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Cross Layer Based Multimedia Transmission using Cache in Mobile Ad hoc Networks

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ABSTRACT

Mobile ad hoc networks have been the subject of active research for a number of years. Mobile ad hoc networking (MANET) community provides us with a wealth of technologies that enable the source and the destination nodes to route the data through a number of intermediate forwarding nodes. This paper proposes a Cross Layer Based Caching technique for transmitting multimedia data in mobile ad hoc networks (CBC). Cross layer technique is used to increase the packet delivery ratio by sharing the data using common database. Caching technique the buffer management decreases the average delay in the data transmission. The simulation results prove that the proposed algorithm (CBC) performs well when compared to existing methods.

Keywords: *Cross Layer, Mobile Ad hoc Networks, Caching, Multimedia.*

I. INTRODUCTION

Mobile ad hoc networks have been the subject of active research for a number of years. Mobile ad hoc networking (MANET) community provides us with a wealth of technologies that enable the source and the destination nodes to route the data through a number of intermediate forwarding nodes. There has been extensive research results in experiences with MANET [3], routing algorithms [4], capacity issues [5], energy aware routing and streaming mechanisms [6], [7], [8], [9] etc. Liu et. al. [2] is attempting to provide a single system image for ad hoc scenarios in MANETs.

Routing protocols for ad hoc networks can be classified into three main categories. In Proactive routing protocols [13], [14], [15] every node in the network has one or more routes to any possible destination in its routing table at any given time. Reactive routing protocols [16], [17], [18] obtain a route to a destination on a demand fashion. When the upper transport layer has data to send, the protocol initiates a route discovery process, if such a route does not already exist, in order to find a path to the destination. In Hybrid routing protocols [19], [20] every node acts reactively in the region close to its proximity and proactively outside of that region, or zone. Hybrid protocols take advantage of both reactive and proactive protocols, but may require additional hardware, such as GPS devices, separated or integrated into the communication device.

The routing protocols that have been developed for Mobile Ad hoc Networks are directly affecting data transmission, the performance of network applications and the end user experience. Each protocol has its own routing strategy that is used in order to discover a routing path between two ends. The performance varies, depending on network conditions like the density of nodes in a specific area, their speed and direction. As the mobile and handheld devices are becoming even more popular, and the use of ad hoc networks is increasingly perceived as significant, there is substantial relative work by the research community, regarding the differences among the existing ad hoc routing protocols. In [10], a comparison of the performance of two prominent on-demand reactive routing protocols for MANET (DSR and AODV) is presented along with the traditional proactive DSDV protocol.

In [11], the effects of various mobility models on the performance of DSR and AODV are studied. The experimental results illustrate that the performance of routing protocols vary across different mobility models, node densities and length of data paths. Another performance evaluation of the three widely used MANET routing protocols (DSDV, AODV and DSR) with respect to group and entity mobility models is presented in [12].

Most of the research on MANETs has focused on the development of Media Access Control protocols [22], [23] and routing protocols [24], [25] to increase connectivity among mobile hosts in a constantly varying topology. Because reliable and efficient access to information is the ultimate goal of networking, the design of higher layer protocols to meet user requirements is necessary. Cooperative caching has been widely used on the Internet to improve the performance of web services. In a web caching system, cache proxies' work cooperatively to minimize user perceived query latency, improve data availability, reduce network traffic and balance server workload [26]. These cooperative caching schemes work well on the Internet. However, they cannot be directly deployed in a MANET environment due to the mobility of nodes in MANETs, and wireless network characteristics. Recently, several schemes have been presented to use the concept of cooperative caching in MANETs [27], [28], [29]. These schemes allot every mobile node a certain amount of cache space. In addition to providing a local cache service, the network's nodes cooperate with their neighboring nodes on server data requests. In this way, a mobile node can get most of the requested data items from a local or neighboring cache space without accessing the remote Data Center, or the gateways to the Internet.

