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(54) COMMUNICATIONS PROTOCOL FOR WIRELESS LAN HARMONIZING THE IEEE 802.11A AND ETSI HIPERLA/2 STANDARDS

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(57) **ABSTRACT**

A unified communications protocol for wireless local area networks (WLANs) (**400**) which provides for the fair co-existence of the IEEE 802.11a ("11a") and HiPerLAN/2 ("HL2"), broadband communications standards. Wireless network devices (MT's) operating in accordance with 11a and HL2 may co-exist without interference by partitioning a 2 ms periodic lime domain, based on the HL2 standard, into a first slice for use by 11a MT's and a slice for use by HL2 devices. An Arbitrator entity (ARB) broadcasts the time slices periodically at an interval which is greater than or equal to the periodic time domain. A first access Point (E-AP) handles communication with the E-MT's, and a second Access Point (M-AP) handles communications with the e-MTSs and the M-MT's. In this manner, convergence is provided between 11a and HL2, providing users with the best or both worlds, e.g., full interoperability, QoS and co-existence.

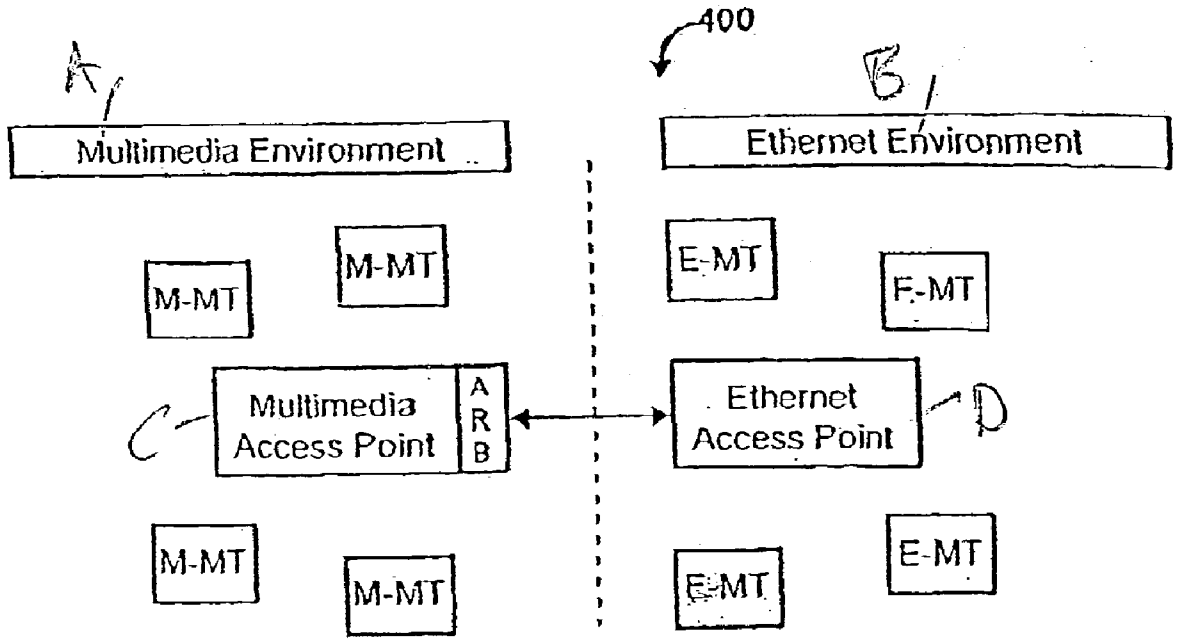


Figure 1

