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(54) Mobile satellite communication system using non-geosynchronous orbiting satellites

(57) The system permits easy assignment of a land earth station 2, 2' or 2'' to handle communication with a mobile terminal 1. Information on the position of each land earth station 2, 2', 2'' and each mobile terminal 1 and orbit information of all satellites 3, 3', 3'' is used to determine for how long each land earth station would be capable of handling the communication of a mobile terminal from the call initiation time. An appropriate land earth station 2, 2' or 2'' can then be selected and assigned for the call of the mobile terminal so that more than a predetermined call duration can be ensured. If more than one earth station would be capable of handling the call for more than the predetermined duration, selection from those stations may be on the basis of which one makes the terrestrial line connected to the called party 9 shortest, or according to a priority ordering of the earth stations in relation to the mobile terminal 1.

Fig. 1

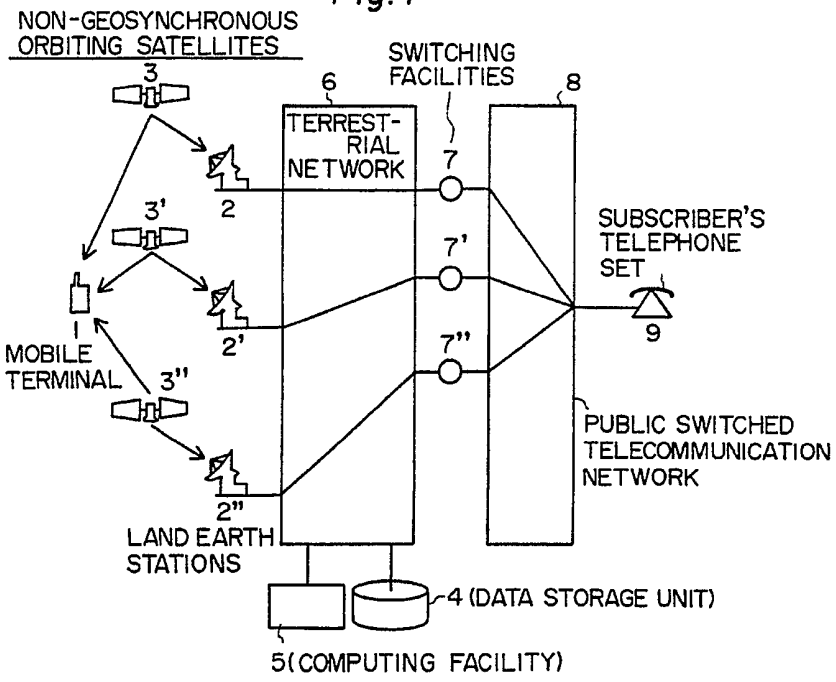

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Fig. 1

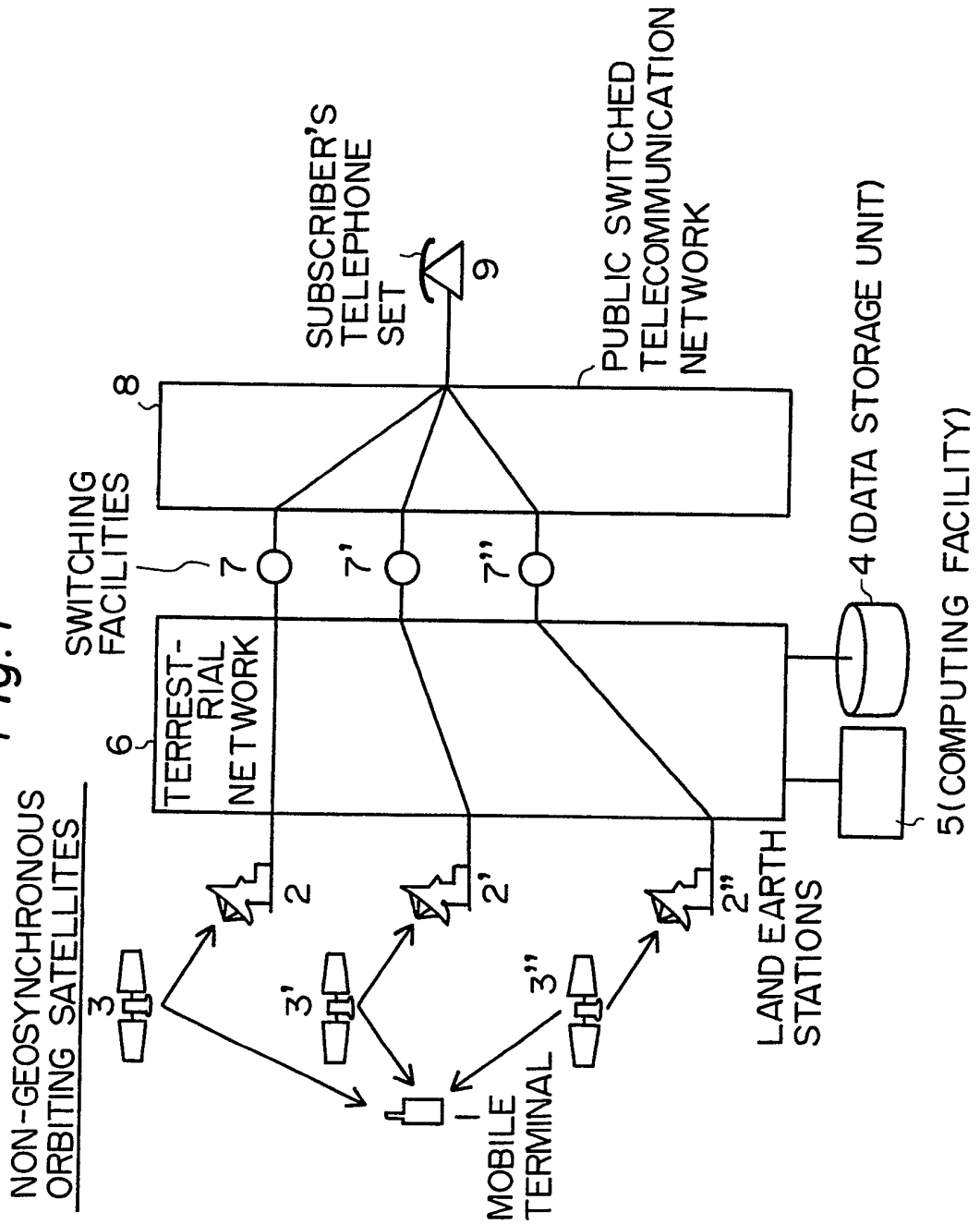

NON-GEOSYNCHRONOUS ORBITING SATELLITES
3
3'
3''
MOBILE TERMINAL
1
2
2'
2''
LAND EARTH STATIONS
6
TERREST-RIAL NETWORK
SWITCHING FACILITIES
7
7'
7''
8
SUBSCRIBER'S TELEPHONE SET
9
PUBLIC SWITCHED TELECOMMUNICATION NETWORK
4 (DATA STORAGE UNIT)
5(COMPUTING FACILITY)

