利用分享式鏈結遷移法來建立無線非同步傳輸之分散式群播樹型架構

A Distributed Multicast Tree using Share Link Migration Scheme for Wireless ATM Network

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摘要

使用分享式鏈結遷移法來建立無線非同步傳輸之分散式群播樹型架構，此種方法可以盡可能增加分享式鏈結的數目減少連接佔線及因用戶端移動所導致的斷線可能。

Abstract

In recent years, wireless ATM networks have become popular and are in widespread use for supporting various types of data transmission. To minimize the cost in setting up the route and to meet the QoS constraint in time-sensitive traffic, in addition to bandwidth capacity, this paper focuses on the optimize the number of shared links to reduce the call-blocking rate and the handoff failure rate. Besides, the average longest path length and the average of the average path length of the constructed multicast trees are shown to be stable when the network load becomes heavy.

1. Introduction

When a mobile terminal becomes active in the wireless ATM network, we must setup a connection between the source node and the destination node before starting to transmit the data. As described in the previous section, we first look up the databases maintained in the node. At the same time, the source node broadcasts search messages to find the neighboring nodes that have existing route toward the destination node. We use the two-level shortest feasible path routing algorithm to find a common node that belongs to the shortest sub-path of the connection between the source node and the destination node. The most efficient route will be selected and other routes will be released. Since the traffic in wireless ATM networks can be divided into two types: time-sensitive and throughput-dependent traffic. In a lightly loaded network, we can use the same routing scheme to construct the time-sensitive multicast trees and throughput-dependent multicast trees. While in a heavily loaded network, to guarantee QoS, we can use different routing schemes to construct the different multicast trees separately.

Furthermore, if mobiles roam within the same cell (intracell), we do not need to rebuild a new connection to the ATM switch node. If mobiles roam into another cell (intercell), we must do the common node rerouting to setup a new connection between the common node and the destination node.

2. Algorithms

As stated in [1], the Shortest-Feasible-Path Routing (SFPR) scheme always tries to find the shortest path among all the feasible paths between the source and the destination node. This scheme is good when the performance is measured by the average of route distance. However, this scheme has a higher blocking probability for the future calls when the call requests are focused on some hot vertices or edges. The Least Loaded Routing (LLR) scheme is proposed to overcome the drawback of SFPR. It might obtain a lower call-blocking rate. However, the tradeoff is the longer average route distance since the least loaded route may not be the shortest. Even in light load, the LLR still changes the route dynamically. And this is quite unnecessary

The traditional multicast route has focused on reducing the bandwidth and delay cost in building the path. For supporting multimedia applications which require real-time data transmission in addition to end-to-end delay, the route bandwidth must be reserved so that the minimum transmission rate is guaranteed [2]. When the traffic is time-sensitive and the user is a new joined one, the connection should be setup as soon as possible. We first examine the neighboring nodes that belong to G_l. If we can find such a node, it is involved in the shortest feasible path routing. If not, we shall search the nodes that belong to G_h. If none is available, we can suspend the throughput-dependent traffic for a while and try to meet the bandwidth requirement needed by the time-sensitive applications. If the suspension of throughput-dependent traffic can't meet the bandwidth required, we try other nodes that belong to G_h and these nodes are preferred to the shortest feasible path routing. In the mean time, if the time limit of suspension expires, we can continue the throughput-dependent traffic in a round robin queue and search for the dynamic alternative routing to avoid the indefinite postponement problem. If all of these stated above are not feasible, the joining request is rejected.

If the neighboring nodes are available, we first check if there exists a path to the same server node. If the answer is positive, we can share the same links of the path if all links are available. In the mean time, we try the Two-level Shortest Feasible Path Routing algorithm to find the shortest path that has common node to the multicast tree. If the bandwidth capacity can't meet the bandwidth required, the user's request is rejected. We can follow these steps below to construct our own shortest feasible path:

Step 1: Search the preferred neighboring nodes in G_l, if nodes in G_l are not available, then search nodes in G_h. If both are unavailable, we can suspend the throughput-dependent traffic optionally. If this still can't meet the requirements, the request is rejected.

