US006097707A

United States Patent [19]

Hodzic et al.

[11] Patent Number: 6,097,707

[45] Date of Patent: *Aug. 1, 2000

[54] **ADAPTIVE DIGITAL WIRELESS COMMUNICATIONS NETWORK APPARATUS AND PROCESS**

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[*] Notice: This patent is subject to a terminal disclaimer.

[21] Appl. No.: **08/444,553**

[22] Filed: **May 19, 1995**

[51] **Int. Cl.**[7] **H04J 3/16**

[52] **U.S. Cl.** **370/321**; 370/337; 370/347; 455/54.1; 455/57.1

[58] **Field of Search** 370/24, 26, 29, 370/18, 55.3, 68.1, 77, 85.2, 79, 85.3, 84, 94.1, 94.3, 85.7, 95.1, 85.8, 95.2, 95.3, 100.1, 103, 104.1, 105, 105.1; 379/58, 63, 59; 340/825.06, 825.07, 825.08; 455/33.1, 33.4, 16, 15, 49.1, 51.1, 54.2, 53.1, 54.1, 57.1; 375/200, 202, 205

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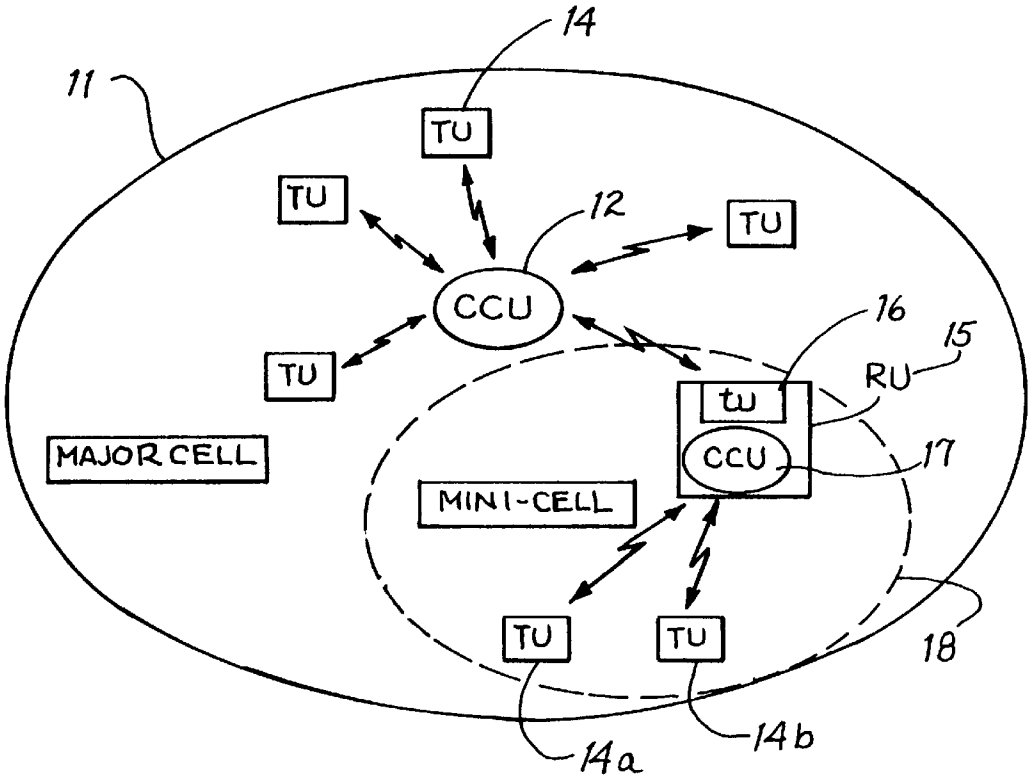
Assistant Examiner—Ricky Q. Ngo
Attorney, Agent, or Firm—Donald J. Lisa

[57] **ABSTRACT**

A single channel wireless digital communication network [**10**] has a cellular topology which includes a central unit [**12**] ("CW") controlling communications with a plurality of remote units [**14**] ("TU") in a star configuration. Network access is synchronously controlled through a time division multiplexed cycle [**20**] of variable total duration having an up-link phase [**21**] of a variable number of fixed size time slots [**25**, **27**, **27***a*], each pre-assigned by reservation by a remote unit, and a down-link phase [**22**] of a variable number of variable size slots [**31***a*, **31***b*] which are adaptively utilized. The CU adaptively manages all slot assignments according to a variety of parameters. RU up-link slot reservations are confirmed by the CU in a variety of ways. During the up-link phase, RU's which did not reserve a slot on the previous up-link cycle are temporarily suspended and are then polled or periodically tested for re-entry. A repeater unit [**15**] ("RU") having a back-to-back coupled ccu-tu pair operates as a minicell within the major cell where major cell coverage is not broad enough to reach all major cell TU's.