Fig. 2

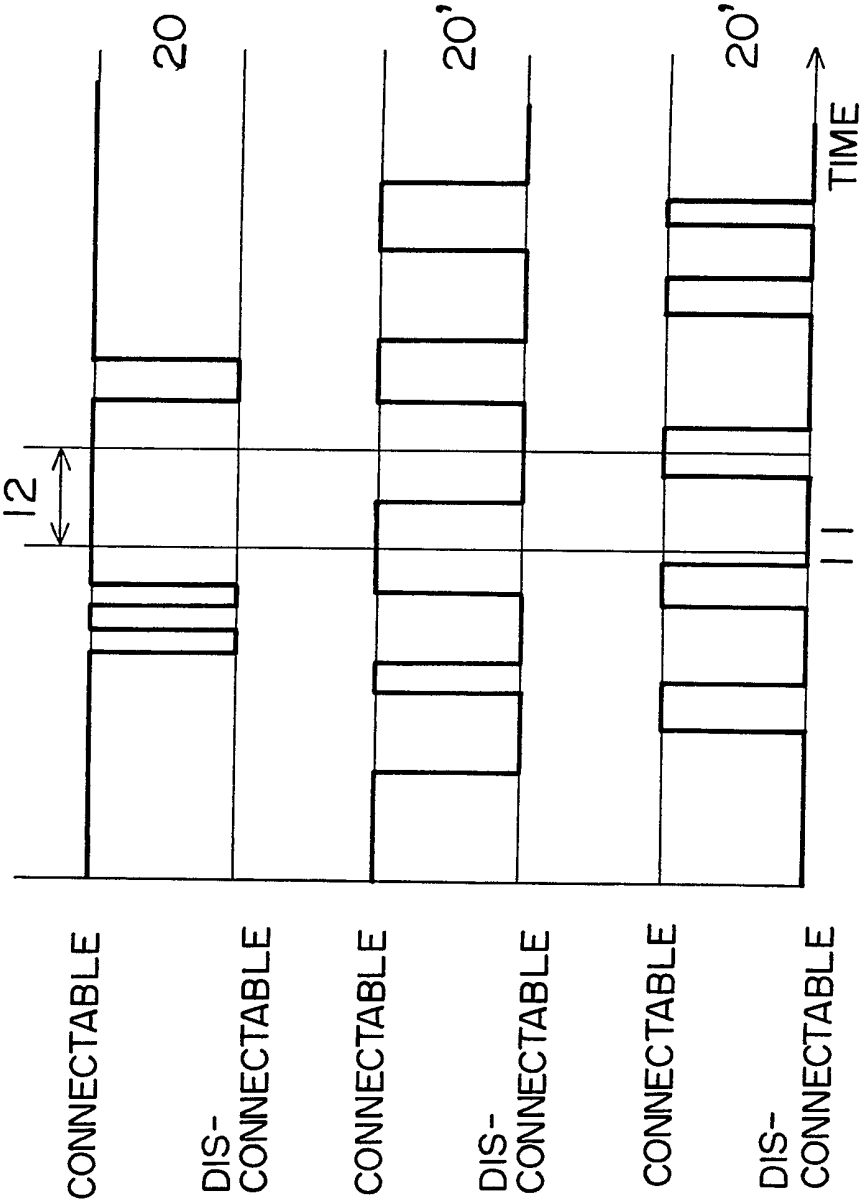

20
20'
20''
12
11
TIME
CONNECTABLE
DIS-
CONNECTABLE
CONNECTABLE
DIS-
CONNECTABLE
