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(56) Documents Cited:
GB 2436911 A **US 20040223535 A1**
US 20040171957 A1

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INT CL **H04B, H04L**
Other: **Online : wpi ; epodoc**

(54) Abstract Title: **A wireless communications apparatus for establishing wideband wireless communication**

(57) A wireless transceiver, operable to communicate in an ultra wide band spectrum, comprises communications activity collection means for collecting information relating to communications activity in the spectrum and interference avoidance means operable on the basis of said collected information to identify narrowband regions of the spectrum not for use by said device. Communications control means are provided which are operable to avoid communication in an identified narrowband region of the spectrum.

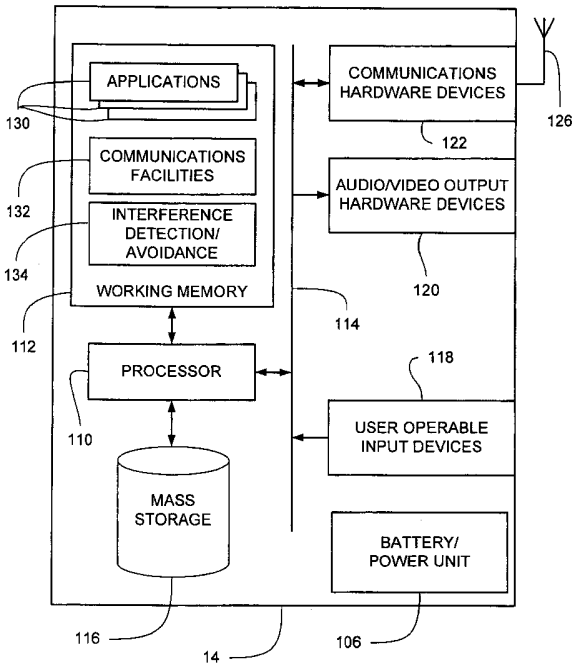

FIGURE 2

GB 2 451 683 A

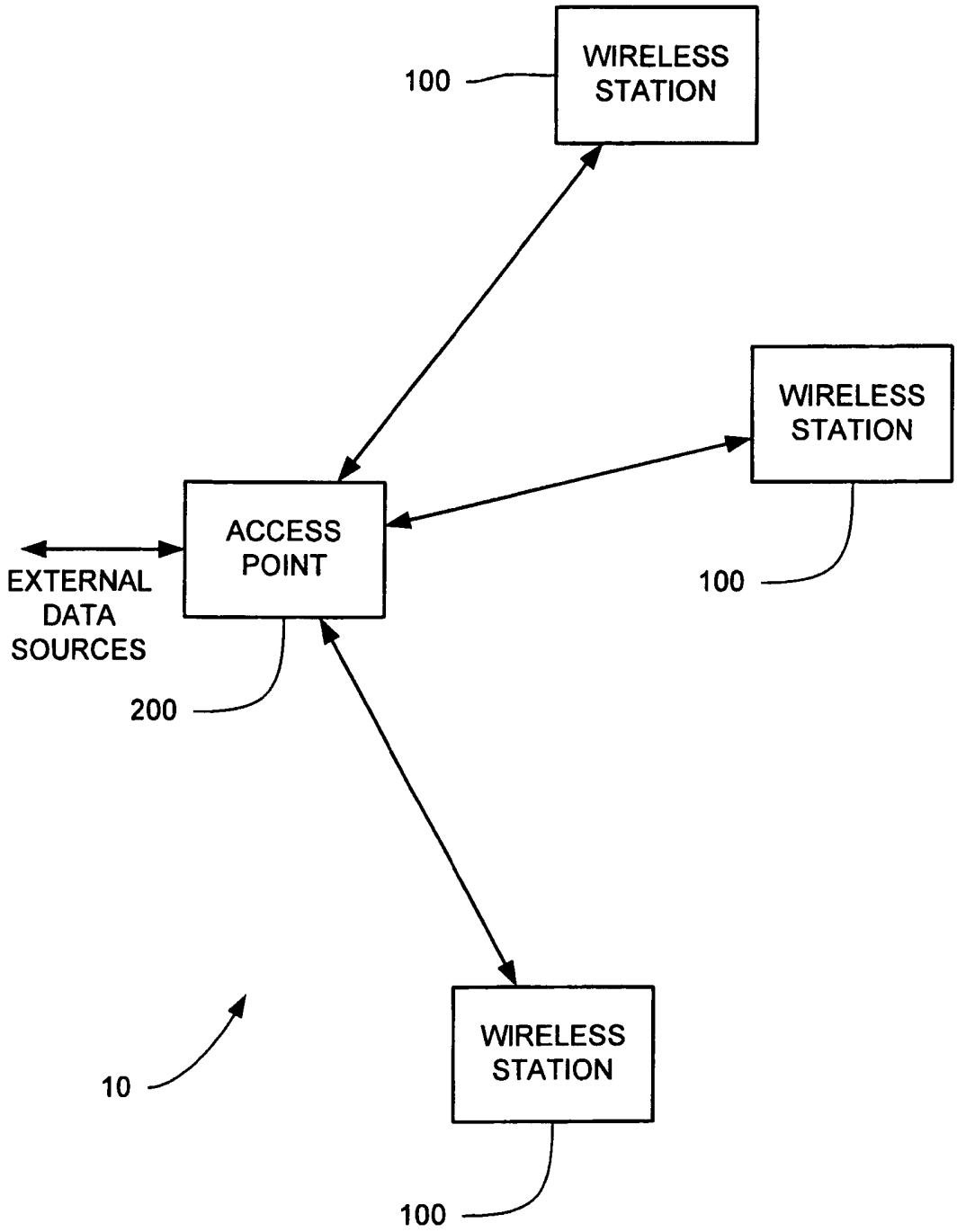
WIRELESS STATION
100
WIRELESS STATION
ACCESS POINT
EXTERNAL DATA SOURCES
100
200
WIRELESS STATION
10
100

