Abstract—With the rapid development of network technology, Internet business has been transferred from a simple text into a host text, audio, video and other streaming services. Application layer multicast is one of the key technologies to protect the large-scale service quality of streaming media system, which has become an important part of study. Based on the application layer multicast technology, it focused on analyzing the effects of application layer multicast to the large-scale of media streaming system, and summarized the typical characteristics of the system. It takes efficiency of multicast robustness, scalability, and the continuity as evaluation indexes, and summarized the typical multicast. In the end, the drawbacks and development directions of application layer multicast were discussed.

Index Terms—Streaming Media, Application layer multicast, group communication

I. INTRODUCTION

According to China Internet Network Information Center published the “27th China Internet Development Status Survey Report”[1] shows the following items:
1) The number of netizens in China has reached to 0.457 billion.
2) Internet penetration soared to 34.3%.

Shown in Figure 1:

Figure 1. The scale of Chinese Internet users

IResearch the “2010 annual data on China online video”[2] shows: China online video industry market reached 3.14 billion Yuan output value, and achieve a rapid growth; in the future, the scale of China's video industry will be toward the direction of a more diversification, the market prospects are looking well, be very competitive.

Network video services classifies: live-streaming media and streaming media-on-demand. For example, PPLive[3], PPS[4] and QQLive[5]. Large-scaled video download and video-on-demand provider, began to comes from 2007, like Xunlei[6], eMule[7], Youku[8], Tudou[9], leshi[10], etc.

The rapid expansion of video services in users promotes the uninterrupted growth of streaming media technology. Streaming media refers to the continuous flow of data which produces, transports and broadcasts in chronological order on the Internet[11]. Streaming media technology is a interdisciplinary study conducted between network and multimedia technology, and it can be divided into three parts: generation of streaming media technology, streaming media transmission technology and streaming media broadcast technology. One of the core issues is how to transmit high quality video services to users more steady and speedy.

Since the early eighties, on the initial stage one to one unicast transmission mode is a centralized service model. Using Client / Server architecture consists of some clients and a central server for each client service request. This main server must send the same multiple copies of data to each user in order to producing huge amounts of data in the system. So the client easily met network congestion. For these reasons, it is not suitable for large-scale promotion of client service.

In 1985, S. Deering firstly proposed IP Multicast communication model[12], as shown in Figure 2. Its core ideas including: in the network layer setting multicast technology, multicast function implementing in routers, copying and forwarding packet in the router. Network router using a distributed algorithm constructs multicast data forwarding tree. The multicast data forwarding along the forwarding tree when the branch nodes in the tree, the multicast router packet copy.

Figure 2. IP multicast communication model
In this communication mode, don’t need repeat the copy and send the same data content, and its efficiency is high, but because of the high deployment costs, algorithm design problems, it is not better multicast traffic charging model. It is difficult to achieve reliability and congestion control protection, and management problems, so they can’t be widely applied.

Then to the late 90s, in order to ease the pressure on the server side, Content Delivery Networks has developed rapidly to become an effective scheme to solve past problems[13], as shown in Figure 3. It is an established and covers over the Internet by nodes in different regions of the composition of the virtual network server group. It is responsible for the content of the servers efficient, stable release to the nearest place from the client to ensure that the content in a very efficient way to provide services for the user's request.

![Figure 3. CDN Content distribution network deployment](image)

The CDN basic idea is to avoid as much as possible on the Internet the link which may affect the data transmission speed and stability, allows users to get the desired data information nearby, for which reduces latency, and also can alleviate network congestion issues.

But want to CDN doing like this that in each area of the edge of a large number of classification placed the cost of deploying the proxy server is very high, and the overall of it, has not reduced the same content on the network bandwidth usage and transmission of waste. Similarly, it does not meet the increasing demand for video users.

Francis and Chu respectively in 1997 and 1998 proposed independence the idea of application layer multicast, to shift attention from the network layer to application layer, from the server node to a terminal node, the application layer multicast (ALM) is capable of resolving in the promotion of the problems in IP multicast[14].

Application layer multicast is the basic idea: the deployment of multicast technology to the application layer, at end systems to achieve copy of information between users and forwarding the data, as shown in Figure 4.

