

CLAIMS

1. A method of creating a monitoring network, comprising:

associating a first master node (424, 426, 428) with a first set of packages (430), the first master node (424, 426, 428) comprising a first type of wireless communications interface (446) and a second type of wireless communications interface (452) with a longer communications range than the first type of wireless communications interface (446);

associating a first set of peripheral nodes (410, 414) with respective packages in the first set of packages (430), wherein the peripheral nodes (410, 414) comprise the first type of wireless communications interface (444) to communicate with the first type of wireless communications interface of the first master node (424, 426, 428), and the peripheral nodes (410, 414) comprise sensors operative to generate respective sets of sensor data by sensing local environmental conditions and storing the generated sensor data in the respective peripheral nodes;

responsive to one or more requests by the first master node (424, 426, 428), the peripheral nodes wirelessly transmit the respective sets of sensor data to the first master node (424, 426, 428); and

processing, by the first master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, wherein the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.

2. The method of claim 1, wherein the one or more summary statistics of the aggregated sensor data comprise one or more of: a respective number of data values in each set of sensor data, a histogram for each set of sensor data, high and low data values for each set of sensor data, and a range of data values for each set of sensor data.

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3. The method of claim 1, wherein the processing comprises, by the first master node (424, 426, 428), aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate respective histograms of the sensor data.

4. The method of claim 3, further comprising:

associating a second master node (424, 426, 428) with a second set of peripheral nodes (410, 414) in a second set of packages (430);

responsive to one or more requests by the second master node (424, 426, 428), the peripheral nodes associated with the second set of packages (430) wirelessly transmit the respective sets of sensor data to the second master node (424, 426, 428); and

processing, by the second master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, wherein the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes in the second set of associated packages (430) to generate the one or more summary statistics.

5. The method of claim 4, further comprising:

responsive to one or more requests by a third node (424, 426, 428), the first master node (424, 426, 428) and the second master node (424, 426, 428) each wirelessly transmits to the third node (424, 426, 428) a respective set of summary statistics relating to the processed sensor data and a respective number of data values in the set of sensor data; and

merging, by the third node (424, 426, 428), the respective sets of summary statistics of the processed sensor data received from the first master node (424, 426, 428) and the second master node (424, 426, 428) to create a merged set of summary statistics.

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6. The method of claim 5, wherein the third node (424, 426, 428) is operative to transmit an alert to a server (404) based on the merged set of the summary statistics of the processed sensor data.

7. The method of claim 1, further comprising instructing a designated peripheral node (410, 414) to transmit an advertising packet to a target one of the peripheral nodes (410, 414) in the set, and generating, by the designated peripheral node (410, 414), an alert based on a failure to receive a corresponding acknowledgement packet from the target peripheral node (410, 414) within an alert interval.

8. The method of claim 7, wherein the alert comprises an electronic message sent by the designated peripheral node (410, 414) to the master node (424, 426, 428).

9. The method of claim 1, wherein the first type of wireless communications interface is a Radio Frequency Identification (RFID) communications interface, and the second type of wireless communications interface is a Bluetooth communications interface.

10. The method of claim 1, wherein the first type of wireless communications interface is a Bluetooth communications interface, and the second type of wireless communications interface is a LoRaWAN communications interface.

11. The method of claim 1, further comprising:
grouping the packages in the first set of associated packages with packages in a second set of associated packages to form a grouped set of packages on a pallet, wherein the second set of associated packages is associated with a second master node (424, 426, 428), and a package in the second set of associated packages is associated with a second peripheral node (410, 414) that comprises a sensor operative to generate sensor data based on sensed local environmental conditions;

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processing, by the second master node (424, 426, 428), the sensor data generated by the sensor of the second peripheral node (410, 414);

associating a third master node (424, 426, 428) with the grouped set of packages; and

combining, by the third master node (424, 426, 428), the processed sensor data generated by the first and second peripheral nodes (410, 414).

12. The method of claim 11, further comprising, by the third master node (424, 426, 428), producing one or more second-level statistics of the processed sensor data generated by the first and second peripheral nodes (410, 414).

13. The method of claim 11, further comprising:

transmitting, by the first master node (424, 426, 428) to the third master node (424, 426, 428), a packet comprising an indication of a location of a first physical premises where the first peripheral node (410, 414) generated the sensor data;

transmitting, by the second master node (424, 426, 428) to the third master node (424, 426, 428), a packet comprising an indication of a location of a second physical premises where the second master node (424, 426, 428) generated the sensor data; and

transmitting, by the third master node (424, 426, 428), the indications of the locations of the first and second physical premises to a server (404).

