Group Based Replica Relocation for On Demand Video Streaming in Manets

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Abstract— *Mobile Ad Hoc Networks (MANETs) are very useful in various fields as they can be established and maintained without any infrastructure and can be formed with many hand held devices of various capacities. On demand video streaming is one of the popular application area in MANETs and requires special attention. A major challenge in this area is to keep the replication copies available all the time for smooth streaming. In this paper we proposed a Group Based Replication and Relocation (GBRR) scheme for streaming applications in MANETs and can be used in conjunction with any of the routing protocols. We implemented the scheme with EMRP_R (An Efficient Multipath Routing Protocol with Replication) for on demand video streaming. The simulation results show that the protocol when used with GBRR gives better results than the protocols without this scheme.*

***Keywords: Data Replication, Group based relocation, Video streaming, MANETs**.*

I. Introduction

The hand held devices that are in use today can be used for various purposes such as wireless communications, establishing network and communicate with each other in a coordinated environment. The most popular use of them is forming an ad-hoc network in which the nodes form a network among them without the need for any infrastructure. One among such networks is a Mobile Ad Hoc Network (MANET). In this type of networks nodes move at their wish while communicating among them. The major advantage in MANETs is that the nodes themselves act as routers between source and destination [1]. This characteristic is also the disadvantage in MANETs as the nodes are moving. Hence, routing should be handled carefully. The mobility of the nodes (in turn routers also), limited computing and memory capacity of the nodes and dynamic topology changes are major concern in MANETs. This nature of dynamic topology changes poses a challenge on applications such as video streaming which are time critical. The problem becomes more severe when these type of applications depend on replication and relocation of data. Information may be available on one node at one moment and, just after that, this node may move away from another requesting node or may just become inaccessible.

The time and context sensitive information such as the transmission range, node stability, data in cache memory, availability and consistency in replication data etc., should be handled carefully as the nodes move and the topology changes occur in the network. The choice of nodes where the replicas are to be kept has a great impact on the performance of the protocols and applications that are based on the replicas and the status of the nodes that are storing the replicas. The relocation of the replicas is more dynamic in nature and very challenging task in MANETs. The very dynamic nature of the MANETs makes the replica relocation algorithms to produce solutions that may not be optimal for a given time period [2].

In this paper, we adopted a group based scheme for replication relocation in MANETs, Group Based Replication and Relocation (GBRR), in which a group of nodes exchange information and take decisions based on the current status of the nodes in the network and is integrated into our earlier routing protocol, Efficient Multipath Routing Protocol with Replication (EMRP_R) [3], designed for on demand video streaming in MANETs.

II. LITERATURE SURVEY

Hara et.al [4] discussed about the data replication and consistency models. They have classified the consistency models into three groups or schemes: 1. Static Access Frequency (SAF) 2. Dynamic Access Frequency and Neighborhood (DAFN) and 3. Dynamic Connectivity based on Grouping (DCG). In SAF, the consistency of the replication and the relocation was usually based on static measures and is suitable for the networks in which nodes may not move frequently. The DAFN considers the replication consistency model based on the access frequency of the data items dynamically. The DCG model is based on grouping of the nodes together and considers the consistency among the group of nodes. The groups are managed by a group coordinator. The coordinator periodically collects the information about the access frequency of a data item and allocates the nodes for the replication of the data item. But, the scheme do not take into account the topology changes of the network and therefore is not suitable for networks with high mobility factor [5].

SCALAR [5] model follows a different approach for data look up and replication in MANETs. The Network topology is used to form a graph and then the nodes that form the connected dominating set are extracted. The nodes that are participating in the dominating set are considered for data lookup and replication. The data items are distributed over these nodes and the replicas are kept in these nodes. It guarantees that the data item is always available in one of the nodes in the dominating set. SCALAR achieves better performance when compared with the SAF and DAFN, but at the cost of increase network overhead. The instability of the nodes in the network is not taken into account in SCALAR [6].

Gisane A. Michelon et. all [6] follows a different approach for replicating the data items among the nodes in the MANETs. It uses three parameters into consideration: i) Access Frequency ii) Distance in hops to get the data and iii) instability of the node(s). The model is based on the Virtual Magnetic Fields (VMFs) [7]. The dynamic nature of the network is considered into account and the replicas are placed in the best nodes, which are determined by using Weighted Centrality by Potential which is computed by making use of the concept VMFs.

The replica allocation strategy is further improved by Shinohar et.al [8]. The scheme proposed in [8] takes into account the battery power of the nodes before allocating replicas. The replication decision is based on the expected access of the data items using a method known as Weighted Expected Access and Battery (WEAB). The method tries to balance the replica allocation and the battery power remaining at the nodes.

