

Buffer Scheduling Policy for Opportunistic Networks

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Abstract— In Delay Tolerant Networks (DTNs), the optimal use of buffer management policies can improve the network throughput. In this paper, we propose a buffer management strategy called as Message Drop Control (MDC). This technique controls the message drop by using an upper bound which is the count of buffered message at router and size of the messages. If count exceed the upper bound drop will not occurs else large size message will be dropped from queue. We examine the performance of proposed drop policy by comparing it with existing MOFO, DOA, and LIFO. The simulation results proves that MDC policy out perform well as existing ones in terms of delivery probability, message drop, overhead and buffer time average.

Index Terms—buffer drop policies, Delay tolerance network, Algorithm, buffer scheduling, upper bound, large size message.

1 INTRODUCTION

THE internet has turn out to be the most central component in connecting the devices across the world. In the past decade academic and professional researcher has proposed numerous approaches to enhance this communication architecture. The traditional networking design like TCP/IP supports end-to-end reliable transmission of data over a wired media. However, in some environments such as military activities, emergency operations, and disaster recoveries these fixed physical configurations are difficult to deploy and very expensive. Therefore, there is a need to handle the communication in such highly disrupted applications.

Delay Tolerant Networks (DTNs) [2] is a challenge crisis networks by irregular connectivity, high latency time and lacking of end-to-end path from the source to the destination. In these environments, the transmission is carried out by "Store-Carry-Forward" paradigm, where the node stored incoming message, carries it while moving and forward it when transmission opportunity arises. Hence, each node act as router and message delivery is achieved via multiple hops through dynamically connected mobile terminals.

DTN routing protocols can be classified in two categories (i) single copy and (ii) multi copy. Multi copy routing protocols [5], [6], [7] diffuse the multiple copies of each message in the network which increases the delivery probability but consumes high volume of network resources such as bandwidth, buffer and energy. The single copy [9], [2], [8] routing strategies forwards the single copy of message in the network thus produce less overhead on network resources.

Regardless of above valued contributions in routing protocols, one of area which can influence and improve existing routing strategies is the use of message drop policies. In normal conditions the drop occurs when message finds destination or its Time to live (TTL) expires. We consider the scenarios when node buffer runs out of space and it need to store new message. Recent work [11], [12], [10], [4] and [3] have proved that router performance can be improved by adopting accurate drop sequence of already buffered messages.

In this paper we propose buffer management policy for single copy routing protocol First contact. The technique is called as Message Drop Control (MDC) and it schedules the drop sequence by utilizing the number of messages buffered at router and size of messages. To exhibit the performance of MDC, we assess four routing performance metrics Message drop, delivery probability overhead and buffer time averages. The proposed policy maximizes delivery probability, buffer time average and minimizes message drop and overhead as compared to existing MOFO, LIFO and DOA.

The rest of this paper is organized as follows: Section 2 presents the existing buffer management policies. In section 3, we discuss about the first contact routing protocol. The section 4 gives core idea of the buffer optimization and section 5 maps the algorithms of MDC policy. Section 6 displays simulation results and compares it with other buffer strategies followed by conclusion in section 7.

2 INTRODUCTION

2.1. Drop Random

In this strategy when node buffer overflows then the router randomly drop the message from queue. Hence all messages have equal deletion priority. The schemes work with out network knowledge and perform poorly in highly congested networks

2.2. Drop – Last-In First-Out (LIFO)

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The message with minimum arrival time in the queue will be selected to drop. In this scheme the probability of dropping the source messages is extremely high.

2.3. Drop-Oldest (DOA)

The message with the longest stay time in buffer will be dropped. The idea is that the packet with in buffer for long time has less probability to be conceded to other nodes.

2.4. N-Drop

In N-Drop [11], the message that achieves N number of forwarding will be selected to drop. If there are no messages with N number of forwarded then last packet will be drop first.

2.5. E-DROP (Equal Drop)

When node buffer is full and new transmission arrives with size S, the node search and drops the buffered message B, if the size of buffered and new arrival is equal. This scheme minimizes the drop of messages. [4]

2.6. MOFO - Evict most forwarded first

The message that has been forwarded to maximum number of times will be dropped first, thus that the messages with fewer times more chances of getting forwarded [10].

