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SUPPORTING DATA CONSISTENCY USING EFFICIENT INVALIDATION SCHEME IN MOBILE ADHOC NETWORKS

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ABSTRACT

Caching frequently accessed data in mobile nodes is an effective technique to improve the performance in Mobile Adhoc NETworks (MANETs). Cache invalidation plays a vital role in maintaining the data consistency among source and cache nodes. The conventional cache invalidation techniques are unsuitable for MANETs due to frequent disconnections and resource constrained mobile nodes. This work proposes the Data-update Pattern-aware Invalidation Prediction in caching (DPIP). The proposed DPIP consists of Access Frequency aware Data Classification, Cache Update Prediction based Dynamic Invalidation and Adaptive Query Searching in MANET. Selecting the most popular data to replicate in multiple mobile nodes is critical in caching. The DPIP divides the data into different classes according to the frequency of data access and replicates the most popular data in multiple locations. By applying the prediction at an update time of a particular data using prior information, the DPIP adaptively adjusts the invalidation interval to the cache nodes of particular data. It effectively balances the access delay and cache consistency. The Adaptive Query Searching enables the cache node to utilize the Query Directory nodes (QDs) and look for a cache node through broadcasting the route discovery packets to QDs. Thus, the DPIP caching successfully increases the data availability and improves the lifetime. Finally, the proposed system is implemented on Destination-Sequenced Distance-Vector (DSDV) routing. The simulation demonstrates a better performance of DPIP than the existing caching system in terms of cache hit ratio, throughput, routing overhead and access delay.

Keywords: *Mobile Adhoc Network, Cache Placement, Invalidation, Dynamic mobility and Invalidation Prediction*

1. INTRODUCTION

With the advances in wireless communication technologies and increasing popularity of mobile devices, the Mobile Ad-hoc NETwork (MANET) has received immense attention. The MANET is a self-organizing network and it consists of wireless mobile nodes without fixed infrastructure. A MANET is employed in special situations where installing infrastructure is temporary or not easy for instance on battlefields or disaster areas. In most of the applications the nodes attempt to access the same data and so the data caching plays a vital role in improving the efficiency of data access [1]. In caching, cooperative caching and replication are promising solutions for improving the network performance as these techniques allow the source node to share and coordinate the replicas among multiple mobile nodes in MANET. By applying the caching, the mobile nodes need not send requests to the data source always. Consequently, mobile nodes improve the data availability in the network resulting in less query delay. However, frequent cache update and node mobility make them difficult to maintain the data consistency.

The data consistency is a primary issue when the caching is performed [2]. It is essential to ensure that the received data from the cache node is valid or not. Several cache invalidation techniques have been introduced in MANET [3][4]. The invalidation techniques are classified as stateful and stateless approaches. In stateful invalidation approach, the node of origin maintains the details of cache nodes. Once the data changes, the source sends invalidation reports to all the cache nodes. In stateless approach, the cache nodes need to query the source node to ensure the validity of the cached data, since the source node does not maintain the information of cache nodes. However, these techniques are unsuitable for MANET due to frequent disconnections between nodes. Due to frequent disconnections, the nodes are likely to miss some invalidation reports from the source node. A data validity prediction scheme is essential to balance both the cache consistency and control overhead to overcome the problem of the cache invalidation scheme.

1.1 Contributions

- This work proposes the DPIP which consists of Data Classification, Cache Update Prediction and Adaptive Query Searching that aims at improving the data availability and consistency while reducing the routing overhead in MANET.
- The DPIP classifies the data according to the frequency of the data item by extracting the popular data from previous routing information and evicting the lesser number of requested data.
- The DPIP adaptively adjusts the invalidation interval to the cache nodes of a particular data and effectively uses the cache memory of a node by applying the prediction on update time of a particular data using history information.
- The DPIP caching reduces the network traffic successfully and also increases the data availability by utilizing the advantages of query directory based searching scheme.

2. RELATED WORKS

Several data cache algorithms have been proposed for MANETs [5][6]. Although data caching techniques improve the availability of popular data in the network, it is essential to deal efficiently with the cache invalidation and data consistency. When querying the node, it is necessary to inform about the nearest cache node immediately. Moreover, the resource of the query node is not sufficient for caching all the data, and hence the selection of popular data is necessary for efficient cache usage.

