A Forwarding-chain based Mobile Multicast Scheme with Management Support

Zhiwei Yan, Huachun Zhou, Hongke Zhang
National Engineering Laboratory for Next Generation Internet Interconnection Devices,
Beijing Jiaotong University
Beijing, China
{06120232, hczhou, hkzhang}@bjtu.edu.cn

Abstract—In this paper, we propose a mobile multicast architecture with management support. In this architecture, a powerful entity called Multicast Controller (MC) is deployed which handles most of the multicast management-related tasks. Based on this architecture, the mobile multicast routing protocol called Fast Chain Mobile Multicast (FCMM) is proposed, which processes the handover in advance and spans the multicast tree using the forwarding chain. Our analysis demonstrates that the FCMM protocol outperforms other related protocols and is a promising alternative for providing efficient and flexible mobile multicast services.

Keywords—centralized management; mobile multicast

I. INTRODUCTION

IP multicast is a term associated with the network support for efficient data delivery to more than one interested recipients [1-2]. However, it is challenging to support the ongoing IP multicast communication with minimal disruption while the hosts are moving. In order to solve this problem, it has been studied as a hot topic to accommodate the multicast service in the Mobile IPv6 (MIPv6) network [3]. Based on MIPv6, the multicast can use one of two models to support the mobility. In Bi-directional Tunneling (BT), the Mobile Node (MN) joins the group via a bi-directional tunnel to its Home Agent (HA). Alternatively, in Remote Subscription (RS), the node joins the group directly via the Access Router (AR) to which the MN is connected. Although the BT and RS offer a functional platform for the mobile multicast in IPv6 network, a plethora of limitations have been identified. Typical examples include tunnel convergence and handover issues. As a result, the handover causes delay, loss, jitter and packet duplication for the mobile multicast. In order to overcome the various performance issues of BT and RS, many extensions have been proposed. As different approach adopts different style, the result is a large number of deployment options and the following is a brief sample:

- Dynamically adaptive schemes. This type of solutions attempt to “adapt” the join process according to the current location of the MN. A representative example of this category is Range-Based Mobile Multicast (RBMoM) [4]. RBMoM is a balance between the BT and RS mechanisms. It defines a special role, the Multicast Home Agent (MHA). Initially the operation is based on the BT scenario as the MHA is the HA itself. It continues to be so as long as the MN falls within a pre-defined hop range. When MN goes beyond this range, the role of the MHA is taken by an AR, thus switching the operation to RS.
- Hierarchical designs. In the protocols of this style [5], there is an attempt to hide micro-mobility of MN by deploying a hierarchy of routers.
- Proactive schemes. Representative example of this category is MFH [6]. It configures the new Care-of-Address (CoA) using the link layer (L2) information in advance to shorten the handover delay, and creates the tunnel between Previous Access Router (PAR) and New Access Router (NAR) to minimize the packet loss.

Each of the above solutions can address a specific set of problems. However, their gains have to be integrated to design a novel mobile multicast scheme. So we address the problem of providing efficient, flexible and manageable mobile multicast services for mobile users in this paper. The remainder of this paper is organized as follows. In Section II and Section III, we give the detailed descriptions of the new mobile multicast architecture and the newly proposed mobile multicast routing protocol, namely Fast Chain Mobile Multicast (FCMM). In Section IV and Section V, we evaluate the performance of the FCMM and give the numerical results. Finally, we summarize the paper and discuss some future work in Section VI.

II. DESIGN ISSUES OF OUR SCHEME

A. Architecture

The proposed scheme is based on the architecture illustrated in Fig. 1, which has three layers: management layer, routing layer and access layer.