14. The method of claim 11, further comprising, by the third master node (424, 426, 428), producing a histogram of the processed sensor data generated by the first and second peripheral nodes (410, 414).

15. The method of claim 14, wherein the producing comprises, by the third master node (424, 426, 428), producing a histogram of at least one of temperature data and acceleration data.

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17. A monitoring network, comprising:

a first master node (424, 426, 428) associated with a first set of packages, the first master node (424, 426, 428) comprising a first type of wireless communications interface and a second type of wireless communications interface with a longer communications range than the first type of wireless communications interface;

a plurality of peripheral nodes (410, 414) associated with respective packages in the first set of packages, wherein each peripheral node comprises the first type of wireless communications interface to communicate with the wireless communications interface of the first master node (424, 426, 428), and one or more of the peripheral nodes (410, 414) comprise a respective sensor operative to generate respective sets of sensor data by sensing local environmental conditions and storing the generated sensor data in the respective peripheral nodes;

wherein, responsive to one or more respective requests by the first master node, the peripheral nodes are operative to wirelessly transmit the respective sets of sensor data to the first master node (424, 426, 428); and

wherein the first master node (424, 426, 428) is operative to process the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, wherein the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.

18. The monitoring network of claim 17, wherein the first master node (424, 426, 428) is operative to generate a histogram based on the one or more statistics.

19. The monitoring network of claim 17, comprising:

a grouped set of packages comprising the first set of associated packages and a second set of associated packages, wherein the second set of packages is associated with a second master node (424, 426, 428) and a package in the second set of

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associated packages is associated with a second peripheral node that comprises a sensor operative to generate sensor data by sensing local environmental conditions;

wherein the second master node (424, 426, 428) is operative to process the sensor data generated by the second peripheral node;

the third node (424, 426, 428) is operative to associate with the grouped set of packages; and

the third node (424, 426, 428) is operative to combine the processed sensor data generated by the first and second peripheral nodes (410, 414).

20. The monitoring network of claim 19, wherein the third node (424, 426, 428) is operative to produce one or more second-level statistics of the processed sensor data generated by the first and second peripheral nodes (410, 414).

21. The monitoring network of claim 19, wherein:

the first master node (424, 426, 428) is operative to transmit to the third node (424, 426, 428) one or more packets comprising an identifier of a first physical location where the first master node (424, 426, 428) acquired the sensor data generated by the first peripheral node;

the second master node (424, 426, 428) is operative to transmit to the third node (424, 426, 428) one or more packets comprising an identifier of a second physical location where the second master node (424, 426, 428) acquired the sensor data generated by the second peripheral node; and

the third node (424, 426, 428) is operative to transmit the identifiers of the first and second physical locations to a server (404).

22. The monitoring network of claim 19, wherein the third node (424, 426, 428) is operative to produce a histogram of the processed sensor data generated by the first and second peripheral nodes (410, 414).

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23. A computer program product for execution by a computer system and comprising at least one non-transitory computer-readable medium having computer-readable program code portions embodied therein, the computer-readable program code portions comprising:

an executable code portion to associate a master node (424, 426, 428) with a first set of packages, the master node (424, 426, 428) including a first type of wireless communications interface and a second type of wireless communications interface with a longer communications range than the first type of wireless communications interface;

an executable code portion to associate a peripheral node with respective packages in the set, wherein the peripheral node comprises the first type of wireless communications interface to communicate with the wireless communications interface of the master node (424, 426, 428), and the peripheral node comprises a sensor operative to generate sensor data by sensing an ambient condition;

an executable code portion to associate the master node (424, 426, 428) with the peripheral node; and

an executable code portion to process, by the master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more statistics of the processed sensor data; and

an executable code portion to aggregate, by the master node (424, 426, 428), the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.

