(12) UK Patent Application (19) GB (11) 2 341 293 (13) A

(43) Date of A Publication 08.03.2000

(21) Application No 9819305.5

(22) Date of Filing 05.09.1998

(51) INT CL[7]
H04Q 7/38

(52) UK CL (Edition R)
H4L LDSHS L1H10

(56) Documents Cited
EP 0777396 A1 WO 97/25802 A1 WO 95/32594 A1

(58) Field of Search
UK CL (Edition Q) H4L LDSHS LDSHX
INT CL[6] H04Q 7/38
ONLINE: WPI

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(54) Abstract Title

Apparatus and method for assisting handover in a cellular communications system

(57) An apparatus and method for soft handover of a call in a CDMA cellular communications network enhances system capacity by transmitting a portion of the call data from a mobile unit to a serving base station (13) and the remaining portion of the data to a handover candidate base station (14). Both portions are re-combined (29) at a controlling station (20) for onward transmission. The same arrangement can be employed on the downlink with data being split in the base stations (13, 14) and re-combined (18) in the mobile unit. Data can be split (3, 30) in proportion to relative quality of the links to each base station (13, 14) with extra error coding being applied to the poorer link.

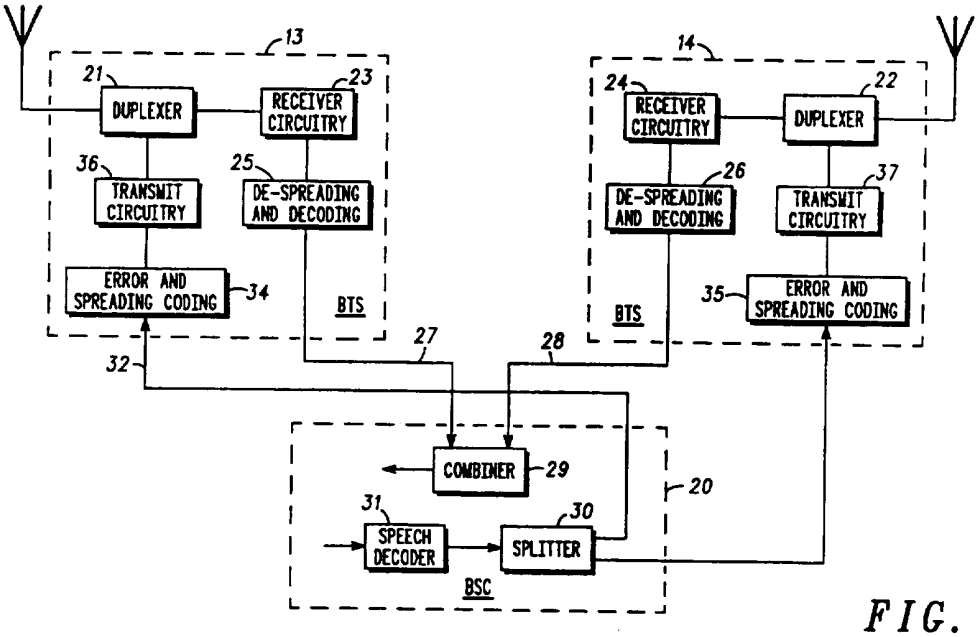

FIG. 2

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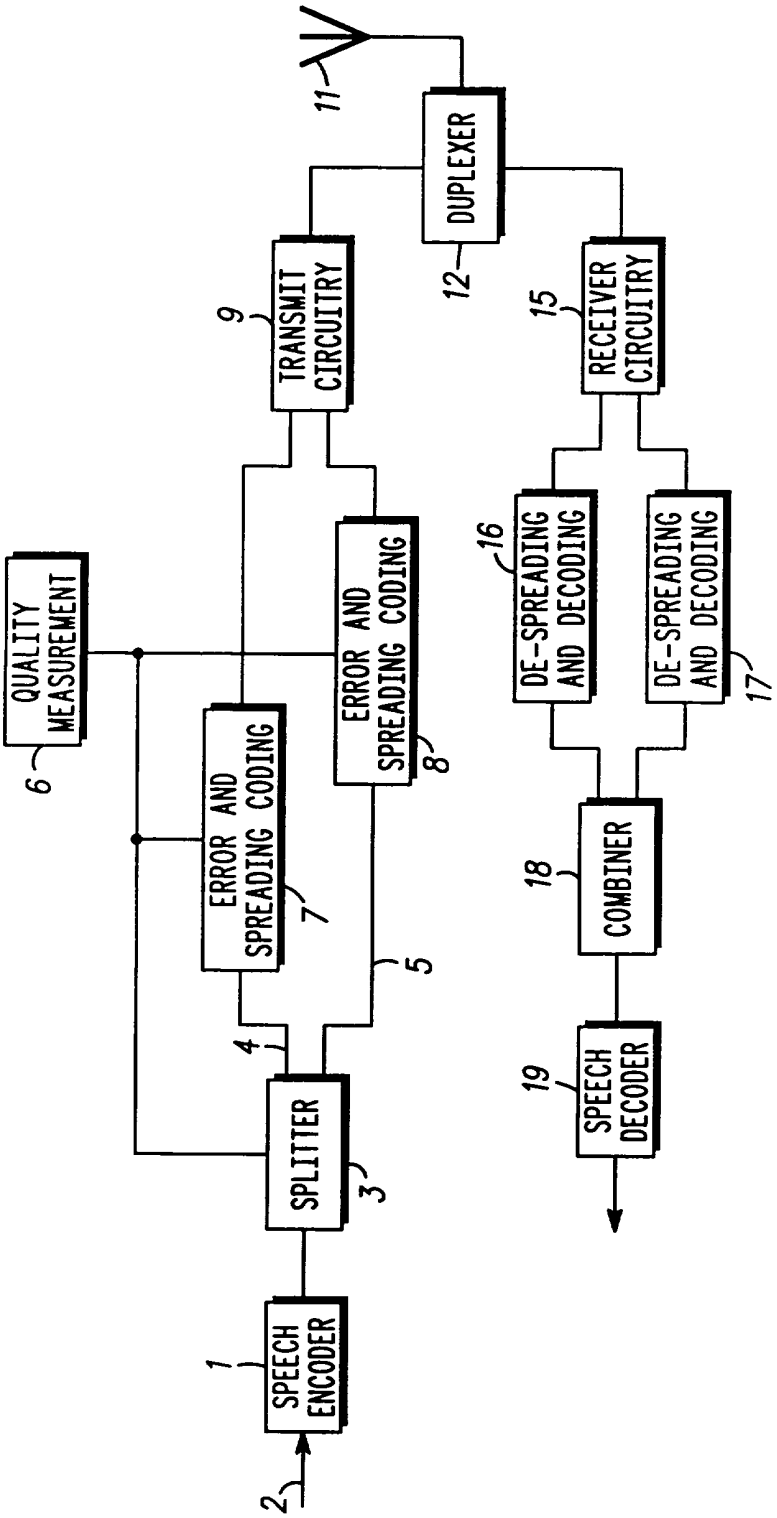
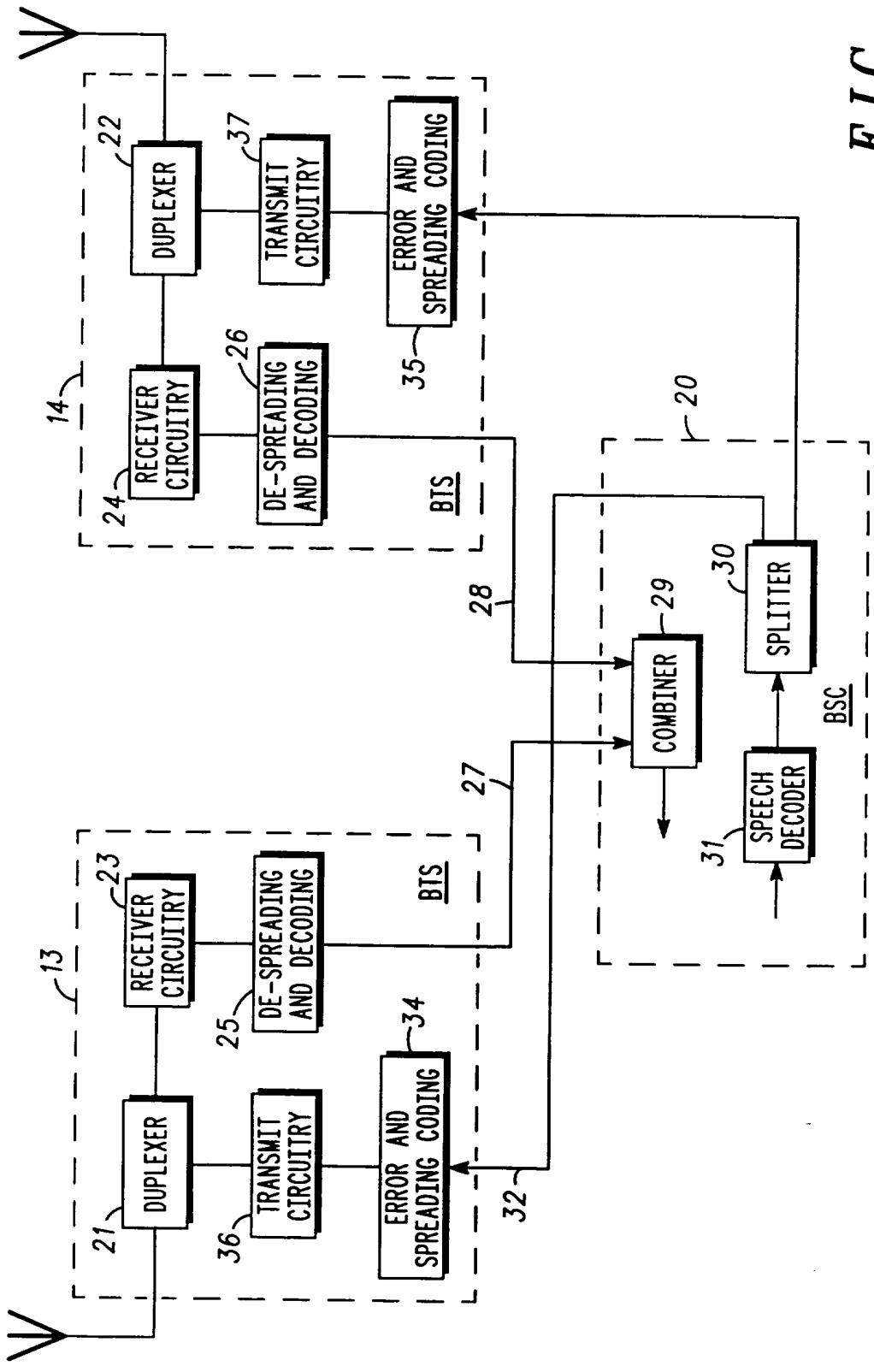

