# Basic Needs for Designing a Good Cooperative Caching Management Technique

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## ABSTRACT
A Mobile Ad Hoc Network (MANET) is a network that allows servers and client to communicate in the absence of a fixed infrastructure. MANET is fast growing area of research as its finds use in a various applications. In MANETs, dynamic topologies and the failure of mobile nodes due to exhaustion of their battery power can considerably decrease data availability. Data caching on clients is widely seen as an effective solution to improve data availability. In particular, cooperative caching based on idea of sharing and coordination of cached data among multiple client are moving frequently. A number of cooperative caching schemes have been proposed in the past year. In this paper, discusses the features for designing a good cooperative cache management scheme.

## Keywords
Mobile Ad Hoc Network, Caching, Cooperative Caching, Data Caching, Cross-layer

## 1. INTRODUCTION
Mobile Ad Hoc Networks (MANETs) is special type of wireless network in which collection of mobile network interfaces may forms a temporary network with-out the aid of any established infrastructure or centralized administration. MANETs have dynamic topologies; mobile nodes can change position, join and leave the entirely. In this situation, gives a number of problem likes message loss, unpredictable disconnection of mobile devices and network partitioning [1] [2]. The absence of any fixed infrastructure makes MANETs very attractive for military operation, rescue operation, sensor network, and time-critical applications [2] [3].

Most of the research effort focuses on neighbor discovery protocol and network layer solution (routing protocol) to increases reliable connectivity among mobile nodes in a constantly varying a topology. Although routing is an important issue in mobile ad hoc networks, Routing protocols for MANETs have classified in to three categories: first one is proactive, second one is reactive and third one is combination of both (Hybrid). Different routing protocols try to solve a different problem in different cases. Proactive that means route is always available for data item or predefine such as OLSR [4] and DSDV [5], reactive that means a route is discover when mobile node need a data item to other node such as AODV [6] and DSR [7], and hybrid that means a combination of both routing protocol such as ZRP [8] and OPHMR [9].

The ultimate goal of these networks is to data availability among mobile nodes. In MANETs due to frequent network partition, data accessibility is lower compared to traditional wired networks. Cooperative caching and data replication offer a solution to this problem. The main difference between caching and replication can be stated as the caching occurs after the retrieval of data item, while replication of a replica (copy of data item) can occur before a request received for that item [10] [11]. Various issues and a survey solution associated with the data replication and cooperative caching for mobile ad hoc networks are given in [12] [13] [11].

In addition, caching techniques are developed for improve data accessibility. With caching, the data access delay is reduces since data requests can be served from the cached client before reaching the server. Caching has been successfully applied in design of CPUs, multi-processors, and routers. It has also been employed in internet based technologies, such as the cache design of the World Wide Web (WWW) [14], proxy caches [15], Internet Cache Protocols [16] for proxy servers, cache digests [17] and summary caches [18], various distributed system, with the purpose of reducing data access delays. Furthermore, several caching clients can also work together to form a cooperative caching environment, further improving the overall caching performance.

The rest of this paper is organized as follow. In section 2, we present cooperative caching in MANETs and we study the cooperative design and architecture. Then discuss the Cross layer implementation for cooperative caching in MANETs in section 3 and Section 4 finally gives the conclusion and identified guidelines for possible future research direction.

## 2. COOPERATIVE CACHING IN MANETs
Caching is copy a portion of data that is called data item from the data provider or server to a smaller and faster storage device (Cache) interposed between the data consumer or client or mobile nodes and the data provider and server, so that in future, data access can resolved from the cache with low cost. Caching can decrease the access latency of such request and also decrease the resources needed to access data which is important in mobile device that have greatly reduce resources than traditional network devices. Cooperating caching based on the idea of sharing and coordination of cached data among multiple mobile nodes or client can be particularly effective for data access in mobile ad hoc networks. However, limited cache space, movement of nodes and frequent disconnection limit availability of data. By cooperative caching frequently accessed data item in the MANETs, we can improve data accessing rate and data availability.

In cooperative caching based data access architecture, mobile nodes cache the data or cache the path or hybrid to reduce latency and to increase data availability. A good cooperating cache management technique should have proper cache discovery, cache admission control, cache replacement, and cache consistency scheme.

## 2.1 Cache Discovery

Cache discovery scheme addresses not only how to resolve a data request with minimum cost of latency, power consumption, distance, bandwidth, but also how to improve the successfully request access ratio. The important of cache discovery in cooperative caching is to answer how mobile node can assist each other in resolving data items request to improve general network performance. A cache discovery algorithm is required to determine if and where the requested data item has been cached when the requested node does not have information of the destination.

The cache discovery processes can be either push based or pull based. In push based approach, the requesting node can directly find the node which has the cached copy of data item. In pull based approach, when a local cache miss occurs then the request is broadcasted to its neighboring nodes and a node which has the cached data item will respond [19] [20]. A common approach is hop-by-hop cache resolution for cache discovery has used in most cooperative caching schemes. In hop-by-hop cache resolution, a data request is checked at every hop along the forwarding path. If a forwarding node has the requested data item, the request get resolve before reaching the server.

## 2.2 Cache Admission Control

Cache admission control decides whether the data item is cacheable or not. The objective of cache admission control, how can store more distinct data items in the given cache space. Inserting a data item into the cache might not always favorable.

