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Acampora

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(54) **ADAPTIVE LOCAL WIRELESS COMMUNICATION SYSTEM**

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(Continued)

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(57) **ABSTRACT**

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A radio link management system for a home or office substantially (i) an ad hoc network of agents wirelessly communicating among themselves, while (iii) clients wirelessly communicate with proximate agents. Control of the network may be centralized as network controller integrated with an agent, or may be distributed upon the network of agents. Some agent or agents, which may include an agent that is also the network controller, typically serves as a gateway device which connects to a worldwide communications network external to the home or office, normally by fiber or by wire.

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Related U.S. Application Data

(63) Continuation of application No. 09/663,068, filed on Sep. 15, 2000, now Pat. No. 6,751,455.

(60) Provisional application No. 60/154,615, filed on Sep. 17, 1999.

(51) **Int. Cl.**
H04Q 7/20 (2006.01)

(52) **U.S. Cl.** **455/522**; 455/41.2; 455/426.1; 455/343.1; 370/338

(58) **Field of Classification Search** 455/41.2, 455/426.1–426, 573–574, 522, 69, 343.1–343, 455/402; 370/338; 340/693.1, 538, 7.29, 340/310.11; 709/248, 203
See application file for complete search history.

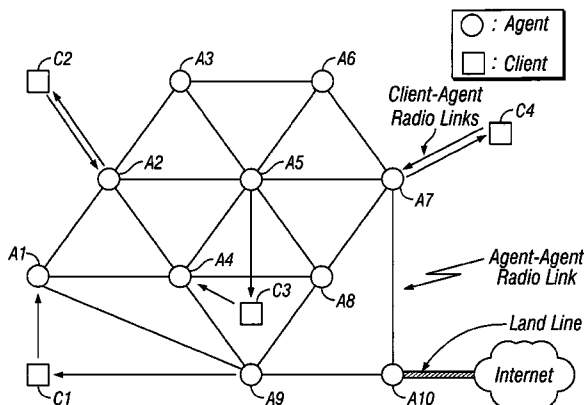
Each agent is most commonly a small radio transceiver plus logic and power supply that mounts upon a wall and plugs directly into an AC power socket. Agents wirelessly communicate among themselves and with the controller—which may be centralized or distributed—in a bandwidth-efficient mode since prime power is not an issue. Each client, which is most commonly a battery-powered user device, wirelessly communicates with one or more proximately-located agents. Consistent with overall demand for the radio resource, parameters for radio communication are allocated ad hoc in a manner which is (a) client-dependent, and which (b) uses the least power from the battery-powered client. The agents establish an ad-hoc network among themselves, with routing among and between the agents being both multi-hop and “minimum hop” to conserve bandwidth. Accordingly both power and bandwidth are conserved, each as and where required and desired.

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63 Claims, 1 Drawing Sheet



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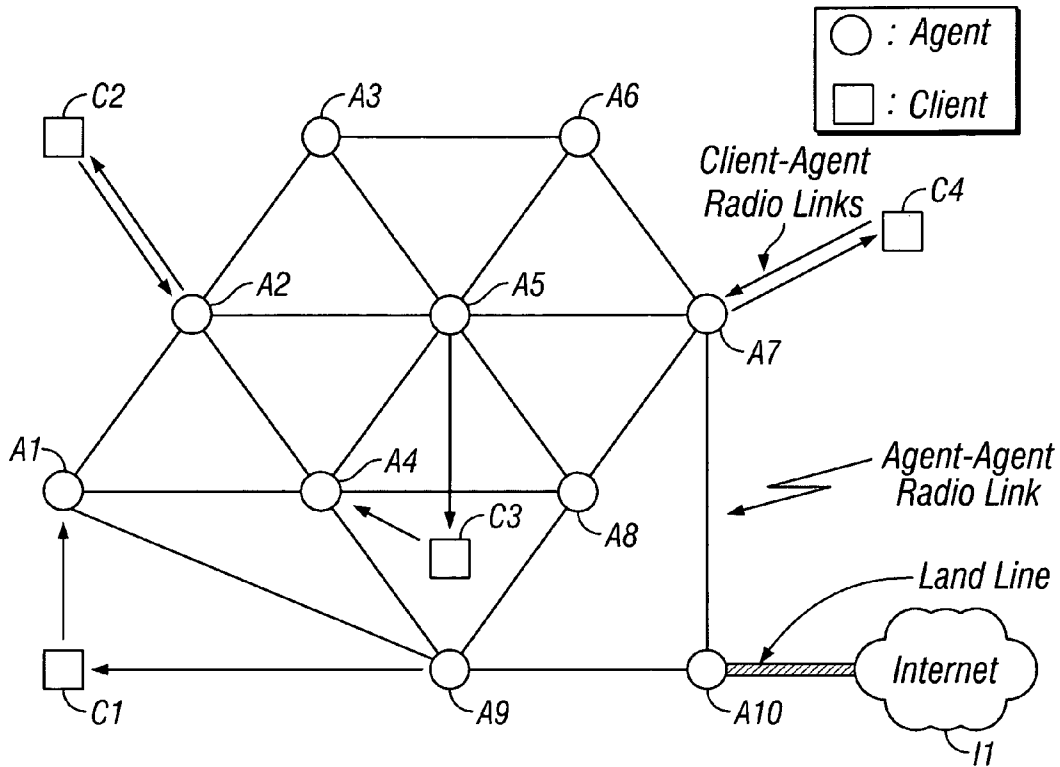


