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Effective cooperative caching techniques for information retrieval in mobile ADHOC networks

Anupriya,
Asst. Professor, SOC (School of computing),
GEHU-Dehradun Campus
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Abstract: In a perfect setting, caching plays a crucial function in increasing access to data. To improve data accessibility in the network, a system of cooperative caching should be implemented in a mobile setting. To solve the problem of limited data availability in mobile ad hoc networks, we suggest a new cooperative caching technique. Cache management strategies, cache sharing schemes, and cache consistency techniques are introduced in this thesis work to improve data availability and retrieval in a mobile ad hoc setting. The problem of cache management is of crucial importance in cooperative caching. Despite the abundance of offered solutions, each one has its own set of limitations. We present the Time Index BAsed Caching (TIBAC) method, the Heap Oriented Time Based (HOT-B) protocol, and the Collaborative Clustering for Cooperative Caching (4C) scheme, all of which are methods of cache management with varying goals.

Keywords: Cooperative Caching, mobile ad hoc networks, Time Index BAsed Caching (TIBAC), Heap Oriented Time Based (HOT-B)

Introduction

Because of the exponential development of computers and communication technologies, computer networking has undergone radical transformations. Organizational requirements determine the necessary network's characteristics, including its kind, size, and complexity. In particular, the sort of network relies on the organization's geographical spread and the specifics of the transactions taking place inside it. If your company isn't spread out too much geographically, a small number of computers and other tech gadgets may get the job done over a shared media network. Large geographic dispersion necessitates the deployment of complicated switching networks with many nodes. The two most common types of switched networks in use today are local area networks (LANs) and wide area networks (WANs), both of which make use of shared media. Computer networks, as defined by Peterson and Davie (2012), are groups of two or more computers that are connected such that they may share data and have conversations with one another. There are two main types of networks: wired and wireless. LANs, MANs, and WANs are the three main types of wired telecommunications networks. The use of PANs, or personal area networks, is on the rise in the realm of wireless networks. The physical channel of communication in these networks is air, as opposed to wires in traditional networks (Stallings, 2005). Data transmission in wireless networks is wholly dependent on radio frequency channels. As a result, all nodes within a source node's direct communication range will eventually get all of the data being communicated by the source. There is no need for a direct wire connection between nodes in these networks. Wireless technology enables widespread use in areas like voice and video communication through radio and television networks. Two-way, simultaneous voice communication is made possible by cellular networks, which were a key contribution to wireless technology (Murthy & Manoj, 2004). When it comes to phone calls, wireless networks perform well. Nevertheless, they have a ways to go in terms of data exchange, both in terms of dependability and security. All parties involved are enthusiastic about the widespread adoption of wireless networks because of the rapid rate at which wireless technology is progressing. Integration of wired and wireless networks is essential for communication for the foreseeable future. Figure 1 depicts a common setup for a wireless network.

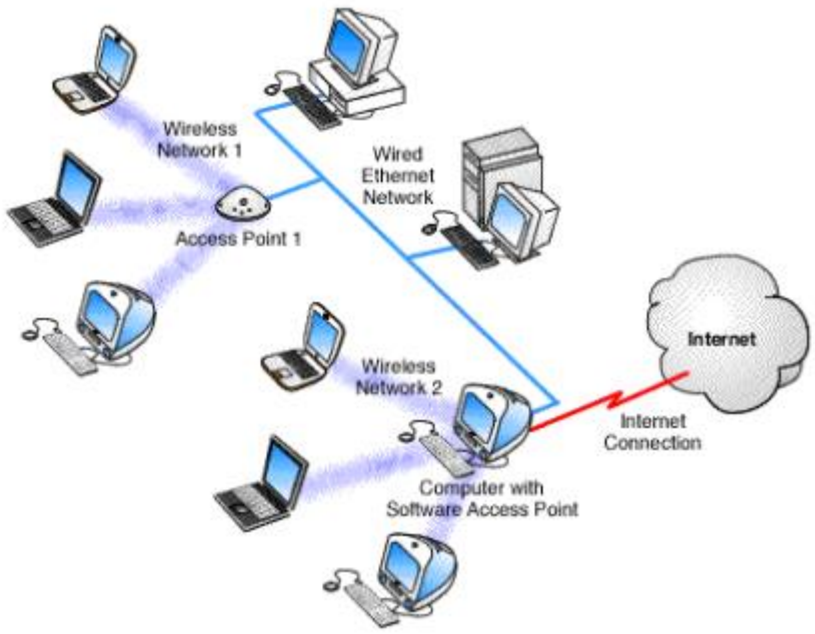

Figure 1. Wireless networks (http://mydataone.net/articles/wireless.html)

