FIG. 3 illustrates a simplified block diagram of a satellite radio communication station suitable for use in a preferred embodiment of the present invention;

FIG. 4 illustrates a simplified block diagram of a system control station and an Earth terminal suitable for use in a preferred embodiment of the present invention;

FIG. 5 illustrates a simplified block diagram of a subscriber unit suitable for a preferred embodiment of the present invention;

FIG. 6 illustrates a small portion of broadcast channel antenna patterns projected by a satellite on the surface of the Earth;

FIG. 7 shows the broadcast channel antenna patterns of FIG. 6 with the size of one antenna pattern reduced;

FIG. 8 shows the broadcast channel antenna patterns of FIG. 6 with a high demand area located in a center cell;

FIG. 9 shows the broadcast channel antenna patterns of FIG. 8 shifted in time;

FIG. 10 shows a flowchart of a procedure for adjusting the broadcast channel signal level of a cell suitable for use in a preferred embodiment of the present invention; and

FIG. 11 shows a flowchart of a procedure performed by a subscriber unit responsive to broadcast channel signal quality suitable for use in a preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE DRAWINGS

While the method and apparatus of the present invention are described for a constellation of low-Earth orbiting satellites, this is merely for convenience of explanation and not intended to be limiting. The present invention applies to any cellular communication system having at least one moving communication node whose cells have some overlap.

A "satellite" is defined herein to mean a man-made object or vehicle intended to orbit a celestial body (e.g., Earth). A "constellation" is defined herein to mean an ensemble of satellites arranged in orbits for providing specified coverage (e.g., radio communication, photogrammetry, etc.) of portion(s) or all of the celestial body. A constellation typically includes multiple rings (or planes) of satellites and may have equal numbers of satellites in each plane, although this is not essential. As used herein the terms "cell" and "antenna pattern" are not intended to be limited to any particular mode of generation and include those created by either terrestrial or satellite cellular communications systems and/or combinations thereof. The present invention is applicable to systems including satellites having low-Earth, medium-Earth and geo-synchronous orbits. Additionally, it is applicable to orbits having any angle of inclination (e.g., polar, equatorial or other orbital pattern).

FIG. 1 shows a layout diagram of an environment which supports communications system 10 within which the present invention may be practiced. Communication system 10 is dispersed over and surrounding a celestial body (e.g., Earth) through use of orbiting satellites 12 occupying orbits 14. Exemplary communication system 10 uses six polar orbits 14, with each orbit 14 holding eleven satellites 12 for a total of sixty-six satellites 12. However, this is not essential and more or fewer satellites, or more or fewer orbits, may be used. While the present invention is advantageously employed when a large number of satellites are being used, it is also applicable with as few as a single satellite. For clarity, FIG. 1 illustrates only a few of the satellites in the constellation.

For example, each orbit 14 encircles Earth at an altitude of around 780 km, although higher or lower orbital altitudes may be usefully employed. Due to the relatively low orbits of satellites 12, substantially line-of-sight electromagnetic (e.g., radio, light etc.) transmission from any one satellite or reception of signals by any one satellite involves or covers a relatively small area of Earth at any instant.

For the example shown, satellites 12 travel with respect to Earth at around 25,000 km/hr, allowing satellite 12 to be visible to a terrestrial station for a maximum period of approximately nine minutes.

Satellites 12 communicate with terrestrial stations which may include some number of radio communication subscriber units (SUs) 26 and Earth terminals (ETs) 24 connected to system control segment (SCS) 28. ETs 24 may also be connected to gateways (GWs) 22, which provide access to the public switched telephone network (PSTN) or other communications facilities. Only one each of GWs 22, SCS 28 and SUs 26 are shown in FIG. 1 for clarity and ease of understanding. ETs 24 may be co-located with or separate from SCS 28 or GW 22. ETs 24 associated with SCSs 28 receive data describing tracking of satellites 12 and relay packets of control information while ETs 24 associated with GWs 22 only relay data packets (e.g., relating to calls in progress).

SUs 26 may be located anywhere on the surface of the Earth or in the atmosphere above the Earth. SUs 26 are preferably communications devices capable of transmitting data to and receiving data from satellites 12. By way of example, SUs 26 may be a hand-held, portable cellular telephones adapted to communicate with satellites 12. Ordinarily, SUs 26 need not perform any control functions for communication system 10.

Communication system 10 may accommodate any number, potentially in the millions, of subscriber units 26. In the preferred embodiments of the present invention, subscriber units 26 communicate with nearby satellites 12 via subscriber links 16. Links 16 encompass a limited portion of the electromagnetic spectrum that is divided into numerous channels. Links 16 are preferably combinations of L-Band frequency channels and may encompass Frequency Division Multiple Access (FDMA) and/or Time Division Multiple Access (TDMA) communications or combination thereof. As a minimum, a satellite 12 continuously transmits over one or more broadcast channels 18. Subscriber units 26 synchronize to broadcast channels 18 and monitor broadcast channels 18 to detect data messages which may be addressed to them. Subscriber units 26 may transmit messages to satellites 12 over one or more acquisition channels 19. Broadcast channels 18 and acquisition channels 19 are not dedicated to any one subscriber unit 26 but are shared by all subscriber units 26 currently within view of satellite 12.

On the other hand, traffic channels 17 are two-way channels that are assigned to particular subscriber units 26 by satellites 12 from time to time. In the preferred embodiments of the present invention, a digital format is used to communicate data over channels 17–19, and traffic channels 17 support real-time communications. At least one traffic channel 17 is assigned for each call, and each traffic channel 17 has sufficient bandwidth to support, as a minimum, a two-way voice conversation. To support communications over channels 17–19, a time division multiple access (TDMA) scheme is desirably used to divide time into frames, preferably in the 60–90 millisecond range. Particular traffic channels 17 are assigned particular transmit and receive time-slots, preferably having durations in the 3–10