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SIGNALING FOR MOBILE INTERNET TELEPHONY[1]

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Abstract Internet telephony realizes the transmission of two-way, real-time, synchronous traffic over IP-based networks. The dominant standard for Internet telephony is ITU-T Rec. H.323. The current version of H.323 allows interoperability with circuit-switched telephone, but IP telephone mobility is not supported. In this paper, mobile extensions to H.323 that enable mobile IP telephony, particularly in connection with roaming and with the consideration of firewall issues, are proposed. The system architecture is described and signaling functions for mobility management are presented. We will demonstrate an approach that, through the inter-Gatekeeper cooperative support, ensures mobile IPtel services to work smoothly even with the existence of firewalls.

1. INTRODUCTION

Internet telephony, also known as voice over IP or IP telephony (IPtel), promises to transmit real time, two-way, synchronous voice traffic over the Internet or corporate Intranets. The dominant standard of Internet telephony is the International Telecommunication Union - Telecommunication Standardization Sector (ITU-T) Recommendation H.323 [1, 2]. H.323 specifies technical requirements for multimedia communications over packet switched networks, including the system components, control messages and functions for component communications. With H.323, data, voice, and video in an IP call are transmitted using the Real-time Transport Protocol [3]. Call setup and other call control signaling messages are carried out-of-band, sent through different paths other than those for the payload traffic. Such separation creates a variety of opportunities to introduce new services for advanced Internet telephony systems, just like the separation of signaling from voice traffic on the Public Switched Telephone Network (PSTN) creates opportunities for advanced Intelligent Network services.

Roaming refers to the ability to ensure that the global connectivity for an endpoint is still assured while moving. It is an attractive feature, as can be proven by the explosive growth of digital cellular phones and by the popularity of portable IP hosts like PDA and laptop computers. Such reachability can either be discrete or continuous. Discrete reachability is the synonym of portability, implying no on-line reachability and communications taking place while moving. Continuous reachability is the synonym of mobility, allowing seamless roaming while communicating. Obviously,

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mobility encompasses portability. Mobile IPtel services allows a mobile terminal to be reached or to stay on the line while moving. Mobile IPtel services mandates the integration of IP telephony with mobility capability.

To realize mobile IPtel services, one may consider adopting Mobile IP [4] as the transport mechanism with IPtel running on top of it. Mobile IP is the major standard for IP host mobility on the Internet. It redirects all data destined to a given IP address via IP tunneling. Mobile IP is based on connectionless, datagram IP service on the network layer. No concept of connection, and therefore handoff, is considered in Mobile IP. A handoff denotes a new connection being set up for a mobile terminal in a new location area before the old connection in the previous location is torn down. It is essential for mobile IPtel to handle handoffs, ensuring seamless roaming while the conversation is in progress. As a result, a handoff must be handled through the higher layer protocols, namely, through IPtel. With the current version of H.323, the mobility feature is still missing, not to mention handoffs.

We have proposed [5] mobile extensions to H.323 that provides a framework for mobile IPtel services. Through proper call setup signaling with the H.323 Gatekeeper, the address of the target endpoint (i.e., callee or called party) can be resolved before call establishment, enabling the service redirection to be completely handled in the application layer. This approach does not require the bearer (payload) traffic flowing through a given address to be redirected, eliminating the redirection enforced by Mobile IP in the network layer. Hence, bundling of IPtel with Mobile IP for mobile IPtel service is relaxed, realizing mobile IPtel services with IP rather than with the Mobile IP mechanism. This allows mobile IPtel services to be deployed long before Mobile IP is widely available, and to be easily integrated with other servers for service enhancement. Our approach enables mobility support without the need for additional new entities and with minimal modifications to the H.323 standard, allowing such mobile IPtel service to be a valued-added feature in the existing H.323-compliant Internet telephony systems. Another approach [6] for mobile IPtel is to use the Mobile Internet Telephony Protocol as the complementary protocol for mobile extensions to the Session Initiation Protocol (SIP) [7].

In this paper, roaming with mobile H.323 terminals and with the consideration of the firewall issues is discussed. The system architecture is described and signaling functions for mobility management are presented. The existence of firewalls on the Intranet, and therefore Internet, complicates the provision of IP host mobility. Such application –level firewall performs functions like filtering to discriminate against data that do not meet some strict criteria, thereby protecting the resources of internal domain from outside access. We will propose an approach that, through the inter-Gatekeeper cooperative support, ensures mobile IPtel services to work smoothly even with the existence of firewalls.

