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Overview of Data Replication Strategies in Various Mobile Environment

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Abstract: *With the tremendous growth of the portable computing devices and wireless communication, the mobile computing has become extremely popular. The wireless enabled portable computing devices with massive storage capacity and high-end processing capabilities have started to make the extensive use of mobile databases already. The rising popularity in these computing paradigms demands that the mobile computing be reliable enough to ensure the continuous data availability and integrity. However mobility comes at the cost of bandwidth, limited power, security and interference. In modern mobile computing systems data replication has been adopted as an efficient means to ensure the data availability and integrity as well as an effective means to achieve the fault tolerance. Data replication not only ensure the availability of the data but also reduce the communication cost, increase data sharing and increase the safety of the critical data. Furthermore, it also determine when and where (location) to place the replica of data, controlling the number of data replicas over a network for efficient utilization of the network resources. In this study we survey the research work in data replication for mobile computing. We reviewed some of the existing data replication techniques proposed by the research community for mobile computing environment for efficient management of data replicas*

Keywords - *About five key words in alphabetical order, separated by comma*

I. INTRODUCTION

The field of wireless and mobile computing is a conjunction of the personal computing, distributed computing, wireless networks and Internet applications. This integration is supported by a large number of devices and wireless networks, which is based on a continuously and increasing interaction between communication and computing. Mobile computing system is a type of distributed system (Biswas and Neogy, 2010). The success of mobile data communication lies in the expectation to provide different services to users anytime and anywhere. In simple terms mobile computing can be defined as the computing on the go. Mobile computing is a new software paradigm that is of tremendous interest in the Information Technology research community. Today, mobile computing technology is used to link portable computing equipment to corporate distributed computing and other sources of information. Many researchers and scientists from both academia and industry are undertaking efforts to explore new technology for mobile computing and wireless communication, in a heterogeneous wireless and wired network environment, with mobile computing applications (Boukerche, 2006). We begin by considering the requirement for mobility and its cost. Mobility and portability are important aspects in mobile computing. With its popularity, it is very important that these systems be dependable and fail safe. To address the question of data availability various data replication protocols and techniques have been proposed and developed in the mobile computing systems. Data replication increases data availability and reduces data access latency may be at the cost of data storage. The main goal of mobile computing was to support the anytime, any-form and anywhere computing with the tremendous growth in the mobile technologies. To provide the data to the users with portable computers and mobile phones, the many a more techniques have been proposed for the improvement of QoS. All these requirements made mobile data management, transaction processing and query processing and data dissemination hot topics for research. Pitoura and Chrysanthis (2007) listed three challenges for the research in mobile computing:

Mobility: Hampers the capability of processing at the network layer. The nodes being highly moveable pose greater challenge and a number of complexities.

Limited resources: Limited battery, limited processing capabilities and memory of mobile devices also contributes toward the challenges for mobile computing to be a dependable computing environment.

Intermittent connectivity: The absence of a permanent communication link caused frequent disconnection due to signal strength.

The networking infrastructure in a wireless computing environment can be categorized into two main types i.e., single-hop and multi-hop. In the former infrastructure each of the mobile devices are connected with a stationary host, which corresponds to its point of attachment in the network. The stationary host (MSS) is

responsible for all the routing and processing in the network. In the later type an ad-hoc wireless network is formed in which different host participate in routing messages among each other. In the former type a data dissemination tree is formed by the stationary devices (MSSs) while in the later the same is performed by corresponding wireless hosts. The hosts in the tree may store the data and take part in processing. Therefore caching or replicating data at the mobile host or at the stationary nodes of the dissemination tree are important for improving system performance and availability (Pitoura and Chrysanthis, 2007). According to Walke (2002), setting up three neighbouring cells with each of them serving 120° sector (120°×3 = 360°) could help reduce the number of base stations and hence reduced the overall cost.The regular algorithms designed to manage the data are not suitable for the mobile environments because the number of clients, bandwidth, connection model, base structure, capacity of the clients and base station may differ from one region to another (Sorkhabi and Shahamfar, 2010). We have observed in the literature that the replication cost and the placement of data replicas have been widely studied for the performance issues (Korupolu et al., 1999; Li et al., 1999; Qiu et al., 2001; Venkataramani et al., 2001) by the research community. The data availability issues have also been explored for the traditional database (Barbara and Molina, 1986; Coan et al., 1986) concept as well. The active replication techniques have also been discussed at length where the clients communicate by multicast with all replicas (Coulouris et al., 2001; Wiesmann et al., 2000; Guerraoui and Schiper, 1997; Schneider, 1990). The aim of this study is to provide a comprehensive study that helps the designer to choose the most appropriate data replication strategies for mobile computing environment or design their own replication schemes based on the characteristics of previously done research work. This study surveys the existing data replication protocols that have been proposed in the Fig. 1: A typical mobile computing scenario literature and summarizes some of them. This detail study would further our understanding and knowledge base for the design of more suitable data replication scheme for our environment and would serve as the base line for our research work.

