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A Comparative Study of Cluster-based Data Replication Techniques for MANETs

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Data replication is one of the popular services in mobile ad-hoc networks (MANETs),and increase data availability by creating local or nearly located copies of frequently used items, reduce communication overhead, achieve fault-tolerance and load balancing. In MANETs, frequent network partitioning and the failure of mobile nodes due to exhaustion of their battery power and switch off mobiles can considerably decrease data availability.In this paper performance analysis of existing Cluster-based MANETs techniques based upon of available techniques into various classes, with respect to various issues they address (such as Client/server classification, Data availability and data consistency, Partition detection, etc.) is carried out.

Keywords: Mobile Ad-hoc Network, Clustering, Cluster Head, Data Replication, Data Consistency.

1. Introduction

A Mobile Ad Hoc Networks (MANETs) is a self-organizing, infrastructure less, dynamic wireless network of autonomous mobile devices (nodes) [1, 3]. The network is ad-hoc, because there is no fixed and known network structure that every other node forwards data. These nodes are capable of both single and multi-hop communication. Some envisioned MANETs, such as mobile military networks or future commercial networks may be relatively large (e.g. hundreds or possibly thousands of nodes per autonomous system). In mobile ad hoc networks, mobile nodes move freely, disconnections occur frequently, and this divide the network into groups/regions/zones and then create a virtual backbone between delegate nodes in each group.

In mobile ad hoc network this operation is called clustering, giving the network a hierarchical organization. A cluster is a connected graph including a cluster head responsible of the management of the cluster, and some ordinary nodes. Each node belongs to only one cluster. Clustering has several advantages. First clustering allows the reuse of resource which can improve the system capacity, in the way that information is stored once on the cluster head. Secondly clustering may optimally manage the network topology, by dividing this task among specified nodes which can be very useful for routing since any node is identified by its identity and the identity of the cluster-head of the cluster to which it belongs, simplifying by this way the forwarding of messages.

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2. Data Replication

Ad hoc data replication problem (ADRP) was first introduced by Hara [1], which was further extended to incorporate various network connectivity related issues. Replication allows better data sharing. It is a key approach for achieving high availability. It is suitable to improve the response time of the access requests, to distribute the load of processing of these requests on several servers and to avoid the overload of the routes of communication to a unique server.

2.1. Research Issues Concerning Data Replication

(a) Server Mobility: Servers in MANET are mobile nodes and the speed at which the network topology changes are higher than that in conventional mobile databases.

(b) Client Mobility: Clients send their transactions to the nearest servers to get a faster response. The decision to replicate a data item in a particular server may be based on the access frequency of that data item on that server.

(c) Power Availability: Client nodes also run using their battery power. They are limited by the amount of energy they can use before their batteries need to be recharged [5].

(d) Response Time: Data is accessed from the nearby replicated nodes than from the owner to improve the response time.

(e) Network Partitioning: Due to frequent disconnection of mobile hosts, network partitioning occurs more often in MANET databases than in traditional databases.

3. Cluster based Data Replication Techniques

3.1. The Clustering-Based Data Replication Algorithm (CDRA)

Zheng et al. [3] is proposed that the network is clustered into several clusters and network partitions often present between clusters, especially clusters without overlap. The basic idea of CDRA (Clustering-based Data Replication Algorithm) is that the requested data object in the clusters is replicated to prevent deterioration of data accessibility at the point of network partitioning. The CDRA algorithm composed of the replica allocation and replica consistency is described as follows:

Replica Allocation

Every cluster head maintains states of all other cluster heads in the networks. When a node requests to access a data object, the node broadcasts the access request in the whole network that the node belongs to. If there are some replicas of the data object in cluster the closest replica node serves the access request. The cluster head of particular network sends the data to request nodes. A node in particular network, which has request to the data object, is chosen to replicate the data object. Nodes in multiple clusters have the priority to be chosen as replica nodes.

Replica Consistency: The CDRA (cluster based data replication algorithm) can be combined with some replica management protocols that provide sometimes weak or strong consistency. The write requests for the data object are propagated to all cluster heads whose cluster has the replica of the data object, and then are forwarded to the replica nodes in the cluster. If the write request is granted, data update message is propagated to all the replica nodes in the same way.

