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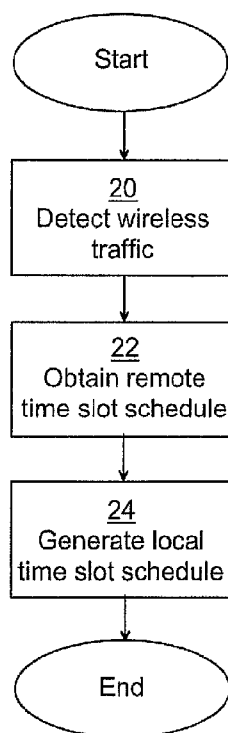
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(54) Title: A WIRELESS NETWORK MANAGER, METHOD AND SYSTEM FOR REDUCING INTERFERENCE BETWEEN WIRELESS NETWORKS



(57) Abstract: It is presented a method for reducing interference between wireless networks for industrial devices. The method comprises the steps of : detecting, in a local wireless network manager, wireless traffic between a wireless device and a remote wireless network manager; obtaining a remote time slot schedule of the remote wireless network manager; and generating, based on the remote time slot schedule, a local time slot schedule for the local wireless network manager, the local time slot schedule comprising time slot assignments at least partly avoiding time slots in use by the remote wireless network. A corresponding wireless network manager, wireless system and computer program product are also presented.

Fig. 3



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A WIRELESS NETWORK MANAGER, METHOD AND SYSTEM**TECHNICAL FIELD**

The present invention relates generally to wireless network managers, and more particularly to reducing a
5 risk of interference between wireless networks.

BACKGROUND

Wireless sensor networks are becoming more and more common in industrial plants. This naturally gives the advantage of communication from and/or to sensors, or
10 other device, without the need for wires. Consequently, the networks are easier to deploy, maintain and eventually, de-commission.

However, when multiple wireless networks are used, interference between networks may cause problems. This
15 interference may result in packets not being received properly, which may require re-transmission of any packets which have been subject to interference. This will delay the communication and will also use more energy, which is particularly problematic when the
20 sensors are battery powered, which is frequently the case with industrial wireless sensor networks.

The United States patent application with publication number US2006/0094371 describes automatic channel selection in a wireless access point. An automatic
25 channel selection (ACS) process enables an access point to determine a best channel available, i.e., the channel with a least amount of interference, for its operation. When ACS is enabled, the access point scans frequencies for all neighboring access points and their signal
30 strengths. Based on this data, the access point then

determines which frequency is least likely to be interfered with by these other access points. The access point switches itself to this frequency and begins operation. This rudimentary approach may work in
5 situation where only the aspect of frequency is used to separate channels. However, the automatic channel selection described can not be used for situations where the same frequency is used across several access points.

SUMMARY OF THE INVENTION

10 An object of the present invention is to reduce interference between wireless networks for industrial devices.

In a first aspect of the invention, it is presented a method for reducing interference between wireless
15 networks for industrial devices. The method comprises the steps of: detecting, in a local wireless network manager, wireless traffic between a wireless device and a remote wireless network manager; obtaining a remote time slot schedule of the remote wireless network manager; and
20 generating, based on the remote time slot schedule, a local time slot schedule for the local wireless network manager, the local time slot schedule comprising time slot assignments at least partly avoiding time slots in use by a remote wireless network associated with the
25 remote wireless network manager.

By avoiding the time slots in use by the remote wireless network when generating the local time slot schedule, the risk of interference is reduced.

It is to be noted that the terms local and remote are
30 only in relation to what wireless network manager is to

be generated a new time slot schedule for. In other words, the local wireless network manager is called so because it is the wireless network manager in question for which a time slot schedule is generated. Analogously,
5 the remote wireless network manager is only called so because it is not the local wireless network manager, and in relation to the local wireless network manager it is remote since it is not in the exact same location.

