SYSTEM AND METHOD OF MINIMIZING ENERGY CONSUMPTION IN AN AD-HOC WIRELESS NETWORK

Field of the Invention

[0001] The present invention generally relates to wireless networks, and more particularly to a system that is capable of minimizing energy consumption in an ad-hoc wireless network, and further to a method for minimizing energy consumption in an ad-hoc wireless network.

Background of the Invention

[0002] A typical ad-hoc wireless network setup comprises one or more wireless end devices (*i.e.*, sensor nodes) that are usually powered by batteries. In operation, the sensor nodes need to be active (*e.g.*, awake) when they are sending/receiving data; in order to keep the sensor nodes awake, the energy consumption is high. However, the sensor nodes do not need to send/receive data all the time; thus the energy consumed when the sensor nodes are unnecessarily active is wasted, resulting in shortened life spans for batteries.

[0003] One way to save energy consumption by sensor nodes in an ad-hoc wireless network was using a scheduling message that selectively powers-on or powers-off one or more sensor nodes at scheduled times. As shown in FIG 1, the process starts when monitor point receives affiliation messages from neighboring sensor nodes **1205**; then monitor point inserts node IDs from affiliation messages into database "Affiliated Children IDs" data **1210**; then monitor point constructs "Tx/Rx schedule" based on the number of affiliated children **1215**; then monitor point transmits schedule message to affiliated sensor nodes containing monitor point's "transmitting node ID", "Parent Tx", and "next tier activity" **1220**; and finally checking whether the schedule message is received **1225**; if not received, resend the schedule message at regular intervals **1230**. It is apparent that the sensor nodes in the ad-hoc wireless network are powered-on or powered-off according to the preset schedules.

[0004] In a similar approach, a controller in a wireless sensor network selectively switches on node devices according to a timetable; the node devices maintain synchronization with and receive beacon transmissions from other nodes in the wireless sensor network. If a failure is observed in previously maintained synchronization, the controller reads from memory previously received information about neighboring nodes with which said node device did not yet maintain synchronization; the controller utilizes such stored information to selectively switch on the receiver to attempt receiving a beacon transmission from such a neighboring node.

[0005] While the timetable- or schedule-based approaches are straightforward in achieving their intended objective in saving energy consumption in the wireless networks, they are short in many other objectives. For example, when there is a need to switch on sensor nodes non-periodically (i.e., at-will), the timetable- or schedule-based approaches will fail.

[0006] Therefore, it would be useful to have a wireless network that enables its sensor nodes to be switched on non-periodically and at the same time has minimized energy consumption.

Summary of the Invention

[0007] One embodiment of the present invention provides an energy saving system being capable of implementation in an ad-hoc wireless network that comprises at least one coordinator and one or more end devices, wherein the one or more end devices send data back to or receive from the coordinator. In one embodiment, the energy saving system comprises at least one RF transmitter being electronically coupled with the at least one coordinator, wherein the at least one RF transmitter controlled by the coordinator is able to send RF assert signals; and one or more RF receivers, wherein at least one of the one or more RF receives is electronically coupled to one of the one or more end devices and capable of receiving the RF assert signals sent by the at least one RF transmitter; whereby the one or more RF receivers are on all the time so that the coordinator is able to activate the end devices from a power saving mode to a ready mode for data transmission non-periodically by sending the RF assert signals to the RF receivers electronically coupled

with the end devices; and whereby the end devices are in the power saving mode during the period without data transmission, thus saving energy for the ad-hoc wireless system.

[0008] In another embodiment of the energy saving system, the end device comprises a DATA transmitter/receiver, sensors, memory, digital I/Os and processing unit. In a further embodiment of the energy saving system, the sensors are selected from the group consisting of acoustic sensors, motion-detection sensors, radar sensors, sensors that detect specific chemicals or families of chemicals, sensors that detect nuclear radiation or biological agents, magnetic sensors, electronic emissions signal sensors, thermal sensors, and visual sensors that detect or record still or moving images in the visible or other spectrum.