![Figure 1. Proposed multicast architecture](image-url)
In the management layer, we introduce an entity, called Multicast Controller (MC), to control and manage the multicast service. MR is the Multicast Router in the routing layer. Although the MR and AR can adopt any kind of multicast routing protocol, we illustrate it for the Protocol Independent Multicast-Sparse Mode (PIM-SM) [7] case in this paper and RP denotes the Rendezvous Point. As shown in Fig. 1, the RP and MC are logically separated in order to separate the multicast management service and multicast routing service, although they can be co-located for simplicity. Each MC should be owned by an ISP who provides multicast service, so that the ISP centralizes most of the service management related tasks on the MC. An ISP may own more than one MC in the Internet for scalability and robustness considerations. However, we only consider the simplest case in this paper with only one MC in one ISP [8]. Access layer consists of physical links of the end hosts. The AR in this layer bridges the access layer and the routing layer. Besides, AR has the responsibility to authenticate the multicast source and receivers. The MC is responsible for starting a new multicast session, tearing down an expired multicast session, and providing the multicast Authentication, Authorization and Accounting (AAA) [9] service, using the ‘Request’, ‘Reply’, ‘Report’ and ‘Command’ signaling messages. The Command message is sent from MC to the AR for the multicast service configuration and Report message is its response. While the Request message is sent from AR to the MC for the information query and the Reply is its response. Besides, they can be used for the communication between ARs. The management modules and their interactions are illustrated in Fig. 2.

![Figure 2. Management modules](image)

The ‘AR module’ and ‘MC module’ are used to implement the AR and MC functions. The ‘Management files’ are used to store the information of the related multicast service. Between the ‘AR module’ and ‘MC module’, there is a logical interface to support the communication between them. As shown in Fig. 1 and Fig. 2, four types of messages shown in Fig. 3 are defined to bridge the entities.

![Figure 3. Format of the newly defined messages](image)

<table>
<thead>
<tr>
<th>Type</th>
<th>Reserved</th>
<th>Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
<td>4</td>
</tr>
</tbody>
</table>

The 8-bits length ‘Type’ is used to identify the message type. The 8-bits length ‘Reserved’ area is used for the functional extension. The ‘Length’ area is used to identify the length of the related message. The ‘ID of source or receiver’ and ‘Multicast Identifier (MI)’ are used to identify the source or receiver and related multicast group. Then the optional Attribute-Value Pairs list (“AVP” list) is attached [9]. In our scheme, some new AVPs shown in Fig. 4 are defined. The Join-Indication is an one bit flag to instruct the MN’s join event. However, its value set to ‘1’ or ‘0’ means the local join or RP join respectively, and this will be explained in the next section in detail. The Leave-Indication is another one bit flag and its value set to ‘1’ means the MN want to leave the multicast group. The AR-RP-Address carries the address of target AR or RP. And AR-MAC-Address carries the Media Access Control (MAC) address of the target AR.

![Figure 4. Newly defined AVPs](image)

### III. FCMM

In the proposed mobile multicast scheme, namely, Fast Chain Mobile Multicast (FCMM), the original multicast tree is constructed using the basic PIM-SM protocol.

![Figure 5. Operation of the FCMM scheme](image)

When the receiver moves, the MC determines how the multicast tree should be spanned to the new location of the receiver. In the first case, the multicast path is extended from the current location to the new location directly. In the second case, the join message is sent from the new AR to the RP for the multicast rejoin. As proposed in study [10], we define two types of Multicast Path (MP) for the multicast packets transmission: active MP and passive MP. The active MP is the one from the RP to the current AR and is currently used to transmit multicast data and the first AR which joins the multicast tree through RP is denoted as ‘master AR’ in this paper. Besides, the passive MP is the one from the current AR to the new AR and this MP is not currently used until its activation. All the information of ARs is stored in MC and the target AR is selected by the MN according to the L2 information. When the handover is triggered, the MC indicates the current AR whether the exiting multicast tree should be extended or reconstructed using the ‘Join-Indication’ AVP.
During the handover process, the current AR buffers the in-flight multicast packets to avoid the packet loss. After the handover, the management information in MC should be updated. The detailed operation of the FCMM scheme is depicted in Fig. 5 and the explained as follows:

(1) Once the MN enters an overlapped area of the boundary cells of two subnets, it receives a L2 beacon from the possible target AR.

(2) Immediately, the MN notifies the Current AR for the possible handover by sending a Handover Initiation (HI) signaling message, which contains the MAC address of the new Access Point (AP) as in [7]. Note that in this case, the MN is not yet connected to the radio link of the Target AR.

(3) When the current AR receives the HI message, it sends the Request message (including the MN’s ID, MI and the AR-MAC-Address AVP) to the MC.

(4) Based on the history mobility of MN stored at MC, MC replies with the indication of how to span the multicast tree to the Target AR.