In the step of generating, optionally, only time slots of
10 wireless devices within range of the local wireless network manager are considered when avoiding time slots in use by the remote wireless network.

In other words, other time slots, used by devices not within the range of the local wireless network manager,
15 can be used by the local wireless network manager. By re-using these time slots, the overall system capacity is increased.

Optionally, the method is performed only in conjunction with deployment of the local wireless network manager. In
20 cases where the time slot schedules are fixed over time, it is only necessary to perform the method during deployment.

The step of obtaining may include obtaining the remote time slot schedule from the remote network manager. By
25 obtaining the remote time slot schedule directly from the remote wireless network manager, no central repository is required.

The step of obtaining may include obtaining the remote time slot schedule from a central multi-network manager.
30 Using a central multi-network manager as a central

repository for time slot schedules, any time slot schedule can be obtained even if, for example, the remote wireless network manager in question temporarily is non-operational.

- 5 A second aspect of the invention is a wireless network manager, being a local wireless network manager, arranged to reduce interference between wireless networks for industrial devices. The local wireless network manager comprises: means for detecting wireless traffic between a
10 wireless device and a remote wireless network manager; means for obtaining a remote time slot schedule of the remote wireless network manager; and means for generating, based on the remote time slot schedule, a local time slot schedule for the local wireless network
15 manager, the local time slot schedule comprising time slot assignments at least partly avoiding time slots in use by a remote wireless network associated with the remote wireless network manager.

The wireless network manager may be arranged to consider
20 only time slots of wireless devices within range of the local wireless network manager when avoiding time slots in use by the remote wireless network.

The wireless network manager may be arranged to obtain the remote time slot schedule from the remote network
25 manager.

The wireless network manager may be arranged to obtain the remote time slot schedule from a central multi-network manager.

The local network manager may be arranged to, on request,
30 provide information regarding its time slot schedule.

A third aspect of the invention is a wireless system comprising at least two wireless network managers according to the second aspect.

Each of the at least two wireless network managers may
5 operate as either a local wireless network manager or a remote wireless network manager.

The wireless system may further comprise a central multi-network manager arranged to provide time slot schedules.

A fourth aspect of the invention is a computer program
10 product loadable into the internal memory of a wireless network manager, arranged to perform the method according to the first aspect, when the product is executed in the wireless network manager.

It is to be noted that any feature of the first, second,
15 third, fourth and/or fifth aspects may, where appropriate, be applied to any other aspect.

Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise
20 herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method
25 disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

BRIEF DESCRIPTION OF DRAWINGS

The invention is now described, by way of example, with reference to the accompanying drawings, in which:

Fig 1a is a schematic diagram illustrating an environment where the present invention can be embodied,

Fig 1b is a schematic diagram illustrating a system according to an alternative embodiment of the present
5 invention,

Fig 2a is a schematic diagram of a remote time slot schedule of the remote wireless network manager of Figs 1a-b,

Fig 2b is a schematic diagram of a local time slot
10 schedule of the local wireless network manager of Figs 1a-b, and

Fig 3 is a flow chart illustrating a method of obtaining a time slot schedule for a wireless network manager, such as the local wireless network manager of Figs 1a-b.

15 **DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS**

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown. This invention may, however, be embodied in many
20 different forms and should not be construed as limited to the embodiments set forth herein; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the
25 art. Like numbers refer to like elements throughout the description.

Fig 1a is a schematic diagram illustrating an environment where the present invention can be embodied.

In the situation, schematically depicted as a top view of network topology for the two networks 6 and 7, a first wireless network manager 1 is to be deployed, e.g. in an industrial setting. The first network manager will be
5 responsible for a first network 6, enabling communication for devices 5a-c of the first network. A second network manager 2 is already deployed and is in an operating state, responsible for network 7. There is a geographical overlap between the two networks 1 and 2, indicated by
10 the dashed area 10.