FIG. 1

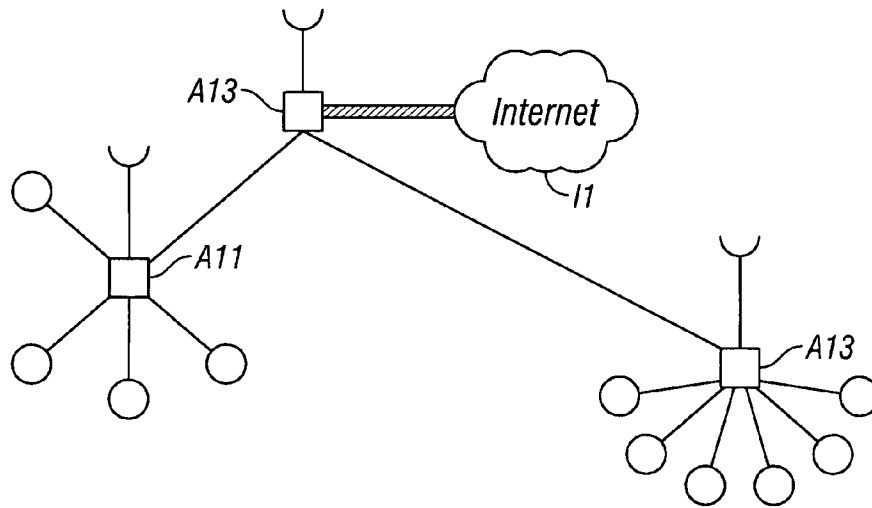


FIG. 2

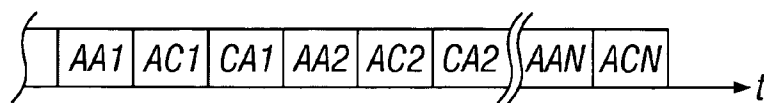


FIG. 3

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ADAPTIVE LOCAL WIRELESS COMMUNICATION SYSTEM

REFERENCE TO A RELATED PATENT APPLICATION

This application is a continuation of 09/663,068, filed Sep. 15, 2000 now U.S. Pat. No. 6,751,455, which claims priority to U.S. Provisional Patent Application Ser. No. 60/154,615 filed Sep. 17, 1999. The entire disclosures of the above-referenced patent applications are hereby incorporated by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention generally concerns wireless communication, including in the home or office.

The present invention particularly concerns power, and bandwidth, management in and for wireless communications systems, most particularly as may be located in the home or office.

The present invention still more particularly concerns power and bandwidth management for wireless communications systems, especially as are used in the home or office, that is adaptive, and tailored to communications conditions.

2. Description of the Prior Art

2.1 Bluetooth and Home RF: Industry Efforts for Wireless Networking

The present invention will be seen to concern power management in and for home and office wireless communications systems. Before specifically considering power management, it is useful to understand just what is the "state of the art" in home and office wireless communications, circa 1999. In this regard, Bluetooth and Home RF are the leading international efforts for wireless networking.

