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Multicast Support for End-to-end Wireless ATM Networks

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Abstract

This paper proposes a wireless ATM architecture that can support mobile multicast services using ATM group addressing. In the architecture, it is assumed that the wireless link, IEEE 802.11, serves as a physical link in the ATM network. Thus, every mobile station in a wireless LAN is an ATM terminal. To integrate mobile ATM terminals gracefully into the ATM network, we use the "multiple signaling channels" feature specified in UNI 4.0 to provide a "virtual UNI" between a mobile station and the ATM network. The virtual UNI enables simple implementation and management of mobile ATM terminals. Furthermore, the access point (AP) implements "proxy" multicast services for mobile ATM terminals to fully exploit the broadcasting feature of wireless communications. This requires the AP to intelligently involves in group address management and multicast data transfer. Finally, we propose handoff protocols for supporting mobile multicasting when the membership is unchanged, split, merged, and moved due to terminal traveling.

1. Introduction

To support global user mobility in Personal Communication Services (PCS), a high-speed backbone network is required to interconnect wireless networks in the world. An obvious candidate for the backbone network is the ATM (Asynchronous Transfer Mode) network. ATM uses cell based technology and is designed to provide high-quality services for data, voice, and video transmission. Thus, ATM networks can carry wireless traffic of variable data rates across long distances.

Since ATM networks and wireless networks use different protocols, their interconnection has been an interesting research topic in the past. Basically, there are two schools of thought. Firstly, a wireless network is considered as another type of LAN with different MAC protocol and is connected to the ATM network through a LAN Emulation (LANE) protocol. This approach argues that wireless networks and ATM networks are very different operational environments and thus their interconnection should go through a bridge type of device. This can make each type of network operate under its best suited environment. The other approach considers a wireless network as a physical link in the ATM network. Thus, each station of the wireless network is an ATM terminal. This approach argues that bridging two protocols is very expensive and thus why not use a single protocol for the entire network; after all, this is the design goal of the ATM network. The second approach is so called the end-to-end wireless ATM (WATM) [5],[7] and is the focus of this paper.

The fundamental problem that must be resolved in WATM is to support mobility. While wireless networks support terminal traveling, the existing ATM protocol does not support mobile stations. Thus, how to extend the existing ATM protocol to support mobility has been an important work in the ATM working group. Besides, many researches have focused on this topic [5]-[7]. These works mainly focus on the mobility support for point-to-point communications and mobile multicast is not considered.

Multicasting is the process which a source host or protocol entity sends a packet to multiple destinations simultaneously using a single, local 'transmit' operation. The implementations of multicasting in ATM and wireless communications are very different. Since ATM is a connection-oriented based technology, multicasting can be done only after connections have been set up, while wireless communications in itself uses broadcast media for data transmission and thus mutlicasting can be implemented by data filtering. This fundamental difference in multicasting implementation results in very different multicasting design, such as group address management, multicasting data transmission, and signaling.

Multicasting becomes further complex when mobility is considered. To support mobile multicasting, the existing ATM protocol must work with the handoff protocol of wireless communications. Besides, terminal traveling may result in membership changes in each basic service area (BSA). This implies that the ATM protocol must handle different membership change scenarios. These scenarios include unchange, split, move, and merge.

The rest of the paper is organized as follows: Section 2 introduces our proposed end-to-end WATM architecture, design goal and principle, components and its data structure in WATM. In Section 3, the multicast schemes in WATM networks are described. In section 4, the handoff protocols for multicasting are proposed and explained. Finally, section 5 summarizes the paper.

2. End-to-end wireless ATM networks

In an end-to-end wireless ATM network, the ATM network serves as a backbone to connect mobile ATM terminals (STAs) through Access Points (APs). An STA can not only communicate with other STAs but also with wired ATM hosts. Figure 1 shows an example of an end-to-end WATM network where 802.11 MAC and PHY [3] serves as a physical link in the WATM network.

