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(54) **METHODS AND SYSTEMS FOR PRESERVING THE POWER SOURCE LIFE OF A WIRELESS END NODE PRIOR TO DEPLOYMENT IN A TRANSPORT REFRIGERATION SYSTEM**

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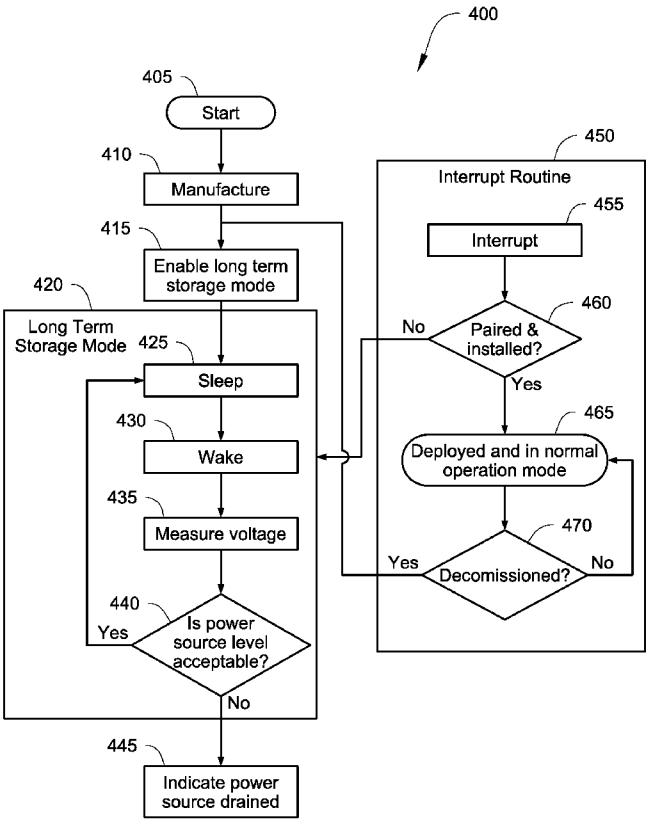
(57) **ABSTRACT**

Methods and systems for preserving the power source life of a wireless end node prior to deployment in a wireless communication system are provided. In one embodiment, a method is provided that includes operating the wireless end node in a long term storage mode prior to deploying the wireless end node in a wireless communication system in order to reduce current being drawn from a power source of the wireless end node. The method also includes the wireless end node detecting an interrupt request to pair the wireless end node to a wireless communication system. Also, the method includes the controller of the wireless end node switching from a long term storage mode to a normal operation mode when the wireless end node is paired to a wireless communication system.