Step 2: If neighboring nodes are available, search the common node, which is destined to the same server, from the source to the destination node with the two level shortest feasible path algorithm to construct the shortest path. At the same time, we use the two level shortest feasible path routing algorithm to find the shortest feasible sub-path to the multicast tree if the bandwidth capacity of every link is feasible.

Step 3: Select the shortest path that has common node to the same multicast tree; otherwise, select the shortest feasible sub-path.

3. Migration for Exclusive and Shared Links

As stated in [3-4], if a mobile user roams into another cell, it uses the shortest feasible routing algorithm to setup the connection. Then the candidate node sends control messages to find the nearest common node to do the exclusive link migration. To improve the overall performance of the network, we use two-level shortest feasible path routing algorithm to setup the connection. In addition, to reduce the overhead incurred by the broadcast of control signals in doing the exclusive link migration, we progress the migration and the setup of the connection at the same time. After the roaming of the mobile users, it first uses the common node re-routing which has the shortest path to share the link as many as it can. If the sharing of the shortest connection is not available, then a new shortest feasible connection is setup. The network efficiency is evaluated to compare with a threshold value. As more users dispersed in the wide area ATM network, the bandwidth resource consumed by migration schemes for exclusive and shared links becomes an important factor which can affect the efficiency of the network. The algorithm for the exclusive link migration scheme is stated briefly as follows.

For v ∈ T, T is the set of leaf nodes
{Send search messages to all adjacent nodes u ∈ U, U is the set of adjacent nodes;

Update the search messages for each adjacent node;

If (eligible node not found){discard messages; release the channels occupied;}
Else {reserve channels for the connection;}
Select the first confirm message returned from u ∈ U;
Release the channels not used in this connection;
Inform the nearest common node ∈ U to do the connection chores if available
Else do shortest feasible path routing;
}

We propose a distributed algorithm with or without shared link migration scheme to compare them with the exclusive link migration scheme. Instead of finding the nearest common node of the multicast tree, we broadcast 'search' messages to find feasible paths that attach to the same multicast tree. And then we select the shortest among them. If this path is unavailable, we rebuild a new connection between the source and destination node. Once the path has been selected, the others will be released. The algorithm of our scheme is as follows:

Step1: Find common nodes that have connections to the destination;

Step 2: Select the most efficient one; release others;

Step 3: If both are unavailable, setup a new path using TSFPR

Similarly, the shared link migration scheme can be activated from the common node after the stability of the roaming user. And if the shared link migration would result in the congestion of the network, this migration will be aborted. We can maintain the status of each link in nodes involved in the connection between the source and the destination node. After reducing the number of shared links, we expect that the blocking rate and handoff rate will be reduced. And this means that the probability of joining and roaming in the network successfully increases. We also anticipate that the average of the average path length of these multicast trees becomes stable and the bandwidth resource of the network will not be consumed too much. The share link migration algorithm is as follows:

Share Link Migration Algorithm

Step1: The leaf node sends a control signal to common nodes of this path;

Step 2: The first common node then sends messages to find a shared path that is shorter than the old one;

Step 3: If found then do shared link migration else search next common node;

Step 4: If no common remained in the old path then done else go to Step 3

4. Simulation Model

There are two commonly used methods to evaluate the effectiveness of the network: one is mathematical model and the other is simulation. We shall adopt the latter one to verify the efficiency of the proposed multicast tree migration schemes. In our work, a torus style network model with bi-directional links connecting all its neighboring nodes is considered. The model for the network is ATM switch-based backbone with a size 10 by 10.