2.1 Conventional Caching Techniques:

An improved cooperative caching scheme named as Group based Cooperative Caching (GCC) [7] enables the nodes to exchange the bitmap data periodically among them and improves the performance of the group based cooperative caching scheme in MANET. It reduces the cache discovery overhead as well as access delay while providing better cooperative caching performance. In cache discovery, there are several works which have been proposed along with the clustering model [8] and most of them combine both the passive and active query techniques. In [9], a single Voronoi diagram is used to limit the update frequency of cache information and reduce the data access cost. The lightweight cache management algorithm in [10] improves the traffic served from the cache nodes while minimizing the overall bandwidth utilization in the network. The content replacement strategy is designed in [11] by allowing the cache nodes to store the newly arrived popular data and effectively distribute the content among multiple nodes. Thus, it provides a better performance and creates the content diversity between its own and cache of neighboring nodes.

By taking into account the remaining resources available in a node the data replication scheme is designed in [12]. The strength of both Cache Data and Cache Path is utilized in facilitating the caching decisions at intermediate nodes. It efficiently balances the data access delay and energy consumption of the nodes in the network. The cache placement algorithm in [13] [14] can minimize the total data access cost in MANET even with multiple popular data. The work in [13] has also reviewed the challenges and basic concepts behind cooperative caching in MANETs. From the conventional techniques, it is observed that these schemes are likely to produce varying results in different scenarios such as latency, hop count, and cache hit ratio regarding the cache size and node density. The data replication avoids the impact of network partitioning on caching due to node mobility. Several data replication schemes have been proposed and reviewed in [6]. The basic notion of replication is to copy the most frequently accessed data locally and increase the data availability in MANETs [15].

2.2 Data Invalidation Techniques:

Cache invalidation is to decide the data which has to be kept in cache locations or removed from the cache memory when the access frequency of data is less. The cache updation and invalidation is to keep the cached data consistent with the source data. The cache invalidation scheme in [16] reduces the interval for sending invalidation reports of the data which receives the request packets more than threshold range. However, it does not consider the requests for other data. Clustering in the distributed caching nodes either through direct connection or tree structure and formulating the cache placement problem as a linear program, and an optimal solution is provided in [17]. By applying the probabilistic transition model the cache replacement policy called Location Dependent Cooperative Caching (LDCC) [18] analyzes the communication cost. A push-based replication scheme [19] propagates the invalidation reports to both the cache and query directory nodes to utilize the advantage of pull based caching and establish the communication between client and server.

Full replication of the indices of data items in the query directory and two partial replications of the data items that improve the efficiency of caching technique. Another pull based Distributed Cache Invalidation Mechanism (DCIM) [20] adapts the Time To Live (TTL) to provide strong data consistency. The implementation of piggybacking and pre fetching in DCIM and Ant Colony Optimization (ACO) technique in [21] improve the data availability in networks and reduces the access delay of cache data. The extended Cooperative and Adaptive Caching System (COACS) [22] reduce the access delay by exploiting the query nodes. However, this is not appropriate for the large-scale network, as it increases the access delay of a data drastically. The algorithm in [23] is designed especially for a large scale network topology. The server based consistency scheme [24] adapts the data update according to the popularity of data and handle disconnections of both the cache and query directory nodes. However, this method consumes high energy due to the small interval of invalidation reports.

3. PROBLEM STATEMENT

Many works have been proposed for data caching and invalidation techniques in MANETs. Conventional cache invalidation techniques are unsuitable for dynamic network topology due to the frequent disconnections. A majorly used invalidation techniques in MANET is the propagation of invalidation reports. However, the propagation of invalidation reports has two main problems with caching. First, a long data access delay is associated with the invalidation reports, since after receiving the data request the cache node waits until the interval of next invalidation reports. Next if the broadcasting interval of invalidation reports is too short, routing overhead is likely to increase. Moreover, it results in large query delay and unnecessary bandwidth utilization. Instead of all cache nodes querying the source node to obtain the data from it separately, when a source changes its popular data, it is easy to shorten the invalidation report interval. Also, if the data access is relatively smaller than others, the broadcasting interval has to be widened accordingly. Even though several cache invalidation approaches have been proposed for MANETs to maintain cache consistency, they lack in explaining how the interval is being decided. Thus, it is essential to propose an effective caching and invalidation technique with considerable energy conservation in MANET.

