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(54) Abstract Title  
**Handover between mobile networks**

(57) When a mobile requests handoff from a currently serving network, the current network provides a list of other available networks to the mobile, where it is stored. The mobile selects a preferred network and advises the current network accordingly. The current network thereupon sends information regarding neighbouring cells in the preferred network to the mobile. A list already stored in the mobile may be updated by information from the current network.

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HANDOVER BETWEEN MOBILE NETWORKS

5 The present invention is concerned with handover of a call between networks. The invention is particularly concerned with handover between UMTS networks and GSM networks but is also applicable to handover between different GSM networks and different cellular mobile networks generally.

10 In current GSM systems, it is possible for a user to select manually between a plurality of available GSM networks when a mobile device (User Equipment) is off line. It is also possible for the User Equipment to select a network automatically from among the available networks based on preferences stored in the User Equipment, normally in the SIM card. However, when a call is in progress, this selection is not possible. In the present specification, the term User Equipment is intended to encompass any equipment capable of communicating with a network; this will typically be a mobile telephone, but may be, for example, a dedicated data, facsimile, E-mail or video communication device or combination device.

15 During call progress, the majority of the User Equipment's radio resources are involved in the active call and so it is not possible to scan broadly for available networks. To enable a mobile device to move between cells, while a call is in progress, the network supplies a limited list of adjacent cells, normally confined to cells provided by the same network provider and permits the mobile device to make limited investigation of signal strength from the neighbouring cells. In the event that the mobile device finds a stronger signal from another cell, it can signal a change to the other cell.

25 Pursuant to the invention, it has been appreciated that it would be desirable to enable User Equipment to select a preferred one of a plurality of available networks while a call is in progress. This would be particularly beneficial when handing over from a UMTS network to a selected GSM network, but would also be useful, particularly when travelling outside the User Equipment's home network territory, to enable handover between preferred "foreign" networks.

Pursuant to the invention, it has been appreciated that, although this is not normally done, it would be possible for an active network to supply a list of cells not only belonging to the active network, but also including cells of other network providers. This potentially offers a solution to the problem mentioned above, and may be provided independently in an aspect of the invention.

However, the above mentioned potential solution has the attendant problem that the list of available cells may become too large in practical terms for the User Equipment to investigate during an active call. Thus, to implement the system, the network provider would have to supply a significant amount of information concerning other network providers' cells, and this may degrade performance of the network. This solution may therefore be undesirable for many network providers.

Pursuant to the invention, an improved solution has been proposed. According to the first main aspect of the invention, the invention provides a method of facilitating handover from a first network with which User Equipment is in communication to another network, the method comprising:

providing via the first network a list of available other networks;  
in the User Equipment, selecting between the available networks based on preference information and signalling to the first network at least one preferred other network; and  
providing, via the first network, neighbour cell information for the at least one preferred other network.

In this way, the User Equipment may signal a preferred network and then cell information for only the preferred network(s) need be transmitted to that User Equipment.

The preference information may be stored in the User Equipment, preferably in the SIM card. The preference information may include a list of networks which are "black listed" with which the User Equipment is not able to connect. The preference information may also include a list of networks which are "white listed" with which communication is preferred. The white list may include partner networks of the home network provider. The preference information may include an explicit "grey list" of networks which are to

be tried in the absence of a "white listed" network; alternatively, networks which are not explicitly in the white list or black list may be deemed to be in the grey list. Multiple levels of preference may be stored.

5 Preferably, the method includes storing in the User Equipment a list of available networks based on information supplied by the first network. This feature, using information supplied by a network rather than that obtained by a (relatively lengthy) search performed by the User Equipment, offers advantages and may be provided independently in a second aspect.

10 The method may include incrementally adding to or deleting from the list of available networks stored in the User Equipment. This feature avoids the need to re-transmit a complete list, thereby allowing shorter messages to be used, and may be provided independently in a third aspect.