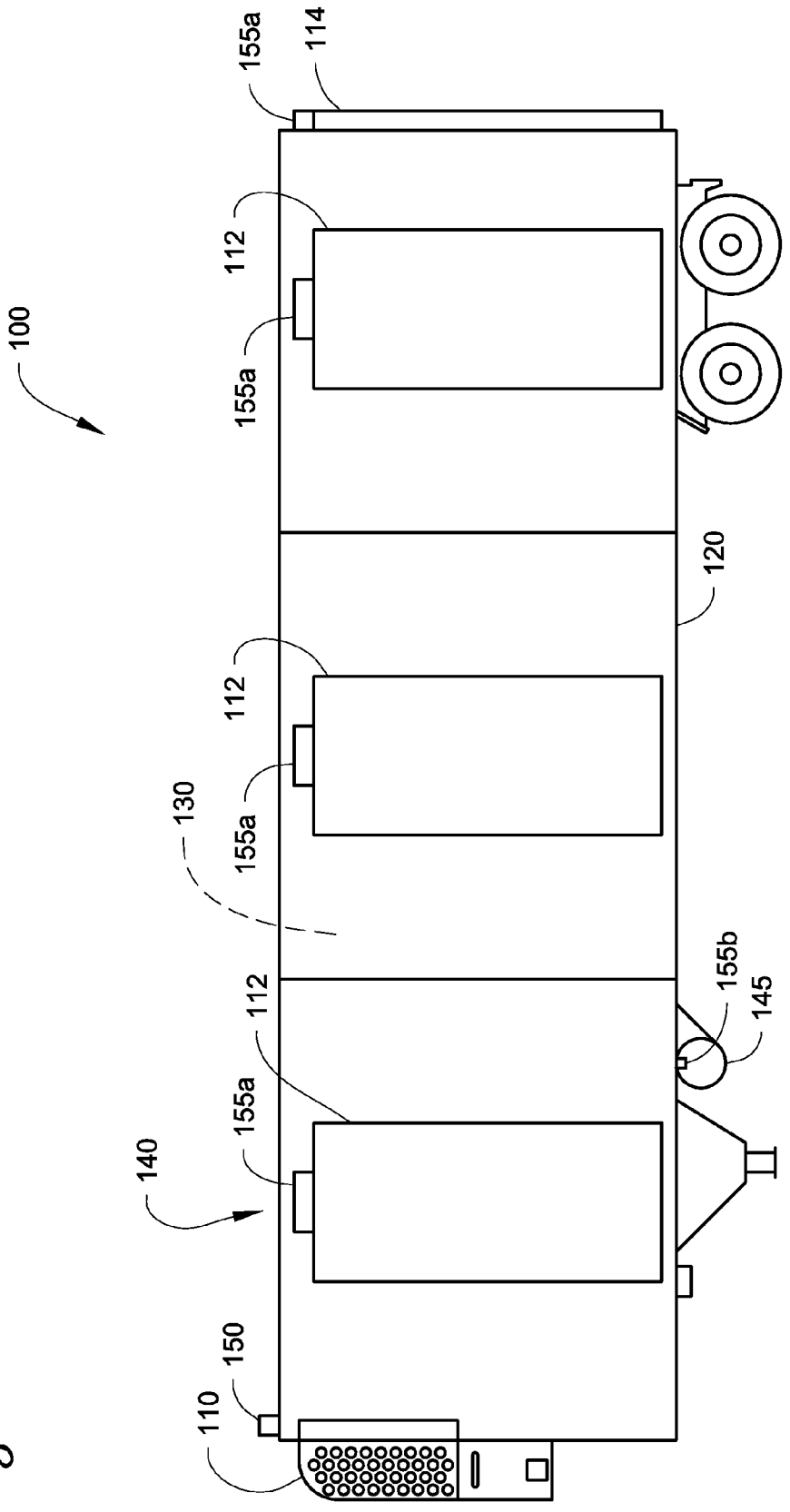


Fig. 1

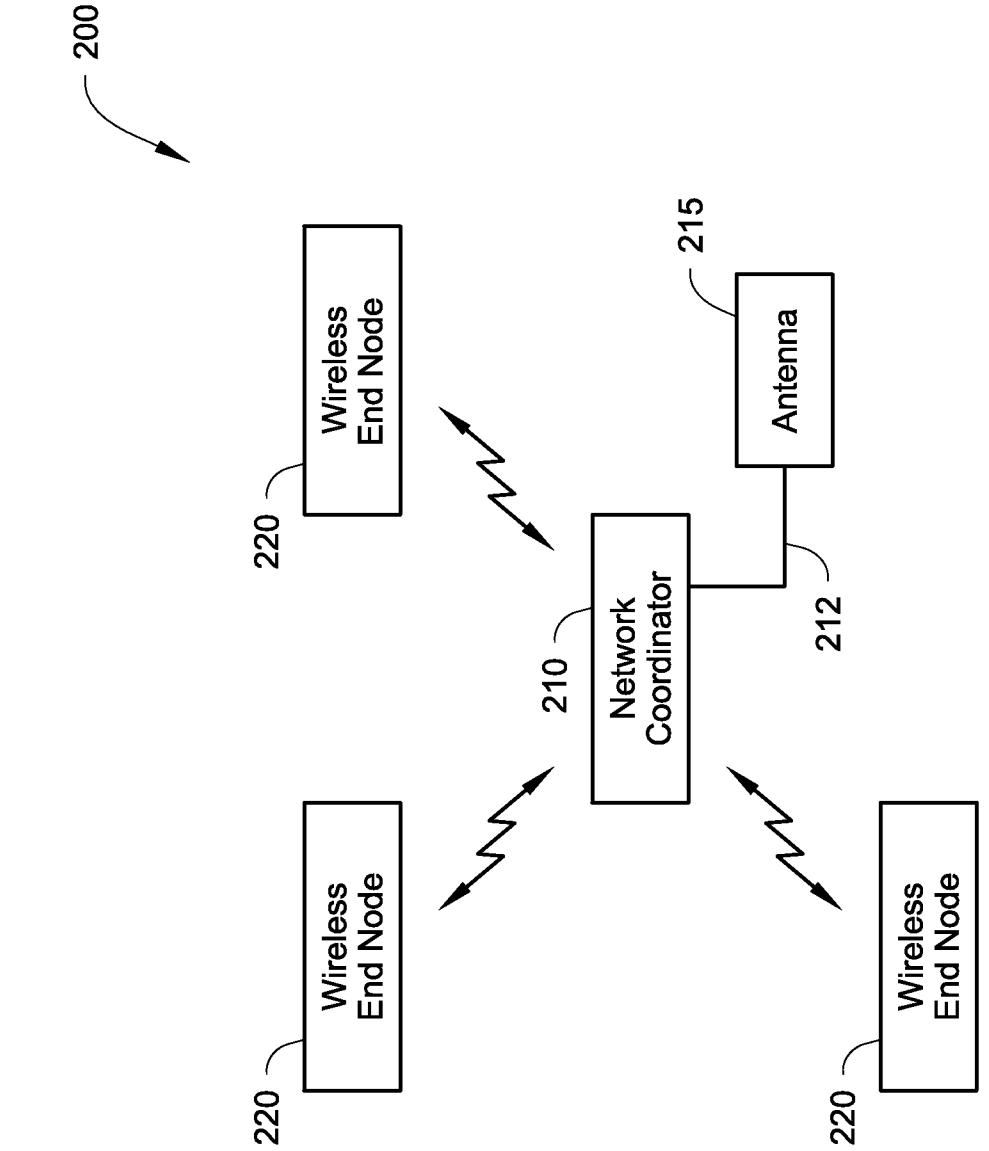

200
Wireless End Node
220
Wireless End Node
220
Network Coordinator
210
212
Antenna
215
Wireless End Node
220

Fig. 2

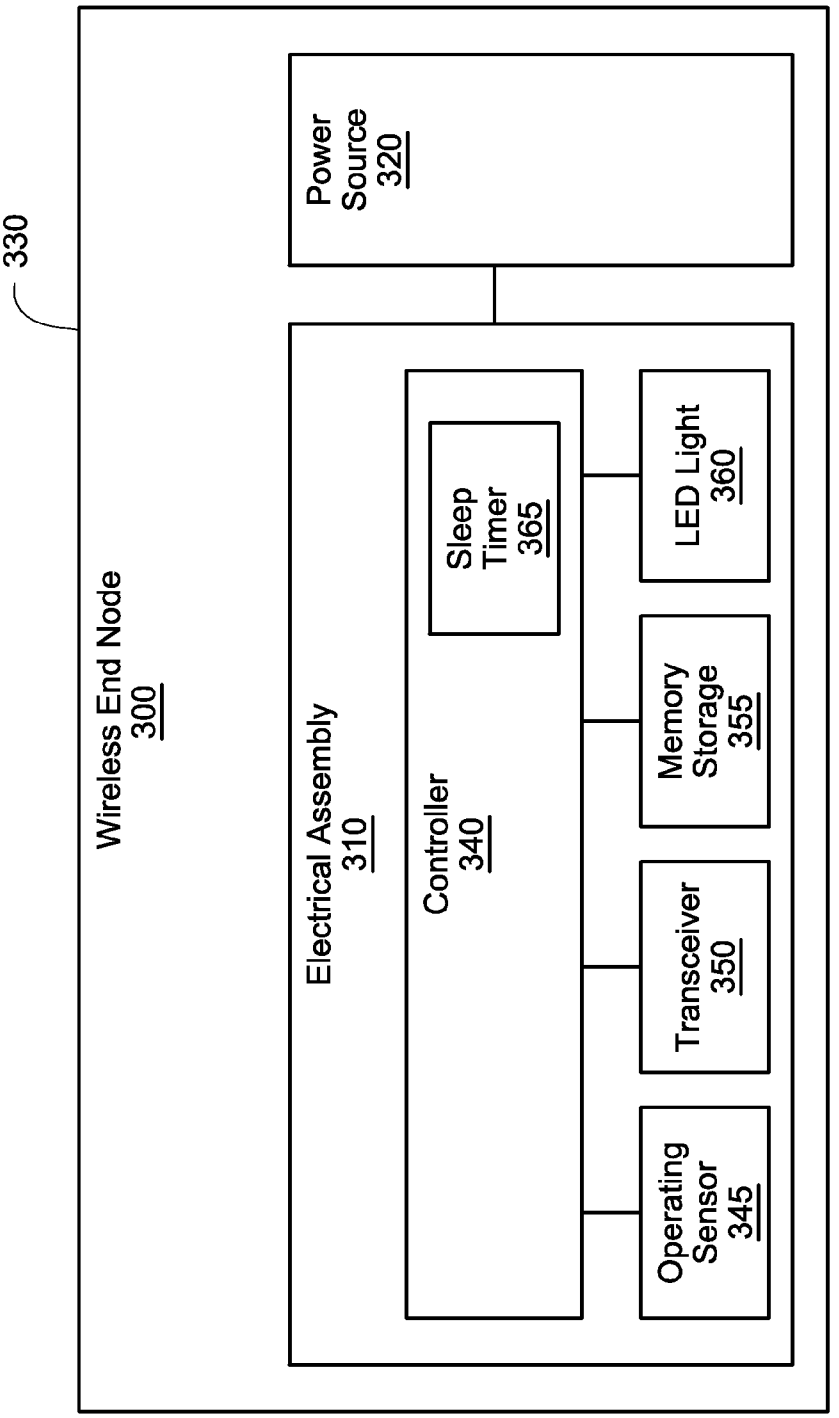
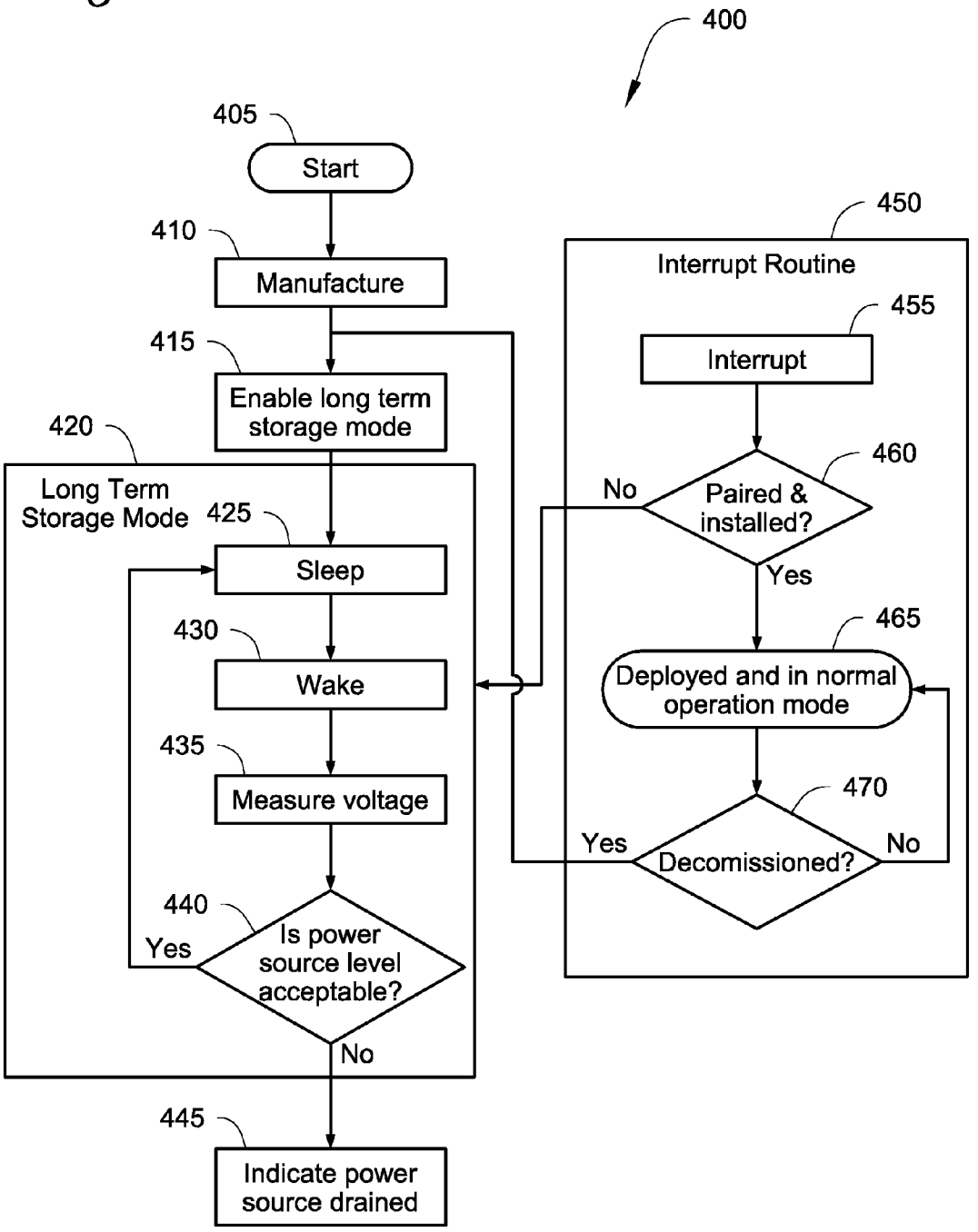

330
Wireless End Node
300
Power Source
320
Electrical Assembly
310
Controller
340
Sleep Timer
365
LED Light
360
Memory Storage
355
Transceiver
350
Operating Sensor
345

Fig. 3

Fig. 4


400
405
Start
410
Manufacture
415
Enable long term storage mode
420
Long Term Storage Mode
425
Sleep
430
Wake
435
Measure voltage
440
Is power source level acceptable?
Yes
No
445
Indicate power source drained
450
Interrupt Routine
455
Interrupt
460
Paired & installed?
No
Yes
465
Deployed and in normal operation mode
470
Decomissioned?
Yes
No

METHODS AND SYSTEMS FOR PRESERVING THE POWER SOURCE LIFE OF A WIRELESS END NODE PRIOR TO DEPLOYMENT IN A TRANSPORT REFRIGERATION SYSTEM

FIELD

[0001] The embodiments disclosed herein relate generally to a transport refrigeration system. More particularly, the embodiments relate to preserving the power source life of a wireless end node prior to deployment in a wireless communication system for use in a mobile environment, such as a transport refrigeration system.