4. SYSTEM MODEL

Considering a MANET is a graph G, which consists of a collection of mobile nodes (V) connected via wireless links, where each link (E) connects two nodes in the communication range (R). Consider a node N Є V with the id and NH_N is a set of one-hop neighbors of node N. Each node N_i has its own data di, where the set of all data items are denoted as $D = \{d_1, d_2, . . . , d_N\}$ and $|V|=N$. When a set of wireless nodes need to access the data item d maintained by the data source S with the frequency of A_f, the data d is called as popular data item $D_{popular}$. Among D, the most accessed data in G is denoted as $D_{popular} = \{d_1, d_4, d_s, d_{N-1}\}$. DPIP selects a set of cache nodes $C_k = \{C_1, C_2, ..., C_g\}$ to minimize the access delay. Each node in C_k stores a copy of $D_{popular(i)}$ and a set of Query Directory nodes $QD_M = \{QD_1, QD_2, ..., QD_M\}$, where each node in QD redirects the data request to the corresponding cache node. It is essential to maintain the data consistency between $D_{popular(i)}$ stored in all cache nodes and source node. In network G, there is no server to maintain cache consistency. The data source S updates the data $D_{popular(i)}$ with the given frequency of U_f i.e. the data is changed with the time interval of T_u. Defining a prediction update function which decides the data update time dynamically depending on the history of update frequency of particular data.

5. OVERVIEW

Caching frequently used data in a MANET is an effective approach to reduce the wireless bandwidth utilization. Once data is changed, the source sends invalidation message to the nodes which cache that particular data. An efficient invalidation scheme satisfies the cache consistency and also reduces the amount of overhead in MANET. This work proposes the Data-update Pattern-aware Invalidation Prediction in caching (DPIP). The proposed DPIP consists of Access

Frequency aware Data Classification, Cache Update Prediction based Dynamic Invalidation and Adaptive Query Searching. Firstly, the DPIP divides the data into different classes according to the number of requests and selects the cache nodes for most popular data in the network. Secondly, the DPIP applies the prediction at an update time of a particular data from history information and adaptively adjusts the invalidation interval to the cache nodes of a particular data based on its prediction and access frequency. It effectively balances the access delay and cache consistency. Thirdly, the Adaptive Query Searching selects query directory nodes to retain the information of cache nodes and looks for a cache node through broadcasting the route discovery packets. When the Query directory node receives a request for a particular data, it redirects the request to the concerned Caching Node. Adhering to the mobility prediction based invalidation scheme, the DPIP caching reduces the network traffic and also increases the data availability in MANET.

5.1 Access Frequency Aware Data Classification

The classification of the data item is achieved based on the previous access of data items from the source node. There are many advantages in the classification task using Data Access Frequency (DAF). A data item is classified as a popular data item and ostracized data item. The popular data items are frequently requested by nodes in the network, and conversely, the ostracized data items are rarely accessed data item that does not favor for other nodes. Because of limited memory space in MANET, only the popular data item is given priority in the cache nodes for the storage. When the cache is full, a DPIP replaces the unwanted data using DAF algorithm. During replacement, the ostracized data item is replaced rather than random removal of the data item from the cache. The separation of popular and ostracized data item is accomplished by finding out the number of times it is requested by the nodes in the network from previous routing information maintained on that network. DAF identifies the popular data item by maintaining the accessing table for every data item in a source. Accessing table consists of three labels such as i) the number of times requested by the nodes ii) destinations iii) hop count from requested destination node to the data source. Finally, DAF provides cache priority to the most requested data items called popular data item and effectively utilizes the memory space of cache nodes.

5.2 Cache and Query Directory Node Selection

The proposed DPIP algorithm follows a Cooperative and Adaptive Caching System (COACS) to decide the cache and query directory nodes in MANET. Nodes can act as either the Cache Node (CN) or Query Directory node (QD). The role of CN and QD are to cache the popular data items and redirect the cache query submitted by the destinations to the nearest CN respectively. Instead of caching the data items with their queries in a node, the DPIP enables the QDs to cache the queries and associate these queries with the corresponding cache nodes. The QD node takes the responsibility of redirecting the queries of mobile nodes to the concerned CN. Initially, a node which accesses the particular popular data item initiates the QD selection process by sending a COACS Score Packet (CSP) to one of its neighboring nodes. The CSP contains id, cache score, and exhausted node list.