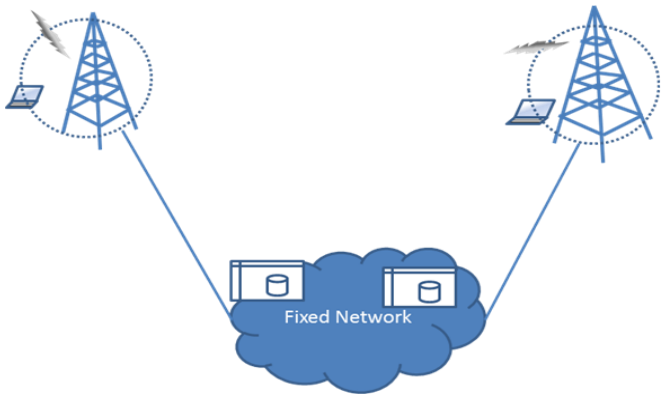

Fig 1: A typical mobile computing scenario

Data replication technology: Data Replication in the computing terms means the mutual sharing of information so as to ensure consistency between redundant resources, such as software or hardware components, to improve reliability, fault-tolerance, or accessibility. Data replication in databases has been a hot topic for research and development. The prime objective of the replication is to ensure the easy availability of data in case of any failure or disastrous event. The data replicated at different sites will also increase the speed of access and hence reduce the communication cost of the network. However, replication also brings some extra processing and communication into the system in the form of updates and synchronization of various copies of data at various sites. For large databases many reliable replication tools are available in the market. The data replication techniques (Wolfson et al., 1997; Ratner, 1998; Acharya and Zdonik, 1993; Huang et al., 1994) for mobile computing take into consideration an environment where Mobile Hosts (MH) access the data at sites in the fixed network like in our strategy and create the replica of data on mobile hosts. These strategies also assume the one-hop communication. If the data is replicated onto a mobile host in this type of communication and if the Mobile Host becomes unavailable for any reason then it can cause the data unavailability hence degrading the performance of overall system. The mobile host failure with replicated data can cause the consistency, availability and accessibility problem. The data replication is one very important aspect in the distributed systems. There exist a number of well cited models for data replication each with its own distinct feature and properties (Marton and Attila, 2009). Transactional replication model is used for replicating transactional data, for example a database or some other form of transactional data structure. The single-copy serialize model is employed in this case, which defines legal outcomes of a transaction on replicated data in accordance with the overall properties. Another important scheme is State machine replication model. This model assumes that replicated process is a deterministic finite automaton and that atomic broadcast of every event is possible. It is

based on a distributed computing problem called distributed consensus and has a great deal in common with the transactional replication model. This is sometimes mistakenly used as synonym of active replication. State machine replication is usually implemented by a replicated log consisting of multiple subsequent rounds of the Paxos algorithm. Virtual synchrony is another computational model which is used when a group of processes cooperate to replicate in-memory data or to coordinate actions. This is a group based scheme where different members join a group with current data scheme. The process then send multicast to the group members. The data transactions in mobile systems might have to be split into sets of operations due to disconnections and mobility properties and may share their current states and partial results with other Transactions. Therefore, the mobile computing transactions require computations and communications to be supported by stationary hosts. A mobile computations may be divided into a set of actions some of which execute on mobile host while other; on stationary host. When the MH moves from one cell to another, the state of transaction, states of accessed data objects and the location information also move, this process is known as the hand off procedure. The mobile transactions are little different in nature from the normal database system transaction due to the mobility of both the data and users and due to the frequent disconnections. Therefore in order to support mobile transactions, the transaction processing models should accommodate the limitations of mobile computing, such as unreliable communication (due to wireless link), limited battery life, low band-width communication and reduced storage capacity. Mobile computations should minimize the stoppages faced due to the frequent disconnections. Operations on shared data must ensure correctness of transactions executed on both MSS and MH. The blocking of transactions execution on either the MH or MSS must also be minimized to reduce communication cost. A Proper mechanism may also be required to support local autonomy to allow transactions to be processed and committed on the MH regardless of disconnections (Madria and Bhargava, 1997).