15 Using the method of the first aspect, it becomes possible for a network to send different neighbour cell information to different terminals (User Equipment), based on preferences expressed by the terminals and not solely dependent on the area in which the terminals are located. This may be provided independently according to a fourth aspect of the invention.

20 The signalling of available networks by a first network, the first step in the method of the first aspect, is of itself a useful step as it provides a terminal with information concerning available networks without the terminal having to search. Thus, this feature may be provided independently in a fifth aspect.

25 The signalling by a terminal to an active network with which the terminal is in communication of a preferred (other) network (effectively the second step in the method of the first aspect) in itself provides useful information to the active network and may be provided independently in a sixth aspect.

The invention extends to methods of operating terminals and to methods of operating

networks, terminals and network for implementing any the above aspects.

In a first preferred implementation, the first network is a UMTS network and the list of available networks comprises a list of available GSM networks. This implementation facilitates handover from UMTS to a selected GSM network.

- 5 In a second implementation, the first network is a GSM network (or a UMTS network) provided by a first network provider and the list of available networks comprises a list of other GSM networks (or UMTS networks) provided by other network providers. This facilitates handover within a communication system between network providers.

An embodiment of the invention will now be described, by way of example.

- 10 By way of explanation, we will describe in general terms, the elements of a practical implementation of a handover system embodying several of the above aspects and advantageous features. The following applies to both handover between networks of a similar type (e.g. GSM) belonging to different network providers, or between networks of differing types (e.g. UMTS to GSM), unless otherwise stated. Indeed, in certain  
15 applications it may be possible to select between multiple networks of multiple types, for example GSM 900, GSM 1900, UMTS and local coverage networks.

#### Features of User Equipment

- In addition to "standard" user equipment features, for communicating with the networks between which handover is to be performed (for a UMTS to GSM handover, this requires  
20 a dual mode terminal), the user equipment should ideally have the following components:-

- A store for a list of network preferences.

- This may be based on an existing store, preferably in the SIM card (which term as used in this specification is intended to encompass any removable device which is used to configure a standard handset), and will normally be at least partially pre-programmed by  
25 the home network provider. The equipment may be configured to allow the user to edit

at least part of this list, for example by adding networks or modifying preference levels. In particular, where a network provider has two or more partner networks in a given (foreign) country and the charges vary (either permanently or from time to time) between networks, the user (or the network provider) may update the preference list so that the cheaper network is always preferred. The preference list may simply be binary, 0 for never use ("blacklisted"), 1 for use if possible ("white listed"), unlisted networks being used if a network annotated 1 is not found. Alternatively, multiple levels may be stored; this facilitates differentiation on the basis of pricing. If multiple levels are used, the home network may be given a unique, highest, preference. If only two or a few levels are provided, the home network may nonetheless be specifically marked, if desired. Although it is greatly preferred to store the preferences, the user may be prompted to select an alternative network on demand; this will normally be inconvenient during a voice call, but may be more acceptable in a data communication application. The order in which the networks are listed may or may not be significant; if it is, even in a binary system, the order of networks within the stored list may be used to designate preference and all white-listed networks may be ranked in order. Thus, in the selecting step, the User Equipment may be arranged to find the first white-listed available network.

- Means for receiving and interpreting a message specifying available networks.

The User Equipment must be able to interpret a special message sent during an active call from the active network listing possible handover networks. This may be based on existing facilities for interpreting messages during a call, the special message being identified by a special prefix or identifier agreed with the network. It is to be noted that it may only be possible to perform preferential handover from certain networks but not others, particularly where certain networks are not configured to provide special messages identifying neighbouring networks. For example, in the case of UMTS to GSM handover, the UMTS network may be arranged to provide a list of candidate GSM networks, but, when attempting to hand back to UMTS from a GSM network, or when attempting to hand over between at least certain GSM networks, this may not be possible as the GSM network(s) may not be adapted to provide lists of candidate networks.

- Means for maintaining list of available networks.