The rest of the paper is organized as follows. The system architecture is presented in Section 2. The mobility management for mobile IPtel is proposed in the following three sections. Registration is described in Section 3. Call establishment for mobile IPtel is demonstrated in Section 4. Roaming is covered in Section 5. Finally the concluding remarks are made in Section 6.

2. SYSTEM ARCHITECTURE FOR MOBILE IPTEL

We now describe our proposed system architecture for mobile IPtel. A zone as shown in Fig. 1, is defined as a collection of H.323 entities (e.g., terminal, Multipoint

Control Unit, Gateway) managed by a single Gatekeeper. Gatekeepers provide such services as address translation and resolution, admission control, bandwidth control, zone management, as well as other call control related functions in their administrative domains. The definition of the H.323 terminal is extended to include stationary and mobile H.323 terminals. Each zone contains *exactly one* Gatekeeper, but allows multiple subnets connected by routers. [5] has shown that the zone plays a similar role to the service area of the cellular phone system, say GSM [8], and the corresponding Gatekeeper, similar to that of the mobility agent such as the Home Location Register (HLR) or Visitor Location Register (VLR). The *home zone* is defined as the zone that an H.323 terminal normally resides, and *foreign zone*, a zone that the H.323 terminal may visit. The corresponding Gatekeepers are called the *home Gatekeeper* and the *foreign Gatekeeper*, respectively. Mobility management is realized by the cooperative support of the home and foreign Gatekeepers, in a similar fashion as HLR and VLR in GSM.

When roaming to a foreign zone, a visiting terminal notifies the visited foreign Gatekeeper of its existence with the transport address (a temporary IP address and a port number in a TCP/UDP environment) through registration. A temporary IP address of the visitor may be acquired dynamically by such means as the Dynamic Host Configuration Protocol (DHCP) [9] in the respective subnet. The foreign Gatekeeper then informs the home Gatekeeper of the reachability information using the address of the affiliated foreign Gatekeeper as the care-of address of the visiting terminal, hiding the actual point of attachment of the visitor behind a coarser destination. The home Gatekeeper performs mobility binding which associates the home address of the moving terminal with the temporary care-of address. Such coarser mobility binding than Mobile IP reduces the number of location update messages when a terminal is roaming from subnets to subnets in a zone.

3. REGISTRATION

As part of the configuration process, an endpoint registers with the Gatekeeper identified through the discovery process. Gatekeeper discovery[2] is a process used by a terminal to determine which Gatekeeper to register with. Registration refers to the process by which an endpoint joins a zone and informs the Gatekeeper of its existence with its address. Registration occurs before any call attempts. If a mobile terminal stays in the home zone, normal registration takes place. A Registration Request (RRQ) message issued by the mobile terminal is sent to the home Gatekeeper. Each RRQ message contains transport address and alias addresses, along with the sending source address and the user identifier. The home Gatekeeper makes the decision, replying with a Registration Confirm (RCF) for approval or Registration Reject (RRJ) for refusal.

If a mobile terminal is currently away from home, a two-stage registration is performed. An RRQ message issued by the mobile terminal is sent to the visited foreign Gatekeeper, and then in turn forwarded to the home Gatekeeper to acquire the user profile[3] of the visitor. Again, both Gatekeepers are identified through a Gatekeeper discovery process. From the RRQ message, the home Gatekeeper can tell the message being forwarded from a foreign Gatekeeper, and updates the current location of the roaming terminal to the sending source address. The reply message (RRQ/RCF) is routed

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[2] We do not include the detail discussion of Gatekeeper discovery with registration. The same mechanism of Gatekeeper advertisement and Gatekeeper solicitation defined in [5] is applicable in this paper. Without loss of generality, registration implicitly follows Gatekeeper discovery.