The wireless networks 6,7 are any wireless networks utilising Time Division Multiplex Access (TDMA) which is suitable for use in an industrial environment. For example, the wireless networks 6,7 can conform to
15 wireless sensor networks according to the IEEE 802.15.4 standard, such as WirelessHART or ISA100, or other standards such as Bluetooth®. It is to be noted that even if frequency hopping can be used in the network to reduce the risk of interference, in the embodiments shown
20 herein, the risk for interference is reduced even further.

The second network manager 2 enables communication for any of the devices 4a-4d within its network 7.

The first network 6 is herein also denoted the local
25 network 6, with the first wireless network manager 1 being denoted a local wireless network manager 1. Analogously, the second network 7 is herein denoted a remote network 7 with the second wireless network manager 2 being denoted a remote wireless network manager 2. It
30 is to be noted that the terms local and remote are only in relation to deploying the local wireless network

manager 1. In other words, the local wireless network manager 1 is called so because it is the wireless network manager in question which is being deployed. Analogously, the remote wireless network manager 2 is only called so because it is not the local wireless network manager 1 which is being deployed, and in relation to the local wireless network manager 1 it is indeed remote since it is in another location.

When the local wireless network manager 1 is to be deployed, there is potential interference in the overlapping area 10. As the skilled person will realise, this is a simplification of reality where there the ranges of the networks 6, 7 are not as definitively defined. Nevertheless, such a simplification makes the explanation of the embodiment clearer, and the loss of this detail does not matter in this context.

In this example, there are two devices 4a, 4b of the remote wireless network 7 in the overlapping area 10. Since these devices 4a-b are in range of the local wireless network manager 1, the local wireless network manager 1 can listen to any communication between the devices 4a, 4b and the remote wireless network manager 2. The local wireless network manager 1 can in this way obtain information about the remote network 7. In the case that the network is an IEEE 802.15.4 network, such as WirelessHART, the header of each data link layer (DLL) packet contains a network identifier. Hence, the local wireless network manager 1 can obtain the identity of the remote wireless network 7 by scanning for DLL packets. Moreover, addresses of the devices 4a, 4b are also obtainable by listening to the DLL packets. The addresses can be used to identify the devices 4a, 4b, e.g. to

identify time slots used by these devices 4a, 4b in the scenario described in conjunction with Figs 2a-b below.

Once the local wireless network manager 1 obtains the identity of the remote wireless network 7, it sends a message to the remote wireless network manager 2 to obtain a remote time slot schedule. The local wireless network manager 1 and the remote wireless network manager 2 are typically connected with a wire based connection 8, e.g. an Ethernet connection, a universal serial bus (USB), an RS232 serial connection, etc. However, any suitable wire based or wireless connection 8 can be used, including IEEE 802.11a/b/g/n, wireless USB, mobile phone based connection, etc. Optionally, the connection 8 is used to allow the devices 4a-f, 5a-c and/or the wireless network manager 1,2 to communicate with other entities, including, but not limited to desktop/laptop computers, servers, hand-held computers, and/or mobile phones, using e.g. local networks, wide area networks, and/or mobile networks. After receiving the request for the remote time slot schedule, the remote wireless network manager 2 sends its remote time slot schedule to the local wireless network manager 1 via the connection 8.

As is explained in more detail below, the local wireless network manager 1 then generates a local time slot schedule which, to the extent that it is possible, avoids using time slots of the remote time slot schedule which can interfere, at least in the overlapping area 10.

Fig 1b is a schematic diagram illustrating a system according to an alternative embodiment of the present invention. The main difference in this embodiment is that a central multi-network manager 9 is connected to the

connection 8, allowing the multi-network manager 9 to communicate with the local wireless network manager 1 and the remote wireless network manager 2. This multi-network manager 9 is responsible for storing all time slot
5 schedules within its area of responsibility. The multi-network manager 9 can for example be a desktop computer, a server, or a custom made product. The only requirements on the multi-network manager 9 for this purpose is that it is connected to the connection 8 and that it can
10 provide time slot schedules when requested.

