US 20020006135A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2002/0006135 A1**

SATO et al. (43) **Pub. Date: Jan. 17, 2002**

(54) **WIRELESS COUPLING OF INCOMPATIBLE NODES VIA A VIRTUAL NETWORK**

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(*) Notice: This is a publication of a continued prosecution application (CPA) filed under 37 CFR 1.53(d).

(21) Appl. No.: **09/093,212**

(22) Filed: **Jun. 8, 1998**

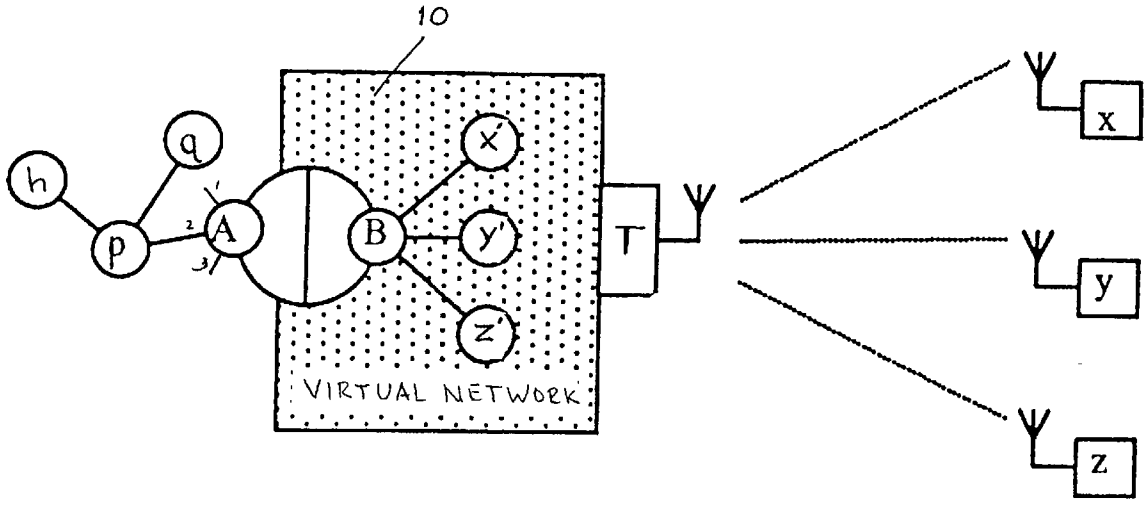
Publication Classification

(51) **Int. Cl.**[7] **H04B 7/00**

(52) **U.S. Cl.** **370/466**; 370/329

(57) **ABSTRACT**

A method and apparatus are provided for establishing wireless communications between standardized and non-standardized information devices. In association with a network of standardized information devices, a virtual network is formed which includes a virtual node representing each of the non-standardized information devices.