The power consumption in utilizing the replicas is further improved in PADARA, Power-Aware Dynamic Adaptive Replica Allocation Algorithm, proposed by Wang et al. [9]. The PADAR considers the locality of access of a data item. Every node periodically expands or contracts the replica based on the frequency and locality of data access of a replica along with its power and mobility.

A replica relocation scheme was proposed in [10] by K Muralidhar et.al. The schemes considers the movement of the nodes, residual energy and memory availability of a node. It then calculates a weighting function base on the three parameters. The individual nodes then decide to reallocate the replica if needed.

III. PROPOSED SYSTEM

Unlike the above discussed replica relocation schemes, our proposed scheme is implemented by using all the factors that influence the replicated data dynamically. The typical factors we consider are the mobility of the node (in other words the stability of the node), remaining power of the node, the queue status of the node. We have followed a simple forecasting method, Weighted Moving Average, to estimate the future values of the above factors and used these values in replication relocation. The scheme is integrated into our earlier routing protocol, EMRP_R (Efficient Multipath Routing

Protocol with Replication for on-demand video streaming in MANETs).

A. The EMRP_R

EMRP_R is used for routing the video from source to destination on demand. This is a multipath routing protocol, which establishes two routes between source and destination to route the video packets. The paths are initially established by using a weighted function. The primary route, which is computed to be more stable and efficient, is used for routing the packets. The second best route, a route which is just below the efficiency of the primary route among all the other routes that were computed, is used for transmitting the replication copy of the video stream. The one hop neighbor of the destination on the secondary route is used to store the replication copy. However, unlike the other replicas, the replication copy is not stored permanently. The replication copies of the stream, that can be used in case of the requirement in near future, are only stored. The replication copies are discarded as soon the time expires.

B. Group Based Replica Relocation

Once the streaming of the video starts from source to destination, the destination, D, sends a choke packet with a request to get reply from the one hop neighbors. The one hop neighbors of the destination reply to this choke packet. The destination then sends list of one hop neighbors to the one hop replica node, RN, on the secondary route. The replica node then forms a group, whose members are these one hop neighbors of the destination. The RN then starts communicating with the one hop neighbors of the destination. The RN requests the following information from the group members, which is updated at regular intervals.

i) Forecasted value of the remaining energy, EF_m

ii) Forecasted value of the queue status, QF_m

iii) Forecasted value of the movement, MF_m

where EF_m is the energy forecast value, QF_m is the queue forecast value and MF_m movement forecast value of node m. All these values are normalized to 1 so that the heterogeneous nodes can also be handled smoothly.

Based on the values received from the group members, the RN maintains a table of rankings, TabNeighborRankings. The ranking of each of the member of the group is calculated using the equation 1.

$$Rank_m = 0.4 * EF_m + 0.3 * QF_m + 0.3 * MF_m \quad \text{----} \quad 1$$

The RN keeps track of the neighbor nodes rankings at regular intervals and the table is updated accordingly. When the RN detects a failure or failure probability in the secondary route in receiving the replicas of the stream, it immediately selects the best ranked one hop neighbor as the next node in which replication is to be stored. The same is informed to the destination. The destination node, D, then sends the information to the source along with the new node that is selected as replication node. The source then finds a path to this node (which becomes new RN) and establishes a route to this node considering this route as secondary route. The replication streaming process then continues in this new secondary path.

C. The Forecasting method

As mentioned earlier, all the members of the group are requested to send three forecasted values to the RN: Remaining power, Queue memory and Position. The following subsections gives a detailed view of the computation of the forecasting of the corresponding values.

Power Forecasting:

Every node observes the power consumption at regular intervals and stores the past three consumptions: PC_{t-2}, PC_{t-1} and PC_t. Based on these values, the power consumption in the next coming time period is estimated using the equation 2.

$$PC_{t+1} = 0.2 * PC_{t-2} + 0.3 * PC_{t-1} + 0.5 * PC_t \quad \text{-----} \quad 2$$

where t is the current time slot.

The value of is normalized to 1 based on the remaining energy (battery power) of the node using the equation 3 and is sent to RN.