The multi-network manager 9 can for example be responsible for the time slot schedules of wireless network managers of a building or a plurality of buildings within a plant or factory. Hence, after the
15 local wireless network manager 1 has obtained the identity of the remote wireless network 7, the local wireless network manager 1 obtains, upon request, the remote time slot schedule from the multi-network manager 9. Optionally, all time slot schedules available to the
20 multi-network manager are provided to the requesting party, whereby the requesting party can discard superfluous time schedules and only use the time schedule(s) of interest.

Furthermore, after generation of the local time slot
25 schedule, the local time slot schedule is communicated to the multi-network manager 9. This communication of the local time slot schedule can either be push based, whereby the local wireless network manager 1 initiates the communication upon generation of the local time slot
30 schedule, or the communication can be pull based, whereby the multi-network manager 9 asks the local wireless

network manager 1 for the local time slot schedule. All other elements of Fig 1b correspond to those of Fig 1a.

Fig 2a is a schematic diagram of a remote time slot schedule 11 of the remote wireless network manager 2 of
5 Figs 1a-b.

As is known in the art per se, a time slot schedule can be used when Time Division Multiple Access (TDMA) is at least part of the solution for multiplexing a plurality of channels. TDMA allows a band of a particular frequency
10 range to be divided into channels by assigning time slots for each such channel. In this example, the remote time slot schedule 11, corresponding to one frame, is divided into sixteen time slots s0-s15. Four slots s2, s6, s7, s9 have been assigned in this particular case, allowing
15 separate channels for each of the devices 4a-d of the remote wireless network of Figs 1a-b.

Fig 2b is a schematic diagram of a local time slot schedule of the local wireless network manager 2 of Figs 1a-b. This local time slot schedule 14 is generated using
20 the remote time slot schedule 11 as an input. Hence time slots s2, s6, s7, s9 can be avoided to reduce the risk for interference. In this example, the local time slot schedule 14 assigns slots s4, s13 and s14 for the devices 5a-c of the local network 6.

25 Optionally, during the generation it is attempted to avoid to assign local time slots directly adjacent to assigned time slots of the remote time slot schedule 11. Hence, in this case, time slots s1-s3 and s5-s10 are avoided. This can reduce the interference, particularly
30 if the local wireless network manager 1 and the remote

wireless network manager 2 are not synchronised. A guard time slot is thus provided between the two networks 6, 7, reducing the risk for interference even further.

Furthermore, optionally only the time slots of the remote
5 time slot schedule 11 corresponding to the devices 4a-b
of the overlapping area 10 are avoided. So for example,
if the device 4a is assigned time slot s2 and the device
4b is assigned time slot s6, only time slots s2 and s6
(or if guard time slots are used, s1-s3 and s5-s7) are
10 avoided. This allows for more efficient use of the
available wireless resources. Since, for example,
communication between the remote wireless network manager
2 and the device 4d will not interfere with the local
network 6, the time slot associated with this
15 communication can be re-used.

It is to be noted that the number of time slots, sixteen
in this case, is just an example. The present invention
can be embodied where any number of suitable time slots
are used.

20 Fig 3 is a flow chart illustrating a method of obtaining
a time slot schedule for a wireless network manager, such
as the local wireless network manager 1 of Figs 1a-b.

In a detect wireless traffic step 20, the local wireless
network manager 1 detects wireless traffic between
25 devices and one or more remote wireless network managers
2. For example, in Fig 1a-b, the local wireless network
manager 1 detects packets sent from the devices 4a-b to
the remote wireless network manager 2. This can be done
since the devices 4a-b are within the network range 6 of
30 the local wireless network manager 1. As explained above,

from the detected packets, a number of data items can be extracted. Specifically, an identifier of the remote network 7 and/or the remote wireless network manager 2 is extracted. Moreover, addresses and/or other identifiers
5 of the devices 4a-b can be extracted. Other useful data may also be extracted from the detected packets.