CONNECTABLE
DIS-
CONNECTABLE

Fig. 3

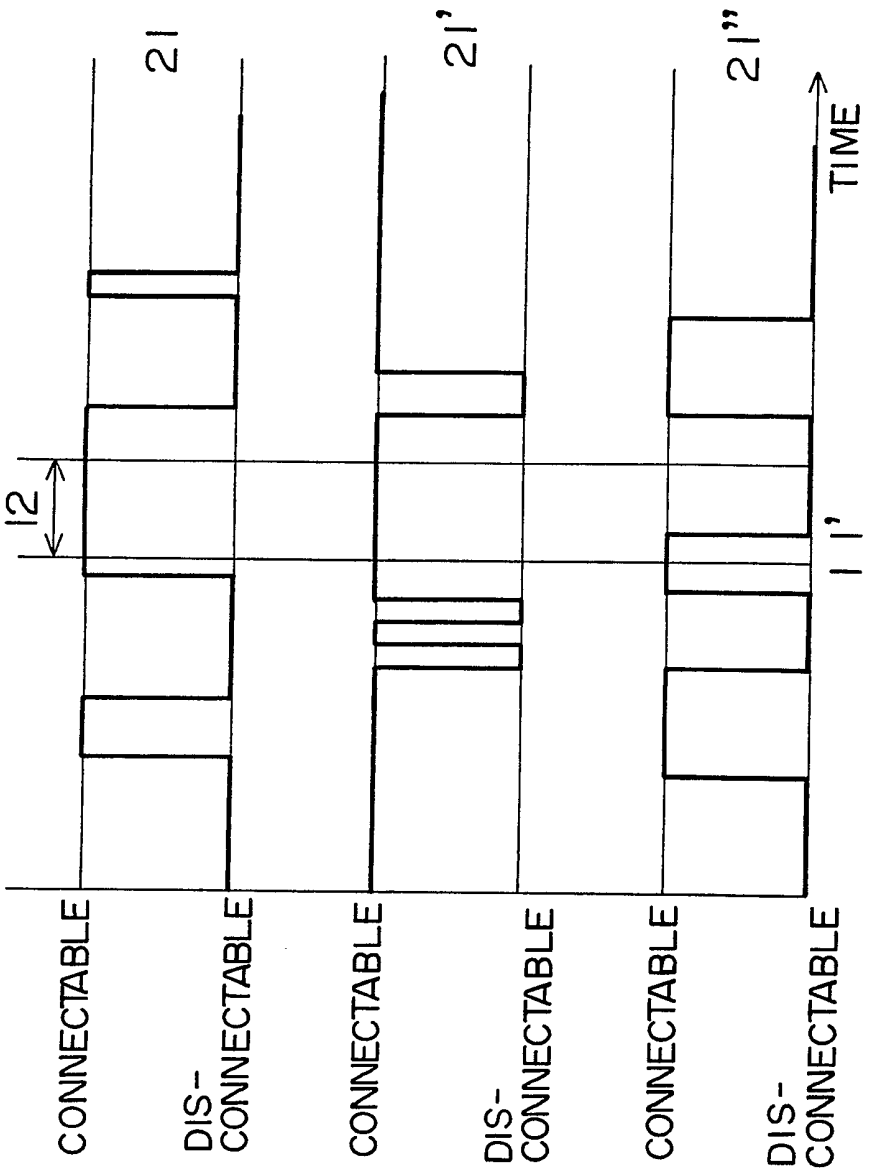
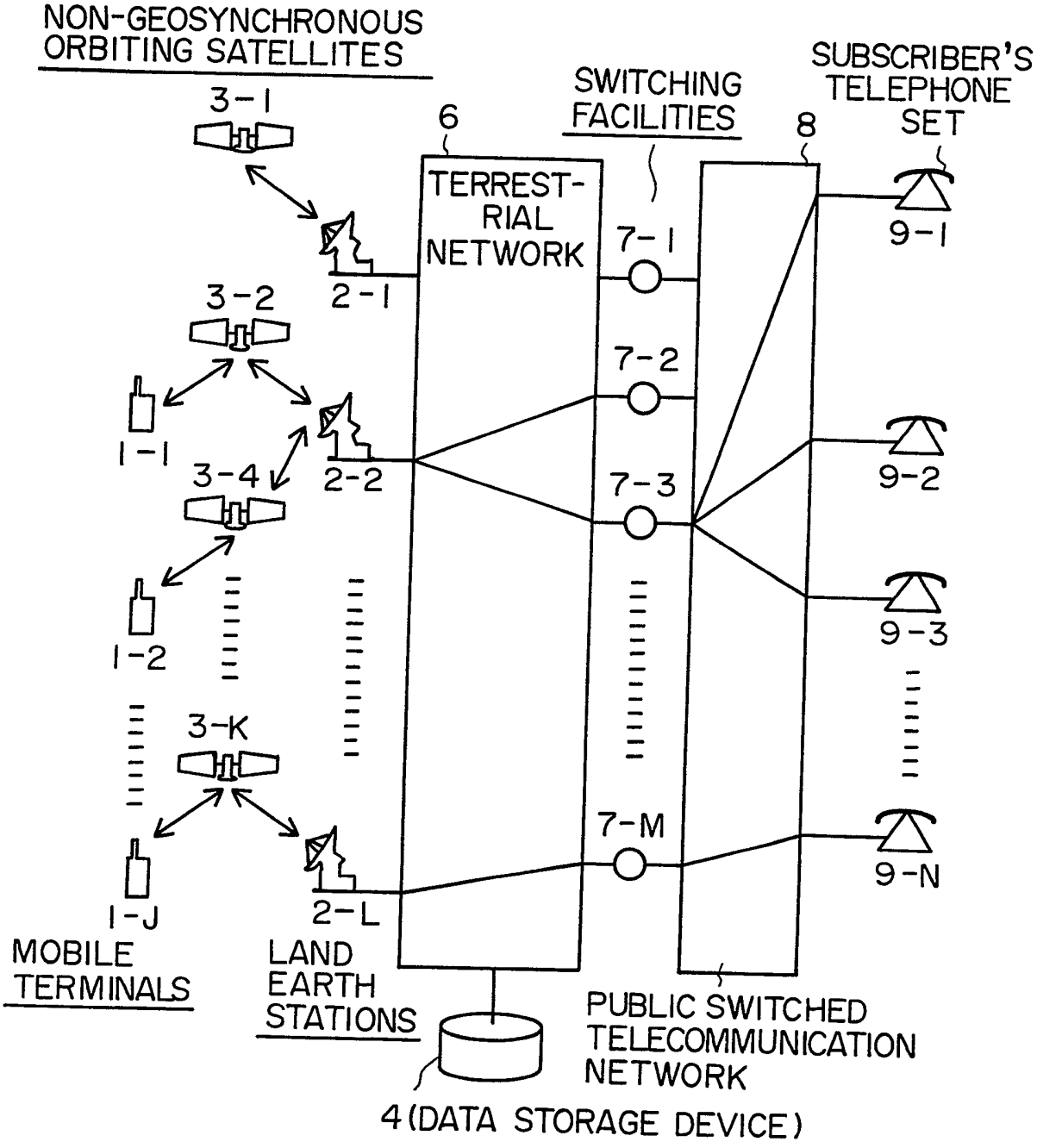

