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(71) Applicant(s)
**Roke Manor Research Limited**
**(Incorporated in the United Kingdom)**
**Roke Manor, Old Salisbury Lane,**
**ROMSEY, Hampshire, SO51 0ZN,**
**United Kingdom**

(72) Inventor(s)
**Eric Douglas Murray**

(74) Agent and/or Address for Service
**Marc Morgan**
**Siemens Shared Services Ltd,**
**Intellectual Property Department, Oldbury,**
**BRACKNELL, Berkshire, RG12 8FZ,**
**United Kingdom**

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**H04B 7/26**

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(56) Documents Cited
**GB 2312357 A** **GB 2301739 A**
**GB 2277232 A** **WO 2001/024411 A1**
**US 5663958 A** **US 5590160 A**

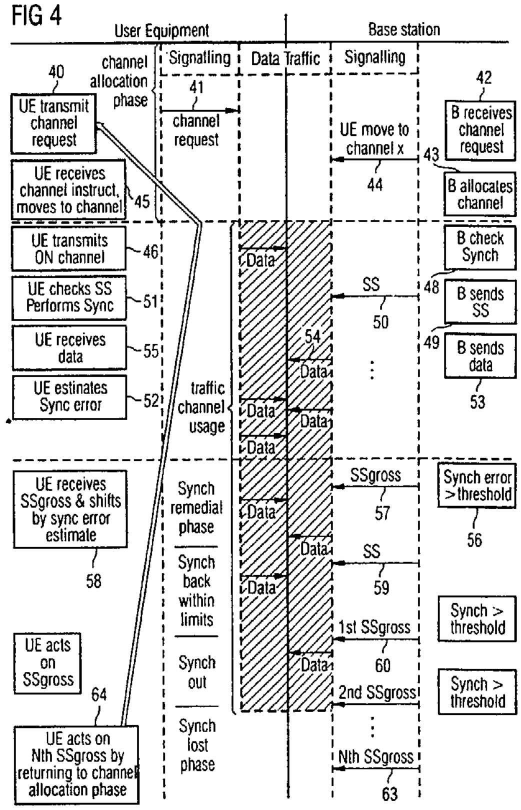
(58) Field of Search
UK CL (Edition T ) **H4L** LDCC LDSS LRPTC
INT CL[7] **H04B** 7/26, **H04J** 3/06, **H04L** 7/00 7/02 7/04 7/08
Other: **ONLINE: WPI, JAPIO, EPODOC**

(54) Abstract Title

# Maintaining synchronisation during signal path changes

(57) In a communication system comprising a number of base stations and user equipment, particularly a CDMA system, synchronisation commands from a base station are used to synchronise the user equipment so that it remains within the allocated channel. These commands tell the user equipment to adjust its timing as appropriate, e.g. stay the same or advance or retard one chip. In addition, the time of arrival of a command at the user equipment and its variation from an anticipated time of arrival can be used by the user equipment to determine a synchronisation error due to a change in the signal path. When the base station experiences a larger synchronisation drift than can be coped with by the normal commands, e.g. due to a rapid change in the signalling path resulting from changes in multipath reflections when the user equipment moves, it sends a special synchronisation command indicating this. Thus the synchronisation commands can be grouped into two types, the first type catering for a first level of synchronisation mismatch and comprising the normal commands, "Advance", "Retard", "Stay Same", and the second type catering for a second level of synchronisation mismatch and comprising a "Gross" command indicating that a synchronisation error threshold has been crossed. When the user equipment receives the second type of command it varies the timing of its transmissions on the basis of the synchronisation error that it has determined from the time of arrival of the synchronisation commands. If this does not work, after receiving a predetermined number of the second level commands, the user equipment sends a channel allocation request to the base station.

