

PROGRAMMABLE MOBILITY ENABLED CONNECTION MANAGEMENT
SYSTEM

Field of the Invention

5

The present invention relates to an improved means and method of managing resources in a communication network. The method is particularly suited to the management of resources in a communication network where requests for network services may emanate from either fixed or mobile user terminals.

10

Background of the Invention

Multimedia networking is an emerging technological trend and there is presently an increasing user demand for networks to support multimedia traffic in wide and local area network environments. With the increasing usage of mobile terminals such as laptop computers, users are also demanding the ability to transmit and receive multimedia traffic from their mobile terminals.

As compared with text based communication, multimedia traffic generally involves much greater quantities of data and additionally, due to the time sensitive nature of multimedia traffic, this type of traffic has specific latency requirements.

It is generally recognised that in order to guarantee the strict performance requirements of multimedia traffic, connection oriented network communication is more efficient as compared with datagram based networking.

However, a connection oriented approach to handling multimedia traffic that provides for mobile terminals causes a significant increase in the management complexity of the network as compared with providing for only fixed terminals.

A number of approaches based upon "mobile agents" have been suggested in an attempt to overcome the problems introduced by considering mobile terminals in connection oriented network communication.

- 5 One of these approaches, US 5,825,759 (Liu), suggests the use of mobile floating agents and a predictive mobility management algorithm. The combination of these two concepts as taught by Liu provides for the network to predict the likely movement of the mobile user and to pre-establish a network connection for them in their "predicted" new location such that the connection
10 management overhead is less likely to cause a delay to the transmission of multimedia traffic and hence reduce the likelihood of breaching the strict latency requirements for the transmission.

- Whilst mobile floating agents or mobility agents as proposed by Liu may provide
15 a means by which network communications with mobile terminals may be accommodated within strict latency requirements, they do increase network load. This is generally as a result of network traffic associated with the management overhead of reporting and maintaining a record of the network location of the mobile terminal and/or the mobile agent itself. Accordingly, the
20 placement and mobility of mobile representatives within a network represent two critical design decisions.

- Ultimately, the provision of network services to users irrespective of their mobility and a minimal increase in network load as a result of management
25 overhead is ideal. The precise placement and mobility of any representatives or agents generally represents a trade off between the two ideals of reduced network overhead and transparency of service provision to mobile users.

- It is an object of the present invention to provide an alternative to proposals
30 involving mobile agents in the provision of network services that accommodate the possible existence and use of mobile network terminals. Additionally, it is

also an object to provide an alternative approach that offers a comprehensive range of network management services.

5 The above discussion of documents, acts, materials, devices, articles or the like is included in this specification solely for the purpose of providing a context for the present invention. It is not suggested or represented that any or all of these matters formed part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

10

Summary of the Invention

15 The present invention provides a method of managing a connection oriented communication network wherein network services are provided by a centralised network management entity, the method including the steps of a network entity generating a request for a network service, transmitting that request to the centralised network management entity, the network management entity processing that request by at least ascertaining the available, controllable network resources that may be used to satisfy, or partly satisfy, the service request and the centralised network management entity transmitting control signals to the appropriate network entities to satisfy the network service request.

25 In the context of this specification, the term "centralised network management entity" refers to the provision of network services from a single entity. In any actual embodiment, the "centralised network management entity" may be implemented by means of numerous hardware devices and software utilities. However, such an arrangement would still fall within the scope of the term "centralised network management entity" if the entity represented a single entity to which service requests are directed to and provided from.

30

It is preferred that a consistent signalling protocol be implemented between the individual network entities and the centralised network management entity. However, In a particularly preferred embodiment, network entities that do not include support for the signalling protocol of the network management entity
5 may communicate requests through a signalling gateway. As a result, existing installed network entities that do not include support for the signalling protocol of the management entity are not excluded from requesting network services where such a management entity is introduced into an existing the network. Of course, the purpose of such a gateway is to provide a translation of network
10 service requests into requests that comply with the signalling protocol of the management entity. Whilst also enabling the inclusion of existing devices that do not include support for the signalling protocol of the network management entity, signalling gateways also provide for the inclusion of future network entities that similarly do not include support for the relevant signalling protocol.

15

Therefore, it is preferable that in the method of the present invention, the step of a network entity transmitting a request to the centralised network management entity includes the transmission of that request to an intermediate network entity so that the intermediate network entity translates the request into a format
20 recognised by the network management entity and subsequently transmits the translated request to the network management entity.

Preferably, the centralised network management entity updates the status of available resources in a database having satisfied a request for a network
25 service thereby maintaining a record of network available to satisfy future service requests.