5 Preferably, the User Equipment is able, in addition to (or instead of) receiving a complete list of available networks, to receive and interpret messages specifying incremental addition or deletion of networks from the current list of available networks. In this way, a complete list of available networks may be built up in the User Equipment by a series of "ADD" messages, rather than by transmitting a complete list. This feature is particularly desirable in regions where there are a number of networks from which to choose and the availability of each network changes from place to place frequently, as it avoids the need to re-transmit a long list each time one network becomes or ceases to be  
10 available.

- Means for requesting a list of available networks.

15 The network may be arranged to transmit available network information regularly or when the network determines that handover is desirable (for example when the received signal becomes weak). However, preferably, the User Equipment is able specifically to request this information; this may be achieved in a similar manner to the conventional manner for User Equipment to send a handover, but using a message identifier agreed with the network as signifying a request for available networks.

- Means for comparing the list of available networks to the list of preferences and selecting a network.

20 This may be achieved simply by searching for each available network in the list of preferences and returning the one (or top several) with the highest preference. Where more than one available network has an equal top preference, the User Equipment may select several in turn and then, following receipt of radio cell information, select the network with the strongest signal. Alternatively, other criteria may be provided.

25 - Means for signalling the preferred network.

This may be achieved simply by sending a message with an identifier agreed with the network to signify a network selection.

5 Thereafter, the network would supply neighbour cell information for the selected network(s) in a similar manner to that presently used to enable cell-to-cell handover and the User Equipment would treat this cell information (radio frequencies, time slots codes, etc) in the same way to find the most suitable handover candidate.

### Features of Network

In addition to “standard” network parameters, a network should implement the following features:-

10 - Store of list of available other networks.

This list varies from point to point, so it is conveniently stored at each base station or radio access point. This may be based on stored information, obtained either based on knowledge of other networks in the area and predicted coverage, or based on empirical data, for example obtained by scanning for radio coverage throughout the region covered by a cell, or by fixed receivers located at the access point and surrounding access points. Normally the network will not know the position of the User Equipment to much better than 1 cell accuracy (although, by triangulation from other cells in the network, accurate positioning is possible; alternatively, a rough idea of direction within the cell may be obtained), so the list of potentially available networks may include all networks receivable at any point within the cell. If the list omits certain networks which are in fact available, then handover to those networks will not be possible, so it is desirable to include more rather than fewer in the list. However, where too many networks are included, efficiency will be degraded, as the User Equipment may be instructed to search for an “available” network which is in fact not available. It may be possible to update the list dynamically, based on information returned from User Equipment concerning availability of networks.

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For each available network, corresponding neighbour cell information (frequencies, time



slots etc) should be stored.

The network is configured to send and respond to messages described above in relation to the User Equipment. Thus, in a practical example, there may be the following processing steps and exchange of messages, where [] signifies a processing step and <> signifies a transmitted message:-

	UE	Network
	[Determine handover required]	
	<Request available networks>	
		[Look up list of available networks]
10		<List of available networks>
	[Compare list to preferences]	
	[Select preferred network]	
	<Signal preferred network>	
		[Look up cell info for preferred
15	network]	<Signal neighbour cell information>
	[Search for cell availability]	
	[Determine cell and network]	
	<Signal handover to specific cell>	
20		-Handover to new network-

The above deals with transmission of a complete list of available networks in response to a specific request. The following deals in particular with incremental updating of the list of available networks, and these details may be used in other contexts (not only in the UMTS to GSM handover case in which it is explained), for example in GSM to GSM handover.

#### Application to UMTS to GSM handover

Three novel signalling procedures are proposed as below. All these procedures rely on

local interaction between the dual mode terminal and the UTRAN, with no involvement of the VLR or core network.

5 We will assume that while a dual mode terminal has a call in progress, it maintains a list of potential GSM handover candidates { G1, G2, G3,...} (which may contain no entries if no potential GSM handover candidate is available). At any time it also has a preferred candidate Gpref which is a member of { G1, G2, G3,...}. This proposal describes signalling means whereby this list is maintained.

