CHAPTER 1

INTRODUCTION

1.1 WIRELESS NETWORKS

Fast and rapid growth of computing and communication technologies, have brought remarkable changes in computer networking. The type, size and complexity of the required network depend on the needs of an organization. In particular, the type of network depends both on the nature of transactions taking place in the organization and the geographical dispersion of the organization. If the geographical dispersion of the organization is less, then shared media networks with limited number of computing systems and peripherals are sufficient. In case of large geographical dispersion, the organization has to go for large and complex switched networks. Shared media networks and switched networks are commercially termed as Local Area Networks (LANs) and Wide Area Networks (WAN) respectively.

Generally speaking, computer network (Peterson & Davie 2012) is a group of two or more computers linked together in a way that communication is made possible among them through exchange of data. They are broadly categorized into wired networks and wireless networks. LAN, Metropolitan Area Networks (MAN) and WAN are the categories of wired networks. In the context of wireless networks another category of networks called Personal Area Networks (PAN) is becoming popular.
Unlike wired networks, these networks use air as their physical medium for communication (Stallings 2005). Wireless networks completely rely on radio frequency channels to exchange data. Hence all nodes within the direct communication range of a source node ultimately receive all the information transmitted by the source. These networks do not depend on physical connection existing between nodes. Common applications like radio and television networks which involve voice and video communication, would not be possible without wireless technology. However major contributor of wireless technology came in the form of cellular network which in turn provides two-way simultaneous voice communication (Murthy & Manoj 2004).

Wireless networks are quite successful in the area of voice communication. However they have to go a long way in the area of data communication due to their unreliability and vulnerability. The wireless technology is developing at a tremendous pace and hence all the stakeholders are optimistic about the wide spread usage of wireless networks in the society. At least for a foreseeable future, communication is going to depend on the integration of wired and wireless networks. A typical wireless network scenario is shown in Figure 1.1.
Undoubtedly wired networks are infrastructure networks. However in the case of wireless networks there are two possibilities namely infrastructure based and infrastructure less networks. Typical examples of these two are cellular networks and wireless sensor networks respectively.

1.1.1 Infrastructure based Networks

These wireless networks are also known as infrastructure dependent network which highly relies on a wired backbone (Stallings 2005). Moreover communication in these infrastructure-based wireless networks takes place only between wireless nodes and the access points, but not directly between the wireless nodes (Schiller 2001). Mobile nodes can communicate with other wired or wireless network only through these access points. In the case of

Figure 1.1 Wireless networks

(http://mydataone.net/articles/wireless.html)
cellular networks the access points are nothing but the base stations. Figure 1.2 depicts an ideal infrastructure based network.

![Infrastructure based networks](http://www.eusso.com/Models/Wireless/UGL2454-SU2/UGL2454-SU2.html)

**Figure 1.2 Infrastructure based networks**

1.1.2 **Ad hoc Networks**

It is not possible to deploy infrastructure based wireless everywhere. There are many applications and scenarios where it is not possible to deploy equipments like access points and base stations. Typical examples for such scenarios are forests, battlefields and areas affected by natural disasters. In such unfriendly terrains it should be possible for a set of wireless devices to form a network on the fly and communicate among themselves. Such infrastructure less networks are popularly known as wireless ad hoc networks.
Ad hoc networks, otherwise known as infrastructure less networks as depicted in Figure 1.3 are defined as the category of wireless networks that utilize multi-hop radio relaying and are capable of operating without the support of any fixed infrastructure (Murthy & Manoj 2004). In short it provides for any time any where communication. Its decreased dependence on infrastructure enables such a type of network to be deployed easily with reduced cost and time.