3.2. Distributed Hash Table Replication (DHTR)

Hao et al. [2] proposed that DHTR employs a cluster-based hierarchical structure, and uses a distributed hash table technique and a distributed replica information directory to improve the efficiency of update propagation. Distributed hash table technology is normally applied in peer-to-peer networking environments to help the user locate the resources quickly. DHTR system is mainly composed of two elements: replica managers and cluster heads. A replica manager periodically communicates with its cluster head to register and update replica information. The cluster head is organizing and maintaining a distributed replica directory server and forming a virtual backbone to transmit control messages. In the DHTR service model, the authors assume that each node has a unique address, called node ID, and is reachable via the underlying ad-hoc routing protocols. They also assume that each replica has an update count, which increases monotonically when a new update is committed on this replica. The update count plays an important role in recording the update status of each replica and helping to maintain the consistency of the replicas.. After receiving all the broadcast information, each mobile node puts the node IDs into a sequential list sorted by their capacity. The node at the top of the list becomes the initial cluster heads and their specific location in the sequential list becomes their cluster ID. For a query request, a client sends the request to its cluster head.

3.3. K-Hop Clustering Algorithm in Adhoc Networks

Derhab et al.[4] propose a localized algorithm that creates a set of clusters called; stable K-hop direct acyclic graphs (SKDAG). SKDAG is a K-hop DAG, in which each node has a strong path toward the sink node. Each cluster must ensure the following property:

(1) The cluster is a direct acyclic graph rooted at the cluster head.

(2) Each node of the cluster is K hops away from the cluster head.

(3) The path between a node and its cluster head consists only of long-lived nodes and links, i.e. nodes and links whose residual life time is greater than a given threshold.

3.4. Exploring Group Mobility for Replica Data Allocation in a Mobile Environment (DRAM)

Huang et. al [5] proposed in DRAM, each mobile node first exchanges its motion behavior with some neighbors. Then, a decentralized clustering algorithm is used to cluster mobile nodes with similar motion behavior into mobility groups. Hence, clusters which are likely to connect with one another later merged into an allocation unit to save the aggregate storage cost. Finally, data items are replicated according to the resulting allocation units. DRAM maintains the mobility groups in an adaptive manner which keeps the number of information broadcasts as small as possible and hence reduces the generated network traffic. It consists of two phases:

(1) The allocation unit construction phase- In the allocation unit construction phase, each node exchanges its motion information with nodes located within a determined hop count. Then, a clustering algorithm groups mobile nodes with similar motion behavior into clusters.

(2) The replica allocation phase.-In this phase, the replicas of all data items are allocated in accordance with the access frequencies of the data items and the derived allocation units.

4. CONCLUSION

The study presented in paper helps us to understand Cluster-based data replication techniques for MANETs and their performance based upon categorization of existing techniques into various classes, with respect to various issues they address such as Architecture Client/server classification, Data availability and data consistency, cluster formation detection, Read/write assumptions, Replication scheme, Routing protocol dependency, Replication level/cost and positioning system.

Table 1
Comparison of Various Cluster based Techniques

	CDRA[3]	DHTR[2]	K-HOP DAG [4	DRAM[5]
Architecture	Decentralized	Centralized	Decentralized	Decentralized
Cluster formation	High	High	Low	High
Data consistency	Medium low	Medium low	Medium	Medium low
Energy aware	No	Yes	Yes	No
Localized	No	No	Yes	No
Maintenance cost	High	High	Low	High
Read only	No	No	No	Yes
Replication cost	O (n)	Not known	O (n/f(k))	O (n)
Query cost	O (n + √n)	O (n + √n)	O (K)	O (√n)
Update cost	O (n + √n)	O (n + √n)	O (n + k)	Not known

REFERENCES

[1] A.Moon, H. Cho,: "Energy Efficient Replication Extended Database State Machine in Ad Hoc Network", International Conference on Applied Computing, pp. 224–228, (2004).

[2] Hao Yu and Hossam Hassanein Patrick Martin. "Cluster-based Replication for Large-scale Mobile Ad-hoc Networks". In International Conference on Wireless Networks, Communications and Mobile Computing, Pages 552–557, June 2005.

[3] Jing Zheng, Jinshu Su, and Xicheng Lu. "A Clustering-based Data Replication Algorithm in Mobile Ad hoc Networks for Improving Data Availability". In Proc. 2nd International Symposium on Parallel and Distributed Processing and Applications (ISPA 2004), Pages 399–409, 2004.

[4] Abdelouahid Derhab and Nadjib Badache. "Localized Hybrid Data Delivery Scheme using k-hop Clustering Algorithm in Ad hoc Networks", In Proc. 3rd IEEE International Conference on Mobile Adhoc and Sensor Systems Conference, (MASS 2006), October 2006.

[5] Jiun-Long Huang, Ming-Syan Chen, and Wen-Chih Peng. "Exploring Group Mobility for Replica Data Allocation in a Mobile Environment". In Proc. Twelfth International Conference on Information and Knowledge Management (CIKM '03), Pages 161–168, 2003.