FIGURE 1

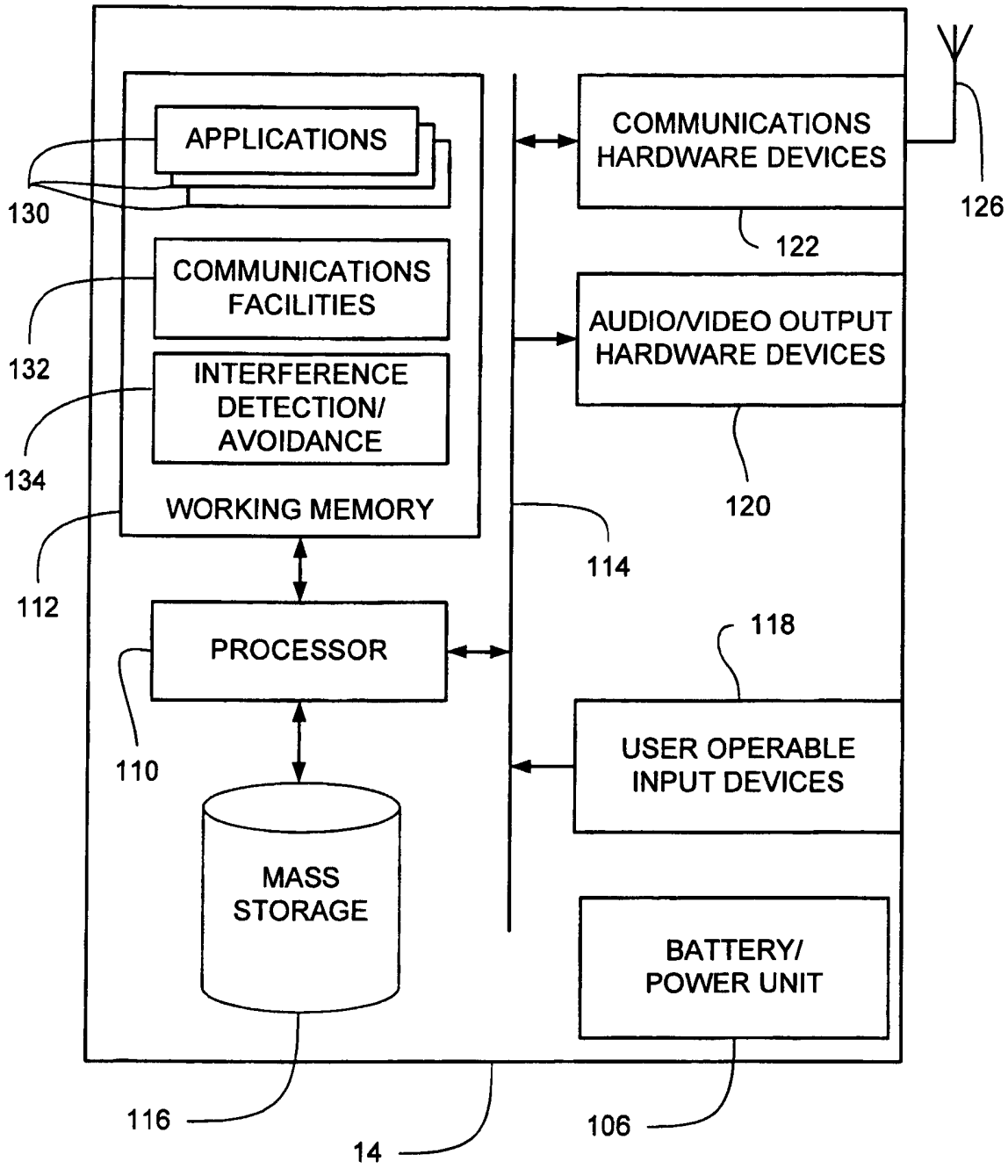
APPLICATIONS
130
COMMUNICATIONS FACILITIES
132
INTERFERENCE DETECTION/ AVOIDANCE
134
WORKING MEMORY
112
PROCESSOR
110
MASS STORAGE
116
14
COMMUNICATIONS HARDWARE DEVICES
122
126
AUDIO/VIDEO OUTPUT HARDWARE DEVICES
120
114
118
USER OPERABLE INPUT DEVICES
BATTERY/ POWER UNIT
106

