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A method of determining timing advance information in a cellular radio system

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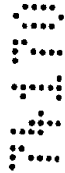
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(56) Related Art
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ABSTRACT

The invention relates to a method of determining timing advance information in a cellular radio communication system, the method being of the type comprising the following steps: a mobile station interrupts its call on a current channel with a first base station, to send a synchronization signal sequence to a second base station over a first target channel, said signal sequence enabling said second base station to calculate timing advance information associated with said mobile station relative to said second base station; the mobile station continues with its call over said current channel with the first base station immediately after sending said synchronization signal sequence to the second base station; and said timing advance information as calculated by said second base station is transmitted to said mobile station via at least one controller. Said first target channel is an access channel common to a plurality of mobile stations.



AUSTRALIA

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ORIGINAL
COMPLETE SPECIFICATION
STANDARD PATENT

Invention Title:

"A METHOD OF DETERMINING TIMING ADVANCE INFORMATION
IN A CELLULAR RADIO SYSTEM"

The following statement is a full description of
this invention, including the best method of
performing it known to us:-

This invention relates to cellular digital radio communication systems for use with mobile stations, and particularly, but not exclusively, systems designed to implement the public GSM radio telecommunications standard.

5 The term "GSM standard" is used herein to cover both the GSM 900 standard ("global system for mobile communications" operating in the 900 MHz band) and the DCS 1800 standard (digital cellular System" operating in the 1800 MHz band).

10 More precisely, the invention relates to a method of determining timing advance information in a cellular radio communications system, and to a method of performing a handover between cells, and to a method of localization using such timing advance information.

The description below makes use of terms that are commonly used in GSM terminology. For more information, reference can be made to the journal "Digital cellular mobile communication seminar" relating to the seminar held on this subject at Nice on October 16 to 18, 1990.

15 As a general rule, a cellular digital radio communication system is implemented as an array of geographical cells through which mobile stations travel. A base station is associated with each cell and in general makes use of a plurality of carriers. A mobile station communicates via its current base station, i.e. the base station associated with the cell in which the mobile station is to be found.

20 Conventionally, each carrier is time-divided using a fixed time division multiple access (TDMA) scheme. In such a scheme, the time axis is subdivided into successive frames of fixed duration, each frame is itself subdivided into a determined number of time slots. The recurrence of a particular time slot in each frame constitutes a physical channel over which a plurality of logical channels can be multiplexed.

25 One of the problems associated with GSM is synchronizing time slots in a mobile station with the master clock of the current base station. In order to avoid a mobile station transmitting data during a time slot allocated to another mobile station, it is necessary to take account of the propagation time of radio waves between said mobile station and the current base station, each of which stations has its own bit clock.
30

When a mobile station seeks to make a connection with a base station, it sends thereto an access signal known as an "access burst". On receiving this signal, the

base station computes timing advance information (TA) associated with said mobile station, and it sends a message to the mobile station informing it that it should transmit signals with timing advance TA relative to its own clock signal, in order to avoid overlapping signals transmitted by other mobile stations. Thereafter, the timing advance information T_k is updated frequently, so as to keep account of possible movement of the mobile station relative to the base station.

It is also necessary to handle transfer between cells, known as "handover", i.e. the transfer of a mobile station from one cell to another. This requires the timing advance information TA to be altered so that the mobile station becomes synchronized with the base station of the new cell.

Various types of handover are known, and their characteristics are summarized briefly below.

Synchronous handover assumes that the clocks of the various base stations are synchronous. Thus, when a mobile station passes from one cell to another, there is no need to supply it with new timing advance information since the new information can be deduced immediately from the information that was previously in use. Such a solution is extremely expensive because it requires all of the base stations to be synchronized.

Pseudo-synchronous handover makes it possible to synchronize a mobile station with the clock of the base station of the new cell by taking account of the time difference that exists between the base stations in the old cell and the new cell. This solution is complex to implement and requires a learning stage for the radio subsystem (base station system or BSS).

A Conventional, asynchronous handover is such that when the mobile station passes from a first cell to a second cell (respectively associated with first and second base stations): a (target) channel of the second base station is allocated to the mobile station; the mobile station sends a synchronization signal sequence (a "handover access") to the second base station over the target channel; on receiving the synchronization signal sequence, the second base station computes the timing advance information and sends it to the mobile station in a message known as "physical info"; the mobile station synchronizes itself and communicates with the second base station on the basis of the new timing advance information; and finally,

once the procedure has terminated, the first base station releases the channel previously allocated to the mobile station.