2.7. MOPR - Evict most favorably forwarded first

Each message in node is related with a forwarding predictability FP, initially assigned to 0. When the message is forwarded the FP value is modified and the message with maximum FP value will be dropped first. [10]

2.8. T-DROP (Thresh hole Drop)

The message lies in the threshold size range will be selected to drop. [3]

2.9. SHLI - Evict shortest life time first

The message contain smallest TTL will be selected to drop. [10]

2.10. LEPR - Evict least probable first

"Since the node is minimum amount likely to deliver a message for which it has a low P- value. Drop the message for which the node has the lowest P value." [10]

2.11. Drop Largest

According to this strategy when node buffer is full, the message with large size will be drop. [13]

2.12. GBD (Global Knowledge based Drop)

GBD based on global knowledge about the network state. As global Knowledge is required, GBD is difficult to be implemented, thus, it will serve as a point of reference. [12]

2.13. HBD (History based Drop)

"A deployable variant of GBD that uses the new utilities based on estimates of m and n, the m is the number of

nodes that have seen the message and n is those whom have copy of it". [12]

2.14. FBD (Flood Based Drop)

FBD accounts only for the global information collected using simple message flooding, that is, without considering past history or other messages. [12].

2 FIRST CONTACT ROUTING

First contact algorithm [2] transmits the single copy of message along a distinct path from the list of intermittently connected mobile nodes. This path selection is random and depends on the local knowledge of router. If no contact is available then router waits until the transmission opportunity arises. First contact router only carries the single copy of message thus minimizes the number of transmission, bandwidth, buffer space and energy in contrast to multi copy schemes.

3 APPROACH

The objective of buffer management policies is to minimize the effect of message drop on the network throughput. It has been evicted [12] that the control on the message drop proves efficient use of network resources and provides additional growth in the router performance. In this section, we give a theoretical summary about the proposed buffer scheduling policy and compare it with existing scheme MOFO. However the policy also out performs well as compared to DOA and LIFO.

Case 1 Scenario First Contact in MOFO -Drop Sequence

TABLE 1
NODE CONFIGURATIONS

Node	Mid	Ms	NoF	AT	DEST
A	M1	800KB	4	10s	B
	M2	200KB	6	23s	D
	M3	900KB	3	25	B
	M4	320KB	5	30s	C
	M5	280KB	7	35s	B
B	M10	300KB	12	22s	A
	M11	250KB	9	25s	A
	M12	500KB	8	35s	D
	M13	650KB	4	38s	A
	M14	900KB	2	40s	G

Consider a snap shot (Table 1) of node A and B modeled by store-carry-forward network. Each node has stored M message (s) in its local buffer with message id (Mid), message size (Msize), number of forwarding (NoF), Arrival time (AT) and destination (DEST).

We further assume that buffer space for each node is 2500KB, while λ is the message rate between two nodes and $\lambda=1/E\langle Z \rangle$ where $E\langle Z \rangle$ is the average meeting time. When node A moves in the transmission range B, then according to FIFO forwarding order, node A forwards message M14 of size 900KB to node B. In order to accommodate this new arrival node B will follow the MOFO sequence and iteratively drop M5 (280), M2 (200), M4 (320), and M1 (800). This redundant drop of message raises the overhead ratio while minimize buffer time average and delivery ratio.

TABLE 2
NODE CONFIGURATIONS

Node	Mid	Ms	NoF	AT	DEST
A	M1	800KB	4	10s	B
	M2	200KB	6	23s	D
	M3	900KB	3	25	B
	M4	320KB	5	30s	C
B	M10	300KB	12	22s	A
	M11	250KB	9	25s	A
	M12	500KB	8	35s	D
	M13	650KB	4	38s	A
	M14	900KB	2	40s	G

Case 2 Scenario First Contact in MDC (Message Drop Control)-Drop Sequence with N number of messages \geq Upper-Bound

Message Control Drop strategy (MDC) minimizes the drop by defining an upper bound limit (UB). By this, a node while carrying N number of message will not drop any message if $N \geq UB$. In view of table 1, assume that the Upper- Bound (UB) is 5. When a new transmission arrives, node B ($N \geq 5$) will not drop any message which alternatively increase the buffer time average, minimize the overhead and raise the delivery probability.

Case 3: Scenario First Contact in MDC Drop Sequence with N number of messages $\leq UB$

When Upper-Bound (UB) is less then N number of messages and new transmission arrives at node the largest size message will be dropped from queue. Table 2 depicts the scenario where $UB \leq N$ and node A has forwards the message M14 of size 900KB to B. The available buffer

space is 280Kb therefore M1 and M3 will be dropped to make the room for new arrival.