[0009] In another embodiment of the energy saving system, the end devices in the ad-hoc wireless network have a multi-hops configuration; thereby the ad-hoc wireless network is segmented to let each end device have the data transmission path with the lowest aggregated bps/watt. In a further embodiment of the energy saving system, the data transmission path with the lowest aggregated bps/watt is determined by during initial network setup, transmitting by each end device various test packets to the coordinator; wherein the test packets is embedded with the power consumption associated with transmitting the test packets; and determining by the coordinator the data transmission path with the lowest aggregated bps/watt for each end device along the wireless network based on the test packets with the power consumption information; whereby the data transmission paths with the lowest aggregated bps/watt are designated as segments, wherein each end device is assigned a unique RF code to determine which segment it is on; thereby in actual operations, only the intermediate devices along the segment are activated by the RF assert signal to effect data transfer, thereby reducing power consumption of the network.

[0010] In another embodiment of the energy saving system, the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end device; wherein the n is an even number. In a further embodiment of the energy saving system, the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.

[0011] Another embodiment of the present invention provides an ad-hoc wireless network. In one embodiment, the ad-hoc wireless network comprises at least one coordinator; at least one RF transmitter being electronically coupled with the at least one coordinator, wherein the at least one RF transmitter controlled by the coordinator is able to send RF assert signals; one or more end devices, wherein the one or more end devices send data back to or receive from the coordinator; and one or more RF receivers, wherein at least one of the one or more RF receives is electronically coupled to one of the one or more end devices and capable of receiving the RF assert signals sent by the at least one RF transmitter; whereby the one or more RF receivers are on all the time so that the coordinator is able to activate the end devices from a power saving mode to a ready mode for data transmission non-periodically by sending the RF assert signals to the RF receivers electronically coupled with the end devices; and whereby the end devices are in the power saving mode during the period without data transmission, thus saving energy for the ad-hoc wireless system. In a further embodiment of the ad-hoc wireless network, the coordinator comprises a DATA transmitter/receiver, memory for storing information, processing unit, Input devices, and output devices. In yet another further embodiment of the ad-hoc wireless network, the coordinator is a computer, microprocessor, PDA, or laptop. In yet another further embodiment of the ad-hoc wireless network, the end device comprises a DATA transmitter/receiver, sensors, memory, digital I/Os, and processing unit. In still another further embodiment of the ad-hoc wireless network, the sensors are selected from the group consisting of acoustic sensors, motion-detection sensors, radar sensors, sensors that detect specific chemicals or families of chemicals, sensors that detect nuclear radiation or biological agents, magnetic sensors, electronic emissions signal sensors, thermal sensors, and visual sensors that detect or record still or moving images in the visible or other spectrum.

[0012] In another embodiment of the ad-hoc wireless network, the end devices in the ad-hoc wireless network have a multi-hops configuration; thereby the ad-hoc wireless network is segmented to let each end device have the data transmission path with the lowest aggregated bps/watt. In a further embodiment of the ad-hoc wireless network, the data transmission path with the lowest aggregated bps/watt is determined by during initial network setup, transmitting by each end device various test packets to the coordinator; wherein the test packets is embedded with the power consumption associated with

transmitting the test packets; and determining by the coordinator the data transmission path with the lowest aggregated bps/watt for each end device along the wireless network based on the test packets with the power consumption information; whereby the data transmission paths with the lowest aggregated bps/watt are designated as segments, wherein each end device is assigned a unique RF code to determine which segment it is on; thereby in actual operations, only the intermediate devices along the segment are activated by the RF assert signal to effect data transfer, thereby reducing power consumption of the network.

[0013] In another embodiment of the ad-hoc wireless network, the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end device; wherein the n is an even number. In a further embodiment of the ad-hoc wireless network, the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.

[0014] In another embodiment of the ad-hoc wireless network, the coordinator is movable within the network.

[0015] Another embodiment of the present invention provides a method for reducing energy consumption in an ad-hoc wireless network, wherein the ad-hoc wireless network comprises at least one coordinator and a plurality of end devices, wherein at least one RF transmitter is electronically coupled with the at least one coordinator and able to send RF assert signals to the end devices, and wherein at least one RF receiver is electronically coupled with each of the plurality of end devices and is always on so as to be able to receive the sent RF assert signals from the coordinator; said method comprising performing by the RF transmitter to send the RF assert signals to the end devices; performing by the RF receivers to receive the sent RF assert signals; and activating the end devices from a power saving mode to a ready mode for data transmission to the coordinator if the sent RF assert signals are intended for the end devices; whereby the end devices are in power saving mode when they are not activated by the sent assert signals, reducing the energy consumption of the wireless network.

[0016] In another embodiment of the method, the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end

device; wherein the n is an even number. In a further embodiment of the method, the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.