Wired networks are, without a question, infrastructure networks. However, there are two types of wireless networks: those that rely on existing infrastructure and those that don't. Cellular networks and wireless sensor networks are two common types of this technology. A key goal of the Time Index BAsed Caching (TIBAC) method is to provide up-to-date information on demand. The information to be cached is accompanied by a timestamp corresponding to the refresh rate at which the data server updates its information. In order to make data accessible even with constrained means, this work implements three policies: Item Discovery, Item Admission, and Item Replacement. To maintain accuracy and reliability of data, if the mobile client gets the same data item with an updated time, the prior content along with time is changed. These mobile nodes guarantee data accessibility. By implementing an automatic replacement policy and a forced replacement policy in case the former fails to offer enough capacity to accept new entities, the amount of available space in a node may be increased. A suitable data structure for the time index based caching strategy is proposed by the Heap Oriented Time Based (HOT-B) protocol. Data Discovery, Data Admission, Data Update, and Data Replacement are all a part of it. We suggest a Min Heap data structure for storing time-critical data in this protocol, which can work in tandem with cache memory. Insertion and deletion are two fundamental operations of every data structure. When new data is added to the heap, its position is determined by its time index, and when data is removed from the heap, its place is determined by the percolation of the existing data along the heap. Instead of doing a laborious search over the whole of the contents of a linked list-like structure, just the data at the root has to be deleted during cache replacement. As a result, less time is spent looking for data in the cache. Mobile ad hoc networks heavily use clustering to organize network nodes into groups for more efficient communication. To enhance overall cache maintenance, the Collaborative Clustering technique for Cooperative Caching (4C) employs clustering and time index based caching in a mobile ad hoc network. For caching to function well in this work, all of the nodes inside a cluster coordinate via the cluster head, and all of the cluster heads in the network coordinate with one another. The overhead of sending and receiving messages is greatly reduced by this. Furthermore, it enhances the network's effectiveness in information retrieval by increasing the pace at which data is retrieved. Its other goal is to reduce congestion around the data center. It is crucial to identify the potential caching nodes in order to facilitate cache sharing. In this study, we suggest a method for MANETs called Enhanced Cache Sharing through Cooperative Data Cache (ECSCDC). By eliminating unnecessary nodes from the network's path, ECSCDC pinpoints the cache-bound nodes. Using an asymmetric cooperative caching strategy, only certain intermediate caching nodes will store data packets en route from the data center to the request originator. Based on the scaled power community index, we choose the caching nodes that will keep the data in its cache for later retrieval. Since consistency is vital to the data retrieval process, the suggested method decreases communication overhead, access latency, and average traffic ratio near the data center while enhancing the cache hit ratio. Due to the convenience of data retrieval from mobile node caches, it is preferable that an identical copy of the original data be kept. A Push-Pull Cache Consistency (2P2C) technique is used to guarantee data integrity across all of the nodes. With this setup, the server and the cache nodes that have previously stored the data both have up-to-date copies of the data at all times. Here, the server keeps a registration table to store information about all registered clients and refreshes the information for those clients by pushing the new data to them whenever the server is updated. In this way, we can ensure that only our registered users are getting the most up-to-date information without overwhelming our servers. This approach for maintaining cache integrity lessens the time it takes to run queries, cuts down on the amount of data server traffic, and improves response times..

Mobile Ad Hoc Networks.