![Ad hoc networks](http://support.hp.com/us-en/document/c01131593)

Figure 1.3 Ad hoc networks

It in turn provides support to two different types of topologies (Stallings 2005) namely,

- Heterogeneous topology
- Homogeneous topology

While homogeneous topology deals with nodes with identical capabilities, heterogeneous topology connects together nodes with dissimilar capabilities. For instance, a network consisting of all laptops comes under the category of homogeneous topology while a network comprising of different types of computing devices like PDAs, laptops, notebook computers, etc., forms a heterogeneous topology.
1.2 MOBILE AD HOC NETWORKS

With further advancements in technologies, customers have been motivated towards a mobile environment which can provide continuous connectivity and in turn services to wireless mobile devices regardless of their physical location. In this kind of environment, the need to rely only on static or rigid computing systems for communication has been reduced considerably. Now a days end users prefer to access or communicate with each other, even when they are moving around. In order to accomplish this, mobility has been incorporated into ad hoc networks, leading to a heterogeneous network known as mobile ad hoc network. These networks exploit the usage of technologies like Bluetooth, Wi-Fi, etc. Figure 1.4 depicts a simple mobile ad hoc network.

![Figure 1.4 Mobile ad hoc networks](http://www.acorn.net.au/telecoms/adhocnetworks/adhocnetworks.html)

Mobile Ad hoc NETwork (MANET) is a dynamic infrastructure independent network consisting of a collection of wireless mobile nodes that communicate with each other without the use of any centralized authority
(Aarti & Tyagi 2013). It is a network that supports dynamic formation and deformation of network. It has support for either peer to peer communication or peer to remote communication. Every device or node here, functions as both a router and an end system. Moreover mobility of nodes here leads to frequently changing or dynamic topology.

1.2.1 MANET Characteristics

MANETs have evolved into a popular network with widespread acceptance because of their high end qualities and features to support communication irrespective of the location of the user. The characteristics of a typical mobile wireless network are specified by Aarti & Tyagi (2013), as follows

- **Distributed operation**: No single entity in the network is entitled to take control of entire network functionalities. Every node in the network has to cooperate in controlling the network. In short, control is distributed among the nodes. All nodes in a MANET should cooperate with each other and forward the packets on behalf of others. If needed nodes should relay information related to routing and security operations.

- **Multi hop routing**: When a mobile host desires to send some information to another node which is not present within its communication range, then the information has to be forwarded through intermediate nodes. The packets from the source might traverse one or more intermediate nodes to reach the ultimate destination.
• **Autonomous terminal**: Every node in a MANET is independent and can either function as a host or as a router or both.

• **Dynamic topology**: Since MANET is a self organizing network, nodes arbitrarily move with varying speeds. Hence the topology of the network changes frequently. As the nodes move around routing protocols assists them in identifying their neighboring nodes and forming their own network.

• **Light-weight terminals**: Mostly, MANET comprises of nodes with less computing capability in addition to constraints in energy and memory size. In other words, the nodes in a MANET are resource constrained devices.

• **Shared Physical Medium**: MANET highly relies on wireless medium for communication. It is a shared medium that can be easily accessed by any device with appropriate and adequate equipments. Moreover, access to this shared medium cannot be restricted.

### 1.2.2 Advantages of MANET

MANETs have many inherent abilities and merits which has made it a widely accepted network among other types of networks. The major advantages of opting for a MANET (Yadav & Uparosiya 2014) include:

• Access to information regardless of geographic position

• Independence from central network administration

• Self-configuring network where nodes also act as routers

• Less expensive when compared to wired networks
- Scalable—accommodates the addition of more nodes
- Improved flexibility
- Robust due to decentralized administration
- The network can be set up at any place and time

1.2.3 MANET Challenges

In order to achieve all these merits and characteristics, MANET has to overcome many hurdles and bottlenecks majorly contributed by resource constraints and mobility factors (Goyal et al. 2011). The major challenges imposed on mobile ad hoc network include:

- **Limited bandwidth**: The capacity of wireless links is significantly lower than wired networks. In addition, the throughput of wireless communication after taking into account the effect of multi user access, noise, fading, interference conditions, etc., is often much less than the radio’s maximum transmission rate.