[0017] The objectives and advantages of the invention will become apparent from the following detailed description of preferred embodiments thereof in connection with the accompanying drawings.

Brief Description of the Drawings

[0018] Preferred embodiments according to the present invention will now be described with reference to the Figures, in which like reference numerals denote like elements.

[0019] FIG 1 shows a process of utilizing schedule messages to switch on sensor nodes in a wireless network known in the prior art.

[0020] FIG 2 is a diagram showing one coordinator and one end device illustrating the simplest form of an ad-hoc wireless network of the present invention.

[0021] FIG 3 is a functional block diagram of the coordinator in accordance with one embodiment of the present invention.

[0022] FIG 4 is a functional block diagram of the end device in accordance with one embodiment of the present invention.

[0023] FIG 5 shows an exemplary network during the initialization with possible transmission paths.

[0024] FIG 6 shows the optimal paths determined for the network shown in FIG 5.

[0025] FIG 7 shows a flowchart of segmenting an exemplary wireless network and selecting the path with the lowest aggregate bps/watt in accordance with one embodiment of the present invention.

[0026] FIG 8 is an exemplary diagram for RF signal activating end device in accordance with one embodiment of the present invention.

Detailed Description of the Invention

[0027] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0028] Throughout this application, where publications are referenced, the disclosures of these publications are hereby incorporated by reference, in their entireties, into this application in order to more fully describe the state of art to which this invention pertains.

[0029] The present invention provides an ad-hoc wireless network that is capable of switching on one or more end devices non-periodically and at the same time has minimized energy consumption. For better clarification, the following discussions will use limited number of coordinators and end devices as examples, but it is to be noted that the operation of the principles of the present invention are not so limited.

[0030] Now referring to FIG 2, there is provided a simplest form of an ad-hoc wireless network of the present invention. The ad-hoc wireless network **1** comprises a coordinator **10** and an end device **20**, where the coordinator **10** and end device **20** communicate with each other wirelessly, transmitting/receiving data from the other side. Usually, the coordinator is electrically coupled to mains, thus the battery life is not an issue for the coordinator; in contrast, end devices are usually powered by batteries, thus the conservation of battery powers for end devices is of concerns.

[0031] As shown in FIG 2, the ad-hoc wireless network comprises a RF transmitter **11** that is electronically coupled with the coordinator so that the coordinator instructs the RF transmitter to send RF signals, and a RF receiver **21** that is electronically coupled with the end device so that the RF receiver receives the RF signals from the RF transmitter and consequentially switches on the end device. The RF transmitter **11** may be integrated into the coordinator; it can also be an independent part that can be plugged into the coordinator. The RF receiver **21** may be integrated into the end device; it can also be an independent part that can be plugged into the end device. Without wish to be bound any particular theories, the minimization of energy consumption by the end device is achieved by the utilization of the RF receiver. The inventors of the present invention discovers that the end device consumes large amount of power (about 50mA) in the IDLE (ready) mode, but consumes much less amount of power (less than 10uA) in the HIBERNATE (power

saving) mode; thus when the end device is kept in a HIBERNATE mode when not being used, it will significantly reduce the energy consumption. The inventors of the present invention further discovers that the RF receiver consumes less than 5mA of current for the same voltage, using the RF receiver to wake up the end-device on demand resulting in a reduction of energy consumption by a factor of 10 on the side the end device. It is to be noted that actual energy consumption will depend upon the actual energy consumption by the end device and RF receiver. It is apparent that the utilization of RF receiver to wake up the end device from a HIBERNATE mode to an IDLE mode on demand saves the energy consumption by the end device and at the same time enables the wireless network to wake up the end device non-periodically (*i.e.*, at will) for the RF receiver is always on.

[0032] Now referring to FIG 3, there is provided a functional block diagram of the coordinator in accordance with one embodiment of the present invention. The coordinator **10** comprises a RF Transmitter **11** as aforedescribed, a DATA transmitter/receiver **12** known in the art, clock **13**, memory **14** for storing information, processing unit **15**, Input devices **16**, and output devices **17**. The modules are electronically coupled with each other; their configurations are well known to one skilled in the art. The coordinator may be any suitable electronic apparatus including computer, microprocessor, PDA, laptop or the like.