21
21'
21''
12
11'
TIME
CONNECTABLE
DIS-
CONNECTABLE
CONNECTABLE
DIS-
CONNECTABLE
CONNECTABLE
DIS-
CONNECTABLE

Fig. 4


NON-GEOSYNCHRONOUS ORBITING SATELLITES
3-1
3-2
3-4
3-K
SWITCHING FACILITIES
6
TERREST-RIAL NETWORK
7-1
7-2
7-3
7-M
8
SUBSCRIBER'S TELEPHONE SET
9-1
9-2
9-3
9-N
2-1
2-2
2-L
1-1
1-2
1-J
MOBILE TERMINALS
LAND EARTH STATIONS
PUBLIC SWITCHED TELECOMMUNICATION NETWORK
4 (DATA STORAGE DEVICE)

MOBILE SATELLITE COMMUNICATION SYSTEM USING NON-GEOSYNCHRONOUS ORBITING SATELLITES.

The present invention relates to communication systems using non-geosynchronous satellites and, more particularly, to a system for determining or selecting a land earth station through which a mobile terminal communicates with its called party.

There has been proposed, as one of next-generation mobile satellite communication systems, some mobile or personal communication systems using multi-spot beam satellites in non-geosynchronous orbits. In these communication systems, a plurality of satellites are put into orbits at an altitude lower than those for geosynchronous orbiting satellites of conventional satellite communications systems, that is, into a low earth orbit (in the altitude range of 500 to 2,000 kilometers) or medium earth orbit (in the altitude range of 10,000 to 35,000 km) and to link the satellites and mobile terminals through spot beams.

Communications systems using non-geosynchronous orbiting satellites, as described above, have advantages such as low propagation loss, short propagation delay, a simple satellite configuration, and a smaller number of spot beams required for each satellite than that for a multi-spot beam satellite in the geosynchronous orbit.

Fig. 4 of the accompanying drawings shows a conceptual diagram of communication between a mobile terminal and land earth stations in the communication system using non-geosynchronous orbiting satellites. In Fig. 4, reference

numerals 1-1 through 1-J denote mobile terminals, 2-1 through 2-J land earth stations, 3-1 through 3-K non-geosynchronous orbiting satellites, 4 a data storage unit which manages information on mobile terminals, 6 a terrestrial network of the communication system, 7-1 through 7-M switching facilities, 8 a public switched telecommunication network and 9-1 through 9-N subscriber's telephone sets. Since the coverage areas of orbiting satellites with the altitudes lower than those of geosynchronous orbiting satellites are narrower than the coverage areas of geosynchronous orbiting satellites, communication system using satellites on lower earth orbits employs a plurality of satellites to provide the service.