50 Claims, 3 Drawing Sheets



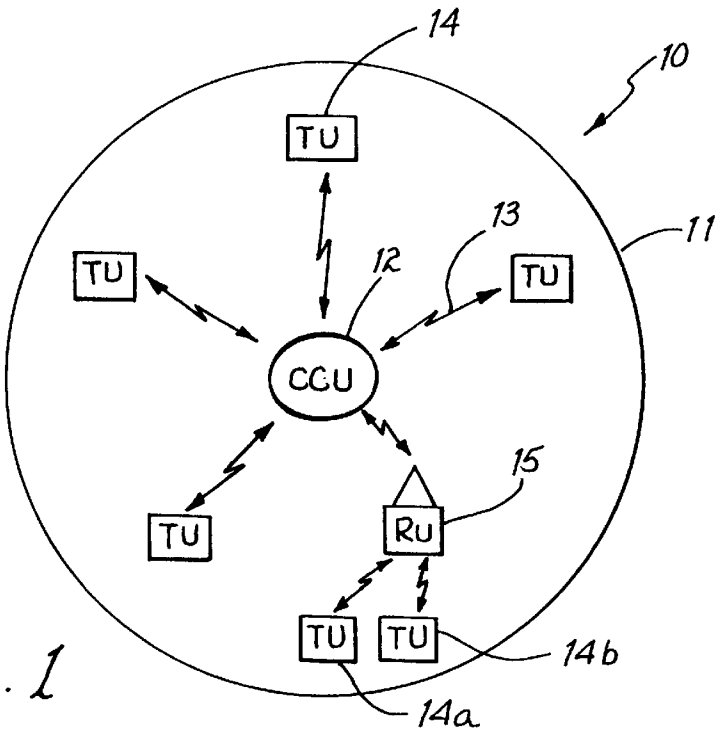


FIG. 1

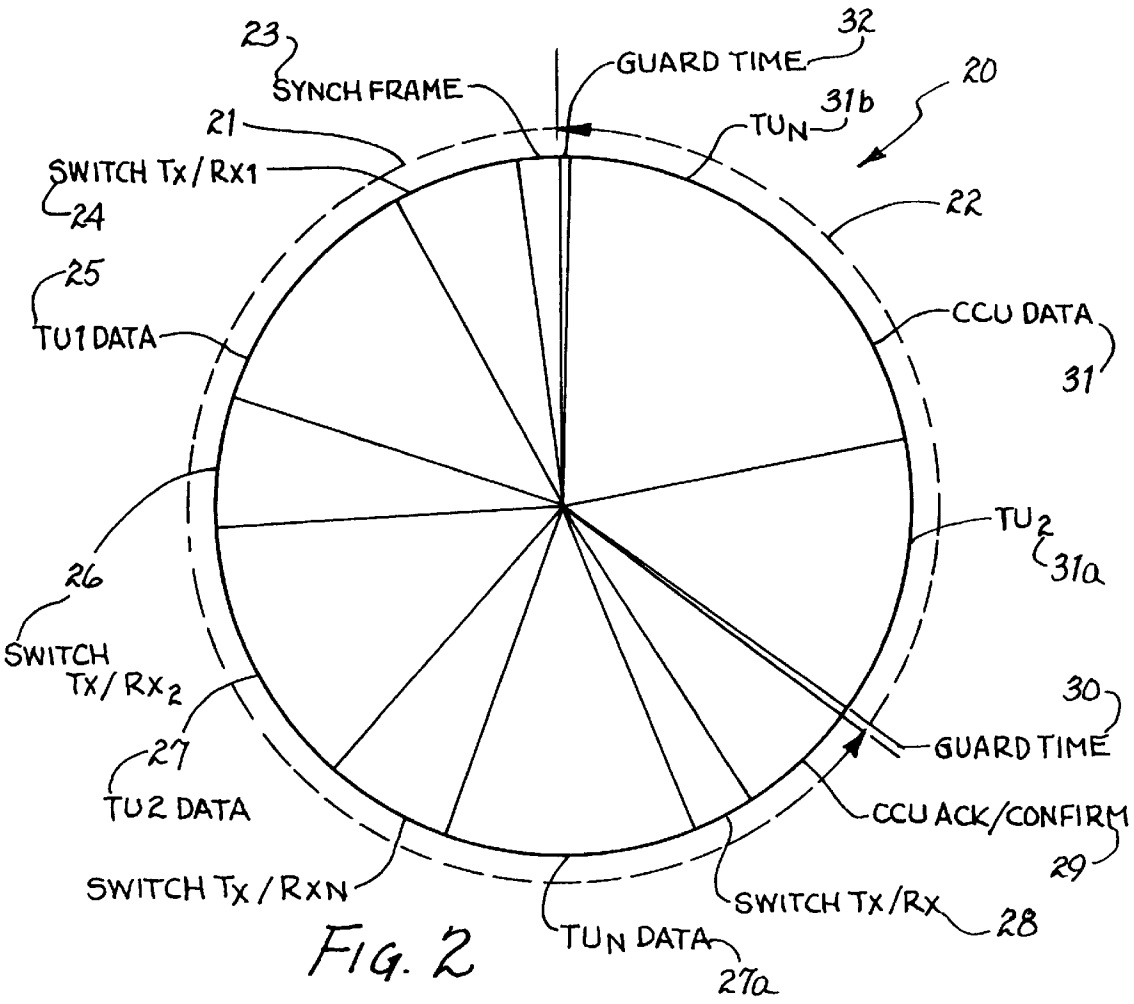


FIG. 2

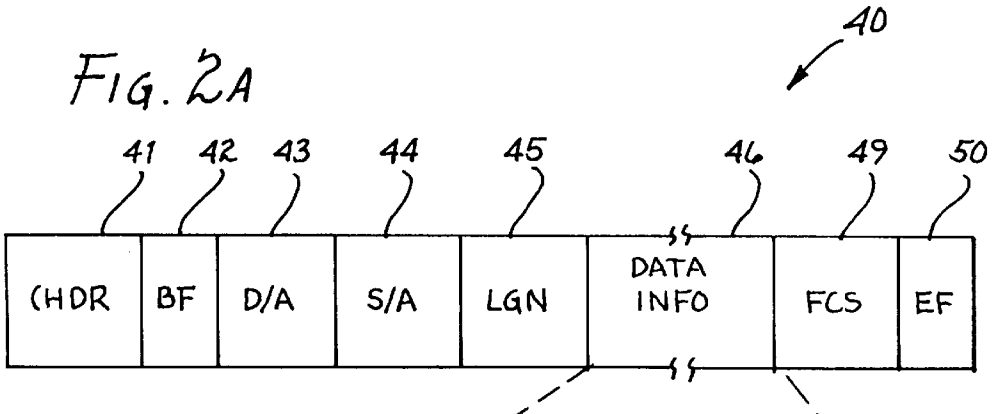


FIG. 2A

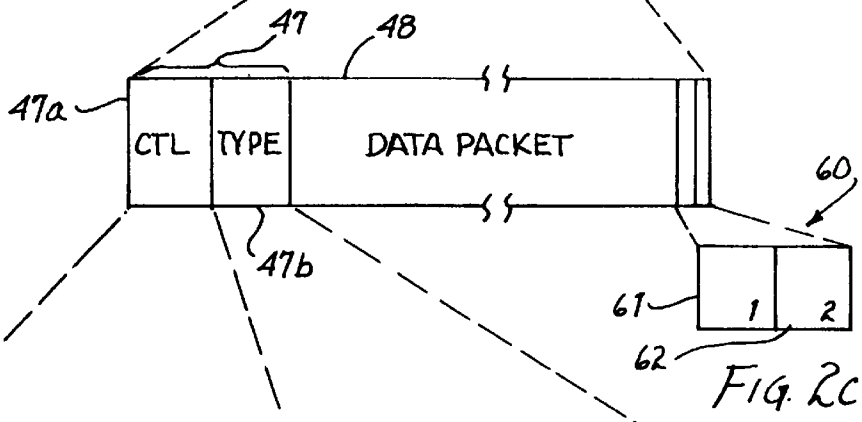


FIG. 2C

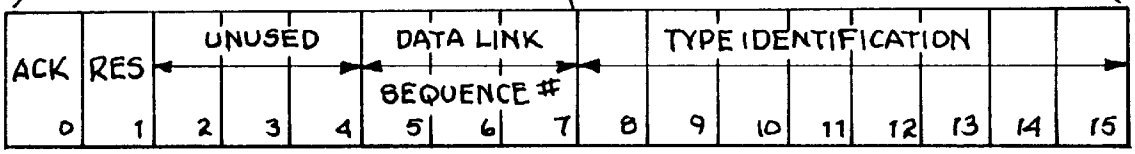


FIG. 2b