![Figure 4. Pure P2P](image)

ALM inherited the original Internet network's simple, unreliable, unicast features, by the end systems to achieve forwarding function which is "end-to-end argument" thinking[15]. The advantage is that need not to change underlying network architecture, multicast routers do not need to rely on the construction and maintenance. So it is flexible to facilitate the deployment of group communication; but on the other hand, from the network in terms bandwidth efficiency, application layer group is better than IP multicast broadcast. Application layer multicast still has to improve for these current problems in research. Meanwhile, other technologies such as Cover Network, P2P and coding technology also greatly promoted the progress of the application layer multicast.

During 2009, IEEE-P2P meeting will let P2P defined as: any decentralization and sharing of resources characterized large-scale distributed systems[16]. Every node in P2P can directly access each other's data, computing resources, such systems constitute the distributed computing model, shown in Figure 4. Typical model: BitTorrent[17] and eMule.

P2P technology has increased the scalability and robustness, and was introduced into the field streaming media services. With users continue to increase, the whole system's resources and service capabilities have been greatly improved. However, on the one hand in resolving the current large-scale streaming media applications, while network and system bottlenecks; on the other hand in addition to heterogeneity and scalability issues, P2P-based streaming media techniques the program also need to consider streaming media applications such as delay, jitter performance requirements for the degree of QoS, IP Multicast and its transmission delay compared to the larger, transmission and low efficiency, but also to a large-scale streaming media system brings a new challenge[18].

Document list summarizes the various stages of technology out of comparing the advantages and disadvantages, as shown in Table 1:

<table>
<thead>
<tr>
<th>Streaming media transmission technology</th>
<th>Development time</th>
<th>the user's scale Support</th>
<th>Deployment costs</th>
<th>QoS (delay)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unicast</td>
<td>Early 80s</td>
<td>10^2</td>
<td>Medium</td>
<td>Very good</td>
</tr>
<tr>
<td>IP multicast</td>
<td>Late 80s</td>
<td>10^3</td>
<td>Ultrahigh</td>
<td>Good</td>
</tr>
<tr>
<td>CDN</td>
<td>Late 90s</td>
<td>10^4</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>ALM</td>
<td>Since 2001</td>
<td>10^4</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>P2P content distribution</td>
<td>Since 2002</td>
<td>&gt;10^4</td>
<td>Low</td>
<td>Poor</td>
</tr>
</tbody>
</table>

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II. OVERVIEW OF APPLICATION LAYER MULTICAST

ALM is an overlay multicast network, it will copy the data, forward and to accepted by the application layer instead of relying on the network layer, so it is large-scale Internet-based distributed applications.

Based on the application layer multicast, network nodes are multicast members of the host, data routing, copying, forward done by the members of the host. Members of the host to establish a network layer superimposed on top of business logic to achieve the functionality of the multicast network.

A. Application level multicast infrastructure

The basic function of application layer multicast is divided into: multicast group management, session management, multicast routing protocols, link state monitoring, overlay network structure and dynamic optimization and multicast tree construction and optimization.

(1) Multicast group member management

Management of multicast group members include members of the multicast group to join, quit the multicast group, and members of the state maintenance. If the larger group, you must consider the cost of management team members; if the overhead is too large, will hinder the system performance and scalability.

(2) Session Management

Is the corresponding session and multicast group, and its main task is to identify the session, the definition and maintenance of conversational strategies, management, multicast group creation and exit.

(3) Multicast routing protocol

Multicast routing multicast data distribution. Relationship between members of random, requiring multicast routing based on the change in time to ensure reliable data distribution.

(4) Link Status Monitoring

ALM periodically during operation is monitoring network link state, according to the state parameter to the constructor and the timely adjustment of the multicast tree overlay network, as well as members of the group management. Accuracy of the results of its monitoring and the resulting cost is an important application layer multicast system evaluation.

(5) Overlay network construction and optimization

Multicast overlay network connecting all participating end-host, host-side intelligence is to construct the logical topology. End hosts self-organization algorithm for establishing and maintaining overlay networks.

(6) Multicast tree construction and optimization

Multicast tree construction can improve the quality of the end nodes of the processing and data distribution capabilities, optimizing bandwidth utilization. Multicast tree construction algorithm usually used in a shortest path trees and minimum spanning tree.

Node degree of the tree was affected by the delay, the smaller node degree, the greater the depth of the tree, the tree the greater the delay; the tree node allocation of delay and conflicting issues.