In an obtain remote time slot schedule step 22, the time slot schedule 11 (Fig 2a) of the remote wireless network manager 2 is obtained. This can either be obtained
10 directly from the remote wireless network manager 2, as illustrated in Fig 1a, or via a central multi-network manager 9 as illustrated in Fig 1b.

In a generate local time slot schedule step 24, the local time slot schedule 14 (Fig 2b) is generated in the local
15 wireless network manager 1. The principle is to avoid any time slots which may interfere with the network being deployed, as described in more detail in conjunction with Fig 2b above.

Once the local time slot schedule 14 is generated, it is
20 used when the network 6 is activated for the local wireless network manager 1.

The method just described can be implemented as embodied in computer code, to be loaded in internal memory of the local wireless network manager 1, to be executed in a
25 controller in the local wireless network manager 1.

Although the invention has herein been described in a context of two networks, it is to be noted that the invention can be used in any number of networks, as long as there are at least two networks. The local wireless
30 network manager 1 would then perform in the way described

above in relation to the remote wireless network manager 2, only repeated for each remote wireless network manager which comprises any devices within the coverage of the local network 6.

- 5 The invention has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by
- 10 the appended patent claims.

CLAIMS

1. A method for reducing interference between wireless networks for industrial devices, comprising the steps of:
detecting (20), in a local wireless network manager
5 (1), wireless traffic between a wireless device (4a,4b) and a remote wireless network manager (2);
obtaining (22) a remote time slot schedule (11) of said remote wireless network manager (2); and
generating (24), based on said remote time slot
10 schedule (11), a local time slot schedule (14) for said local wireless network manager (1), said local time slot schedule (14) comprising time slot assignments at least partly avoiding time slots in use by a remote wireless network associated with said remote wireless network
15 manager (2).
2. The method according to any claim 1, wherein in said step of generating, only time slots of wireless devices (4a,4b) within range of said local wireless network manager (1) are considered when avoiding time slots in
20 use by said remote wireless network.
3. The method according to claim 1 or 2, wherein said method is only performed in conjunction with deployment of said local wireless network manager (1).
4. The method according to any one of the preceding
25 claims, wherein said step of obtaining includes obtaining said remote time slot schedule (11) from said remote network manager.
5. The method according to any one of claims 1 to 3, wherein said step of obtaining includes obtaining said

remote time slot schedule (11) from a central multi-network manager.

6. A wireless network manager, being a local wireless network manager (1), arranged to reduce interference
5 between wireless networks for industrial devices, said local wireless network manager (1) comprising:

means for detecting wireless traffic between a wireless device (4a,4b) and a remote wireless network manager (2);

10 means for obtaining a remote time slot schedule (11) of said remote wireless network manager (2); and

means for generating, based on said remote time slot schedule (11), a local time slot schedule (14) for said local wireless network manager (1), said local time slot
15 schedule (14) comprising time slot assignments at least partly avoiding time slots in use by a remote wireless network associated with said remote wireless network manager (2).

7. The wireless network manager according to claim 6,
20 arranged to consider only time slots of wireless devices (4a,4b) within range of said local wireless network manager (1) when avoiding time slots in use by said remote wireless network.

8. The wireless network manager according to claim 6 or
25 7, arranged to obtain said remote time slot schedule (11) from said remote network manager.

9. The wireless network manager according to claim 6 or 7, arranged to obtain said remote time slot schedule (11) from a central multi-network manager.

10. The wireless network manager according to any one of claims 6 to 10, wherein said local network manager is arranged to, on request, provide information regarding its time slot schedule.

5 11. A wireless system comprising at least two wireless network managers according to claims 6 to 10.

12. The wireless system according to claim 11, wherein each of said at least two wireless network managers can operate as either a local wireless network manager (1) or
10 a remote wireless network manager (2).

