Adaptive P2P caching for video broadcasting over wireless Ad Hoc network

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Abstract

With the advance of science and technology, wireless networks are becoming a significant part of today's access networks. Ad hoc networks are wireless mobile networks without an infrastructure. Recently more and more multimedia services are applied to ad hoc networks. Because of the problem of the mobility, it always makes the interruption of video packets transmission, which causes the worse quality of videos. In order to solve above problem, we propose a novel peer to peer (p2p) caching system, using radius-based binary search algorithm and mobile management. In order to transmit video packages via ad hoc network, we adopt layered scalable video coding. Video is encoded into three layers by layered scalable video coding. By radius-based binary search algorithm and mobile management, we can increase the hit radio of the p2p catching and shorten the cache distance.

Keywords: peer to peer ,cache , ad hoc

1. Introduction

In the last few years, Peer-to-Peer (P2P) systems have widely developed over the Internet. The p2p offers many advantages. In this paper, we propose a p2p caching system, using radius-based binary search algorithm and mobile management, in which mobile nodes can request nearby nodes for lost video clips through p2p model. P2P caching can reduce the loading of cluster head and shorten the cache distance and increase hit ratio. Video is encoded into three layers and broadcasts all layers to Cluster Head via the backbone. Radius-based binary search algorithm can evenly distribute clients caching which video of layers. Mobile management can predicate the time when mobile nodes leave cluster by predication model, and then Cluster Head can inform members to help cache videos. We propose novel P2P caching system, able to solve problems which mobility cause the interruption of the video packets transmission. The rest of this paper is organized as follows. In Section 2, we present p2p caching system in detail. Section3 provides the results drawn from our simulation study on the performance of p2p caching system. Finally we concluded this study in Section IV.

2. System Architecture

This Figure 1 indicates that our p2p caching system consists of server, cluster Head, and clients. The server stores video content. Hereafter, we assume that network is cluster-based. Therefore, we propose to install a scatter of cluster head. A cluster head is a key component of p2p caching system, taking the roles of managing node mobility and p2p caching. Clients are the mobile hand held device. The server allows video content to be encoded into multiple layers by layered scalable video coding .One of compressed layers is the base layer. Other compressed layers are enhancement layer1(E1) and enhancement layer2(E2). The server and cluster heads form a service backbone, the server sends video packets to Cluster Head via the backbone. Every cluster head receives the video packets from the server, and then broadcasts the packets to the clients.

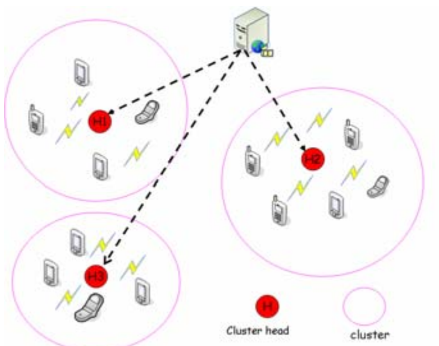

Fig 1 system Architecture

2.1 layered scalable video coding

In this section, we briefly summarize the conception of scalable video coding [1]. In general, each video is encoded into one compressed bit-stream, which is referred to as non-scalable video coding. In contrast, the layered scalable coding is to encode video into multiple layers, including a base layer and one or more enhancement layers. The base layer can be independently decoded and provides the version of least quality. Furthermore, enhancement layers which can only be decoded together with the base layer and provide a better quality. It is the highest qualities that combine with all the layers. Let us describe the layered scalable video coding in more detail. It can be classified into (1) SNR Scalability, (2) Spatial Scalability, (3) Temporal Scalability. Owing to Spatial Scalability is used in our video encoder, the following discussion focuses on Spatial Scalability.

2.1.1 Spatial Scalability

A characteristic of spatial scalability [2] is the same video in different spatial resolutions or sizes. For example: A spatial scalability video encoder compress a video which has solution 352x288(CIF) into two layers at the same frame rate, but different spatial resolutions. The base layer is encoded at a lower spatial resolution, and therefore the reconstructed base-layer picture resolution only has 176x144(QCIF). In other words, it is the highest qualities (352x288) that combine with all the layers.