- **Dynamic topology**: Due to dynamic topology nodes are free to enter and leave the network independently. But the reliability of the entire network may be disturbed if any of the nodes in the network is compromised.

- **Routing overhead**: In MANET, owing to mobility, nodes often move from one place to another. This might result in the generation of stale routes in the routing table leading to unnecessary routing overhead.

- **Hidden terminal problem**: Receiving node at some times might receive packets simultaneously from the nodes that are
not within the direct transmission range of each other, but are within the transmission range of the receiving node. This results in collision of packets at the receiving end.

- **Packet loss due to transmission errors:** Presence of hidden terminals, interference, uni-directional links and frequent path breaks due to mobility of nodes results in MANET experiencing higher packet loss.

- **Mobility-induced route changes:** Frequent topology changes are quite inevitable due to frequent movement of nodes in MANET. Hence MANET suffers from frequent path breaks and frequent route changes.

- **Battery constraints:** Mobile devices are confined to reduced size and weight in order to provide for better portability. This in turn imparts constraints in power resource, since the battery is expected to have less weight

- **Security threats:** MANETs depend on shared wireless medium for communication. But this attracts all kinds of security breaches. Eavesdropping is a profound attack that happens in a shared medium. Moreover, as all ad hoc network functionalities are achieved through cooperation between nodes, the network gets exposed to various security attacks.

This research work considers limited bandwidth, dynamic topology, mobility induced route changes and battery constraints into account while proposing the cache algorithms.
1.2.4 MANET Applications

MANETs in spite of all these challenges have found widespread acceptance in real world, due to their inherent capabilities to satisfy user requirements. Some of the typical applications (Kumar & Mishra 2012, Bang & Ramteke 2013) include:

- **Battlefield**: An ad hoc network that connects the soldiers, the commandos and the military head quarters is quite inevitable for a military application. Sensitive information should be frequently communicated to all the entities involved in the battle.

- **Collaborative Work**: In business, collaborative environment is essential not only within the office but also the company premises Business projects might involve open meetings organized to mutually exchange information related to the project irrespective of the location of the people involved in the meeting.

- **Content Sharing**: Ad hoc networks can be employed in application like virtual classroom where multimedia content can be instantly shared among participants with notebook computers.

- **Personal Area Network and Bluetooth**: MANET can be established as a personal area network covering short ranges specific to a limited geographical area. Technology like Bluetooth can be used to accomplish a personal area network. Bluetooth can enable short range communication within a network comprising of mobile devices like laptops, cell phones, etc.
• **Emergency and Rescue Services:** Emergency rescue operations must take place where we face non-existing or damaged communication infrastructure and rapid deployment of a communication network is required to handle situations like flood or fire or earthquake. MANET can be deployed in such emergency situations as it does not depend on any pre-existing infrastructure.

• **Commercial Sector:** When a sporting event is planned in any remote place, interested users might either visit the place or the users might be interested in accessing information pertaining to the sporting event from the specific sports server through their mobile devices. In such cases MANET can be deployed to enable instant and easy access to information irrespective of the location of the server.

### 1.2.5 Research Issues

Many applications of MANET are the results of intensive research carried out in various segments related to the scope of wireless ad hoc networks. Most of these research, aim at mitigating certain issues with an intention to enhance the overall performance of the mobile ad hoc network. Few such research issues (Padma & Suresh 2013, Kumar et al 2008) given keen importance are discussed here:

• **Routing:** Routing includes exchange of route information in order to find an apt path to the destination considering mobility, bandwidth, energy, error prone medium, etc. into account. Any routing protocol should provide for a distributed routing approach with minimum control overhead, minimum delay in acquiring routes and quick reconfiguration in case of path breaks.
• **Medium Access Scheme:** This involves transmission of packets using a shared channel. The major issues here evolve around distributing the operations, providing synchronization in transmission and reception, evading hidden and exposed terminals and opting for maximum channel utilization by minimizing both collisions and exchange of additional control packets.

