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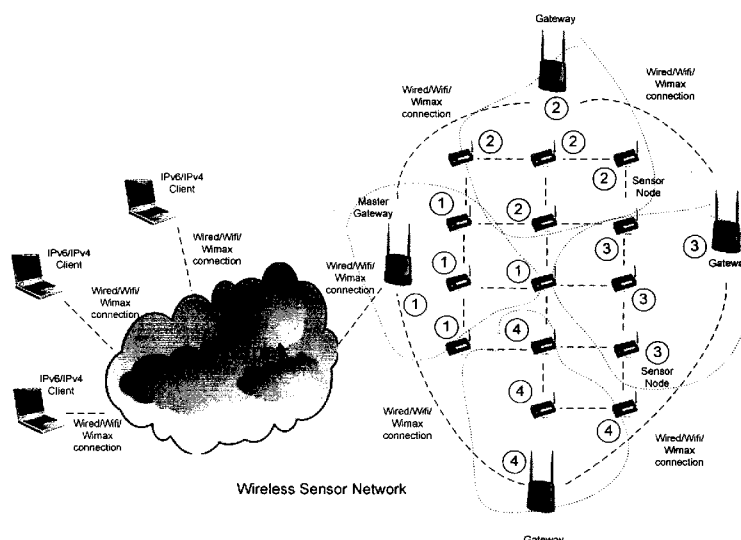
- as to the identity of the inventor (Rule 4.17(i))
- of inventorship (Rule 4.17(iv))

[Continued on next page]

(54) Title: METHOD OF COMMUNICATION IN WIRELESS SENSOR NETWORKS

FIGURE 1

100



(57) Abstract: A method of communication in wireless sensor networks comprising enabling usage of multi gateway in a wireless sensor network, assigning a gateway as master gateway, enabling sensor nodes to choose gateway, creating members list by the gateway and receiving request message from IP network client by the master gateway.



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METHOD OF COMMUNICATION IN WIRELESS SENSOR NETWORKS

TECHNICAL FIELD

The present invention relates to a method of communication in wireless sensor
5 networks and more particularly to a multi gateway communication in wireless
sensor networks.

BACKGROUND ART

In wireless sensor networks, the sensor nodes discover the gateway and then
10 get bound to it so they can send their data periodically to the gateway. The
existence of only one gateway would lead the entire sensor nodes to send their
data to the gateway and so the traffic for the nodes near the gateway will be high.
When the traffic goes higher, it will lead to higher message collision in the
network, higher retransmissions and then higher power consumption. Also in
15 networks such as 6LoWPAN where the sensor nodes will receive requests from
out of the network, the traffic would be higher.

Wireless sensor networks use multi-hopping to pass the messages which means
when a gateway wants to send a request to the sensor node, the entire nodes in
20 the way have to receive and pass the message to the next hop until the message
reaches the destination node. The further the destination node, more sensor
nodes will be involved in passing the message. In mesh networks where the
sensor nodes communicate with each other, the traffic can go higher as well

which will lead to more power consumptions of the sensor nodes and reduction of the life time of the sensor network.

Wireless sensor networks normally has a single gateway which the sensor node
5 would conduct gateway discovery and thereafter periodically will send their data to the gateway. The nodes have to do multi hopping in order to send their message to the gateway and the intermediate nodes in the path for multi hopping will consume power to receive and forward the message to the next node. The nodes which are closer to the gateway will consume more power since the most
10 of the messages have to be forwarded through them to the gateways and so they will die faster. If the nodes near the gateway die, then the messages will not be forwarded to the gateway and so the network will go down.

Since the traffic for the sensor nodes near the gateway is higher, the message
15 collision will also be higher. Higher message collision will lead to retransmitting the messages which will result in higher power consumption. In the case the gateway fails to work properly then the sensor nodes will not have any other gateway to pass the data to it and so the network will be down until the gateway is up.