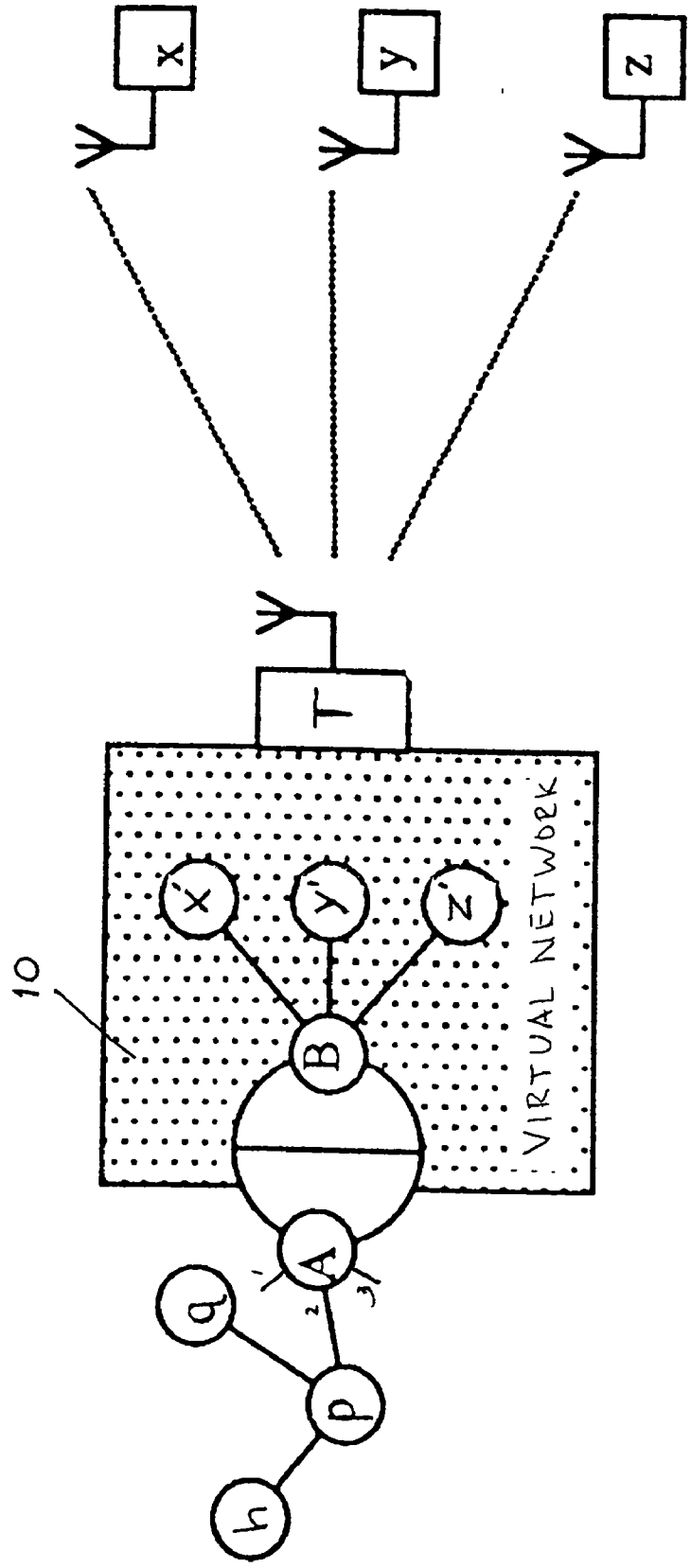


Fig. 1

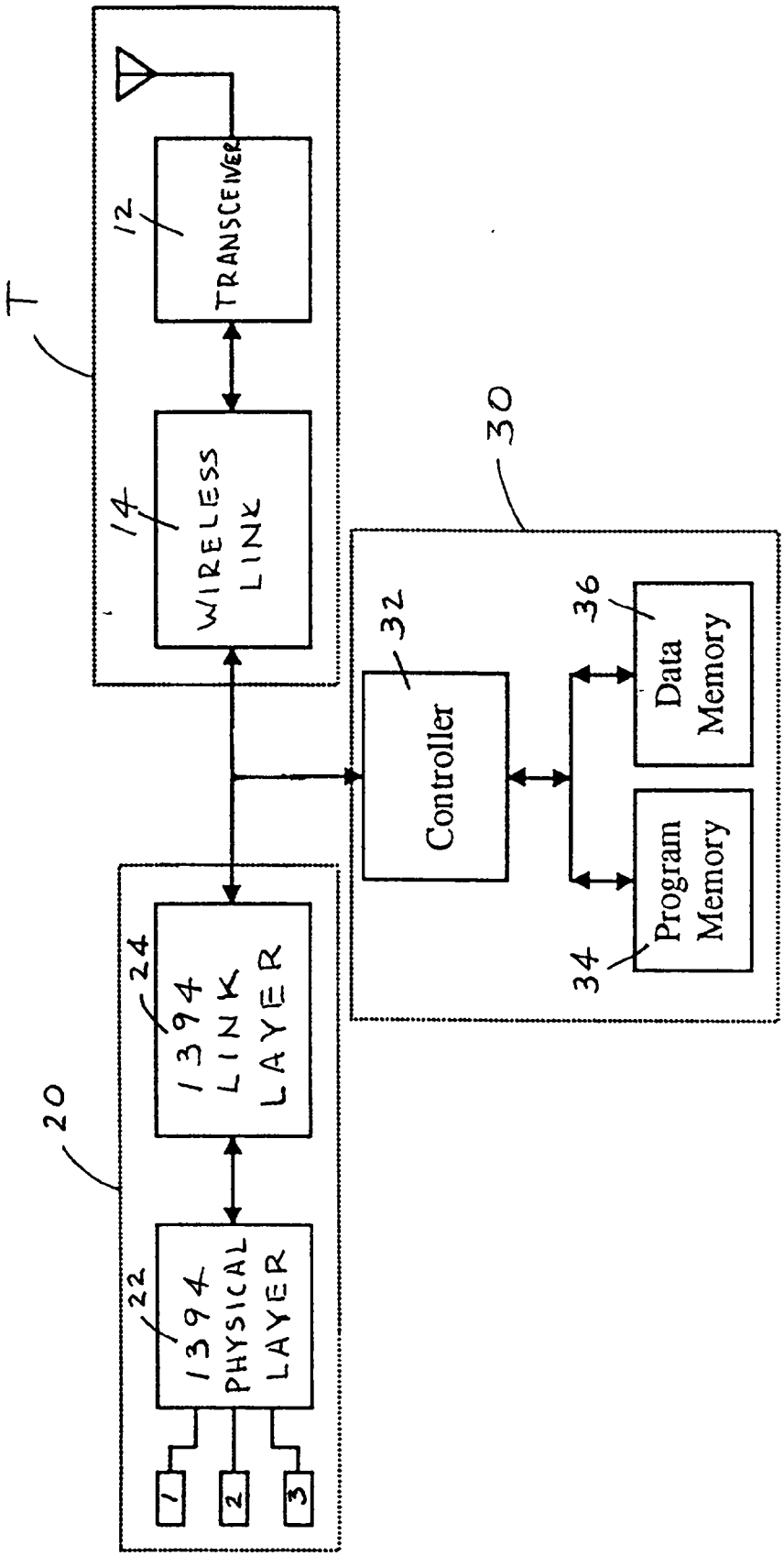

T
12
TRANSCEIVER
14
WIRELESS LINK
30
32
Controller
36
Data Memory
Program Memory
34
20
24
1394 LINK LAYER
22
1394 PHYSICAL LAYER
1
2
3

Fig. 2

WIRELESS COUPLING OF INCOMPATIBLE NODES VIA A VIRTUAL NETWORK

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to wireless coupling in information systems and, in particular, to wireless coupling of standardized information devices to non-standardized information devices.

[0003] 2. Description of Related Art

[0004] Wireless coupling of information devices has been described in a number of publications. For example, published PCT Application Number WO 97/29605 describes a wireless virtual Local Area Network (LAN) which enables workgroup membership to be redefined without physical wiring changes. This is particularly useful, for example, to facilitate communication between remotely-located LANs and to permit ad hoc networking between a group of portable computers.

[0005] Such known wireless coupling arrangements are very useful, but they are limited to the coupling of standardized information devices, i.e. information devices that are adapted to communicate with each other in accordance with a common standard. A typical example is a network of computers that are adapted for communication over a common information bus. There are also, however, many other applications where it is desirable to establish wireless communications between standardized information devices and non-standardized information devices, i.e. information devices that are not adapted to communicate in accordance with a common standard. Non-standardized information devices include both standard-capable information devices, such as computers that have not been adapted to communicate in accordance with commonly-used standard, and standard-incapable information devices which do not have sufficient intelligence to be so adapted. Examples of typical standard-incapable information devices with which wireless communications are of particular interest are security apparatus, audio and video equipment, telephone equipment etc. Although it is possible to provide each non-standardized information device in a system with sufficient hardware to enable it to communicate in accordance with a common standard, this is an expensive and often impractical solution. It would require substantial modification of every non-standardized information device in the system.

SUMMARY OF THE INVENTION

