An Active Handoff Algorithm based on The Retention Time of Complementary Nodes

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Abstract. Due to the frequent joining and quitting of nodes in P2P network, it often leads to the failure of accessing nodes, and the decrease of system availability. Some of the existing methods are to switch a node's service to its backup node after it is found to exit, and the backup node will continue to provide services. But the actual results are not ideal. The reason is that the service request of the node is always not responded from the time when the node exits the network to the time when the service switches to the backup node. This paper proposes an active handoff algorithm based on the retention time characteristics of complementary nodes. By predicting the exit time of the node, it finds the node complementary to the node in time as the backup node, and actively switches to the backup node before the node exits the network, so as to realize the service continuity. Experimental results show that the algorithm reduces the access failure and improves the system availability.

1. Introduction
In P2P network, the service provided by the service nodes is often in an unstable state because they freely join and exit the network, especially the exit of these nodes has a great impact on the service availability[1-3]. The service providing node is called the master node here. In order to maintain the stability of the service, the existing researches use backup node, service information synchronization and service switching to replace the service of the master node. In order to get the online status of each master node, the monitoring node is set to regularly monitor the heartbeat messages sent by each master node to sense its online status[4][5]. Once the node fails to send heartbeat messages due to overdue, its service is switched to the backup node. Experiments show that the success rate of service requests reaches 98.993%, but due to the problem of monitoring method, 1.007% of service requests still fail.

This paper proposes an active handoff algorithm based on the retention time characteristics of complementary nodes(AHA). By predicting the exit time of the master node, it finds the node complementary to the master node in time as the backup node, and actively switches to the backup node before the master node exits the network. Experiments show that this method reduces the request failure by 50%, and improves the availability of the system.
2. Bumpy Service
In the experiment, it is found that in the existing monitoring methods, the monitoring node will produce a monitoring blind area in each monitoring cycle. The monitoring node periodically checks the online status of each master node at a fixed time point, and sets the interval between any two adjacent detection time points as a monitoring cycle. However, the master node may exit the network at any time in each monitoring cycle, but the monitoring node will not find that the master node exits until the detection time point, and then the node is switched. During the period from the exit of the master node to the detection time point, because of the exit of the master node, it has been unable to provide services. If a service demand node requests the service of the master node during this period, then its request service will fail. This phenomenon is called bumping in this paper. If the master node exits at the start time of the monitoring cycle, the length of the monitoring blind area will be close to one cycle. With the service switching time, the possibility of service failure is further increased.

3. Active Handoff and Complementary Node Selection Algorithm
The service failure caused by bumping is temporary. As the system transfers the service of the master node to the backup node, the original service can be restored. There are two kinds of service handoff methods: active handoff and passive handoff. Active handoff means that the service is switched to the backup node before the master node exits the network, and the backup node replaces the master node to provide service. Passive handoff means that when the master node exits, the service will be switched to the backup node.

3.1. Properties of Active Handoff
In the network, although the exit of the master node and the request of the service demand node to the master node are independent events, there may be bumps in the process of active handoff.

The probability of bumping in active handoff is less than or equal to the probability of bumping in passive handoff. In the monitoring cycle, let \( t_0 \) be the node exit time, \( t_q \) be the handover start time and \( t_h \) be the handover end time. The period of active handoff bumping is in the node handoff period \((t_q, t_h] \), and the period of passive handoff bumping includes the exit node discovery period and the node handoff period is \((t_0, t_h] \). From the finite additivity of probability,

\[
P_{[t_0 < R < t_q]} = P_{[t_0 < R < t_q]} + P_{[t_q < R < t_h]}
\]

(1)

In (1) \( P_{[t_0 < R < t_q]} \geq 0 \), therefore

\[
P_{[t_0 < R < t_q]} \geq P_{[t_q < R < t_h]}
\]

(2)

In formula (2), that is to say, the probability of bumping in active handoff is less than or equal to that in passive handoff.

3.2. Active Handoff Algorithm
This paper uses complementary nodes as backup nodes. Complementary node is a node that has time intersection with the master node and exits later than the master node. It is possible to extend the service time by switching the service of the master node to the complementary node. In order to select complementary nodes with longer lifetime and reduce the frequency of handoff and the consumption of network resources, this paper proposes an active handoff algorithm based on the retention time of complementary nodes.