20

The mentioned issues will be more important in medium and big wireless sensor networks. In small scale wireless sensor networks one gateway would be enough to cover the network. Since the numbers of hops to pass a message are not high

and the message collision is not high, the existence of one gateway will be enough. But in a medium or high scale wireless sensor networks the number of hops to pass the message are higher and also the message collision is more which is also increases the delay in passing the message to the gateway.

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There are several disadvantages of having one gateway in high traffic sensor networks such as mesh networks or 6LoWPAN wherein, the intermediate sensor nodes which have to relay the message will be using power so the sensor nodes closer to the gateway would be consuming more power and will die faster as compared to the sensor nodes further from the gateway, the traffic for the sensor nodes near the gateway will be very high which will lead to higher message collisions and if the gateway dies and the sensor nodes will not have any gateway to send their data to it.

15 US 20090146833 disclosed a coordinator, a gateway and a transmission method for applying IPv6 in a wireless sensor network (WSN). Dual addressing of a local address using a short address used in the WSN and a global unicast address using an extended unique identifier (EUI) of a node makes it possible to support mobility of the WSN and communicate data with an external network. This patent
20 differs from the present invention wherein the present invention uses multi gateways rather than a single gateway. The present invention also applicable to both IPv6 and IPv4 and the sensor node will choose the most suitable gateway in the network.

In another example of a patent publication, US 20080056261 disclose a zigbee/IP gateway which enables communications. The gateway includes a first interface device for connecting to the personal area network, a second interface
5 device for connecting to the IP network and a gateway controller. As compared to the present invention, the present invention uses multi gateways for communication to avoid from data traffic. The present invention proposed a solution towards data traffic due to the communication by a single gateway.

10 Therefore, there exists a need for multi gateways communication in a wireless sensor network that will reduce the traffic on the sensor nodes and capable of distributing the traffic in the network efficiently.

DISCLOSURE OF THE INVENTION

15 The present invention aims to provide a method to reduce traffic in wireless sensor network and more particularly to multi gateways in a wireless sensor network.

20 In a preferred embodiment of the present invention, a method of communication in wireless sensor networks comprising enabling usage of multi gateways in a wireless sensor network, assigning a gateway as master gateway, enabling

sensor nodes to choose gateway, creating members list by the gateways and receiving request message from IP network client by the master gateway;

In another preferred embodiment of the present invention, assigning a gateway
5 as a master gateway includes determining which gateway is connected to the IP network and assigning that gateway as the master gateway.

In another preferred embodiment of the present invention, enabling the sensor
10 nodes to choose their main gateway includes sending gateway discovery message by the sensor nodes.

In another preferred embodiment of the present invention, enabling sensor nodes to choose gateway includes sending gateway advertisement message by a
15 gateway.

In another preferred embodiment of the present invention, the sensor node will determine number of hops relative to the gateway.

20 In another preferred embodiment of the present invention, the sensor node will determine signal strength from the last hop sending the gateway advertisement.

In another preferred embodiment of the present invention, the sensor node will further save the address of the gateway sending the gateway advertisement
25 message, the hop number and signal strength value.

In another preferred embodiment of the present invention, the sensor node further compares the number of hops among the discovered gateways.

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In another preferred embodiment of the present invention, if the number of hops from the gateways for two or more gateways are the same, the sensor node will choose the gateway in which the first device on path to the gateway has the best signal strength.

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In another preferred embodiment of the present invention, if the signal strength of two or more devices on the path to the gateway are the same, the sensor node will choose the first gateway in the list.

15 In another preferred embodiment of the present invention, the sensor nodes send selection message to the main gateway to inform the gateway that the gateway is selected as the main gateway.

In another preferred embodiment of the present invention, creating members list
20 by the gateway includes adding sensor nodes address to members list by the gateway.

In another preferred embodiment of the present invention, receiving request
message from IP network client by the master gateway and determining whether
25 the address of the destination node is in its members list.