(5) When the Handover Acknowledge (Hack) message is sent from the Current AR to the MN, the MN can configure the new IP address according to the prefix information carried in the Hack message.

(6) Then, the following procedures are separated into two cases.

(6.1) In Case 1, the Current AR prolongs the MP to the Target AR. The multicast data destined to the MN are intercepted by the RP and sent to the Current AR using the existing MP between them. When the handover happens, the packets are forwarded along the AR chain.

(6.1.1) When the Current AR receives the Reply message from MC, it adds the AR in the message to the “downstream” of the routing entry. Doing so, an extra passive MP is established between the Current AR and the Target AR.

(6.1.2) Specifically, the L2 handover is launched by the MN when the received signal strength from the current AP falls below the threshold level. Then the MN sends the Leave message to the Current AR to notify its immediate handover.

(6.1.3) Then, the Current AR initiates the packets buffering.

(6.1.4) Once the L2 handover is accomplished, the network layer (L3) handover is initiated by the MN. When the MN receives the new Router Advertisement (RA) message from the Target AR, it sends the Join message to the Target AR immediately since the new IP address is already configured.

(6.1.5) The Target AR sends the Report message to the MC to notify the handover event of MN. Then the MC updates the management information accordingly.

(6.1.6) Besides, the Target AR activates the passive MP between the Current AR and the Target AR.

(6.1.7) Then the buffered packets and the following traffic will be delivered through the activated MP to the MN.

(6.2) It is easy to see that such a scheme may cause unacceptable delays due to long chain. So we set a threshold on its length denoted by $L_w$ (in terms of the number of movements) [10]. When the threshold is reached, the MC will command the Target AR to join the multicast tree through the RP. At the same time, the Target AR becomes the master AR of the next multicast forwarding chain.

(6.2.1) So in the Case 2, the threshold is reached and the reconstruction of multicast tree is needed. The Join-Indication is set to 0 and the RP address is carried in the Reply message. The Current AR sends the Command message (containing MN’s ID, MI, Join-Indication=0, and the address of RP) to the Target AR directly.

(6.2.2) The Target AR joins the multicast tree through RP.

(6.2.3) When the received signal strength from the current AP falls below the threshold level, the L2 handover is launched by the MN.

(6.2.4) After the handover, the Target AR forwards the Report message to the MC to notify the handover event of MN. As soon as the MC receives the report message, it updates the management information.

(6.2.5) Then the following traffic will be delivered through the newly constructed MP from RP to the target AR and the Target AR will act as the new master AR of MN’s next multicast forwarding chain.

As illustrated above, the performance of FCMM is improved for two reasons: the first one is that the handover of MN is processed in advance and the second one is that some RP joins are replaced by the forwarding chain prolonging.

IV. PERFORMANCE EVALUATION

Although there are many schemes proposed to support the multicast mobility, FCMM is similar with RBMoM because both of them adopt the local join for the mobile multicast. However, the RS scheme can be considered as a special case of FCMM and RBMoM. So in this section, we compare the performance of RS, RBMoM and FCMM in depth.

A. Network mode

During the performance evaluation, we adopt the network model shown in Fig. 6.

For convenience, let $\tau(s,h_{x,y})$ denotes the time takes by a message of size $s$ to be forwarded from entity $x$ to entity $y$ via both wired and wireless links. $h_{x,y}$ denotes the number of wired link hops between $x$ and $y$. Then, $\tau(s,h_{x,y})$ can be expressed as

$$\tau(s,h_{x,y}) = c + h_{x,y}\times\left(\frac{s}{B_w} + L_w\right) + (h_{x,y} + 1)\times P_f$$  \hspace{1cm} (1)

Where $c$ denotes the latency induced by the wireless link,
\[ c = \begin{cases} \frac{s}{B_{wl}} + L_{wl} & \text{if } x = MN \text{ or } y = MN \\ 0 & \text{otherwise} \end{cases} \] (2)

\[ B_{wl} \text{ and } B_{w} \text{ denote the bandwidth of wired link and wireless link respectively. } L_{wl} \text{ and } L_{w} \text{ denote the latency of wired link and wireless link respectively. } P_t \text{ is the routing lookup and processing delay} [10]. \]

The average distance between RP and AR is \( i-1 \), and then \( i \) denotes the distance between RP and MN;

We assume that there exists only one AP within one subnet, then the average number of handovers during a multicast session is \( \frac{N_b}{L_{th}} \), where \( L_{th} \) is the duration time of the multicast session and \( R_{th} \) is the average subnet resident time of MN. And then the average number of reconstructions of the multicast tree for FCMM during a session is \( \frac{N_f}{N_b} / L_{th} \).

