Virtual Mobile Zone Architecture for Mobility Support in Wireless ATM Network

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ABSTRACT - Recently, there has been many studies for high speed ATM technology based mobile multimedia services for the future mobile communication environments. Especially, efficient handoff mechanism for future small cellular environment is a most important issue. Thus, in this study, we propose a simple and efficient handoff method to provide mobile initiated and high speed handoff without modification of current communication devices. According to the simulation results, proposed handoff method could provide different handoff scheme according to the characteristics of traffic and support both radio level handoff and reliable rerouted cell management of network level handoff. Also, proposed scheme could support tree network as well as flat network architecture.

II. Conventional Handoff Rerouting Schemes for Mobility Support

Most conventional handoff rerouting methods are proposed to be used for some dedicated network architecture, and have focused on the protection against call disconnection during handoff. Thus, purpose of conventional handoff schemes is to provide continuous call-connection without disconnection during handoff. For this reason, QoS support for heterogeneous traffics and error recovery, efficient buffer management and cell rerouting scheme for upper layer are not considered. In this chapter, we survey conventional handoff rerouting schemes and consider problems based on network architecture.

1. Introduction

ATM (Asynchronous Transfer Mode) based mobile multimedia communication technology is a core part of future telecommunication services. Most mobile communication service providers anticipate that half of future telecommunication service user will use mobile communication service. Especially, need for high speed personal communication service as well as ATM based wired service will be increased abruptly in future telecommunication environments. Thus, efficient protocol stack and mobility management scheme become most important issues in future telecommunication technology [1],[2],[3],[4]. In future mobile multimedia cellular environments, micro/pico-cell will be generally used for high bandwidth. Thus, more small size cell will cause more frequent handoff between cells. For this reason, efficient, reliable and fast mobility support technologies are important[5].

However, conventional schemes are dedicated to network architecture, and many researches are done in wireless LAN environments. Thus, there is no standard mobility support scheme for future mobile multimedia environments. Most of conventional methods are proposed to provide radio level handoff support, and have no considerations on handoff of upper layer. Also, because most methods consider handoff as a connection-transfer from old base station to new base station, degradation of throughput happens in future mobile multimedia environments due to inefficient cell management scheme[6]. Thus, in this paper, we propose a virtual mobile zone based handoff rerouting method to support fast and reliable handoff in future ATM based mobile multimedia cellular network.

Following this introduction, conventional handoff rerouting schemes to provide mobility support are surveyed and problems are considered in chapter 2. Proposed virtual mobile zone based handoff rerouting method for future mobile multimedia environments is described in chapter 3. Also, performance of proposed method is evaluated and results are analyzed in chapter 4. Finally, conclusions are made in chapter 5.
a connection to one BS in tree network, every BS and switch in the same sub-tree allocates resources for a mobile terminal based on VCT method.

In these methods, if a mobile terminal moves to different tree, long processing time and wired system overhead are required for resource allocation of all devices in sub-tree. However, in most cases, purpose of wireless ATM is the efficient utilization of wireless resources, and the overhead of wired network resources are often neglected[10]. Because, ATM based wire resource is hundred-times larger or over than wireless resource.

3. Hybrid Network

This scheme, called NCNR(Nearest Common Node Reroute) method, is proposed by Bora A. Akyol and Donald C. Cox, to support both flat and tree network. Also, NCNR scheme proposes the refined method of VCT for efficient resource utilization of wired network. Basically, NCNR logically operates in tree mechanism. In NCNR, radio ports connected to same WATM device are grouped as zone. By using this zone concept and zone manager function, adjacent zone managers exchange information of mobile terminals, and reroute handoff according to exchanged information[6].

When handoff occurs, common node( ATM switch) which has both ports for previous zone and new zone manager is explored based on NCNR method. After this node is found, handoff is rerouted by this node. Especially, NCNR method could support QoS of two kinds of traffics, such as time sensitive traffic, and throughput dependent traffics. Example of time sensitive traffic is delay sensitive video/voice, and throughput dependent traffic is loss sensitive data. Thus, different handoff schemes are used for each traffic. This different handoff procedure according to characteristics of traffic is also considered in UMTS of Europe, and becomes a basic service for mobile multimedia environments[5].