The present invention consists of features and a combination of parts hereinafter fully described and illustrated in the accompanying drawings, it being understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

10 BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

To further clarify various aspects of some embodiments of the present invention, a more particular description of the invention will be rendered by references to specific embodiments thereof, which are illustrated, in the appended drawings. It is appreciated that these drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. The invention will be described and explained with additional specificity and detail through the accompanying drawings in which:

20 FIG.1 illustrates multi gateways in wireless sensor networks (100)

FIG.2 illustrates algorithm for multi gateway in wireless sensor networks (200)

FIG.3 illustrates sensor nodes selecting their main gateway (300)

DETAILED DESCRIPTION OF THE ACCOMPANYING DRAWINGS

5 According to FIG.1, multi gateways are introduced in this wireless sensor network and one of the multi gateways will be a master gateway (10). The master gateway (10) will be connected to the IP network (15) to receive the requests from clients (16) through IP network (15) and also to send data to the other clients (16). The gateways (11, 12, 13) will all be connected to the master
10 gateway (10) and so they will collect the data from the sensor nodes (14) and then directly or through the other gateways (11, 12, 13) they will pass it to the master gateway (10).

Now referring to FIG.2, at initial stage when the network starts working, the
15 sensor nodes will be broadcasting router discovery messages (110) to discover the gateways around them. The gateways will be broadcasting gateway advertisement messages (111) so the sensor nodes can discover the gateways. When the gateway receives a gateway discovery message (112) it will reply back with a gateway advertisement message. When a sensor node sends a gateway
20 discovery message, if it does not receive a gateway advertisement message it will wait for an interval (115). When the sensor node receives a gateway advertisement message it will first verify the number of hops (113) from the gateway to the sensor node, and also will determine the RSSI from the last hop

(114) that passed the gateway advertisement message to the sensor node. Each sensor node that receives a gateway advertisement message and before it passes the message, it will increase by one the number of hop in the message, so each node can determine the number of hops between itself and the gateway
5 by checking the hop numeric value in the message.

When the sensor node has collected and saved the hop numbers and the RSSI information (116), it will choose the gateway that has the least number of hops by comparing the number of hops among the discovered gateways (117). If two
10 gateways had the same hop number away from the sensor node (118), (119) the sensor node will chose the gateway in which the first device on the path to the gateway has the best signal strength (120). When the sensor node selects its main gateway (121) it will send a gateway selection message to that gateway to inform the gateway that it has been selected as the main gateway for that sensor
15 node.

The sensor node will choose the main gateway (121) and will also save the address of the other gateways in the network (123) and their hop numbers and RSSI value. In case the main gateway for the sensor node dies or does not
20 respond the sensor node will choose the second best gateway as its main gateway and will send its periodic data to its new main gateway. The method will proceed (125) to the next task once a full cycle completed.

Referring to FIG. 3, when node number 4 wants to discover its main gateway, if there are no multiple gateways, it must select a gateway A as its main gateway and any message that the sensor node wants to send must pass multi hops to reach the gateway. But as shown, node number 4 receives gateway advertisement message from gateway D through node number 5, and also it will receive gateway advertisement message from gateway C through nodes number 1 and 3. Since gateway D is one hop away compare to gateway C which is 2 hops away, node 4 will choose gateway D as its main gateway and then will send a gateway selection message to gateway D and gateway D will save node 4 addresses in its members list.

After the sensor node have discovered the gateways in the network and selected their main gateway, and the gateways added the nodes to their member list, the network will start its main task. In a sensor network, especially sensor networks like 6LoWPAN which have IP network clients; there are two kinds of message transaction. Either the sensor nodes read the sensors periodically and then send the data to the gateway or the IP network clients send a request to the sensor nodes which the sensor nodes have to reply it back.

The sensor nodes read their sensors periodically depending on the application and then each sensor will send the data to its main gateway. When the gateway receives the data, it will reply back with an acknowledge message to the sensor node. If the sensor does not receive an acknowledge message, it will resend the

data to its main gateway. After K times retry (depending on the application), if the sensor node does not receive an acknowledge message, it will consider that its main gateway is dead. Then the sensor node will choose its second best gateway in its list as its main gateway and will send a gateway selection
5 message to that gateway, and so it will send the data to the gateway and awaits for an acknowledge message.