FIGURE 2

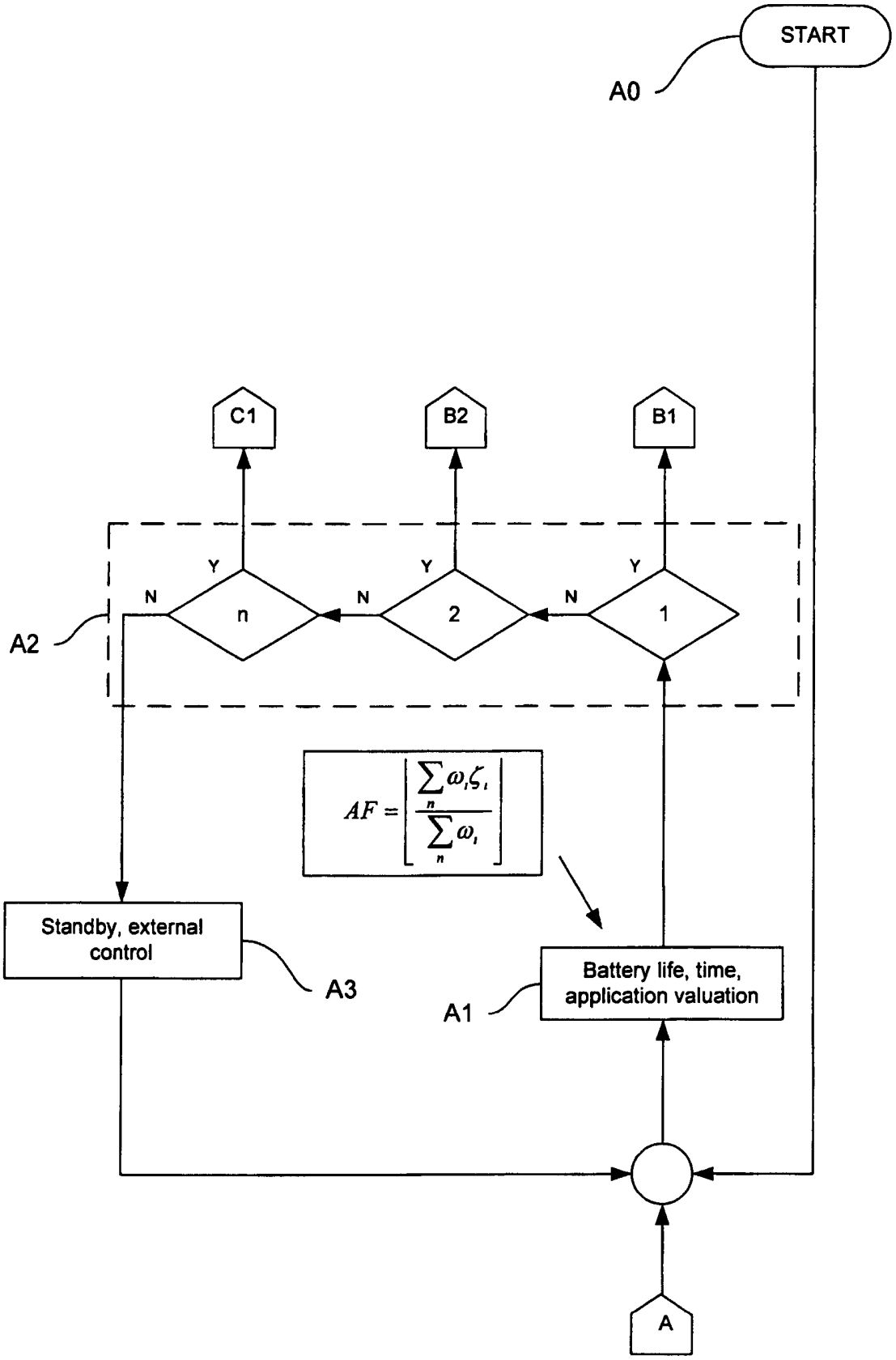
START
A0
C1
B2
B1
Y
N
n
2
1
A2
$AF = \left| \frac{\sum_n \omega_i \zeta_i}{\sum_n \omega_i} \right|$
Standby, external control
A3
Battery life, time, application valuation
A1
A