#### Signalling the availability of candidate GSM networks

10 At any time during a call the serving UMTS network U can signal to the dual mode terminal the identity of one or more GSM network that are available, {Gi.} for potential handover. This signal contains the unique network identifier of each potential GSM network. This message would typically be used when the terminal first enters the coverage area of a potential candidate GSM network while a call is active, or sets up a call while within its coverage area,

15 The terminal records the identity of the GSM networks, and compares it with internally stored information (for example a network preference list stored on the SIM and the identity of other available GSM networks previously signalled to it) and signals its preference Gpref back to the serving network, if it can identify a suitable network.

20 After this the serving network provides neighbour cell information relating to network Gpref until such time as the call ends, the terminal leaves the network or the terminal indicates a new value of Gpref .

#### Signalling the non-availability of an existing candidate GSM network

25 When the terminal leaves the coverage area of a potential candidate GSM network during a call, the serving radio network U can signal to the terminal at any time the identity of GSM networks, {Gi.} that are now unavailable. This signal contains the unique network identifier of the GSM network which is no longer available.

The terminal can note that this GSM network is no longer available, and using internally stored information (for example a network preference list stored on the SIM and the identity of remaining available GSM networks) signals its preference Gpref back to the serving network, if a suitable network is identified.

5 After this the serving network provides neighbour cell information relating to network Gpref until such time as the call ends, the terminal leaves the network or the terminal indicates a new value of Gpref .

#### Terminal network preference

10 At any time the terminal can signal a new preference Gpref back to the serving network, which would be chosen from the list of available networks. After this the serving network provides neighbour cell information relating to network Gpref until such time as the call ends, the terminal leaves the network or the terminal indicates a new value of Gpref .

Typically this signal would be sent if the list of available GSM networks changed in such a way that the preferred network needed to be re-evaluated.

15 In the above described second embodiment, the mobile device always has a preferred other network stored and is therefore regularly updated with neighbour cell information for that preferred network. This is particularly useful in the case of a dual mode terminal (the case of UMTS to GSM handover being one example, GSM 900 to GSM 1900 being another example) where the “unused” mode components can be kept up dated and ready  
20 to change as soon as required.

To summarise, the above embodiments provide the following novel features, each of which may be independently provided:-

- The signalling of available GSM candidate network information.
- The maintenance in the terminal of a list of available networks.
- 25 - The possibility of incremental addition and deletion of elements of that list.
- The ability of the terminal to indicate the preferred network.
- The ability to send selective neighbour cell information to different dual mode terminals,

so that different terminals within the same area may receive different neighbour cell information..

5 The above described features are not presently contemplated in either existing GSM standards or present proposals for UMTS standards. It will be appreciated, however, that the features may readily be incorporated in a modified version of proposals current at the time of filing, and any such modified standards are to be understood as encompassed within any references to UMTS and GSM systems.

The appended abstract is herein incorporated by reference.

Claims

1. A method of facilitating handover from an active network with which User Equipment is in communication to another network, the method comprising:  
providing via the active network a list of available other networks;  
5 in the User Equipment, selecting between the available networks based on preference information and signalling to the active network at least one preferred other network; and providing, via the active network, neighbour cell information for the at least one preferred other network.
  
2. A method of operating an active network to facilitate handover to another network  
10 comprising providing to User Equipment communicating via the active network a list of available other networks.
  
3. A method of operating an active network to facilitate handover to another network  
comprising receiving from User Equipment communicating via the active network an  
indication of at least one preferred other network and, in response thereto, providing  
15 neighbour cell information for the at least one preferred other network.
  
4. A method of operating User Equipment capable of handover between an active  
network and another network comprising storing in the User Equipment a list of available  
networks based on information supplied by the active network with which the User  
Equipment is in communication.
  