Reference [20] gives the below definitions:

Definition 1. Tree diameter: For any node in the tree T for \( \forall v \in \mathcal{F}, \forall e \in \mathcal{E}, \forall r \in \mathcal{R} \). From r to v are the paths of the set of all edges. The \( d(v) = \sum_{e \in \mathcal{E}} c_e \) in the T tree is the longest distance from v. The diameter of the tree is defined as:

\[ \text{Diameter}(T) = \max_{v \in \mathcal{V}} d(v), \quad (v \in \mathcal{V}). \]

Definition 2. Residual degree: For the nodes in the tree T, \( \forall v \in \mathcal{V}, \text{Res}_T(v) = d_{\text{min}}(v) - d(v) \), \( d(v) \) is the degree of the node v in the tree T.

Because each terminal node may be more than to join a multicast session, multicast session if some take up too much bandwidth of the node interfaces, so there may follow the phenomenon can not be established multicast session. In order to reduce demand to prevent the possibility of future multicast session, choose to maximize the smallest residual degree of the tree.

The optimization goal as follows:

1) The optimization goal node:

Maximum bandwidth of the node: the node supports the maximum use of every node within the bandwidth.

The maximum degree of nodes remaining balance: the degree of each node as much as possible the remaining balance, a higher acceptance rate.

2) Tree optimization objective is the shortest path tree, minimum cost tree.

Constraints are as follows:

Node degree constraints: the limited resources of the host side, the node load capacity is limited. Node degree constraints expressed by the node property function \( d_{\text{min}}(v) \).

Tree constraint refers to the multicast tree diameter, radius constraints. Limit the longest path between the tree nodes.

Reference [20] describes the basic architecture of the application layer multicast, shown in Figure 5, where the session management of common management and team members to form a functional unit.

Figure 5. Middleware infrastructure of ALM

As a result, the middleware can be flexible to support multicast applications.
III. THE ALGORITHM OF APPLICATION LAYER MULTICAST BE CLASSIFIED

A. Centralized algorithm

Centralized algorithm lead into centralized control point rendezvous point. RP node collected measurement information among members in the network. And according to the information, we can calculate the application layer multicast tree. Then it can distribute the global or part of data to the multicast tree nodes. The calculation and distribution information about application layer multicast tree are cyclical.

When node to join, exit or fails, the responsible of RP is to recalculate multicast tree and to make the multicast tree structure information distributed to members of node. Centralized scheme is characteristic of the method is simple, defect is extensibility is poorer, and vulnerable to a single point of failure problem influence.

Centralized algorithm for small-scale applications, The agreement on behalf of HBM[25] and the ALMI[26].

B. Distributed algorithm

Distributed algorithm is divided into: tree-first algorithm, the mesh algorithm and the implicit priority algorithm.

1. Tree-First algorithm

In tree-first algorithm, it firstly figured out a shared data distribution tree. Then, each member found some other but not in the overlay network node is its neighbor, group members, and the establishment and maintenance of the additional members of these groups reached the control link. Data distribution tree and additional control links formed tree-first algorithm in the logical structure of the control topology.

Two tree structures: shared tree and the source tree.

- **Shared tree.**
  
  In the tree, the sender first data packet sent to the core of the tree i, core i charge and then in turn forwards the data along the tree to the receiver.
  
  This advantage is greatly reduced price for achievements and shortcomings of the data must be sent to the core, so routing is not optimal, poor communication efficiency.

- **Source tree.**
  
  That each source to its roots, generating an optimal routing tree, it can avoid inefficient routing problem shared tree, but for each source generates a tree, need to maintain large amount of state information due to the extra overhead is relatively large.

In the [27] reference, Host Multicast Tree Protocol (HMTP) is the tree-first algorithm in the application layer multicast protocol. As shown in Figure 6.

The members in HMTP share the responsibility of looking for adjacent nodes in the tree. When one member h wants to join the group, the first rendezvous point asked to share the tree's root informed. Starting from the root, the h try to find a member x which is near the h. If the degree of x is not more than the degree constraint, h will join the group as the child of x. Or, h will advance to the next level and try to find one possible parent in the children of x[27].

![Figure 6. The process of joining HMTP tree](image)

The members in HTMP maintain the information of all members in the root path. By randomly selected members to join the root path to start the process, each member periodically attempt to find a tree that is the better and the nearer the parent node. Members through the root path loops can be detected, so HMTP uses loop detection and loop elimination mechanism.