FIGURE 3A

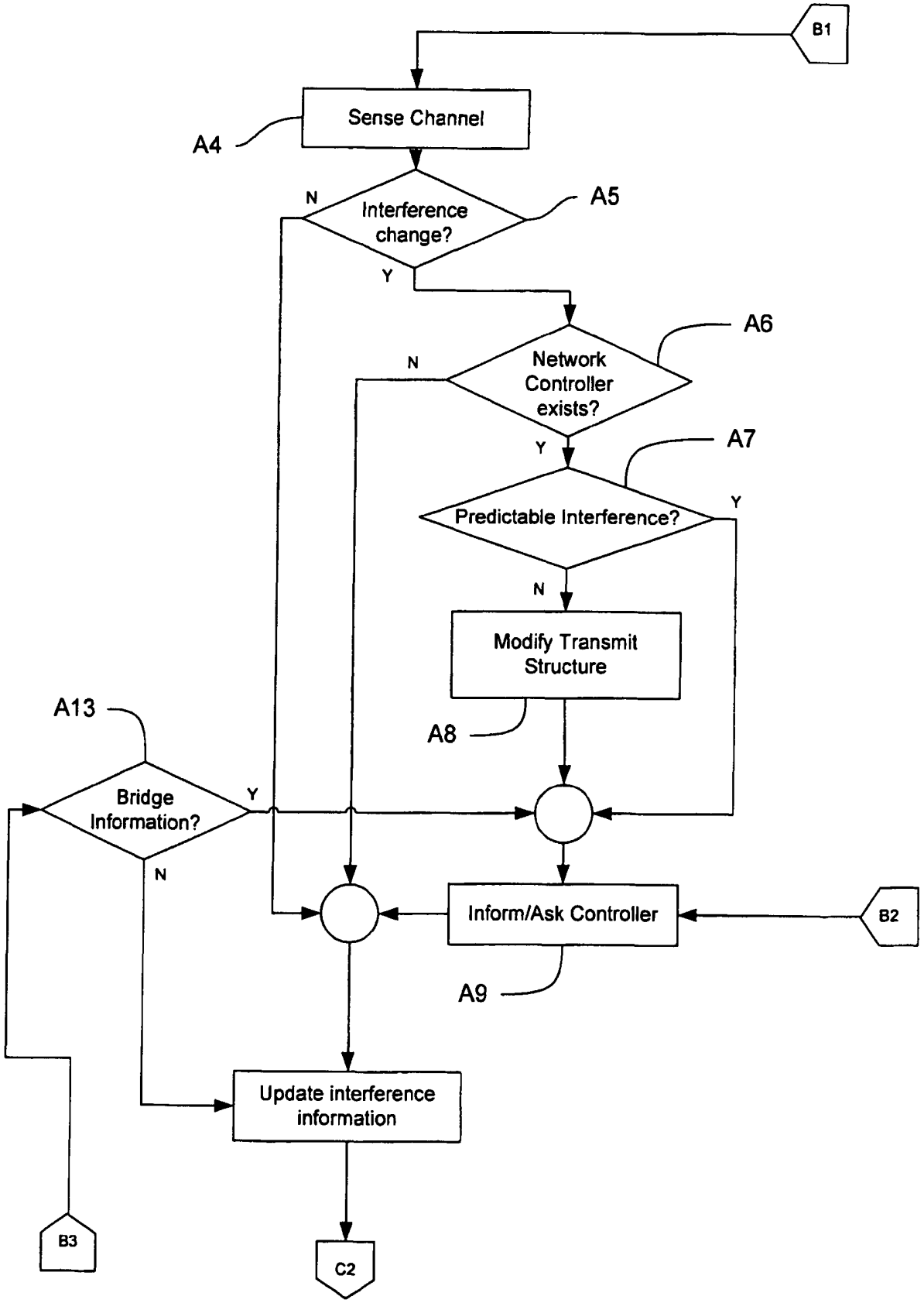
B1
Sense Channel
A4
N
Interference change?
A5
Y
A6
N
Network Controller exists?
Y
A7
Predictable Interference?
Y
N
Modify Transmit Structure
A8
A13
Bridge Information?
Y
N
Inform/Ask Controller
B2
A9
Update interference information
B3
C2