• **Self Organization:** A MANET should be capable of organizing and maintaining the network by itself. It includes neighbour discovery, topology organization and topology reorganization.

• **Security:** Its shared medium and distributed architecture makes it more vulnerable to attacks like denial of service, resource consumption in terms of resource drain, host impersonation, information disclosure and interference.

• **Energy Management:** Its main goal is to improve the life time of the wireless network by managing the transmission power, battery power, processor power and devices power available within the network in such a way that their consumptions are minimized.

• **Deployment Issues:** This requires good planning and estimation. The scenario of deployment, area of coverage, service availability, choice of protocols and integration with outside world should all be taken in to account to provide for cost effective, time effective and reconfigurable deployment.

• **Data Availability and Information Retrieval:** The ultimate goal of a MANET, is to enable mobile clients easily access information. However, it is limited by intermittent network
connections and restricted resource capabilities. These restrictions pose a severe threat to data access applications with respect to data availability and information retrieval efficiency. A successful network should provide for good cache schemes or replication mechanisms in order to improve data availability in the network. Moreover strict management of such schemes is quite inevitable.

This research focuses on providing an efficient cooperative caching environment with an intention to enhance data availability in a MANET taking the resource constraints prevailing in the system into consideration.

1.3 COOPERATIVE CACHING

Most of the research works are concentrating on key areas like routing, security, energy management, etc. But enhancing information availability across the network is very important to satisfy the current customer requirement and it is the need of the hour. The main expectation and interest of mobile users evolve around information access and information retrieval. The end users desire to access or receive their data of interest irrespective of their geographical location. Information access and information retrieval have paramount importance when mobile ad hoc networks are used in commercial sector.

In ad hoc network due to movement of nodes, limited storage space and frequent network partition, data availability is lower than that in traditional wired networks. Caching provides an attractive solution for this problem.

Cache is a component (Ramasubramanian et al 2011) that temporarily stores data so that future requests for that data can be served
faster. The data that is stored within a cache might contain values that have been computed earlier or duplicates of original values that are stored elsewhere. If the requested data is present within the cache, the request can be easily served by simply reading the cache content, which is comparatively faster than retrieving the same information from the original source. Attaining the desired data from the cache is termed as a Cache Hit and if the data is not present within the cache then a Cache Miss is said to occur. In case of a cache miss, the data has to be recomputed or fetched from its original storage location, which is comparatively slower. Hence, greater the number of requests that can be served from the cache, the faster the overall system performance becomes.

Cache is a small and smart memory device (Smith 1982, Peir et al 1999, Hennessey et al 2006) used to store data temporarily. Most of the data exchanged in a MANET are dynamic data. Hence care has to taken to efficiently utilize the small cache space. Almost all dynamic information is time critical and so may render useless after a specific period of time. We refer this time as stale time.

In this research work we design a cooperative caching technique that exploits sharing and coordination among the mobile nodes. By caching frequently accessed data in ad hoc networks we can improve data availability and in turn performance of the network. Many caching techniques have been proposed for wired networks. But these caching techniques cannot be incorporated into mobile ad hoc networks which are constrained by resources and mobility factors.

In many applications, mobile nodes in a MANET share common interests. Typically, nodes cache data items for serving their own needs in future. Cache sharing, however, allows geographically neighbouring mobile nodes to access each other’s cache contents. Sharing cache contents offers
significant benefits like reducing the number of long-distance data accesses to the data centre. The key to this technique is that a node has to know if there is some node in its vicinity that has cached the data it requires and where it is, if any. An ideal approach to deal with this requirement is to let a mobile node record the caching information about a nearby node while forwarding the data requested by the node.