Additionally, when network resources are no longer required, it is preferable that the centralised network management entity update a database to appropriately
30 indicate the status of the network resources as being available for use. Preferably, upon no longer requiring a network service, network entities will

transmit a message to the management entity to indicate that the service is no longer required.

5 In a particularly preferred embodiment the database used by the centralised network management entity is unified. In this regard, it is preferable for the database to be utilised each time a service is requested by a network entity. Preferably, the centralised network management entity includes a unified database of all network resources and the availability thereof, the number of queries to the database to establish the ability to satisfy a network service request being reduced as compared with a distributed database system. This is particularly advantageous as compared with a database distributed over a number of network entities as network traffic would ensure each time the database was queried in relation to the availability of resources.

15 It is also preferable that the database of network resources maintained by the centralised network management entity include details in relation to all current network connections and the user terminals utilising those connections. As the user connections change over time, the database is preferably updated with the details of those user connections. This is particularly useful for mobile users who may change location numerous times during any one session with each location change potentially requiring a modification to the network service in use.

25 Preferably, the network services provided by the centralised management entity include the following individual services:

- Setting up of end-to-end connections between user terminals;
- Releasing of connections between user terminals;
- Adding a connection branch to an existing multicast connection;
- 30 - Deleting a connection branch from an existing multicast connection;
- Mobile user terminal attachment;
- Mobile user terminal detachment;

- Handoff for mobile user terminals;
- Reporting of availability of network resources;
- Reporting of performance in providing services; and
- Reporting of historical data in relation to the provision of services.

5

In addition, it is preferred that the method for establishing each service provided by the centralised network management entity be selectable dynamically. In this regard, dynamic selection refers to the ability to choose or select the preferred method for establishing a service during operation of the network.

10

Such a dynamic arrangement enables the most appropriate algorithm for establishing the service to be adopted depending upon the precise circumstances at the time. For example, it may be that during certain times of each day particular algorithms are better suited for the efficient establishment of
15 a service whereas during other times different algorithms are preferred. This approach is able to be effected whilst not altering the specific interface between the network entities and the centralised management entity and allows the management entity to be programmed to best suit the circumstances of the network at any particular point in time. In addition, such programming of the
20 management entity can occur completely transparently to all the other network entities forming the communication network.

When a network entity requests a network service that is required to establish or modify connections between network entities, it is preferable that the
25 centralised network management entity or a separate entity reporting thereto, analyse the request to determine the optimal route between the connection points. Various techniques exist to determine the optimal path through a network to connect two points and again, it is preferable that the specific algorithm for performing this analysis be dynamically selectable such that
30 different algorithms may be selected depending upon the specific circumstances of the network at the time.

In a particularly preferred embodiment, the analysis and determination of the optimal route for network requests is provided by an entity separate to the network management entity and is referred to as the Route Manager (RM). In this particularly preferred embodiment, when a network entity requests a network service, the network management entity preferably updates the currently recorded location of the mobile network entity in the Route Manager.

In the case of a point-to-multipoint connection route, also referred to as a multicast connection, between network entities with a single connection branch, when providing the service of adding a connection branch it is preferable that the centralised network management entity determine the new network segment required to be connected, referred to as the make segment, by performing a set subtraction operation between two sets. In performing a set subtraction operation, the first set is preferably that formed by the set of network nodes from the root to the new party node. Preferably the second set of such a subtraction operation is formed by an intersection operation between the set of network nodes comprising the initial connection route from the root to the various network nodes and the set of network nodes comprising the connection route from the root node to the new party node. The result of such a set subtraction operation provides the connection route which is required to be added to the existing multicast connection route to include the new node in the multicast communication.

In the case of a point-to-multipoint connection route with multiple connection branches, the set subtraction operation is preferably based upon the second set comprising the result of a union of individual set intersection operations between the connection routes of the multiple connection branches and the route from the connection root node to the new party node.

Similarly, when providing the service of removing a connection branch from an existing multicast connection, it is preferable that the centralised network management entity determine the existing network segment required to be

disconnected, referred to as the break segment, by performing a set subtraction operation between two sets. In this instance, it is preferred that the first set of the subtraction operation is that formed by the set of network nodes from the root to the party node to be removed. The second set is preferably that
5 comprising the union of the individual intersection operations between the connection routes of the branches and the connection route from the root node to the party node to be removed.

In the preferred embodiment of the invention, the handoff service is
10 implemented by considering the handoff from one location to another as consisting of two separate requests for the addition of a connection branch to the new location and the removal of a connection branch from the current location. The ordering of the requests depends upon the specific implementation of the handoff and in particular whether the handoff service
15 being implemented is a forward or backward handoff scheme.