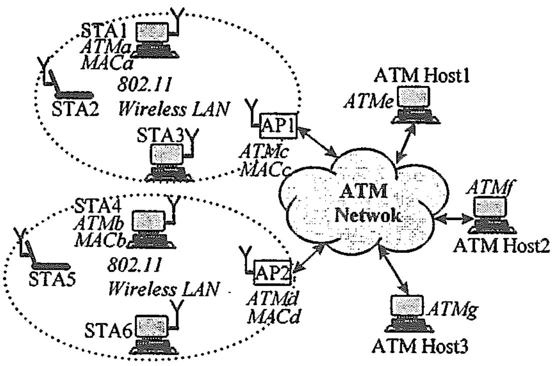

Figure 1 The end-to-end wireless ATM architecture

In WATM, STAs implement ATM protocol suits, including the control plane and the user plane. The protocol stack in the STA is illustrated in Figure 2. The control plane in the STA performs the ATM call setup and release procedures conforming to ITU-T Q.2931/Q.2971. After a call is set up, the user plane in the STA implements a variety of user applications over TCP/IP or IPX in the assigned ATM channel.

The mobile signaling layer consists of ATM signaling specified in UNI 4.0 and its extensions for handoff control. ILMI protocol using AAL-encapsulated Simple Network Management Protocol (SNMP) format packets supports the ATM address registration to implement address and location management for mobile stations.

The additional Pack/Unpack layer is inserted between the ATM layer and the 802.11 MAC layer as shown in Figure 2. This is because the 802.11 MAC frame includes a large overhead to support four MAC address fields. Thus it is very inefficient to transmit short packets such as an ATM cell [6]. In order to support connectionless data service, it is necessary for an 802.11 wireless LAN to transmit an AAL_PDU packet as an 802.11 MAC frame unit.

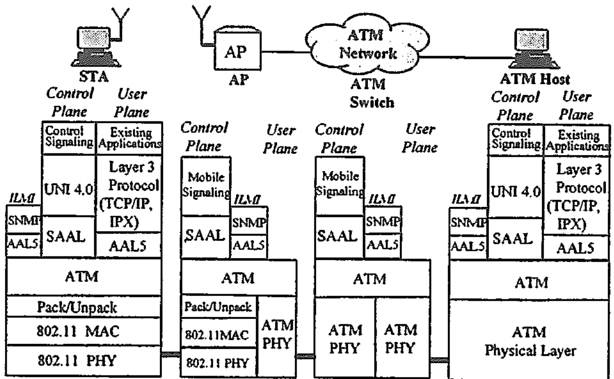

Figure 2 Protocol stack in end-to-end wireless ATM architecture

The last bit of the payload type identifier (PTI) in the ATM cell header is used to signal whether the cell is the last cell of the AAL_PDU packet. The Pack/Unpack layer buffers the ATM cells from the ATM layer until it receives the entire AAL_PDU packet. When the last cell of an AAL_PDU packet is received, the Pack/Unpack layer reassembles those cells into a frame and encapsulates the frame into a 802.11 MAC frame. Finally, the 802.11 MAC frame is transmitted via the 802.11 physical layer. At the receiving end, the Pack/Unpack layer decapsulates the 802.11 MAC frame de-assembles the frame back to ATM cells.

2.1 Design goal

The existing ATM is designed for static point-to-point linked networks. Thus, multicast data must be transmitted through point-to-multipoint trees. A switch must replicate multiple copies of a multicast data when multiple branches of the tree are forked at the switch. As a result, multicast creates heavy traffic to the network. In WATM, a 802.11 wireless link is used as an ATM physical link in the network and provides broadcast capability. Therefore, our first design goal is to exploit this feature to reduce the traffic load incurred by multicasting.