Customers have been encouraged to adopt a mobile environment in response to the proliferation of cutting-edge technologies that provide constant connection and, therefore, services for wireless mobile devices, regardless of their location. The reliance on fixed computer systems for communication has been greatly reduced in such a setting. These days, it's common for people to want to stay connected even while they're on the go. To this end, a heterogeneous network known as a mobile ad hoc network has been

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created by adding mobility to traditional ad hoc networks. Bluetooth, Wi-Fi, and other wireless technologies are tapped into via these networks. A basic mobile ad hoc network is shown in Figure 2.

Figure 2. Mobile ad hoc networks

(http://www.acorn.net.au/telecoms/adhocnetworks/adhocnetworks.html)

Cooperative Caching

Routing, security, energy management, etc., are focal points of several ongoing studies. However, increasing network-wide access to information is crucial in order to meet the demands of today's consumers. Information accessibility and retrieval are at the forefront of mobile consumers' minds and expectations. Users want to be able to access or receive relevant info regardless of their physical location. When mobile ad hoc networks are employed in the business world, the ability to access and retrieve data is of the utmost significance. Data availability is lower in ad hoc networks than in conventional wired networks because of the mobility of nodes, the scarcity of storage capacity, and the frequent partitioning of the network. Caching is a handy workaround for this issue. Cache is a component that caches information for quick retrieval when it is requested again. Some of the information kept in a cache may be copies of original data saved elsewhere, while other information may be previously calculated values. If the information is already stored in the cache, fulfilling the request takes just a few milliseconds rather than the longer time it would take to get the data from its original location. Getting the needed information from the cache is called a Cache Hit, whereas failing to do so is called a Cache Miss. A cache miss causes data to be recalculated or retrieved from its original storage location, both of which are time-consuming processes. As a result, system performance improves as more requests are satisfied by data stored in the cache. Cache is an efficient and lightweight memory Almost all real-time data has a shelf life, and may become obsolete once that time has passed. Stale time is what we call this period now. In this study, we develop a cooperative caching strategy that makes use of coordination and information sharing across mobile nodes. Caching commonly used information in ad hoc networks may increase network speed and reliability. There are a plethora of caching strategies for wired networks. However, mobile ad hoc networks lack the flexibility and resources necessary to implement caching strategies like this. Mobile nodes in a MANET often have similar goals in various use cases. As a rule, nodes store information for their own future use in a cache. However, with cache sharing, mobile nodes in close proximity to one another might benefit from the stored data of their neighbors. The advantages of cache sharing are substantial, including a decrease in the amount of data requests sent to the data center over a long distance connection. The critical part of this method is for a node to know whether or not another node nearby has cached the information it needs, and if so, where to find that node. To meet this need, it is best to have a mobile node cache information about a nearby node while still transmitting the desired data. Designing efficient caching techniques for MANETs is difficult because of their mobility, limited energy, bandwidth, and computational resources. In addition, data servers have progressed throughout time. A data center, often known as a server, is a specialized computer designed to store and process information for a specific dynamic real-time application. Such servers are widely used by both public and commercial institutions to ensure that information is always available to customers. Let's imagine a situation in which people on the go need to access information stored in a central server facility. It's possible that this may cause an excessive quantity of network traffic. This is presumably undesirable since data center traffic places a significant demand on a network's limited resources. If a mobile host is located far from the data center, it may have significant access latency, and there is also a high possibility of packet loss while accessing data over a long distance. In addition, there will be a lot of people and vehicles in the area close to the data center, which might slow things down. All of these issues worsen as the size of the network grows, making the system difficult to scale. These results inspire us to look into other data caching strategies for MANETs. When data is cached on mobile nodes, requests for that data may be fulfilled by the node closest to the user, rather than by the data center. This setup may be able to help achieve the study's primary goal.

Literature Review

Nisha Wadhawan et.al. (2017) With no fixed infrastructure, moving cars establish ad hoc networks known as IVANETs (Internet-Based Vehicular Ad hoc Networks), which are characterized by frequent disconnections and topological changes when vehicles drive at high speeds and take unexpected detours. when a consequence, they experience heavy data traffic and prolonged query latency when items in their cache grow stale and must be refreshed by the server. Data availability and data consistency become very important under these conditions. Consistent and current data availability is a need in VANETs. Because cars may share their cached material, the number of uplink connections to the server can be decreased, and query latency time is lowered. As an enhancement to the current 2Tier CoCS (2tier Cooperative Caching Scheme), we propose a new cooperative caching scheme in this work.