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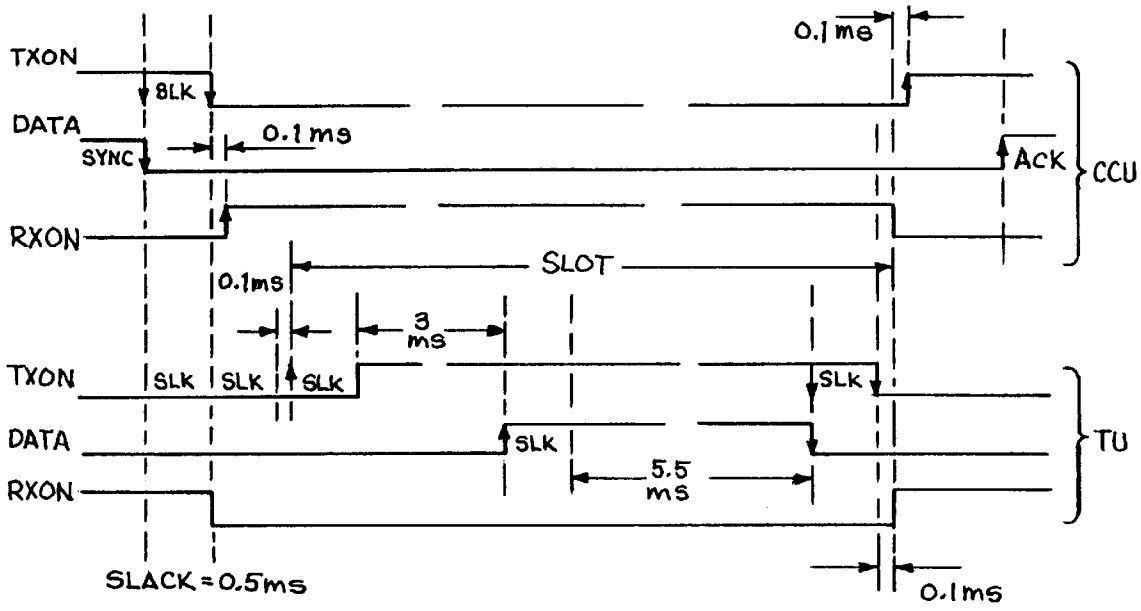

FIG. 3

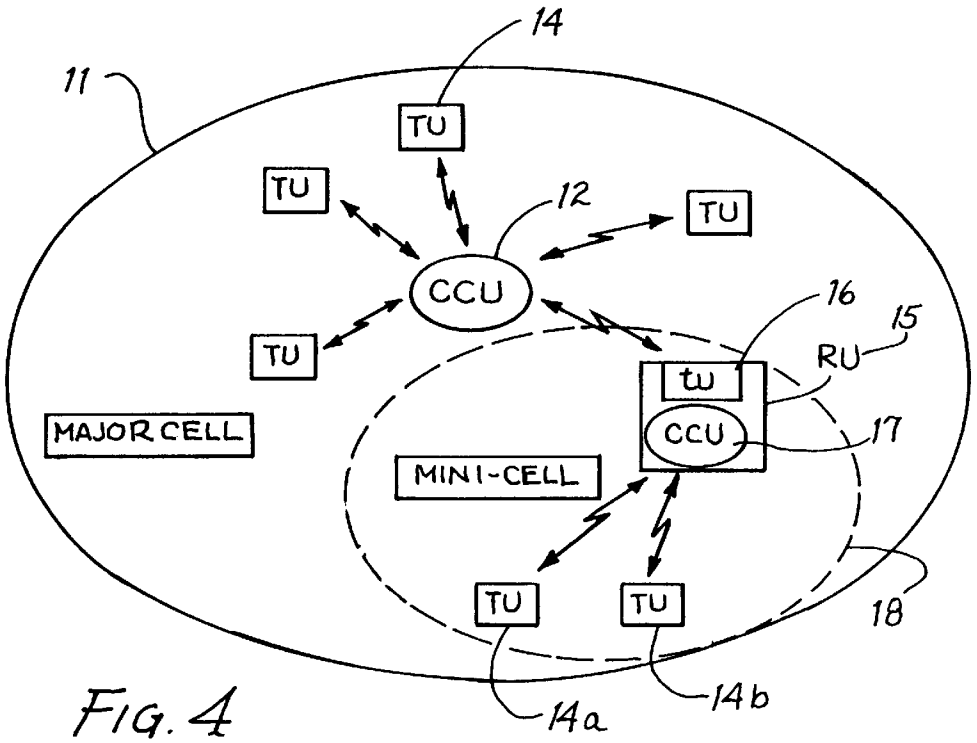

FIG. 4

ADAPTIVE DIGITAL WIRELESS COMMUNICATIONS NETWORK APPARATUS AND PROCESS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to the apparatus and methods of controlling multiple access to a communication network by a plurality of remote stations, and more particularly, to a non-contention, digital, wireless system in which all stations share one channel and a central station synchronously controls access through a cyclic, time division multiplex process.