[3] User profile here refers to any requirements or services related to call handling.

following the same path of the request in the reverse direction back to the foreign Gatekeeper, where the user profile is stored temporarily for proper call handling and the reply message may be modified to enforce the local policy before further forwarding. The reply message is finally delivered to the mobile terminal. With two-stage registration, the mobile terminal registers with the visited foreign Gatekeeper for local services and possible firewall traversal of signaling message exchanges from the home Gatekeeper, and with the home Gatekeeper for call preference on behalf of the mobile terminal and for billing purpose. The registration process is summarized in Fig. 2. Note that authentication and other security issues are important to registration as well. These issues are outside the scope of this paper and the corresponding messages are not shown in the figure.

4. CALL ESTABLISHMENT FOR MOBILE IP TELEPHONY

Call establishment is the ability to set up a call among participants. Such a call may be a point-to-point two-party call, or a multi-point conference call. Only a call between two H.323 mobile terminals is demonstrated. The same approach is applicable to multi-point conference calls with roaming participants. The core operations of call establishment for mobile IPtel include callee location tracking and a point-to-point call setup. Call setup signaling messages are transmitted through three kinds of channels: admission messages on unreliable RAS channels, followed by an exchange of call signaling on reliable H.225.0 [10] call signaling channels, and finally by the establishment of reliable H.245 [11] control channels.

Assume that both caller and callee are currently away from home and have performed the two-stage registration. When caller E1 attempts to place a call in a foreign zone, an Admission Request (ARQ) message is sent to the visited foreign Gatekeeper (FG1), replied with an Admission Confirm (ACF) for approval or an Admission Reject (ARJ) for refusal. If the admission is granted and the request comes from a visiting terminal, FG indicates in the ACF message to send call signaling message directly to the home Gatekeeper of the visitor[4]. Upon reception of the ACF, E1 issues a call setup message to the home Gatekeeper (HG1), from where the setup message is in turn forwarded to the home Gatekeeper of the callee (HG2), leaving the determination of target destination to HG2. The call setup signaling messages are routed through the home Gatekeepers of the two endpoints. These Gatekeepers assist with firewall traversal in the foreign zones. The foreign Gatekeeper who may control the firewall in the zone recognizes their relationship during the two-stage registration, and allows the call signaling messages to flow through the firewalls.

According to the information for mobility binding maintained by HG2, the setup message is then forwarded to the care-of address of E2, the address of the affiliated foreign Gatekeeper (FG2). FG2 replies with a Facility message indicating the actual location of E2 in its zone. HG2 withdraws the previous setup request and forwards the setup message to the final target destination. E2 then responds with the processing status following the same path of the request in the reverse direction back to the caller. E2 commits the connection with a Connect message, which includes its transport address (TA) of the H.245 control channel, to HG2. HG2 replaces the TA of the H.245 control channel with its own, and in turn forwards the Connect message to HG1. Finally, HG1 forwards the Connect message to E1 again, replacing the TA of the H.245 control channel with its own.

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[4] Foreign Gatekeepers can choose to route call signaling with the Gatekeeper routed call signaling model. Here only direct endpoint call signaling is demonstrated.

Call setup signaling is followed by H.245 signaling, through which the capability of two endpoints is exchanged, the master-slave determination is performed, and the logical channels are opened. The home Gatekeeper of the caller that contains a Multipoint Controller (MC) or the co-located Multipoint Control Unit (MCU) wins the master and therefore the MC is activated for future multipoint conference expansion. The reasons for using the home Gatekeeper of the caller to be a master include: (1) Endpoints may be roaming, which can be handled by the same procedure of dynamically joining and leaving the conference as indicated in [5]. They are not suitable to serve as the master, because the active MC departing from a conference results in the end of the conference. (2) This allows the home Gatekeeper of the caller to keep track of the provided services over time, for ease of billing. The procedure of call establishment is summarized in Fig. 3. Note that CID denotes Conference ID.

5. ROAMING

Roaming allows a mobile terminal to move while communicating. There are two roaming scenarios: *intra-zone roaming* and *inter-zone roaming*. The former describes a mobile terminal roaming within a zone, while the latter, one moving from zone to zone. The core operations of roaming include handoff and possible mobility binding. Upon crossing the subnet boundary, resulting in a change of the point of attachment, a connection must be handed off so that the on-going conversation is maintained. Location update is required only upon crossing a zone boundary, namely, inter-zone roaming. [5] has shown that handoffs can be realized through the same procedure of dynamically joining and leaving an ad hoc multipoint conference, a conference capable of expanding from a point-to-point conference involving an MC to a multipoint conference at some time during the call. This expansion may be realized by two alternatives: (1) the invite-to-join approach in which a new endpoint E is invited into the conference by any participant calling E through the MC, or (2) the request-to-join approach in which a new endpoint joins the conference by calling any participant in the conference.