Shivangi Gupta et.al. (2017) Wireless sensor networks (WSNs) are defined by their low power requirements, robustness in the face of failure, decentralized design, and resilience in the face of extreme environments. The most important criteria for a WSN with such qualities are effective storage management and energy utilization. Cooperative caching is a method that allows several nodes to share data in order to meet both of these criteria. Different cooperative caching strategies for wireless sensor networks (WSNs) and mobile ad hoc networks (MANETs) are described and sorted into clear categories in this study. Caching data is useful, but only if it is consistent in the cache. The different cache consistency models are also briefly discussed in this study..

Komal M. Sharma et.al.,(2013) Mobile ad hoc networks are short-lived networks made up of mobile nodes like laptops, PDAs, Tablets, cell phones, etc. These are the networks that don't need any permanent installation. Issues with data item accessibility are common in Mobile Ad hoc Networks. Therefore, we may use data caching to increase the availability of data items in the network. Data caching is also known as Cache Management. An intelligent caching approach called Dynamic Group Caching is employed in this research to facilitate the clustering of mobile hosts inside a single hop. When a group is created, the Group Master and the Head of the group are responsible for its operation. In terms of efficiency, MANETs may benefit from this Cache Management.

Cooperative Caching Scenarios

Scenario1: One mobile node (the Commando) may be linked to the Internet via satellite, acting as a proxy for additional mobile terminals (the Soldiers) in a military context. In the event of a battle, all of the mobile terminals may exchange any gathered data through ad hoc networks. Since this information is relevant to the present state of a military operation, it must be obtained or stored quickly. Therefore, the cached information may not be very relevant for very long, since the situation on the battlefield may have altered by then.

Scenario 2: The number of people using the Internet to get sports-related data from the sports server spikes during major international athletic events like the Olympics. Users with similar interests who happen to be in close proximity to an ad hoc domain may then exchange the obtained data with one another. However, the data accessible is only reliable for a limited time; beyond that, the medal count may have altered.

Scenario 3: Located in a city's sprawling park, this data center serves as a repository for details on the city's many arts, sports, and commerce events. Due to coverage limitations, a client cannot directly connect to the data center. As a result, this slows down access to data in the data center. The client in a MANET forms an ad hoc network with other mobile devices and communicates with them to get access to the desired data.

Performance Analysis

The suggested 2P2C caching system is tested in Network Simulator Version 2 (NS2). NS2 is a popular tool for simulating multilayer networks in both wired and wireless settings. Table 1 summarizes our simulation settings and parameters. Here, nodes that move are simulated for 500 seconds while moving in a 1500 m x 1000 m region. The simulation environment uses a random way point model. The metrics of traffic, delay, update rate, and cache size are used for the study. When comparing the 2P2C scheme against unregistered systems, these indicators are quite helpful. In conclusion, once the registration procedure is put into place, the system's behavior can be accurately assessed..

Table 1 Simulation parameters

Parameter	Values
Simulation time	600 s
Network area	1500*1000 m^2
Transmission range	400m
Number of nodes	0 - 300
Speed	0 m/s - 30 m/s
Data items in the server	2000
Size of data item	10 KB
Cache size	100 KB – 600 KB
Updates/ minute	100 updates/min
Request rate	5 requests/min

2P2C SCHEME

Push and pull based cache consistency techniques are the two most common types of caching used in MANET. A pull-based cache consistency strategy has clients ask the server for the data they need, whereas a push-based scheme has the server send the data to the clients first. In a push-based strategy, the server insists that all cache clients, even if they don't want to, get the most recent data. It's quite improbable that every single customer always expects the most up-to-date information. Given that the requesting node probably isn't all that keen about getting constant data updates, this might waste a lot of bandwidth. As a solution, we use a registration-based hybrid cache consistency method as part of a 2P2C mechanism designed to ensure data integrity between MANET caching nodes and the server. In Figure 3 we see a schematic representation of the 2P2C system.