FIG 4

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG 1

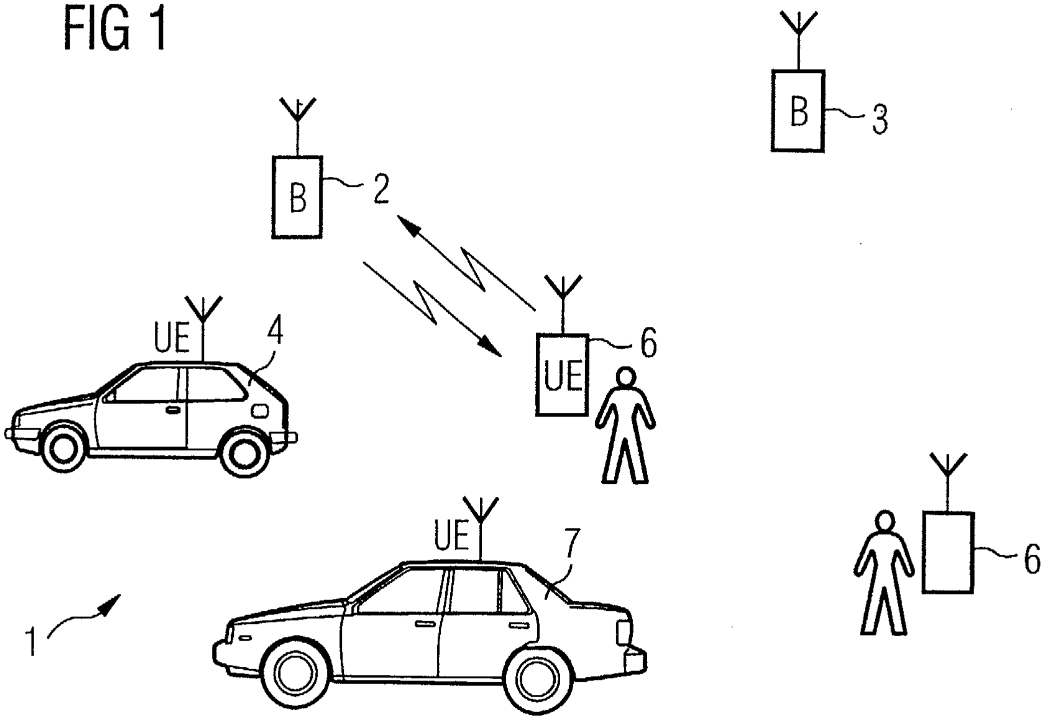