From the signaling point of view, the existing ATM creates a static PMP virtual connection (VC) to transmit multicast data for a group. Basically, the root or leafs of a

PMP tree is assumed to be stable. However, in WATM, an STA can move from one BSA to another at any time. That means the PMP tree needs to be changed from time to time. This creates significant signaling overhead. Thus, our second design goal is to design WATM such that the signaling overhead is minimal.

When an STA travels from one BSA to another, it is also important to provide a seamless handoff service to applications. That is WATM should provide handoff services such that data is transmitted and received by STAs in its original order and no user intervention is needed to resume communication when temporary traffic disruptions occur. WATM should be able to gracefully operate without interrupting the PMP connections in progress. This is our third design goal.

2.2 Design principles

To meet these three design goals, we introduce a concept of "proxy" multicast server. A proxy multicast server plays as an ATM terminal node to an ATM switch, while as an ATM switch to the STAs. From this concept, we develop our solution for mobile multicasting in WATM.

The basic design principle is to implement an AP as a proxy multicast server. This principle has two advantages; first, an AP is attached to an ATM switch port permantly, and thus, it can be treated as a regular ATM terminal node in the existing ATM standard. Secondly, since the AP implements the proxy multicast service, the ATM switches do not need to be involved in the complex mobile multicast service. This can encourage us to implement mobile services as an add-on service to existing ATM networks.

As a proxy multicast server, the AP has to manage group membership in its BSA, and to bridge signaling and multicast data between STAs and its attached ATM switch.

2.3 The components

To support mobile multicast, the components in the WATM architecture need to be enhanced. The enhancement is described as follows:

1. Mobile Station (STA)
   In addition to the function of a mobile station specified in IEEE 802.11, an STA should support the complete functions of an ATM terminal.
2. Access Point (AP)
   In order to support multicasting in a WATM environment, the AP provides not only the function defined in IEEE 802.11 but also the VP MUX and multicast proxy agent function.
3. Multicast Directory Server (MDS): The MDS is a directory server that is used to maintain all the active PMP connections information according to each existing group address. It responds to the queries from STAs. An STA has to obtain the Leaf Initiated Join (LIJ) common ID (root address and LIJ call identifier) from MDS to identify which PMP connection that the STA wishes to add.

2.4 Databases

Several important databases are required to make mobile multicast possible. The follows describe the databases and their content:

1. STA control block: An STA should maintain an STA control block which contains its ATM address, MAC address and an ATM group address list which the STA has joined. This STA control block is used to filter out the non-destined traffic.
2. Forwarding table: In order to support VP MUX function, the AP uses the forwarding table to implement the mapping between the STA MAC address and its assigned VPI value. A multicast table is in the following form:
   ((MAC1, SID1), (MAC2, SID2), ...(MACn, SIDn)).
3. Multicast forwarding table: The multicast table in an AP is used to support the 802.11 frame encapsulation and the multicast handoff. Its data structure is :
   (MAC group address,
   (Common ID, Group VCC, forward/block, redirect),
   (Common ID, Group VCC, forward/block, redirect),
   •
   •
   (Common ID, Group VCC, forward/block, redirect))
   The forward/block flag indicates if the incoming multicast traffic is forwarded to the wireless LAN or blocked. The redirect flag indicates if the incoming multicast traffic should be redirected through another path. Whenever receiving multicast data, an AP uses the multicast forwarding table to determine if the data should be forwarded, blocked or redirected.
4. Multicast membership table:. An AP uses the multicast membership table to determine whether the AP should send a group address registration to the ATM switch. An example of the table entry is shown as below: (ATM group address, MAC group address, (MACa, MACb, ..., MACy)).

3. Mobile multicast over WATM networks

This section describes more detail protocol about mobile multicast in WATM networks.

3.1 Address registration and VP multiplexing

After an AP power is on, the ATM switch first registers a network prefix to the AP using the ILMI address registration mechanism [4]. Since the AP as a proxy agent for STAs in its BSA, the ATM switch only issues a network prefix registration ILMI message to the AP. The AP will retransmit this network prefix registration ILMI message whenever a new STA wishes to associate with the AP.