BACKGROUND

[0002] Existing transport refrigeration systems are used to cool containers, trailers, and other similar transport units (typically referred to as a "reefer"). Modern reefers may be efficiently stacked for shipment by ship or rail. Typically, when reefers are shipped by truck, a single reefer is placed on a trailer chassis. When cargo in the container includes perishable products (e.g., food product, flowers, etc.), the temperature of the reefer must be controlled to limit loss of the cargo during shipment.

SUMMARY

[0003] The embodiments described herein are directed to preserving the power source life of a wireless end node prior to deployment in a wireless communication system for use in a mobile environment, such as a transport refrigeration system.

[0004] In one embodiment, a method for preserving the power source life of a wireless end node prior to deployment in a wireless communication system is provided. The method includes operating the wireless end node in a long term storage mode prior to deploying the wireless end node in a wireless communication system in order to reduce current being drawn from a power source of the wireless end node. The method also includes the wireless end node detecting an interrupt request to pair the wireless end node to a wireless communication system. Also, the method includes the controller of the wireless end node switching from a long term storage mode to a normal operation mode when the wireless end node is paired to a wireless communication system.

[0005] In yet another embodiment a wireless end node for use in a wireless communication system is provided. The wireless end node includes a power source and an electrical assembly connected to the power source. The electrical assembly includes a controller configured to manage, command, direct and regulate the behavior of the wireless end node and configured to switch operation of the wireless end node between a long term storage mode that reduces current being drawn from the power source and a normal operation mode. The controller includes a sleep timer configured to count down a long term storage time period. The controller is configured to operate the wireless end node in the long term storage mode prior to deploying the wireless end node in a wireless communication system and is configured to switch from the long term storage mode to the normal operation mode when the wireless end node is paired to the wireless communication system.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] Referring now to the drawings in which like reference numbers represent corresponding parts throughout.

[0007] FIG. **1** illustrates a side view of an embodiment of a transport temperature controlled trailer unit with a transport refrigeration system.

[0008] FIG. **2** illustrates a block diagram of an embodiment of a wireless communication system for use in a mobile environment.

[0009] FIG. **3** illustrates a block diagram of an embodiment of a wireless end node of a wireless communication system for use in a mobile environment.

[0010] FIG. **4** illustrates a flow chart of an embodiment of preserving the power source life of a wireless end node prior to deployment in a wireless communication system.

DETAILED DESCRIPTION

[0011] The embodiments described herein are directed to preserving the power source life of a wireless end node prior to deployment in a wireless communication system for use in a mobile environment, such as a transport refrigeration system.

[0012] References are made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration of the embodiments in which the methods and systems described herein may be practiced. The term "reefer" generally refers to, for example, a temperature controlled trailer, container, or other type of transport unit, etc. The term "wireless communication system" refers to a communication system that is configured to transmit data over a short distance in a mobile environment, such as, for example, between different points of a reefer that is in transport. The term "wireless end node" refers to an electronic device that is an endpoint of a wireless communication system and is capable of monitoring a property of a temperature refrigeration system and transmitting data transmissions to and receiving data transmissions from a network coordinator of the wireless communication system. The term "network coordinator" refers to an electronic device that is configured to manage, command, direct and regulate the behavior of one or more wireless end nodes of the wireless communication system. The term "deployment" refers to a wireless end node being paired to a wireless communication system and installed in a transport refrigeration system.

[0013] FIG. **1** illustrates a side view of a transport temperature controlled trailer unit **100** with a transport refrigeration system **110**. The trailer unit **100** is installed on a frame **120** and has a plurality of side doors **112** and a rear door **114**. The transport refrigeration system **110** is installed on a side wall of the trailer unit **100**. The transport refrigeration system **110** is configured to transfer heat between an internal space **130** and the outside environment. In some embodiments, the transport refrigeration system **110** is a multizone system in which different zones or areas of the internal space **130** are controlled to meet different refrigeration requirements based on the cargo stored in the particular zone.

[0014] It will be appreciated that the embodiments described herein are not limited to trucks and trailer units. The embodiments described herein may be used in any other suitable temperature controlled apparatuses such as a ship board container, an air cargo cabin, an over the road truck cabin, etc. The refrigeration system may be a vapor-compres-

sor type refrigeration system, or any other suitable refrigeration systems that can use refrigerant, cold plate technology, etc.

[0015] The transport refrigeration system **110** includes a wireless communication system **140** and a fuel tank **145**. The wireless communication system **140** includes a network coordinator (not shown), an antenna **150**, and a plurality of wireless end nodes **155**. As shown in FIG. **1**, the wireless end nodes **155** include a door sensor **155***a* for each of the side doors **112** and the rear door **114**, and a fuel tank level sensor **155***b* for the fuel tank **145**. In some embodiments, the wireless end nodes **155** can also include other types of sensors such as, for example, an air space temperature sensor, a humidity sensor, a cargo temperature center, etc. Also, the wireless end nodes **155** are sealed to prevent failure due to water ingress, extreme temperatures, UV exposure, exposure to oil/solvents, etc. The wireless communication system **140** is configured to communicate information regarding the transport temperature controlled trailer unit **100** to a controller unit (not shown) of the transport refrigeration system **110** for controlling the refrigeration of the internal space **130**. In some embodiments, the wireless communication system **140** also includes one or more wired sensor modules (not shown) that are connected to the network coordinator via a wired connection. The wired sensor modules, like the wireless end modules **155** can include, for example, a door sensor, a fuel tank sensor, an air space temperature sensor, a humidity sensor, a cargo temperature center, etc.