Suppose that mobile terminal M is moving from a subnet (subnet1) to another (subnet2) in a foreign zone while communicating with the other endpoint E. A handoff is required to maintain the on-going conversation. Let M' denote mobile terminal M in subnet2. M' may obtain a temporary address in subnet2 dynamically using such method as DHCP. To use local resources and services, M' must request admission with an ARQ message to the foreign Gatekeeper (FG), followed by an ACF or an ARJ in reply. Upon the reception of a permission, M' joins the conference, using either the invite-to-join or the request-to-join approach. For invite-to-join, M calls M' to join the conference through the MC contained in Gatekeeper HG; for request-to-join, M' calls M to join the conference between M and E with conference ID (CID) equal to N. HG then follows normal procedure for a new participant joining an ad hoc conference for M'. M leaves the conference after M' has successfully joined. M follows the normal procedure for a participant to leave the conference, except the Disengage Request (DRQ) message is sent to FG rather than HG. FG is the one who needs to know the release of resources. FG then replies with a Disengage Confirm (DCF) message. The signaling procedure for intra-zone roaming is summarized in Fig. 4. Only the invite-to-join approach is demonstrated.

If M is in inter-zone roaming while communicating with E, registration is required for M' before joining the conference, and de-registration is required for M after leaving the conference. It ensures the correct location update in the home Gatekeeper (HG) of M and firewall traversal in the new foreign zone. M cancels the registration by sending an Unregister Request (URQ) message to the foreign Gatekeeper FG1, which is in turn forwarded to the home Gatekeeper HG. HG then responds with an Unregister Confirmation (UCF) message or an Unregister Reject (URJ) message. The reply message (UCF/URJ) is sent to FG1, and then to M. With de-registration, FG knows there is no more signaling messages coming from HG, and informs HG of the related information required for billing. The signaling procedure for inter-zone roaming is summarized in Fig. 5. Only the request-to-join approach is demonstrated.

6. CONCLUDING REMARKS

We have proposed an approach that realizes roaming with mobile H.323 terminals even with the existence of the firewall in a foreign zone. The system architecture has been described, and the corresponding mobility management has been presented. Mobility binding, which associates the home address of the moving terminal with the temporary care-of address, is coarser than Mobile IP, resulting in a reduction in the number of location update messages while roaming. Our proposed architecture also allows inter-Gatekeeper communications. The inter-Gatekeeper communications between the foreign Gatekeeper and the home Gatekeeper are advantageous in that (1) the calling preference and call related functions used in the home zone can still be enforced in the foreign zone, while the local policy is still restricted by the foreign Gatekeeper, (2) proper firewall traversal can be ensured; and (3) the home Gatekeeper can keep track of its registered "home" users over time for roaming.

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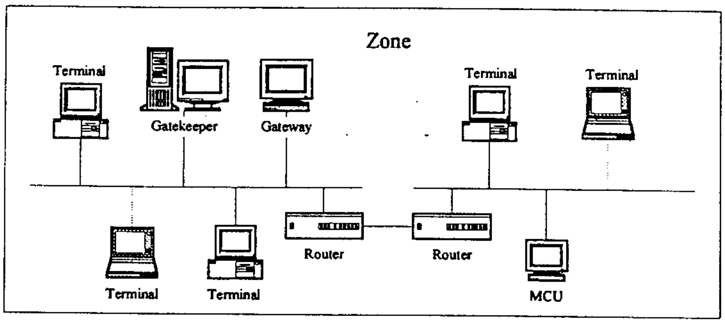