The AP utilizes "multiple signaling channels on a UNI" defined by UNI 4.0 [8] to provide a "virtual UNI" between each STA and the ATM network. With "multiple signaling channels" feature, multiple users can use the same VPI/VCI which is mapped through a VP MUX (VP Cross Connect or VP switch) to different unique VPI/VCI values (See Figure 3). That is, user devices are required to use VPI=0, VCI=5 for signaling. On the network side signaling messages would use VPI=X, VCI=5 where a different X is associated with different user. MSC allows peripheral devices to use their own VPI configurations even they may conflict with other devices. Thus, by using this feature, the AP can assign all member STAs the same VPI/VCI value for a PMP connection.

In Figure 3, AP assigns a unique VPI value for each STA to distinguish different STAs. In order to simplify the implementation complexity, we assign the VPCI value to be equal to station ID (SID) specified in IEEE 802.11 and assume the VPCI value to be equal to the VPI value in the network side. Thus, when an STA (re-)associates with an AP by sending (Re-)Association Request to the AP, the AP assigns an SID value whose value can not be greater than 256 and returns an (Re)Association Response message with SID to the STA. Then the AP adds the MAC address of the STA and the assigned VPI value pair to its forwarding table.

After sending (Re-)association Response to the STA, the AP retransmits the network prefix registration ILMI message to the STA. The new STA combines its own MAC address with network prefix to form a ATM address and then returns the ATM address registration message to registers it ATM address to the ATM switch through its AP.

The VPI value for each STA is VPI 0 on the STA side. Upon receiving an incoming 802.11 MAC frame, the AP decapsulates it into cells and replaces the VPI value in the cell headers by the SID value corresponding to the STA's MAC address in the forwarding table. The AP then retransmits the cells to the ATM network. On the other hand, when cells are delivered to the AP, the AP replaces the cells' VPI value by the VPI 0 and encapsulates the cells to a MAC frame. The MAC address of the frame is derived by searching the forwarding table with the SID of the cells. Figure 3 shows that both the STA and the ATM switch maintain a translation table between VPCI and VPI to implement "multiple signaling channels" function.

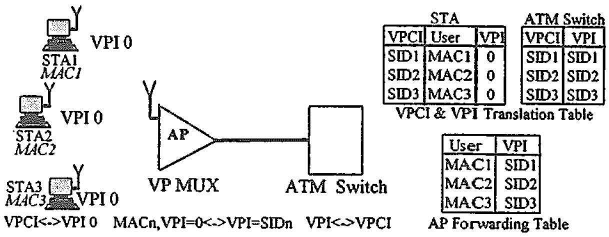

Figure 3 An example for VPI multiplexing

3.2 Group Address Management

In WATM, multicast is made possible by using two levels of group addressing: ATM group addressing, and 802.11 MAC group addressing. To implement multicast efficiently in the ATM layer, it is assumed that the ATM switches support ATM group address defined in UNI 4.0. Whenever an STA wishes to join a group, the STA registers its membership to its AP. To the switch, the AP is a terminal node and the switch only care the existence of a group membership, and thus the AP sends the message to the switch only if the group is new. Thus, an AP will not report any membership updates to its attached switch as long as no new group is created or no old group is discarded due to the membership updates.

On the other hand, to exploit a 802.11 link for traffic reduction due to multicating, we can implement multicast by selective broadcasting in a BSA. That is, only the STA which is registered to the particular group can receive the multicast data. This requires 802.11 to support group addressing. Furthermore, the multicast data in WATM is transmitted to an ATM group. Thus, it is required that the 802.11 MAC group address and the ATM group address is one-to-one mapped. Here, we use an algorithm mapping approach to generate a MAC group address when an ATM group address is registered. When a multicast data is transmitted in 802.11 links, the data is sent to the MAC group address corresponding to the targeted ATM group.