In mobile, or personal communication systems employing non-geosynchronous orbiting satellites, the area where one land earth station can communicate with mobile terminals via satellites changes with time according to the satellite rotation around the earth, which is a major difference from communication system using geostationary satellites, in which the satellites do not move with respect to a point fixed on the earth and each land earth station is continuously capable of communicating through the same satellite or satellites at all times, and hence is capable of communicating with mobile terminals at all times. Mobile satellite communication systems using non-geosynchronous orbiting satellites require a method whereby, upon occurrence of an originating call from a mobile terminal or routing a call thereto, appropriate land earth stations as well as appropriate satellites to handle the calls are determined or

selected.

An object of the present invention is to provide a system by which an appropriate land earth station is selected or determined for each call.

The mobile satellite communication system using non-geosynchronous orbiting satellites according to the present invention has a configuration in which information on the location of each land earth station and the mobile terminal, and orbital information on all satellites are used to obtain information as to which land earth station is capable of communicating with the mobile terminal during the prescribed call duration after the call initiation. On the basis of the above information, an appropriate land earth station is selected and determined which will handle the communication of the mobile terminal.

Embodiments of the present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a conceptual diagram illustrating the positional relationships of mobile terminal, non-geosynchronous orbiting satellites, and land earth stations in embodiments of the communication system of the present invention;

Fig. 2 is a diagram showing connectivity characteristics between a particular mobile terminal and land earth stations from a certain moment of time through a certain duration in one embodiment of the communication system of the present invention;

Fig. 3 is a diagram showing connectivity characteristics between a particular mobile terminal and land earth stations from a certain moment of time through a certain duration in another embodiment of the communication system of the present invention; and

Fig. 4 is a conceptual diagram of a conventional mobile satellite communication system using non-geosynchronous orbiting satellites.

A first embodiment of the present invention will be described with reference to the accompanying drawings.

Figs. 1 and 2 conceptually illustrate the land earth station assigning system according to the first embodiment of the present invention. In Fig. 1, reference numeral 1 denotes a mobile terminal, 2, 2′ and 2" land earth stations, 3, 3′ and 3" non-geosynchronous orbiting satellites employed in the communication system, 4 a data storage unit, 5 computing facility, 6 a terrestrial network of the mobile satellite communication system, 7, 7′ and 7" switching facilities, 8 a public switched telecommunication network and 9 a subscriber's telephone set. Fig. 1 shows positional relationship of the mobile terminal 1, the land earth stations 2, 2′ and 2", and the satellites 3, 3′ and 3" at a certain time, corresponding to 11 in Fig. 2. In Fig. 2, reference numerals 20, 20′ and 20" indicate the connectivity characteristics between mobile terminal 1 and land earth stations 2, 2′, and 2", respectively, 11 the moment of time at which the mobile terminal 1 initiates the communication, and 12 a predetermined call duration.

In this embodiment, a computing facility 5 provides the terrestrial network with information on connectivity characteristics of the land earth stations, 2, 2′ and 2" in this case, with the mobile terminal, for example, in such a format as shown in Fig. 2. Connectivity characteristics is evaluated based on the orbit information of all satellites, locations of land earth stations, and location information of the mobile terminal. The orbit information of satellites could be calculated in such methods as shown in the reference "Methods of Orbit Determination", John Wiley & Sons Inc., 1965. Location information of all mobile terminals are registered in data storage units, and updated when the terminal is turned on, periodically while it is activated, and/or when the terminal largely changes its location. In Fig. 1, the latest location information of the mobile terminal 1 is stored in the data storage unit 4.

