

CLAIMS

What is claimed is:

1. A method of operating a node, comprising:

timing a synchronization timeout period on a clock of the node, wherein a duration of the synchronization timeout period is set at least in part as a function of:

a number of beacon requests received over a period of time; and

a number of beacon requests sent over the period of time;

listening for a beacon during the synchronization timeout period, the listening including reception of radio frequency (RF) signals on a control channel defined in a mesh network;

sending a beacon request, upon a conclusion of the synchronization timeout period and when no beacon has been received, the sending including RF transmission on the control channel of a packet addressed to a parent of the node;

receiving a beacon from the parent, in response to the beacon request, the beacon providing a time indicator;

updating the clock of the node according to the time indicator;

restarting the synchronization timeout period; and

classifying the node as a leaf node when the node has not received a beacon request in a leaf-indicating period of time measured by the clock.

2. The method as recited in claim 1, additionally comprising:

receiving a beacon request from a second node;

configuring a second beacon with a second time indicator based on the clock of the node; and

sending the second beacon to the second node.

3. The method as recited in claim 1, wherein sending the beacon request comprises:
determining a node from which more beacons have been obtained; and
sending the beacon request to the determined node.
4. The method as recited in claim 1, wherein a duration of the synchronization timeout period of the node is adjusted based on a position of the node within the mesh network.
5. The method as recited in claim 1, wherein a duration of the synchronization timeout period of the node is based in part on randomization.
6. The method as recited in claim 1, wherein a duration of the synchronization timeout period of the node is adjusted based in part on a position of the node within the mesh network and based in part on randomization.
7. The method as recited in claim 1, additionally comprising: listening for beacon requests from children of the node during the leaf-indicating period of time.
8. The method as recited in claim 1, additionally comprising: listening for a beacon request during the leaf-indicating period of time, the listening including reception of RF signals on the control channel defined in the mesh network.
9. A node, comprising:
a processor;
a memory, in communication with the processor;
a clock, in communication with the processor;

a synchronization function, defined in the memory and executable by the processor, the synchronization function configured to measure a synchronization timeout period using the clock;

a beacon request function, defined in the memory and executable by the processor, the beacon request function configured to:

generate a beacon request in response to a conclusion of the synchronization timeout period without receipt of a beacon, wherein the clock is configured to be updated according to a time indicator in a beacon received in response to the beacon request; and

shorten the synchronization timeout period in response to a number of beacon requests received by the node being larger than a number of beacon requests being sent by the node in a same time period; or

lengthen the synchronization timeout period in response to a number of beacon requests received by the node being smaller than a number of beacon requests being sent by the node; and

a leaf-classification function, defined in the memory and executable by the processor, and configured for:

measuring a leaf-indicating period of time using the clock;

determining when a beacon request arrived at the node during the leaf-indicating period of time; and

classifying the node as a parent node or a leaf node based on the determination.

10. The node as recited in claim 9, wherein a duration of the synchronization timeout period of the node is based in part on randomization.

11. The node as recited in claim 9, additionally comprising:
- a radio, in communication with the processor and configured for:
 - sending beacon requests in response to the beacon request function;
 - receiving beacons in response to the beacon requests; and
 - performing a frequency hopping function.
12. A method of operating a node, comprising:
- timing a leaf-indicating period of time on a clock;
 - listening for a beacon request during the leaf-indicating period of time, the listening including reception of radio frequency (RF) signals on a control channel defined in a mesh network;
 - determining when a beacon request has been received from a child node of the node, during the leaf-indicating period of time;
 - classifying the node as a leaf node when the node has not received a beacon request within the leaf-indicating period of time; and
 - timing a synchronization timeout period on the clock, wherein a duration of the synchronization timeout period is set at least in part as a function of:
 - a number of beacon requests received over a period of time; and
 - a number of beacon requests sent over the period of time.
13. The method as recited in claim 12, additionally comprising:
- when a beacon is received prior to expiration of the synchronization timeout period then resetting the synchronization timeout period;
 - when a beacon is not received prior to expiration of the synchronization timeout period then:
 - sending a beacon request;

receiving a beacon in response to the beacon request; and
resetting the synchronization timeout period;
updating the clock according to a time indicator within the received beacon.

14. The method as recited in claim 12, additionally comprising:
receiving a second beacon request from a second node;
configuring a second beacon with a time indicator based on the clock; and
sending the second beacon to the second node.
15. The method as recited in claim 12, additionally comprising:
setting a duration of the synchronization timeout period of the node to be shorter than synchronization timeout periods of nodes that are further from the cellular router than the node.
16. The method as recited in claim 12, additionally comprising:
setting a duration of the synchronization timeout period of the node to be longer than synchronization timeout periods of nodes that are fewer hops from the cellular router than the node.
17. The method as recited in claim 12, additionally comprising:
setting a duration of the synchronization timeout period of the node based in part on a number of hops from the cellular router.
18. The method as recited in claim 12, wherein a duration of the synchronization timeout period of the node is adjusted to reduce network traffic.