Bluetooth (www.bluetooth.com) is an effort by a consortium of companies to design a universal framework that offers a way to access information based on a diverse set of devices (e.g. PDA, mobile PCs, phones, pagers) in a seamless, user-friendly and efficient manner. Bluetooth envisages a functional and connectivity model based on a combination of wireless access technologies—each matched to different device capabilities and requirements.

Another group of companies has formed the Home RF Working Group or Home RF (www.homerf.org), which has created the Shared Wireless Access Protocol (or SWAP).

The present invention will be seen to be a system and a method that can be implemented by use of the Bluetooth, or the HomeRF, standard and protocol, among other standards and protocols. Review of these wireless communications standards is useful primarily so as to show that the wireless communications links realized by the present invention are neither new nor exotic; circa 2000.

2.2 Bluetooth

"Bluetooth" is each of a consortium, a standard, and a (prospective) class of products. The present invention will be seen to be none of these: it is a system and a method that can be implemented by use of the Bluetooth standard and protocol, among other standards and protocols. Review of Bluetooth is useful primarily so as to show that the wireless communications links realized by the present invention are readily implemented, circa 2000.

A few years ago, the telecommunications and computing

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a ubiquitous link would provide the basis for small portable devices to communicate together in an ad-hoc fashion. A study was performed, and a technology code named "Bluetooth" began to be defined. The goal was to provide effort-less service for mobile and business users by means of a small, short range radio-based technology suitably integrated into production line models of a range of different devices.

Five companies—Ericsson, IBM, Intel, Nokia and Toshiba—teamed up in May, 1998, to address the rising tide of information currently received on mobile computers, cell phones and personal digital assistants. The result was the Bluetooth wireless communications initiative.

As of October, 1998, some 200 companies including 3Com, Compaq, Dell, Hewlett-Packard, Lucent, Motorola, NTT DoCoMo, Philips, Samsung, Siemens and Texas Instruments have joined the Bluetooth Special Interest Group (SIG).

Bluetooth technology is intended to enable users to connect their mobile computers, digital cellular phones, hand-held devices, network access points and other mobile devices via wireless short-range radio links unimpeded by line-of-sight restrictions.

Eliminating the need for proprietary cables to connect devices, Bluetooth technology will increase the ease and breadth of wireless connectivity. Users will be able to automatically receive e-mail on their notebook computers via the digital cellular phones in their pockets, or synchronize their primary PC with their hand-held computer without taking it out of their briefcase.

The overwhelming interest in Bluetooth technology from a wide range of industries demonstrates the growing importance of wireless communication, said Andrew M. Seybold, editor-in-chief, Andrew Seybold's Outlook and keynote speaker at the Bluetooth Developers Conference. Mr. Seybold found the Bluetooth SIG to include the right balance of industry leaders who can make the vision a reality.

The Bluetooth specification version 1.0 was publicly released on Jul. 26, 1999, and product announcements are imminent as of Fall, 1999. Early Bluetooth-enabled products are expected to include mobile computers, hand-held PCs, digital cellular phones and peripherals such as printers, projectors, PC Cards and hands-free head-sets. Network access points will also be available to facilitate access to LANs and WANs.

The core Bluetooth programmed wireless transmitter/receiver is expected to permit a free flow of data without bulky cables. The technology, which ultimately may cost as little as \$5, is designed to work anywhere, even on airplanes.

Low power consumption—drawing only 0.3 mA in standby mode—enables maximum performance longevity for battery-powered devices. During data transfer the maximum current drain is 30 mA. However, during pauses, or at lower data rates, the drain will be lower.

2.3 The HomeRF Working Group

"HomeRF" is also each of a consortium, a standard, and a (prospective) class of products. As before, the present invention will be seen to be none of these, but only susceptible of implementation under the HomeRF standard. Review of HomeRF is useful primarily so as to again show, as with Bluetooth, that the wireless communications links realized by the present invention are readily implemented, circa 2000.

The HomeRF Working Group (HRFWG) was formed to

cation for wireless digital communication. The specification is directed to wireless digital communication between PCs and consumer electronic devices anywhere in and around the home. The HRFWG, which includes the leading companies from the personal computer, consumer electronics, peripherals, communications, software, and semiconductor industries, has developed a specification for wireless communications in the home called the Shared Wireless Access Protocol (SWAP).