[0016] Referring to FIG. **2**, a block diagram of one embodiment of a wireless communication system **200** for use in a mobile environment is described. The wireless communication system **200** includes a network coordinator **210**, an antenna **215** and a plurality of wireless end nodes **220**. The wireless communication system **200** can be a wireless personal area network ("WPAN") that uses a ZigBee communication protocol. In other embodiments, other types of communication protocols can be used such as, for example, Bluetooth or any other type of wireless communication protocol that allows for accurate transmission of data between different points of a reefer during transport.

[0017] In some embodiments the network coordinator **210** is a WPAN module that is configured to be installed in a control box (not shown) of a transport refrigeration system. The network coordinator **210** is configured to transmit to and receive data from each of the plurality of wireless end nodes **220** via the antenna **215** using a short distance wireless communication protocol such as, for example ZigBee, Bluetooth, etc. Also, the network coordinator **210** is configured to connect to a control unit of a transport refrigeration system stored in the control box.

[0018] The antenna **215** is a weatherproof antenna that is configured to be installed outside of the control box and is connected to the network coordinator **210** via a wired communication link **212** such as, for example, a coaxial cable. In some embodiments, the antenna **215** can be configured to be installed inside the control box with the network coordinator **210**.

[0019] Each of the plurality of wireless end nodes **220** is configured to transmit and receive information with the network coordinator **210** using a short distance wireless communication protocol such as, for example ZigBee, Bluetooth, etc. In some embodiments, one or more of the wireless end nodes **220** are weatherproof by using a sealed housing (not shown) to prevent failure due to water ingress, extreme temperatures, UV exposure, exposure to oil/solvents, etc.

[0020] Each of the plurality of wireless end nodes **220** can be, for example, a door sensor, a fuel tank temperature sensor, an air space temperature sensor, a humidity sensor, a cargo temperature center, etc. When the wireless end node **220** is a door sensor, the wireless end node **220** is configured to transmit a data signal to the network coordinator **210** when a door of the transport refrigeration system being monitored by the wireless end node **220** is opened or closed. When the wireless end node **220** is a fuel tank temperature sensor, the wireless end node **220** is configured to transmit a data signal to the network coordinator **210** indicating the temperature of a fuel tank of a transport refrigeration system. When the wireless end node **220** is an air space temperature sensor, the wireless end node **220** is configured to transmit a data signal to the network coordinator **210** indicating the temperature of an internal space of a reefer. When the wireless end node **220** is a humidity sensor, the wireless end node **220** is configured to transmit a data signal to the network coordinator **210** indicating the humidity of an internal space of a reefer. When the wireless end node **220** is a cargo temperature sensor, the wireless end node **220** is configured to transmit a data signal to the network coordinator **210** indicating the temperature of cargo stored in the reefer.

[0021] FIG. **3** illustrates one embodiment of a block diagram of a wireless end node **300** for a wireless communication system in a transport refrigeration system of a reefer. The wireless end node **300** can be, for example, a door sensor, a fuel tank temperature sensor, an air space temperature sensor, a humidity sensor, a cargo temperature center, etc. The wireless end node **300** includes an electrical assembly **310** and a power source **320** connected to the electrical assembly **310**. The electrical assembly **310** and the power source **320** are enclosed within a sealed housing **330**.

[0022] For transport refrigeration systems, the housing **330** must satisfy vigorous environmental sealing requirements for the wireless end node **300** to be acceptable for use. Accordingly, once the wireless end node is manufactured, the electrical assembly and the power source are not serviceable and any feature within the housing that can penetrate to the outside of the housing could be considered a possible failure point.

[0023] The electrical assembly **310** includes a controller **340**, an operating sensor **345**, a transceiver **350**, a memory storage **355**, and a light emitting diode (LED) light **360**. The controller is provided to control the wireless end node **300** and includes a sleep timer **365**.

[0024] The controller **340** is configured to manage, command, direct and regulate the behavior of the wireless end node. Also, the controller **340** is configured to direct the wireless end node **300** to operate in a long term storage mode prior to deployment of the wireless end node **300** in a wireless communication system and a normal operation mode and a sleep mode upon deployment in a wireless communication system. In the normal operation mode, the electrical assembly **310** draws current from the power source **320**, the operating sensor **345** can monitor a portion of the transport refrigeration system, the transceiver **350** can transmit data to and receive data from the network coordinator of the wireless communication system. In the sleep mode, the electrical assembly is powered down to reduce the amount of current drawn from the power source. During the sleep mode, sufficient current is drawn from the power source **320** to allow the sleep timer **365**

to count down an amount of time to indicate to the controller **340** when the wireless end node **300** should switch to the normal operation mode and monitor an interrupt request from a user or the network coordinator of the wireless communication system. Also, sufficient current is drawn from the power source **320** to switch the wireless end node **300** from the sleep mode to the normal operation mode when an interrupt request is received or when the sleep timer indicates to the controller **340** to switch to the normal operation mode.

[0025] Similar to the sleep mode, in the long term storage mode the electrical assembly is powered down to reduce the amount of current drawn from the power source. During the long term storage mode, sufficient current is drawn from the power source **320** to allow the sleep timer **365** to count down an amount of time to indicate to the controller **340** when the wireless end node **300** should power up to measure a power source level of the power source **320** and to monitor an interrupt request from a user to deploy the wireless end node **300** to a wireless communication system. Also, sufficient current is drawn from the power source **320** to power up the wireless end node **300** when an interrupt request is received or when the sleep timer indicates to the controller **340** to measure the power source level of the power source **320**.

[0026] The operating sensor **345** is connected to the controller **340** and performs a sensing operation for the transport refrigeration system. For example, if the wireless end node **300** is a door sensor, the operation sensor **345** can sense when a door that is being monitored by the wireless end node **300** is opened or closed and can notify the controller **340** of this information. If the wireless end node **300** is a fuel tank temperature sensor, the operation sensor **345** can measure the temperature of a fuel tank of a transport refrigeration system and can notify the controller **340** of this information. If the wireless end node **300** is an air space temperature sensor, the operation sensor **345** can measure the temperature of an internal space of a reefer and can notify the controller **340** of this information. If the wireless end node **300** is a humidity sensor, the operation sensor **345** can measure the humidity of a reefer and can notify the controller **340** of this information. If the wireless end node **300** is a cargo temperature sensor, the operation sensor **345** can measure the temperature of cargo stored in a reefer and can notify the controller **340** of this information.