Since the focus of our work is on the construction and improvement of multicast trees which are built and based on wired ATM network, we shall ignore the wireless portions of this network. Each vertex represents a cell that is connected to an ATM switch and with a unique identifier. There are databases associated with each cell in the network to keep track of all transactions. The information that is recorded in these databases includes types of traffic, routing/rerouting strategies, residual capacity, buffering of throughput-dependent data, and so on. We assume that the transmission capacity of each link is one hundred and fifty megabits per second. Since the transmission rate of wireless portions in wireless ATM network is about two megabits per second, we assume that the maximum number of two megabits per second multimedia services that can fill up a link is seventy-five. With fifty megabits per second of capacity reserve for voice, data and control signaling, we have one hundred megabits per second for multimedia applications. The assumed maximum number of joined mobile terminals for each multicast service, such as video on demand (VOD) and video conferencing, is limited as M. The destined server is randomly selected from the existed feasible servers for newly joining request. When the associated multicast tree has a size less than the limitation M, we say that the existed server is available. We use the two level shortest feasible path routing algorithm to establish the new join connection. When a new mobile joins into the network, the two level shortest feasible path routing algorithm is used to find a shortest feasible path from the source node to the node that is on the same multicast tree and that has the shortest path to the destination node. At the same time, we find the shortest sub-path to the multicast tree that is destined to the same server. Then we select the more efficient one to be our new connection and release the others. We assume that there are 2000 users wanting to join in the network. The arrival rate of new join request is assumed to be a Poisson distribution with mean A. When the residual capacity of the path is exhausted or the limitation of the multicast tree M is exceeded, the join request of a mobile is rejected. The departure rate of joined mobiles is also assumed to be a Poisson distribution with mean D. We select R users among the active users randomly to roam within the network. If the roaming mobiles move within the same cell, we do not need to rebuild the connection. Otherwise, we must perform the rerouting algorithm to find an efficient path.

In the simulation of our work, the following parameters are considered:

(1) There are totally 2000 users wanting to participate in the network;
(2) On the average, there are ten joined mobile users which are randomly selected to depart from the network per unit time, D=10;
(3) On the average, there are one hundred mobile users who arrive and join the network per unit time, A=100;
(4) We try R=25 to investigate the behavior of the network;
(5) We assume that the maximum number of mobile users allowed to join in a multicast tree is twenty, M=20 and there are 10 servers randomly selected from these network nodes;

In this network we apply the two-level shortest feasible path routing scheme that finds the shortest path to the same multicast tree. And we find the Shortest Feasible Path Routing with exclusive link migration scheme. Then we select the shortest feasible path to be our new path. Besides, the shared link migration scheme is implemented to investigate the performance of the same network.

For a generated mobile user request r_i ($1 \leq i \leq c$), if the request is accepted, we let accept(r_i)=1; otherwise, accept(r_i)=0. While the mobile roams, we let roam_accept(r_i)=1 if the request of connection is accepted; otherwise, roam_accept(r_i)=0. We also let distance(r_i) equal the hop count of the established connection between the source and the destination node if the request r_i is accepted; otherwise, distance(r_i) is set to be infinity.

We define the following metrics to evaluate the performance of the migration schemes:

(1) Call Blocking Rate :

$$1 - \sum_{i=1}^{c} accept(r_i) / c \;,\; r_i = 0;$$

c is the total users that want to join in the network.

(2) Handoff Failure Rate :

$$1 - \sum_{i=1}^{d} roam\_accept(ri) / d \;,$$

r_i=0; d is the total users that want to roam within the network.

(3) Average of the Average Path Length : Let

$$AVG\_P(i) = \sum_{i=1}^{p} Path\_Length(i) / p$$

, we have the average of the average path length as

$$\sum_{i=1}^{t} AVG\_P(i) / t \;.$$

(4) ALP : the average of the longest path length in the constructed multicast trees;

ALP= (total of the length of the longest path in every constructed multicast tree)/(number of multicast trees)

In the next section, we shall explain and show the simulation results by charts.

