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Efficient Cache Consistency in Server-Based MANET with Cache Replication

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Abstract: This Paper proposes a cache replication scheme based on a previously proposed architecture for caching database data in MANETs. The queries that are submitted by requesting nodes in special nodes called query directories(QDs),and uses these queries to locate the data that are stored in the nodes that requested them ,called Caching Nodes(CNs). The overall design provides a complete caching system in which the server sends to the clients selective updates that adapt to their needs this reduces wireless traffic in MANET. The Replication scheme are implemented to minimize the maximum hit occurs in the nodes. In this method only one caching node is allowed to cache for a particular data and if the request rate for the particular data is high then there is more number of hits in a particular QD&CN for that data .In order to avoid this the concept of cache replication is implemented. The replicated cache cannot come under the same QD in order to avoid the network congestion in that QD. This system improves the performance of the query response rate. Average response time of node request is estimated. Moreover ns2 simulation were performed to measure parameters, like the hit ratio and average data response time

Keywords: Mobile Ad Hoc Networks, Cache Replication, cache consistency. Smart server

I. INTRODUCTION

A Mobile ad hoc network (MANET) is a collection of wireless mobile nodes forming a temporary network without the need for base station or any other preexisting network infrastructure .In a mobile ad hoc network data caching is essential as it reduces contention in the network. It is dynamic in nature, and therefore ,a reliable caching scheme is more difficult to achieve. Links between nodes may constantly change as nodes move around, enter, or leave the network. This can make storing and retrieving cached data particularly difficult and unreliable .the use of mobile devices adds even more complexity due to their relatively limited computing resources and limited battery life. However, frequent disconnections and mobility of the clients make cache consistency a challenging problem. Routing protocols are responsible for finding an efficient path between any two nodes in the network that wish to communicate ,and for routing data messages along this path. The path must be chosen so that network throughput is maximized and message delays and other undesirable events are minimized. Effective cache invalidation strategies are required to ensure the consistency between the cached data at the clients and the original data stored at the server. when cache technique are used, data consistency issues must be addressed to ensure that clients see only valid states of the data, or at least do not unknowingly access data that is stale according to the rules of the consistency model. Depending on whether or not the server maintains the state of the client’s cache, two invalidation strategies are used : the stateful server approach and the stateless server approach. In the stateful server approach, the server maintains thee information about which data are cached by which client. Once a data item is changed, the server sends invalidation messages to the clients with copies of the particular data. This server invalidation is a strong consistency algorithm, where the users are served with strictly fresh data items .The consistency between the server data and the cached copy is achieved by using this strong consistency approach.

This work describes a server based scheme is implemented on top of the COACS caching architecture in order to maintain the consistency between the server and the cache node .COACS provides an efficient and reliable caching in MANET environment. In COACS a node sends its request to the nearby QD, it maintains a table which consist of id of data item and the address of the CN that caches the data .If the QD finds the Query in its cache ,it forwards the request to the CN caching the item. MDPF algorithm is used to forward the search message to the nearest node. Since COACS did not implement a consistency strategy, the system described in this paper fills that void and adds several improvements:1) enabling the server to be aware of the cache distribution in the Network, 2) making the cached data items consistent with their version at the server, and 3) adapting the cache update process to the data update rate at the server relative to the request rate by the clients.4) minimizing the cache hit ratio by cache replication With these changes, the overall design provides a complete caching system in which the server sends to the clients selective updates that adapt to their needs and reduces the average query response time, and minimizes cache hit ratio.

The rest of the paper is organized as follows: Section II presents the related work on consistency approaches and caching system. Section III describes the SSUM mechanism Section IV we propose replication technique for reducing cache hit ratio. We devote Section V the performance evaluation of our scheme .Finally, we conclude the paper in Section VI.

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II. RELATED WORKS

A. Cache Invalidation Scheme

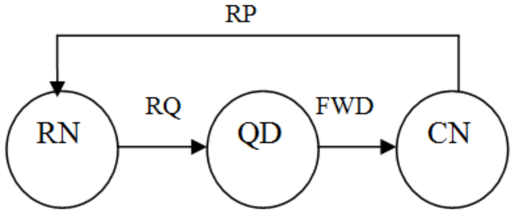
In a mobile computing system, in order to reduce the data access delay, some data items are cached at the client machines. Cache invalidation scheme called Invalidation by absolute Validity Interval(IAVI) for mobile computing system. In IAVI, we define an absolute validity interval(AVI), for each data item based on its dynamic property such as the update interval. A mobile client can verify the validity of a cached item by comparing the last update time and its AVI. A cached item is invalidated if the current time is greater than the last updated time plus its AVI. With this self-invalidation mechanism, the IAVI scheme uses the invalidation report to inform the mobile clients about changes in AVIs rather than the update event of the data items. As a result ,the size of the invalidation report can be reduced significantly.