FIG 2

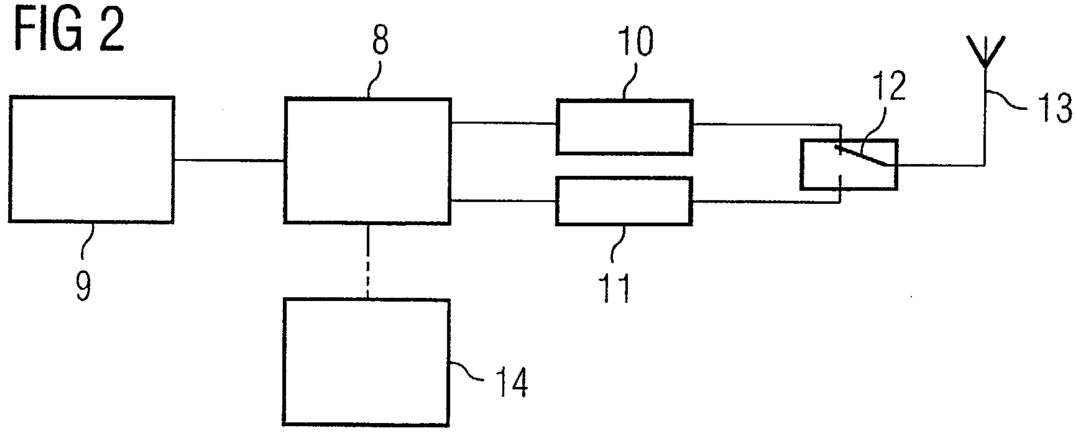



FIG 3

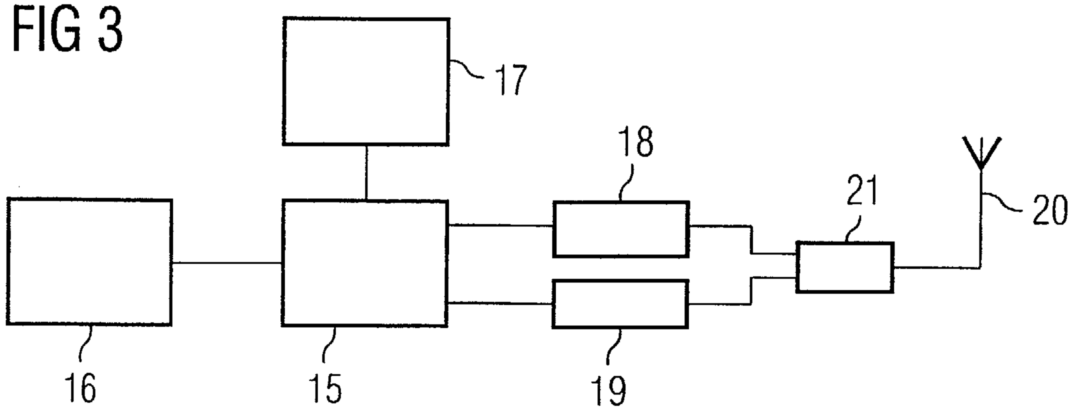