Suppose that at the time 11 represented in Fig. 2, the mobile terminal 1, the land earth stations 2, 2′, and 2", and the satellites 3, 3′ and 3" bear such positional relationships as shown in Fig. 1 and that the mobile terminal 1 starts communication with the subscriber's telephone set 9. The mobile terminal 1 transmits the call originating request message toward the terrestrial network through satellites. Since at the time 11, the mobile terminal 1 and the land earth stations 2, and 2′ are capable of communicating, as indicated by connectivity characteristics shown in Fig. 2, the call originating request message is received by the land earth stations 2 and 2′. The land earth stations 2 and 2′ each

reports the reception of the call originating request message to the computing facility 5. The computing facility 5, by referring to the latest location information stored in the data storage unit 4 and by using the orbit information of all satellites, obtains the information on connectivity characteristics 20 and 20′. The appropriate land earth station is so selected, that it can serve the communication of the mobile terminal 1 from the call initiation through more than the predetermined call duration 12. Then, in this case, the land earth station 2 is selected and assigned to the call of the mobile terminal 1. The predetermined call duration should be determined on the basis of statistics on the call duration. In this instance, the mobile terminal 1 and the subscriber's telephone set 9 are mutually connected via land earth station 2, the terrestrial network 6, the switching facility 7 and the public switched telephone network 8, which are permitted to communicate for more than the predetermined duration 12.

A second embodiment of the present invention will be described with reference to the accompanying drawings.

Figs. 1 and 3 conceptually illustrate the second embodiment of the land earth station assigning system according to the present invention. Fig. 1 shows the positional relationships of the mobile terminal 1 the land earth stations 2, 2′ and 2", and the satellites 3, 3′ and 3" at a time 11′. In Fig. 3, reference numerals 21, 21′ and 21" indicate the connectivity characteristics between mobile terminal 1 and land earth stations 2, 2′, and 2", respectively, 11′ the moment of time at which the mobile

terminal 1 initiates the communication.

In this embodiment, when a plurality of land earth stations are selected as are capable of handling the communication of the mobile terminal 1 from the call initiation time 11′ through more than the predetermined call duration, the land earth station which makes the terrestrial line connected to the called party shortest, is selected to handle the call for the mobile terminal.

Suppose that at the time 11′ represented in Fig. 3, the mobile terminal 1, the land earth stations 2, 2′, and 2", and the satellites 3, 3′ and 3" bear such positional relationships as shown in Fig. 1 and that the mobile terminal starts communication with the subscriber's telephone set 9. The mobile terminal 1 transmits the call originating request message toward the terrestrial network through satellites. Since at the time 11′, the mobile terminal 1 and the land earth stations 2, 2′ and 2" are capable of communicating, as indicated by connectivity characteristics 21, 21′ and 21", respectively, the call originating request message is received by the land earth stations 2, 2′ and 2". The land earth stations 2, 2′ and 2" each reports the reception of the call originating request message to the computing facility 5. The computing facility 5, by referring to the latest location information stored in the data storage unit 4 and by using the orbit information of all satellites, obtains the information on connectivity characteristics 21, 21′ and 21". Candidate land earth stations are so selected, that they can serve the communication of the mobile terminal from the call initiation

through more than the predetermined call duration 12. Then, in this case, the land earth stations 2 and 2′ are selected as candidate stations. Furthermore, the computing facility 5 compares with each other the lengths of terrestrial lines between the land earth stations 2 and 2′ and the subscriber's phone set 9. The land earth station 2′ is assigned to the call of the mobile terminal 1 as make the terrestrial line connected to the subscriber's phone set 9 shortest. In consequence, the mobile terminal 1 and the subscriber's telephone set 9 are connected via land earth station 2′, the terrestrial network 6, the switching facility 7′ and the public switched telecommunication network 8, which are permitted to communicate for more than the predetermined duration 12 with the shortest length of the terrestrial line.

A third embodiment of the present invention will be described with reference to the accompanying drawings.

Figs. 1 and 3 conceptually illustrate a third embodiment of the land earth station assigning system according to the present invention.