The main appeal of wireless cellular and ad hoc networks is that they allow both user mobility and undeterred connectivity. However, user mobility poses significant challenges to network operations such as routing, resource management, and Quality of Service (QoS) provisioning, especially when it comes to the QoS provisioning of multimedia services. The problem is more challenging in wireless ad hoc networks, since the mobile nodes constitute the communication infrastructure — a node acts as both a packet router and an end host. Node mobility leads to frequent disconnections of wireless links and dynamic changes of the network topology. To improve network connectivity, many mobility prediction schemes have been proposed [39], [40], [41] to predict the future availability of wireless links, for the purpose of building more stable end-to-end connections at the network layer.

Mobile ad hoc networks have received considerable attention due to the potential applications in battlefield, disaster recovery, and outdoor assemblies. Ad hoc networks are ideal in situations where installing an infrastructure is not possible because the infrastructure is too expensive or too vulnerable. Due to lack of infrastructure support, each node in the network acts as a router, forwarding data packets for other nodes. Most of the previous research [44], [45], [46], [47] in ad hoc networks focuses on the development of dynamic routing protocols that can efficiently find routes between two communicating nodes. Although routing is an important issue in ad hoc networks, other issues such as information (data) access are also very important since the ultimate goal of using ad hoc networks is to provide information access to mobile nodes.

II. RELATED WORK

The mechanism in order to provide some control over the resource consumed without a major revamp of existing operating systems or requiring special hardware is explored in [1]. The primary goal in this work is to investigate the suitability of ad hoc networks for streaming multimedia contents. First experiment is carried out with a wide variety of operating systems and hardware setups to show that there is a mis-match between expectations of the local system designers and the demands placed by ad hoc traffic.

In [27], three caching schemes, CacheData, CachePath and HybridCache, were proposed to provide efficient data access in MANETs. In the CacheData scheme, forwarding nodes between the requester and the data source cache frequently accessed data items. Then, those nodes were able to handle future requests, instead of forwarding them to a remote data source, in order to reduce query delay. CachePath works in a similar manner to CacheData, but the forwarding nodes cache data path information for future use, instead of just the data. HybridCache takes advantage of the above two schemes benefits to further improve caching performance. A caching scheme for Internet based MANETs was presented in [28]. In this scheme, if a mobile node cannot find the requested data item in the local cache, and does not have a direct link to an access point, which is the gateway to the Internet, it uses constrained flooding to send the request to its neighbors.

To provide an efficient platform for multimedia retrieval, multimedia data is clustered based on their semantic contents in [43], then construct a virtual hierarchical infrastructure overlaid on the ad hoc network. The rationale of semantic-based clustering is discussed. The importance of multimedia data access has motivated considerable research on content-based retrieval. Many of the present multimedia information systems employ the feature vectors to facilitate content based retrieval [42]. The approaches proposed on the feature-based representation can be categorized as two classes: 1) The partition-based approaches (e.g. quadtree [30], k-d-tree [31], and vp-tree [31]) that recursively divide the multi-dimensional feature space into disjoint partitions, with clustering or classifying algorithms, while generating a hierarchical indexing structure on these partitions. 2) The region-based approaches (r-tree family [32]) employing small regions (either in the form of Minimum Bounding Rectangles or Spheres) to cover the multimedia data objects in the feature space. These approaches work well in retrieving multimedia data in traditional centralized systems; however, they rely on an assumption that the whole system is homogeneous and can be organized with centralized indices. The disadvantages of centralized approaches have motivated the research on various decentralized information retrieval models for ad hoc networks [33], [34]. Many of these models employ flooding strategies to ensure retrieval accuracy and adaptation to network topology changes [33]. However, the flooding search strategy achieves good performance only when dealing with text information [34]. Due to the sheer size of the multimedia data, the flooding strategy may drastically consume system resources. Moreover, the flooding strategy may cause duplicated queries and retrieval results, which may further deteriorate the system performance [42]. Some recently proposed models in the literature try to make use of data distribution to facilitate information retrieval [35], [36], [42].The content-addressable network (CAN) model was proposed as a decentralized infrastructure that provides hashtable-like

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functionality on large-scale distributed networks [35]. A distributed hash table (DHT) is employed in a CAN to map the data objects into a logical Cartesian space; this allows the storage and retrieval of (key, object) pairs. Further improvements of CAN have led to the logical overlay networks (e.g. pSearch [36] and SSW [42]) that use dimension-reduction techniques to reduce search cost. However, the performance of these models is far from satisfactory due to their reliance on feature-based representation. Multimedia data objects with similar feature values may not share common semantic contents, known as the semantic gap [42].