[0033] Processing unit may perform all data processing functions for inputting, outputting and processing of data including data buffering and end device control functions. Memory may include random access memory (RAM) and/or read only memory (ROM) that provides permanent, semi-permanent, or temporary working storage of data and instructions for use by processing unit in performing processing functions. Memory may also include large capacity storage devices, such as magnetic and/or optical recording devices. Output devices may include conventional mechanisms for outputting data in video, audio and/or hard copy format. For example, output devices may include a conventional display for displaying sensor measurement data. Input devices may permit entry of data into end device. Input devices may include, for example, a touch pad or keyboard. Clock may include conventional circuitry for maintaining a time base to enable the maintenance of a local time. Alternatively, the coordinator may derive a local time from an external clock signal, such as, for example, a GPS signal, or from an internal clock synchronized to an external time base.

[0034] In addition, the coordinator may further connect to another microprocessor via a network. Network may include one or more networks of any type, including a Public Land Mobile Network (PLMN), Public Switched Telephone Network (PSTN), Local Area Network (LAN), Metropolitan Area Network (MAN), Wide Area Network (WAN), Internet, or Intranet.

[0035] Now referring to FIG 4, there is provided a functional block diagram of the end device in accordance with one embodiment of the present invention. As shown in FIG 4, the end device **20** comprises a RF receiver **21**, DATA transmitter/receiver **22**, sensors **23**, memory **24**, digital I/Os **26**, and processing unit **25**. Other than the sensors, the components in the end device are similar to the ones as described in the coordinator. The sensors suitable for the present invention include one or more of any types of conventional sensing device, such as acoustic sensors, motion-detection sensors, radar sensors, sensors that detect specific chemicals or families of chemicals, sensors that detect nuclear radiation or biological agents, magnetic sensors, electronic emissions signal sensors, thermal sensors, and visual sensors that detect or record still or moving images in the visible or other spectrum. Sensors may perform one or more measurements over a sampling period and transmit the measured values via packets, datagrams, cells or the like to coordinator.

[0036] Now referring back to FIG 2, there is provided a brief description of the operation of the two-component wireless network. First, the RF transmitter **11** at the coordinator **10** sends an assert signal to the end device **20**; then the RF receiver **21** at the end device **20** receives the assert signal and the received assert signal wakes up the end device from the HIBERNATE mode to the IDLE mode; and finally the end device **20** transmits data to or receive data from the coordinator. After the completion of data transmission, the end device falls back to the HIBERNATE mode until another assert signal wakes it up.

[0037] The present invention further provides an ad-hoc wireless network that provides the highest transmission rate with the lowest power consumption level. Prior to any detailed discussion, it is to be noted that the practice of the present invention is not limited to any specific number of devices or any specific configuration; the simplified version of the network used herein for description is employed for the sole purpose of clarification for illustrating the principles of the present invention. As shown in FIG 5, the ad-hoc wireless network comprises one coordinator and four end devices, where there are

multi-hops across intermediate nodes before reaching the destination coordinator; for instance, the data transmitted from the furthest end device to the coordinator can go through paths 1, 2, 3 and 4. Apparently, each path has its own transmission rate and energy consumption. The present invention provides to predetermine bps per watt of data for each possible data path.

[0038] Referring to FIG 5, during initial network setup, each end device transmits various test packets to the coordinator; along with the test packets, the power consumption associated with transmitting the test packets is also relayed; and the intermediate end devices will then relay the test packets with the power consumption back to the coordinator. Then the coordinator determines the optimal path for each end device along the wireless network based on the test packets with the power consumption information. FIG 6 shows an exemplary optimal paths for the wireless network shown in FIG 5, where the optimal paths are determined by the test packets as aforedescribed. The optimal paths are designated as segments, where each end device is assigned a unique RF code to determine which segment it is on. In actual operations, only the intermediate devices along the optimal transmission path (segment) will be activated by the RF signal to effect data transfer, thereby reducing power consumption of the network.

[0039] Now referring to FIG 6, there is provided a brief description of data transmission via segment 1. First, the coordinator sends out the RF signal for end devices located on segment 1; the intermediate end device along the segment 1 will be switched from "HIBERNATE" to "IDLE" mode to enable data forwarding, and the furthest end device along the segment 1 will be awakened from "HIBERNATE" to "IDLE" mode so as to be able to send data back to or receive from the coordinator; once the data transmission and forwarding are done, the end devices along segment 1 will again go back to the "HIBERNATE" mode. During the operation, other end devices will receive the RF signal, but the received RF signal will not trigger the end devices because the RF signal is not for their segment.