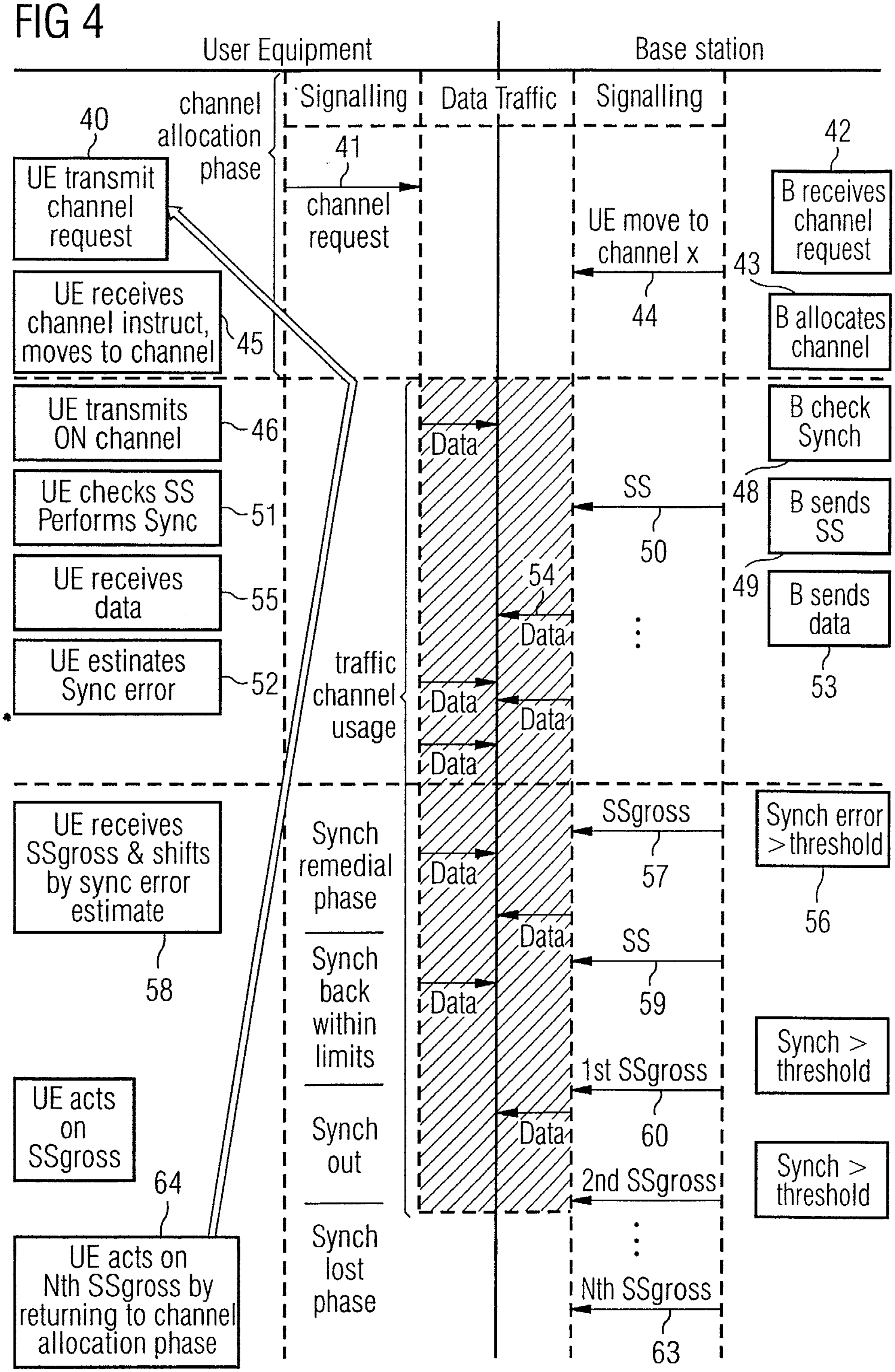
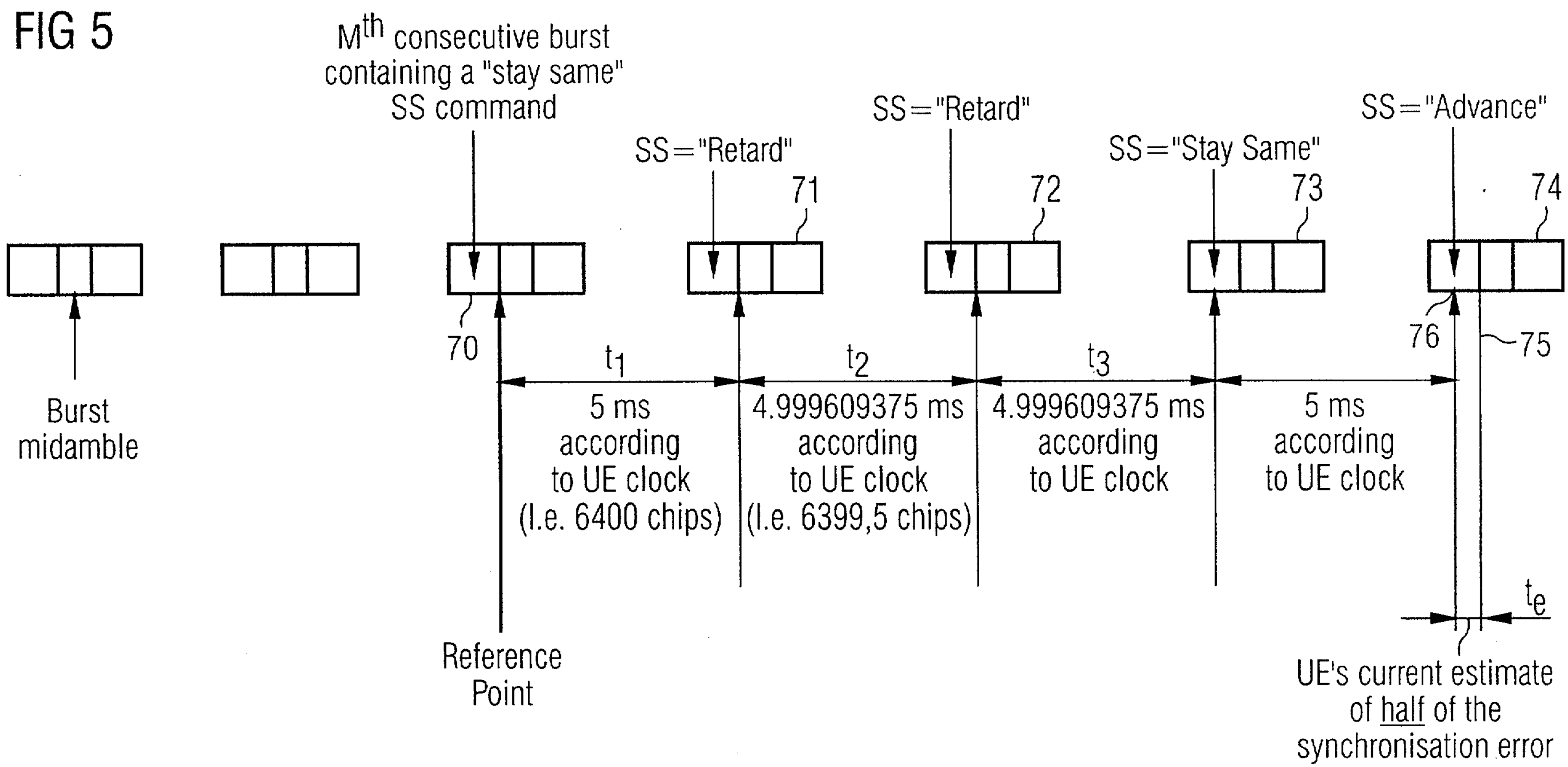