$EF = 1$ if $RE / PC_{t+1} > 6$

$= RE / PC_{t+1}$ otherwise ------- 3

Queue Forecasting:

Every member of the group stores the queue occupancy rate for the past three time slots: QOR_{t-2}, QOR_{t-1} QOR_t. The occupancy rate is 1 if the queue is full at any time interval. The occupancy rate is 0 if the queue is empty. These values are then used to estimate the queue occupancy rate for the next time interval using equation 4.

$$QOR_{t+1} = 0.2 * QOR_{t-2} + 0.3 * QOR_{t-1} + 0.5 * QOR_t \quad ----- \; 4$$

Using this value, the queue occupancy rate is normalized to 1 by using equation 5 for the next 6 time intervals and is sent to the RN.

$QF = 1$ if $QC / QOR_{t+1} > 6$

$= QC / QOR_{t+1}$ otherwise ------ 5

Position Forecasting:

Each member of the group gets the position of the source node and calculates the displacement of itself with respect to the source. If the direction of the movement of the node is away from the source, the value that is forecasted will be negative and is positive otherwise. The direction is calculated using the distance of the node from the source. The distance is calculated using the Euclidian distance formula given by the equation 6.

$$Dist = Sqrt\ ((Xs – X)^2 + (Ys – Y)^2) \quad --------- \; 6$$

where (Xs, Ys) and (X, Y) are the positions of the source and the node itself at given time.

The Dist value is calculated for the past three time intervals $Dist_{t-2}$ and $Dist_{t-1}$ and $Dist_t$. The movement of the node is away from the source if $Dist_{t-1} - Dist_t < 0$ and is towards the source if $Dist_{t-1}$ and $Dist_t >0$.

The distance of the node from source is then estimated using the equation 7.

$$DistF = 0.4 * |Dist_{t-2} – Dist_{t-1} |+ 0.6 * |Dist_{t-1} - Dist_t | \quad ----- \; 7$$

The movement forecast is then normalized using the following equations.

If $Dist_{t-1} - Dist_t < 0$ (i.e. the node is moving away from the source) then

$MF = -1$ if $(6 * (DistF) / TR > 1)$ // Node moves away from the source in next six time intervals

$= - (6 * (DistF) / TR)$ ---- 8

If $Dist_{t-1} - Dist_t > 0$ (i.e. the node is moving towards the source) then

$MF = 1$ if $(6 * (DistF) / TR > 1)$ // Node moves close to the source in next six time intervals

$= (6 * (DistF) / TR)$ ------- 9

IV. Simulation and Performance Evaluation

In this section we evaluate the GBRR method with the two earlier methods, NDMP_AODV and EMRP_R (without replica relocation), for video streaming against various metrics. The NS2 simulator is used for the evaluation. The following table gives the overview of the network configuration used for simulation.

Parameter	**Values**
Simulator	**NS2**
Simulation time	**700sec**
Simulation area	**1200x1200 sq.meter**
Number of nodes	**50**
Transport protocol	**UDP**
Routing protocols	**GBRR, EMRP_R and NDMP-AODV**
Mobility model	**Random way-point**
Pause Time	**0 to 20 sec**
Video Codification	**H.264SVC**
Number of Primary Routes	**01**
Number of Secondary Routes	**01**

Fig 1a and 1b below show the Packet Delivery Ratio versus speed and pause time respectively.

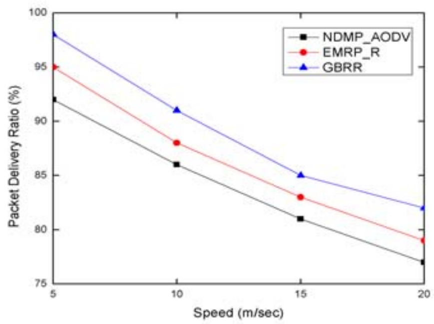

Fig 1a. PDR versus Speed

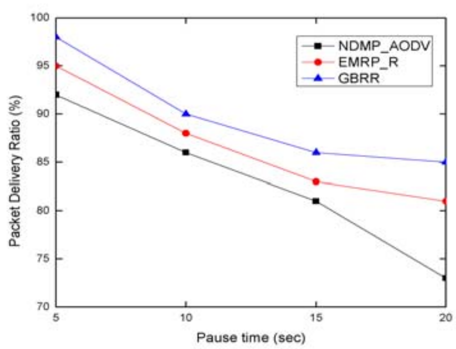

Fig 1b. PDR versus Pause time

The packet delivery ratio has been improved a lot due to the high availability of data even in case of route failures.

Fig 2a and 2b below show the average end to end delay versus speed and versus pause time respectively.