To date, the high cost and impracticality of adding new wires have inhibited the widespread adoption of home networking technologies. Wired technologies also do not permit users to roam about with portable devices. In addition, multiple, incompatible communication standards have previously limited acceptance of wireless networks in the home. The HRFWG believes that the open SWAP specification will break through these barriers by (1) enabling inter-operability between many different consumer electronic devices available from a large number of manufacturers, while (2) providing the flexibility and mobility of a wireless solution. This flexibility is important to the success of creating a compelling and complete home network solution.

Since the formation of the HRFWG was announced in March 1998, the total number of member companies has risen to more than 90, and continues to expand quickly. The inclusion of nearly all the leading consumer electronics companies in the working group ensures that consumers will benefit from a wide variety of innovative, inter-operable devices for use in and around the home.

2.3.1 Shared Wireless Access Protocol

The SWAP specification of the HomeRF Working Group (HRFWG) defines a new common interface that supports wireless voice and data networking in the home. Representation from the wide range of member companies, which span diverse industries, ensures that the final specification is complete and robust, and that devices envisioned as part of the home network are inter-operable. The SWAP specification is on target for release at the end of 1998.

Some examples of what users will be able to do with the availability of products that adhere to the SWAP specification include:

- setting up a wireless home network to share voice and data between PC's, peripherals, PC-enhanced cordless phones, and new devices such as portable, remote display pads;

- accessing the Internet from anywhere in and around the home from portable display devices;

- sharing an ISP connection between PC's and other new devices;

- sharing files/modems/printers in multi-PC homes;
- intelligently forwarding incoming telephone calls to multiple cordless handsets, FAX machines and voice mailboxes;
- reviewing incoming voice, FAX and e-mail messages from a small PC-enhanced cordless telephone handset;

- activating other home electronic systems by simply speaking a command into a PC-enhanced cordless handset; and

- enabling multi-player games and/or toys based on PC or Internet resources.

2.4 Issues of Power, and Bandwidth, Utilization Optimization in the Home and Office Wireless Communications Environment

The present invention deals with issues, and problems,

the home and/or office. These issues and problems are reasonably sophisticated, and sometimes subtle.

It is, of course, immediately obvious that wireless-communicating, normally radio-communicating, devices that are battery-powered should attempt to conserve power to (i) maximize the duration(s) of communication connectivity, and (ii) minimize the duration, frequency, inconvenience and expense of any necessary battery recharging and/or replacement. It is less obvious that there is a tradeoff between battery power and communications bandwidth. Less power may be used to realize a given signal-to-noise ratio if more radio communications bandwidth is used, and vice versa.

Each individual radio-communicating device may normally acceptably use relatively more radio bandwidth without unduly interfering with other devices—which may also desire large communications bandwidths—if the radius of communication is relatively shorter. But how can a short communication radius invariably be assured? And, if sufficient power is normally provided for only but a short communication distance, how can it be assured that enough power will be available should communications need to transpire over a longer distance? And how can it be assured that multiple broadband communicating devices will never be in conflict?

Worse, power and/or bandwidth communications allocations requirements may change (i) over time and (ii) with the location(s) of communicating devices. A intrinsically low-power device, or just a device running low on power, may simply refuse to communicate at a high data rate, or in a high-power channel communications code. Such a low-power device may need a lot of bandwidth to successfully communicate at all. A wireless communications system must accommodate the requirements of communicating both to, and from, such a low-power device.

However, at another time, and/or in another location, another device, or even the same device, may have abundant power, and may reasonably have a requirement to communicate at a high rate and/or in channel communications mode that is of high overall power and/or a narrow bandwidth (i.e., at a high power per unit bandwidth).

The present invention will be seen to (i) present a communications system framework that is intrinsically superior for the home and office wireless communications environment, and then, this framework being established, (ii) show how wireless communications may be dynamically adapted and optimized—both in power and bandwidth—to the exigencies of the moment, communicating optimally for conditions.

SUMMARY OF THE INVENTION

The present invention contemplates a new system organization, and method, for wirelessly communicating within the home or office, and certain new equipments needed to realize this new method.

Major problems associated with wireless at-home networks include (i) the wide variety of devices and applications which must be supported, (ii) cost, (iii) power constraints, and (iv) bandwidth constraints. The present invention deals with these problems in and by a dual strategy: (i) a superior home and office communications system “framework” is adopted, and then, this “framework” being set in place, (ii) wireless communications upon the

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