II. STATE OF ART

a. Distributed Mobile Environment

Replication is one such widely accepted phenomenon in distributed environment, where data is stored at more than one site for performance and reliability reasons. Applications and architecture of distributed computing has changed drastically during last decade and so has replication protocols. Different replication protocols may be suitable for different applications. In this manuscript we present a survey of replication algorithms for different distributed storage and content management systems ranging from distributed Database Management Systems, Service-oriented Data Grids, Peer-to-Peer (P2P) Systems, and Storage Area Networks.

A replicated database is a distributed database in which multiple copies of some data items are stored at multiple sites. By storing multiple copies, the system can operate even though some sites have failed. Maintaining the correctness and consistency of data is of prime importance in a distributed DBMS. In distributed DBMS it is assumed that a replicated database should behave like a database system managing a single copy of the data. As replication is transparent from users' point of view, users may want to execute interleaved executions on a replicated database to be equivalent to a one-copy database, the criterion commonly known as one-copy serializability(1SR) (Bernstein, 1987).

Replication Protocols

- **ROWA and ROWA-Available**

In most cases, the system is aware of which data items have replicas and where are they located. A replica control protocol is required to read and write replicated data items. The most simple replica control protocol is the Read-One-Write-All (ROWA) protocol. In ROWA protocol, a transaction requests to read an item and the system fetches the value from the most convenient location. If a write operation is requested, the system must update all the replicas. It is clearly evident that the read operation benefits from data replication, as it can find a replica near the site of request. But, write operations may adversely affect the performance of the system. A very obvious alternative of ROWA protocol is ROWA-Available. ROWA-A was proposed to provide more flexibility to ROWA algorithm in presence of failures. Read operation of ROWA-A can be performed similar to ROWA, i.e. on any replicated copy. But to provide more flexibility, write operations are performed only on the available copies and it ignores any failed replicas. ROWA-A solves the availability problem, but the correctness of the data may have been compromised. After the failed site has recovered, it stores the stale value of the data. Any transaction reading that replica, reads an out-of-date copy of the replica and thus the resulting execution is not 1SR

- **Quorum Based**

An interesting proposal to update only a subset of replicas and still not compromise with correctness and consistency is based on quorums (Bernstein, 1987). Every copy of the replica is assigned a non-negative vote (quorum). Read and write threshold are defined for each data item. The sum of read and write threshold as well as twice of write threshold must be greater than the total vote assigned to the data. These two conditions

ensure that there is always a non-null intersection between any two quorum sets. The non-null set between read quorum and write quorum guarantees to have at least one latest copy of the data item in any set of sites

Lock Requested\Lock held	Read	Write
Read	No Conflict	Conflict
Write	Conflict	Conflict

All transactions must collect a read/write quorum to read/write any data item. A read/write quorum of a data is any set of copies of the data with a weight of at least read/write threshold. Quorum-based protocols maintain the consistency of data in spite of operating only on a subset of the replicated database.

b. Mobile Ad-hoc Network

A mobile ad hoc network (MANET) is a network that allows mobile servers and clients to communicate in the absence of a fixed infrastructure. MANET is a fast growing area of research as it finds use in a variety of applications. In order to facilitate efficient data access and update, databases are deployed on MANETs. These databases that operate on MANETs are referred to as MANET databases. Since data availability in MANETs is affected by the mobility and power constraints of the servers and clients, data in MANETs are replicated. A number of data replication techniques have been proposed for MANET databases. Here we identifies issues involved in MANET data replication and study existing MANET data replication techniques based on the issues they address.