Network like 6LoWPAN have IP network clients which will send request messages to the sensor nodes. When the master gateway receives a request
10 message, it will first verify the destination address of the request message. If the destination address of the request message is in the members list of the master gateway, the master gateway will send the request message to the destined sensor node. If the destination address is not in the members list, the master gateway will send the request message to all the gateways in the network. The
15 receiving gateways will receive and also pass the request message to the other gateways in the network which are not in direct connection with the master gateway. All the gateways will check their members list and any of them that has the destination address of the request message in its members list will send the request message to the destined sensor node. This method will reduce the traffic
20 in the network and since the gateway that has the destination address in its members list is the closest gateway to that sensor node, it will take the least number of hops to pass the request message to the sensor node. The sensor node will receive the request message and reply back with the reply message.

The main gateway for that sensor node will receive the reply message and will send the reply message to the master gateway in the network and so the master gateway of the network will send the reply message to the IP network client.

- 5 If none of the gateways have the destined sensor node address in their member list, they will discard the request message. When the main gateway does not receive any reply message it will resend the request message for K times. After K times retrial if the main gateway does not receive any reply message, it will send a message to the IP network client that the sensor node does not exist.

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If a sensor node dies, its main gateway should delete it from its members list. A sensor node dying will also affect the routing path for the other sensor nodes in the network, because the neighbour nodes would not be able to send or receive any messages through said node. The nodes that their routing path gets affected

15 is because of a dying sensor node should choose the second best gateway as their main gateway.

- When a sensor node dies, it will not be able to reply to any request messages. So when its main gateway, which has the address of the dead sensor node in its
- 20 members list, sends a request message to that sensor node , it will not receive any reply. After K times retrial, it will not receive any reply message from the dead sensor node and so it will delete the address of that sensor node from its members list.

When a sensor node dies, it will also affect the routing path in the network. So when the other sensor nodes send their data messages, the message will not reach the gateway because the routing path which passes the dead sensor has been broken. So after K times retrial the sensor node will consider a new path which will not go through the dead sensor node or it will change its main gateway by selecting the second best gateway in its memory as the main gateway.

The breakdown of the sensor node will not lead to manipulation of the whole network and the gateways will delete that node from their members list to avoid sending redundant messages to the network. Also the other sensor nodes which their routing path has been affected will change their main gateway and will send a gateway selection message to their second best gateway and the gateways will update their members list.

In the foregoing specification, specific embodiments of the present invention have been described. However, one of ordinary skill in the art will appreciate that various modifications and changes can be made without departing from the scope of the present invention as set forth in the various embodiments discussed above and the claims that follow. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of present invention. The benefits, advantages, solutions to problems, and any element(s) that may

cause any benefit, advantage, or solution to occur or become more pronounced are not to be construed as a critical, required, or essential features or elements as described herein.

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CLAIMS

1. A method of communication in wireless sensor networks comprising
enabling usage of multi gateway in a wireless sensor network;
assigning a gateway as master gateway;
5 enabling sensor nodes to choose gateway;
creating members list by the gateway; and
receiving request message from IP network client by the master gateway;
2. The method according to claim 1 wherein assigning a gateway as the
10 master gateway includes selecting the gateway which is connected to the
IP network as the master gateway.
3. The method according to claim 1 wherein assigning a gateway as main
gateway includes sending gateway discovery message by sensor nodes
15 (110) and waits for interval (115).
4. The method according to claim 1 wherein enabling sensor nodes to
choose gateway includes sending gateway advertisement message by a
gateway (111).
- 20 5. The method according to claim 1 wherein the sensor node will determine
number of hops relative to the gateway (113).

6. The method according to claim 1 wherein the sensor node will determine signal strength from the last hop sending the gateway advertisement (114).
- 5 7. The method according to claim 1 wherein the sensor node will further save the address of the gateway sending the gateway advertisement message and the hop number (116) to determine signal strength value.
8. The method according to claim 1 wherein the sensor node further
10 compares the number of hops among the discovered gateways (117).
9. The method according to claim 1 the sensor node further selects the gateway as main gateway (121) when best signal strength is achieved.
- 15 10. The method according to claim 1 wherein the sensor nodes send selection message to the main gateway (122) to choose the gateway as the main gateway.
11. The method according to claim 1 wherein creating members list by the
20 gateway includes adding sensor nodes address to members list (123) by the gateway.
12. The method according to claim 1 wherein receiving request message from IP network client by the master gateway to determine whether the address
25 of the destined node is in its members list.