B. Mobility model of MN

Let \( X(t) \) be the hops between the master AR and the subnet in which the MN is located at time \( t \). The residence time of the MN in subnet \( i \) is assumed to be exponentially distributed with the mean value \( \frac{1}{\mu} \). \( \{X(t), t \geq 0\} \) forms a Continuous-Time Markov Chain (CTMC) with state space \( S = 0, 1, 2, \ldots, (L_{th} - 1) \) as depicted in Fig. 7 [10].

![Figure 7. CTMC of the proposed mobility model of MN](image)

Let \( \Pi_i = \lim_{t \to \infty} \text{Pr} \{X(t) = d\}, d \in E1 \), be the stationary probability distribution of \( X(t) \). Based on Fig. 7, the balance equations can be derived as follows:

\[ 2p\mu\Pi_0 = p\mu\Pi_1 + p\mu\Pi_{L_{th}-1} \]
\[ 2p\mu\Pi_1 = 2p\mu\Pi_0 + p\mu\Pi_2 \]
\[ 2p\mu\Pi_d = p\mu\Pi_{d-1} + p\mu\Pi_{d+1} \]
\[ \forall 2 \leq d \leq (L_{th} - 2) \]
\[ 2p\mu\Pi_{L_{th}-1} = p\mu\Pi_{L_{th}-2} \]
\[ \sum_{d=0}^{L_{th}-1} \Pi_d = 1 \] (3)

Solving these equations, we obtain:

\[ \begin{align*}
\Pi_0 &= \frac{1}{L_{th}} \\
\Pi_d &= \frac{2(L_{th} - d)}{L_{th}^2} \forall 1 \leq d \leq (L_{th} - 1)
\end{align*} \] (4)

Let \( TH \) denote the average transmission hops of multicast packets, which is the number of hops for packet delivery from RP to the MN’s currently attached AR. For RS, multicast packets are always delivered through the shortest path. Hence, multicast packets sent from the RP to AR traverse \((l-1)\) hops. However, if the AR is selected to be the MHA in RbMoM, and the hop threshold is also set to \( L_{th} \). The average value of \( TH \) in RbMoM and FCMM can thus be given by

\[ TH (\text{RbMoM/FCMM}) = (l-1) + \sum_{d=1}^{L_{th}-1} d\Pi_d \] (5)

Where the first term \((l-1)\), is the number of hops from the RP to the MHA/master AR and the second term is the mean path length used to forward packets from the MHA/master AR to the current AR (i.e., average forwarding chain size).

C. Handover latency

The handover latency \( HL \) is the time interval from the moment that MN can not receive any multicast packets from the current AR to the moment that MN receives the first multicast packet from the new location.

\[ \begin{align*}
HL(\text{RS}) &= D_{12} + D_{AB} + D_{AC} + t(s_i, \tilde{h}_{MN-AR}) + t(L_{th}, \tilde{h}_{MN-AR}) \\
HL(\text{RbMoM}) &= D_{12} + D_{AB} + D_{AC} + t(s_i, \tilde{h}_{MN-AR} + \tilde{h}_{AB-MHA}) \\
&+ \frac{N_f}{N_b} t(s_i, \tilde{h}_{MN-AR}) + \frac{N_f}{N_b} t(s_i, \tilde{h}_{MN-AR}) \\
&+ \frac{N_f}{N_b} t(s_i, h_{MN-AR}) \\
HL(\text{FCMM}) &= D_{12} + t(s_i, \tilde{h}_{MN-AR} + h_{AB-MHA}) + \frac{N_f}{N_b} t(s_i, \tilde{h}_{MN-AR}) \\
&+ t(s_i, \tilde{h}_{AB-MHA}) + \frac{N_f}{N_b} t(s_i, h_{MN-AR}) \end{align*} \] (6)