The cache score summarizes the resource capacity, expected lifetime of a node, available bandwidth, and memory for caching. A neighboring node that receives the CSP appends its id and cache score in the cache table, and forwards the packet to the neighbor, which is not present in its cache table and exhausted node list. The receiving node ensures that whether all nodes in its routing table are present in the CSP table. If yes, it appends its address in the exhausted node list and sends the CSP to a node which is in the cache list but not in the exhausted list. This strategy ensures that all the nodes in the network receive CSP sequentially. When a node identifies the CSP table which includes the scores and caching capacities of all nodes in the network excluding itself, it plays the role of a QD assigner which selects the query directory nodes based on the cache score in the network.

The QD assigner selects the nodes that have high-quality attributes including high memory space and the remaining energy is elected as QDs. When the network does not cache the requested data, the data is retrieved from the source. Upon receiving the reply packet from the source, the node that requested the data acts as a CN by caching this data. Each cache node needs to update the popular cached data and their ids to the nearest QDs periodically and ensure less access delay of popular data. The closest QD to the CN caches the query and makes an entry in its hash table to link the query to its response. Each cache node needs to update the cached popular data and their ids to the nearest QDs periodically, and ensures the cache consistency and also less access delay of popular data in MANETs. In dynamic network topology, to maintain the cache consistency the query directory update phase has to be adjusted based on the topology changes. When a CN moves to another location, it selects a new cache node from its neighbor list and hands over the cached data to it. The DPIP enables the new CN to inform the corresponding QD to remove the stale information. In the case of QD movement, the QD assigner will predict and select a new QD for the cache node.

5.3 Cache Update Prediction based Dynamic Invalidation

The source node needs to periodically or aperiodically broadcast the invalidation reports to its cache nodes who cache the popular data item to save network bandwidth. The static update time is not adequate since short update interval is likely to increase the routing overhead whereas a long update interval increases the access delay of data.

Notations

T_{ci} : Time stamp of cached data item d_i

IR_s: Invalidation Reports

T_0 : Time stamp for current received IR for data d_i

$T_{previous\ (i)}$: Time stamp of i^{th} last received IR for data d_i

T_{query} :Time stamp of received query before receiving IR

History Interval :

$T_{previous\ (i))}$:{($T_{previous\ (i-1)}$ - $T_{previous(i-2)}$) , …………,($T_{previous\ (2)}$- $T_{previous\ (1)}$) }

To solve this issue, the DPIP adjusts the broadcast interval of invalidation reports by predicting the update time interval using history information.

```
Algorithm: Cache Invalidation Prediction
Measuring $T_0$ ()

When a CN receives the query from mobile node,
  If {
  AVG Int($T_{previous\ (i)}$) < ($T_{previous\ (1)}$ - $T_{Query}$)
  Send cached data to the requesting node
  }
  Else {
        Wait $T_{new}$ time;
         If { it does not receive reply from
              source
         Drop the request message ;}
  }
When a source node identifies error in the $T_0$,
  If {
        Data $d_i \neq d_i$ provided at time $T_{ci}$
        Send invalidation report;
                  Send Updated data to CN ;
  }
  Else {
        Send validation report message to
        CN ;
  }
```

Algorithm 1: Cache Invalidation Prediction in DPIP

The CN in DPIP has information about the update pattern of each data item at the source node for a "t" period. It stores the history of data updates regarding last t update time of the data item and its interval. It uses this information to identify the next update time approximately. The adaptive interval of invalidation reports is given in Algorithm 1. This algorithm enables the source node that has popular data with frequent changes to broadcast the update messages more frequently and enables the source node of popular data with less frequent changes to broadcast the update messages less frequently. Moreover, it maintains the cache consistency, and also avoids unnecessary energy and bandwidth utilization.