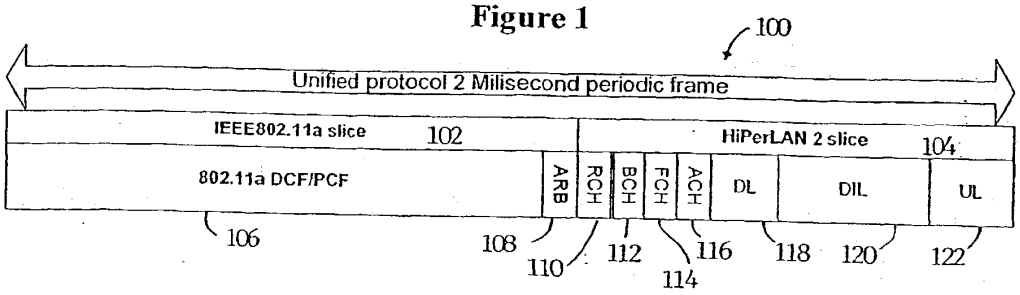


Figure 2

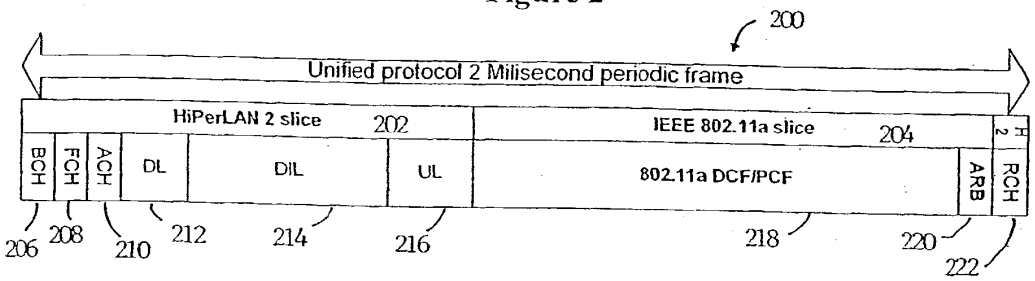


Figure 3

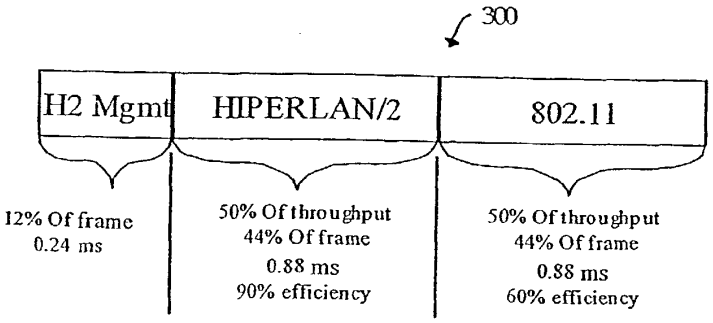


Figure 4

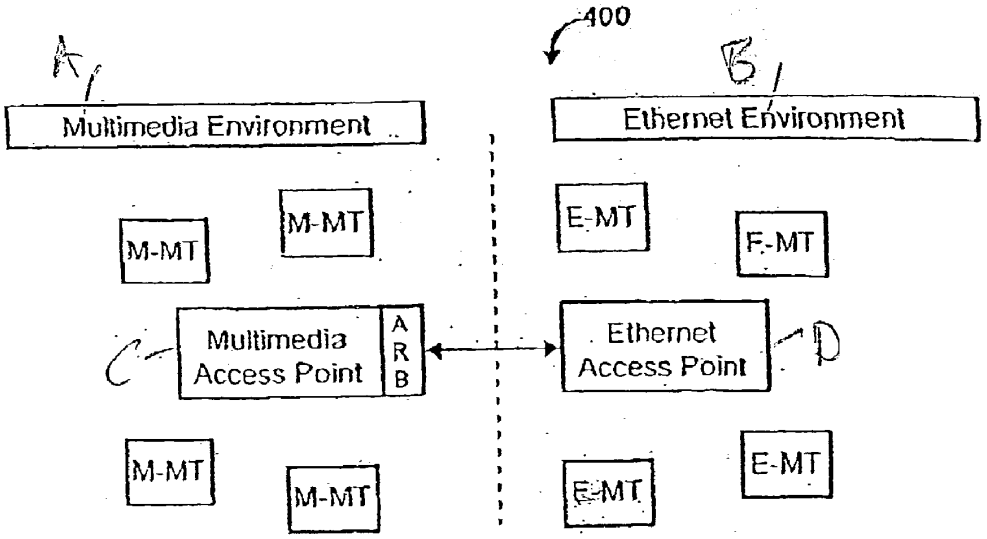
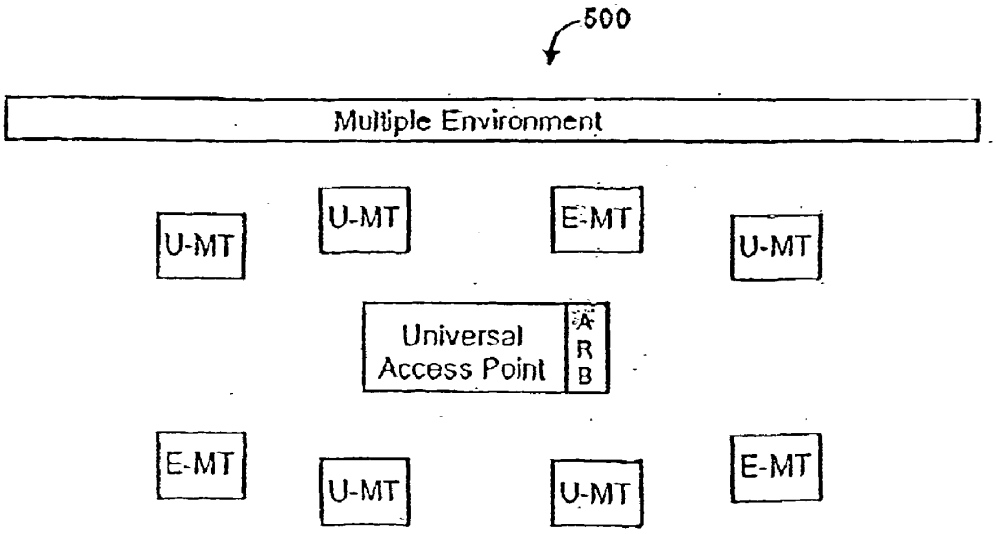


Figure 5



COMMUNICATIONS PROTOCOL FOR WIRELESS LAN HARMONIZING THE IEEE 802.11A AND ETSI HIPERLA/2 STANDARDS

TECHNICAL FIELD OF THE INVENTION

[0001] The invention relates to wireless communications and, more particularly, to a communications protocol (standard) for wireless local area network (WLAN) applications, taking into account the IEEE 802.11a standard and the ETSI HiPerLAN/2 standard.

BACKGROUND OF THE INVENTION

[0002] A local area network (LAN) is a network of independent computers, usually confined to a geographic area, such as a single building or a college campus. LANs can be small, linking as few as three computers, but often link hundreds of computers used by thousands of people. The development of standard networking protocols and media has resulted in worldwide proliferation of LANs throughout business and educational organizations.

[0003] Ethernet is the most popular physical layer LAN technology in use today. The Institute for Electrical and Electronic Engineers (IEEE) defines the Ethernet standard as IEEE Standard 802.3. This standard defines rules for configuring an Ethernet network as well as specifying how elements in an Ethernet network interact with one another. By adhering to the IEEE standard, network equipment and network protocols can communicate efficiently.

[0004] Ethernet uses Collision Sense Multiple Access with Collision Detection (CSMA/CD). When an Ethernet station is ready to transmit, it checks for the presence of a signal on the cable. If no signal is present then the station begins transmission, however if a signal is already present then the station delays transmission until the cable is not in use. If two stations detect an idle cable and at the same time transmit data, then a collision occurs. The two stations involved with the collision lay off transmitting again for a time interval which is randomly selected. If the collision occurs again, then the time interval is doubled, and if the collision happens repeatedly, an error is reported.

[0005] The 'Ether' part of Ethernet denotes that the system is not meant to be restricted for use on only one medium type. Copper cables, fibre cables and radio waves can be used.