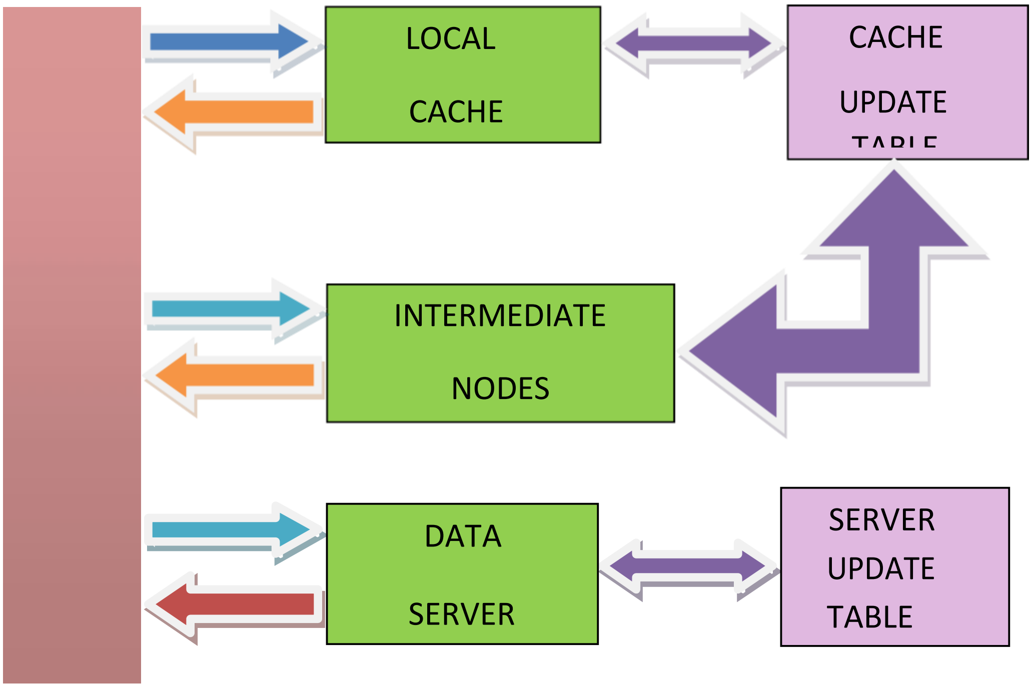

Figure 3 .2P2C scheme

Here, we examine a system using a Non Registered Scheme (NRS), called Smart Server Update Mechanism (SSUM), and compare it to our own 2P2C scheme, which requires registration.As the number of queries for a given piece of information rises, the server and any cache nodes it uses will get more bogged down. Figure 4 makes this very clear. However, query latency is minimized when compared to SSUM since both the server node and the cache node work together throughout the updating process..