[0040] FIG 7 shows a flowchart of segmenting an exemplary wireless network and selecting the path with the lowest aggregate bps/watt in accordance with one embodiment of the present invention. For an ad-hoc wireless network with a coordinator and a plurality of end devices, the initializing and configuring step **71** positions end devices in a desired field; then in the step of sending test packets **72**, each end device sends test packets back to

the coordinator via all possible paths, where the test packets are embedded with associated power consumption to effect transmission and corresponding data rate; then in the step of calculation **73**, the coordinator calculates total bps/watt for each possible data path based on information returned by the test packets; then the coordinator selects the lowest bps/watt for each device and segments the network so that each end device sends the data back to receive from the coordinator via the path with the lowest aggregate bps/watt **74**; and finally the segmented network is ready for effecting data transmission **75** via the lowest aggregate bps/watt path while not affecting other end devices in the network.

[0041] Now referring to FIG 8, there is provided an exemplary diagram for RF signal activating end device in accordance with one embodiment of the present invention. In one example scenario, 8-bit data is used for segmentation and activation; out of the 8 data bit, only one bit is needed for waking up the end devices whereas the destination addresses are determined by the remaining 7 bits, which match the segmentation code preset at the end devices through simple DIP-switches. In actual operation, the RF transmitter from the coordinator sends out the data through serial port such as those from RS232 protocol; at the end device, a RF receiver **81** receives signal data in serial form from the RF transmitter. The serial data is then converted into parallel form by serial-to-parallel converter **83**. The comparator **84** compares the first 7 address bit with the address set by the DIP switch **82**. If the address matches each other, "1" will be produced and "AND" from the AND Gate **85** with the data bit to wake up the end device **86**.

[0042] The present invention further provides an ad-hoc wireless network with a movable coordinator. The mobility provided by a moving coordinator further reduces the needs to activate end devices unnecessarily as only those within the coverage zone and of interests to the data acquisition are activated; the remaining end devices will be placed in the power saving "HIBERNATE" mode.

[0043] The present invention significantly minimizes the power consumption by end devices in an ad-hoc wireless network and at the same time enables the wireless network to activate any end devices non-periodically (*i.e.*, at will). The present invention achieves its objectives by placing the end devices in a "HIBERNATE" (power saving) mode and keeping a RF receiver on all the time for receiving any assert signal from the RF transmitter of a coordinator, where the RF receiver associated with the end device consumes much less power than that of the end device.

[0044] In addition, in a typical ad-hoc wireless network, there may be multi-hops across intermediate nodes before reaching the destination coordinator. Using this invention, the network is able to predetermine optimal path for each node along the wireless network during initial system setup. In actual operation, only the intermediate nodes along the optimal transmission path will be activated by the RF signal to effect data transfer thereby reducing power consumption of the network. In calculating and selecting the optimal path, the system takes into consideration, the bits per second (bps) per watt associated with each path before selecting the optimal path.

[0045] While the present invention has been described with reference to particular embodiments, it will be understood that the embodiments are illustrative and that the invention scope is not so limited. Alternative embodiments of the present invention will become apparent to those having ordinary skill in the art to which the present invention pertains. Such alternate embodiments are considered to be encompassed within the spirit and scope of the present invention. Accordingly, the scope of the present invention is described by the appended claims and is supported by the foregoing description.

CLAIMS

What is claimed is:

1. An energy saving system being capable of implementation in an ad-hoc wireless network that comprises at least one coordinator and one or more end devices, wherein the one or more end devices send data back to or receive from the coordinator; said energy saving system comprising:

at least one RF transmitter being electronically coupled with the at least one coordinator, wherein the at least one RF transmitter controlled by the coordinator is able to send RF assert signals; and

one or more RF receivers, wherein at least one of the one or more RF receives is electronically coupled to one of the one or more end devices and capable of receiving the RF assert signals sent by the at least one RF transmitter;

whereby the one or more RF receivers are on all the time so that the coordinator is able to activate the end devices from a power saving mode to a ready mode for data transmission non-periodically by sending the RF assert signals to the RF receivers electronically coupled with the end devices; and whereby the end devices are in the power saving mode during the period without data transmission, thus saving energy for the ad-hoc wireless system.

2. The energy saving system of claim 1, wherein the end device comprises a DATA transmitter/receiver, sensors, memory, digital I/Os, and processing unit.