SPEECH ENCODER
1
2
SPLITTER
3
4
5
ERROR AND SPREADING CODING
7
ERROR AND SPREADING CODING
8
QUALITY MEASUREMENT
6
TRANSMIT CIRCUITRY
9
DUPLEXER
12
11
RECEIVER CIRCUITRY
15
DE-SPREADING AND DECODING
16
DE-SPREADING AND DECODING
17
COMBINER
18
SPEECH DECODER
19

FIG. 1


13
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DUPLEXER
RECEIVER CIRCUITRY
DE-SPREADING AND DECODING
TRANSMIT CIRCUITRY
ERROR AND SPREADING CODING
BTS
BTS
COMBINER
SPLITTER
SPEECH DECODER
BSC

FIG. 2

APPARATUS AND METHOD FOR ASSISTING HANDOVER IN A CELLULAR COMMUNICATIONS SYSTEM

This invention relates to an apparatus and method for assisting a handover procedure in a cellular communications system and is particularly, though not exclusively, applicable to systems employing code division multiple access (CDMA) techniques.

In a cellular communications system, a plurality of base stations provides a radio telecommunications service to a plurality of mobile subscriber units. Each base station defines a particular geographical area or cell proximate to the base station to produce coverage areas. The communications link from the base station to a mobile subscriber unit is referred to as the downlink. Conversely, the communications link from a mobile subscriber unit to the base station is referred to as the uplink.

Multiple access techniques permit the simultaneous transmissions from several mobile subscriber units to a single base station.

The CDMA system employs spread spectrum signalling. Spread spectrum signalling can be broadly defined as a mechanism by which the bandwidth occupied by a transmitted signal is much greater than the bandwidth required by a base band information signal. Two categories of spread spectrum communications are direct sequence spread spectrum (DSSS) and frequency hopping spread spectrum (FHSS). In the case of DSSS for example, the spectrum of a signal can be most easily spread by multiplying it with a wide band pseudo random code-generated signal. It is essential that the spreading signal be precisely known so that the receiver can de-spread the signal.