In [37], a cross-layer design approach is employed to improve the performance of combined cooperative caching and prefetching schemes. The cross-layer information is maintained in a separate data structure and is shared among layers. We also combine prefetching with cooperative caching to further improve performance. We carried out extensive simulation experiments and compared various approaches including simple caching, cooperative caching with prefetching, and cooperative caching without prefetching.

In [38], *NonStop*, a collection of novel middleware-based runtime algorithms that ensures the continuous availability of such multimedia streaming services, while minimizing the overhead involved is proposed. On the other hand, for a fully connected network to partition into completely disconnected components, such large-scale and structured topology changes can only be caused by correlated movements of a group of nodes, whereas independent movement of individual nodes can only cause random and sporadic link breakage. This insight agrees with the simulation results from [49], [50] which have shown that, the group mobility behavior of mobile users causes frequent network partitioning, and the resulting partitions are the separate mobility groups.

In [48], a two stage error control scheme is proposed that improves the effective throughput of wireless networks. Error control is applied to the packet header and packet load separately. The network intermediate nodes either use header FEC or header CRC checksum to successfully transport the packets from the source to the destination. Only at the destination, the error of the load is corrected. Many related works described in [51], [52], [53], [54] describes importance of cross layer design and its effectiveness in providing solutions to various issues of mobile and wireless networks.

III. DESCRIPTION OF PROPOSED APPROACH

In this paper, we improve the throughput of the system for multimedia data transmission by signal strength, maintaining buffer at each node. The system is implemented using cross layer architecture where, a database is maintained to share the data among the different layers of the network. In the cross layer network data items that are cached using data cache can be retrieved by the network layer. The middleware layer can retrieve the network traffic information from the data link layer. Cache is maintained with every node along with the buffer. Buffer is used to store the data when there is a link breakage whereas cache is used to store the data items by the receiver and sender for the fast retrieval and transmission of data. Any intermediate node caches the data if it finds the link breakage along with buffering the data. The buffered data is sent through the new route and it will maintain a copy of the cached item. The cache management is done based on direct mapping technique, LRU replacement policy is used and write through policy is followed for updating of cache contents. When there is a request for a particular data, the node searches in its cache for the required data. If any intermediate node could find the data in its cache, the data could be sent to the requested node. Otherwise the request is forwarded.

The signal strength of the mobile nodes is used to measure the link stability. When it is observed that there is a high probability of link failure, then new route is discovered. If suddenly, route failure occurs, then the packets sent by the sender are buffered by an intermediate node and the route re-discovery process will be carried out. Route re-discovery process is a general one by sending beacon messages to the node in the network. So, the procedure for route re-discovery is not dealt in detail in this paper. If the new route is not found before the buffer is full, then route failure notification is sent to the sender which will be in stable state until the route re-established message is received from the effected node. If the new route is found before the buffer is full, then the process of forwarding the packets will be done in normal way.

IV. DISCUSSION ON RESULTS

A) Simulation Parameters:

The proposed system is tested using two parameters like packet delivery ratio (PDR) and average end – to – delay and evaluated for multimedia transmission

1) Packet Delivery Ratio (PDR)

This factor is the ratio of the number of data packets sent by the source to the number of the data packets received by the destinations. If TCP is used, network congestion results with the retransmission due to high packet loss [21]. Usage of UDP reduces the quality of end user experience.

2) Average End-to-End Delay

This factor includes all kinds of delay like delay in packet transmission, delay during route re-discovery, retransmissions, propagation delay etc.