[0027] The transceiver **350** is also connected to the controller **340** and is configured to transmit to and receive data signals from a network coordinator of a wireless communication system. For example, if the wireless end node **300** is a door sensor, the transceiver **350** can receive an acknowledgement message from the network coordinator to indicate that the wireless communication system is for use in a normal operation mode, and can send a sensing message to the network coordinator when the door being monitored by the wireless end node **300** is opened or closed. The transceiver **350** is configured to transmit and receive data using a short distance wireless communication protocol such, for example, ZibBee, Bluetooth, etc.

[0028] The memory storage **355** is connected to the controller **340** and can store information such as an acceptable power source level threshold. The memory storage **355** can also store information such as, for example, the information provided in the table below:

Log #	Title	Description
1	Paired Wake Count	The total number of wake up events after pairing.
2	Unpaired Wake Count	The total number of wake up events before pairing.
3	Successful Pair	The total number of successful pairings.
4	Unsuccessful Pair	The total number of unsuccessful pairings
5	Enter Pair State	The number of times the sensor enters a pairing state.
6	User Succ. Pair	The user was able to enter a pairing state using the sequence described.
7	User Unsucc. Pair	The user was unsuccessful in entering a pairing state using the sequence described.
8	Cross Pair	The number of times two or more network coordinators were paired to the same sensor.
9	Succ. Unpair	The network coordinator and wireless end node were able to unpair successfully.
10	Unsucc. Unpair	The network coordinator and wireless end node were not able to unpair successfully.
11	LQI Value <5	Link Quality Indicator is low.
12	LQI Value <10	As above
13	LQI Value <15	As above
14	Door Open Ev.	The wireless end node detected a fully filtered open door event.
15	Door Close Ev.	The wireless end node detected a fully filtered closed door event.
16	Door Ajar Ev.	The wireless end node detected 20 door open/closed transitions in a 5 minute period.
17	Recov. Door Ajar Ev.	The wireless end node polled the door input 4 times every 5 minutes and did not notice a change in the door state.
18	Battery Low Ev.	The wireless end node detected a low battery 2.2 V
19	AD Short Ev.	The A/D wireless end node value exceeded the maximum allowable A/D value.
20	AD Open Ev.	The A/D wireless end node value was below the minimum allowable A/D value.
21	32k Hz Osc Failed Event	The wireless end node failed to transition properly from the 2k oscillator to the 32k crystal.
22	Lost Comm. 1	Lost communication with wireless end node ID 1 for five or more consecutive transmissions.

-continued

Log #	Title	Description
23	Lost Comm 2	Lost communication with wireless end node ID 2 for five or more consecutive transmissions.
24	Lost Comm 3	Lost communication with wireless end node ID 3 for five or more consecutive transmissions.
25	Lost Comm 4	Lost communication with wireless end node ID 4 for five or more consecutive transmissions.
26	Lost Comm 5	Lost communication with wireless end node ID 5 for five or more consecutive transmissions.
27	Dial Back Event	The wireless end node has lost communication with the network coordinator and reduces the transmit time interval
28	Dial Back Transmission Event	The number of times the wireless end node transmits to the network coordinator while in dial back mode.
29	PLL Unlock Event	The number of times the wireless end node does not 'lock in' to the proper frequency.
30	Wake on Error	The number of times the wireless end node awakes to flash an error code.
31	Wake on A/D Ev.	The number of times the wireless end node awakes to read the A/D sensor.
32	Wake to Trans. Ev.	The number of times the wireless end node awakes to transmit a message to the network coordinator.
33	Sleep Ev.	The number of times the wireless end node returns to a sleep state.
34	Door Open Int. Ev.	The number of times the wireless end node detects a door open interrupt (not necessarily debounced).
35	Door Close Int. Ev.	The number of times the wireless end node detects a door closed interrupt (not necessarily debounced).
36	Wake on Timer Ev.	The number of times the wireless end node awakes from the timeout timer.
37	Wake on Temp Change	The number of times the wireless end node transmits a change of temperature greater than 5 degrees Celsius.
38	Wake on Power up	The number of times the wireless end node wakes from either a power cycle or a low on the reset line.

[0029] The LED light **360** is connected to the controller **340** and is visible outside of the sealed housing **330**. The LED light **360** can be a multi-colored and blinking LED light that is visible to a user of a transport refrigeration system and can be used for pairing the wireless end node **300** to a wireless communication system and for communicating diagnostic information about the wireless end node **300**. In one embodiment, the LED light **360** can blink red to indicate to a user that the power source life of the power source **320** is no longer acceptable for deployment in a wireless communication system.

[0030] The power source **320** can be a native 3.6 volt Li—SOCl2 battery. In other embodiments, the power source **320** can be a lithium based battery (e.g. a lithiumion battery, a lithium/Iron Disulfide (LiFeS2) battery, etc.).

[0031] FIG. **4** illustrates one embodiment of a process **400** for preserving the power source life of a wireless end node for a wireless communication system for use in a mobile environment. As shown in FIG. **3**, a wireless end node can include a controller, an operation sensor, a transceiver, a power source, and a memory storage that stores an acceptable power source level threshold.

[0032] The flowchart **400** begins at **405**. At **410**, a wireless end node is manufactured. In some embodiments, the wireless end node is manufactured such that the controller, the operation sensor, the power source and the memory storage are encapsulated in a sealed housing.

[0033] At **415**, when the wireless end node is manufactured the controller is set to operate in a long term storage mode **420** until the wireless end node is paired to a wireless communication system.

[0034] The long term storage mode **420** is now described. At **425**, the wireless end node uses the sleep timer in the controller to set a long term storage time period that the wireless end node remains in the long term storage mode. The long term storage time period of the sleep timer can be set by the manufacturer to a time limit that allows the wireless end node to provide accurate power source level information regarding the power source of the wireless end node while preventing excessive use of the power source that can drain lifespan of the wireless end node. In one embodiment, the long term storage time period of the sleep timer can be set to, for example, approximately 24 hours.