Since MANETs are mobile and constrained by limited energy, bandwidth and computation power, designing appropriate caching protocols for such networks is a great challenge. Added to this was the evolution of data servers. A data centre or server is a highly efficient information system aimed at maintaining data of any particular dynamic real time application. Most of the public and private organizations predominantly employ such servers to provide for information at all times to the end users.

Let us consider a scenario in which mobile devices desire to retrieve data from the data centre. This may result in a large amount of traffic in the network. This, apparently, is undesirable as traffic directed towards the data centre consumes considerable power and bandwidth of the already resource constrained network. A mobile host might suffer from high access latency if it is far away from the data centre and in addition packet loss probability for long-distance data access is high. Furthermore, traffic near the data centre will be heavy, and this leads to a potential performance bottleneck.

All these problems are more pronounced when the network size is large, leading to poor scalability of the system. The above observations motivate us to investigate new data caching techniques for MANETs. With data cached in mobile nodes, a data request may be satisfied by a nearby mobile node, instead of being serviced by the data centre. This arrangement has the potential to meet the major objective of this research work.
1.3.1 Merits of Cooperative Caching

Cooperative caching within nodes in a mobile network brings with it the following advantages (Wang 1999, Krishnan & Sugla 1998, Michael et al 1998) which are enlisted as follows:

- Caching improves data availability within the network.
- It also reduces access latency by minimizing the time taken to retrieve data.
- Moreover traffic near the data center is highly reduced as data can be retrieved from nearby cache.
- The overall consumption of bandwidth is reduced because of reduced traffic within the network.

1.3.2 Demerits of Cooperative Caching

All these merits of cooperative caching would not have been possible if the setbacks that caching imposes on a mobile kind of ad hoc networks were not considered or taken into account. There are several disadvantages (Wang 1999, Caceres et al 1998) of using a caching system.

- The cache system ought to be at least as efficient as using direct contact with the original source of information.
- A client might be looking at stale data due to inconsistency. Hence, to ensure consistency, stale data should either be removed or replaced at proper intervals.
- Access latency might increase in case of a cache miss due to extra processing. Hence, cache hit rate should be maximized.
and the cost of a cache miss should be minimized when designing a caching system.

- Using a cache will reduce the hits on the original server which might disappoint a lot of information providers, since they cannot maintain a true log of the hits to their data.

### 1.3.3 Cooperative Caching Scenarios

**Scenario 1:** In case of a military application one mobile node (Commando) may be connected to the Internet by a satellite and this serves as a proxy to other mobile terminals (Soldiers). Any accessed information in case of a war can be shared to the rest of the mobile terminals via local ad hoc communication (Zhoa et al 2010). Even in this case the accessed or cached information is time sensitive since it relates to the current scenario of a military mission. Hence the cached information might not tend to be useful for long durations because by then the scenario might have changed in the battlefield.

**Scenario 2:** During international sporting events like Olympic Games (Lim et al 2006), the demand from users to access the Internet to get related information from the sports server increases. This accessed information can then be shared with other users of same interest if they are in the vicinity of an ad hoc domain. However the accessed information can be considered valid only for a short period of time, after which the medal tally might have changed.

**Scenario 3:** In a large park of a city (Chiu & Young 2009), there exists a data centre that stores information about various cultural, entertainment, sporting or commercial activities of the surrounding area. A client cannot reach the data centre in a single hop due to constraints in the coverage range. This in
turn restricts the retrieval of desired information from the data centre. In case of a MANET, the client can access the information via other mobile devices or through multiple hops by forming an ad hoc network.

1.3.4 Simple Cooperative Caching Environment

Figure 1.5 is a self configured network of mobile terminals connected by wireless links. This network in turn is connected to a data server. Data server is a highly efficient information system which maintains and manages data of real time, mission-critical and transactional applications. These servers can be employed where enhanced performance, easy utility, minimized maintenance cost and reduced memory usage are desired. As requirements and needs change, these servers tend to be highly scalable. Hence these are predominantly employed in most information access environments. Mobile terminals such as cell phones, portable gaming devices, PDAs and tablets all have wireless networking capabilities. By participating in the network (Lim et al 2006), these terminals may reach the Internet when they are not in the range of Wi-Fi access points or cellular base stations, or communicate with each other when no networking infrastructure is available.