A cellular communications system using DSSS is commonly known as a Direct Sequence Code Division Multiple Access (DS-CDMA) system, according to TIA/EAI standard IS-95. Individual users in the system use

the same RF frequency but are separated by the use of individual spreading codes. Hence, multiple communications channels are allocated using a plurality of spreading codes within a portion of radio spectrum, each code being uniquely assigned to a mobile subscriber unit.

The capacity of a cell ie. the number of calls that it can support simultaneously, is limited by factors such as the available radio spectrum and the degree of interference that can be tolerated between channels.

To provide mobility to a subscriber within a cellular communication network, there needs to be a mechanism for transferring an ongoing call from one cell to another. This mechanism is known as "handover" or "handoff".

One known handover procedure for handing a call link from one cell to another is initiated when the base station handling the call detects that the received signal strength from a mobile subscriber unit falls below a pre-determined threshold value. A low signal strength indication implies that a mobile subscriber unit is near a cell border. When the signal level falls below a threshold, the base station queries the system controller to determine whether a neighbouring base station is receiving a mobile telephone signal with better signal strength than the current base station.

The system controller in response to the base station enquiry sends messages to the neighbouring base stations for the handover requests. The neighbouring base stations employ scanning receivers which look for the signal of the base station on a specified channel. Should one of the neighbouring base stations report an adequate signal level to the system controller, then a handover is attempted.

A handover is initiated when an idle channel from the new base station is selected. A control message is sent to the mobile subscriber unit commanding it to switch from the current channel to a new channel. At

the same time, the system controller switches the call link from the first base station to the second base station.

In one known system, such as disclosed in US 5,101,501, the call link from the first base station is maintained for a period after initiating and establishing a call link to the second base station. This process is called "soft handover" and has the advantage of reducing the perception of the handover due to loss of data during the actual handover.

However, this soft handover procedure has the disadvantage of being wasteful of resources because the same information is being simultaneously handled by the two base stations involved in the handover process. This necessitates increased transmission resource requirements in the cellular network infrastructure and over the air interface, thereby limiting its capacity.

An object of this invention is to provide a means for soft handover which mitigates this disadvantage.

In a first aspect, the present invention comprises apparatus for assisting handover of a call from a first base station serving a mobile subscriber unit to a second neighbouring base station, the apparatus including;

means for generating a data-carrying communications signal,
means for establishing a first communications link between the mobile subscriber unit and the first serving base station,
means for establishing a second communications link between the mobile subscriber unit and the second neighbouring base station,
a splitter for splitting the data carried on the communications signal into first and second portions,
means for transmitting the first portion over the first communications link,

means for transmitting the second portion over the second communications link,
means for receiving the first and second transmitted portions,
and a combiner for combining the received first and second portions for re-generation of the communications signal.

In a second aspect, the present invention comprises a method for assisting handover of a call from a first base station serving a mobile subscriber unit to a second neighbouring base station, the method including the steps of;

generating a data-carrying communications signal,
establishing a first communications link between the mobile subscriber unit and the first serving base station,
establishing a second communications link between the mobile subscriber unit and the second neighbouring base station,
splitting the data carried on the communications signal into first and second portions,
transmitting the first portion over the first communications link,
transmitting the second portion over the second communications link, receiving the first and second transmitted portions,
and combining the received first and second portions for re-generation of the communications signal.

In one embodiment, data to be transmitted from a mobile subscriber unit (i.e. on the uplink) is split by a data splitter incorporated in the mobile subscriber unit into two equal parts, with a first part being transmitted to the serving cell base station and the second part being transmitted to the neighbouring base station of the handover candidate cell. Both received parts are re-combined by a data combiner incorporated in a base station controller (BSC) which controls the operation of both base stations. On the downlink, data to be transmitted from the base station controller to the mobile subscriber unit (MSU) is also split into two equal halves by a data splitter incorporated in the BSC. One half is sent to the base station in the

serving cell and the other half to the base station of the handover candidate cell for transmission over the air interface to the MSU. At the MSU the two parts received are re-combined by a data combiner incorporated in the MSU.