In the preferred embodiment, the centralised network management entity provides a reporting service wherein detailed information regarding the usage or otherwise of network resources is provided. In addition, in the preferred
20 embodiment, the network management entity provides reports in relation to its own performance whilst establishing services. This service preferably also provides historical data in this regard and enables users and network management personnel to establish the usage characteristics of the network and hence determine the most appropriate algorithms to be dynamically
25 selected during operation of the network to most efficiently effect network services.

Whilst the invention is suited to all types of communication networks, it is particularly well suited to wireless asynchronous transfer mode (ATM) networks.
30

In a particularly preferred embodiment of the invention, the interfaces to the centralised management entity are "open" in that the details of the

communication protocol with the management entity is publicly available. This promotes the adoption of the centralised management entity into existing networks and promotes the usage of the management entity by third party providers of network services.

5

In another aspect, the present invention provides a connection oriented communication network including a centralised network management entity wherein all requests for network services are transmitted to the centralised network management entity and provided therefrom.

10

Preferably, the centralised network management entity includes a database that is used to maintain a record of available network resources.

Detailed Description of the Preferred Embodiment of the Invention

15

A preferred embodiment of the method of the invention will now be described in relation to the accompanying drawings. However, it is to be appreciated that the following description is not to limit the generality of the above description.

20 In the drawings:

Figure 1 illustrates a representative wireless ATM network including mobile and fixed terminals, access points and supporting ATM switches;

25 Figure 2 diagrammatically represents direct communication between user terminals and a Mobility Enabled Connection Manager (MECM);

Figure 3 diagrammatically represents indirect communication between user terminals and a Mobility Enabled Connection Manager (MECM) through
30 signalling gateways;

Figures 4 and 4a provide a diagrammatic representation of a signalling protocol as implemented in the preferred embodiment for establishing and disestablishing an end-to-end connection;

- 5 Figures 5 and 5a provide a diagrammatic representation of a signalling protocol as implemented in the preferred embodiment for establishing and releasing connection to/from an existing multicast connection;

- Figure 6 provides a diagrammatic representation of a signalling protocol as
10 implemented in the preferred embodiment for mobile attachment and detachment to/from a network ;

- Figures 7 and 7a provide a diagrammatic representation of a signalling protocol as implemented in the preferred embodiment for a backward and forward
15 handoff of a user mobile terminal;

- Figures 8 and 8a provide a diagrammatic representation of a signalling protocol and the corresponding connection route respectively for the example network of Figure 1 in which a MECM establishes an end-to-end connection;

- 20 Figure 9 provides a diagrammatic representation of a signalling protocol for the example network of Figure 8a in which a MECM releases the established end-to-end connection;

- 25 Figures 10 and 10a provide a diagrammatic representation of a signalling protocol and the corresponding connection route respectively for the example network of Figure 10a in which a MECM adds a new party to an existing multicast connection;

- 30 Figures 11 and 11a provide a diagrammatic representation of a signalling protocol and the corresponding route respectively for the example network of Figure 1 in which a MECM removes an existing connection branch;

Figure 12 provides a diagrammatic representation of a signalling protocol in which a MECM manages the attachment of a mobile terminal;

- 5 Figure 13 provides a diagrammatic representation of a signalling protocol in which a MECM manages the detachment of a mobile terminal; and

Figures 14, 14a and 14b provide a diagrammatic representation of signalling protocols and the corresponding connection route for the example network of

- 10 Figure 1 in which a MECM manages the backward and forward handoff of a mobile terminal.

With reference to Figure 1, an example wireless Asynchronous Transfer Mode (ATM) network is provided detailing various network components such as a
15 user mobile terminal (MT) and fixed terminals (FT), access points (AP) and ATM Switches. In Figure 1, the mobile terminal (MT) is contained within a circle with a dotted outline representing the transmission/reception range for the cell associated with the mobile terminal access point.

- 20 Figures 2 and 3 represent user terminal connection to a centralised network management entity, referred to in this description of the preferred embodiment as a Mobility Enabled Connection Manager (MECM), both directly and through a signalling/proxy gateway. In a particularly preferred embodiment of the invention, network entities that do not use the signalling protocol of the network
25 management entity communicate requests through a signalling gateway. Such a gateway may provide translation of network service requests into requests that observe the signalling protocol of the MECM. Whilst also enabling the inclusion of existing devices that do not include support for the signalling protocol of the network management entity, signalling gateways also provide for
30 the inclusion of future network entities that similarly may not include support for the signalling protocol of the MECM.

Although a single MECM is depicted in Figures 2 and 3, it is of course possible for a number of MECMs to exist simultaneously within a network. In this instance, the network would be considered to comprise a number of sub-networks in which case individual MECMs would provide management services for each individual sub-network. As a result, it will be seen that it is not necessary for an entire network to be managed by a single MECM for the invention to operate successfully. For example, in some networks there may exist an ATM network that forms a component of the overall network. In this instance, it is feasible to install a MECM to provide the management services of the ATM sub-network whilst retaining the existing management mechanism for the remainder of the network.