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CLAIMS

1. A method of creating a monitoring network, comprising:

associating a first master node (424, 426, 428) with a first set of packages (430), the first master node (424, 426, 428) comprising a first type of wireless communications interface (446) and a second type of wireless communications interface (452) with a longer communications range than the first type of wireless communications interface (446);

associating a first set of peripheral nodes (410, 414) with respective packages in the first set of packages (430), in which the peripheral nodes (410, 414) comprise the first type of wireless communications interface (444) to communicate with the first type of wireless communications interface of the first master node (424, 426, 428), and the peripheral nodes (410, 414) comprise sensors operative to generate respective sets of sensor data by sensing local environmental conditions and storing the generated sensor data in the respective peripheral nodes;

responsive to one or more requests by the first master node (424, 426, 428), the peripheral nodes wirelessly transmit the respective sets of sensor data to the first master node (424, 426, 428); and

processing, by the first master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, in which the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.

2. A method according to Claim 1, in which the one or more summary statistics of the aggregated sensor data comprise one or more of: a respective number of data values in each set of sensor data, a histogram for each set of sensor data, high and low data values for each set of sensor data, and a range of data values for each set of sensor data.

3. A method according to Claim 1, in which the processing comprises, by the first master node (424, 426, 428), aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate respective histograms of the sensor data.

4. A method according to Claim 3, further comprising:

associating a second master node (424, 426, 428) with a second set of peripheral nodes (410, 414) in a second set of packages (430);

responsive to one or more requests by the second master node (424, 426, 428), the peripheral nodes associated with the second set of packages (430) wirelessly transmit the respective sets of sensor data to the second master node (424, 426, 428); and

processing, by the second master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, in which the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes in the second set of associated packages (430) to generate the one or more summary statistics.

5. A method according to Claim 4, further comprising:

responsive to one or more requests by a third node (424, 426, 428), the first master node (424, 426, 428) and the second master node (424, 426, 428) each wirelessly transmits to the third node (424, 426, 428) a respective set of summary statistics relating to the processed sensor data and a respective number of data values in the set of sensor data; and

merging, by the third node (424, 426, 428), the respective sets of summary statistics of the processed sensor data received from the first master node (424, 426, 428) and the second master node (424, 426, 428) to create a merged set of summary statistics.

6. A method according to Claim 1, further comprising instructing a designated peripheral node (410, 414) to transmit an advertising packet to a target one of the peripheral nodes (410, 414) in the set, and generating, by the designated peripheral node (410, 414), an alert based on a failure to receive a corresponding acknowledgement packet from the target peripheral node (410, 414) within an alert interval.

7. A method according to Claim 6, in which the alert comprises an electronic message sent by the designated peripheral node (410, 414) to the master node (424, 426, 428).

8. A method according to Claim 1, in which the first type of wireless communications interface is a Radio Frequency Identification (RFID) communications interface, and the second type of wireless communications interface is a Bluetooth communications interface.

9. A method according to Claim 1, in which the first type of wireless communications interface is a Bluetooth communications interface, and the second type of wireless communications interface is a LoRaWAN communications interface.

10. A method according to Claim 1, further comprising:

5 grouping the packages in the first set of associated packages with packages in a second set of associated packages to form a grouped set of packages on a pallet, in which the second set of associated packages is associated with a second master node (424, 426, 428), and a package in the second set of associated packages is associated with a second peripheral node (410, 414) that comprises a sensor operative to generate sensor data
10 based on sensed local environmental conditions;

 processing, by the second master node (424, 426, 428), the sensor data generated by the sensor of the second peripheral node (410, 414);

 associating a third master node (424, 426, 428) with the grouped set of packages; and

 combining, by the third master node (424, 426, 428), the processed sensor data generated
15 by the first and second peripheral nodes (410, 414).

11. A method according to Claim 10, further comprising, by the third master node (424, 426, 428), producing one or more second-level statistics of the processed sensor data generated by the first and second peripheral nodes (410, 414).

12. A method according to Claim 10, further comprising:

20 transmitting, by the first master node (424, 426, 428) to the third master node (424, 426, 428), a packet comprising an indication of a location of a first physical premises where the first peripheral node (410, 414) generated the sensor data;

 transmitting, by the second master node (424, 426, 428) to the third master node (424, 426, 428), a packet comprising an indication of a location of a second physical premises
25 where the second master node (424, 426, 428) generated the sensor data; and

 transmitting, by the third master node (424, 426, 428), the indications of the locations of the first and second physical premises to a server (404).

13. A method according to Claim 10, further comprising, by the third master node (424, 426, 428), producing a histogram of the processed sensor data generated by the first and second peripheral nodes (410, 414).