Where \( D_{12} \), \( D_{AB} \) and \( D_{AC} \) are the handover latency components corresponding to L2 handover, movement detection, and new address configuration respectively. \( s_i \) and \( L \) are the average size of signaling message multicast packet length. The hops between AR and the nearest router in the tree is denoted by \( h_{MN-AR} \), which was formulated in study [11].

\[ \tilde{h}_{MN-AR}(N, \rho) = \frac{1}{\sqrt{\pi}} + \frac{1 - \sqrt{\rho}}{8} (1 - \rho) \sqrt{N} (1 - \sqrt{\rho}) \] (7)

Where, \( \rho = M / N \) is the multicast density. \( M \) and \( N \) denote the number of routers already in the multicast tree and the total number of routers in the network respectively. For RbMoM, there are two cases for the handover, the first one is the local join from the target AR to the MHA and it equals to \( t(s_i, \tilde{h}_{MN-AR} + \tilde{h}_{AB-MHA}) \), \( \tilde{h}_{AB-MHA} = \sum_{d=1}^{L_{th}-1} d\Pi_d \) denotes the average number of hops between the current AR and MHA.
\[ N_l \frac{1}{N_k} (s_l, h_{MN \rightarrow AR}) \] denotes the effect of rejoin process and the last two parts are the average packet transmission latency. The process of FCMM is similar with that of RBMoM.

D. Protocol cost

Protocol cost (noted as PC) consists of the signaling cost (noted as CS) which is the sum of signaling cost for the multicast tree spanning and the delivery cost (noted as CD) which is the sum of packets delivery cost during the residence time in a subnet. In this subsection, \( hops \times packet\ size \) is used to compute the cost [12]. If the multicast packet arriving rate is \( \lambda \), the total cost of the RS is

\[ PC_{RS} = CS_{RS} + CD_{RS} \]

\[ = s_l \times h_{MN \rightarrow AR} + \lambda LR \times (h_{MN \rightarrow AR} + h_{AR \rightarrow RP}) \] (8)

In RBMoM and FCMM, a local join is required as long as the length of forwarding chain does not reach the threshold. Otherwise, a rejoin process is performed. This happens when the distance between the current AR and the master AR/MHA is \( L_0, 1 \)-1 and the MN moves in the direction that increases this distance (which happens with probability \( p \) ) [10]. Then the protocol cost of the RBMoM scheme is

\[ PC_{RBMoM} = CS_{RBMoM} + CD_{RBMoM} \]

\[ = \left[ \frac{1}{N_f} s_l \times h_{MN \rightarrow AR} + \sum_{j=1}^{l-1} \rho \Pi_j s_j (h_{MN \rightarrow AR} + d) \right] \]

\[ + \lambda LR \times TH(\text{RBMoM}) \] (9)

Where the first part denotes the average effect of rejoin signaling cost, the second part denotes the average effect of local join signaling cost and the last part is the average packet delivery cost during the residence time in a subnet.

Just like in RBMoM, the protocol cost of the FCMM is

\[ PC_{FCMM} = CS_{FCMM} + CD_{FCMM} \]

\[ = \left[ \frac{1}{N_f} s_l \times h_{MN \rightarrow AR} + \sum_{j=1}^{l-1} \rho \Pi_j s_j (h_{MN \rightarrow AR} + h_{AR \rightarrow AR}) \right] \]

\[ + \lambda LR \times TH(\text{FCMM}) \] (10)

V. NUMERICAL RESULTS

The parameter settings are listed in Table 1 [10–13].

![Table 1: Related Parameters](#)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>( L_0 )</td>
<td>1000s</td>
<td>( B_w )</td>
<td>100Mbps</td>
</tr>
<tr>
<td>( R_f )</td>
<td>30s</td>
<td>( L_w )</td>
<td>1ms</td>
</tr>
<tr>
<td>( L )</td>
<td>1000bits</td>
<td>( P_f )</td>
<td>0.001ms</td>
</tr>
<tr>
<td>( s_l )</td>
<td>48bits</td>
<td>( B_{ref} )</td>
<td>100Mbps</td>
</tr>
<tr>
<td>( L_{th} )</td>
<td>1~10(default 4)</td>
<td>( L_{col} )</td>
<td>2ms</td>
</tr>
<tr>
<td>( D_{L2} )</td>
<td>100ms</td>
<td>( D_{MD} )</td>
<td>25ms</td>
</tr>
<tr>
<td>( l-1 )</td>
<td>3~10 (default 5)</td>
<td>( D_{AC} )</td>
<td>1s</td>
</tr>
<tr>
<td>( h_{AR \rightarrow AR} )</td>
<td>1 ((N, \rho))</td>
<td>( h_{MN \rightarrow AR} )</td>
<td>( 100, 0.25 )</td>
</tr>
</tbody>
</table>

A. Handover latency

Fig. 7 shows the impact of \( l-1 \) and \( L_{th} \) on the handover latency for the three schemes.