FIGURE 3B

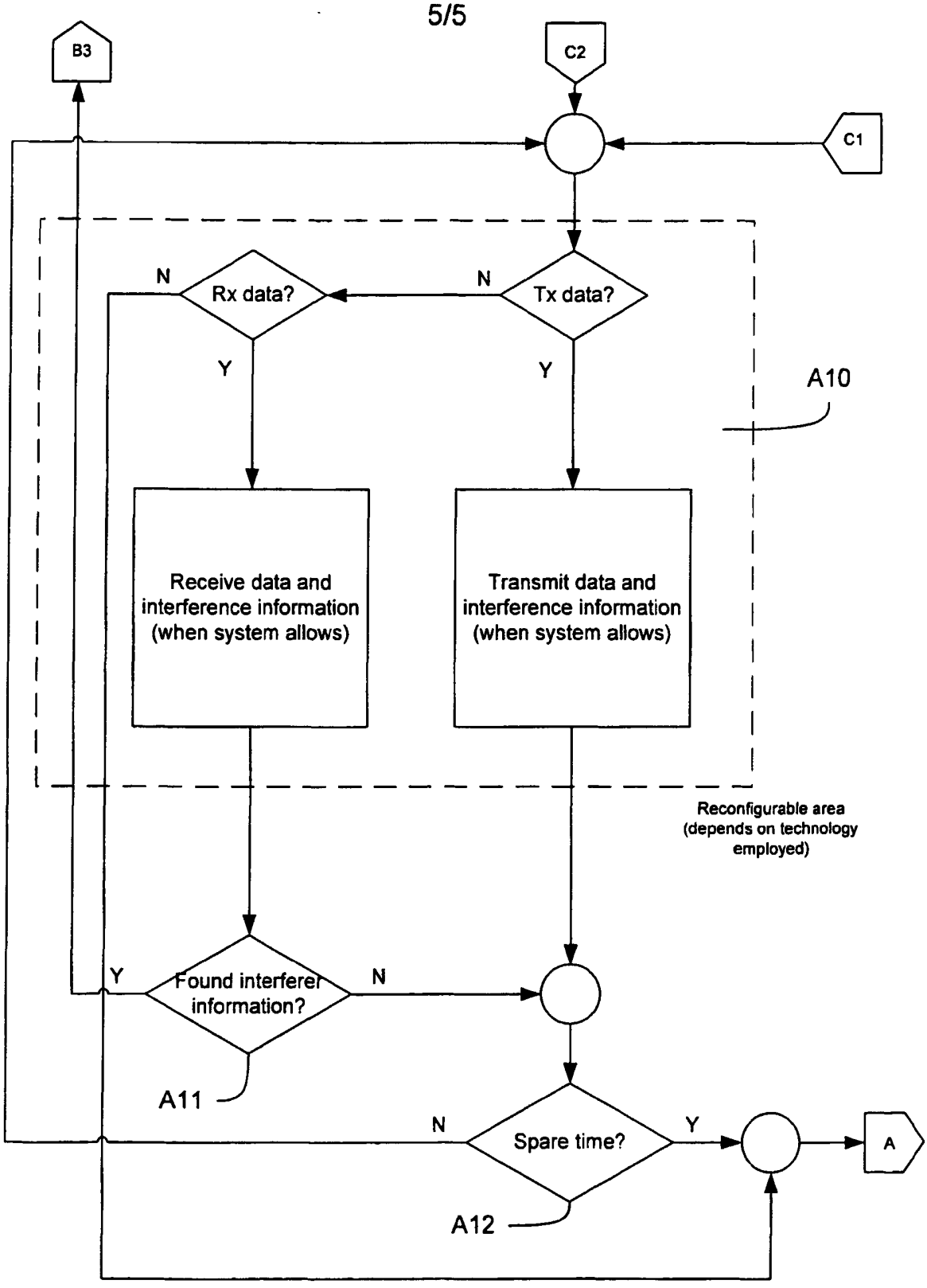
B3
C2
C1
N
Rx data?
N
Tx data?
Y
Y
A10
Receive data and interference information (when system allows)
Transmit data and interference information (when system allows)
Reconfigurable area (depends on technology employed)
Y
Found interferer information?
N
A11
N
Spare time?
Y
A
A12

FIGURE 3C

Wireless Communications Apparatus

This invention relates to wireless communications apparatus and particularly, but not exclusively, to wireless communications apparatus for establishing wideband wireless communication.

Ultra wide band (UWB) communication systems provide substantial performance enhancement over narrowband systems, by making use of all available spectrum in establishing communication. However, UWB is vulnerable to interference, as narrowband activity will cause interference at points in the spectrum.

Narrowband Interference has been avoided in the past in UWB systems by nulling tones or moving sub-bands (MB-OFDM), or by using adaptive filters (DS-CDMA). These two techniques aim at combating interference at the physical layer, but do not consider the control and management of interference information, or the optimisation of the data flow in the wideband network when exposed to narrower band interference.

Various approaches have been taken to this, in published documents.

EP1453217 (also published, in English, as US2004/171957) describes a method of attenuating the influence on UWB communications of interference produced by bursty radio transmission systems. Detection and demodulation are blocked if a received signal exceeds a power threshold value.

CN1551511 (also published, in English, as US2004/223535) describes UWB transceiver designed for dynamically reducing interference by including in the transceiver a plurality of narrowband devices operable to be switched into or out of use on the basis of interference detection.

"A new piconet formation algorithm for UWB ad hoc networks" (Gong, M.X.; Midkiff, S.F.; Buehrer, R.M.) is operable only with interference from network peers. It therefore remains vulnerable to narrowband interferers located within the vicinity of the wideband network. These can be considered third-party systems beyond the control of the UWB operator.

An aspect of the invention provides a transceiver operable to manage the detection of interference impinging on said transceiver in a wideband wireless network and thereby to mitigate the effects of this interference and prevent causing interference to third party devices

Another aspect of the invention provides a receiver operable to detect and/or avoid narrowband interference. Such interference can be from, for example, communication devices with a bandwidth in the range 1~40MHz. Such interference detection and/or avoidance can be achieved by one device independently or by more than one device acting cooperatively.

Another aspect of the invention provides a transmitter of construction similar to the abovedescribed receiver. The transmitter and receiver capabilities can be provided in one device, termed a transceiver.

A receiver and/or a transmitter in accordance with the invention can, in one embodiment of the invention, determine and take account of status information in a process of upgrading interference information. Such status information can include information describing remaining battery life of the device, the identity or the type of software application being executed by the device, or idle time.

Another aspect of the invention provides a device establishing or operating in a network, the device being operable to record information describing a map of devices causing interference in the network. The device may be operable to record said map information by measuring the strength of received signals and the angles of arrival of said signals.