Issues concerning data replication for manet databases

- **Server power consumption:** Servers in MANET run on battery power. Power consumption of servers that provide database management system (DBMS) services to potentially many clients should be minimized. Servers with higher power availability are expected to perform more work than those that have lower power. If a server has low power remaining and if it is replicated with many frequently accessed data items (hot data), then frequent data access requests for these hot data might drain its power soon. Servers with no power remaining would not be able to provide any more services. The replication algorithm should thus replicate data items in such a way that the power consumption of servers is reduced, and is balanced among all servers in the system.
- **Server mobility:** Servers in MANET are mobile and the speed at which the network topology changes is higher than that in conventional mobile databases. Due to their mobility, servers might sometimes move to a place where they cannot be reached by other servers or clients. The replication technique should avoid replicating hot data items in such isolated servers.
- **Client mobility:** Clients that query the servers can be mobile. Clients sometimes send their transactions to the nearest servers to get a quicker 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. Clients, after issuing their requests for data access to a server, might move to new positions after a certain interval of time, and they might send their query and update requests to the nearest servers from their new locations. Hence, the access frequencies must be dynamic in nature and the decision to replicate data items in appropriate servers must also be dynamic.
- **Client power:** Client machines also run using their battery power. Some clients like PDAs are more power restricted than servers. They are limited by the amount of energy they can use before their batteries need to be recharged. A client might lose its power rapidly if it waits for its transactions' results for a long time. The replication technique should be able to replicate data items in appropriate servers in such a way that client power consumption is reduced.
- **Real-time applications:** MANET applications like rescue and military operations are time-critical and may contain both firm and soft real-time transactions. Therefore, the replication technique should be able to deliver correct information before the expiry of transaction deadlines, taking into consideration both real-time firm and soft transaction types in order to reduce the number of transactions missing their deadlines.
- **Frequent disconnection of mobile hosts:** Mobile hosts often get disconnected from the network due to various factors like power failure or their mobility. In addition, some mobile users switch their units on and off regularly to save power, causing more network disconnections. Servers which hold the data cannot provide services if they are disconnected from other mobile hosts. Thus, ideally, the replication

algorithm should be able to determine when a particular mobile host would be disconnected and, accordingly, replicate its data items in a different server to improve data accessibility.

- **Network partitioning:** Due to frequent disconnection of mobile hosts, network partitioning occurs more often in MANET databases than in traditional databases. Network partitioning is a severe problem in MANET when the server that contains the required data is isolated in a separate partition, thus reducing data accessibility to a large extent. Therefore, the replication technique should be able to determine the time at which network partitioning might occur and replicate data items beforehand

III. CURRENT DEVELOPMENT

a. Activity based data mining techniques and SOP

A centralized collaborative system between nodes and Base Stations (BSs) isdeveloped, and a new data replication scheme based on group and query prediction mobility scheme with Data Mining techniques is proposed. Utilizing the group mobility with the properties of data objects this new scheme (in various sites) minimizes the cost of remote access and improves the response time of the queries. A series of algorithms is developed so that the system can provide the "prefetch" operation for the group of users according to their mobility and their shared data have to wait for them in their next appropriate cell. The data have to follow the user moves. Three tier data replication approach contains a prediction scheme for Group and Query Mobility (GQM) based on two phases the Merge Itemset Algorithm (MIA) and the Dynamic Replication Scheme with three Criteria (DRS3C) respectively. After the data reservation operation by site, the DRS3C can guarantee the acceleration of the query execution. DRS3C works in cooperation with MIA and Connection Admission Control (CAC) in order to minimize the network messages, and the response time. It can also be used in the design of any new architecture for distributed query processing. Simulation results are provided.

Smart products are heterogeneous real-world objects with embedded computing and networking functionality. They are associated with digital object memories, which contain object-related product life-cycle information. Since smart products are in general not able to locally store all data objects of the digital object memory gathered during their lifecycle, there is a need for scalable data management mechanisms that achieve ubiquitous data availability. As part of a distributed storage mechanism, this paper proposes SORPA, a distributed and self-organizing replication algorithm for smart products. SORPA is capable of maintaining the locality of data objects and approaches the trade-off between data availability and consistency. In this way, SORPA fosters ubiquitous data availability, while taking into account the challenges of smart products

b. Content Replication in Mobile Environment

Performance and reliability of content access in mobile networks is conditioned by the number and location of content replicas deployed at the network nodes.

c. Data Replication in mobile tactical network

In tactical networks, nodes move according to tactical maneuvers and network partitions occur frequently. To mitigate this problem, data replication is commonly used to increase data availability and reduce data access delay. However, different tactical maneuvers lead to different node mobility models, which affect the performance of data replication schemes. In this paper, we comprehensively study the data replication problem in mobile tactical networks. We propose a new intra-group data replication scheme and extensively quantify the effects of mobility on different inter-group data replication schemes from various perspectives. The study is based on several metrics, which include the average access delay and data availability, and the temporal and spatial analysis of these values. Through extensive experiments its prove that three typical mobility models in tactical networks on data replication, and identify the most suitable data replication schemes under various mobility models.

IV. CONCLUSION

In this paper we have discuss various data replication strategies over the different environment like MANET, Distributed Database, Mobile database, cellular network, etc. Its found that we are having the various algorithm and experimental setups to perform the data replication and achieve high performance. In future we will experiment and examine all the work.

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