What is claimed is:

1. A method of operating a node, comprising:
 - 5 timing a synchronization timeout period on a clock of the node;
 - listening for a beacon during the synchronization timeout period, the listening including reception of radio frequency (RF) signals on a control channel defined in a mesh network;
 - 10 sending a beacon request, upon a conclusion of the synchronization timeout period and if no beacon has been received, the sending including RF transmission on the control channel of a packet addressed to a parent of the node;
 - receiving a beacon from the parent, in response to the beacon request, the beacon providing a time indicator;
 - 15 updating the clock of the node according to the time indicator;
 - restarting the synchronization timeout period; and
 - classifying the node as a leaf node if the node has not received a beacon request in a leaf-indicating period of time measured by the clock.
- 20 2. The method as recited in claim 1, additionally comprising:
 - receiving a beacon request from a second node;
 - 25 configuring a second beacon with a second time indicator based on the clock of the node; and
 - sending the second beacon to the second node.

3. The method as recited in claim 1, wherein sending the beacon request comprises:

determining a node from which more beacons have been obtained; and
sending the beacon request to the determined node.

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4. The method as recited in claim 1, wherein a duration of the synchronization timeout period of the node is adjusted based on a position of the node within the mesh network.

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5. The method as recited in claim 1, wherein a duration of the synchronization timeout period of the node is based in part on randomization.

6. The method as recited in claim 1, wherein a duration of the synchronization timeout period is set in part as a function of:

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a number of beacon requests received over a period of time; and
a number of beacon requests sent over the period of time.

7. A node, comprising:

a processor;

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a memory, in communication with the processor;

a clock, in communication with the processor;

a synchronization function, defined in the memory and executable by the processor, the synchronization function configured to measure a synchronization timeout period using the clock;

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a beacon request function, defined in the memory and executable by the processor, the beacon request function configured to generate a beacon request

~~in response to a conclusion of the synchronization timeout period without receipt of a beacon;~~

~~a clock configured to be updated according to a time indicator in a beacon received in response to the beacon request; and~~

5 ~~a leaf-classification function, defined in the memory and executable by the processor, and configured for:~~

~~measuring a leaf-indicating period of time using the clock;~~

~~determining if a beacon request arrived at the node during the leaf-indicating period of time; and~~

10 ~~classifying the node as a parent node or a leaf node based on the determination.~~

8. The node as recited in claim 11, wherein a duration of the
15 synchronization timeout period of the node is based in part on randomization.

9. The node as recited in claim 11, additionally comprising:
a radio, in communication with the processor and configured for:

20 ~~sending beacon requests in response to the beacon request function;~~

~~receiving beacons in response to the beacon requests; and~~

~~performing a frequency hopping function.~~

10. The node as recited in claim 11, wherein the beacon request
25 function is additionally configured for:

~~setting the synchronization timeout period shorter in response to a~~
number of beacon requests received by the node being larger than a number of
beacon requests being sent by the node in a same time period; or

5 ~~setting the synchronization timeout period longer in response to a~~
number of beacon requests received by the node being smaller than a number
of beacon requests being sent by the node.

11. A method of operating a node, comprising:

timing a leaf-indicating period of time on a clock;

10 listening for a beacon request during the leaf-indicating period of time,
the listening including reception of radio frequency (RF) signals on a control
channel defined in a mesh network;

determining if a beacon request has been received from a child node of
the node, during the leaf-indicating period of time; and

15 classifying the node as a leaf node if the node has not received a beacon
request within the leaf-indicating period of time.

12. The method as recited in claim 11, additionally comprising:

timing a synchronization timeout period on the clock;

20 if a beacon is received prior to expiration of the synchronization timeout
period then resetting the synchronization timeout period;

if a beacon is not received prior to expiration of the synchronization
timeout period then:

 sending a beacon request;

25 receiving a beacon in response to the beacon request; and

 resetting the synchronization timeout period;

updating the clock according to a time indicator within the received
beacon.

13. The method as recited in claim 12, additionally comprising:
5 receiving a second beacon request from a second node;
configuring a second beacon with a time indicator based on the clock;
and
sending the second beacon to the second node.

10 14. The method as recited in claim 12, additionally comprising:
setting a duration of the synchronization timeout period of the node to
be longer than synchronization timeout periods of nodes fewer hops from the
cellular router or to be shorter than synchronization timeout periods of nodes
further from the cellular router.

15 15. The method as recited in claim 12, wherein a duration of the
synchronization timeout period of the node is adjusted to reduce network
traffic.