Another aspect of the invention provides a device for establishing or operating in a network, the device being operable to record information describing a map of devices causing interference in the network, by receiving information relayed by a network coordinator. By this, the device can be used to improve coexistence and overall network data throughput in the network so established.

Another aspect of the invention provides a wireless transceiver operable to communicate in an ultra wide band spectrum, the transceiver comprising communications activity collection means for collecting information relating to communications activity in said spectrum, interference avoidance means operable on the basis of said collected information to identify narrowband regions of said spectrum not for use by said device, and communications control means operable to avoid communication in an identified narrowband region of said spectrum.

Another aspect of the invention provides a method of determining interference avoidance information for use in a wireless transceiver operable to communicate in an ultra wide band spectrum, the method comprising collecting information relating to communications activity in said spectrum, identifying on the basis of said collected information narrowband regions of said spectrum not for use by said device, and avoiding communications communication in an identified narrowband region of said spectrum.

Another aspect of the invention provides a computer program product comprising computer executable instructions, the instructions when executed on a general purpose communications apparatus causing said apparatus to become configured as any one of the above aspects of the invention. The computer program product may comprise a carrier medium, such as a storage medium as in an optical or magnetic storage device, or a computer receivable signal such as might be encountered in a download.

The invention is particularly, but not exclusively, contemplated for implementation in a wireless device that communicates by transmitting wideband signals (especially low power), which are subject to interference from coexisting transmitters.

Specific embodiments of the invention will now be described with reference to the accompanying drawings, in which:

Figure 1 is a schematic diagram of a wireless communications network in accordance with a specific embodiment of the invention;

Figure 2 is a schematic diagram of a wireless communications device in the network of figure 1; and

Figures 3A to 3C in combination illustrate a flow diagram of a method of interference detection and/or avoidance executed by the device illustrated in figure 2, in accordance with a specific embodiment of the invention.

A specific example embodiment of the invention will now be described with reference to the drawings. In particular, figure 1 illustrates a simple wireless communications network 10 comprising a plurality of wireless communications stations (devices) 100 in communication with an access point 200. The wireless communications devices 100 can be configured in accordance with any suitable UWB based communications technology, examples thereof being given above.

Figure 2 illustrates schematically a wireless communications device 100 operably configured (by means of software or application specific hardware components) in accordance with the specific embodiment of the invention. The communications device 100 comprises a processor 110 operable to execute machine code instructions stored in a working memory 112 and/or retrievable from a mass storage device 116. By means of a general purpose bus 114, user operable input devices 118 are capable of communication with the processor 110. The user operable input devices 118 comprise, in this example, a keyboard and a mouse though it will be appreciated that any other input devices could also or alternatively be provided, such as another type of pointing device, a writing tablet, speech recognition means, or any other means by which a user input action can be interpreted and converted into data signals.

Audio/video output hardware devices 120 are further connected to the general purpose bus 114, for the output of information to a user. Audio/video output hardware devices 120 can include a visual display unit, a speaker or any other device capable of presenting information to a user.

Communications hardware devices 122, connected to the general purpose bus 114, are connected to an antenna 126. In the illustrated embodiment in Figure 2, the working memory 112 stores user applications 130 which, when executed by the processor 110, cause the establishment of a user interface to enable communication of data to and from a user. The applications in this embodiment establish general purpose or specific computer implemented utilities that might habitually be used by a user.

Communications facilities 132 in accordance with the specific embodiment are also stored in the working memory 112, for establishing a communications protocol to enable data generated in the execution of one of the applications 130 to be processed and then passed to the communications hardware devices 122 for transmission and communication with another communications device. It will be understood that the software defining the applications 130 and the communications facilities 132 may be partly stored in the working memory 112 and the mass storage device 116, for convenience. A memory manager could optionally be provided to enable this to be managed effectively, to take account of the possible different speeds of access to data stored in the working memory 112 and the mass storage device 116.

A power unit 106 is also provided, for providing power to all components set out above as required, by means of power buses not illustrated in the figure for reasons of clarity. The power unit 106 incorporates a battery or other electrical energy storage means, and is capable of providing an output for indicating the amount of available energy remaining for use.

On execution by the processor 110 of processor executable instructions corresponding with the communications facilities 132, the processor 110 is operable to establish communication with another device in accordance with a recognised communications protocol.

An interference detection/avoidance facility 134 is also executed, by means of software stored in working memory, as illustrated. It will be appreciated that this is but one way in which the facility can be implemented and an application specific hardware device, or a segregated part of another hardware device, or a mixture of hardware and software, could equally be provided.

The above described device 100 is operable to perform a method of collecting information and processing such information to avoid transmission on frequencies subject to interference. According to this method, information is collected by the device from neighbouring narrowband (in-band) transceivers. Subsequently the device coordinates transmissions so that active detected narrowband frequencies (which are thus subject to interference) are avoided. If the statistics of usage of the frequencies associated with the interferers are shown to be predictable, then these frequencies may be used in the time gaps between third party transmissions to alert other potentially hidden nodes on the network that they must avoid these frequencies, or that they should expect transmissions from the alerting node not to be using these frequencies.