In a second embodiment, either one or all of the mobile subscriber unit, the base station controller or the base stations, are equipped with a device for measuring and comparing the quality (ie for example, signal strength or signal to noise ratio) of received signals, and the data to be transmitted is split into two unequal parts, with the greater proportion of data being transmitted on the communications link with the better quality.

The signal quality may be constantly monitored during the handover process as the MSU moves out of the serving cell's area of coverage and into the handover candidate cell area and the split of data varied in accordance with the relative quality of each communications link. Signal quality monitoring may be done either by the MSU, the base stations or the BSC or any combination of these.

In a refinement of the second embodiment, either or all of the MSU, base stations or BSC are equipped with a device for applying extra error coding to that part of the data signal being transmitted over the poorer link.

By splitting the data between the two base stations involved in the handover process, network resources are conserved and so reduction of capacity due to transmitting the same data over two links (as in the known system) is avoided.

Some embodiments of the invention will now be described, by way of example only, with reference to the drawings of which

Figure 1 is a schematic block diagram of certain components a mobile subscriber unit showing receive and transmit apparatus in

limited detail and incorporating apparatus in accordance with the invention,

and

Figure 2 is a schematic block diagram of base station components in a cellular communications network showing receive and transmit circuitry in limited detail and incorporating apparatus in accordance with the invention.

The mobile subscriber unit (MSU) of Figure 1 includes a speech encoder 1 for encoding an outgoing speech signal generated on line 2. The output of the speech encoder 1, comprising encoded speech data, is connected to a splitter 3 whereupon the data carried by the encoded speech signal is split into two parts, one part being output on line 4 and the second part being output on line 5. A second input to the splitter 3 is provided by the output of a received signal quality measurement module 6.

Both parts of the data signal have error coding and a spreading code applied to them by known techniques by modules 7 and 8 respectively. The error coding functions of the modules 7 and 8 are under the control of the output of the quality measurement module 6.

The coded parts of the data signal are then modulated onto a radio frequency (RF) carrier by transmit circuitry 9 in accordance with known techniques, and subsequently transmitted (on the uplink) by means of an antenna 11 via a duplexer 12 for reception by base transceiver stations 13 and 14 (see Figure 2).

Also included in the mobile subscriber unit of Figure 1 is receiver circuitry 15 connected to the duplexer 12 for demodulating signals received over the air interface (on the downlink) from the base transceiver stations 13 and 14. Two outputs of the receiver circuitry 15, corresponding to signals

received from the base transceiver station (BTS) 13 and the base transceiver station (BTS) 14 respectively, are de-spread and de-coded in a conventional manner in de-spreading and decoding modules 16 and 17. The data on the outputs of the de-spreading and decoding modules 16 and 17 are re-combined by a combiner 18 to give a composite signal which is fed to a speech decoder 19.

The base station circuitry of Figure 2 comprises the two base transceiver stations 13 and 14 and a base station controller (BSC) 20. Uplink signals received over the air interface from the MSU of Figure 1 at each BTS 13 and 14 are fed via the respective duplexers 21 and 22 to conventional receiver circuitry 23 and 24, and thence to de-spreading and decoding modules 25 and 26. The outputs of each of the despreading and decoding modules 25 and 26 are transmitted via datalinks 27 and 28 to the BSC 20 where they are combined by a combiner 29 for onward transmission to a remote subscriber unit with which the MSU of Figure 1 is communicating.

The BSC 20 also includes a splitter 30 for splitting into two parts encoded speech data which is output by a speech encoder 31 incorporated in the BSC 20. Additional data links 32 and 33 convey each of the two parts to one of the base transceiver stations 13 and 14. On reception, both parts of the data have error coding and a spreading code applied to them by modules 34 and 35 respectively and are subsequently transmitted (on a downlink) to the MSU of Figure 1 via transmit circuits 36 and 37 and duplexers 21 and 22.

In operation, initially at time T1, the MSU of Figure 1 is in communication with the BTS 13 over a communications channel having a particular frequency and spreading code assigned to it.

At time T2, the MSU has moved towards the area of coverage of BTS 14 and a need for a handover from BTS 13 to BTS 14 has been identified. (The mechanisms for making a handover decision are well known and will not be elaborated herein). The quality measurement module 6 measures the

quality of the downlink transmissions from both BTS 13 and BTS 14. Say for example, that the link to BTS 13 is presently better than that to BTS 14 and on this basis, the data from the speech encoder 1 is split so that 70% thereof is transmitted to BTS 13 and 30% thereof to BTS 14.