13. The wireless system according to claim 11 or 12, further comprising a central multi-network manager arranged to provide time slot schedules.

14. A computer program product loadable into the internal
15 memory of a wireless network manager, arranged to perform the method according to any one of claims 1 to 5, when said product is executed in said wireless network manager.

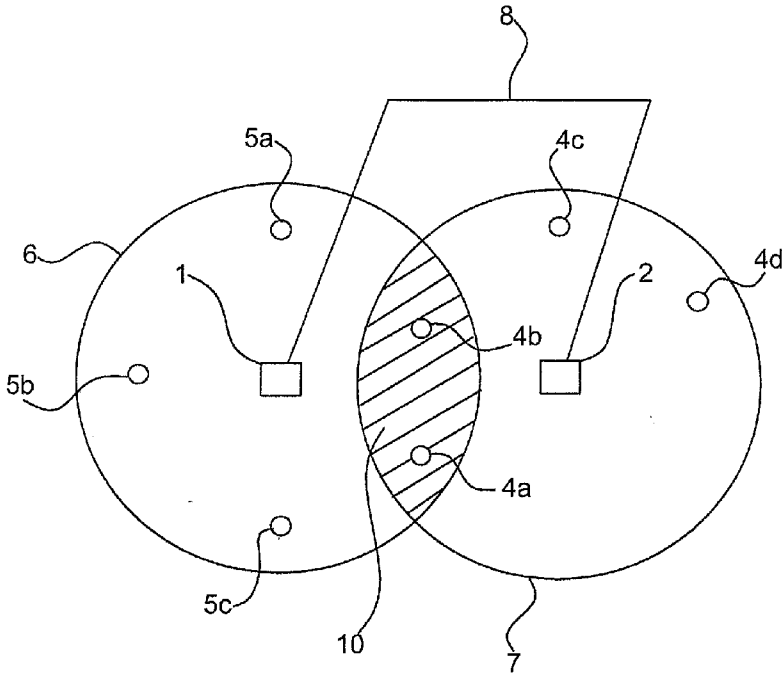


Fig. 1a

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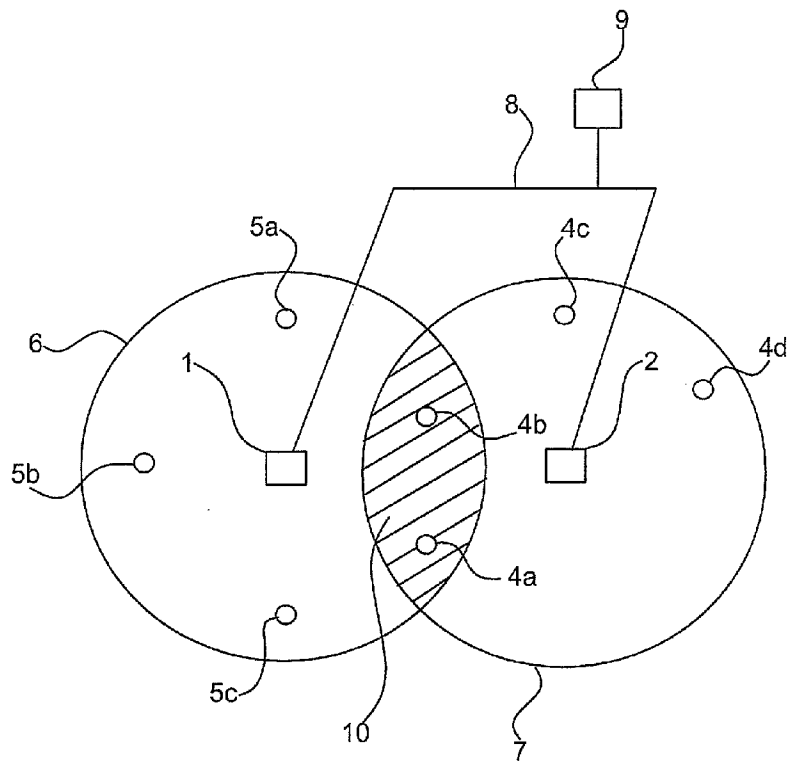