NCNR has the characteristics supporting both flat network and hierarchical network. However, if we consider deep depth tree architecture, required processing time for finding common node is large. Most of all, to support NCNR, every node and device in network must include NCNR function. Thus, performance degradation of ATM switch is easily anticipated. Especially, as described in [5], previous BS initiated handoff scheme could causes many problems in future mobile multimedia environments.

Therefore, mobile initiated handoff procedures and fast handoff rerouting based on simple network requirements are core technologies for frequent handoff network.

III. Virtual Mobile Zone Based Mobility Support Scheme

To provide efficient wireless ATM based mobile multimedia service, we consider some requirements of new handoff rerouting scheme, which is described as follows.

First, handoff is initiated by mobile terminal, and rerouting is initiated by new RAS(or BS). Second, requirements for conventional wired network devices will be minimized to support fast handoff rerouting and little processing time for handoff procedures. Third, different handoff rerouting procedures are provided to support heterogeneous traffic characteristics. Fourth, efficient buffer management and cell rerouting methods are provided for network level handoff as well as radio level handoff to support reliable traffic recovery during handoff. Finally, handoff scheme must support both flat and tree network. Handoff scheme must provide reliable and fast handoff rerouting method for mobile multimedia terminal. Then, some wired resource overhead could be neglected and point-to-multipoint communication method for multi-cast operation must be used[12][13].

To meet the above mentioned requirements, VMZ handoff rerouting scheme similar to NCNR is proposed. Multiple RASs, BSs and ATM switches are grouped as zone. Fig.1 shows zone concept using cellular architecture. As described in Fig.1, adjacent seven cells are grouped as one zone. In proposed scheme, zone manager is located for one zone, and mobility information for each mobile terminal is exchanged by zone managers. Zone manager could be a physically dedicated device, or a functional architecture of ATM switch. Zone managers have inter communication link with adjacent zone manager via PVC or SVC. Inter mobile zone manager communication uses multi-cast property of ATM switch. Also, zone-to-RAS(BS) communication is based on multi-cast property. Thus, mobile terminal could be serviced based on VCT method, when a mobile moves among cells in the same zone.

Handoff type is classified as two methods. First method is intra mobile zone handoff, where a mobile terminal moves in the same zone. Second method is inter mobile zone handoff, where a mobile terminal moves from one zone to different zone.

In intra mobile zone handoff, only allocation of radio resource is considered since all devices in same zone communicate with zone manager based on multi-cast method. Thus, we will describe inter zone handoff procedure more seriously.

Virtual mobile zone concept is proposed in this paper to provide efficient handoff rerouting scheme. Virtual mobile zone is constructed according to the location of mobile terminal. Thus, the difference between physical zone and virtual mobile zone exists. Physical zone is constructed and fixed by physical location of cells and zone manager. However, virtual mobile zone is changed as mobile terminal moves. Fig.2 describes the concept of virtual mobile zone. Virtual mobile zone is constructed by current RAS, where mobile terminal is located concurrently, and adjacent RASs of current RAS.

In Fig.2, zone-A is a group of RASs which are physically connected to zone manager A. In this case, RASs in zone-A are A-1 to A-7. When a mobile terminal moves from A-1 to A-5, virtual mobile zone of mobile terminal is reconfigured as a group of RAS A-1/4/6/7, C-7, B- 2/3. Thus, virtual mobile zone is a group of possible RASs, where mobile terminal could enter.

Newly included RASs C-7, B-3, B-2 will activate wired resource pre-allocation procedure for possible handoff in proposed VMZ method. Thus, only radio resource allocation is required when a node moves from current RAS to adjacent RAS. However, in this case, allocated wired resource will be deactivated for efficient resource management. In addition, radio resource could be managed based on VMZ method. When radio resource management based on CDMA technology is used, new code allocation is decided based on code allocation information of adjacent RASs. Thus, when a mobile terminal moves to new RAS, probability using same CDMA code will be increased. Then, more fast and efficient handoff could be supported without changing of CDMA code during handoff[11].