Hence, a second connection is established between the MSU and the BTS 14 on a second channel having a particular designated frequency and spreading code, by means of the transmit circuitry 9 and appropriate coding module 7 or 8.

Extra error coding is applied to the poorer link to BTS 14 via the appropriate coding module 7 or 8.

At the base transceiver stations 13 and 14, the received uplink signals are demodulated by the receiver circuitry 23 and 24. The extra error coding which was added to the poorer link is removed by the decoder 26 prior to onward transmission over the data link 28 because such extra coding is unnecessary over this (latter) type of link.

Similarly, the portion of data received at BTS 13 is transmitted over the datalink 27 whereupon it is combined with the portion of data received from the BTS 14 by the combiner 29 in the BSC 20.

The data to be transmitted on the downlink can be treated in a similar fashion. The MSU reports the quality measurements to the BSC 20 via the base transceiver stations 13 and 14 and on this basis, the BSC 20 adjusts the split of data to be transmitted in the same fashion. Additional error coding can be applied by the appropriate coding module 34 or 35 in the base transceiver stations 13 and 14 to the poorer link.

Say at time T3, the quality of the links to both base transceiver stations 13 and 14 are comparable. The splitters 3 and the MSU 30 and BSC 20 can now adjust the split of data to 50% into each link. No additional error

correction to either link need be applied, if both links are of good quality. If both links are poor however, a comparable amount of error correction can be applied to both.

At time T4, as the MSU recedes from base transceiver stations 13 area of coverage, less data can be sent over this link and more over the link to BTS 14.

At time T5, as the MSU moves away from the BTS 13 area of coverage and wholly into that of BTS 14, the link with BTS 13 is disconnected, splitters 3 and 30 are effectively disabled and all data is transmitted over the one link.

In alternative embodiments, a quality measurement module may be provided at each BTS instead of or in addition to the quality measurement module 6 included in the MSU. In this way, uplink quality measurements can be made and if desired, reported to the MSU.

CLAIMS

1. Apparatus for assisting handover of a call from a first base station serving a mobile subscriber unit to a second neighbouring base station, the apparatus including;

means for generating a data-carrying communications signal,
means for establishing a first communications link between the mobile subscriber unit and the first serving base station,
means for establishing a second communications link between the mobile subscriber unit and the second neighbouring base station,
a splitter for splitting the data carried on the communications signal into first and second portions,
means for transmitting the first portion over the first communications link,
means for transmitting the second portion over the second communications link,
means for receiving the first and second transmitted portions,
and a combiner for combining the received first and second portions for regeneration of the communications signal.

2. Apparatus according to Claim 1 including means for comparing the quality of signals received over the first and second communications link, and in which the splitter is adapted to vary the proportion of data comprising the first and second portions dependant on the comparison.

3. Apparatus according to either preceding Claim including means for applying error coding to that portion of data being transmitted over the communications link having the poorer quality.

4. A method for assisting handover of a call, from a first base station serving a mobile subscriber unit to a second neighbouring base station, the method including the steps of;

generating a data carrying communication signal, establishing a first communications link between the mobile subscriber unit and the first serving bases station,
establishing a second communications link between the mobile subscriber unit and the second neighbouring base station,
splitting the data carried on the communications signal into first and second portions,
transmitting the first portion over the communications link,
transmitting the second portion over the second communications link,
receiving the first and second transmitted portions,
and combining the received first and second portions for re-generation of the communications signal.

5. Apparatus for assisting handover of a call substantially as hereinbefore described with reference to the drawings.

6. A method for assisting handover of a call substantially as hereinbefore described with reference to the drawings.

The Patent Office

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Application No: GB 9819305.5
Claims searched: 1-6

Examiner: Robert Macdonald
Date of search: 15 January 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): H4L(LDSHS, LDSHX)

Int Cl (Ed.6): H04Q(7/38)

Other: ONLINE: WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	EP 0777396 A1	(NOKIA) Whole document.	
X	WO 97/25802 A1	(KONINKLIJKE) See page 20, lines 3 to 20.	1,4
A	WO 95/32594 A1	(NTT MOBILE COMMUNICATION NETWORK) See figure 1 and abstract.	

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.