Although the group membership in 802.11 can be locally registered to implement selective broadcasting, we require STAs to register its group membership to its AP. The APs use this information to detect the membership changes when an STA moves from one BSA to another.

An example for group address registration procedure is shown in Figure 4. The steps of group address registration procedure is performed as follows:

1. If an STA wants to join a group, the STA passes the group address registration ILMI message to the 802.11 MAC layer. The MAC group address is then

algorithmically generated from the ATM group address which is registered. After that, the AP creates/adds the MAC address of the STA to the group membership list in the multicast membership table.

2. If the group address is not new and the AP has already become the leaf node of the PMP connection of the group, the AP terminates the group address registration ILMI message and initiates the add party call to add the STA to the existing PMP connection.
3. If the group address is new, the AP registers an ATM group address and the desired scope of the registration by transmiting the SetRequest ILMI message with the AP's ATM address to the ATM switch.
4. Because the group address is new, the AP asks MDS whether any PMP connection corresponding to the group address exists by issuing a PMP Connection Check.
5. If a PMP connection has already existed, the MDS should return a PMP Connection Response containing the associated LIJ common identifiers (root address and LIJ call identifier) to the AP.
6. Following the acceptance of the PMP Connection Response with a LIJ common identifier, the AP should add itself as a leaf node of the PMP connection by a LIJ call setup specified in UNI 4.0. After completing the LIJ call procedure, the AP and the STA will obtain the group VPCI/VCI, the associated LIJ common identifier and group address for creating a multicast forwarding table entry. After that, the AP can start to receive the incoming multicast traffic from the PMP connection.

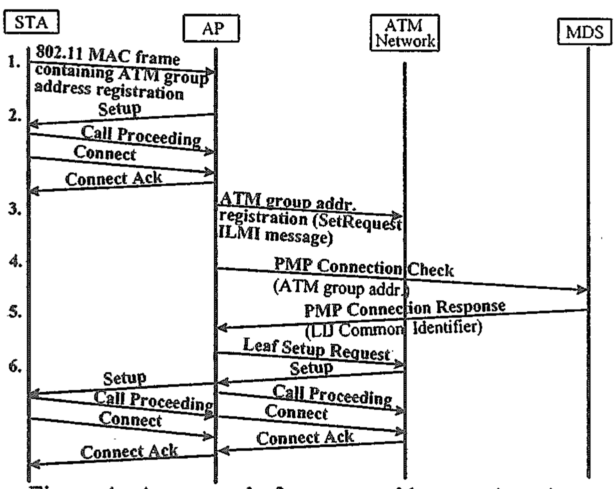

Figure 4 An example for group address registration

3.3 Multicast data PMP connection signaling

Since an AP serves as an end node to the ATM switch, the PMP connections are assumed to be ended at an AP. On the other hand, an STA implements full fledge of the ATM protocol. Thus, they should behave the same as a wired ATM terminal in signaling and data transmission. Also the network should be observed and responded to STAs in the same manner as an ATM network. Under these requirements, an AP must behave like an end node to the ATM switch while behave as an ATM switch to STAs. That is an AP also serves as a "proxy" ATM switch, which can generate/terminate control signals to/from STAs.

The signaling of connection set up for STAs should remain the same as a wired ATM terminal. However, since we use selective broadcast to implement multicast in 802.11 links, the PMP connections for the group members in a BSA must be established intelligently. Here, we use the AP to mimic a switch for its STAs. An AP responds to PMP connection requests differently in the following three generic scenarios:

1. All group members are located in the same BSA: In this case, the PMP connection should be set up between the STAs in the BSA. The AP will respond to the connection request from the root STA and generate the corresponding connection set up messages to the leaf STAs. The entire connection set up signaling is happening within the BSA. Thus, ATM switches are not involved in the connection set up.
2. The root is in the BSA but some members are not in the BSA: As in the first case, the AP continues the connection set up signaling in its BSA after it receives the connection request. Meanwhile, it forwards the request to the ATM switch as if it is the root.
3. The root is not in the BSA: When the AP receives a PMP connection request from the ATM switch, it responds to the signal as if it is a leaf node. Meanwhile, it forwards the set up signaling to the air and returns the appropriate responses in its BSA transparently to the ATM switch.