[0006] It is an object of the invention to provide a method and apparatus for enabling economical wireless communication between standardized nodes and non-standardized nodes. As used herein:

[0007] "node" means any device that is capable of producing, processing or utilizing information;

[0008] "standardized node" means a node that is adapted for communicating with other nodes in accordance with a common standard;

[0009] "non-standardized node" means a node that is not adapted for communicating with other nodes in accordance with a common standard;

[0010] "wireless communication" means communicating information via any energy propagation mode which is feasible for the information being communicated, including, for example, radio frequency (RF), infra-red (IR), and sonic energy propagation modes.

[0011] It is another object of the invention to provide such a method and apparatus which automatically adapts to the addition and removal of both standardized and non-standardized nodes from a wireless communication system.

[0012] In a method in accordance with the invention, wireless communication in a system including standardized nodes and non-standardized nodes is achieved by:

[0013] establishing a virtual network including a respective virtual node representing each non-standardized node;

[0014] communicating information between each non-standardized node and the respective virtual node in a communication format/protocol compatible with that non-standardized node;

[0015] communicating information between each virtual node and the standardized nodes in a communication format/protocol compatible with the standardized nodes.

[0016] In an apparatus in accordance with the invention, a wireless information system is formed which includes:

[0017] at least one non-standardized node having a transceiver for wireless communication;

[0018] a standardized network including a bus for carrying communications between any standardized nodes that are connected to the bus;

[0019] a wireless station including a transceiver for wireless communication with the at least one non-standardized node;

[0020] a virtual network coupled to the wireless station and including a controller and a memory for cooperatively:

[0021] establishing in the memory a virtual node representing each non-standardized node;

[0022] communicating information between each non-standardized node and the respective virtual node in a communication format/protocol compatible with the non-standardized node;

[0023] communicating information between each virtual node and each standardized node in a communication format/protocol compatible with the standardized node.

