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Partial Caching Scheme for Streaming Multimedia Data in Ad-hoc Network

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Abstract. The streaming technique is a sequence of data made available over time. In the ad-hoc network, the streaming service is hardly served as the path is frequently broken due to the movement of nodes. In this paper, we propose partial caching scheme to reduce the service blocking rate. With the proposed scheme, mobile nodes store the data passing through and by-passing themselves. The cache replacement algorithm is based on the popularity of multimedia contents and the distance of the data block. This has resulted in the increases of the probability that mobile node stores the data to be used in future request. In evaluation, we examined our proposed scheme in the view of the cache hit ratios as the function of the number of mobile nodes and in the view of service block rate as the function of the service request rates. The simulation results show that the proposed caching scheme has better performance in cache hit ratio and service blocking rate.

Keywords: Mobile ad-hoc network, caching, multimedia, streaming service

1 Introduction

Multimedia is larger volume of data than general data such as program code, text, etc. The streaming is a sequence of data made available over time. This method has a merit that it can play multimedia data without saving the full data. Mobile nodes can freely move to anywhere in mobile environment [1]. For this reason, the delivery route for streaming multimedia data is frequently changed. The path can be broken due to the node mobility, the limitation of network bandwidth and node’s battery power in some cases. To support streaming service, the data should be ceaselessly served for a long time.

To reduce the network bandwidth consumption and battery power, we adopt partial caching scheme. In this scheme, the multimedia data can be preserved in nodes only locating in the delivery route. The amount of cached data is depended on the distance from the data sender. The longer the distance is, the more the data can be stored.

The remainder of the paper is organized as follows: Section 2 introduces the proposed partial caching scheme for streaming multimedia data. In section 3, we present the simulations and analysis of the results. Finally, we give out conclusion in section 4.

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2 Partial Caching Scheme for Streaming Multimedia Data

In this section, we propose a distance-based partial caching scheme for streaming multimedia data in ad-hoc networks. We assume that the multimedia data is consisted of n blocks and the size of each block is equal. Initially, as there is no data transmission, nodes in ad-hoc network have not stored any multimedia data at all. When a node requests the service for a multimedia, it first surveys its own cache to find that. If the data is stored, the multimedia data is served with the cached data without sending the request packet to the data server such as access point (AP) or base node (BN) to receive it. If not, sends a request packet to the data server. The request packet is arrived through the intermediate nodes that locate in the route between the request node and the data server. When an intermediate node receives the request packet, it operates under the same way that the request node does. Only when both the request node and the intermediate nodes have not stored the requested multimedia data, the request packet arrives at the data server. When the data server receives the request packet, the server sends the requested multimedia data back to the request node. At this time, the intermediate nodes cache the data in its own cache to support future usage. Let the interval of executing the routing algorithm be Γ and the data transmission rate be ν. The size of multimedia data block is $\nu \bullet \Gamma$. If a node, N_i, has joined the delivery route for m consequent time, the amount of cached data is $m \bullet \nu \bullet \Gamma$ and the available playing time is $[0, m \bullet \Gamma]$. Assume that N_i leaves the delivery tree after $m \bullet \Gamma$ and rejoins the tree after $(m+n)\ \Gamma$. N_i starts to store the by-passing data in its own cache. If N_i leaves the delivery tree after $(m+k)\ \Gamma$ where $k > n$, N_i has cached the data $[0, m \bullet \Gamma]$ and $[(m+n)\ \Gamma, (m+k)\ \Gamma]$.

As the cache capacity is limited, the stored data should be deleted when there is no space in node's cache. For this, we adopt cache replacement algorithm based of the popularity and distance of the data, and its sequences are as follows: 1) the data that has the lowest popularity is deleted. 2) In case of the same popularity, the data that has the longest distance is deleted. 3) In case of the same distance, the block has the highest distance among blocks greater than its hop count is deleted. The popularity is based on the request frequency of the multimedia data. According to Zipf-like distribution [2], the multimedia contents are accessed in skew condition. The access frequency of the lower popular contents is almost same. In this case, we use the distance to delete the cache data. The distance is calculated by 2 factors: block distance and hop counts. Block count indicates nth block of the multimedia contents. Hop count is a distance between the data server and node itself.