4 ALGORITHM

5 SIMULATION AND RESULTS

In this section we will show the comparisons of proposed

TABLE 3
SYMBOL TABLE

Symbol	Meaning
M_i	Message size
UB	Upper bound
AT	Arrival Time
A_{BS}	Available Buffer size
F_{BS}	Free Buffer size
R_{MN}	Nr.of message(s) on router
M_{ID}	Message id
DM_{Size}	Size of dropped message
R_M	Buffered messages(s) on router

ALGORITHM

MessageDropControl (Mid)

```

Begin
  If ( $R_M \geq UB$ )
    return null; // no drop of message occur
  else
    begin
      While ( $A_{BS} < M_{size}$ )
      {
        Dropped.Message.id = FindLargest ();
        DropMessage (Dropped.Message.id);
         $A_{BS} = DM_{size} + F_{BS}$ ;
      } // end while
    End // end else
  
```

FindLargest (Mid) // Method

```

Largest= Mid;
Begin
  For each message M in Router  $R_M$ 
  {
    If ( $R_M \rightarrow Size \geq Largest.Size()$ )
      Largest=  $M_{id}$ ;
  }
  return Largest;
End
  
```

buffer scheduling strategy (MDC) with existing DOA, MOFO and LIFO. The evaluation of schemes have been analyzed under ONE [15] simulator. ONE is a discrete event simulator written in JAVA and have been massively used by various researcher to measure the statistics of disrupted store-carry-forward applications.

We have simulation setup scenario simulated as six groups, in which two of them are pedestrians and one is car group and three of them are from trains group. Three groups(2 pedestrians, 1cars) have 40 nodes and other trains groups have six nodes which are randomly spread with random source and destination over a simulation area of 4500mx3400m. Then, three group moves with a mobility model by shortest path Map Based movement (SPMBM) and trains groups with Map route movement (MBM). Speeds of groups (pedestrians, cars and trains) are 0.5-1.5km/h, 2.7-13.9 km/h and 7-10km/h respectively. Every node have DTN capabilities of bundle layer and follow the store carry forward mechanism.

Some other parameters, we suppose that the all DTN nodes converse with one another by transmission range of 10M with 2 Mbps link bandwidth. We have random selected size of messages range from 200k to 500k with infinite TTL time which are randomly created during inter message interval. Also we varied the inter message interval from [15s,25s],...[55s,65s] to see the source message creation on the mobile nodes in term slow/fast generated sources messages. Furthermore, we suppose that three groups have a buffer size of 4MB and other have 10MB with FIFO forwarding order. The above explained set up we generate numerous scenarios for First contact routing protocol with the existing DOA,MOFO,LIFO and proposed Message drop control (MDC) drop policy with simulation end Time 200000s to see the mobility effects on large scale.

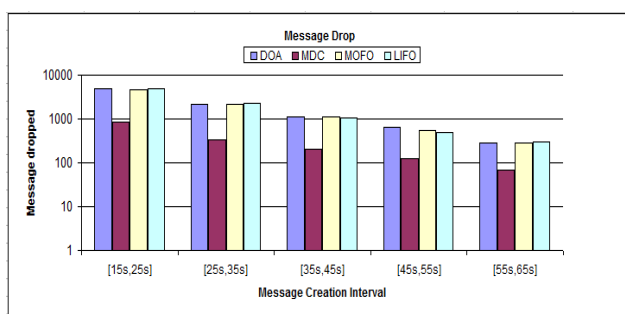


Fig. 1. Message Drop Control

When a node transmits the messages the most important aspect on its delivery depends on the storage capability (buffer) of the intermittently connected mobile nodes. In DTN environment the nodes keeps the messages for long period of time due to network partitioned and end-to-end path unavailability. Hereby the node buffer may run out of space, as a result buffer drop policies overcome this congestion by dropping messages.

Fig 1 plots the effect of message drop with existing

DOA, MOFO LIFO and proposed MDC strategy. Message creation interval has been used to monitor the impact of source message creation on the storage. We can observe that at each simulation instance Message Drop Control (MDC) policy reduces the drop and performs better then the existing buffer scheduling schemes. This control on message drop has two fold advantages; first message gets more time to stay in the buffer which raises its delivery probability. Secondly, when a message is dropped out it is the waste of all resources (bandwidth, buffer, transmissions, and energy) which it consumes during its mobility.