5. Simulation Results

The performance of the three schemes on the torus network is shown in Figure 1 through Figure 4. Figure 1 shows the blocking rates while the number of roaming users is twenty-five. Obviously, the scheme with share link migration can reduce the call-blocking rate. This means that the new joining mobiles have more chances to build the connection successfully. Using our scheme without doing share link migration, the call-blocking rate is better than that with the exclusive link migration scheme since it consumes less bandwidth resource. Owing to the hot node effect, the network will saturate with the control messages to build the new connection. This accounts for the abrupt rising of the call-blocking rate and handoff failure rate curves. After that saturation point, the call-blocking rate increases slowly. In the wireless ATM network, if the number of roaming users is small, the overhead incurred by sending control messages doesn't affect the performance of the share link migration scheme much. In Figure 2, as the roaming users increase, the overall performance of our schemes with share link migration is better than the other two schemes on the average. There is also a saturation point. Our scheme without share link migration is still better than that using exclusive link migration scheme. In Figure 3, the average of the average path length of our scheme with share link migration is better than that with exclusive link migration scheme. And our scheme without share link migration also has shorter AAL than that with exclusive link migration scheme. Once we select the path in our scheme, it is the shortest among other paths. This is why our scheme without doing further migration has shorter AAL than using exclusive link migration scheme. And it is a good metric because longer path length means more consumed bandwidth resource. While the roaming users increase, the probability of selecting a node that is destined to the same multicast tree increases. The tradeoff between the bandwidth that is occupied by control messages and the increased probability that a user can build a new connection makes the blocking rate grow slowly. In Figure 4, the average of the longest path length in the constructed multicast trees tends to be stable. Our schemes with or without share link migration have shorter longest path lengths than the longest path lengths that the exclusive link migration scheme has. This metric also accounts for the reason why our schemes spend less bandwidth resource and have lower call-blocking rates and handoff failure rates.

6. Conclusions

Three algorithms for the construction of multicast trees on wireless ATM communication networks are studied and compared in this paper. The heuristic algorithm with/without share link migration that we proposed shows that it has lower blocking rate and handoff failure rate in general when the network load is heavy and the roaming users increase. Finally, we show that when mobile users increase and the network load becomes heavy, the AAL and ALP metrics become stable and our proposed scheme with/without share link migration is better than the exclusive link migration scheme.

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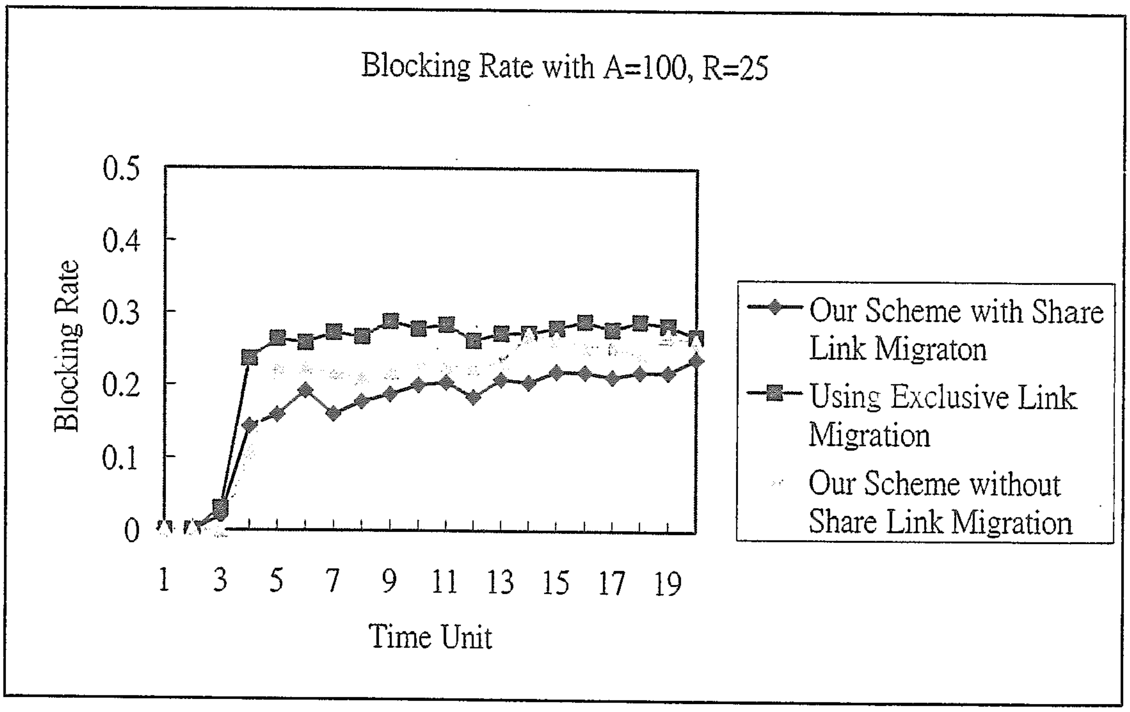