The setup of the first party of a PMP call with a group address is always initiated by the root. Once the root node initiates a PMP connection to the ATM group address, the network will connect all the nodes that are registered with that particular ATM group address by the ILMI group address registration.

In order to meet the multicast requirement in RFC 1112 [2], we adopt the LIJ feature in UNI 4.0. In UNI 3.1 [1], only a root node has the right to add one leaf to the PMP connection, i.e. a leaf node cannot add itself to the PMP connection. This restriction is relieved by the Leaf Initiated Join (LIJ) capability defined in UNI 4.0, which allows users to independently join PMP calls created by other parties in the network.

A Multicast Directory Server (MDS) is used to maintain all the active PMP connection information. When a new PMP connection is set up, the root node must register its ATM address and the LIJ call identifier to the MDS. Whenever an STA join a group, its AP queries the MDS about the existence of the PMP connection associated with the group address. After the AP obtains the root address and the LIJ call identifier of the PMP connection, it can use the LIJ feature to add the STA to the PMP connection.

An example for the PMP connection signaling is shown in Figure 5. In WATM, we adopt the ATM group addressing to perform PMP connection signaling. The steps to handle are stated as follows:

1. The STA which wants to multicast data sets up a PMP connection by sending a SETUP message to the ATM switch via the AP.
2. It is assumed that the ATM switches support the ATM group address registration and multicast/broadcast function, and thus the root STA is able to establish a PMP connection to all leaf nodes without knowing any ATM address of the leaf nodes prior to call setup. That means the group address management and a multicast data path establishment all can be done in the ATM switches. By the group address registration procedure, the ATM network maintains the group address and its membership mapping table. That is why the ATM network is capable of connecting all nodes that are registered with that particular ATM group address. On the other hand, the ATM network only transmits a single copy of the signaling message to the proxy AP, which is the leaf node in the PMP connection instead of the member STAs. And then the AP retransmits it to the STAs which participate the particular group in the same BSA. Meanwhile, the AP not only responds to the signaling message from the switch but also from the STAs behind the AP. In Figure 6 we assume that STAa, STAb, STAc and STAd are members of the particular group. The APs and the STAs in the source or the destination can cache the group VCC and LIJ common identifier through accepting CALL PROCEEDING or SETUP message.
3. To deal with the case where the root STA and leaf STAs are all behind the same AP, the AP serves as an ATM switch to issue a SETUP message with the assigned group VCC and LIJ common ID for initiating an incoming PMP connection call setup.
4. In order to update the newest PMP connection information in MDS, an AP registers to the MDS with the LIJ common identifier of the PMP connection and its corresponding ATM group address by sending a PMP Connection Registration message to MDS whenever the AP completes a new PMP connection.

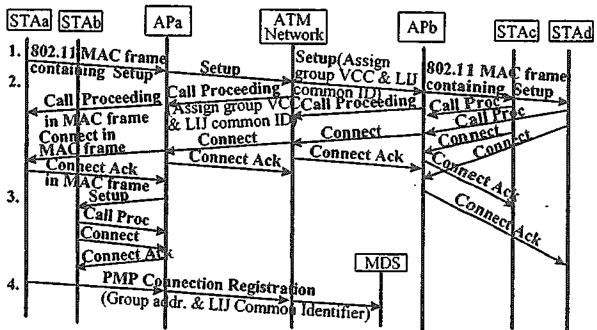

Figure 5 An example for PMP connection signaling

3.4 Multicast Data Transfer

Once a PMP connection is established, the root STA can multicast data to all the leaf STAs through the PMP connection paths. After the PMP connections are established, the multicasting can be done as follows in three different cases:

1. All group members are in the same BSA: After the AP receives multicast data from the root, it broadcasts the data to the 802.11 MAC group corresponding to the ATM group with the common VPI/VCI in the header of the data.
2. The root is in the BSA while some members are not: The AP not only broadcast the data to the BSA as in case (1), it also sends the data to the attached ATM switch.
3. The root is not in the BSA: The AP will map the VPI/VCI to the 802.11 MAC group address and broadcast the data to the BSA.