5 A "conventional", asynchronous handover is the technique that is most commonly encountered and that is the simplest to implement. Nevertheless, it suffers from the major drawback of giving rise to an interruption in the call that is too long to be masked by speech extrapolation software. The time required by the second base station to measure the timing advance information is relatively long (about 40 ms to 80 ms), and during this time the mobile station can no longer continue to transmit data.

10 "Improved" asynchronous handover seeks specifically to reduce the time during which a call is interrupted while handover is taking place. For more details, reference can be made to French patent FR 92/10996 entitled "Procede de transmission d'une information d'avance temporelle a un mobile evoluant dans des cellules d'un reseau GSM a BTSs asynchrones" ["A method of transmitting timing advance information to a mobile station moving in cells of a GSM network having asynchronous BTSs"], which patent is included in the present description by reference.

15 "Improved" asynchronous handover differs from "conventional" asynchronous handover essentially in that the mobile station continues its call over the original channel via the first base station immediately after sending the synchronization signal sequence to the second base station. Thereafter it synchronizes itself and communicates with the second base station over the target channel only after it has received the new-timing advance information as transmitted by the second base station. In this way, call interruption between the moving station and the first base station is restricted to the time required for transmitting the synchronization signal sequence, and can therefore be masked by speech extrapolation software. In addition, transfer of the call from the first base station to the second is very fast and can also be masked.

20 Nevertheless, "improved" asynchronous handover, as presently implemented, does not provide optimum utilization of resources.

30 At present, the target channel of the second base station is allocated to the mobile station from the beginning of the handover procedure. It is thus generally constituted by a traffic channel (TCH), i.e. a working resource. Unfortunately, until it

comes into use by the mobile station for synchronizing and communicating with the second base station, this working resource is monopolized for the sole purpose of transmitting the synchronization signal sequence.

5 In addition, it can happen that the handover procedure is not carried through, in which case the target channel is released without ever carrying the call with the mobile station. At present, under such circumstances, the working resource constituted by the target channel is therefore monopolized to no useful purpose.

10 Localization methods are also known that are based on knowing a plurality (at least two, and generally three) different items of timing advance information concerning a single mobile station relative to a plurality of base stations. Given the propagation speed of a radio wave (300 meters per microsecond ($m/\mu s$)), each item of timing advance information provides range information relative to a given base station. By combining a plurality of such items of range information (generally by triangulation), it is possible to obtain information concerning the location of the mobile station.

15 Conventionally, timing advance information is obtained on each occasion as follows: a (target) channel of the base station concerned is allocated to the mobile station; the mobile station sends a synchronization signal sequence to the base station concerned over the target channel; finally the base station concerned, on receiving the synchronization signal sequence, calculates the timing advance information and sends it to the mobile station in a message.

20 As presently implemented, such localization methods do not make optimum utilization of resources. Each time timing advance information is computed, the target channel of the base station concerned is, at present, a traffic channel (TCH) or a stand-alone dedicated control channel (SDCCH), i.e. a working resource. In other words, localization is achieved in return for a relatively high radio cost in terms of working resources.

A particular object of the present invention is to mitigate those drawbacks of the state of the art.

30 More precisely, one of the objects of the present invention is to provide a method of determining timing advance information in a cellular radio communication system, said method making it possible to optimize utilization of working resources

(and specifically of TCH and SDCCH channels).

According to the invention there is provided a method of determining timing advance information in a cellular radio communication system, the method being of the type comprising the following steps:

- 5 - a mobile station interrupts its call on a current channel with a first base station, to send a synchronization signal sequence to a second base station over a first target channel, said signal sequence enabling said second base station to calculate timing advance information associated with said mobile station relative to said second base station;
- 10 - the mobile station continues with its call over said current channel with the first base station immediately after sending said synchronization signal sequence to the second base station; and
- said timing advance information calculated by said second base station is transmitted to said mobile station via at least one controller,
- 15 wherein said first target channel is an access channel common to a plurality of mobile stations.