BRIEF DESCRIPTION OF THE DRAWING

[0024] **FIG. 1** is a schematic diagram illustrating an embodiment of an information system which communicates in accordance with the invention.

[0025] **FIG. 2** is a block diagram illustrating an embodiment of a portion of the information system of **FIG. 1**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0026] The information system of **FIG. 1** includes a real network having standardized nodes h, p, q and a half bridge A, which is itself a standardized node; a plurality of non-standardized nodes x, y, z; a virtual network **10** having a virtual half bridge B and virtual nodes x', y', z'; and a wireless station T. Practical information systems of this type include, for example:

[0027] an office computer system having standardized nodes including personal computers h, p, q wired for communication over a common information bus with each other and with the half bridge A; and non-standardized nodes including a printer x, a hard-disc drive y, and an image scanner z;

[0028] a residential entertainment and security system having standardized nodes including a digital TV h, a digital VCR p, and a digital stereo system q, wired for communication over a common information bus with each other and with the half bridge A; and

[0029] non-standardized nodes including a security system x, a wireless telephone y, and a loudspeaker system z.

[0030] The half bridge A controllably passes information between the real network and the virtual network. Depending on the design of the half bridge, it may also control the passage of information between the nodes h, p, q in the real network.

[0031] The non-standardized nodes x, y, z each include, in addition to a particular type of information device, a transceiver for wireless communication with the wireless station T. Each of these nodes also includes at least minimal intelligence for locally coordinating information flow between the respective information device and transceiver. Depending on the innate complexity of the particular information device, this minimal intelligence may take any one of a variety of forms, e.g. added logic hardware and/or software in an already-existing processor or microprocessor, a dedicated microprocessor, or dedicated logic hardware.

[0032] The wireless station T includes a local transceiver for wireless communication with the transceivers of nodes x, y, z and a wireless link for coordinating information flow between this local transceiver and the virtual network. The wireless station and the non-standardized nodes x, y, z also each include a respective transducer for propagating the mode of energy chosen for wireless communication. In the exemplary embodiment shown in **FIG. 1**, antennas are shown for propagating RF energy.

[0033] The virtual network **10** is a model that is formed with reference to the standardized half bridge A and the non-standardized nodes x, y, z. The virtual half bridge B is modeled to be complementary to the real half bridge A, such that half bridges A and B collectively form a standardized full bridge. The virtual nodes x', y', z' are modeled to represent the respective non-standardized nodes x, y, z, but modified to communicate with virtual half bridge B in the same standard as the real nodes h, p, q communicate with the real half bridge A.

[0034] **FIG. 2** illustrates an exemplary embodiment of a subsystem for forming the half bridge A, the virtual network **10** and the wireless station T. This subsystem includes a bridge-interface unit **20**, a virtual intelligence unit **30**, and the wireless station T mentioned in conjunction with the description of **FIG. 1**.

[0035] The wireless station T includes a transceiver **12** and a wireless link **14**. The transceiver is a conventional device, with the type of transceiver depending on the mode of propagation chosen for wireless communication. The wireless link **14** is also a conventional device for performing the functions of:

[0036] converting signals received from the non-standardized nodes x, y, z, via the transceiver **12**, to a format compatible with the virtual intelligence unit **30**;

[0037] converting signals received from the virtual intelligence unit to a format compatible with the transceiver and the non-standardized nodes; and

[0038] exchanging timing and control signals with the virtual intelligence unit to effect arbitration, i.e. to coordinate the transfer of information to and from the non-standardized nodes. The wireless link may be implemented by using, for example, a microprocessor and software for performing the format conversions. Alternatively, if the formats chosen for communication with the non-standardized nodes are not so complex as to require extensive hardware, the wireless link may be constructed by using logic circuitry. See, for example, the wireless link described in PCT Application WO 88/07794, published on Oct. 6, 1988.

[0039] The virtual intelligence unit **30** includes a controller **32**, a program memory **34** and a data memory **36**. The controller, which is coupled to the wireless station T and to the bridge-interface unit **20** via a bus, may be e.g. a microprocessor, a micro-controller or a digital signal processor. The controller, under the direction of instructions in the program memory, has the capability of cooperating with the wireless station T to:

[0040] detect the existence of any non-standardized nodes (e.g. the nodes x, y, z) that are currently capable of wireless communication with the virtual network;

[0041] form virtual nodes (e.g. the nodes x', y', z') representing the detected nodes by storing in the data memory a description of each real node (x, y, z) and data which is either received from, or to be transmitted to, the respective node;

[0042] coordinating with the wireless station to exchange communications between the virtual nodes (x', y', z') and the real nodes (x, y, z).