[0035] At **430**, the wireless end node powers up after the long term storage time period set in the sleep timer lapses. At **435**, the controller measures the voltage of the power source. Based on the measured voltage, at **440**, the controller determines whether the power source life of the wireless end node is above an acceptable power source life threshold. In one embodiment, the acceptable power source level threshold is ~2.9 volts for a native ~3.6 volt battery. However, in other embodiments, the acceptable power source level threshold can be set at the manufacturer's discretion. If the power source life of the wireless end node is above the acceptable power source life threshold, the long term storage mode **420** returns to **425**. If the power source life of the wireless end node is not above the acceptable power source life threshold, the wireless end node exits the long term storage mode **420** and the process **400** proceeds to **445**.

[0036] At **445**, the wireless end node indicates to the user that the power source life of the wireless end node is no longer acceptable for use. For example, in one embodiment, the LED light of the wireless end node blinks a red light when the power source life of the wireless end node is no longer acceptable for use.

[0037] The process **400** also includes an interrupt routine mode **450**. The interrupt routine mode **450** begins at **455** when the wireless end node receives an interrupt message. In some embodiments, the interrupt message is sent to the wireless end node via a magnet swipe. In other embodiments, the interrupt message is sent to the wireless end node via a button press or a resistive float. At **460**, the controller of the wireless end node determines whether the wireless end node is paired to a wireless communication system and installed in a network coordinator a transport refrigeration system for a reefer. If the controller determines that the wireless end node is not paired to the wireless communication system, the process **400** proceeds to the long term storage mode **420**. If the controller determines that the wireless end node is paired to the wireless communication system, the process **400** proceeds to **465**.

[0038] At **465**, the controller determines that the wireless end node has been deployed and sets the wireless end node into a normal operation mode. The process **400** then proceeds to **470**. At **470**, the controller checks periodically, for example, once a day, whether the wireless end node has been decommissioned from the wireless communication system. If the controller determines that that the wireless end node has not been decommissioned, the process **400** returns to **465**. If the controller determines that the wireless end node has been decommissioned, the process **400** returns to **415**.

Aspects:

[0039] It is noted that any of aspects 1-7 below can be combined with any of aspects 8-14 and any of aspects 15-21. Also, any of aspects 8-14 can be combined with any of aspects 15-21.

[0040] 1. A method for preserving the power source life of a wireless end node prior to deployment in a wireless communication system comprising:

[0041] operating the wireless end node in a long term storage mode prior to deploying the wireless end node in a wireless communication system in order to reduce current being drawn from a power source of the wireless end node;

[0042] the wireless end node detecting an interrupt request to pair the wireless end node to a wireless communication system;

[0043] a controller of the wireless end node switching from a long term storage mode to a normal operation mode when the wireless end node is paired to a wireless communication system.

[0044] 2. The method of aspect 1 further comprising:

[0045] during the long term storage mode, powering the controller of the wireless end node after a sleep timer of the wireless end node determines a long term storage time period has lapsed to determine a power source level of a power source of the wireless end node;

[0046] the controller determining the power source level of the power source;

[0047] the controller comparing the power source level of the power source to an acceptable power source level threshold stored in a memory storage of the wireless end node; and

[0048] indicating a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0049] 3. The method of aspect 2, wherein the long term storage time period is 24 hours.

[0050] 4. The method of aspects 2-3, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

[0051] 5. The method of aspects 2-4, blinking a red color light emitting diode light of the wireless end node to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0052] The method of aspects 1-5, further comprising:

[0053] the controller determining whether the wireless end node is decommissioned from the wireless communication system; and

[0054] the controller setting the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

[0055] 7. The method of aspect 6, wherein the controller determines whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

[0056] 8. A wireless end node for a wireless communication system comprising:

[0057] a power source;

[0058] an electrical assembly connected to the power source, the electrical assembly including:

[0059] a controller configured to manage, command, direct and regulate the behavior of the wireless end node and configured to switch operation of the wireless end node between a long term storage mode that reduces current being drawn from the power source and a normal operation mode, the controller including a sleep timer configured to count down a long term storage time period;

[0060] wherein the controller is configured to operate the wireless end node in the long term storage mode prior to deploying the wireless end node in a wireless communication system and is configured to switch from the long term storage mode to the normal operation mode when the wireless end node is paired to the wireless communication system.

[0061] 9. The wireless end node of aspect 8, wherein the electrical assembly further includes a memory storage,

[0062] wherein, when the wireless end node is operating in the long term storage mode and the sleep timer of the wireless end node counts down the long term storage time period, the controller is configured to power up, determine the power source level of the power source, and compare the power source level of the power source to an acceptable power source level threshold stored in the memory storage, and

[0063] wherein the wireless end node is configured to indicate a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0064] 10. The wireless end node of aspects 8-9, wherein the long term storage time period is 24 hours.

[0065] 11. The wireless end node of aspects 9-10, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

[0066] 12. The wireless end node of aspects 9-11, wherein the electrical assembly further includes a light emitting diode light, and

[0067] wherein the light emitting diode light is configured to blink a red color light to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0068] 13. The wireless end node of aspects 8-12, wherein the controller is configured to determine whether the wireless end node is decommissioned from the wireless communication system, and

[0069] wherein the controller is configured to set the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

[0070] 14. The wireless end node of aspect 13, wherein the controller is configured to determine whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

[0071] 15. A wireless communication system for a mobile environment comprising:

[0072] one or more wireless end nodes, each of the one or more wireless end nodes including:

[0073] a power source;

[0074] an electrical assembly connected to the power source, the electrical assembly including:

[0075] a controller configured to manage, command, direct and regulate the behavior of the wireless end node and configured to switch operation of the wireless end node between a long term storage mode that reduces current being drawn from the power source and a normal operation mode, the controller including a sleep timer configured to count down a long term storage time period;

[0076] wherein the controller is configured to operate the wireless end node in the long term storage mode prior to deploying the wireless end node in a wireless communication system and is configured to switch from the long term storage mode to the normal operation mode when the wireless end node is paired to the wireless communication system;

[0077] a network coordinator connected to each of the one or more wireless end nodes.