The general principle of the invention thus consists in providing, in the second base station, a common access channel for all mobile stations needing timing advance information to be computed. In other words, each mobile station is not given its own target channel, but shares a target channel with other mobile stations.

This greatly reduces the radio resource required by the second base station to determine timing advance information for a plurality of mobile stations.

Preferably, said first target channel uses an up link whose associated down link is otherwise used by another channel.

- 25 In other words, a previously unused channel is used. In this way, timing advance information for the mobile station relative to the second base station does not monopolize any working resource (and in particular it monopolizes neither a TCH channel nor an SDCCH channel).

Advantageously, said other channel is a broadcast channel.

- 30 Advantageously, said first target channel is included within a multiframe structure in the same manner as the up link of a stand-alone dedicated control channel.

Advantageously, each mobile station accessing said first target channel is allocated a distinct access reference.

In this way, the second base station knows that each mobile station transmits thereto over the first target channel.

5 Preferably, access to said first target channel is controlled using a predetermined access method.

Thus, collisions on the first target channel between signals coming from different mobile stations are avoided.

10 Preferably, said predetermined access method is a sequential access method of the "starting time" type.

This method is presently in use in GSM, in particular for redefining frequency, where it serves to tell a mobile station the instant from which it is to use a new set of frequencies.

15 The invention also provides a handover method of the asynchronous type in a cellular radio communication system, wherein the method comprises the steps of the above-specified method for determining timing advance information; and

20 wherein the method further comprises a step during which said mobile station takes account of the timing advance information as calculated in this way and as delivered by said second base station, to synchronize itself and communicate with said second base station over a second target channel different from said first target channel.

In this way, the handover method of the invention provides a further improvement to the above-described prior art "improved" asynchronous handover. It differs in that for each mobile station, two target channels (and not just a single target channel) of the second base station are used in succession, namely a first target channel common to a plurality of mobile stations and used only for determining timing advance information, and a second target channel specific to the mobile station and used by that station only after the base station has sent it the timing advance information.

30 In terms of working resources, and in particular of TCH, the handover method of the invention thus makes it possible to save the working resource constituted by the second target channel, by replacing it with the first target channel (which is not a

working resource) throughout the entire first portion of the handover procedure corresponding to determining the timing advance information.

5 The invention also provides a method of locating a mobile station in a cellular radio communication system, the method comprising, reiterated at least one, the steps of the method for determining timing advance information as specified above, thereby obtaining, in addition to timing advance information associated with said mobile station relative to the first base station, timing advance information associated with said mobile station relative to at least one second base station, and further comprising a step of calculating the location of said mobile station on the basis firstly of the various items of timing advance information, and secondly on the basis particularly of information concerning the location of each of the first and second base stations concerned by said timing advance information.

10 In this way, the localization method of the invention can be implemented without cost in terms of working resource, since the first target channel does not constitute a working resource.

15 Other characteristics and advantages of the invention appear on reading the following description of a preferred embodiment of the invention, given by way of non-limiting indication, and with reference to the accompanying drawings, in which:

20 Figure 1 is a diagram of a fragment of the structure of a GSM type radio communication network;

Figure 2 is a flow chart of the method of the invention for determining timing advance information;

Figure 3 is a flow chart of the method of the invention for handover between cells; and

25 Figure 4 is a flow chart of a particular implementation of the localization method of the invention.

In the description below, a GSM type radio communication system is considered. Nevertheless it is clear that the invention is applicable to any type of cellular digital radio communication system.

30 Firstly, with reference to Figure 1, the structure of a GSM network is recalled. A mobile station MS is travelling in a cell C1 corresponding to the geographical coverage of a base station BTS1. Other cells C2 and C3 are each associated with respective

other base stations BTS2 and nTS3. The base stations BTS1 to BTS3 are controlled by a base station controller BSC. The associated base station controller BSC and some number of base stations constitute a base station system BSS. A plurality of base station systems BSSs can be controlled by a switching center MSC which constitutes the master structure of a GSM network.

The method of the invention for determining timing advance information is described below with reference to the flow chart of Figure 2. In the example used for explanatory purposes, it is assumed that the mobile station MS is in cell C1 (it is communicating via base station BTS1), and that it is necessary to determine its timing advance information (TA) relative to the base station BTS2 of cell C2.