Network architecture based on VMZ is depicted in Fig.3.
As depicted in Fig. 3, RASs, BSs, and ATM switches are logically managed based on tree architecture in VMZ based method. Then, zone manager for each group manages devices in sub-tree. Multi-cast communication is used to communicate among zone managers via PVC or SVC, and to transmit traffic from zone manager to devices in sub-tree. For example, zone manager A multi-casts traffic to ATM switch A/B. Then, ATM switch A/B multi-casts traffic to RAS-A-D. As a result, a mobile terminal could communicate without additional wired resource allocation procedure, when it moves within same zone. Also, in proposed architecture, dedicated channel is provided from LE (Local Exchange) to RASs. This channel is used to service asynchronous connection-less packet traffic. In this case, asynchronous connection-less packet traffic needs no wireless channel establishment.

Inter mobile zone handoff, where mobile terminal moves from zone A to zone B, is simple and fast due to the proposed simplified handoff procedure as described in Fig. 4.

When a mobile terminal moves from zone A to RAS E in zone B, handoff procedure is initiated by mobile terminal as depicted in Fig. 3. Then, RAS E allocates radio resource and activates pre-allocated wired resource which is previously allocated to a mobile terminal based on VMZ method. Thus, wired resource from RAS E to ATM switch C is activated and data could be rerouted to RAS E. ATM switch C transfers handoff indication to LE and zone manager function in LE transfers indication to zone manager A. In this procedure, wired resources for a mobile terminal are activated from ATM switch to zone manager A. Thereafter, zone manager B could multi-cast traffic to a mobile terminal. Zone manager A reroutes buffered traffic to a mobile terminal through zone manager B. In this case, buffered delay is monitored and only satisfactory traffics are rerouted. Thus, delay sensitive traffics are truncated, if its buffered delay could not meet QoS. However, loss sensitive traffics are reliably rerouted by using cell management mechanism of VMZ handoff rerouting method, which provides cell sequence control method. At the same time, zone manager A de-activates network resources which still exist in virtual mobile zone of a mobile terminal, and de-allocates network resources in zone A which are not included in virtual mobile zone. At the end of handoff, input traffic is rerouted to a mobile terminal through zone manager A to zone manager B. Thus, traffic is multi-casted to devices in sub-tree, and RAS E in sub-tree transmits to mobile terminal.

As a result, in proposed method, mobile terminal initiates
handoff rerouting. Newly required function for existing wired network is simple. That is, only VMZ concept based zone manager function is required for LE. Thus, high speed and minimized processing overhead are required for proposed method. Also, different network level handoff rerouting procedure is provided for delay sensitive traffic, loss sensitive traffic and connection-less packet traffic. For efficient handoff performance, proposed VMZ method support network level handoff mechanism as well as radio level handoff, for reliable cell management and error recovery from handoff situation. In view of network architecture, proposed VMZ method could support both flat and tree network architecture.

IV. Simulation Environments and Results Analysis

We have evaluated the performance of proposed method by using computer simulation on Ultra SPARC workstation. To evaluate the performance, we assume the network architecture depicted in Fig.3, where a mobile terminal moves from RAS D to RAS E. We also compare the performance of proposed VMZ method with that of NCNR method.

Simulation related parameters are described in Table. 1.