6. SIMULATION SETUP AND RESULTS ANALYSIS

The performance metrics of caching algorithms under various data access frequencies have been simulated using NS2. The performance of the proposed DPIP is implemented on Destination sequenced distance vector (D-DPIP) routing protocol and it is compared with the Smart Server Update Mechanism [24] based DSDV (D-SSUM). In the simulation of D-SSUM, the source node acts as a server for particular data. The functions of cache placement and invalidation improve the data availability and network lifetime. During cache placement, the data is classified according to its access frequency in the network. Moreover, it simulates the cached data invalidation prediction scheme using history information. The number of nodes is varied from 50 to 250 and simulated for 100 seconds. The speed of the nodes is 10 m/s. Pause time is set at 15 seconds. The simulation table shows the values of simulation parameters. To evaluate the performance of D-DPIP the number of popular data items varied are from 5 to 25.

Table 1: Simulation Model

Simulation Parameters	**Values**
Number of Nodes	50-250
Network Size	500m x 500m
Nodes Transmission Range	100m
Node Speed	10 m/s
Node Pause Time	15 Sec
Number of Popular Data Items	5-25
Routing Protocol	D-DPIP
Transport Agent	UDP
Application Agent	CBR
Mobility Model	Random Way Point
Simulation Time	100 Sec

6.1 Performance metrics

The performance metrics such as Throughput, Cache Hit Ratio, Delay, and Overhead are measured to evaluate the performance of DPIP.

6.2 Simulation Results

6.2.1 Packet Delivery Ratio

The number of nodes is increased from 50 to 250 while the network area is kept constant at 500 m x 500 m as shown in Figure1. The Figure2 illustrates the results of the packet delivery ratio by varying the number of popular data from 5 to 25. From the figure1, it is observed that the packet delivery ratio of both the protocols stays close to 96.3% up to 100 nodes. . Figure2 illustrates the results of the packet delivery ratio by varying the number of popular data from 5 to 25. From the figure1, it is observed that the packet delivery ratio of both the protocols stays close to 96.3% up to 100 nodes. Since the network topology is too sparse, when the number of nodes is 100, there is no possibility of selecting a sufficient number of cache nodes and delivering the data packets to the destination. The packet delivery ratio of D-DPIP rapidly increases when the number of nodes raises from 100 to 250, compared to D-SSUM. For instance, the packet delivery ratio of D-DPIP is 98.8% when the number of nodes is 250, but in D-SSUM, it has decreased by 3.3% compared to the D-DPIP.

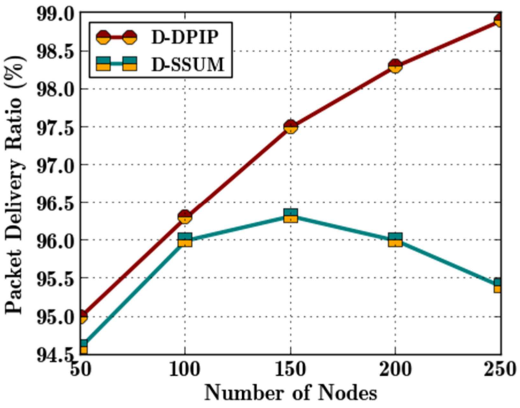

Figure 1: Number of Nodes Vs Packet Delivery Ratio

However, in D-SSUM, the network becomes saturated with 150 nodes, since it enables the source node to maintain the cache node information and periodically send the invalidation reports to all the cache nodes, resulting in high network traffic. Beyond the point of 150 nodes, the packet delivery ratio of D-SSUM starts to degrade, however up to 250 nodes, the D-DPIP improves the packet delivery ratio. As the load increases, the packet loss incurred by invalidation scheme increases significantly, thereby decreasing the packet delivery ratio of the network. The packet delivery ratio of both the protocols starts to degrade while increasing the number of popular data.

6.2.2 Cache Hit Ratio

The proposed D-DPIP and the existing D-SSUM protocols are compared by varying the number of popular data to show the results of Cache Hit Ratio in Figure3.