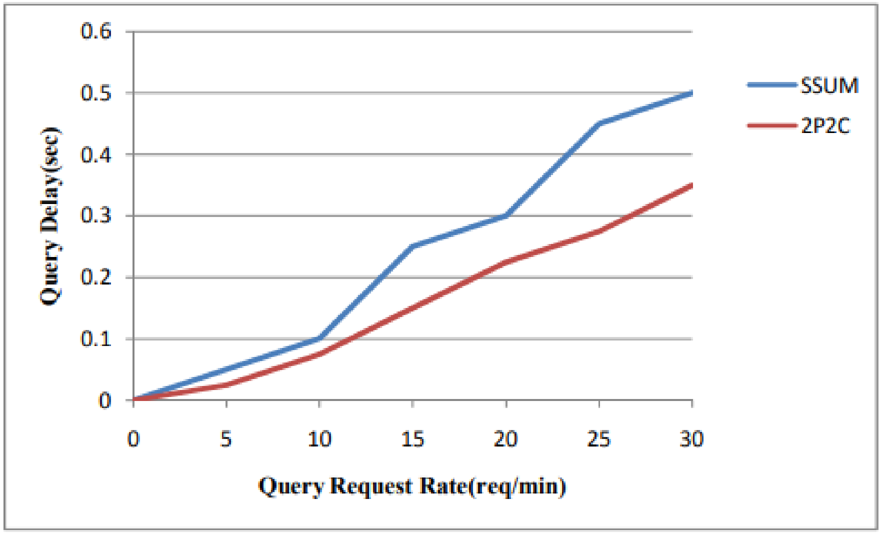

Figure 4. Query delay Vs query request rate

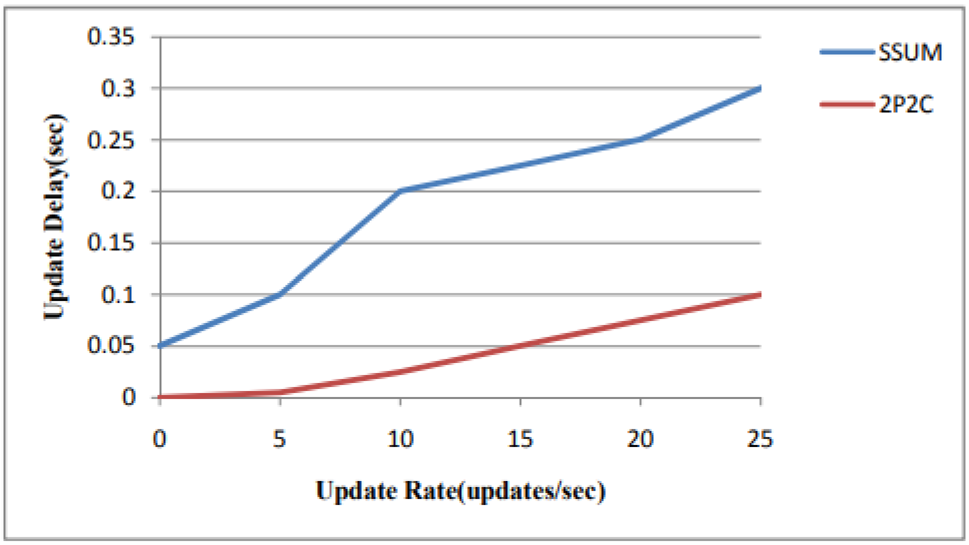

Figure 5.Update delay Vs update rate

Compared to systems using unregistered techniques, the update latency in our 2P2C scheme is much lower, as seen in Figure 5. This is so because the server and the cache node both participate in the registration process and efficiently provide their services to their respective clients. Unlike SSUM, which relies only on the server, both of these systems actively participate in pushing the needed data items to the appropriate registered clients.

Conclusion: The lack of uniformity is also problematic. Now that information may be accessed from the local storage of moving nodes, it is crucial that an identical copy of the original be kept. A Push Pull Cache Consistency (2P2C) strategy is used to guarantee cache consistency cooperatively by keeping the same data in both the server and the cache nodes that have previously cached the data at any given moment. Here, the server keeps a registration table to store information about all registered clients and refreshes the information for those clients by pushing the new data to them whenever the server is updated. In order to prevent unregistered users from obtaining outdated information, we limit updates to registered users only. This approach for maintaining cache integrity lessens the time it takes to run queries, cuts down on the amount of data server traffic, and improves response times.