Figure 4 details an example signalling protocol involved in establishing a connection between two parties, namely, a calling party and a called party. Once the end-to-end signalling is complete, the parties engage in data transfer over the connection that is established. The connection could be released either by the called party or by the calling party, as detailed in Figure 4a.

Figure 5 details an example signalling protocol involved in adding a new party to an existing multicast connection. The request could either be initiated by the party at the root of an existing multicast connection (root initiated join) or by a party to become a new leaf node to an existing multicast connection (leaf initiated join). Similarly, a party at a leaf node can be dropped from an existing multicast connection by the party itself or by the party at the root as shown in Figure 5a.

Figure 6 details an example protocol for the attachment or detachment of mobile terminals. During initialisation of a mobile terminal, the mobile terminal preferably attaches itself to an access point (power-up attachment). During handoff, the mobile terminal preferably first detaches from the current access point (handoff detachment) and attaches to the new access point (handoff attachment). The mobile terminal may release all the connections and detach

from the network (shutdown detachment). All these scenarios are treated separately by a MECM. The access point preferably relays the attachment/detachment signalling messages between the mobile terminal and the MECM providing the management services for that part of the network.

5

Figures 7 and 7a detail an example signalling scenario for the two types of handoff, namely, forward handoff and backward handoff. In backward handoff, the mobile terminal initiates the hand off signalling with the current access point whereas in forward handoff, the mobile terminal initiates handoff signalling with the new access point. In backward handoff, the handoff detachment (from the current access point) and the handoff attachment (to the new access point) follow the handoff request. In forward handoff, the handoff request follows the handoff attachment. In this case, an explicit handoff detachment doesn't occur due to loss of radio connectivity with the current access point. The access point relays the handoff signalling messages between the mobile terminal and the MECM. The terminal with which the mobile terminal is communicating is referred to as the corresponding terminal (CT). There are various approaches to re-routing the connections during handoff including virtual channel extension, anchor-based re-routing and dynamic crossover switch based re-routing.

20

In the preferred embodiment of the invention, the MECM provides a range of network services including:

- Setting up of end-to-end connections between user terminals
- 25 - Releasing of connections between user terminals
- Adding a connection branch to an existing multicast connection
- Deleting a connection branch from an existing multicast connection
- Mobile user terminal attachment
- Mobile user terminal detachment
- 30 - Handoff for mobile user terminals

In providing some of these services, a MECM manages and controls various network resources including bandwidth and namespace. To establish some of these services, the network entities utilise one or more of the following MECM requests (with appropriate parameters):

5

- Setup-Request
- Setup-Response
- Release-Request
- Add-Party-Request
- 10 - Drop-Party-Request
- Attachment-Request
- Detachment-Request
- Handoff-Request

15 A MECM processes the abovementioned requests and transmits control signals to network entities using appropriate "open" interfaces provided by network entities.

In Figures 8 and 8a there is provided a diagrammatic representation of the
20 sequence of requests and the establishment route for the example network of Figure 1 in which a MECM establishes an end-to-end connection. In this instance, the end-to-end connection has been requested between the mobile terminal (MT) and the fixed terminal 1 (FT 1). The sequence of requests for the connection are represented in Figure 8 and a diagrammatic representation of
25 the connection route is detailed as a dashed line extending from FT1 to MT through switch 1, switch 3 and access point 1 (AP 1) in Figure 8a.

As can be seen from Figure 8, the MECM establishes the optimal connection route by sending a request to a Route Manager. Having established the optimal
30 connection route the MECM sends connection setup requests to switch 1, switch 3 and AP 1.

The algorithm used by the MECM in the preferred embodiment for processing the relevant requests are as follows:

Setup-Request

- 5
- Assign a connection identifier to the connection request
 - Invoke Route Manager and obtain the optimal route between the calling party and the called party
 - Assign connection identifiers (e.g., vpi/vci values in the case of an ATM link)
 - 10 for individual links on the route.
 - Insert the route and connection details into connection information table.
 - Setup the connection at the network nodes involved along the route. (different algorithms could be used for this' for example, hop-by-hop connection setup or a parallel connection setup could be used). Invoke
 - 15 *Setupindication* on the called party
 - Return the connection identifier assigned to the connection to the requesting entity.

Setup-Response

- 20
- If this is the first party of the connection then
 - update the connection information table and invoke *SetupConfirm* on the calling party
 - Else
 - 25 - update the connection information table and invoke the *AddPartyConfirm* on the calling party

Figure 9 provides a diagrammatic representation of a signalling protocol for the example network of Figure 8a in which a MECM releases the previously

30 established end-to-end connection.