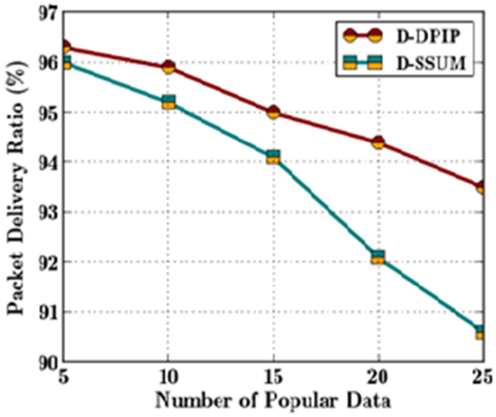

Figure 2: Number of Popular Data Vs Packet Delivery Ratio

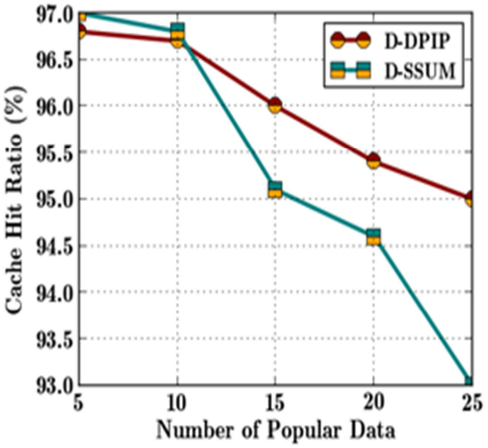

Figure 3: Number of Popular Data Vs Cache Hit Ratio

The D-SSUM handles the broadcasting interval of invalidation reports too short to retain the data consistency. However this is likely to increase the routing overhead resulting in long query delay and unnecessary packet loss. Beyond the point of 10, the cache hit ratio of both the protocols degrades. For instance, the cache hit ratio of D-DPIP has degraded from 96.7% to 95% when increasing the number of popular data from 10 to 25. The results of figure 3 reveal that the D-SSUM outperforms D-DPIP in terms of cache hit ratio when the number of popular data is limited to 10. It means that it is propagating more number of invalidation reports in the network. Thus, the network traffic has increased drastically, and attains the saturation point. However, the proposed D-DPIP adaptively adjusts the invalidation interval to the cache nodes of a particular data by applying the prediction on update time of a particular data using history information and reduces the network traffic. For instance, the cache hit ratio of D-DPIP is 95%, but in D-SSUM, it decreases to 93% when the popular data is 25.

6.2.3 Delay

The Figure 4 shows the impact of the number of popular data on the performance of D-SSUM and D-DPIP in terms of delay. The delay of both the D-DPIP and the D-SSUM increase remarkably while the number of popular data increases. The D-SSUM periodically sends invalidation reports to all the cache nodes. As the network traffic increases, the packet loss incurred by D-SSUM increases significantly, thereby increasing the delay. Figure 4 shows the impact of the number of popular data on the performance of D-SSUM and D-DPIP in terms of delay. The delay of both the D-DPIP and the D-SSUM increase remarkably while the number of popular data increases.

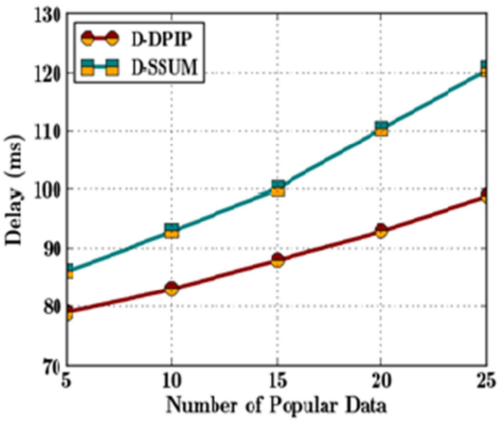

Figure 4: Number of Popular Data Vs Delay

The delay of both the D-DPIP and the D-SSUM increase remarkably while the number of popular data increases. The D-SSUM periodically sends invalidation reports to all the cache nodes. As the network traffic increases, the packet loss incurred by D-SSUM increases significantly, thereby increasing the delay. For instance, the D-DPIP delivers the packet in 80 ms with five popular data, but it prolongs to 100 ms when the number of popular data increases to 25. As the negative impact of network traffic on communication delay is high, D-DPIP enables the mobile nodes to update the cache nodes dynamically and decrease the unnecessary bandwidth utilization. Moreover, this strategy reduces the network congestion and packet delay. Even when the maximum number of popular data reaches, D-DPIP still enables the cache nodes to deliver the packets in 100 ms while the delay of D-SSUM extends to nearly 120 ms.