<table>
<thead>
<tr>
<th>Simulation Parameters</th>
<th>Method</th>
<th>NCNR</th>
<th>VMZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Link Capacity at Radio Channel</td>
<td></td>
<td>64Kbps</td>
<td>64Kbps</td>
</tr>
<tr>
<td>Transmission Delay between RAS and Higher ATM Switch</td>
<td>10ms</td>
<td>10ms</td>
<td></td>
</tr>
<tr>
<td>Transmission Delay between ATM Switch and LE</td>
<td>10ms</td>
<td>10ms</td>
<td></td>
</tr>
<tr>
<td>Transmission Delay between LE</td>
<td>10ms</td>
<td>10ms</td>
<td></td>
</tr>
<tr>
<td>NCN Function Processing Time at Node</td>
<td>10ms</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>De-activated Channel Activation Processing Time</td>
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<td>10ms</td>
<td></td>
</tr>
<tr>
<td>Message Generation</td>
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</tr>
<tr>
<td>Mean Message Length</td>
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<td>1024bytes</td>
<td></td>
</tr>
</tbody>
</table>

As described in Table. 1, most of simulation parameters are equally used in proposed VMZ method and conventional NCNR method. Especially, additional time is not required in activation of de-activated ATM channel. Because, these de-activated channels are previously established before handoff occurs in VMZ method, as depicted in Fig.2. However, we assume this activation time to be 10ms in VMZ method for fair performance comparison with NCNR method. Thus, most of performance improvements are due to the simplicity of proposed VMZ method. In fact, in NCNR, method processing overhead in wired network increases due to the complex distributed common node finding mechanism for all nodes in ATM network.

In this paper, we measure the required buffer size of transmission buffer in mobile terminal. Mobile terminal generated traffic could not be transmitted in handoff situation, and must be buffered in transmission buffer at mobile terminal. Thus, long handoff procedure time need larger buffer size than fast handoff procedure. However, efficient handoff rerouting mechanism needs a little buffer size during handoff. We assume only loss sensitive connection oriented data traffic in simulation environ-
Based on this simple handoff rerouting method, almost twicetimes performance improvements could be obtained in proposed VMZ method in comparison with NCNR method. However, these performance improvements come from the assumption that activation time of de-activated channel is equal to NCN finding processing time of NCNR method. In fact, this is not fair. Because, channel activation time of ATM switch does not require large processing time and complexity. Thus, more performance improvements could be easily anticipated[14],[15],[16].

V. Conclusions

Recently, wireless ATM based wired-wireless integrated mobile multimedia service becomes core issue in future telecommunication environments. To integrate wireless network and high speed ATM based wired network, mobility support technology such as location management, handoff, path re-establishment must be developed. In these technologies, most important issue in current study on FPLMTS, UMTS and ATM Forum is handoff problem. Efficient handoff method is important, when we consider high speed mobile multimedia service, due to micro/pico-cell based very small cell size cellular network. Small size cell network causes frequent handoff rerouting, when mobile terminal moves among cells.

In this paper, we propose efficient virtual mobile zone based handoff method to support high speed mobile multimedia communication service, and evaluate the performance by using computer simulation. Proposed method provides mobile terminal initiated handoff rerouting, and modification of existing ATM devices are simple. That is, only VMZ zone manager function is required for LE. Thus, high speed and minimized processing overhead could be obtained in the proposed method. For efficient handoff performance, proposed VMZ method supports network level handoff mechanism as well as radio level handoff for reliable cell management and error recovery during handoff situation. Different level handoff rerouting procedure is provided at network level handoff when delay sensitive traffic, loss sensitive traffic and connection-less packet traffic co-exist. Moreover, in view of architecture, proposed VMZ method could support both flat and tree network architecture.

According to simulation results, improved fast handoff rerouting could be supported in proposed method compared with conventional NCNR. Especially, proposed VMZ method has merit on using current ATM devices with little modification. Thus, fast and simple rerouting could be supported via wired network. On the other hand, inefficiency exists in wired network resource due to multi-cast based operation of proposed method. However, our focus is to provide fast and simple handoff rerouting scheme in frequent handoff environment, and our target network architecture is ATM based wireless network where wired network resource is hundreds times or larger than wireless network resource. Thus, the inefficiency of wired network resource is negligible. In further study, we will extend this study for efficient and fast mobile terminal handoff rerouting scheme in multi-tier cellular network environments.

References