FIG 4



User Equipment
Base station
channel allocation phase
Signalling
Data Traffic
Signalling
40
UE transmit channel request
41
channel request
42
B receives channel request
UE move to channel x
43
44
B allocates channel
UE receives channel instruct, moves to channel
45
UE transmits ON channel
46
B check Synch
Data
UE checks SS Performs Sync
51
SS
48
B sends SS
50
UE receives data
55
54
Data
49
B sends data
UE estinates Sync error
52
traffic channel usage
Data
Data
Data
53
UE receives SSgross & shifts by sync error estimate
Synch remedial phase
Data
SSgross
57
Synch error > threshold
56
58
Synch back within limits
Data
SS
59
Data
UE acts on SSgross
Synch out
1st SSgross
60
Synch > threshold
Data
64
2nd SSgross
Synch > threshold
UE acts on Nth SSgross by returning to channel allocation phase
Synch lost phase
Nth SSgross
63

FIG 5


Mth consecutive burst containing a "stay same" SS command
SS="Retard"
SS="Retard"
SS="Stay Same"
SS="Advance"
71
72
73
74
70
76
75
t1
t2
t3
5 ms according to UE clock (I.e. 6400 chips)
4.999609375 ms according to UE clock (I.e. 6399,5 chips)
4.999609375 ms according to UE clock
5 ms according to UE clock
te
Burst midamble
Reference Point
UE's current estimate of half of the synchronisation error

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# A Communication Method and Apparatus

This invention relates to a communication method and apparatus particularly, but not exclusively for a code division multiple access based communication system.

A code division multiple access system requires that the units used in such a system operate in a synchronised manner. In essence communication channels are formed a slots and it is important that transmissions remain in allocated slots.

The requirement for the synchronisation is difficult to achieve because the mobile units in such a system for example hand-held user equipment or mobiles will be moving relative to base stations with which they communicate. Proposed systems can, in theory, accommodate motion upto 2900m/s. However, it is not only the speed of the motion of the user equipment that is important but rather the rate of change of the length of the signaling path. As will be appreciated user equipment is not always used in a manner which results in line of sight transmission and reception. Radio signals are reflected along multiple paths between a transmitter and a receiver . The most direct path may be blocked by a building and it will be appreciated that as a user moves during communication the most favourably received path may change and that change can be exceedingly rapid for example as a user walks around a corner. This rate of change can exceed that catered for and consequently the equipment may lose synchronisation to such an extent that the communication link cannot be maintained and the call is "dropped".