6.2.4 Overhead

In figure 5, the proposed D-DPIP and the existing D-SSUM are compared by varying the number of nodes. The overhead of both the protocols increase as the number of nodes increases. The overhead includes the direct control messages for route discovery and sending error reports, and also the messages used for updating the cache information. Since both the protocols implement the Adaptive Query Searching on Cache Data, the impact of query searching on overhead is less. In the low-density scenario, both the D-DPIP and D-SSUM protocols show similar performance. However, in the high dense network, D-SSUM increases the overhead rapidly when compared to the D-DPIP. For instance, with 50 nodes, both the D-DPIP and D-SSUM have attained the overhead of 0.41. An efficient cache invalidation algorithm of D-DPIP introduces a prediction scheme on data update time using history information, which certainly reduces additional control messages.

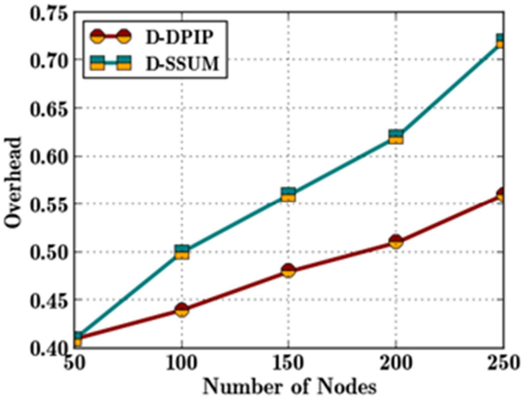

Figure 5: Number of Nodes Vs Overhead

However, when the number of nodes increases, the overhead becomes high due to link disconnections. For instance, the D-DPIP reaches the overhead of 0.55 whereas the D-SSUM reaches 0.73 when the number of nodes is 250.

7. CONCLUSION

This work proposes the Data-update Pattern-aware Invalidation Prediction in caching. By dividing the data into popular and ostracize classes according to the data access frequency, the DPIP selects the cache nodes for most popular data and improves the caching performance in MANETs. With the help of history information, the DPIP applies the prediction on update time of a particular data and adaptively adjusts the invalidation interval to the cache nodes, resulting in a better trade-off between the access delay and cache consistency in MANET. The Adaptive Query Searching for Cache Data maintains the query directory nodes and thus, the nodes can easily look for data by broadcasting the route discovery packets. By adhering to the mobility prediction based invalidation scheme, the DPIP caching reduces the network traffic significantly and also increases the data availability. The performance of the proposed DPIP integrated with the DSDV routing protocol is simulated using the NS2 and has analyzed the cache hit ratio and routing overhead over dynamic network topology. The simulation results reveal that the proposed D-DPIP is suitable for cache invalidation over MANET.

7.1 Contribution

The main contributions of the work in terms of performance are,

- Extracting the popular data observed from the routing information reduces the number of hops per flow and overall network traffic without dropping the packets due to congestion.
- Adaptive adjustment of invalidation reports in DPIP reduces the network overhead while maintaining the cache hit ratio.
- The usage of query directories in data searching reduces the delay of cache node discovery and data delivery as well as packet drop even when increasing the number of popular data in the network.

7.2 Limitations

- Predicting the location of mobile nodes is not always suitable for MANET. It may increase the hop count to reach the cache node rather than the hop count to reach the source node
- Less concentration on Query directory maintenance may lead the system to stale cache node-id storage and poor cache hit ratio
- There is no constraint to store the data in cache nodes except the data popularity. The storage of highly accessed data is not efficient if either it changes frequently or large in size.
- Prediction of data invalidation not only depends on the previous changes, and it also depends on the application and nature of data.

8. FUTURE DIRECTION

The caching algorithms cache the data, only after accessing the data more than the threshold. However multiple data requests for a fresh data at a time lead the system to fail. Moreover, it is also not scalable when the total number of popular data has increased in the network. Thus, in future, the source node predicts the access frequency of the fresh data from the long history regarding its dependency and selects the cache node in advance to improve the data availability. In future work, the study of the influence of cache parameter, such as an access frequency threshold on the performance of the caching system, and it is necessary to consider the threshold measurement in real time applications.

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