References

1. N. Wadhawan and M. Dave, "Improved 2Tier cooperative caching scheme for internet based vehicular adhoc networks (IVANETs)," *2017 International Conference on Computing, Communication and Automation (ICCCA)*, Greater Noida, India, 2017, pp. 653-657, doi: 10.1109/CCAA.2017.8229882.
2. S. Gupta and T. P. Sharma, "Cooperative data caching in MANETs and WSNs: A survey," *2017 International Conference on Intelligent Computing, Instrumentation and Control Technologies (ICICICT)*, Kerala, India, 2017, pp. 1473-1479, doi: 10.1109/ICICICT1.2017.8342787.
3. B. Nancharaiah and B. Chandra Mohan, "Modified Ant Colony Optimization to enhance MANET routing in Adhoc on demand Distance Vector," *2014 2nd International Conference on Business and Information Management (ICBIM)*, Durgapur, India, 2014, pp. 81-85, doi: 10.1109/ICBIM.2014.6970938.
4. K. M. Sharma and A. Raut, "Improving the performance of Mobile Adhoc networks using dynamic group data caching scheme," *2013 Students Conference on Engineering and Systems (SCES)*, Allahabad, India, 2013, pp. 1-4, doi: 10.1109/SCES.2013.6547520.
5. S. Soleimani, X. Tao and Y. Li, "Cooperative Group Caching Strategy in Content-Centric Wireless Ad Hoc Networks," *2018 IEEE/CIC International Conference on Communications in China (ICCC)*, Beijing, China, 2018, pp. 793-797, doi: 10.1109/ICCChina.2018.8641166.
6. W. Huang, T. Song, Y. Yang and Y. Zhang, "Cluster-based Selective Cooperative Caching Strategy in Vehicular Named Data Networking," *2018 1st IEEE International Conference on Hot Information-Centric Networking (HotICN)*, Shenzhen, China, 2018, pp. 7-12, doi: 10.1109/HOTICN.2018.8605950.
7. C. -T. Yen, F. -T. Chien and M. -K. Chang, "Cooperative Online Caching in Small Cell Networks with Limited Cache Size and Unknown Content Popularity," *2018 3rd International Conference on Computer and Communication Systems (ICCCS)*, Nagoya, Japan, 2018, pp. 173-177, doi: 10.1109/CCOMS.2018.8463254.
8. X. Huang, Z. Zhao and H. Zhang, "Latency Analysis of Cooperative Caching with Multicast for 5G Wireless Networks," *2016 IEEE/ACM 9th International Conference on Utility and Cloud Computing (UCC)*, Shanghai, China, 2016, pp. 316-320.
9. Q. Li, C. Zhang, X. Ge, T. Chen and T. Zhang, "A cost-oriented cooperative caching for software-defined radio access networks," *2016 IEEE 27th Annual International Symposium on Personal, Indoor, and Mobile Radio Communications (PIMRC)*, Valencia, Spain, 2016, pp. 1-6, doi: 10.1109/PIMRC.2016.7794942.
10. L. Xi, A. Ying, W. Jian-Xin and L. Yao, "Content Migration Based Cooperative Caching for Content-centric Networks," *2015 8th International Conference on Intelligent Computation Technology and Automation (ICICTA)*, Nanchang, China, 2015, pp. 328-332, doi: 10.1109/ICICTA.2015.89.

ISSN- 2394-5125 VOL 07, ISSUE 09, 2020

11. X. Zhou, Z. Lu, Y. Gao and Z. Yu, "An Effective Cooperative Caching Scheme for Mobile P2P Networks," *2014 International Conference on Computational Intelligence and Communication Networks*, Bhopal, India, 2014, pp. 408-411, doi: 10.1109/CICN.2014.96.
12. P. T. Joy and K. P. Jacob, "A location aided cooperative caching protocol for mobile ad hoc networks," *2013 6th IEEE/International Conference on Advanced Infocomm Technology (ICAIT)*, Hsinchu, Taiwan, 2013, pp. 173-178, doi: 10.1109/ICAIT.2013.6621556.
13. W. Wu and J. Cao, "Efficient Cache Discovery for Cooperative Caching in Wireless Ad Hoc Networks," *2012 IEEE 18th International Conference on Parallel and Distributed Systems*, Singapore, 2012, pp. 323-330, doi: 10.1109/ICPADS.2012.52.
14. N. Chauhan, L. K. Awasthi and N. Chand, "Global cooperative caching for Wireless Sensor Networks," *2011 World Congress on Information and Communication Technologies*, Mumbai, India, 2011, pp. 235-239, doi: 10.1109/WICT.2011.6141250.
15. N. Chauhan, L. K. Awasthi and N. Chand, "Cooperative data caching with prefetching in mobile ad-hoc networks," *2009 First Asian Himalayas International Conference on Internet*, Kathmundu, Nepal, 2009, pp. 1-4, doi: 10.1109/AHICI.2009.5340352