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B) Simulation Setup:

Simulation Parameters

S.No.	Parameters	Value
1	Simulation duration	100 seconds
2	Topology	1000m * 1000 m
3	Transmission range	250 m
4	Node Movement model	Random waypoint model
5	Traffic type	CBR (UDP)
6	Data payload	512 bytes
7	Routing Protocol	AODV
8	Number of nodes	25
9	Mobility of the node	0 – 30m/s
10	MAC	802.11

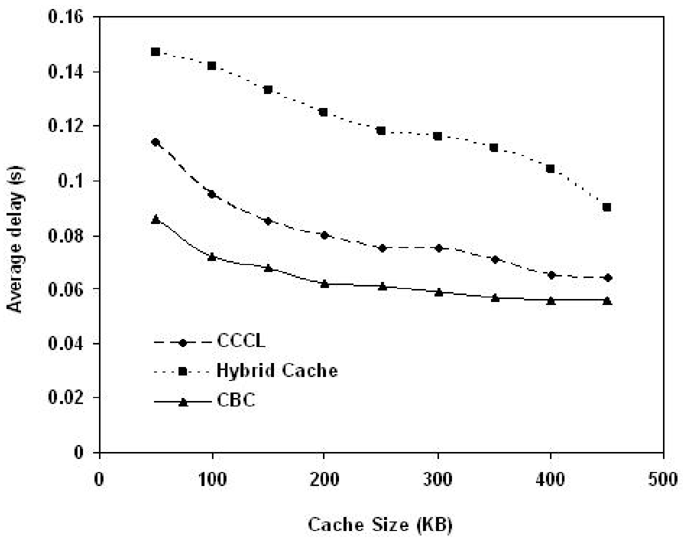

Fig. 1 Comparison of CCCL, Hybrid Cache and CBC in terms of Average delay

It can be observed from the Fig. 1 that the performance of cross layer based caching technique is better when compared to the hybrid cache and CCCL – Cooperative caching with cross layering and prefetching approaches. The average delay is reduced by the proposed work as the number of retransmissions is reduced. The caching technique and the buffer maintenance are the main factor for reducing the delay in the system.

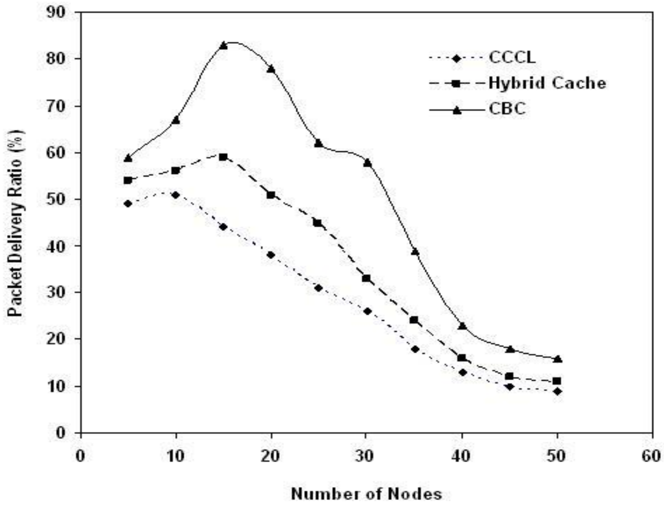

Fig. 2 Comparison of CCCL, Hybrid Cache and CBC in terms of Packet Delivery Ratio

The Fig. 2 shows that the packet delivery ratio is noticeably increased using the proposed algorithm, CBC when compared to CCCL and hybrid cache techniques. The proposed algorithm performs better in terms of packet delivery ratio because of the cross layer technique and the buffer management system. The detection of the link failure in prior using the signal strength also helps in improvement of the packet delivery ratio.

V. CONCLUSION

Mobile ad hoc networks (MANETs) are becoming more essential to wireless communications due to growing popularity of mobile devices. Their ability to be self-configured and form a mobile mesh network using wireless links, makes them suitable for a number of cases that other type of networks cannot fulfill the necessary requirements. MANETs offer the freedom to use mobile devices and move independently of the location of base stations (and outside their coverage) with the help of other network devices. This paper proposed a cross layer based caching technique for transmitting multimedia data in mobile ad hoc networks (CBC). The proposed algorithm is compared with CCCL and hybrid cache in terms of packet delivery ratio and average delay and shown that CBC performs better. The cross layer technique and buffer management helps in increasing the packet delivery ratio and caching technique and buffer management, prior detection of the link failure using signal strength helps in reducing the delay of the transmission in the system.

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