13. The method according to claim 1 wherein in case the main gateway for the sensor node dies or does not respond the sensor node will choose the second best gateway or at least another suitable gateway as its main gateway and will send its periodic data to its new main gateway.

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14. The method according to claim 1 wherein in the case of breakdown of the sensor node the gateways will delete that node from their members list to avoid sending redundant messages to the network.

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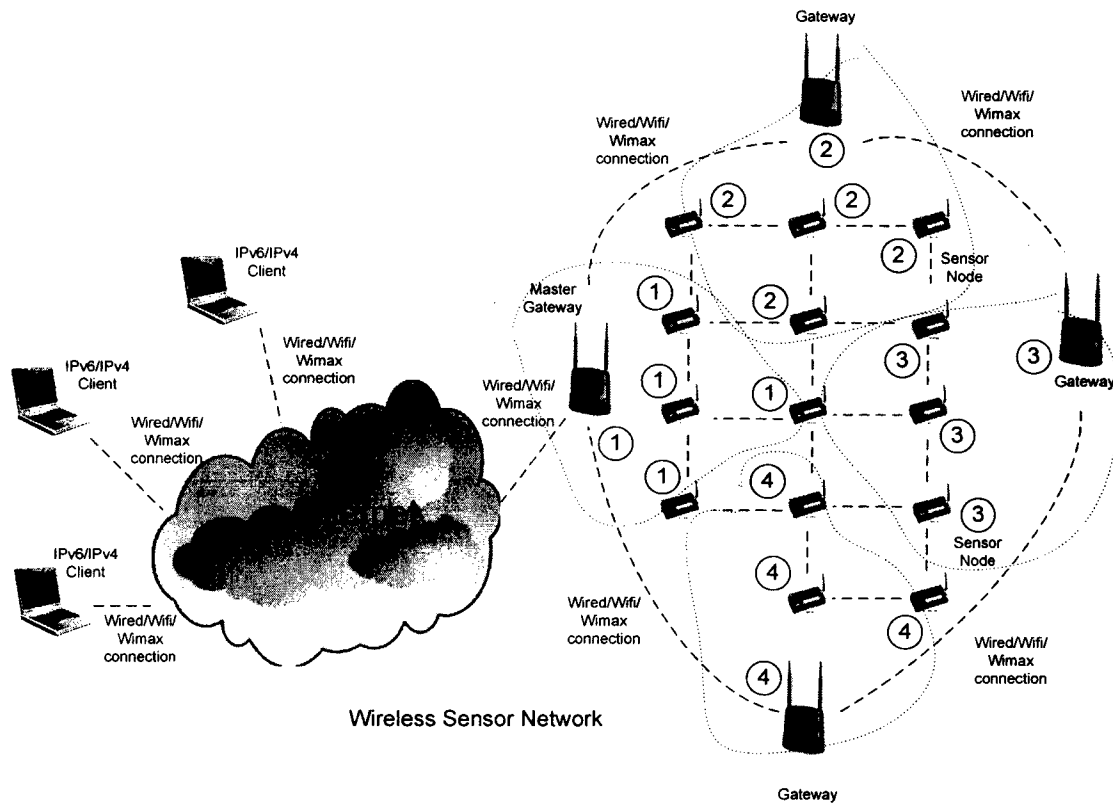