Application layer multicast protocols YOID[28-31] also used the network topology tree priority, this priority structure, the advantages of the tree in the literature[28] has been proved that the size of the tree growth is the recipient of several levels of scale growth.

The application layer multicast, the source tree has an advantage over the shared tree. First, the efficiency of application layer multicast is not high. Secondly, the host processing power can not be compared with the router. If using shared tree, the tree roots in a shared office can easily cause a bottleneck, especially in the application of multi-source group.

2. Mesh-first algorithm

Mesh-first, the group members were first distributed to their organization as an overlay mesh topology. In the mesh there are multiple paths between two members. Controlling the topology of each member should be added to the routing protocols, so as to reach the other members of the distributed computing only the overlay network path. Department in any member of a group, can be constructed through the inverse path of a source-based transmission technology tree.

In reference [21] describe that: a multi-dimensional mesh is a multi-dimensional by dividing the cartesian space, the multicast group in which each host to obtain an area. Using the multi-parameter coordinate marked every area. According to the rule, the multi-dimensional mesh can be divided by two parts as shown in figure 7:

![Figure 7. 2-D mesh of the example](image)
Overlay network in type of the mesh provide a number of links between the two group members. Therefore, mesh overlay network robustness is better, because a host is unlikely to leave or failure caused by separation between the alternate host Path exists, no need to rebuild the path of breaking the above reason.

Thus, mesh-based application layer multicast overlay network protocol is robust. Also, if you have good design and reasonable mesh topology the host logical address allocation mechanism (such as Content-Addressable Network) mesh network, can be next hop mesh routing information encoded into the logic area address in order to ensure the stability and quality of service routing.

However, mesh covered by the hosts on the network link between the redundant, routing algorithm needs to build among members of the group's forward loop-free path.

In [34] and [35] the agreement were introduced NARADA and CAN-based multicast overlay network based on multi-dimensional mesh of the two representative application-layer multicast protocol.

Narada protocol control path and data distribution path as shown, Narada node to specify a particular host, called the rendezvous point, the new member node is used for bootstrap operation.

When a new member want to join the group, it start with the RP to obtain a mesh has been added to the group members list.

New members of the group members randomly from the list, selecting the number of group members, and members of these groups as neighbors tried to cover the mesh in the past.

Add mesh, the new members need and refresh the mesh neighbors periodically exchange information.

Members join or leave multicast group, the group change information on the adoption of mesh transmission to all other members.

Each member of the group retains all of the members of the group's status information. This information is also periodically refreshed.

Each member state to the other members to send the message control information led to a heavy burden.

So Narada protocol multicast group members only in the case of a smaller number to be valid.

Narada protocol design allows the system to such a high burden of getting better control of the robust performance an agreement in time to recover from the failure group members.

The tree and mesh overlay network path between hosts coverage of the number of different, so the two different overlay network based on application layer multicast protocol topology with different performance characteristics.

Mesh overlay network based on application layer multicast protocol is robust, but less efficient routes;

Tree-based application layer multicast overlay network multicast routing protocol will reduce the complexity of the algorithm, but the robustness of the poor, vulnerable.

Both topologies are suitable for your application, we need a different application needs to select the appropriate topology, that is, the choice of overlay structure is carried out based on the application.

3. Implicit algorithm

Implicit algorithm and data structure topology of the routing control is no strict order to forward topology. Members of the nodes do not need additional interactive information. It has some special control topological properties to creating implicit agreement. These special properties of the implicit rules that define the data transfer, which implies the determination of the multicast path.

It can be seen, implicit agreement also defines tree or mesh, thus eliminating the need of interaction between members through the group to generate data from the control topology, or topological expansion for the control of the data topology.

The representation NICE protocol uses implied algorithms. Its basic idea is: the end nodes organized into a hierarchical structure, each layer formed over the size of the members to 3k-I k clusters, where k is a constant.

Closer to the physical location of the nodes in the same cluster, each cluster has a cluster head node, cluster head to the other members of the cluster the maximum distance in the least. All members are located in the bottom of L0, the first layer Li of all cluster group members Li +1. NICE will be located in the top cluster of cluster head is set to RP.