In step 1, the mobile station MS interrupts its call on a current channel with base station BTS1. In step 2, the mobile station MS sends a synchronization signal sequence (of the handover access type) to the base station BTS2 over a first target channel. In step 3, immediately after sending the synchronization signal sequence to the base station BTS2, the mobile station MS returns to its call over the current channel with the base station BTS1. In Step 4, which is performed simultaneously with step 3, the base station BTS2 calculates the timing advance information TA associated with the mobile station MS relative to the base station BTS2. In step 5, the base station BTS2 transmits the timing advance information TA that it has calculated to the mobile station MS via at least one controller BSC. In step 6, which is symmetrical with step 5, the mobile station MS receives the calculated timing advance information TA as issued by the base station BTS2 via at least one controller BSC. Together these steps are given a common reference 20.

According to an essential characteristic of the invention, the first target channel is a common access channel, i.e. a channel that can be used by all mobile stations for which timing advance information TA needs to be calculated by the base station BTS2.

By way of example, this first target channel may use an up link whose associated down link is otherwise occupied by a cell broadcast channel (CBCH). It may be included, for example, within a multiframe structure in the same manner as the up link of a stand-alone dedicated control channel (SDCCH).

Provision may also be made for a distinct access reference (of the "handover reference" type) to be allocated to each mobile station MS accessing the first target

channel. Thus, in its application to handover (explained in greater detail below with reference to Figure 3), each access reference allocated to a mobile station serves to make a link between messages sent by the system (such as "handover command"), and in particular the base station BTS2 to the mobile station, and secondly messages (such as "handover access") sent by the mobile station to the base station BTS2 over the first target channel.

Optionally, access to the first target channel can be controlled using a predetermined access method, such as the "starting time" type sequential access method, for example. In the present case, this "starting time" method consists in informing each mobile station MS of the frame number from which it can transmit over the first target channel without risk of collision with transmissions from other mobile stations.

As shown in the flow chart of Figure 3, the handover method of the invention is of the asynchronous type and comprises:

- the set 20 of steps 1 to 6 of the method for determining timing advance information as described above with reference to Figure 2; and
- a step 30 during which the mobile station MS, while taking account of the timing advance information TA as calculated and issued by the base station BTS2, synchronizes itself and communicates with said base station BTS2 over a second target channel.

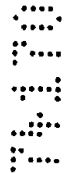
It is important to observe that the second target channel, e.g. a TCH channel, is specific to the mobile station and entirely distinct from the first target channel (which is common to all mobile stations).

As shown in the flow chart of Figure 4, in a particular implementation, the locating method of the invention comprises:

- the set 20 of steps 1 to 6 comprising the method of determining timing advance information as described above with reference to Figure 2;
- a reiteration 20' of the set 20 of steps 1 to 6 of the method of determining timing advance information as described above with reference to Figure 2, but applied to base station BTS3. This ensures that not only is timing advance information TA obtained relative to BTS2, but a second item of timing advance information TA' is obtained relative to BTS3; and

- a step 40 of computing information concerning the location of the mobile station MS on the basis of the items of timing advance information as calculated, and on the basis of information concerning the locations of the various base stations concerned.

5 In the example described, the calculation of step 40 is performed using any triangulation method (well known to the person skilled in the art) since three items of timing advance information are known, namely: TA and TA' relating to BTS2 and BTS3 respectively, and also TA" relating to BTS1. The mobile station knows its own timing advance relative to BTS1, since BTS1 is the base station of the current cell.



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It is clear that other types of calculation could be envisaged without going beyond the ambit of the invention. In other words, more than three items of timing advance information can be used, or perhaps only two. If only two items are in use, then it is also appropriate to provide decision means that rely on other items of information (for example measurements of mobile station travel provided by sensors, or cartographic information).



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Two applications of the method of the invention for determining timing advance information are described above, namely handover (Figure 3) and localization (Figure 4). It is clear that other applications could also be envisaged, without going beyond the ambit of the invention.



20

The claims defining the invention are as follows:

1. A method of determining timing advance information in a cellular radio communication system, the method being of the type comprising the following steps:

5 - a mobile station interrupts its call on a current channel with a first base station, to send a synchronization signal sequence to a second base station over a first target channel, said signal sequence enabling said second base station to calculate timing advance information associated with said mobile station relative to said second base station;

10 - the mobile station continues with its call over said current channel with the first base station immediately after sending said synchronization signal sequence to the second base station; and

- said timing advance information calculated by said second base station is transmitted to said mobile station via at least one controller,

15 wherein said first target channel is an access channel common to a plurality of mobile stations.