B. Consistency Algorithms

The study compares three consistency approaches: adaptive TTL, polling-every-time and invalidation. The two approaches such as invalidation and polling-every-time are considered as strong consistency. In invalidation approach, The server keeps track of all the client sites that cache a document, and when the document is changed, sends invalidation messages to the clients. In the Polling-every-time approach, every time the user requests a document and there is a cached copy , the cache first contacts the web server to validate the cached copy, then returns the copy to the user. In adaptive TTL, the cache manager assigns a time-to-live attribute to a document, if TTL value expires then the cached copy needed to be updated. This approach is considered as weak consistency model and consumes more network bandwidth. Thus strong consistency approach overcomes the problem by minimizing the bandwidth consumption.

C. Cooperative and adaptive caching system.

The idea is to create a cooperative and adaptive caching system that minimizes delay and maximizes the likelihood of finding data that is cached in the ad hoc network, all without inducing excessively large traffic at the nodes.
In COACS System , the RN request the particular data item to the nearby QD, the QD maintains the table consist of the id of data item and the address of the cache node which contain the desired data item, if the requested data item is in the particular query directory then it forwards the request to the cache node that contains the desired data item and CN replies to the RN. If the request is not in the QD then it forwards to the nearby QD , These is done by using the MDPF algorithm. The requested data item is not in any of the QD then the message is forwarded to the server and the server reply to the RN directly.



D. Replication scheme

Dynamic replica allocation scheme is used for improving data availability in mobile environments. There are some replication protocols for maintaining consistency in data transfer .In This paper cache replication is used minimize the cache hit ratio also and made data frequently available in the network.

III.OVERALL APPROACH

A. Problem Statement

The Cooperative Caching architecture for mobile environments minimizes delay and maximizes the likelihood of finding data that is cached in the ad hoc network, but there is no consistency between the cached data item and the server data. To maintain the consistency, smart server is implemented on the top of the COACS system ,in which the server maintains the information about the cache node and the data item .The data item in the CN is consistent with the version in the server by sending an invalidation report to CN by using Push algorithm. The server autonomously sends data updates to the CNs, meaning that it has to keep track of which CNs cache which data item.

In SSUM the RN sends request to the nearby QD, The QD forwards the request to the CN containing desired data item, if the request is not in any of the QD it is forwarded to the server and the server reply to the CN. If there is more number of request in the Particular QD & CN , then there is more number of hit in the QD & CN . Average response time increases and lead to more traffic . The maximum Hit in the CN & QD leads to the overhead in that particular CN & QD . SSUM reduces wireless traffic by tuning the cache update rate to the request rate for the cached data.

In this paper, cache replication mechanism is used for minimizing the hit occur in the CN & QD. Frequently accessed data item is replicated to two or more nodes so that the average response time decreases and the minimize the cache hit ratio. The replication scheme is implemented in the SSUM system.

B. Packet forwarding algorithm

Packet forwarding algorithm is used for traversing the QD system. The idea behind PFA is to use routing table information for visiting nodes in the order of shortest distance. According to PFA , the client uses the information in the routing tables to send its request to the nearest QD. If an QD does not have the requested data ,it uses PFA and forwards the request to the nearest unvisited QD . Nodes request database data, which may be cached in any of the caching nodes (CNs). The QD cache previously submitted request (queries), and for each such query, an QD maintains a reference to the result that resides on a CN

In fig 2. The first scenario, the client submits its request to the nearest QD (QD3), which does not have a matching query. the request is then forwarded in accordance with PFA through QD1 and QD4 before it arrives to QD2, where a match is found. Using the reference that is stored

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along with the cached query, the request of the client is forwarded to the CN that stores the result. This CN sends the result to the client whose address is found in the forwarded packet. In the second scenario, no match is found in the QDs, and so, the last visited QD (QD5) forwards the request to the data server via the access point. The server retrieves the result and sends it directly to the client, which, in turn, asks QD3 to cache the query. it is noted that he nod at which the client requested the dataitem that was retrieved from the outside dataserver becomes a CN for this particular item.

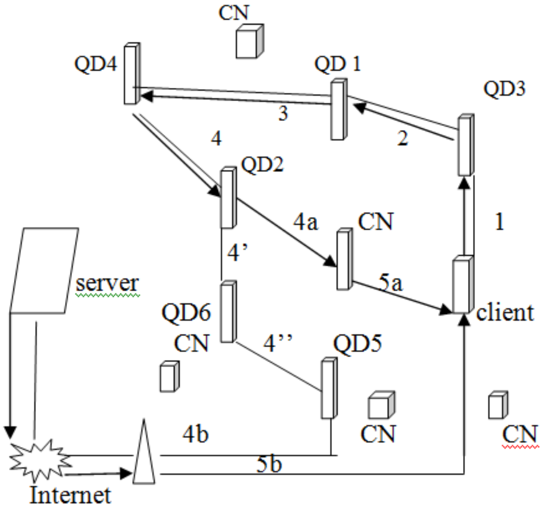

Fig 2. Two scenarios for request forwarding: scenario 1 corresponding to a hit and includes steps 1-4, 4a and 5a. Scenario 2describes a miss and includes steps 1-4,4',4'',4b,and 5b.