2. Discussion of Background and Prior Art

Modern communications systems must be designed to meed a wide variety of practical applications which have varying needs.

a. MOBILITY

One important need is mobility. Increasingly in our society there is a requirement for mobile communication systems which eliminate expensive wire pulling, such as, in multi-building and various campus environments.

There is a need for and it is an object of the present invention to provide omnidirectional short range communications within buildings and between adjacent building structures without running phone lines and without interferences from the wall or building structures.

b. DIGITAL

Digital communications systems are dramatically pushing out our communications frontiers because of the flexibility and reliability of digital techniques. Nevertheless, in multi-point-to-point or multi-point-to-multi-point networking systems between multiple radio units, there is a need for and it is an object of the present invention to provide such a system which handles digitized video, audio and data at error-free and higher through-put rates.

c. LOW COST

Cellular topology has found wide acceptance worldwide in multi-point-to-point and multi-point-to-multi-point networks. The use of a cellular structure in wireless communications systems eliminates the need for telephone lines and cable lines. A vast infra-structure of cellular radio towers now exist worldwide.

Wireless networks are especially well adapted for use in cellular topology because they can be formed by combining numerous single cells to accommodate particular applications. Different cells would use different spreading codes to minimize the potential interference problems. There is a need for and it is an object of the present invention to provide a wireless radio frequency communications network which can utilize the existing worldwide cellular infra-structure in a variety of practical commercial applications.

d. EFFICIENT ORGANIZATION

A star configuration is an efficient organization for controlling multiple access of numerous remote units in a single cell communication scheme. The central unit acts as the control or master while the remote or terminal units act as slaves so far as channel access and scheduling are concerned. The remote units can communicate between each other via corresponding central units which can also act as repeaters. Constant monitoring of remote units by the central control improves the reliability of the network. There is a need for and it is an object of the present invention to provide a wireless, single channel, media access control which has the efficiencies of a star configuration.

e. REMOTE COVERAGE

In cellular, star configuration, multi-point-to-point systems, major problems have been the fading of the broadcast signals at the far corners or remote areas of a covered region and interference from multiple transmissions.

Spread spectrum technology is well known and has been available since World War II. Spread spectrum is a technique that uniformally distributes the information bandwidth of a data signal over a frequency range that is much larger than required for transmission. The technique adds redundancy to the signal, which allows data to be recovered in the presence of strong interfering signals. It has wide commercial application in digital wireless networks to avoid interference and provide reliable signal detection in the presence of multiple signal sources. Two fundamental techniques for spreading the digital bandwidth over a wide spectrum are well known and include direct-sequence and frequency hopping. In the basic direct-sequence technique, a base band data signal is combined with a pseudo-random noise ("PRN") code using an exclusive-OR ("XOR") gate.

The out-put is a combined signal with a "chipping rate" much faster than the data-signal rate which spreads the signal over a frequency range larger than the data-signal bandwidth which is then demodulated coherently by conventional techniques at the receiver end.

Thus, in spread spectrum the data and spread signals are combined. The spreading signal dominates the content. The combined signal looks like noise, but is correlatable because the spread spectrum has a unique code that can be detected and demodulated.

In a typical multi-point-to-multi-point system the central control unit functions as a repeater for remote terminal units where the coverage of the major cell central unit is insufficient to reach all remote units within the major cell.

There is a need for and it is an object of the present invention to provide the advantages of spread spectrum and repeater capability in a digital wireless network of broad practical application.

f. LIMITED SPECTRUM AND MEDIA ACCESS CONTROL

The limited spectrum for radio frequency broadcasting has long been a major problem for communications systems. The need to effectively and efficiently use existing spectrum has spawned many new types of systems and capabilities. Multi-point-to-point wireless systems have created multiple access problems as multiple units contend for channel availability. Single channel systems have aggravated the need for good multiple access control of the media. Numerous channel access schemes are well known including frequency division multiple access ("FDMA"), code division multiple access ("CDMA"), and time division multiple access ("TDMA").

In FDMA, the total spectrum assignment is divided into channels in the frequency domain. A major disadvantage of the FDMA system is that it requires considerably more equipment at the base station to handle a given number of subscribers.

CDMA is the characteristic form of multiple access that is used for spread spectrum systems. In these systems each unit

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