Figure 1: A zone in a mobile IP telephony system

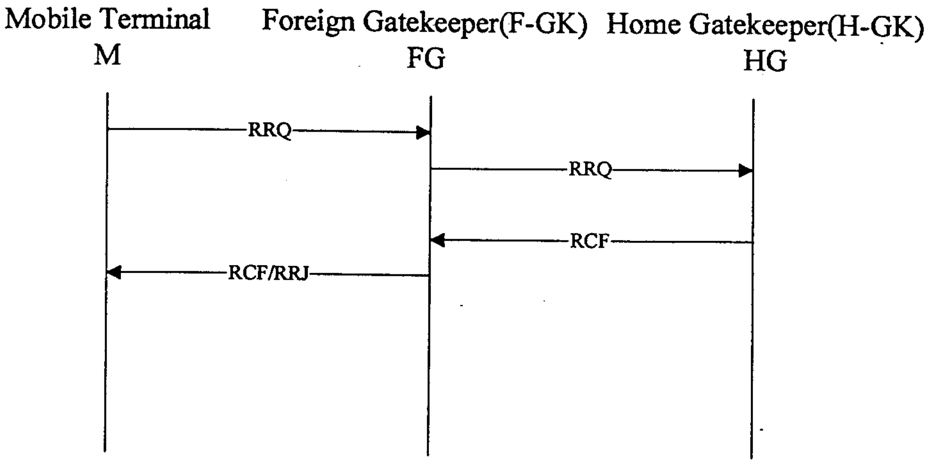

Figure2: Two-stage registration

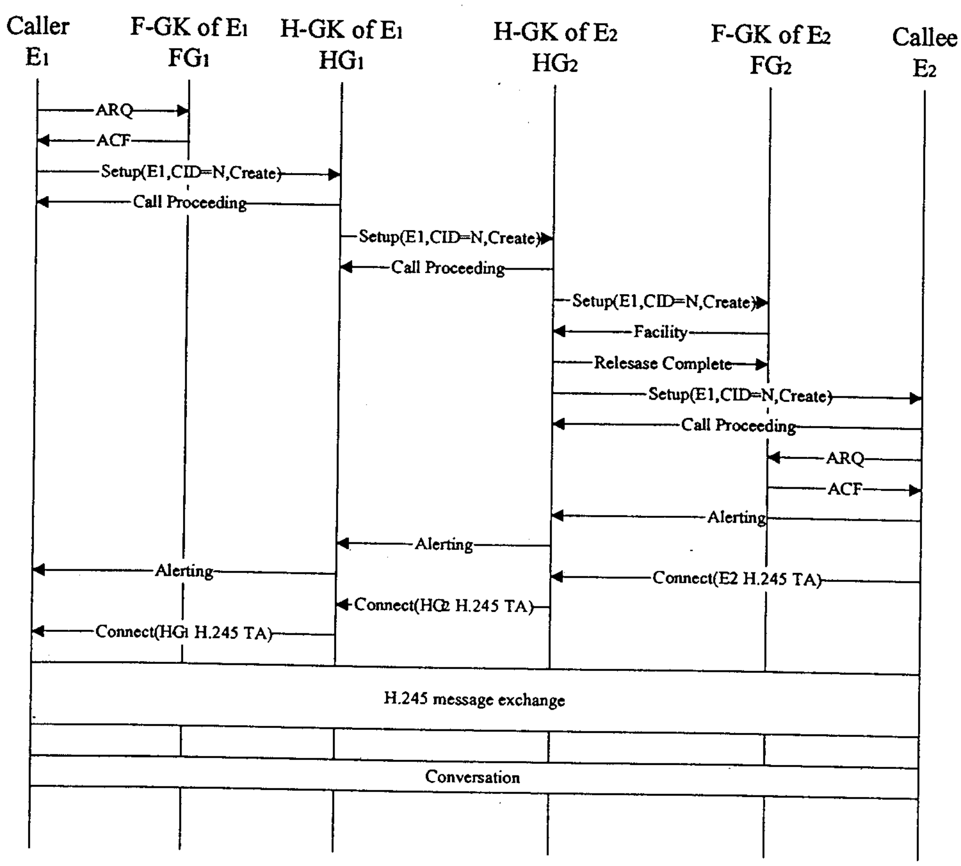