- 20 5. A method according to Claim 4 further comprising incrementally adding to or  
subtracting from the list of available networks.
  
6. A method according to Claim 2 further comprising sending a message to the User  
Equipment containing information for incrementally adding to or subtracting from the list  
of available networks.
  
- 25 7. A method of operating an active network to facilitate handover to another network

comprising providing to User Equipment communicating via the active network a message containing information for incrementally adding to or subtracting from a stored list of available networks.

5 8. A method of operating User Equipment capable of handover between an active network and another network comprising incrementally adding to or subtracting from a stored list of available networks based on information supplied by the active network with which the User Equipment is in communication.

10 9. A method of operating User Equipment capable of handover between an active network and another network comprising signalling to the active network with which the User Equipment is in communication a preferred other network for handover.

10. A method according to Claim 9, wherein said preferred other network is selected by the User Equipment from a list of available networks supplied by the network.

15 11. A method of operating an active network comprising sending neighbour cell information to User Equipment based on network preferences communicated by the User Equipment.

12. A method according to Claim 11 comprising sending mutually different neighbour cell information to mutually different User Equipment terminals based on mutually different network preferences.

20 13. A method according to Claim 1, 3, 9 or 10, wherein the preferred other network is selected based on information stored in the User Equipment, preferably in a SIM card.

14. A method according to any preceding claim, wherein the active network is a UMTS network and the other network is selected from available GSM networks.

15. A method according to any preceding claim wherein the active network is provided by a first network provider and the other network is selected from networks provided by

other network providers.

16. User Equipment for a mobile telecommunications system capable of handover from an active network to another network comprising means for storing a list of available other networks supplied by the active network.

5 17. User Equipment according to Claim 16, further comprising means for updating the stored list of available other networks based on information supplied by the active network.

10 18. User Equipment for a mobile telecommunications system capable of handover from an active network to another network comprising means for updating a stored list of available other networks based on information supplied by the active network.

19. User Equipment for a mobile telecommunications system capable of handover from an active network to another network comprising means for signalling a preferred other network to the active network during a call.

15 20. User Equipment according to Claim 19, further comprising means for storing network preference information.

21. User Equipment according to any of Claims 16 to 20, wherein the active network is a UMTS network and the other network is a GSM network, having means for communicating over both networks.

20 22. A mobile telecommunications network or component thereof including means for communicating to User Equipment communicating with the network a list of available other networks.

23. A mobile telecommunications network or component thereof according to Claim 22 having means for sending a message to the User Equipment containing information for incrementally adding to or subtracting from the list of available networks.

24. A mobile telecommunications network or component thereof including means for sending a message to User Equipment containing information for incrementally adding to or subtracting from a list of available networks stored in the User Equipment.

5 25. A mobile telecommunications network or component thereof including means for receiving from User Equipment communicating with the network an indication of a preferred other network and means for supplying neighbouring cell information for the preferred other network.

10 24. A mobile telecommunications network or component thereof including means for sending neighbour cell information to User Equipment based on network preferences communicated by the User Equipment.

25. A mobile telecommunications network or component thereof according to Claim 24 arranged to send mutually different neighbour cell information to mutually different User Equipment terminals based on mutually different network preferences.

26. A method substantially as any one herein described.

15 27. User Equipment substantially as any one herein described.

28. A network or network component substantially as any one herein described.





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Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:
UK CI (Ed.R): H4L (LDSC, LDSHN)
Int CI (Ed.7): H04Q 7/38
Other: Online: WPI, EDOC, JAPIO

Documents considered to be relevant:

Table with 3 columns: Category, Identity of document and relevant passage, Relevant to claims. Rows include GB 2289191 A (MOTORLA) and WO 99/45723 A1 (SBC).

X Document indicating lack of novelty or inventive step
Y Document indicating lack of inventive step if combined with one or more other documents of same category.
& Member of the same patent family
A Document indicating technological background and/or state of the art.
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