Figure 1 Call Blocking Rate with R=25

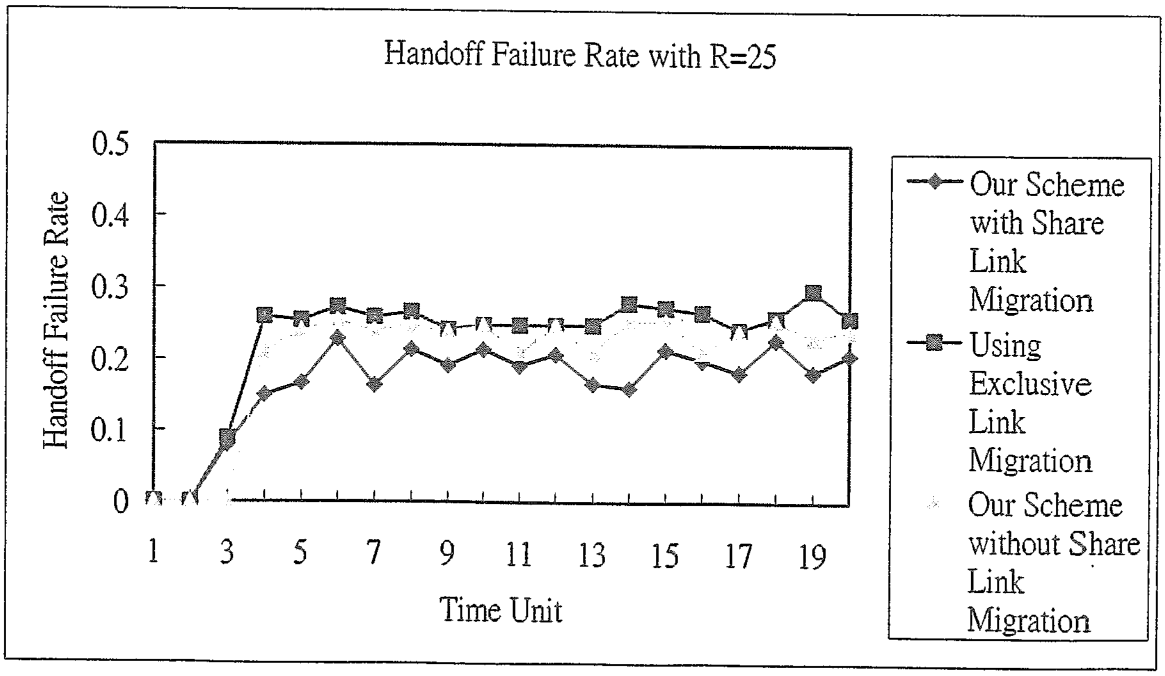

Fig 2 Handoff Failure Rate with R=25