2.2 P2P caching management

As discussed in section 2.2, server allows video content to be encoded into multiple layers and broadcasts all layered videos to all cluster heads via the backbone. And, then all cluster heads broadcast all layered videos to their via separate channels. When clients move far away or quit cluster, which causes the interruption of receiving video packets. In order to solve above problem, we propose a novel P2P caching technique, called radius-based binary search algorithm. A cluster head assigns the members of cluster to cache one of the bit-streams, including base layer, E1 layer and E2 layer. When a mobile node joins a cluster, it can request cluster head for lost video clips. Then the cluster head will response to the request with cached node ID and position. By that responding message, the mobile node can request for the cached video clips from the nearby clients, and then nearby clients can send cached video clips to mobile nodes using unicast protocol. We use clients to cache the video clips for reducing the cluster head loading. When many clients moved at the same time, the cluster head will become overloaded if they all request video clips from it. Caching video clips by nearby clients is not only reducing server loading, but also decreasing cache distance. In next section, we will describe radius-based binary search algorithm.

2.2.1 Probability analysis

In the cluster, we assume that the arriving nodes get base layer with probability p, get E1 layer with probability q, and get E2 layer with probability (1-p-q).It is apparent that getting base layer, E1 layer and E2 layer are independent events. Therefore, at the same time the probability of getting base layer, E1 layer, E2 layer is w. As eq1 indicates, the probability of w is pxqx(1-p-q). Assuming that the number of members in the cluster is T, the number of nodes that cache base layer is B, the number of nodes that cache E1 layer is E1and the number of nodes that cache E2 layer is (T-B-E1).Following the assumption above, we obtain eq2. Transposing terms and simplifying, we get eq3. As eq3 indicates the probability of w in proportion to the result of BxE1xE2.

$$w = p \times q \times (1 - p - q)(1)$$

$$w = (\frac{B}{T}) \times (\frac{E1}{T}) \times (\frac{T - B - E1}{T})(2)$$

$$w = B \times E1 \times E2(3)$$

The number of B,E1,E2	96,12,12	84,24,12	72,48,12	60,36,24	48,36,36	40,40,40
Result of BxE1xE2	13824	24192	41472	51840	62208	64000

Table 1 number of base ,E1,E2 layer V.S Probability

As Table1 indicates, we assume that there are 120 nodes. We use different rates to distribute numbers of members among caching base layer, E1 layer and E2 layer, and then we will substitute the numbers of three different layers into eq3. From table1, we can know that the numbers of getting base layer, E1 layers and E2 layers distribute more averagely, the probability of w is higher.

2.2.2 radius-based binary search algorithm

According to the results of the previous section, on the proposed radius-based binary search algorithm, cluster head can evenly distribute one of base, E1 and E2 layered video to clients for caching. As shown in figure3 we describe the radius-based binary search algorithm. In this paper, we assume that clients are built-in GPS system. We can get the position and distance between nods and nodes by GPS system. Then, figure3 is a flow chart which shows how a cluster head uses the radius-based binary search algorithm.

```
• int search_R(ID,low,up)
{     int result=0;
      middel= low +(up-low)/2;
      result=node_number(low,middel);
       If(|result-(totoal neighbor/3)|<threshold);
            Return middle;
       else if(result- (totoal neighbor/3)) >threshold);
            search_R(id,low,middle);
       else if((totoal neighbor/3)-result) >threshold);
            search_R(id,middel,up);
}
```