In this embodiment, when a plurality of land earth stations are selected as are capable of handling the communication of the mobile terminal 1 from the call initiation time 11′ through more than the predetermined call duration, the land earth station with the highest priority predetermined to each mobile terminal is selected to handle the call for the mobile terminal. The priority is predetermined in relation to the mobile terminal 1 in the order [land earth station 2" - land earth station 2 - land

earth station 2′].

Suppose that at the time 11′ represented in Fig. 3, the mobile terminal 1, the land earth stations 2, 2′, and 2", and the satellites 3, 3′ and 3" bear such positional relationships as shown in Fig. 1 and that the mobile terminal starts communication with the subscriber's telephone set 9. The mobile terminal 1 transmits the call originating request message toward the terrestrial network through satellites. Since at the time 11′, the mobile terminal 1 and the land earth stations 2, 2′ and 2" are capable of communicating, as indicated by connectivity characteristics 21, 21 ′ and 21", respectively, the call originating request message is received by the land earth stations 2, 2′ and 2" . The land earth stations 2, 2′ and 2" each reports the reception of the call originating request message to the computing facility 5. The computing facility 5, by referring to the latest location information stored in the data storage unit 4 and by using the orbit information of all satellites, obtains the information on connectivity characteristics 21, 21′ and 21" . The candidate land earth stations are so selected, that they can serve the communication of the mobile terminal from the call initiation through more than the predetermined call duration 12. Then, in this case, the land earth stations 2 and 2′ are selected as candidate stations. Furthermore, the computing facility 5 refers to the priority of the land earth stations predetermined in relation to the mobile terminal 1 and determines that the land earth station 2 of the higher priority should handle the calls of the mobile terminal 1. In

consequence, the mobile terminal 1 and the subscriber's telephone set 9 are connected via land earth station 2, the terrestrial network 6, the switching facility 7 and the public switched telecommunication network 8, which are permitted to communicate for more than the predetermined duration 12.

As described above in detail, according to the present invention, the land earth station which is capable of handling the communication of a mobile terminal for more than a predetermined call duration after the call initiation, is selected therewith; hence, the principle of land earth station assignment is simple and permits the construction of an economical system.

CLAIMS

1. A mobile satellite communication system using non-geosynchronous orbiting satellites wherein at least one mobile terminal in a given service area on earth can communicate through said non-geosynchronous orbiting satellites and a terrestrial network including a plurality of land earth stations set upon the earth, wherein said system has a construction in which communication of said mobile terminal is conducted via one of said land earth stations which is capable of continuous communication, through at least one of any one of said satellites, with said mobile terminal at each moment in time during more than a predetermined period after the time of initiating communication.

2. A mobile satellite communication system according to claim 1, wherein when a plurality of said land earth stations are capable of continuous communication, through at least one of any one of said satellites, with said mobile terminal at each moment in time during more than said predetermined period after the time of initiating communication, one of said plurality of land earth stations is selected for which the length of a terrestrial line required for connecting with a called party is shorter than the length of terrestrial line required for the or each other land earth station.

3. A mobile satellite communication system according to claim 1, wherein when a plurality of said land earth stations is capable of continuous communication, through at least one

of any one of said satellites, with said mobile terminal at each moment in time during more than said predetermined period after the time of initiating communication, one of said land earth stations is selected on the basis of its priority predetermined in relation to said mobile terminal.

4. A mobile satellite communication system substantially as herein described with reference to Figure 1 with reference to Figure 2 and/or 3 of the accompanying drawings.

Patents Act 1977 Examiner's report to the Comptroller under Section 17 (The Search report) -13-	Application number GB 9415855.7
Relevant Technical Fields (i) UK Cl (Ed.M) H4K KYS; H4L LDRR, LDRSX (ii) Int Cl (Ed.5) H04B 7/185, 7/195, 7/204, 7/26	Search Examiner M J BILLING Date of completion of Search 19 OCTOBER 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASE: WPI	Documents considered relevant following a search in respect of Claims :- 1-3

Categories of documents

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P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
A,P	EP 0562374 A1	(MOTOROLA) - eg see column 18 line 12 - column 32 line 37; published 29 September 1993	1
A	EP 0510789 A1	(TRW) - eg see abstract	1

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