14. A method according to Claim 13, in which the producing comprises, by the third master node (424, 426, 428), producing a histogram of at least one of temperature data and acceleration data.

15. A method according to Claim 1, further comprising communicating, using a scheduling description language, instructions to the first master node on a measurement to be performed by the sensors and the aggregation of the sensor data to be generated, the first master node being configured to execute the scheduling description language to obtain the aggregated sensor data, the execution including communicating instructions using the scheduling description language to the first set of peripheral nodes to obtain the sensor data and transmit the sensor data to the first master node.

16. A method according to Claim 1, further comprising transmitting, to the first master node via the second type of wireless communications interface, programmatic code executable by the first master node to function as a master node with respect to the peripheral node.

17. A monitoring network, comprising:

a first master node (424, 426, 428) associated with a first set of packages, the first master node (424, 426, 428) comprising a first type of wireless communications interface and a second type of wireless communications interface with a longer communications range than the first type of wireless communications interface;

a plurality of peripheral nodes (410, 414) associated with respective packages in the first set of packages, in which each peripheral node comprises the first type of wireless communications interface to communicate with the wireless communications interface of the first master node (424, 426, 428), and one or more of the peripheral nodes (410, 414) comprise a respective sensor operative to generate respective sets of sensor data by sensing local environmental conditions and storing the generated sensor data in the respective peripheral nodes;

in which, responsive to one or more respective requests by the first master node, the peripheral nodes are operative to wirelessly transmit the respective sets of sensor data to the first master node (424, 426, 428); and

in which the first master node (424, 426, 428) is operative to process the respective sets of aggregated sensor data to generate one or more summary statistics of the processed sensor data, in which the processing comprises aggregating the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.

18. A monitoring network according to Claim 17, in which the first master node (424, 426, 428) is operative to generate a histogram based on the one or more statistics.

19. A monitoring network according to Claim 17, comprising:

a grouped set of packages comprising the first set of associated packages and a second set of associated packages, in which the second set of packages is associated with a second master node (424, 426, 428) and a package in the second set of associated packages is associated with a second peripheral node that comprises a sensor operative to generate sensor data by sensing local environmental conditions;

in which the second master node (424, 426, 428) is operative to process the sensor data generated by the second peripheral node;

the third node (424, 426, 428) is operative to associate with the grouped set of packages; and

the third node (424, 426, 428) is operative to combine the processed sensor data generated by the first and second peripheral nodes (410, 414).

20. A monitoring network according to Claim 19, in which the third node (424, 426, 428) is operative to produce one or more second-level statistics of the processed sensor data generated by the first and second peripheral nodes (410, 414).

21. A monitoring network according to Claim 19, in which:

the first master node (424, 426, 428) is operative to transmit to the third node (424, 426, 428) one or more packets comprising an identifier of a first physical location where the

first master node (424, 426, 428) acquired the sensor data generated by the first peripheral node;

the second master node (424, 426, 428) is operative to transmit to the third node (424, 426, 428) one or more packets comprising an identifier of a second physical location where the second master node (424, 426, 428) acquired the sensor data generated by the second peripheral node; and

the third node (424, 426, 428) is operative to transmit the identifiers of the first and second physical locations to a server (404).

22. A monitoring network according to Claim 19, in which the third node (424, 426, 428) is operative to produce a histogram of the processed sensor data generated by the first and second peripheral nodes (410, 414).

23. A computer program product for execution by a computer system and comprising at least one non-transitory computer-readable medium having computer-readable program code portions embodied therein, the computer-readable program code portions comprising:

an executable code portion to associate a master node (424, 426, 428) with a first set of packages, the master node (424, 426, 428) including a first type of wireless communications interface and a second type of wireless communications interface with a longer communications range than the first type of wireless communications interface;

an executable code portion to associate a peripheral node with respective packages in the set, in which the peripheral node comprises the first type of wireless communications interface to communicate with the wireless communications interface of the master node (424, 426, 428), and the peripheral node comprises a sensor operative to generate sensor data by sensing an ambient condition;

an executable code portion to associate the master node (424, 426, 428) with the peripheral node; and

an executable code portion to process, by the master node (424, 426, 428), the respective sets of aggregated sensor data to generate one or more statistics of the processed sensor data; and

an executable code portion to aggregate, by the master node (424, 426, 428), the respective sets of the sensor data received from respective ones of the peripheral nodes to generate the one or more summary statistics.