NICE was stratified as the figure 8 shown. Cases of all three members of the hierarchy of nodes, which led L0 cluster head node in the leadership of C, F, K is a member of L1, while C, F, K F cluster head node is the only member of the layer L2 node; All cluster leaders, L1 L2 constitute the first layer, the first layer L0 of all cluster leaders constitute the first layer L1, all members have joined the L0 layer.

![Figure 8. Hierarchy of Nice Agreement](image)

NICE members of the worst case load needed to control the average load control, the data forwarding path length.

Node degree for the level at which it is related to the maximum degree possible for, so NICE can not guarantee to meet the node degree of agreement this condition is limited, so do not apply to bandwidth-intensive multicast applications.

Directly affected by the other members of the cluster head of the performance, so NICE not suitable for heterogeneous environments.
In references [37] the experimental results show that, NICE in the delay and struck a better balance between costs, but the NICE protocol convergence is poor.

IV. THE INDEXES OF APPLICATION LAYER MULTICAST PERFORMANCE EVALUATION

Services are provided by using traditional unicast in the application layer multicast. The multicast characteristics are realized in the terminal of host application-layer. Then the network capability tried to transmit the unicast in the best-effort, such as group relations, addressing, multicast routing and packet replication.

Facilitated data transmission, efficient overlay network construction and maintenance are all the target of the application-layer multicast. We usually use the following indicators to evaluation the performance of application layer multicast. \([39, 40, 41, 42]\)

1) Multicast efficiency

Mainly reflected in the end to end delay and network bandwidth use, were the following two indicators: stretch and link stress. Stretch defined as a data source to the receiving members of the overlay network path length and the ratio of unicast path length. Link stress defined as multicast protocol to send the same content data packets through the network number of the underlying link. Note, IP multicast link the pressure is always one.

2) Robustness:

Refers to the change in the time group members (such as members join, leave or error), application layer multicast have the ability to quickly return to normal multicast communications.

3) Scalability:

Multicast is a packet distributed to members of a group of scalable way, when the application requires extended to a larger network, system maintenance costs of the non-linear growth is the main factor restricting the size of the user. Usually control the message data to measure the magnitude of the expansion of the system.

4) Load-balance:

Mainly refers to all nodes in the multicast efficiency, robustness, and the terms of control overhead generated by the relative equilibrium, respectively, expressed as follows:

Balanced workload: the terminal nodes and the multicast network link load relative to the average, the available link stress, pressure nodes and stretch the standard deviation indicated.

Failure of equilibrium: refers to the failure of the multicast performance of each node is roughly the same effect, and the smaller range of the node.

Cost equalization: controlling overhead generated by nodes is small, even in large-scale node.

5) Continues:

Continues is a parameter of QoS, which associated with a multimedia streaming player. In the transfer process, due to fluctuations in network throughput and communication conditions and the changes of needs, all led to delay jitter. Delay jitter is the delay between the sender and the receiver changes. The larger delay jitter may cause the player to interrupt or stop. That is not the user hope.

V. SUMMARY

With the application layer multicast level of research, the following aspects need further study:

1) Efficiency Hybrid network;

The application layer multicast and streaming media distribution technology mix, the use of the advantages of each complement each other and establish a network of high-quality mix of application level multicast system.

2) Scalability issues:

Adopt a "cluster" and "hierarchical" thinking to solve. Topological location of the relationship between group members organized according to the formation of cluster in each cluster, select one or more nodes within the cluster is responsible for management and data distribution. And further being selected to build new cluster nodes, the formation of a new level. That can increase the efficiency of multicast in further.

3) Robustness:

Join end systems due to frequent out a greater impact on system reliability, reduce system performance impact of dynamic, to take strict control mechanism, and weigh the good level of performance degradation and control mechanisms to improve relations.

4) Wireless multicast:

Expect to lower the cost of application layer multicast protocols will be extended to the wireless domain, proposed to the existing multicast technology to wireless mesh networks, wireless ad-hoc and wireless sensor networks; will become the future One of the hot.

5) In addition, the need for application layer multicast system on the quality of service, congestion control, security and other in-depth research.

With the deepening of the research and the future expansion of the industry needs, it will encounter more problems. If we can learn from in the types of technology integration framework of each other, such as application layer multicast, develop new hybrid system architecture with high-quality. It will be a reliable pave to the large-scale mass users of streaming media services.

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