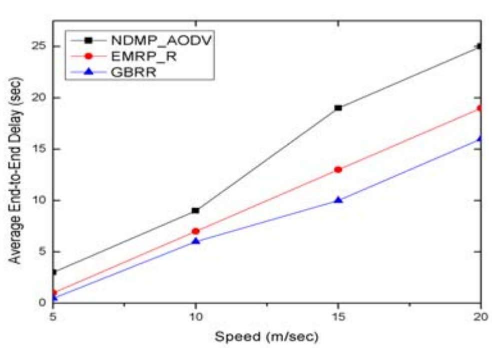

Fig 2a. Average end to end delay versus speed

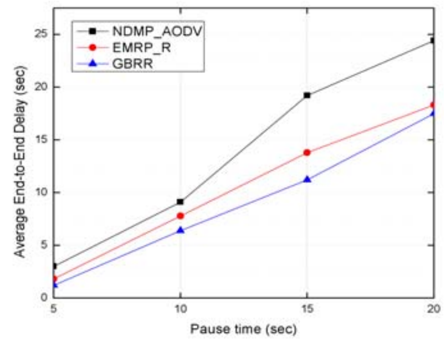

Fig 2b. Average end to end delay versus pause time

Both figures show that there a lot of decrease in the end to end delay when compared with the earlier protocols as the destination can get the streaming data from the replication as and when needed. It outperforms EMRP_R as the replicas are relocated in case of necessity thus allowing the replica available always.

Fig 3a and 3b shows the throughput versus speed and pause time, respectively, of GBRR along with the two earlier protocols

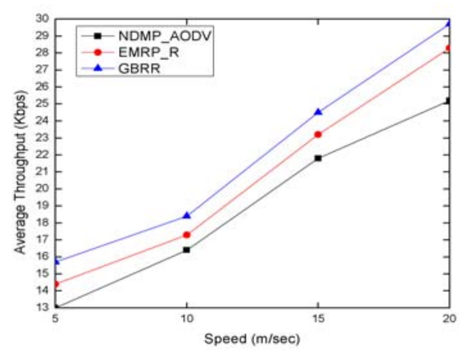

Fig 3a. Throughput versus speed

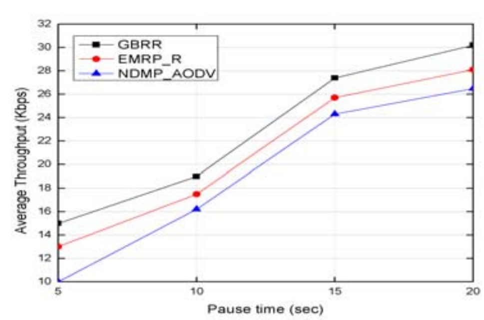

Fig 3b. Throughput versus pause time

The above figures indicate that the throughput of the GBRR is higher than the two protocols that were compared with. This is due to the replica and replica relocation of GBRR, which has made the packets available all the time.

Fig 4a and 4b shows the average Peak Signal to Noise Ratio versus the speed and pause time.

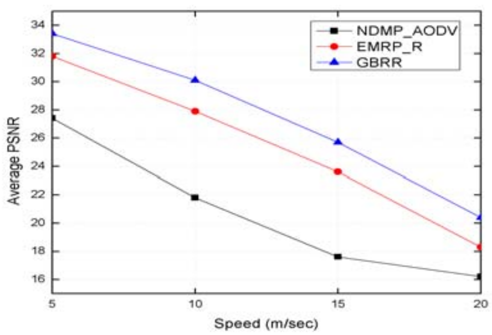

Fig 4a. PSNR vs Spee

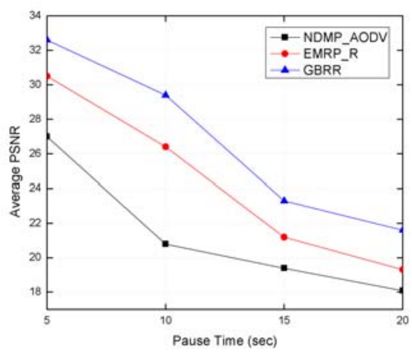

Fig 4b. PSNR vs Pause time

From the figures, it can be seen that the average PSNR has been improved a lot due to the receiving of the packets in time and with high accuracy. The packets are always made available at the replica in the secondary path ensuring the better quality of the video being sent.

V. CONCLUSION

In this paper, we have proposed a new replication relocation mechanism, Group Based Replication and Relocation (GBRR), especially for the purpose of video streaming. This mechanism is then integrated into our earlier protocol, Efficient Multipath Routing Protocol with Replication (EMRP_R) and evaluated for various performance parameters against the earlier protocols without replication and relocation. The results showed that the routing protocol when added with the GBRR performs better than without this mechanism. The proposed approach may be extended by including some more parameters into consideration for the forecasting.

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VI.