As can be seen in Figure 9, a Release-Request signal is transmitted from the MT to the MECM. As a result, Connection Release and Release Indication signals are transmitted to the appropriate network entities in the connection route and the FT 1 respectively. Once the end-to-end connection has been released the example network returns to the configuration as detailed in Figure 1.

The algorithm used by the MECM in the preferred embodiment for processing the relevant request is as follows:

10

Release-Request

- If the connection is point-to-point or if the requestor is the "root" of a multicast connection, then
 - 15 - For each leaf node of the connection:
 - * Invoke *ReleaseIndication* on the party that is connected to that leaf node.
 - * Delete the connection at the network nodes involved along the route to that leaf node
 - Remove the entry from the connection information table.
- 20 • Else, if the connection is point-to-multipoint and the requestor is a leaf node,
 - Delete the connection at the network nodes involved along the route to that leaf node
 - If the leaf node is the last leaf node of this connection then,
 - * Invoke *ReleaseIndication* on the party that is connected to the "root" of
 - 25 this connection.
 - Else,
 - * Invoke *DropPartyIndication* on the party that is connected to the "root" of this connection.
- Update the connection information table.

30

In the preferred embodiment, for point-to-point connections the connection route information received from a Route Manager can be used directly to establish a connection.

- 5 For point-to-multipoint connections, route manipulation is required before establishing connections. For the purposes of this discussion it is assumed that all multicast connections are unidirectional connections from the root to the leaves. In the case of multicast connection management, when a new party requests addition to an existing multicast connection, connection establishment
10 along the complete path from the root to the new leaf node is not necessary. In this instance, part of the existing connections can be re-used. The extra or new segment of the connection that needs to be established is referred to as the "make segment" of the connection and the starting point of this segment is referred to as the "divergent node". This may be determined by comparing the
15 route from the root to the new leaf node with the route followed for the existing leaves.

An overview of the method for determining a route for adding a new party to an existing multicast connection follows. For the purposes of this and subsequent discussions, the symbol " $\setminus$ " denotes the set subtraction operator, the symbol " $\cap$ "
20 denotes the set intersection operator and the symbol " $\cup$ " denotes the set union operator.

Assume that an initial point-to-multipoint connection having a single connection branch exists with route $A = \{a_1, a_2, \dots, a_n\}$ with $a_1, a_2, \dots, a_n$ denoting the nodes. Also, assume that a new party requests to join this group. Determine the route
25 from the root (of the existing multicast connection) to the new party and denote this route as $N = \{n_1, n_2, \dots, n_k\}$. MECM may then determine the make segment of the connection to be established by doing a set subtraction of the routes $M = N \setminus (A \cap N)$ and then proceed to setup connection along the route M . In case there exists multiple connections with individual routes A_1, A_2, A_m , then the
30 make segment for the new party is computed as $M = N \setminus (\cup_{i=1}^m (A_i \cap N))$. The list of nodes in a route is always assumed to be ordered from the root to a leaf node.

Figures 10 and 10a provide a diagrammatic representation of a signalling protocol and the corresponding connection route for the example network of Figure 1 in which a MECM adds a new party to an existing multicast connection.

5

In the example network identified in Figure 10a, prior to the request for the addition of a new party, an existing connection between F1 and MT through switch 1, switch 3 and AP 1 is assumed. As a result of the Add-Party-Request signal transmitted to the MECM by FT 1 requesting the addition of FT 2, a make
10 segment from switch 1 to FT 2 is established.

The algorithm used by MECM in the preferred embodiment for processing the relevant request is as follows:

15 Add-Party-Request

- Assign an end-point identifier to the new end-point
- Invoke the Route Manager and obtain the optimal route between the root party and the leaf node party
- 20 • Assign connection identifiers (e.g. vpi/vci values in the case of an ATM link) for individual links on the route
- Insert details into connection information table
- Setup the connection at the network nodes involved along the make segment of the connection
- 25 • Invoke *SetupIndication* on the party that is connected to the called leaf.

For the same reasons as detailed in the discussion regarding addition of a party to an existing multicast connection, when a party requests removal from an multicast connection only a part of the connection from the root to the party may
30 require to be disconnected. This segment of the connection from the divergent node to the leaf node is referred to as the "break segment".

If the route corresponding to the party to be dropped is N , then the break segment of the route is computed as $B = N \setminus (\cup_{i=1}^m (A_i \cup N))$.

5 Figures 11 and 11a provide a diagrammatic representation of a signalling protocol and the corresponding connection route for the example network of Figure 10a in which a MECM removes an existing connection branch from a multicast connection.