2. A method as claimed in claim 1, wherein said first target channel uses an up link whose associated down link is otherwise used by another channel.

3. A method as claimed in claim 2, wherein said other channel is a broadcast channel.

20 4. A method as claimed in any one of claims 1 to 3, wherein said first target channel is included within a multiframe structure in the same manner as the up link of a stand-alone dedicated control channel.

5. A method as claimed in any one of claims 1 to 4, wherein each mobile station accessing said first target channel is allocated a distinct access reference.

6. A method as claimed in any one of claims 1 to 5, wherein access to said first target channel is controlled using a predetermined access method.

7. A method as claimed in claim 6, wherein said predetermined access method is a sequential access method of the "starting time" type.

30 8. An inter-cell handover method of the asynchronous type in a cellular radio communication system, the method comprising the steps of the method for determining timing advance information as claimed in any one of claims 1 to 7, and

further comprising a step during which said mobile station takes account of the timing advance information as calculated in this way and as delivered by said second base station, to synchronize itself and communicate with said second base station over a second target channel different from said first target channel.

- 5 9. A method of locating a mobile station in a cellular radio communication system, the method comprising, reiterated at least once, the steps of the method for determining timing advance information as claimed in any one of claims 1 to 7, thereby obtaining, in addition to timing advance information associated with said mobile station relative to the first base station, timing advance information associated with said mobile station relative to at least one second base station, and further comprising a step of calculating the location of said mobile station on the basis firstly of the various items of timing advance information, and secondly on the basis particularly of information concerning the location of each of the first and second base stations concerned by said items of timing advance information.
- 10 10. A method substantially as herein described with reference to Figures 1-4 of the accompanying drawings.
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DATED THIS FIRST DAY OF JULY 1998

ALCATEL ALSTHOM COMPAGNIE GÉNÉRALE D'ÉLECTRICITÉ



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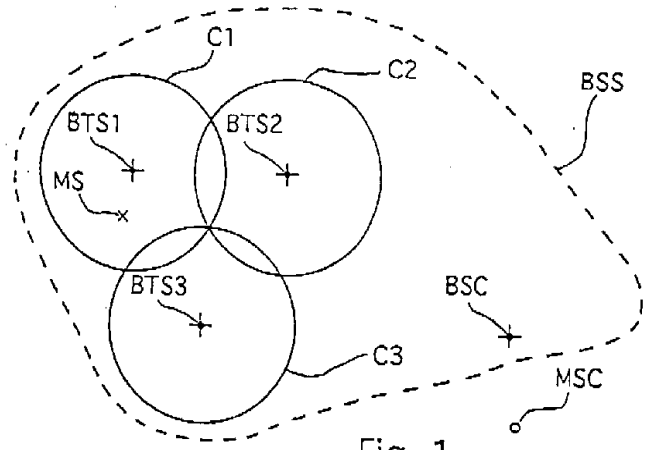