When a call is dropped the user equipment has to go through an initialisation procedure which involves a request for channel call on a pre-allocated signaling channel. The base station on detecting such a request then instructs the user equipment to move to a free time slot and the call is established again. However, such a process is time consuming and uses scarce signaling resource that might otherwise be better employed.

According to the invention there is provided a communication method for use in a radio communications system having a plurality of base stations and user equipment utilising uplinks and downlinks which method comprising: at the base station transmitting a set of synchronisation control signals on a downlink to cater for a first level of synchronisation mis-match and a second level of synchronisation mis-match; at the user equipment receiving the synchronisation control signals and determining therefrom a synchronisation error; where appropriate, acting on the synchronisation control signals and ,in response to the synchronisation signal, indicating the second level of synchronisation mis-match, attempting re-synchronisation using the determined synchronisation error.

A specific embodiment of the invention will now be described with reference to and as illustrated by the drawings in which:

Figure 1 is a schematic diagram of a communication system operating in accordance with the invention;

Figure 2 is a block diagram of a base station used in the system shown in figure 1;

Figure 3 is a block diagram of user equipment used in the system shown in figure 1;

Figure 4 is an explanatory diagram showing processes and signals used in the system shown in figure 1; and

Figure 5 is an explanatory diagram.

With reference to Figure 1, a radio communication system 1 comprises a number of base stations 2,3 and user equipment 4 to 7. The system operates in accordance with a code division multiple access method and has uplinks and downlinks for voice and data traffic, and also signaling.

Each base station (sometimes referred to in the art as a Node B) has substantially the same form. As is shown in Figure 2, each base station includes a processor 8 linked to a memory 9, a transmitter section 10 and a receiver section 11. The transmitter section and the receiver section are in turn operably coupled via an antenna switch 12 to an antenna 13. The base station is linked to a radio network controller 14 via a communication link shown in dotted line and an interface (not shown). The radio network controller performs a network control function by controlling all the base stations in the communication system.

Each base station is allocated to facilitate communication in a particular geographical area in a cellular manner. In the depicted system, base station 2 serves a geographical area within which are located the user equipment 4 to 7.

The general form of the user equipment is shown in Figure 3, and it comprises a processor 15 linked to a memory 16, input and output devices 17, a receiver section 18 and a transmitter section 19. The transmitter and receiver sections are operably coupled to an antenna 20 by means of an antenna switch 21. The antenna switch is controlled by the processor 15 to selectively couple the receiver and transmitter sections to the antenna 20. The input devices include a keypad and the output devices include a display and a speaker. A battery provides the necessary electrical power (not shown).

The general way in which the base station and the user equipment transmits and receives will be familiar to those of ordinary skill in the art of communication systems and will thus not be described. The inventive method employed by the apparatus for synchronisation will now be described with reference to the explanatory diagram shown in Figure 4.

Figure 4 shows the activities carried out by the user equipment (UE) and the base station equipment (referred to as Base or B in the figure) and the signaling and data traffic signals. There are four distinct phases in the depicted interaction. These are, running top to bottom of the figure, a channel allocation phase, a traffic channel usage phase, a synchronisation remedial phase and a synchronisation lost phase.

In the channel allocation phase the User Equipment is activated by the user and in a process represented by box 40 transmits a channel allocation request represented by arrow 41. The base station in a process 42,43, receives the request, determines a suitable available channel and sends an instruction to move to channel in signaling message 44.

The user equipment receives the signal 44 and "moves" to the relevant channel, process box 45. By moving to the channel, it is meant that the user equipment configures itself to transmit and to receive on appropriate logical channels. The traffic channel usage phase is then entered.

The user equipment then transmits on the allocated channel in process 46 resulting in a data signal 47 being transmitted in the uplink to the base station. The data signal 47 is received by the base station and processed. In the processing the base station checks for the synchronisation as represented by box 48 and forms and transmits 49 a suitable synchronisation shift (SS) signal 50. The precise nature of this signal type will be described in detail after this overview.