C. Handling Node Disconnection

Mobile nodes are dynamic in nature, when a CN leaves the network, the QD, which first tries to forward it a request and fails, will set the addresses of all queries whose items are cached by this unreachable CN in its cache to -1,and informs the server about the mobility of the cache node. The server, in turn, changes the address of that CN in its cache to _1 and stops sending updates for these items. If the cache node returns to the network after disconnecting ,it informs the QD about its entry. By this approach the network traffic is reduced. The packet forwarding algorithm handles the node disconnection, it forwards the packets to the nearby node by using AODV routing protocol which avoids network traffic.

IV. PROPOSED CACHE REPLICATION SCHEME

A. Network Model

The network consists of mobile hosts that form a group. Mobile host takes two possible roles such as QD and CN . The network connectivity is maintained using a QD. Routing protocols are responsible for finding an efficient path between any two nodes in the network that wish to communicate, and for routing data messages along this path. RN send a request to nearby QD, and it finds the data in the CN . Reply for the desired data is sent from the corresponding CN.

B. System Model

The system model is assumed to be an ad hoc network where MN(mobile node) access data item held as originals by other MNs. A MN that holds the original value of a data item is called data source/server. A data request initiated by a MN is called RN(request node). The frequently accessed data item is stored in a MN called CN(cache node). The Requested Query and the address of the cache node is stored in a MN called QD (query directory).

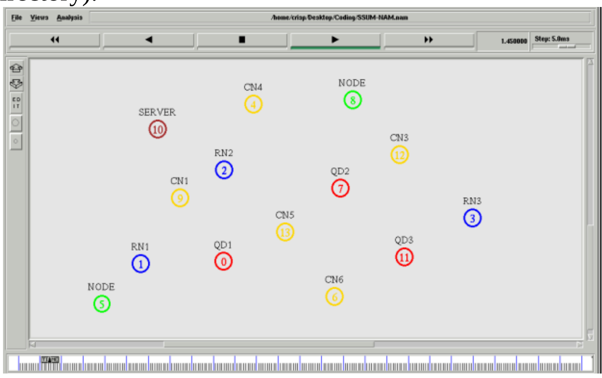

Fig 3. Roles of MN

Nodes takes different roles such as QD,CN and RN for request handling and Network Monitoring in the Mobile ad hoc network

C. Request Handling

The RN sends request to the nearby QD. The QD maintains a table consist of id of the data item and the address of the cache node. When the RN sends the request to the QD, it first checks its table ,if the match is found in QD, it forwards the request to the related CN and the particular CN replies directly to the RN. If any miss occurs in the QD, it forwards the request to the nearby QD ,when a miss occurs in all of the QD the request is forwarded to the server and the server replies to the RN, and act as a cache node for the particular data.

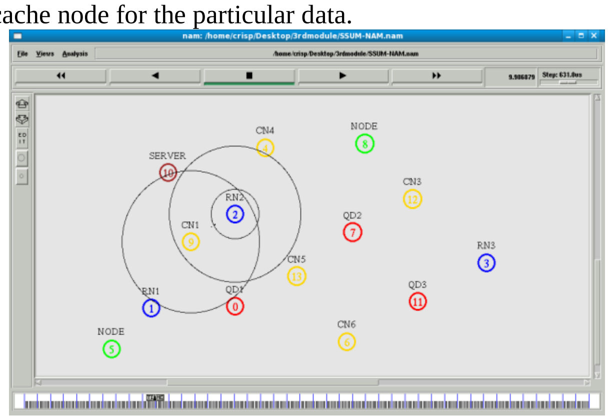

Fig 4. Request Handling

D. Network Monitoring

As mobile nodes are dynamic in nature ,they can move freely from one network to the other network. In Smart server update mechanism when a cache node moves to other location due to mobility it informs the QD. The QD marks the address of the cache node as -1. If again a new node enters into the network it sends the request to the nearby QD, and the address of the Cache node is stored in

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the nearby QD. The server maintains the information about all the cache node in the network. server autonomously sends updates to the all cache node in the network.