FIGURE 1

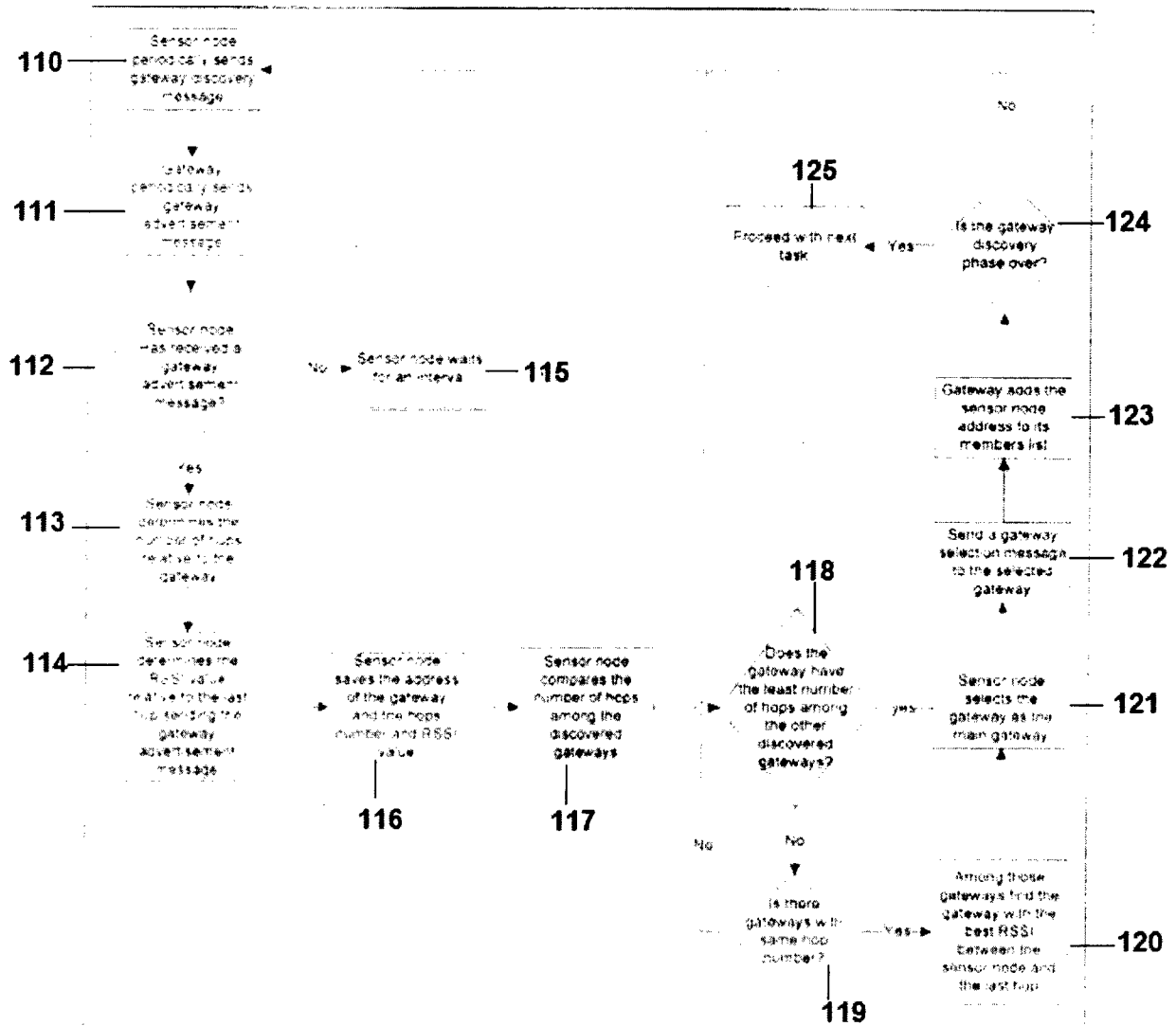
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FIGURE 2