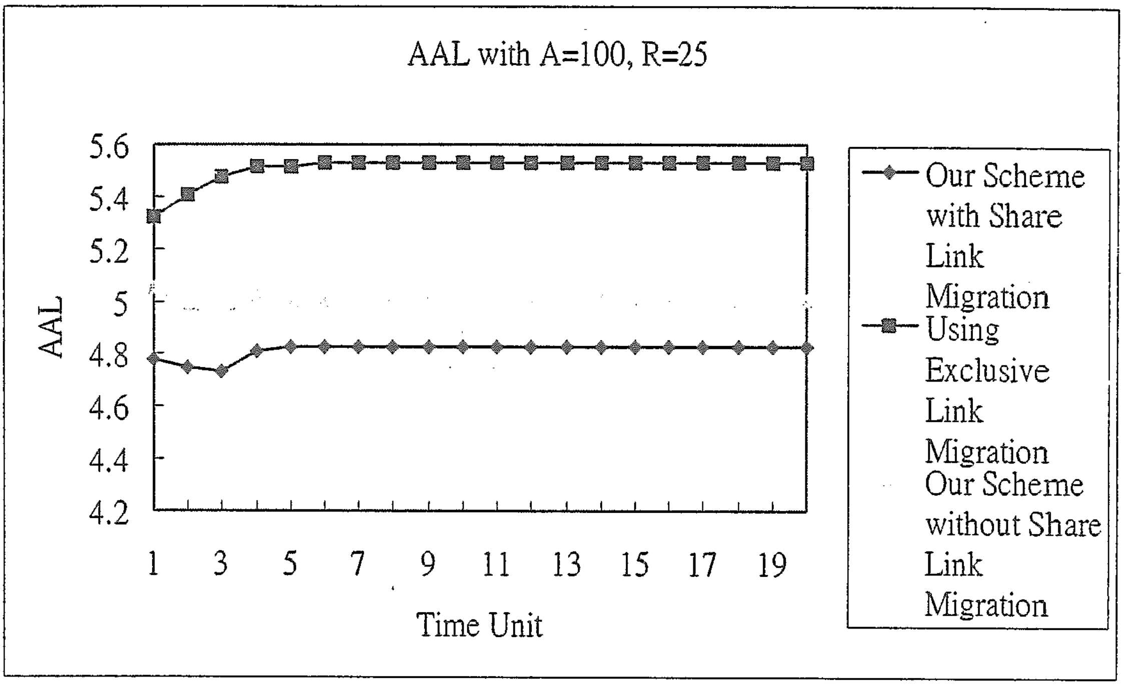

Fig 3 AAL with R=25

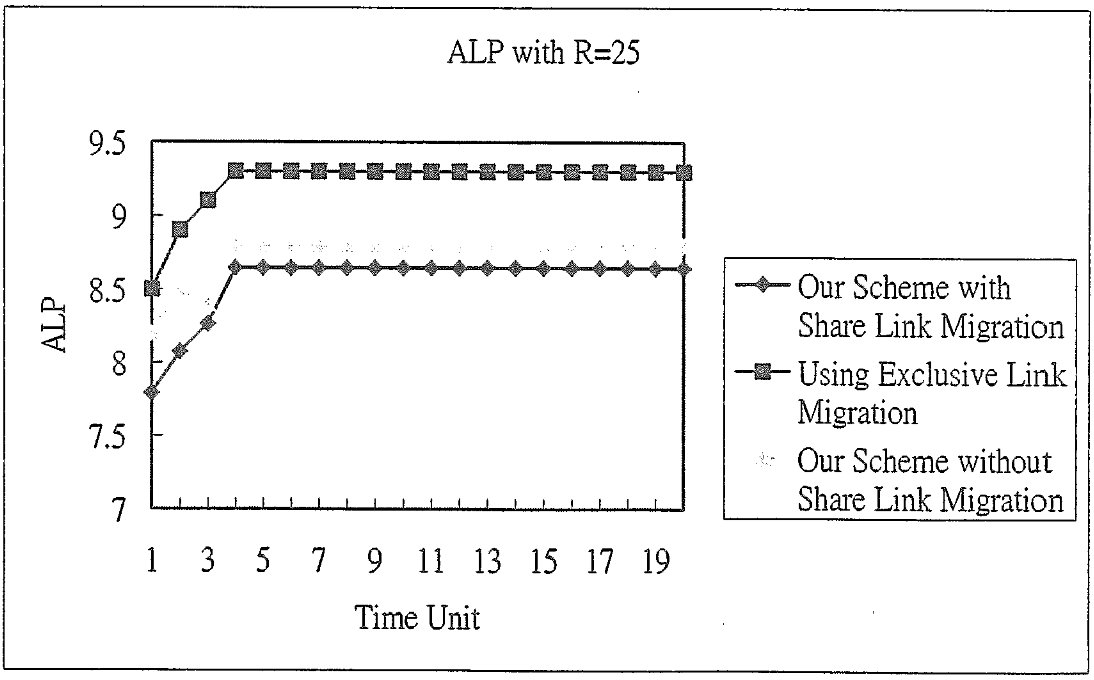

Fig 4 ALP with R=25