[0006] A wireless LAN (WLAN) is a data transmission system designed to provide location-independent network access between computing devices by using radio waves rather than a cable infrastructure. The major motivation and benefit from WLANs is increased mobility. Untethered from conventional network connections, network users can move about almost without restriction and access LANs from nearly anywhere. Wireless LANs also offer the connectivity and the convenience of wired LANs without the need for expensive wiring or rewiring.

[0007] The 5 GigaHertz (GHz) band is of particular interest for high bandwidth WLAN products. Being spectrally clean and wide, the 5 GHz band attracts much attention as being the enabler of wide public acceptance for broadband WLAN products. In the US, the 5 GHz U-NII (Unlicensed National Information Infrastructure) band extends from 5.15 GHz to 5.825 GHz, and is divided into three parts (bands) with different allowed EIRP (Effective Isotropically Radiated Power) values. The 200 mW band provides for in-building operation. The 1 W band allows campus or small neighborhood services. The 4W band allows for services of up to approximately 10 km. The 5 GHz band is open in Europe, the United States and Japan. The current spectrum allocation at 5 GHz comprises 455 MHz in Europe, 300 MHz in the US, and 100 MHz in Japan.

[0008] Two WLAN standards (protocols) for the 5 GHz band have emerged, the IEEE 802.11a (Hereinafter referred to as "802.11" or "11a") and HiPerLAN/2 (hereinafter referred to as "HL2"). A common view in the industry is that these two standards are in competition with one another. Whereas the Ethernet-based 11a standard is particularly well-suited to the business environment, the multimedia-based HL2 standard is particularly well-suited to the home environment. As the industry has learned from past experience, competing standards and uncertainties about standard adoption and interoperability issues can greatly adversely the proliferation of products.

Protocol-Specific Definitions & Abbreviations

[0009] Each of the 11a and HL2 standards utilizes its own definitions and abbreviations. It is therefore useful, for purposes of this document, to establish a common terminology, as follows:

Ethernet elements	11a elements may be referred to as Ethernet elements.
Multimedia elements	HL2 elements may be referred to as Multimedia elements.
Co-existence	The ability of two wireless elements, each consistent with a different protocol both at the same frequency, to work adjacently without interference.
Partial Interoperability	The ability of two wireless elements, each consistent with a different protocol, to exchange information through a third element.
Full Interoperability	The ability of two wireless elements, each consistent with a different protocol, to exchange information directly.
Access Point	This term is used to describe a so-called "base station" in both the 11a and HL2 standard (s). With reference to the present invention, the following prefixes will be used.
E-AP	Ethernet Access Point (consistent with the 11a term-AP/PC)
M-AP	Multimedia Access Point (consistent with the HL2 term-AP/CC)
U-AP	Unified Access Point (a "coined" term)

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Mobile Terminal	This term is used to describe all wireless network elements except the Access Point, including stationary terminals, in both the 11a and HL2 standard (s). With reference to the present invention, the following prefixes will be used.
E-MT	Ethernet Mobile Terminal (consistent with the 11a term-STA)
M-MT	Multimedia Mobile Terminal (consistent the HL2 term-MT)
U-MT	Unified Mobile Terminal (a "coined" term)

IEEE 802.11a ("11a")

[0010] The IEEE 802.11 ("11a") standard is a broadband communication standard for WLANs, and defines two pieces of equipment, a wireless station (STA, herein "MT"), which is usually a personal computer (PC) equipped with a wireless network interface card (MC), and an access point (AP), which acts as a bridge between the wireless and wired networks. An AP usually consists of a radio, a wired network interface (e.g., Ethernet), and bridging software conforming to the IEEE 802.1d bridging standard. The AP acts as the base station for the wireless network, aggregating access for multiple MTs onto the wired network. Wireless stations can be 802.11 PC Card, PCI, or ISA NICs, or embedded solutions in non-PC clients (such as an 802.11-based telephone handset).