When a network controller is available, a device can use the method to be described below to acquire information about the direction-of-arrival and strength of sources of narrowband interference, as 'seen' by other devices on the network. In addition, the transmitter and receiver links can directly share information about interference affecting them, as it is not assumed to be reciprocal, thus working without help from the network controller to reduce network overhead.

The method also allows every terminal to perform an "internal check" to determine the priority level of interference control adaptation. Some of the parameters that can be included are:

the traffic requirements of applications that are running,

battery life, and

the spare time available for scanning the frequency band.

The operation of the method will now be described, with reference to Figures 3A to 3C. For ease of reference, transitions between the three sheets of drawings comprising the flow diagram are indicated by block arrows, with legend representing the two parts of the transition. For instance, transition A in figure 3C goes to the corresponding arrow in firuere 3A, and transition B1 in figure 3A goes to the corresponding arrow in figure 3B, and so on.

The method is activated on "start" [A0], which is located at the top right hand corner of the diagram in Figure 3A. The immediate procedure that is followed is the internal checking of the system [A1], which determines projected battery life, spare time available for scanning the available frequency spectrum, communication requirements of the application running, and any other factors that may be relevant to the transmission of data. After this process, a numerical weight (ω_i) is assigned to every analysed factor (ζ_i) according to their respective importance relative to the transmission of data. For example, a zero weight is assigned to indicate optimal conditions.

Once all of the relevant factors (ζ_i) from the terminal have been quantified and weighted (ω_i), the results are combined, and a single numerical value termed the "adaptation factor" (AF) is computed in [A8] using:

$$AF = \left\lfloor \frac{\sum_{n} \omega_i \zeta_i}{\sum_{n} \omega_i} \right\rfloor \qquad (1)$$

where $\lfloor \cdot \rfloor$ is the floor value, and $AF \in \lceil 1,3 \rceil$.

The AF is then passed on to a decision block [A2] that determines which features of the method are to be enabled. A later example, set out with the aid of table 1 below, demonstrates this.

When the terminal is unable or not required to establish a connection, the process will lapse into a stand-by mode [A3] handing over control to the program which initiated it.

If the internal checking is optimum, a single metric will be issued, reflecting all of the quantitative measures taken of the internal criteria observed by the device. The device will then proceed to scan the frequency spectrum of interest [A4]. The subsequent step is the comparison of previously acquired interference information against the new readings [A5]. If the nature of the interference changes, the terminal controlled by the governing protocol will determine whether a network controller [A6] is present while concurrently sensing the frequency spectrum so as to recognise the characteristics of the interference [A7].

If the interference profile does not allow the transmission of a packet using the regular frequency spectrum, the packet will be modified [A8], according to the interference avoidance/detection technologies available to transmit data, thus avoiding any frequencies that are subject to interference, and at the same time informing the network controller of its situation, and requesting information regarding possible targets for establishing a link in the network [A9]. In case predictable interference is detected, the alerting node can send a relatively small packet just to inform potential communication partners about its presence, the interference, and that it would expect any further incoming transmissions to avoid the interfered frequencies.

Some examples of how information about the identified interferers and avoidance strategies in place is communicated between devices in the WPAN are:

1) In a centralised embodiment (with a dedicated or elected central controller such as in figure 1) this information is polled from the devices either explicitly or through a round-robin scheme as additional information elements in the beacon (assuming there is one).
2) In a distributed network this information is either broadcast in a round-robin style (in order of MAC address or some other unambiguous scheme) periodically (e.g. after beacon transmission) or, if the data is/are suitably compressed, announced within the MAC header of the RTS/CTS/Data/ACK frames (or whatever corresponding frames are used).

After an exchange of initial information with the network controller, the network controller will inform prospective terminal targets of the new terminal trying to gain access to the network under interference conditions. If no network controller is available, the terminal running the method will try to establish a link with the target terminal using either a full (if interference is absent or predictable) or notched frequency spectrum.

At this point the terminal will have established a link with another terminal with or without the help of a network controller. As interference will not always be reciprocal, information about changes in the interference profile as observed at both terminals is shared [A10] [A11] and complemented with a requirement to relay the information to the network controller [A13] when direct connection between the remote terminal and the network controller is greatly affected by interference.

At the end of a group of transmitted packets, the terminal will decide whether time is available to provide an interference update [A12]. If so, the internal check will be repeated and a decision is made on the parts of the method to be used.

This invention addresses the narrowband interference problem in a wideband wireless network by managing available techniques for interference detection and avoidance in a transceiver to allow the continuous flow of data, and the sharing of information with other devices in the network. Consequently, this would reduce the impact of in-band interference on a receiver (e.g. reduction in the fraction of the dynamic range of the ADC available for modulation of a wanted signal, elevation of noise floor, etc). This would benefit both the device on the network and an unknown, but identified interferer. This information may also be used to help establish interference free communication links between network terminals. Current technologies do not consider the network sharing of interference information or the possibility of centralising the narrowband interference information, thus optimising the overall network throughput.