The cache admission control can be either general scheme or functional based scheme. In general scheme, all the incoming data item are cached. In function based, a cost function will decide whether to cache the incoming data items. The cost function is formed by combining different parameter like distance, bandwidth, access frequency, and remaining cache space.

## 2.3 Cache Replacement

When the cache is full, then how can find suitable subset of data items to evict from the cache. Cache replacement algorithms have been studied in operating system, virtual management system and database buffer management system. The cache replacement policies can be either uncoordinated or coordinated. In uncoordinated replacement policies, the data item to be evicted is determined independently by each node based on its local access information. In coordinated replacement policies, the mobile nodes which form cooperative cache collectively take the replacement. Coordinated caching help for two reason; First, coordination allow a busy cache to nearby idle cache in MANETs and second, coordination balances the improve cache hit time achieved by increasing the secondary copy of popular data item against the improve cache hit rate achieved by reducing secondary copy of data items and storing more unique data items. A detailed survey on Cache replacement for cooperative caching is given in [21] [22].

## 2.4 Cache Consistency

Cache Consistency specifies how to maintain consistency between the original data item and the secondary copies of data item at the mobile node. Cache Consistency is to ensuring that each mobile node caching the data item is aware of the data item update at the source node. A strategy for maintaining consistency of cached data item in MANETs can focus on three design aspects: consistency level, consistency control, and cache status maintenance. A survey of various approaches to maintain data consistency in mobile ad hoc networks has given in [23] [24].

### *2.4.1 Consistency Level*

Cache consistency level can be categorized into strong, weak, and delta consistency level. In weak consistency level, allows a stable data item to the returned to the client. While strong consistency level does not allow any stable data item returned to the client, and always enforces original data item held by server. In delta consistency level, allow a stable data item is never out of date by the more than delta time with the source data item at the data source node or server.

### *2.4.2 Consistency Control*

Both the data source node (server) and cache nodes can initiate consistency checking. In this mechanism, cache invalidation messages are broadcast to all cached nodes indicates the update status of data item. Cache invalidation messages have been widely used in distributed system to maintain data item consistency among caches. In the latter approach, the cache nodes poll the server to determine whether it cached data item is stale or not. Consistency control can be either by using push operation or pull operation. In push operation, the data source node pushes the update message to other cached nodes. In pull operation, individual cached nodes to pull the update message from the source data item (server).

### *2.4.3 Cache Status Maintenance*

The data source node or server may be or may not be records the status of cached data item. Cache status can be either StateFul (SF) or StateLess (SL). In StateFul approach, the data source node keeps the information about which mobile nodes cached which data item. When the data source node wants to communicate with these cache nodes, it can send messages instead of broadcasting them. In StateLess (SL) approach, does not require the data source node to be aware of the cache nodes status. Instead, it keeps track of the update history of data item and periodically floods this information in the form of invalidation message.

# 3. CROSS-LAYER IMPLEMENTATION for COOPERATIVE CACHING IN MANETs

The cross-layer design approach has recently emerged important design methodology to cope with performance issues in the mobile ad hoc networking environment. In the layered based architecture, each layer provides specific services to upper layer and lower layer while hiding their detailed implementation. Cross-layer design introduces the stack wide layer independencies to optimized overall network performance. M. Conti [25] (MobileMan Project) introduces inside the layered architecture the possibility that protocols belonging a different layers can cooperate by sharing network-status information while still maintaining separation between the layers in protocol design. In this Project, focus only on providing general layer architecture and does not look at the special problem such as data availability.

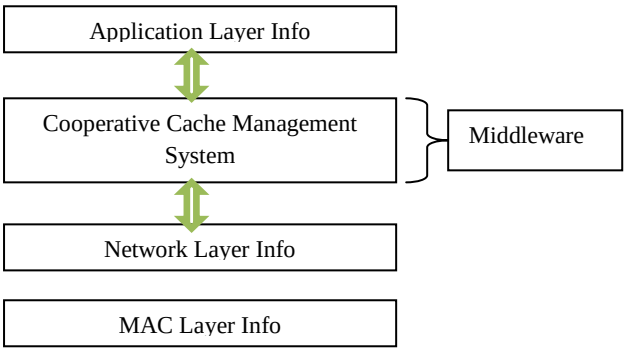


**Figure4: Cross-layer System Architecture**

In figure4 display cross-layer based system architecture for cooperating caching in mobile ad hoc networks. The architecture same as TCP/IP reference model but some of the changes due to cooperating caching scheme. In this architecture, upper layer is application layer info describe the function of application layer, routing services for data accessing in the network layer can cooperate by sharing network status information by using middleware layer. Middleware layer describe the cooperative cache management system. Cross-layer system architecture providing a robust upgrade environment, which allows the addition or removal of protocols belonging to different layers from the stack without modifying the operations at the other layers and it does not modify each layer's core function [25] [26].

## 4. CONCLUSIONS

In this paper, we reviewed basic concepts concerning developing a cooperative caching technique for MANET have been discussed. Most research in mobile ad hoc network focus on routing protocol and Quality of Services over MANETs routing, and not much work was done on increase data availability. In this paper, there is small study to designing the better cooperative caching management technique for MANETs.

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