10 Figure 11 details the sequence of requests associated with removing the connection branch MT from the multicast connection between MT and FT 1 and FT 2. As a result of removing the break segment (MT, AP 1, switch 3, switch 1), the only connection remaining is that from FT 1 to FT 2 as depicted in Figure 11a.

15 The algorithm used by the MECM in the preferred embodiment for processing the relevant request is as follows:

Drop-Party-Request

- 20
- Compute the break segment to the leaf node
 - Delete the connection at the network nodes involved along the break segment to this leaf node
 - If the leaf node is the last leaf node of this connection then,
 - Invoke *ReleaseIndication* on the party that is connection to the "root" of
- 25
- Else,
 - Invoke *DropPartyIndication* on the party that is connected to the "root" of this connection.

30 Figure 12 and Figures 13 provide respectively diagrammatic representations of a signalling protocol for the example network of Figure 1 in which a MECM carries out the attachment and detachment of a mobile terminal.

The algorithms used by the MECM in the preferred embodiment for processing the relevant requests are as follows:

5 Attachment-Request

- Authenticate the user terminal
- Update the mobile termination location at the Route Manager
- Allocation of wireless resources (in the case of wireless terminals)
- 10 • If it is a power-up attachment, then
 - Setup control channels
 - Launch the terminal proxy/agent/gateway, if necessary
- If it is a backward handoff attachment, then
 - Instruct the AP to start transferring the buffered data on the downlink.

15

Detachment-Request

- Update the location of the mobile terminal
- Re-route the connections setup for the terminal if the detachment
- 20 corresponds to a handoff and release the control channels setup for the terminal if the detachment corresponds to terminal shutdown
- Remove the signalling proxy/agent/gateway of the terminal if the detachment corresponds to terminal shutdown
- De-allocate (release) the wireless resources (in the case of wireless
- 25 terminals).

Figures 14, 14a and 14b provide a diagrammatic representation of signalling protocols and the corresponding connection route for the example network of Figure 1 in which a MECM manages the backward and forward handoff of a

30 mobile terminal.

For handoff involving mobile terminals in the preferred embodiment, a divergent node is first determined based on the current and new location of the terminal, and the connections are then re-routed. The connection re-routing is realised as a multicast connection management. A make segment is first determined by
5 treating the mobile terminal at the new location as the new party to be added and the crossover switch as the divergent node. The break segment is determined by treating the mobile terminal at the current location as the party to be dropped and the crossover switch as the divergent node. At that stage, the connection re-routing involves setting up the connection along the make
10 segment followed by deleting the connection along the break segment.

For handoff, the make and break segments of a connection are determined in a similar manner to that of adding and removing connection branches to/from a multicast connection. However, in this case, only two routes are used to
15 determine the make and break segments.

In the particular instance of Figure 14, a diagrammatic representation is provided detailing the sequence of requests in effecting a backward handoff of MT from radio cell 1 to radio cell 2. Figure 14a details the sequence of requests
20 for a forward handoff for the same movement of MT and Figure 14b depicts the example network of Figure 1 detailing the transferred connection, as a dashed line, from FT 1 to MT resident in radio cell 2.

The algorithm used by the MECM in the preferred embodiment for processing
25 the relevant request is as follows:

Handoff-Request

- If the request is for a backward handoff
30 - Decide or select the access point (new AP) to which handoff should take place
 - For every connection originating or terminating at the MT.

5 * Invoke the Route Manager and get the optimal route between the CT and
the new AP. Determine the divergent node and the make segment.
(Setup the connection at the network nodes involved along the make
segment of the connection and delete the connections to the old AP once
the handoff *DetachmentRequest* is received).

10 * Assign connection identifiers (e.g., vpi/vci values in the case of an ATM
link) for individual links on the make segment
* Insert the details into connection information table
- instruct the new AP to allocate resources

• If the request is for a forward handoff
- For every connection originating or terminating at the MT,
15 * Invoke the Route Manager and get the optimal route between the
CT and the new AP. Determine the divergent node and the make
segment.
* Assign connection identifiers (e.g. vpi/vci values in the case of an
ATM link) for individual links on the make segment.
* Insert the details into connection information table.
* Instruct the new AP to allocate resources.
20 * Setup the connection at the network nodes involved along the
make segment of the connection and delete the connections to
the old AP.
- Instruct the new AP to start transferring the buffered data on the
downlink.

25

A set of interfaces have been defined for the preferred embodiment using the
Interface Definition Language (IDL) of CORBA. These interfaces for transmitting
requests have been defined for a MECM designed and implemented for a
wireless ATM network.