There are some rules for P2P nodes to join and exit from the network, for example, some enterprise user nodes have regular exit periods because of their fixed working hours, and social network user nodes also have their own regular work and rest time. In order to predict the joining and quitting time of the master node, the node information table and node activity schedule are set to record the activity time information of all m nodes in the network.
Node information table: node ID, node IP and port information, average join time, average exit time, state s; node activity schedule: node ID, join time, exit time, heartbeat state hb. The execution time of the algorithm is the detection time point of the monitoring cycle. Among them, the average joining time of node $p_i$ is $ET_i = \frac{1}{n} \sum_{j=1}^{n} et_{ij}$. The average exit time of node $p_i$ is $QT_i = \frac{1}{n} \sum_{j=1}^{n} qt_{ij}$. The average exit time of $m$ nodes is $Q^T = \frac{1}{m} \sum_{j=1}^{m} QT_j$. $m$ is the number of nodes, $n$ is the number of times that $p_i$ joins and exits, $et_{ij}$ is the time that $p_i$ joins for the $j$-th time, $qt_{ij}$ is the time that $p_i$ exits for the $j$-th time. Since the complementary node is selected from the online nodes, all the online nodes have time intersection, so the node with the longest average exit time can be selected as the complementary node. The active handoff algorithm based on the retention time of complementary nodes is as follows:

**Algorithm 1** The active handoff algorithm based on the retention time of complementary nodes

Input: Set $P$ of online nodes
Output: The complementary node $CP$ with $p_i \in P-p_i$ is selected and actively switched to $cp$

1. for $p_i$ in $P-p_i$:
   #Check whether the heartbeat of Pi has timed out.
   #pi.hb. Set to 1 by the monitoring node after receiving the heartbeat message
   2. if $p_i.hb=0$:
   3.     Record $p_i.QT_i$  #The $p_i$ exits after checking
   4.     Calculation $p_i.QT_i$ and $QT$
   5.     $p_i.s=0$
   6. elif:
   7.     $p_i.hb=0$
     #θ is less than the monitoring period
   8.     if time()-$p_i.QT_i$ ≤θ:
   9.         $cpq=cpe=p1$  #p1 $\in$ P-pi
10. for $cp_j$ in $P-p_i$:
11.     if $cp_j.s!=1$ and $cp_j.QT_j$ ≥ $cpq.QT$:
12.         $cpq=cp_j$
13.     if $cp_j.s!=1$ and $cp_j.ET_j$ ≥ $cpm.ET$:
14.         $cpe=cp_j$
15.     else:
16.         if $p_i.QT_i$ < $cp.QT$:
17.             $cp=cpq$
18.         else:
19.             $cp=cpe$
20. The service of $p_i$ switches to $cp$
21. $cp.s=1$

4. Experiment And Result Analysis

4.1. Experimental environment
In the simulation environment, the processor is Intel (R) core (th) 2 Duo CPU P8600 @ 2.40GHz 2.40GHz, the memory is 2.0Gb, the operating system is Windows Vista Home Basic, and the test platform is programmed with Python 3.9.0.

4.2. Verification of the nature of bumpy events
In order to verify the effectiveness of the active handoff algorithm based on complementary node retention time, in the experimental environment arranged in Section 4.1, the PHA algorithm is
compared with the AHA algorithm, and their bumps are tested by executing the PHA and AHA algorithms.

The test parameters are set as follows: the frequency of node joining and exiting the network is 1 node / S; The frequency of service request is 10 times / S; The number of network nodes are: 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 450, 500, 1000, 1500, 2000 and 20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 250, 300, 350, 400, 450, 500, 1000, 1500, 2000; The test time is 100s, 200s, 300s. The test results are shown in Figure 1, figure 2 and figure 3.
The above test results show that both AHA and PHA will produce bumps, but there are some differences in the frequency and change of bumps between the two switching modes. Under the same network scale, the bumping times of PHA is 50.89% higher than that of AHA. With the increase of the number of nodes, the bumping rate of PHA algorithm decreases gradually, but it is still very high compared with AHA algorithm.

In order to test the bumpy characteristics of the active handoff algorithm based on the retention time of complementary nodes under different access frequencies, we test the AHA algorithm under 8 access frequencies of 1-100ms, and the test results are shown in Figure 3. The test results show that the bumpy rate of the AHA algorithm is relatively low, the change is relatively stable, and the consistency is good. It shows that the use of complementary nodes as backup nodes for active handoff can reduce the occurrence of bumps.

In a word, under different network sizes, the probability of bumping in the active handoff algorithm based on the retention time of complementary nodes is obviously less than or equal to that of passive handoff, and with the increase of network size and the decrease of access frequency, the probability of bumping events will also decrease. AHA algorithm has better effect than PHA in avoiding bumping events.

5. Conclusions
Our research found that one of the factors affecting the availability of the system is that the master node bumps, because the monitoring node only checks the status of each network master node at a fixed time point in the monitoring cycle. When the master node can not be found for a period of time after it exits, and the node switching processing time, the service request to the master node will fail during this period. In order to reduce the occurrence of bumps, this paper proposes an active handoff algorithm based on complementary node retention time. Compared with the passive handoff method, it reduces the process of monitoring nodes to find the exit of nodes. The experimental results show that this method is better than the passive handoff method in reducing the occurrence of bumps.

Acknowledgments
This work was financially supported by Yunnan Provincial Education Department Scientific Research Foundation of China under Grant 2021J0839 and 2010C011.

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