Fig. 1

FIG. 1

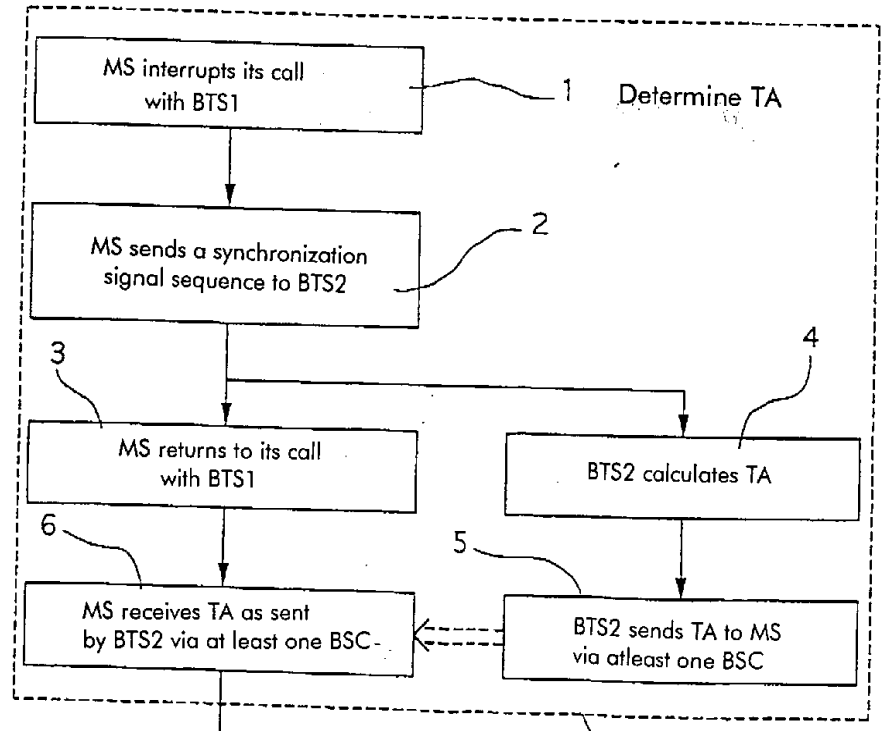


Fig. 2

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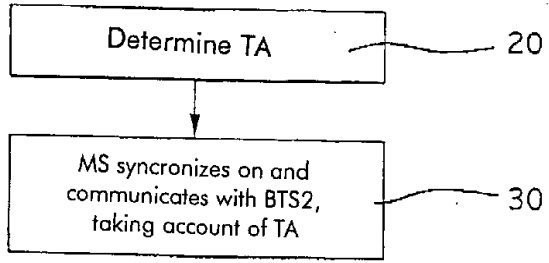


Fig. 3

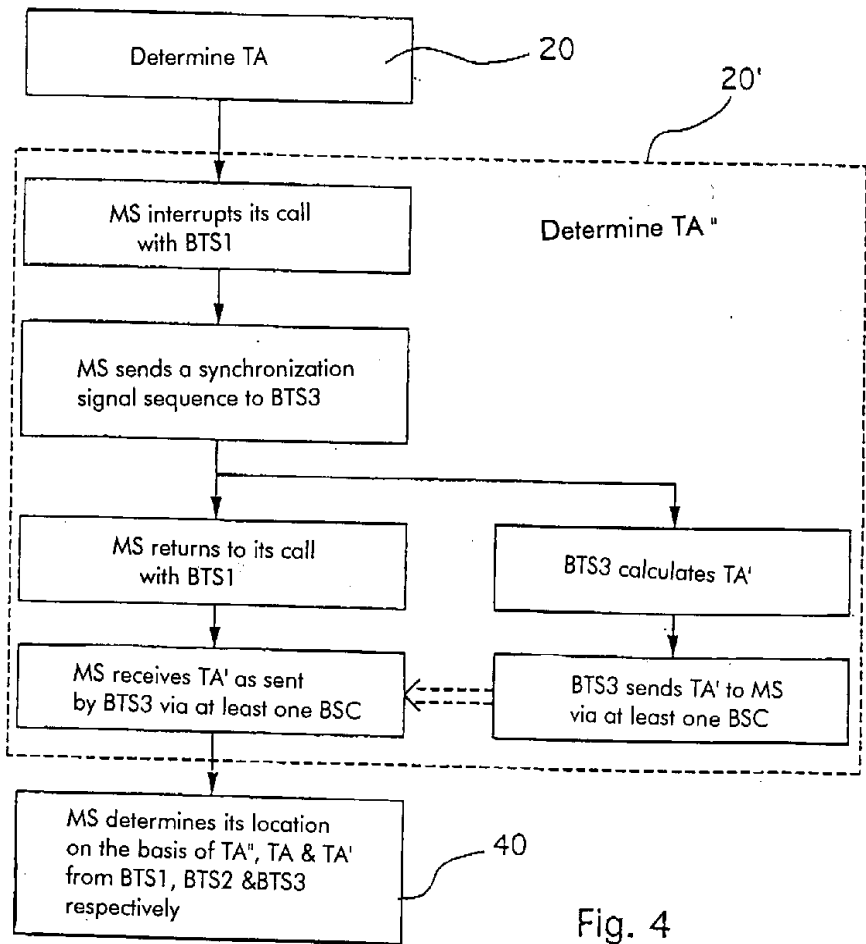


Fig. 4