[0043] Note that a variety of information may be stored in the program and data memories in association with the virtual nodes, including, for example:

[0044] formatting information unique to each of the wireless nodes with which the station T establishes communication;

[0045] algorithms for performing operations on data received from, or to be transmitted to, the wireless nodes;

[0046] relative priorities for communications with the respective wireless nodes.

[0047] Note, further, that the virtual intelligence unit is easily adapted to changes in the types of non-standardized nodes with which the virtual network is to communicate. Information, e.g. program instructions and descriptive data, needed for communicating with new types of non-standardized nodes can be easily added to the program and data memories of the virtual intelligence unit.

[0048] The bridge-interface unit **20** and the virtual intelligence unit **30** cooperatively form the bridge comprising the two half bridges A and B. Half bridge A must communicate with nodes h, p, q in accordance with their common standard, while half bridge B must be capable of universally communicating with the virtual nodes x', y', z' in their respective formats. The half bridges may communicate with each other in any format common to each.

[0049] In the exemplary embodiment shown in **FIG. 2**, the standard chosen for the real network, having the nodes h, p, q and the half bridge A, is the IEEE 1394 Standard. This standard is described in detail in the publication IEEE Std 1394-1995, "IEEE Standard for a High Performance Serial Bus" (Aug. 30, 1996), which is hereby incorporated by reference. This is a particularly useful standard for high performance bus interconnection of computer peripherals and consumer electronics, including the transmission of high-speed digital video data.

[0050] Part of the half bridge A is formed by the bridge-interface unit, which includes a 1394-Standard physical layer **22** and a 1394-Standard link layer **24**. Both of these layers are functional logic elements which are operationally described in the IEEE publication P1394.1 Draft 0.03, "P1394.1 Draft Standard for High Performance Serial Bus Bridges" (Oct. 18, 1997), which is hereby incorporated by reference. The physical layer **22** includes exemplary ports **1**, **2**, **3** for physical connection to a common bus on which 1394-Standard nodes, e.g. the nodes h, p, q, communicate; ensures that only one node at a time transmits information on the common bus by providing an arbitration service; and converts communications received from the link layer **24** to the 1394 Standard. The link layer formats communications received from the physical layer into a standardized datagram which is addressed and framed for transmission to a predetermined one of the non-standardized nodes currently in communication with the wireless station T, i.e. node x, y or z.

[0051] The virtual intelligence unit **30** forms the remainder of the half bridge A and forms the virtual half bridge B. More specifically, the controller **32**, together with the program memory **34** and the data memory **36**, forms:

[0052] a common 1394.1-Standard switching fabric (internal fabric) coupling the two half bridges; and

[0053] the remainder of half bridge B with links to the current virtual nodes (x', y', z').

What is claimed is:

1. A method of wireless communication in a system including a first network having at least one standardized node and a second network having at least one non-standardized node, said method comprising:

a. establishing a virtual network including a respective virtual node representing each said non-standardized node;

b. communicating information between each said non-standardized node and the respective virtual node in the communication format/protocol compatible with said non-standardized node;

c. communicating information between each said virtual node and the at least one standardized node in a communication format/protocol compatible with said standardized node.

2. A method as in claim 1 where the at least one standardized node comprises a real half bridge for communicating with other standardized nodes in the first network and where the virtual network includes a virtual half bridge for communicating with the real half bridge and with the virtual nodes in said communication format/protocol.

3. A method of wireless communication in a system including at least one standardized node and at least one non-standardized node, said method comprising:

a. determining the identity of each non-standardized node and selecting a communication format/protocol compatible with each said non-standardized node;

b. establishing a virtual node representing each said non-standardized node;

c. communicating information between each said non-standardized node and the respective virtual node in the communication format/protocol compatible with said non-standardized node;

d. communicating information between each said virtual node and the at least one standardized node in a communication format/protocol compatible with said standardized node.

4. A wireless information system including:

a. at least one non-standardized node having a transceiver for wireless communication;

b. a standardized network including a bus for carrying communications between any standardized nodes that are connected to the bus;

c. a wireless station including a transceiver for wireless communication with the at least one non-standardized node;

d. a virtual network coupled to the wireless station and including a controller and a memory for cooperatively:

i. establishing in the memory a virtual node representing each said non-standardized node;

ii. communicating information between each said non-standardized node and the respective virtual node in a communication format/protocol compatible with said non-standardized node;

iii. communicating information between each said virtual node and each said standardized node in a communication format/protocol compatible with said standardized node.

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