![Figure 7: Handover latency](#)

As shown in left figure, the handover latency of the three schemes increases with the increase of the distance between RP and AR. However, the slope of RS is larger than that of RBMoM and FCMM. That is because the reconstruction of multicast tree from the current AR to RP happens for every L3 handover in RS. However, the multicast tree only needs to be reconstructed when the hops between the target AR and MHA/master AR reaches the pre-configured threshold in RBMoM and FCMM. Besides, FCMM is the best scheme with the lowest handover disruption time thanks to the fast handover process and optimized local join process.

As shown in the right figure, the chain threshold has no impact on the average disruption time of RS and FCMM. For RS, the disruption time depends on the distance between RP and AR. For FCMM, the disruption time depends on the distance between the neighboring ARs when the chain threshold is not reached. Because the distance between the neighboring ARs is always much smaller than the distance between AR and RP, the disruption time of FCMM is the lowest one. For RBMoM, when the threshold is zero, it is the RS scheme. However, with the increasing of the threshold, the handover disruption time increases due to the distance between the current AR and MHA increases. There is a valley when the threshold equals to one, which is because the MHA is refreshed for every handover of MN and then the current AR and MHA are always two neighbors in this case. When the threshold is larger than eight, the average handover disruption time of RBMoM is larger than that of RS. So the scalability of RBMoM is poor and the threshold should be set carefully.

B. Protocol cost

Fig. 8 plots the different multicast tree spanning cost as a function of \( l-1 \) and \( L_{th} \).
Besides, we can observe from the right figure that the cost of FCMM decreases with the increase of $L_{th}$. Besides, we note that when the threshold is set to one, the FCMM has the same performance with RBMoM and the RBMoM has the lowest cost in this case. That is because the distance between the MHA and the current AR has the lowest value for the local join. Besides, when the threshold is larger than four, the performance of RBMoM deteriorates and its cost is larger than that of RS afterwards. For RS, the multicast tree spanning cost only depends on the distance between AR and the nearest router in the multicast tree.

Fig. 9 shows the effect of the Call-to-Mobility Ratio (CMR) on the total protocol costs for different schemes.

![Figure 9. Effect of CMR on the total cost](image)

CMR is defined as the ratio of the packet arrival rate to the mobility rate [13]. In Fig. 9, we observe that when the CMR is small (i.e., when the MN hands over frequently), the FCMM scheme generates less signaling traffic than RS which is more suitable for MN with high CMR thanks to the optimized packet transmission path. When the CMR is large, the total cost is mainly determined by the packet transmission cost and it increases due to the additional hops induced by the forwarding chain in FCMM and RBMoM. According to these results, we can conclude that the FCMM is more suitable for MN with high mobility speed.

VI. CONCLUSION

In this paper, we propose a management supporting multicast architecture and an efficient mobile multicast scheme (FCMM). Compared to the existing mobile multicast schemes, the FCMM can be used to provide the multicast authentication, multicast security and multicast accounting if necessary. From the analyzing results, we can see that FCMM enables a significant reduction of the multicast join cost during the movement of MN. The RP joins are replaced by simple multicast forwarding chain prolongs. In addition, FCMM is appropriate for MN with high mobility rate, where data packets must be forwarded quickly to its new location.

Our future work includes two parts:

- Designing the coordinating mechanism for multiple MCs;
- Dynamically determining an optimal chain threshold for each MN according to its mobility characteristics, service traffic and some network parameters.

ACKNOWLEDGEMENT

This work was supported in part by the Ph.D Student Innovation Fund Program of Beijing Jiaotong University (No.141062522), National High Technology of China (“863 program”) under contract No. 2008AA01A326 and in part by National Natural Science Foundation of China under Grant No. 60870015 and No. 60833002.

REFERENCES