4. Handoff process

When an STA moves across BSA boundary, the STA will switch its access service from its previous AP to a new AP. This reassociation procedure mainly uses 802.11 protocol. However, since the STA is also an ATM node, the handoff will possibly cause the changes of the group membership of the previous BSA and the new BSA, and of PMP connections. Thus, the AP should invoke ATM signaling for handoff processing in response to the 802.11 reassociation procedure.

If the STA has joined some groups, the handoff may cause four possible membership changes. Lets use BSAnew and APnew to denote the new BSA and its AP respectively, and BSAold and APold to denote the old

BSA and its AP correspondingly. Also denote a group G in the BSAnew as Gnew and in BSAold as Gold and their membership as set Snew and Sold correspondingly. The moving STA is denoted as STAm and belongs to Sold before the handoff. Then the four possible changes can be described as follows:

1. Unchange: If both Sold and Snew are not null after the handoff, then no group is changed. In this case, no PMP connection is affected and thus, only minimal signaling is required to update the membership in BSAnew and BSAold.
2. Move: If Snew = {STAm} and Sold = null after the handoff, then Gnew is newly created in BSAnew and Gold must be dropped from BSAold. Under this condition, PMP connections for the group need to be updated. The PMP connection to APold must be released while APnew should use the LIJ procedure to add APnew to G's PMP connections. Furthermore, to maintain data continuity, APold won't release itself from G's PMP connections until APnew has been added to those connections. Also, APold will buffer the data for G's PMP connections during the handoff period and pass the data to APnew so that STAm will not miss any data due to handoff.
3. Split: If Snew={STAm} and Sold =\ null, the handoff has created Gnew in BSAnew while the group in BSAold remains the same. Under this case, APnew must use LIJ to add itself to G's PMP connections. Meanwhile, APold has to buffer the data for the PMP connections during the handoff period and pass the data to APnew to keep data continuity.
4. Merge: If Snew={STAm, m1, m2,...} and Sold = null, the members in BSAold are merged to BSAnew. Under this case, APold will release itself from G's PMP connections and purge all data for the connections.

In order to handle STAs handoff, APnew should set up a "Handoff VCC (HVCC)" with APold. Through HVCC, APold and APnew coordinate the handoff, and APold redirects the STA traffic from the ATM network to APnew if necessary.

We give examples to demonstrate the multicast handoff procedure. An example for multicast handoff process under unchange condition is shown in Figure 6. Firstly, the STA should hold the traffic to be transmitted during the handoff process . The handoff for multicasting will proceed as follows:

1. The STA issues a Reassociation Request to the new AP. The Request contains the ATM address of the previous AP and the MAC group addresses that the STA joins.
2. Upon accepting the Reassociation Request, the new AP establishes a point to point HVCC connection between the new AP and the previous AP using the ITU-T Q.2931 signaling procedure. Meanwhile, the new AP adds the STA to its multicast membership table.
3. The new AP sends a Disassociation Request containing the MAC address of the STA to the previous AP via the HVCC.

As mentioned previously that the membership of a group may be changed after an STA moves across a BSA boundary. The changes include unchange, move, split, and merge. The handoff procedure for the changes use the same common initial steps as 1-3 steps described above. The following descriptions for each scenario are started to follow step 3.