30

```
long SetupRequest (in Address caller,  
                  In Address called,  
                  In NetworkServiceSpec quality)
```

```
Raises (Reject);
```

This method is invoked by the calling party whose address is given in "caller" to request a connection to be setup to the called party with the given quality of service requirement. This method returns a unique connection identifier that is used in subsequent methods to identify this connection.

```
Void SetupResponse (in long connection_id),  
                    in EndPoint Reference ep_ref)  
10      Raises (Reject);
```

This method is invoked by the called party of a point-to-point connection or the called leaf node of a point-to-multipoint connection to indicate the successful completion of connection setup on its side. The connection_id parameter identifies the connection and the ep_ref parameter specifies the end point reference that was assigned to the leaf node. The first party of a connection is assigned an end point reference of zero and subsequent leaves of the multicast connection are assigned integer values by the root of the connection. On receiving this call, the MECM forwards a connection success indication to the originator of the call.

```
void ReleaseRequest (in long connection_id,  
                    In EndPointReference ep_ref,  
                    In Cause why)  
25      Raises (Reject);
```

This method can be invoked by any party involved in a connection to request a connection tear down procedure. The "why" parameter specifies reasons for the tear down of the call. The connection_id and ep_ref parameters identify the connection and the end point within the connection, respectively. When this method is invoked by the root of a point-to-multipoint connection, all the leaves of the multicast connection are released. If this method is invoked by the leaf node of a point-to-multipoint connection, only the connection branch leading to the particular leaf node is released.

```
void AddPartyRequest (in long connection_id,  
                      In EndPointReference ep_ref,  
                      In Address new_leaf,  
5                      In NetworkServiceSpec quality)  
                      Raises (Reject);
```

This method is invoked by the root of a point-to-multipoint connection that wishes to add new leaves to an already existing multicast connection indicated by connection_id. The node with address new_leaf is added to the multicast
10 connection with quality of service as specified in quality. The ep_ref parameter contains an integer that is assigned to this leaf node by the root.

```
void DropPartyRequest (in long connection_id,  
                      In EndPointReference ep_ref,  
15                      In Cause why)  
                      Raises (Reject);
```

This method is invoked by the root of a point-to-multipoint connection to request the dropping of a single leaf node of the multicast connection. The connection
20 is identified by connection_id, while the leaf node is identified by ep_ref. The "why" parameter specifies reasons for the dropping of this leaf node.

```
void AttachmentRequest (AttachmentType type,  
                        In Address wt_address,  
25                        In Address ap_address)  
                        Raises (Reject);
```

This method is invoked to request the attachment of a Wireless Terminal (WT). Three types of attachments are possible as given in the type argument:

30

ATTACH_POWERUP – this is invoked when the WT attaches to the network for the first time. The MECM assigns resources to the WT and updates the location in the RM.

ATTACH_FORWARD_HANOVER – this is invoked when the WT attaches to a new AP after completing a forward handover procedure.

ATTACH_BACKWARD_HANOFF – this is invoked when the WT
5 attaches to the new AP after completing a backward handover procedure.

```
void HandoverRequest (HandoverType type,  
                      In string old_ap_address,  
                      In sequence<string> new_ap_list)  
10      Raises (Reject);
```

This is invoked to request a handover procedure. The type parameter specifies one of the following types of handover.

15 HANOVER_FORWARD – requests a forward handover procedure in which the WT loses contact with the previous AP before connecting to the new AP.

HANOVER_BACKWARD – requests a backward handover procedure
20 in which the WT remains in contact with the old AP as well as the new AP during the handover.

```
void Getstatistics (in unsigned short method_number, out  
PerformanceStatistics Stats)  
25      Raises (Reject, InvalidArgument);
```

Any client wishing to view the performance statistics that are recorded within the MECM may invoke this method.



CLAIMS

1. A method of managing a connection oriented communication network wherein network services are provided by a centralised network management
5 entity, the method including the steps of a network entity generating a request for a network service, transmitting that request to the centralised network management entity, the network management entity processing that request by at least ascertaining the available, controllable network resources that may be used to satisfy, or partly satisfy, the service request and the centralised network
10 management entity transmitting control signals to the appropriate network entities to satisfy the network service request.
2. A method according to claim 1 wherein the step of a network entity transmitting a request to the centralised network management entity includes
15 the transmission of that request to an intermediate network entity so that the intermediate network entity translates the request into a format recognised by the network management entity and subsequently transmits the translated request to the network management entity.
- 20 3. A method according to claim 1 or claim 2 wherein the step of a network entity generating a request for a network service includes requests to release resources upon no longer requiring the service.
4. A method according to any one of the preceding claims including the
25 step of the centralised network management entity updating the status of available resources in a database having satisfied a request for a network service thereby maintaining a record of available network resources.
5. A method according to any one of the preceding claims including the
30 step of maintaining a record of network connections and the user terminals using those connections.