The user equipment upon receipt of the SS signal performs any requested synchronisation adjustment in process 51 and then in process 52 estimates from the arrival time of the SS signal a synchronisation error. It should be noted that the time of arrival is used to determine this rather than the information contained in the signal. Accordingly, it is possible to do this using any downlink transmission whether for this user equipment or any other. The user equipment will also receive and process data traffic sent by the base station; process 53, data signal 54, process 55.

The data traffic flows in this manner across the data uplink and downlink. The base station regularly sends the SS signals to maintain the synchronisation. If, however, the user equipment is moving, a change in the multipath reflections of the signal, for example, by the most direct path being obscured by a building, may result in a significantly longer or shorter signal path leading to a lag or a lead in the timing of the transmission.

Such a large synchronisation error results in the sending of an SS signal that indicates that there is a "gross" synchronisation error. This type of signal is shown in the figure as "SS gross". Thus when the synchronisation error is detected by the base station to be greater than a threshold in process 56 an SS gross signal 57 is transmitted on the signaling downlink for the base station to the user equipment. The phase is now a synchronisation remedial phase.

The user equipment receives the SS gross signal and shifts its timing by the error that it has estimated from the receipt of the SS signals in process 58. In this instance, the base station detects that the User Equipment has returned to be within normal limits and thus reverts to sending SS messages 59. However, the transmissions move out of synchronisation again due to the motion of the user equipment and remain despite the transmission of a number of consecutive SS gross signals 60 to 62 culminating in an Nth SS gross signal 63. When the user equipment detects the Nth signal (N being a value preprogrammed in memory or it could be a value transmitted from the base station ) it ceases to transmit data having determined that synchronisation has been lost. Synchronisation is re-attempted by the user equipment sending details of itself, the service required to the base station on the currently allocated channel. The call may then be re-established but if it is not by the process taking too long, then the base station drops the call. It then returns to the channel allocation phase via process 64 and requests a channel in process 40.

A sequence of SS signals is shown in figure 5 these being embedded in a channel containing other data (not shown) such as voice data traffic. Each SS signal is QPSK modulated having 2 bits. This provides four signal states 00, 01, 11, 10. These are allocated to the four SS commands "Advance", "Retard", "Stay same" and "Gross". "Advance" means that the user equipment advances its timing by, in this case, one chip (other systems may use different increments). In the case of "Retard", the user equipment retards its timing by one chip. The "Stay same" signal signifies to the user equipment that it should neither advance nor retard its current timing.

The SS signals are transmitted by the base station at the same time interval. However, the time at which they arrive at the user equipment will vary as the path length between the base station and the user equipment varies. That is to say, as the user equipment moves the path length and hence the time between the arrival of the SS signals will vary. The user equipment uses this to estimate a current time delay using as its reference its own internal clock.

As is seen in Figure 5, the time of the burst mid-amble of the SS signal 70 is used as the first reference point. T1, the time between the reference point and the mid-amble burst of the next

SS signal 71, is 5ms which is equivalent to 6400 chips. The received SS signal 71 contains the command "Retard" accordingly the user equipment adjusts its timing and is ready to expect the next SS signal at a further time interval t2 which in this case is 4.999609375ms or 6399.5 chips (the one chip difference being split between the path to and from the base station). Again the user equipment expects the next SS signal to arrive at t3 again equal to 6399.5 chips. The SS command 73 is a "stay same" command and hence the next SS signal is expected by the user equipment to arrive within 5ms. However the time of arrival of the SS signal 74 is indicated by line 75 and this is separated by time te from the anticipated point indicated by arrow 76.

The indicated error is half that experienced over the complete round trip path (uplink and downlink). At this stage the user equipment does nothing with this information other than hold and update it in the memory. However, in the event of the command being "SS gross" then it shifts its timing by the estimated difference. As earlier described with reference to figure 4.