(1) Unchange: Figure 6 illustrates the multicast handoff process under an unchange condition.
   (a) After receiving the Disassociation Request from the new AP, the previous AP disassociate with the STA and returns a Disassociation Response containing the STA MAC address to the new AP. Additionally, the previous AP which serves as the STA proxy agent should issue a SetRequest ILMI message to the ATM network to deregister the STA.
   (b) Upon receiving the Disassociation Response from the previous AP, the new AP assigns a SID as a VPI value to the STA and issues a Reassociation Response with the SID to notify the STA to start receiving multicast traffic from it. In addition, the new AP adds a new entry, the MAC address of the STA and the assigned VPI value pair, to its forwarding table. Finally, the new AP sends a SetRequest message to register the network prefix to the STA. The STA then returns a SetRequest to the new AP for ATM address registration.

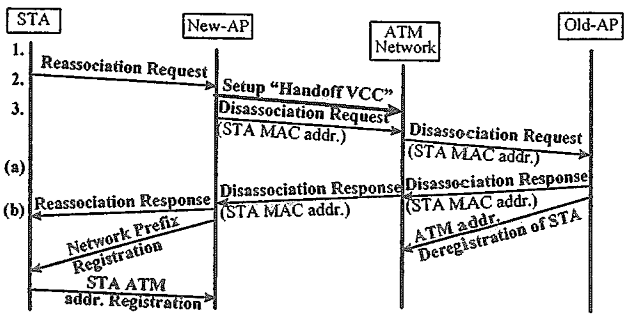

Figure 6 An example for multicast handoff process under unchange condition

(2) Merge: The multicast handoff process in the merge condition is the same as that in the unchange condition except:.
  (a) Because the STA is the only member of the group in the previous AP, the previous AP should drop itself from the PMP connection after receiving Disassociation Request from the new AP.
  (b) After finishing the drop party procedure, the previous AP should delete (i) the LIJ common identifier entry corresponding to the PMP connection in the multicast forwarding table; (ii) the STA from the group membership list in the multicast membership table; (iii) the multicast group entry which the STA participates in the multicast membership table.

(3) Split: The multicast handoff process in the split condition is the same as that in the unchange scenario except:
  (a) After receiving the Disassociation Request with the STA MAC address and the redirect flag from the new AP, the previous AP not only forwards the incoming multicast traffic to its own STAs but also redirects them to the new AP via the HVCC.
  (b) While the new AP forwards the redirect multicast traffic into the STA, the new AP should perform an LIJ call to add itself to the PMP connection.
  (c) After completing the leaf initiated join call procedure, the new AP records the multicast group address to the multicast membership table and issues a Flush message to notify the previous AP to stop redirecting multicast traffic to the new AP. And then the new AP directly forwards incoming multicast traffic from the PMP connection to the STA.

(4) Move: The multicast handoff process in the move condition is the same as that in the split scenario except:
  (a) Because the only STA of the group for the previous AP has left, the previous AP should block incoming multicast traffic to the air.
  (b) Upon receiving the Flush message, the previous AP should drop itself from the PMP connection corresponding to the group

5. Conclusions

This paper proposes a WATM architecture and protocol to support mobile multicast. In the architecture, a 802.11 link is used as an ATM link. The architecture allows us to implement ATM multicast by selective broadcast using 802.11 links. Thus, the traffic load incurred by multicast is reduced. Furthermore, as ATM terminals move across a BSA boundary, the architecture can gracefully update the group membership in the affected BSA's. Meanwhile, the ATM terminals are hooked back to their original PMP connections and continue their group communications after the handoff.

In order to minimize the signaling overhead, we extend the AP to implement the proxy multicast server. A proxy multicast server plays as an end node to the ATM switch while as an ATM switch to the STAs. Thus, the AP can hide most group membership changes from the ATM switch. This is particularly useful when the ATM terminals are moved dynamically. Four different scenarios of group membership changes has been fully addressed to illustrate how data continuity can be maintained in WATM. Finally, some protocol line flows are shown to explain how the proposed architecture can be implement by using IEEE 802.11 and existing ATM standard.

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