6. A method according to claim 5 wherein the record of network connections is maintained in the same database as that used to maintain a record of available network resources.
- 5 7. A method according to claim 4 or 6 wherein the database is a unified database.
8. A method according to any one of the preceding claims wherein the centralised management entity provides at least one or more of the following
- 10 services:
- Setting up of end-to-end connections between user terminals;
 - Releasing of connections between user terminals;
 - Adding a connection branch to an existing point-to-multipoint connection;
 - 15 - Deleting a connection branch from an existing point-to-multipoint connection;
 - Mobile user terminal attachment;
 - Mobile user terminal detachment;
 - Handoff for mobile user terminals;
 - 20 - Reporting of availability of network resources;
 - Reporting of performance in providing services; and
 - Reporting of historical data in relation to the provision of services.
9. A method according to any one of the preceding claims wherein the
- 25 method for satisfying individual service requests is dynamically selectable.
10. A method according to any one of the preceding claims wherein a connection route for services requiring the establishment of a network connection is determined by an entity separate to the centralised network management entity, referred to as a Route Manager, the method including the
- 30 step of the centralised network management entity requesting the Route Manager to determine a connection route.



11. A method according to claim 10 wherein the method used by the Route Manager to determine a connection route is dynamically selectable.
- 5 12. A method according to either claim 10 or 11 wherein the Route Manager maintains a record of the location of mobile network entities the method including the step of the centralised network management entity transmitting data relating to the location of mobile network entities to the Route Manager.
- 10 13. A method according to claim 12 including the step of only transmitting location data to the Route Manager if the location of a mobile network entity changes as compared with previously recorded locations.
14. A method according to any one of the preceding claims when providing
15 the service of adding a connection branch to a previously established point-to-multipoint connection between network entities with a single connection branch, the method including the steps of the centralised network management entity determining the new network segment to be connected by performing a set subtraction operation between two sets, the first set comprising the set of
20 network nodes from the root to the new party node and the second set being that formed as a result of an intersection operation between the set of network nodes comprising the initial connection route from the root to the various network nodes and the set of network nodes comprising the connection route from the root node to the new party node, the result of the set subtraction
25 operation providing the connection route to be added to the existing multicast connection in order to satisfy the network service request.
15. A method according to any one of the preceding claims when providing
the service of adding a connection branch to a previously established point-to-
30 multipoint connection route between network entities with multiple connection branches, the method including the steps of the centralised network management entity determining the new network segment to be connected by



performing a set subtraction operation between two sets, the first set comprising the set of network nodes from the root to the new party node and the second set being that formed as a result of a union operation of individual set intersection operations between the connection routes of the multiple
5 connection branches and the connection route from the root node to the new party node.

16. A method according to any one of the preceding claims when providing the service of removing a connection branch from a previously established
10 point-to-multipoint connection route between network entities, the method including the steps of the centralised network management entity determining the network segment to be removed by performing a set subtraction operation between two sets, the first set comprising the set of network nodes from the root to the party node to be removed and the second set being that formed as a
15 result of a union operation of individual set intersection operations between the connection routes of the branches and the connection route from the root node to the party node to be removed.

17. A method according to any one of the preceding claims when providing a
20 handoff service to accommodate the new location of a mobile terminal, the method including the steps of requesting the addition of a connection branch to the new location and upon successful connection of the mobile terminal requesting the removal of the connection branch to the old location.

25 18. A method according to claim 17 wherein the handoff service is implemented as a forward handoff from the old to the new location.

19. A method according to claim 17 wherein the handoff service is implemented as a backward handoff from the old to the new location.

30

20. A method according to any one of the preceding claims wherein the information provided by the reporting services of the centralised network



management entity is sufficient to enable network management personnel to determine appropriate algorithms to be used for the establishment of network services in an attempt to improve the efficiency and/or performance of the usage of network resources and the centralised network management entity.

5

21. A method according to any one of the preceding claims wherein the communication network is implemented in accordance with the asynchronous transfer mode protocol.

10 22. A connection oriented communication network including a centralised network management entity wherein all requests for network services are transmitted to the centralised network management entity and provided therefrom.

15 23. A connection oriented communication network according to claim 22 wherein the centralised network management entity includes a database in which the centralised network management entity maintains a record of available network resources.

20 24. A connection oriented communication network according to claim 23 wherein the database is a unified database.

25 25. A connection oriented communication network according to any one of claims 22, 23 or 24 wherein the method for providing network services is dynamically selectable.

26. A connection oriented communication network according to any one of claims 22 to 24 wherein the centralised network management entity maintains a record of the performance of the entity in providing network services.



- 31 -

27. A connection oriented communication network according to claim 26 wherein the centralised network management entity provides a report in relation to the performance of providing network services upon request.