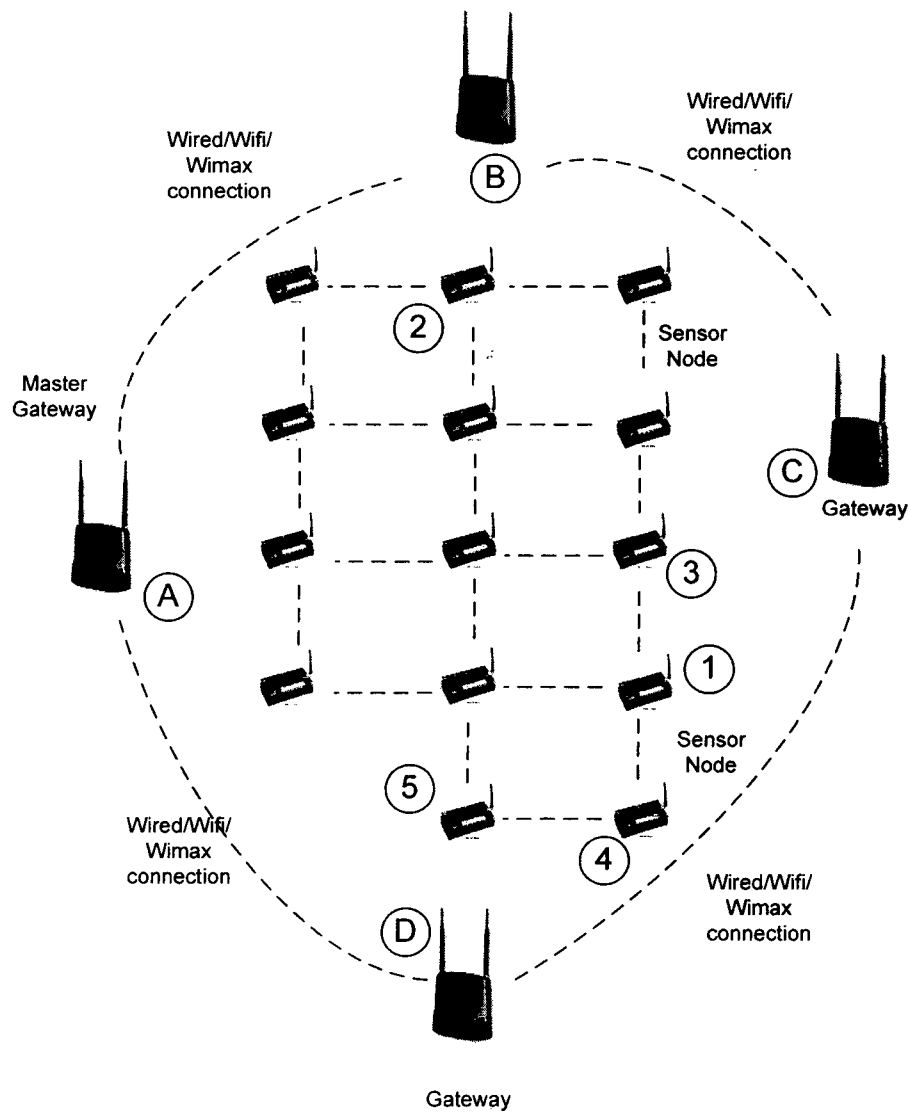


FIGURE 3

INTERNATIONAL SEARCH REPORT

International application No.

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A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl.

H04L 12/56 (2006.01)**H04B 1/00** (2006.01)**H04W 8/02** (2009.01)

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)

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 practicable, search terms used)

EPODOC & WPI: wireless sensor network, master gateway, IP network, message, create list, enable node and similar keywords**Google Patents & Google Scholar:** wireless sensor network, master gateway, IP network, message, create list, enable node and similar keywords

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	MALATRAS et al., "Web Enabled Wireless Sensor Networks for Facilities Management", IEEE Systems Journal, Vol. 2, No. 4, December 2008 Figs. 1, 4, 6, 8 – 10, 14; page 504, right hand column, lines 6 – 26; page 505, left hand column, lines 17 – 26; page 508, left hand column, line 7 – page 509, left hand column, line 15	1 – 14



Further documents are listed in the continuation of Box C



See patent family annex

* Special categories of cited documents:	
"A" document defining the general state of the art which is not considered to be of particular relevance	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"E" earlier application or patent but published on or after the international filing date	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"O" document referring to an oral disclosure, use, exhibition or other means	"&" document member of the same patent family
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