Let P_i and P_j be the popularity of the multimedia content i and j. Assume that N_i has stored the data $[0, m \bullet \Gamma]$ for a content i and $[0, n \bullet \Gamma]$ for a content j. If $P_i > P_j$, the longest distance block of the content j is deleted. Thus, the cached data is changed from $[0, n \bullet \Gamma]$ to $[0, (n-1)\Gamma]$. If $P_i < P_j$, the longest distance block of the content i is deleted and the cached data is changed from $[0, m \bullet \Gamma]$ to $[0, (m-1)\Gamma]$. Let H_i be the hop count of node i. If $m > H_i > n$, the longest distance block of the content i is deleted and the cached data is changed from $[0, m \bullet \Gamma]$ to $[0, (m-1)\Gamma]$. Let P_F be the probability of involving the forwarding node. If $H_i < H_j$ where H_i is hop count of N_i and H_j is of N_j, respectively, P_F of N_i is higher than that of N_j. The number of streaming multimedia contents of N_i is higher than that of N_j. It causes that N_i needs more cache space to store and forward the requested data. For this, A node tries to cache the data for each multimedia contents at least as many as $H_i \cdot \Gamma$ based in its hop count. The closer a node approaches to the data server, the more a node stores diverse multimedia data and the less the amount of stored data for a multimedia is. If a node is far away from the data server, the opposite results can be achieved.

3 Simulation and Analysis

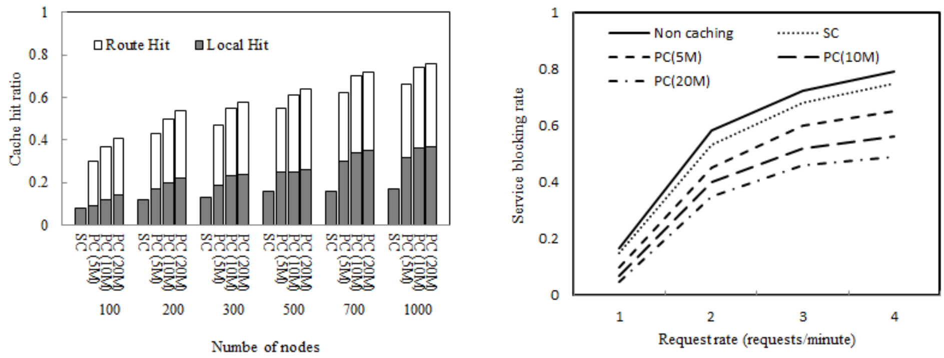
In this section, we show simulation results to demonstrate the benefit of proposed partial caching scheme in ad-hoc network and analyze the results of performance using it.

Table 1. Simulation Parameters

Parameter	Default	Range	Unit
Contents	100	-	
Block	100	-	
Block size	50	-	K Bytes
Cache size	5	5 ~ 20	M Bytes
Bandwidth	10	-	M bits/second
Request rate	1	1 ~ 4	Requests /minute

Simulation parameters are listed in Table 1. The size of simulation network is 500m × 1,000m in rectangular plan. The 100 items are served and AP locates at the center of the network. The contents are consisted of 100 blocks where the size of each block is 50 KB. The access pattern of mobile nodes is depended on cut-off Zipf-like distribution with skew factor 0.85 [2]. We assume that all nodes can communicate to any other nodes in the network. To support the fully connection among mobile nodes, we make a simulation model satisfying the condition mentioned in [3]. To define node's mobility, we use random waypoint mobility model [4], where a node velocity is randomly selected in [0 m/s, 10 m/s] and the angle [0, 2π].
Fig. 1(a) shows the cache hit ratios according to cache schemes such as simple cache (SC) and partial cache (PC) in the view of the number of mobile nodes, where the transmission range is 100m and the capacity of partial cache is 5 Mbytes , 10 Mbytes and 20 Mbytes, respectively. Simple cache is that the requester (node) is only stored the multimedia contents and the requested data can be supplied by using the only data stored in the requester own cache. Simulation results show that partial caching scheme is better performance in cache hit ratio than simple cache scheme does. This is because partial cache stores the passing and by-passing data when nodes join the delivery path. As nodes not joining in and locating at 1 hop away from the delivery path store the data transmitted by forwarding nodes, cache hit ratios with partial cache scheme are higher than those of route cache that only the nodes joining the delivery path store the data. Fig. 1(b) shows the service blocking rates in the view of the request rate. The higher service request rate is, the higher the blocking probability of streaming the service is. But some of the requested data are cached in nodes, the service will be offered by nodes not AP. From the simulation results, we get the proposed caching scheme can reduce the service blocking

rate because the requested data is offered by nodes storing it and the transmission path is not related to AP.



(a) Cache hit ratio (b) Service blocking rate

Fig. 1. Simulation results

4 Conclusion

In this paper, we proposed a caching scheme to support streaming multimedia contents. With the proposed caching scheme, nodes store the data passing through and by-passing themselves for future usage. The cached data is removed and replaced the new one based on the popularity and block distance of the contents. The nodes joining in the delivery path survey their own cache to serve the requested data. The proposed scheme does not try to cache the whole cozntents on the identical item but try to sequentially cache block unit of item. In evaluation, we examined our proposed scheme in the view of the cache hit ratios as the function of the number of mobile nodes and in the view of service block rate as the function of the service request rates. The simulation results show that the proposed caching scheme has better performance in cache hit ratio and service blocking rate.

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