APPLICATION FOR UNITED STATES LETTERS PATENT

by

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for

MULTI-RATE RADIOCOMMUNICATION SYSTEMS AND TERMINALS

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MULTI-RATE RADIOCOMMUNICATION SYSTEMS AND TERMINALS

RELATED APPLICATION

This application is related to U.S. Patent Application Serial No. _______, entitled "Radiocommunication Systems and Terminals with Increased Payload Bandwidth", which application was filed on the same date as this application.

BACKGROUND

Applicant's invention relates generally to radiocommunication systems, e.g., cellular or satellite systems, that use digital traffic channels in a multiple access scheme, e.g., time division multiple access (TDMA) or code division multiple access (CDMA).

The growth of commercial radiocommunications and, in particular, the explosive growth of cellular radiotelephone systems have compelled system designers to search for ways to increase system capacity without reducing communication quality beyond consumer tolerance thresholds. One way to increase capacity is to use digital communication and multiple access techniques such as TDMA, in which several users are assigned respective time slots on a single radio carrier frequency.

In North America, these features are currently provided by a digital cellular radiotelephone system called the digital advanced mobile phone service (D-AMPS), some of the characteristics of which are specified in the interim standard IS-54B, "Dual-Mode Mobile Station-Base Station Compatibility Standard", published by the Electronic Industries Association and Telecommunications Industry Association (EIA/TIA). Because of a large existing consumer base of equipment operating only in the analog domain with frequency-division multiple access (FDMA), IS-54B is a dual-mode (analog and digital) standard, providing for analog compatibility in tandem with digital

FDMA analog voice channels (AVC) and TDMA digital traffic channels (DTC), and the system operator can dynamically replace one type with the other to accommodate fluctuating traffic patterns among analog and digital users. The AVCs and DTCs are implemented by frequency modulating radio carrier signals, which have frequencies near 800 megahertz (MHz) such that each radio channel has a spectral width of 30 kilohertz (KHz). A subsequent standard, referred to as IS-136, adds specifications for digital control channels. This standard document, in particular the version identified as PN-3474.1, dated December 15, 1995 and published by EIA/TIA, is incorporated here by reference.

In a TDMA cellular radiotelephone system, each radio channel is divided into a series of time slots, each of which contains a burst of information from a data source, e.g., a digitally encoded portion of a voice conversation. The time slots are grouped into successive TDMA frames having a predetermined duration. According to IS-54B and IS-136, each TDMA frame consists of six consecutive time slots and has a duration of 40 milliseconds (msec). Thus, each frame can carry from one to six traffic channels (e.g., one to six radio connections). The number of connections which can be supported by each TDMA frame depends on the desired information transmission rate. For example, if the connections are used to support the transmission of voice information, the number of slots used per channel depends on the source rates of the speech coder/decoders (codecs) used to digitally encode the conversations. Such speech codecs can operate at either full-rate or half-rate, with full-rate codecs being expected to be used until half-rate codecs that produce acceptable speech quality are developed.

Thus, a full-rate DTC requires twice as many time slots in a given time period as a half-rate DTC, and in IS-54B, each radio channel can carry up to three full-rate DTCs or up to six half-rate DTCs. Each full-rate DTC uses two slots of each TDMA frame, i.e., the first and fourth, second and fifth, or third and sixth of a TDMA frame's six slots. Each half-rate DTC uses one time slot of each TDMA frame. During each DTC time slot, 324 bits are transmitted, of which the major portion, 260 bits, is due to the speech output of the codec, including bits due to error correction coding of the speech output, and the remaining bits are used for guard times and overhead signalling for purposes such as synchronization.

In addition to voice information being transmitted on the traffic channels, various other types of data can and will be transmitted thereon. For example, facsimile (fax) transmissions are commonly supported by radiocommunication systems. Similarly, packet data transmissions, which divide information streams into packets rather than providing dedicated (i.e., "connection-oriented") channels for each information stream, will be supported in radiocommunication systems. Other types of information transmission, e.g., video or hybrid voice, data and video to support internet connections, will likely be supported in the future.

These various types of information communication (also referred to herein as different "services") will likely have different optimal transmission characteristics. For example, services between a remote user and the internet may benefit by providing a greater bandwidth in the downlink (i.e., from the internet to the remote station) than in the uplink, since many users spend a significant portion of their connection time downloading information from the internet rather than uploading thereto. Thus, it may be desirable in such cases to allocate a triple rate connection in the downlink (e.g., all six time slots of an IS-136 TDMA frame) but only a full rate connection in the uplink (e.g., two time slots of an IS-136 frame). This inequality between uplink and downlink bandwidth is referred to herein as an "asymmetrical" connection. In addition to bandwidth considerations, other transmission characteristics may also be impacted. For example, different services may require different degrees of error protection. Thus, for example, an optimal channel coding for the transmission of voice information might be rate 1/2 since voice information transmission is typically not provided with a procedure for retransmission, while optimal channel coding for the transmission of data, e.g, facsimile, might be rate 5/6 since retransmission procedures are typically provided. Other transmission characteristics, for example, the ability to tolerate delay in the reception of information, may also vary between services. All of these differences in transmission characteristics should be considered together when determining an optimal specification for the air interface.

Accordingly, it would be desirable to provide techniques for transmitting information between remote stations and the system in radiocommunication networks that provide sufficient flexibility for the anticipated variety of information communication services described above, while also providing sufficient compatibility with existing technology so that equipment used by the existing consumer base will not become obsolete.

SUMMARY

According to exemplary embodiments of the present invention, the type of information transmitted in the uplink or downlink may vary depending upon the transmission rate. For example, in a TDMA environment, a first downlink time slot associated with a double- or triple-rate connection may have a first format, while a second time slot associated with the same connection may have a second format different from the first format. The different formats take into account the need to transmit certain types of information at only full rate, and not double- or triple-rate.

According to some exemplary embodiments, bandwidth in the second (or third) time slot can be used to carry information in a fast out-of-band channel (FOC). The FOC may provide information relating to the same connection as the payload or data field in that time slot, e.g., a service type identifier which informs the mobile or base station of the type of information (e.g., voice, video or data) being conveyed in the payload. This information can be used by the receiving equipment to aid in processing the information conveyed in the payload, e.g., by knowing the channel coding rate. These exemplary embodiments find particular application to multimedia communications where the

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