Figure 1.5 Simple cooperative caching scenario
Here P1, P2, P3 are PDAs. L1, L2, L3, L4 are laptops and M1, M2, M3 are cell phones. All these mobile devices come together to collectively form a mobile wireless network. The nodes in this network in turn rely on the data server for accessing data of common interest. These types of networks find its importance in applications like military, disaster rescue and recovery, shopping malls, conference halls, etc.

1.4 OBJECTIVES

Cooperative caching plays a major role in improving information availability in any ideal environment. As MANET already comes along with mobile nodes cooperating among themselves to form an ad hoc network without infrastructure feasibility, imparting cooperative caching within this network becomes quite simple. In this research work we propose an efficient cooperative caching scheme that includes an effective cache sharing and cache consistency mechanism.

A good cache management technique (Jain & Sharma 2014, Kumar et al 2010) should provide the following facilities to ensure an efficient cooperative caching scheme:

- A cache discovery algorithm that is efficient enough to discover requested data items from the neighboring nodes.
- There should be an efficient cache replacement algorithm to identify the victim and replace it when space is not enough to accommodate new information.
- A cache update algorithm to ensure that the cached data items are updated.
On the other hand, a good cache sharing scheme (Chow et al 2004(a), Chow et al 2004(b)) for MANET should take into account the following contexts:

- Caching of data should not be entertained in all the forwarding nodes.
- Only selected nodes should be encouraged to cache the data.

A good cache consistency (Krishnamurthy & Wills 1997, Krishnamurthy & Wills 1998) scheme for MANET should address the following issues:

- Data in the cache must be identical to that present in the original information source at any point of time.
- Any update made in the server should be exactly reflected back to the caches holding the same data at any point of time.

1.5 ACCOMPLISHMENTS AND CONTRIBUTIONS

At this point, as we are convinced that an efficient cooperative caching should be established in a mobile environment to provide better information availability across the network. In this research work, we propose a novel cooperative caching scheme to enhance information availability in mobile ad hoc networks. This thesis work introduces a set of cache management schemes, cache sharing schemes and cache consistency schemes to enhance information availability and information retrieval in a mobile ad hoc environment.

In cooperative caching, the cache management issue is a paramount problem. Though many solutions are proposed, each of them has its own
drawbacks in terms of a different context. In our work, we propose three different cache management schemes with various perspectives namely, Time Index BAsed Caching (TIBAC) approach, Heap Oriented Time Based (HOT-B) Protocol and Collaborative Clustering for Cooperative Caching (4C).

The Time Index BAsed Caching (TIBAC) approach focuses on providing recent data on demand basis. In this system, the data to be cached comes along with a time stamp, pertaining to the update time or refresh rate of the data server. In this work we propose three policies namely Item Discovery, Item Admission and Item Replacement, to facilitate data availability even with limited resources. If the mobile client receives the same data item with an updated time, the previous content along with time is replaced, to ensure data consistency. Data availability is promised by these mobile nodes. The space availability in a node is enhanced by deploying automated replacement policy and proceeding with a forced replacement policy in case the prior one fails to provide for sufficient space to accommodate new entities.

Heap Oriented Time Based (HOT-B) protocol proposes an appropriate data structure for the time index based caching approach. It encompasses four policies namely Data Discovery, Data Admission, Data Update and Data Replacement. In this paper, we propose a Min Heap data structure, which can be used along with caches to store time sensitive information. Two basic functions associated with data structures are insertion and deletion. On inserting an item, it is percolated up to a specified position based on the time index associated with the item, and while deleting an item the remaining data items are percolated down to maintain a specific order. Even during cache replacement, the data at the root can be considered for deletion instead of intensive search being carried, all through the contents of a
linked list like structure. This in turn reduces the traversal time within the cache.

