an effective scheduling mechanism for messages and to determine which messages to be forwarded and which messages required to be dropped. The need arises for handling storage space when the entire buffer is filled up. A message drop strategy is required for mobile opportunistic networks and is a difficult task as various parameters needed to be taken into consideration to decrease the message dropping effect in delivery performance of the network. The message drop strategies can be categorized on the basis of data required.

A. Krifa et al. [16] proposed an effective joint scheduling and message dropping scheme which can improve distinctive performance measurements like delay and probability of message being delivered. Utilizing the hypotheses that the message is spreading as soon as encounter occurs. It is initially proposed an ideal strategy based on entire information of network. At that point, distributed mechanism was introduced that can estimate the performance in practice of the ideal mechanism. It utilizes statistical learning to approximate the needed entire information of the optimized algorithm. It demonstrates that scheme based on statistical learning effectively estimates the performance of the optimized algorithm in every considered scenario

Lindgren and Phanse [17] proposed and assess various combinations of queuing schemes and forwarding techniques in opportunistic networks. It demonstrate that a predictable routing methodology and choosing best option of buffer management approach and forwarding technique can bring the enhancement of message delivery reducing end-to-end delay and overhead in the network.

V. Erramili, M. Crovella [18] presented a distinctive message prioritization plans utilizing real estimations. These plans can be isolated into the plans do not utilize network information and the plans which uses the network information. To begin with set of plans incorporate FIFO/LIFO etc. and so forth and the latter set of plans, there is a key outline decision. To decide if the messages are near to their destination, it depends on a forwarding technique. In this case delegations of forwarding plans which appeared productive in the form of expense incurred are utilized. Another group of prioritization plans on the basis delegation plans has been produced.

Bjurefors *et al.* [19] assessed dropping procedures at nodes which are congested in opportunistic networks with various scenarios along with community associated. The congestion avoidance, managing storage and deciding which message to be dropped is depends on the premise of localized information. Every node does not have complete information about the interest of every other node. Here the utilization of local information about the replication provides a high performance of delivery in comparison to utilizing localized information.

The information object dropping strategies are evaluated on the basis of localized information and the level of replication.

Least Interested-LI: Dropping information object having slightest neighbours is interested in.

Most Interested-MI: Dropping information objects that most neighbours are interested in.

The following methods drops information objects on the basis of localized information about forwarding like number of replication.

Maximum Copies-Maximum: Dropping information objects immediately when a maximum number of duplicates are made on the nearby node.

Most Forwarded (MF): Dropping the information object having the largest level of replications generated on the nearby node.

Least Forwarded (LF): Dropping the information object having the most minimum level of replications generated on the nearby node.

Yun *et al.* [20] proposed to achieve data delivery; a routing mechanism based on flooding algorithm dissemination has been designed for network. However, congestion will happen effectively at a node if the buffer of node is restricted under epidemic routing. To take care of this issue, a novel congestion control technique designated as average forwarding number based on epidemic routing (AFNER) was designed keeping in view of epidemic routing algorithm. The simulations performed with random waypoint mobility model and the outcomes demonstrate the enhancement of AFNER technique.

IV. ANALYSIS OF CONGESTION CONTROL STRATEGIES

The various techniques have been reviewed and discussed to explore the buffer congestion in mobile opportunistic networks. The storage congestion occurs in mobile opportunistic networks at the point when messages go after the utilization of restricted storage at the node. The storage congestion control is classified on the basis of number of message duplicates disseminated the entire network and routing protocols may use flooding based messaging to increase delivery ratio and reduce end to end latency. Psaras et al. [21] The Service Targets such as Delivery Ratio and Delivery Delay and the System Constraints (Energy and Storage) for a opportunistic network structure are difficult to modify, if possible, to finish both High Delivery Ratio and Low Delivery Delay, given that devices are energy and storage constrained. This solution framework should tame the requirements of diverse opportunistic network environments.

V. CONCLUSION

In this paper, we have studied various congestion control mechanisms as surprisingly limiting information loss in the mobile opportunistic network as there is finite buffer space at node. This is main advantage of single copy congestion control, as it uses local information for decision making about hop by hop custody transfer o message, which is liable to fail due to disconnection or change in latency of signal. As the financial model was the simplest and examination of more complex models or algorithm may improve the overall network performance. The replication based routing like epidemic based techniques have been proposed to adapt to with transmission disconnection and improve the delivery ratio. In spite of the fact this can accomplish a high delivery ratio but at the expense of extra overhead, usage of network resource (storage, bandwidth etc.) and energy usages is high. With dynamic congestion control mechanisms buffer space of each node can be effectively utilized and allocate storage space for the potential approaching messages in ahead of time in the network. In the future work self learning algorithms are proposed to be coordinated as well as defined for storage management and to enhance the latency and delivery ratio.

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