Fig. 1b

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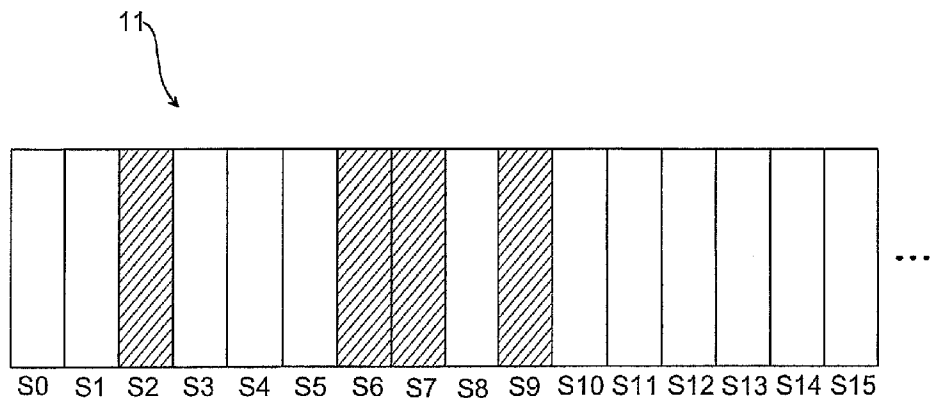


Fig. 2a

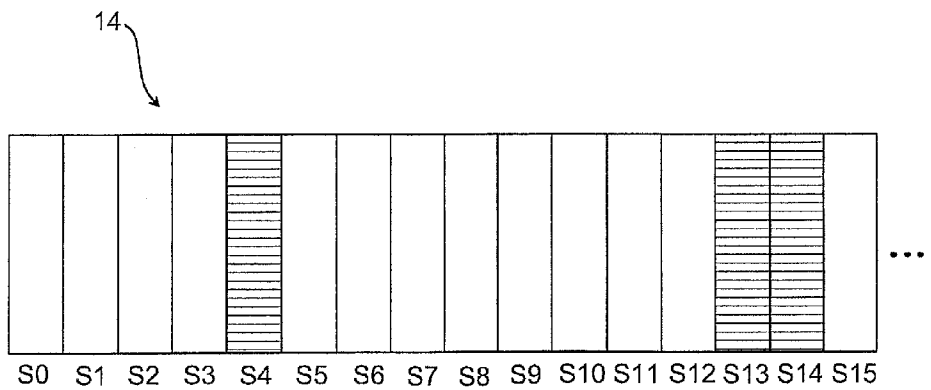


Fig. 2b

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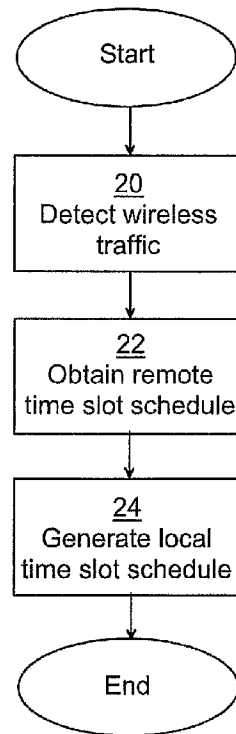


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W16/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/031960 A (KONINKL PHILIPS ELECTRONICS NV [NL]; CORDEIRO CARLOS [US]; CHALLAPALI) 22 March 2007 (2007-03-22) abstract page 3, line 29 - page 5, line 29 page 7, line 1 - line 19 page 8, line 5 - page 9, line 22 page 11, line 10 - page 12, line 30 page 14, line 7 - page 15, line 32 figures 1,2 ----- -/--	1-14



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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