- Low complexity algorithm to improve the flow of information in a wideband network under the presence of narrowband interferers.
- Minimises the impact of noise on third party narrowband transmitters.

- Helps to identify "best possible transmission routes" to extend the range of transmission.

Table 1 gives an example list of adaptation factors (ζ_i) with their respective weights (ω_i) and their possible values, which are employed to produce a single numeric value AF in A1 (Figure 3). In this example, all of the features of the method are activated when AF = 1, as occurs when all of the separate components also have a value of 1.

Table 1

Factor (ζ)	Factor value	Weight (ω)
Battery life	1 to 3	7
Application running	1 to 3	4
Available time for scanning spectrum	1 to 3	3
Available interference information	1 to 3	3
Memory	1 to 3	3
QoS	1 to 3	3

This invention describes a DAA-management mechanism that provides support to specific RF-front-end and baseband interference detection schemes, and, taking into consideration the capabilities and resources of the terminal(s) in question, will weight the available interference avoidance schemes and select an approach which may be optimal. This decision can then be propagated within the network for all devices. This approach is scalable to device capabilities and extendable to future interference detection techniques.

The reader will appreciate that the foregoing is but one specific embodiment of the invention, and other embodiments will also fall within the scope of the invention, which is to be governed by the following claims interpreted in the light of, but not limited by, the description.

CLAIMS:

1. A wireless transceiver operable to communicate in an ultra wide band spectrum, the transceiver comprising communications activity collection means for collecting information relating to communications activity in said spectrum, interference avoidance means operable on the basis of said collected information to identify narrowband regions of said spectrum not for use by said device, and communications control means operable to avoid communication in an identified narrowband region of said spectrum.

2. A wireless transceiver in accordance with claim 1 wherein said communications activity collection means is operable to receive information from further wireless transmitting devices, said information identifying a narrowband region to be avoided.

3. A wireless transceiver in accordance with claim 1 or claim 2 and further comprising interference avoidance information transmission means operable to send, to a neighbouring device, information identifying a narrowband region to be avoided.

4. A wireless transceiver in accordance with claim 3 wherein said interference avoidance information transmission means is operable to send said information in an identified narrowband region.

5. A wireless transceiver in accordance with any one of the preceding claims and further comprising self checking means operable to determine whether to employ said communications activity collection means on the basis of a plurality of criteria.

6. A wireless transceiver in accordance with claim 5 wherein said criteria include one or more of transceiver battery life, transceiver computational demand, available time for scanning the spectrum for activity, the availability of interference information, memory capacity and quality of service requirement.

7. A wireless transceiver in accordance with claim 6 wherein said self checking means is operable to determine a weighted sum of said employed criteria, to determine if said communications activity collection means is to be employed.

8. A method of determining interference avoidance information for use in a wireless transceiver operable to communicate in an ultra wide band spectrum, the method comprising collecting information relating to communications activity in said spectrum, identifying on the basis of said collected information narrowband regions of said spectrum not for use by said device, and avoiding communications communication in an identified narrowband region of said spectrum.

9. A method in accordance with claim 8 wherein said collecting of information relating to communications activity includes receiving information from further wireless transmitting devices, said information identifying a narrowband region to be avoided.

10. A method in accordance with claim 8 or claim 9 and further comprising sending, to a neighbouring device, information identifying a narrowband region to be avoided.

11. A method in accordance with claim 10 wherein said sending includes sending said information in an identified narrowband region.

12. A method in accordance with any one of claims 8 to 11 and further comprising determining whether to perform said collecting on the basis of a plurality of criteria.

13. A method in accordance with claim 12 wherein said criteria include one or more of transceiver battery life, transceiver computational demand, available time for scanning the spectrum for activity, the availability of interference information, memory capacity and quality of service requirement.

14. A method in accordance with claim 13 including determining a weighted sum of said employed criteria, to determine if said collecting is to be performed.

15. A computer program product comprising executable program steps operable to cause a computer to perform a method in accordance with any one of claims 8 to 14.

16. A computer readable carrier medium carrying executable program steps operable to cause a computer to perform a method in accordance with any one of claims 8 to 14.

17. A computer readable storage medium storing executable program steps operable to cause a computer to perform a method in accordance with any one of claims 8 to 14.

18. A computer receivable signal carrying information defining executable program steps operable to cause a computer to perform a method in accordance with any one of claims 8 to 14.

Intellectual Property Office

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Application No: GB0715570.8 **Examiner:** Mr Richard Howe

Claims searched: 1-14 **Date of search:** 18 November 2007

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A,E	1,8	GB2436911 A Toshiba - see abstract
A	1,8	US2004/0223535 A1 You et al - see whole document
A	1,8	US2004/0171957 A1 Farserotu et al - see whole document

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

H4L; H4P

Worldwide search of patent documents classified in the following areas of the IPC

H04B; H04L

The following online and other databases have been used in the preparation of this search report

Online : wpi ; epodoc

International Classification:

Subclass	Subgroup	Valid From
H04L	0025/03	01/01/2006
H04B	0001/10	01/01/2006
H04B	0001/12	01/01/2006