[0078] 16. The wireless communication system of aspect 15, wherein the electrical assembly of each of the one or more wireless end nodes further includes a memory storage,

[0079] wherein, when the wireless end node is operating in the long term storage mode and the sleep timer of the wireless end node counts down the long term storage time period, the controller is configured to power up, determine the power source level of the power source, and compare the power source level of the power source to an acceptable power source level threshold stored in the memory storage, and

[0080] wherein the wireless end node is configured to indicate a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0081] 17. The wireless communication system of aspects 15-16, wherein the long term storage time period is 24 hours.

[0082] 18. The wireless communication system of aspects 16-17, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

[0083] 19. The wireless communication system of aspects 16-18, wherein the electrical assembly of each of the one or more wireless end nodes further includes a light emitting diode light, and

[0084] wherein the light emitting diode light of each of the one or more wireless end nodes is configured to blink a red color light to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

[0085] 20. The wireless communication system of aspects 15-19, wherein the controller of each of the one or more wireless end nodes is configured to determine whether the wireless end node is decommissioned from the wireless communication system, and

[0086] wherein the controller of each of the one or more wireless end nodes is configured to set the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

[0087] 21. The wireless communication system of aspect 20, wherein the controller of each of the one or more wireless end nodes is configured to determine whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

[0088] With regard to the foregoing description, it is to be understood that changes may be made in detail, especially in matters of the construction materials employed and the shape, size and arrangement of the parts without departing from the scope of the present invention. It is intended that the specification and depicted embodiment to be considered exemplary only, with a true scope and spirit of the invention being indicated by the broad meaning of the claims.

What claimed is:

1. A method for preserving the power source life of a wireless end node prior to deployment in a wireless communication system comprising:

operating the wireless end node in a long term storage mode prior to deploying the wireless end node in a wireless communication system in order to reduce current being drawn from a power source of the wireless end node;

the wireless end node detecting an interrupt request to pair the wireless end node to a wireless communication system;

a controller of the wireless end node switching from a long term storage mode to a normal operation mode when the wireless end node is paired to a wireless communication system.

2. The method of claim **1** further comprising:

during the long term storage mode, powering the controller of the wireless end node after a sleep timer of the wireless end node determines a long term storage time period has lapsed to determine a power source level of a power source of the wireless end node;

the controller determining the power source level of the power source;

the controller comparing the power source level of the power source to an acceptable power source level threshold stored in a memory storage of the wireless end node; and

indicating a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

3. The method of claim **2**, wherein the long term storage time period is 24 hours.

4. The method of claim **2**, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

5. The method of claim **2**, blinking a red color light emitting diode light of the wireless end node to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

6. The method of claim 1, further comprising:
the controller determining whether the wireless end node is decommissioned from the wireless communication system; and
the controller setting the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

7. The method of claim 6, wherein the controller determines whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

8. A wireless end node for a wireless communication system comprising:
a power source;
an electrical assembly connected to the power source, the electrical assembly including:
a controller configured to manage, command, direct and regulate the behavior of the wireless end node and configured to switch operation of the wireless end node between a long term storage mode that reduces current being drawn from the power source and a normal operation mode, the controller including a sleep timer configured to count down a long term storage time period;
wherein the controller is configured to operate the wireless end node in the long term storage mode prior to deploying the wireless end node in a wireless communication system and is configured to switch from the long term storage mode to the normal operation mode when the wireless end node is paired to the wireless communication system.

9. The wireless end node of claim 8, wherein the electrical assembly further includes a memory storage,
wherein, when the wireless end node is operating in the long term storage mode and the sleep timer of the wireless end node counts down the long term storage time period, the controller is configured to power up, determine the power source level of the power source, and compare the power source level of the power source to an acceptable power source level threshold stored in the memory storage, and
wherein the wireless end node is configured to indicate a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

10. The wireless end node of claim 8, wherein the long term storage time period is 24 hours.

11. The wireless end node of claim 9, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

12. The wireless end node of claim 9, wherein the electrical assembly further includes a light emitting diode light, and
wherein the light emitting diode light is configured to blink a red color light to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

13. The wireless end node of claim 8, wherein the controller is configured to determine whether the wireless end node is decommissioned from the wireless communication system, and
wherein the controller is configured to set the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

14. The wireless end node of claim 13, wherein the controller is configured to determine whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

15. A wireless communication system for a mobile environment comprising:
one or more wireless end nodes, each of the one or more wireless end nodes including:
a power source;
an electrical assembly connected to the power source, the electrical assembly including:
a controller configured to manage, command, direct and regulate the behavior of the wireless end node and configured to switch operation of the wireless end node between a long term storage mode that reduces current being drawn from the power source and a normal operation mode, the controller including a sleep timer configured to count down a long term storage time period;
wherein the controller is configured to operate the wireless end node in the long term storage mode prior to deploying the wireless end node in a wireless communication system and is configured to switch from the long term storage mode to the normal operation mode when the wireless end node is paired to the wireless communication system;
a network coordinator connected to each of the one or more wireless end nodes.

16. The wireless communication system of claim 15, wherein the electrical assembly of each of the one or more wireless end nodes further includes a memory storage,
wherein, when the wireless end node is operating in the long term storage mode and the sleep timer of the wireless end node counts down the long term storage time period, the controller is configured to power up, determine the power source level of the power source, and compare the power source level of the power source to an acceptable power source level threshold stored in the memory storage, and
wherein the wireless end node is configured to indicate a low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

17. The wireless communication system of claim 15, wherein the long term storage time period is 24 hours.

18. The wireless communication system of claim 16, wherein the acceptable power source level threshold is 2.9 volts for a 3.6 volt battery.

19. The wireless communication system of claim 16, wherein the electrical assembly of each of the one or more wireless end nodes further includes a light emitting diode light, and
wherein the light emitting diode light of each of the one or more wireless end nodes is configured to blink a red color light to indicate the low level power source when the controller determines that the power source level of the power source is below the acceptable power source level threshold.

20. The wireless communication system of claim 15, wherein the controller of each of the one or more wireless end

nodes is configured to determine whether the wireless end node is decommissioned from the wireless communication system, and

wherein the controller of each of the one or more wireless end nodes is configured to set the wireless end node to operate in the long term storage mode when the controller determines that the wireless end node is decommissioned from the wireless communication system.

21. The wireless communication system of claim **20**, wherein the controller of each of the one or more wireless end nodes is configured to determine whether the wireless end node is decommissioned from the wireless communication system every 24 hours.

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