Fig 2 radius-based binary search algorithm

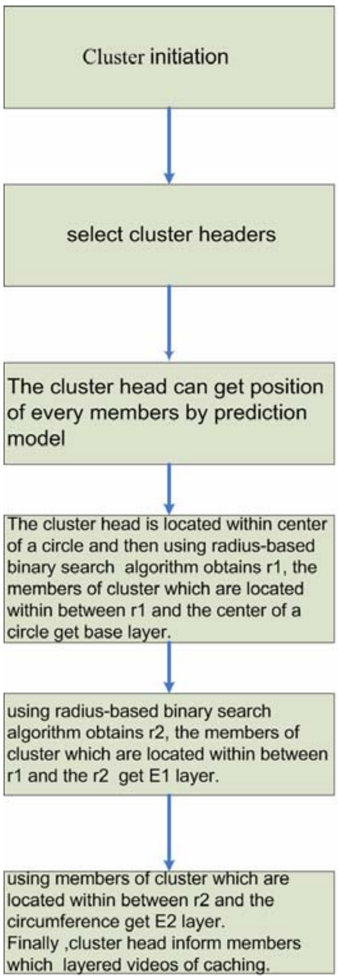

Fig 3 flow char of cluster head using radius-based binary search algorithm

2.2.3 mobile management

In an ad hoc network, mobility is an important issue. In this section, we describe how cluster head manage the mobility and join of members. We will use the prediction model [3] as Table2. We introduce the information of GPS system into predication model, and then, we can get Dt. Dt can predicate How long a node have left its cluster. By the prediction model, a mobile node knows when it will become connectionless with the cluster, and then the mobile node can inform cluster head in advance. When the cluster head receives the message, it forwards the message to a nearby cluster head, so that the members of nearby cluster can help cache videos. When the mobile node moved to the nearby Cluster, they can request for lost video clips from nearby Cluster members.

$$Dt = \frac{-(ab+cd)+\sqrt{(a^2+c^2)Tx^2-(ab-cd)^2}}{(a^2+c^2)}$$

$$a = V_1 COS\theta_1 - V_2 COS\theta_2$$

$$b = x1 - x2$$

$$C = v_1 Sin\theta_1 - V_2 Sin\theta_2$$

$$d = y1 - y2$$

Table 2 prediction model

3. Performance Evaluation

To evaluate the performance of the proposed design, we have conducted some simulation as follows

3.1. Simulation Model

Table3 indicates that summarizes the input parameters of simulation, we implement our simulation by c language.

Parameter	Default value
Number of nodes	100
Clients transmission range	10m
Video size in Mbyte	150
Number of broadcast channels	5
Clients arrival rate	{2,4,6,8,10}
Session	1000

Table3 Simulation Parameters

3.2 Simulation result

As figure3 indicates, y-axis represents the probability of getting cached videos .X-axis represents three situations: The first is mobile nodes getting base layer, the second is at the same time mobiles nodes getting base layer and E1 layer and the third is mobile modes getting three layers at the same time. From figure3, we can know that radius-based binary search algorithm (RBBS) gets the probability of cached videos is generally 10 % more than Random cache algorithm. Figure 3 shows that the probability of getting base layer is 93%. The base layer is the most important of the layered scalable video coding, because of the base layer can be independently decoded and provides the version of least quality. In the meanwhile, the probability of getting base layer and E1 layer is about 70%. It indicates that radius-based binary search algorithm(RBBS) can provide a better quality of the video. In ad hoc networks, it better transmits video clips with short distance. Figure4 shows that radius-based binary search algorithm(RBBS) gets cached video clips is within about 1.5 hops. In contrast, random cache algorithm is within about 2.5hops. Random cache algorithm has more one hop cache distance than radius-based binary search algorithm(RBBS) does.

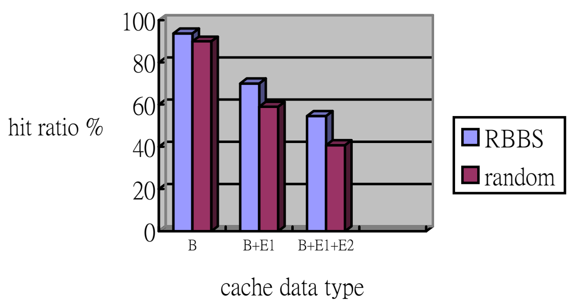

Fig 3 p2p caching hit ratio

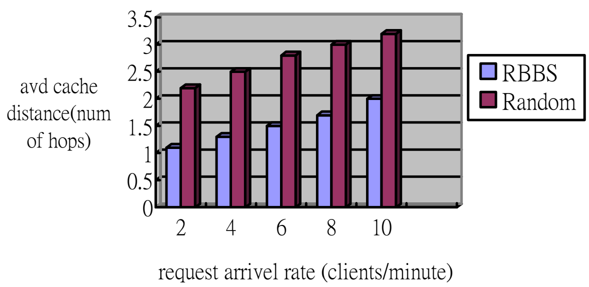

Fig 4 cache distance

4. Conclusions

In this paper, we have proposed a p2p caching system, using radius-based binary search algorithm and mobile management. Mobile management can predicate the time when mobile nodes leave cluster by predication model, and then a cluster head uses the radius-based binary search algorithm to assign members to cache video clips. By the result of simulations, it is apparent that using radius-based binary search algorithm and mobile management can promote p2p caching hit ratio and shorten the cache distance

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