Clustering is highly employed in networks to bind together network nodes into clusters aiming at reducing communication overhead. Collaborative Clustering approach for Cooperative Caching (4C) involves clustering and time index based caching approach in a mobile ad hoc network with an intention aimed at improving overall cache maintenance. In this work, all the cluster nodes within a cluster cooperate for caching and all the cluster heads in the entire network collaborate for efficient cache maintenance. This decreases message exchange overhead. In addition, it also increases the rate at which data is retrieved and thereby improves the performance of the network. It also intends to decrease heavy traffic near the data server.

To provide for cache sharing it is quite mandatory to identify the nodes that might be suitable to cache data. An Enhanced Cache Sharing through Cooperative Data Cache (ECSCDC) approach is proposed for MANETs mainly to identify the nodes that can be destined to cache data instead of all the intermediate nodes. During the transmission of desired data from the data centre back to the request originator, the data packets will be cached by specific intermediate caching nodes, by using the asymmetric cooperative caching approach. The caching nodes that can retain the data in its cache, for future data retrieval are selected based on scaled power community index. The proposed technique reduces the communication overhead, access latency and average traffic ratio near the data centre while increasing the cache hit ratio.

Consistency is also a matter of concern. Since now data can be retrieved from caches of mobile nodes, it is highly desirable to maintain the exact replica of the data, as that present in the original source. In order to ensure cooperative cache consistency by maintaining identical information at
any particular time in both the server and the cache nodes that have previously cached the data, a Push Pull Cache Consistency (2P2C) scheme is employed. Here, the server maintains a registration table to maintain the details of all registered clients and in turn updates those registered, by pushing the updated data, as and when the server gets refreshed. Only the registered clients are updated frequently, thereby, avoiding unregistered clients from receiving the recently updated data. This cache consistency mechanism ensures reduced bandwidth utilization, less query latency, besides decreasing the network traffic and the excessive load at the data server.

1.6 ORGANIZATION OF THE THESIS

The organization of the thesis is as follows:

Chapter two discusses the existing works and the issues related to the work presented in this thesis.

Chapter three briefly presents three different cache management algorithms along with their item admission and item update policy, replacement policy and item discovery policies respectively. First and foremost is Time Index BAsed Caching (TIBAC) algorithm. Here every data is accompanied with a time specification. Moreover a Heap Oriented Time Based (HOT-B) algorithm which involves a minimum heap structure unlike the traditional linked list structure for inserting data into the cache has been elaborated in this chapter. It also gives an insight into cluster based time index algorithm called Collaborative Clustering for Cooperative Caching (4C) in which only cluster heads are entitled to hold the cache information unlike a normal time index algorithm where all nodes are expected to cache all information related to caching events. This chapter also provides the performance evaluation of these algorithms.
Chapter four discusses an Enhanced Cache Sharing Cooperative Data Cache (ECSCDC) scheme which makes use of Cache Data technique for retaining information and the Asymmetric Cooperative Caching approach for selecting the appropriate node that can serve as cache nodes. It also considers the case of retrieving data item both locally and remotely. This chapter provides the performance evaluation of the proposed asymmetric approach and compares the performance of asymmetric approach with existing symmetric approach.

Chapter five focuses on providing a suitable cache consistency scheme for cooperative caching. Providing cache consistency in a mobile environment is highly desirable and challenging, as the data retrieved from a cache node should be the exact replica or identical to the value prevailing in the server at the time of retrieval. Here a Push Pull Cache Consistency (2P2C) scheme has been presented in this chapter. In this scheme either a server initiated consistency policy or a client initiated policy can be triggered based on demand.

Chapter six concludes by showing how the research goals have been met. It also provides deep insight into future research road-map.