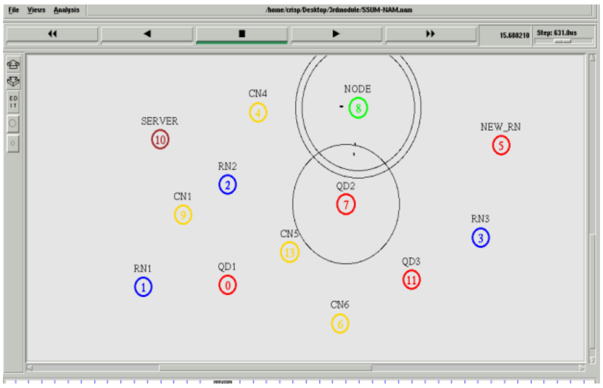

Fig 5. Mobility of Nodes

E. Data Replication

In SSUM, when there is more request in a particular QD and CN ,then there will be more hit in that particular QD & CN. The Average response time also decreases and network traffic arises. In order to minimize the average response time Data is replicated to more than one node in the network. The Replicated Cache node should not come under one QD. The Data Replication minimizes the network traffic and minimizes the maximum hit occur in a particular QD & CN.

The replication cache cannot come under the same QD which stores the information about the present caching node for that data in order to avoid the network congestion in that QD.

V. SIMULATION SETUP

In this section, we are going to reduce the response delay by replicating the data to one or more nodes in the network. we use the ns2 software to implement the replication scheme in the SSUM System .

A. Simulation Parameter

A single database server is connected to the wireless network through a fixed access point, while the mobile nodes are randomly distributed. The client cache size was fixed to 300 Kb, meaning that a CN can cache between 20 and 300 items ,while the QD cache size about 700 items. The SSUM system was implemented as a new C++ agent in ns2 that get attached to the node class in the tcl code at simulation runtime PFA is used for traversing the QD system

Table-1: Simulation Parameters

Simulation Parameter	Default value
Network size	$750x750m^2$
Node transmission range	100m
Number of Nodes	80
Node Speed	2.5(m/s)
Node request period	22sec
Size of data item	1-20kb
Total number of data items	20,000

B. Results

Fig. 5 clearly demonstrates the decrease in hit ratio by replicating the data item to one or more nodes in the network. By data replication the network traffic can be reduced significantly. The delay in the response time reduces and minimizes the maximum hit occur in the CN. The Hit rate is calculated by simply count the number of queries and the number that are cache hits. The hit rate is defined to be the number of cache hits divided by the number of cache queries in the simulation run. The cache hit ratio increases while the cache size increases. when the data is replicated for more than one node, the query delay decreases.

The smart server update Mechanism updates the data in the cache node with the current version in the server so the reply of stale document decreases in the MANET

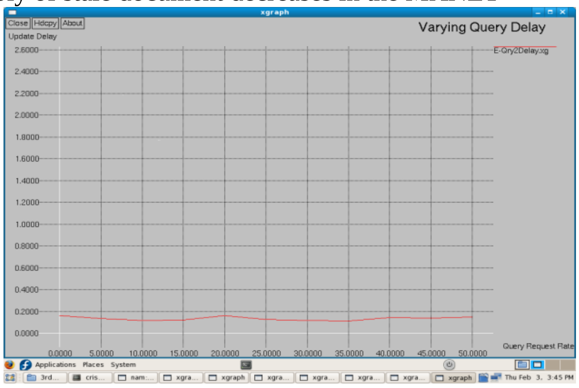

Fig: 6. Varying Query Delay

When the request rate is increased the query delay of Smart server mechanism rises due to queuing more packets in the nodes, while the update delay decreases initially and then settles down because as more items are cached, new CNs are set up

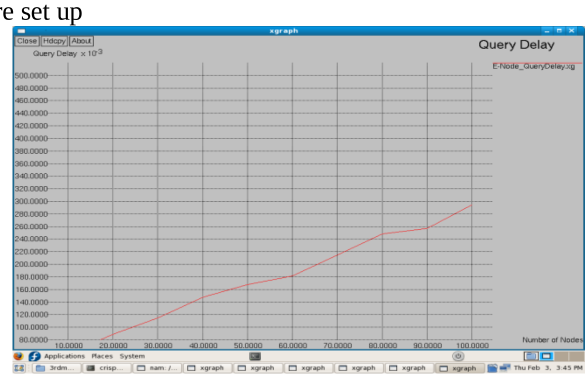

Fig: 7. Query Delay

Query delay is the important issue faced by Smart server update mechanism . By data replication the query delay can be reduced

VI. CONCLUSION

The proposed scheme can minimize the query delay in the Smart server update mechanism and reduces the network traffic. In addition, we have adopted the Data replication model for frequently accessing the data, thus improving the performance of the system as compared to the SSUM, and minimizes the contention in the network. The extensive results have demonstrated that, in comparison with the existing methods, our proposed Replication scheme is more effective and efficient in accessing the data, reducing response time, and improving the Performance of the system.

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