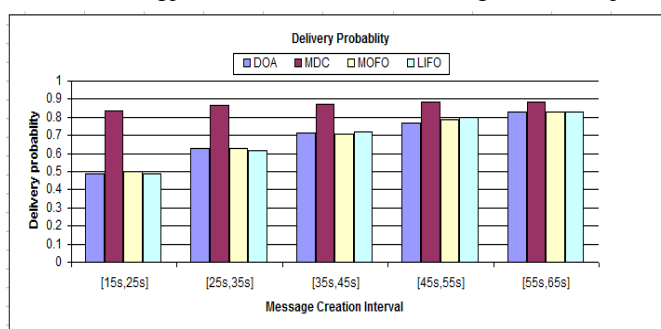


Fig. 2. Message Delievery probability

In opportunistic networks, the delivery of message is accomplished via multiple hop(s). On each transmission the message consumes network resources such as bandwidth, buffer space and energy. Therefore, the successful transmission of messages to their destination proves the efficient use of network resources.

Fig 2 shows the mapping of existing and proposed (MDC) buffer management schemes in terms of delivery probability. We can see that at each message creation interval more messages are delivered then the existing strategies. Reason for this, is that when the congestion arises, instead of blind drop, proposed policy (MDC) uses UB to controls the admission of source and relay messages [14], therefore this block on drops boost the message stay time in buffer which raises its delivery likelihood.

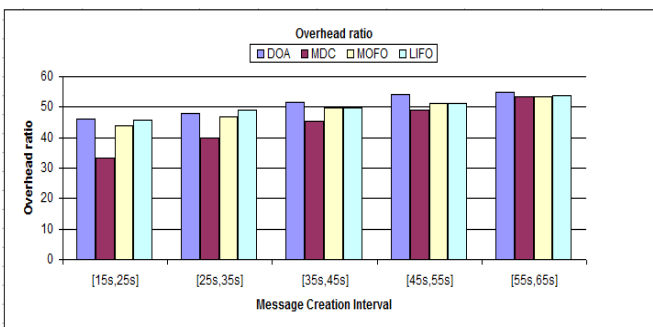


Fig. 3. Overhead ratio

Overhead measure is used to estimate the cost of resources required to process the transmission and storage

of message. The algorithms performing well in terms of increasing delivery probability, but produce high overhead that are not reasonable for practical implementation.

Fig 3 represents the affect of proposed MDC policy and existing policies with respect to overhead ratio. We can see that the proposed MDC reduces the overhead in the considered amount. Reason for this, is that the MDC blocks the number of iterations required to select the drop message. Furthermore, MDC not allows nodes to drop message if the criteria fails and the router already holds messages in reasonable amount. In First contact approach, the router always randomly relay the message to the neighboring nodes which is might not towards the destination that sometimes increase the overhead but our policy reduces these protocol oriented overhead.

Delay Tolerance network (DTNs) suffers from long delays and the delivery of message highly depends on the time it spends in the buffer of intermediate node. Therefore, increase in the buffer time average grantees the message transmission towards next hop which might be able to make progress towards destination.

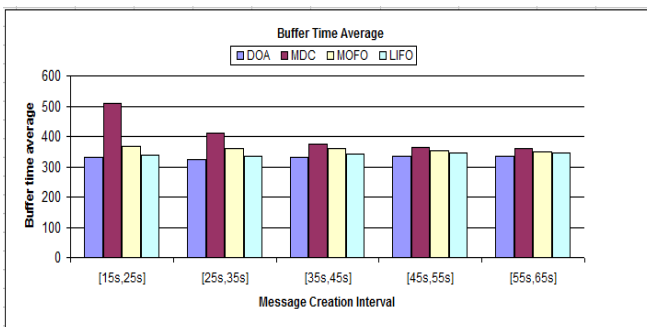


Fig. 4. Buffer Time Average

Fig 4 compares the results of Message Control Drop (MDC) with existing policies in context of buffer time average. We can observe that at each message creation interval, buffer time average of proposed policy is higher then the existing policies. The longer stay of these messages makes router to deliver/relay it to next hops.

6 CONCLUSION

In this paper we propose the buffer scheduling policy Message Drop Control which optimizes the single copy routing protocol First Contact. We examine the performance of proposed policy by comparing it with MOFO, DOA, and LIFO. The simulation model proves that proposed policy MDC out perform well for and maximize the router performance in terms of delivery probability, message drop, overhead and buffer time average.

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