[0011] The 11a standard defines two modes of operation—an infrastructure mode and an ad-hoc mode. In the infrastructure mode, the wireless network consists of at least one AP connected to the wired network infrastructure and a set of MTs. This configuration is called a Basic Service Set (BSS). An Extended Service Set (ESS) is a set of two or more BSSs forming a single subnetwork. Since most corporate wireless LANs require access to the wired LAN for services (file servers, printers, Internet links) they typically operate in infrastructure mode. The ad-hoc mode (also called peer-to-peer mode, or Independent Basic Service Set, IBS) is simply a set of wireless stations (MTs) that communicate directly with one another without using an AP or any connection to a wired network. This mode is useful for quickly and easily setting up a wireless network anywhere that a wireless infrastructure does not exist or is not required for services, such as in a hotel room, convention center, or airport, or where access to the wired network is barred (such as for consultants at a client site).

[0012] The 11 a standard includes both a physical (PHY) layer and a medium access control (MAC) layer of the network. Generally, the PHY layer handles the transmission of data between nodes, and the MAC layer is a set of protocols which is responsible for maintaining order in the use of a shared medium.

[0013] The 11a MAC layer is responsible-for how a wireless station (MT) associates with an access point (AP). When an MT enters the range of one or more APs, it chooses an AP to associate with (also called "joining the Basic Service Set"), based on signal strength and observed packet error rates. Once accepted by the AP, the MT tunes to the radio channel to which the AP is set. Periodically, the MT surveys all of the available channels in order to assess whether a different AP would provide it with better performance characteristics. If it determines that this is the case, the MT reassociates with the new AP, tuning to the radio channel to which that AP is set. Reassociation usually occurs because the MT has physically moved away from the original AP, causing the signal to weaken. In other cases, reassociation occurs due to a change in radio characteristics in the building, or due simply to high network traffic on the original access point. In the latter case this function is known as "load balancing," since its primary function is to distribute the total WLAN load most efficiently across the available wireless infrastructure.

[0014] A MAC-layer problem specific to wireless LAN is the "hidden node" issue, in which two stations on opposite sides of an AP can both "hear" activity from the AP, but not from each other, usually due to distance or an obstruction. To address this issue, the 11a standard specifies an optional Request to Send/Clear to Send (RTS/CTS) protocol at the MAC layer. When this feature is in use, a sending station (MT) transmits an RTS and waits for the access point to reply with a CTS. Since all stations in the BSS can hear the access point, the CTS causes them to delay any intended transmissions, allowing the sending station to transmit and receive a packet acknowledgment without any chance of collision.

HiperLAN/2 (HL2)

[0015] HL2 is a another wireless LAN standard which includes both a Physical (PHY) Layer and a Medium Access Control (MAC) layer, and other layers as described hereinbelow. HL2 provides high-speed communications with a bit rate of up to 54-Mbits/s between Mobile Terminals (MTs) and various broadband infrastructure networks. The HL2 standard relies on cellular networking topology combined with an ad-hoc networking capability. It supports two basic modes of operation: centralized mode and direct mode. The centralized mode is used in the cellular networking topology where each radio cell is controlled by an access point (AP) covering a certain geographical area. In this mode, a mobile terminal (MT) communicates with other mobile terminals (Ts) or with the core network via an AP. This mode of operation is mainly used in business applications, both indoors and outdoors, where an area much larger than a radio cell has to be covered. The direct mode is used in the ad-hoc networking topology, mainly in typical private home environments, where a radio cell covers the whole serving area. In this mode, mobile terminals (MTs) in a single-cell home "network" can directly exchange data.

[0016] The PHY layer maps MAC Protocol Data Units (PDUs) to PHY PDUs, and adds PHY signaling such as system parameters and headers intended for RF signal synchronization. The signal modulation is based on Orthogonal Frequency Division Multiplexing (OFDM) with several sub-carrier modulation and forward error correction combinations that allow to cope with various channel configurations.

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