Figure 3: Call establishment

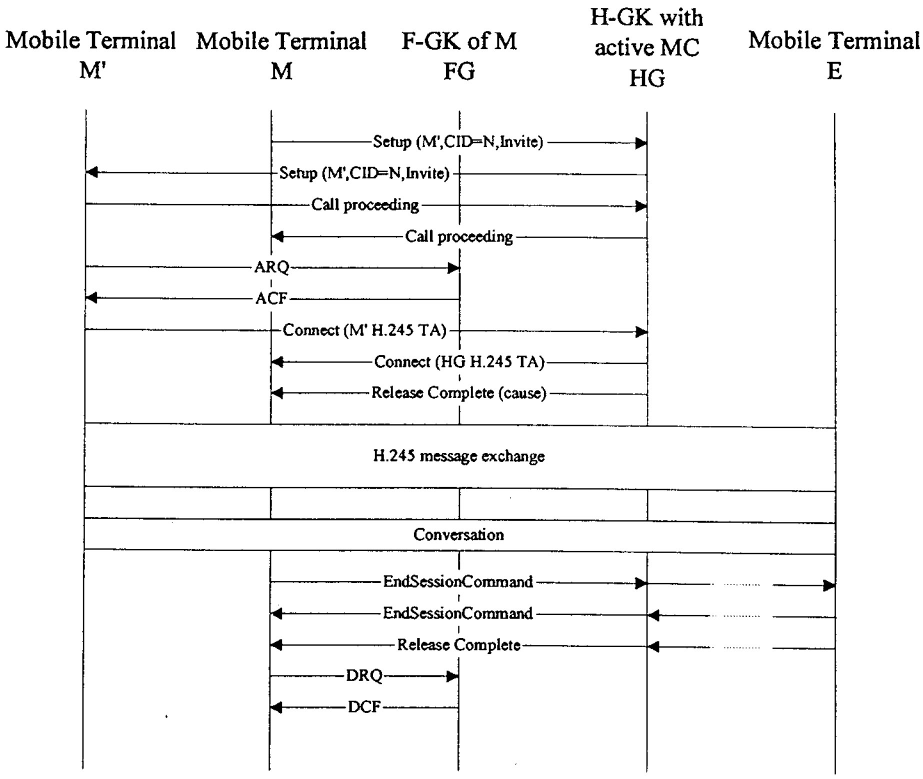

Figure 4: Intra-zone roaming

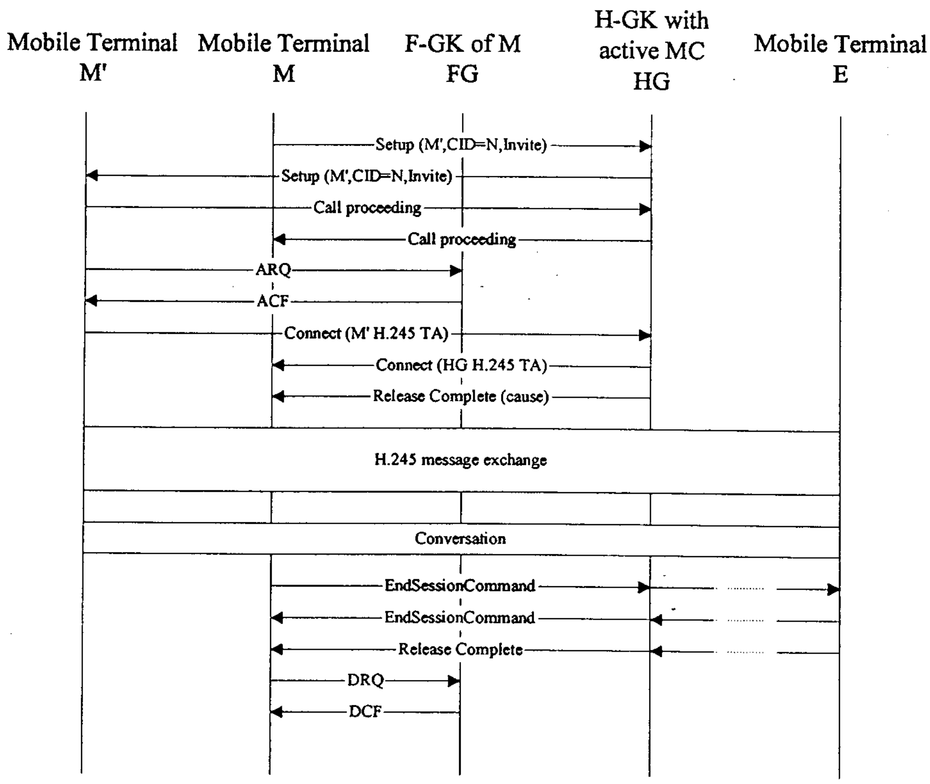

Figure 5: Inter-zone roaming