It will be appreciated that in this example the increment of timing change is one chip but in other alternative arrangements other shifts may be used.

In an enhancement of the described system and method, the base station anticipates the channel allocation request from the user equipment and then reallocates a slot based on the formerly allocated slot. This is achieved by the base station assuming that a channel allocation request following N SSgross messages will be that from the user equipment that was subject to the SSgross messages. Thus, instead of sending a timing correction for the random access channel used in the second phase of the request a channel procedure, it will send a correction for the formerly allocated slot, in the expectation that the user equipment will ignore the second phase and continue using the slot.

# Claims

Claim 1 A communication method for use in a radio communications system having a plurality of base stations and user equipment utilising uplinks and downlinks which method comprising:

at the base station: transmitting a set of synchronisation control signals on a downlink to cater for a first level of synchronisation mis-match and a second level of synchronisation mis-match;

at the user equipment: receiving the synchronisation control signals and determining therefrom a synchronisation error; where appropriate, acting on the synchronisation control signals and ,in response to the synchronisation signal indicating the second level of synchronisation mis-match, attempting re-synchronisation using the determined synchronisation error.

Claim 2 A communication method as claimed in claim 1 wherein synchronisation signals are used to determine an anticipated time of arrival of subsequent signals and the difference between the actual time of arrival and the anticipated time of arrival is used to calculate the determined synchronisation error.

Claim 3 A communication method as claimed in claim 2 wherein the sychronisation signals include commands to the user equipment to advance or to retard its transmissions.

Claim 4 A communication method as claimed in claim 4 wherein the synchronisation signals include a command to the user equipment to correct the timing of its transmissions by using the determined synchronisation error.

Claim 5 A communication method as claimed in claim 4 wherein the user equipment is responsive to a predetermined number of such commands to cause a channel allocation request to be transmitted from the user equipment to the base station.

Claim 6 A communication method substantially as hereinbefore described with reference to and as illustrated by the drawings.

Claim 7 Apparatus for radio communication comprising channel allocation means to allocate a communication channel to a radio transmitting apparatus, a sychronisation controller for transmitting to the radio transmitting apparatus commands to vary the timing of its transmissions; a synchonisation error estimator to determine from the arrival of the commands a syschnronisation error and responsive to a second command indicative of a synchornisation error threshold being crossed to vary the timing of the transmissions in accordance to the determined synchronisation error.

Claim 8 Apparatus as claimed in claim 7 comprising means to determine the number of second commands having been received and responsive thereto to transmit a channel allocation request to the channel allocation means.

Claim 9 Apparatus substantially as hereinbefore described with reference to and as illustrated by the drawings.

Claim 10 A communication system operating in accordance with anyone of claims 1 to 6 and or comprising apparatus as claimed in any one of claims 7 to 9.

Claim 11 User equipment for use in a system as claimed in claim 10.

Claim 12 A base station for use in a system as claimed in claim 10.

**Application No:** GB 0125291.5
**Claims searched:** 1-5, 7-8

**Examiner:** Anita Keogh
**Date of search:** 30 April 2002

## 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.T): H4L (LDCC, LDSS, LRPTC)

Int Cl (Ed.7): H04B (7/26), H04J (3/06), H04L (7/00, 7/02, 7/04, 7/08)

Other: Online: WPI, JAPIO, EPODOC

**Documents considered to be relevant:**

| Category | Identity of document and relevant passage | | Relevant to claims |
|---|---|---|---|
| A | GB 2312357 A | (NEC) see abstract | |
| X | GB 2301739 A | (DSC COMMUNICATIONS) see whole document | 1, 7 |
| A | GB 2277232 A | (MOTOROLA) see whole document | 1-4, 7 |
| A | WO 01/24411 A1 | (SIEMENS) see abstract | |
| A | US 5663958 | (WARD) see whole document | |
| A | US 5590160 | (OSTMAN) see whole document | |

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