3. The energy saving system of claim 2, wherein the sensors are selected from the group consisting of acoustic sensors, motion-detection sensors, radar sensors, sensors that detect specific chemicals or families of chemicals, sensors that detect nuclear radiation or biological agents, magnetic sensors, electronic emissions signal sensors, thermal sensors, and visual sensors that detect or record still or moving images in the visible or other spectrum.

4. The energy saving system of claim 1, wherein the end devices in the ad-hoc wireless network have a multi-hops configuration; thereby the ad-hoc wireless network is segmented to let each end device have the data transmission path with the lowest aggregated bps/watt.

5. The energy saving system of claim 4, wherein the data transmission path with the lowest aggregated bps/watt is determined by:

during initial network setup, transmitting by each end device various test packets to the coordinator; wherein the test packets is embedded with the power consumption associated with transmitting the test packets; and

determining by the coordinator the data transmission path with the lowest aggregated bps/watt for each end device along the wireless network based on the test packets with the power consumption information;

whereby the data transmission paths with the lowest aggregated bps/watt are designated as segments, wherein each end device is assigned a unique RF code to determine which segment it is on;

thereby in actual operations, only the intermediate devices along the segment are activated by the RF assert signal to effect data transfer, thereby reducing power consumption of the network.

6. The energy saving system of claim 1, wherein the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end device; wherein the n is an even number.

7. The energy saving system of claim 6, wherein the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.

8. An ad-hoc wireless network, comprising:

at least one coordinator;

at least one RF transmitter being electronically coupled with the at least one coordinator, wherein the at least one RF transmitter controlled by the coordinator is able to send RF assert signals;

one or more end devices, wherein the one or more end devices send data back to or receive from the coordinator; and

one or more RF receivers, wherein at least one of the one or more RF receives is electronically coupled to one of the one or more end devices and capable of receiving the RF assert signals sent by the at least one RF transmitter;

whereby the one or more RF receivers are on all the time so that the coordinator is able to activate the end devices from a power saving mode to a ready mode for data transmission non-periodically by sending the RF assert signals to the RF receivers electronically coupled with the end devices; and whereby the end devices are in the power saving mode during the period without data transmission, thus saving energy for the ad-hoc wireless system.

9. The ad-hoc wireless network of claim 8, wherein the coordinator comprises a DATA transmitter/receiver, memory for storing information, processing unit, Input devices, and output devices.

10. The ad-hoc wireless network of claim 8, wherein the coordinator is a computer, microprocessor, PDA, or laptop.

11. The ad-hoc wireless network of claim 8, wherein the end device comprises a DATA transmitter/receiver, sensors, memory, digital I/Os, and processing unit.

12. The ad-hoc wireless network of claim 11, wherein the sensors are selected from the group consisting of acoustic sensors, motion-detection sensors, radar sensors, sensors that detect specific chemicals or families of chemicals, sensors that detect nuclear radiation or biological agents, magnetic sensors, electronic emissions signal sensors, thermal sensors, and visual sensors that detect or record still or moving images in the visible or other spectrum.

13. The ad-hoc wireless network of claim 8, wherein the end devices in the ad-hoc wireless network have a multi-hops configuration; thereby the ad-hoc wireless network is segmented to let each end device have the data transmission path with the lowest aggregated bps/watt.

14. The ad-hoc wireless network of claim 13, wherein the data transmission path with the lowest aggregated bps/watt is determined by:

during initial network setup, transmitting by each end device various test packets to the coordinator; wherein the test packets is embedded with the power consumption associated with transmitting the test packets; and

determining by the coordinator the data transmission path with the lowest aggregated bps/watt for each end device along the wireless network based on the test packets with the power consumption information;

whereby the data transmission paths with the lowest aggregated bps/watt are designated as segments, wherein each end device is assigned a unique RF code to determine which segment it is on;

thereby in actual operations, only the intermediate devices along the segment are activated by the RF assert signal to effect data transfer, thereby reducing power consumption of the network.

15. The ad-hoc wireless network of claim 8, wherein the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end device; wherein the n is an even number.

16. The ad-hoc wireless network of claim 15, wherein the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.

17. The ad-hoc wireless network of claim 8, wherein the coordinator is movable within the network.

18. A method for reducing energy consumption in an ad-hoc wireless network, wherein the ad-hoc wireless network comprises at least one coordinator and a plurality of end devices, wherein at least one RF transmitter is electronically coupled with the at least one coordinator and able to send RF assert signals to the end devices, and wherein at least one RF receiver is electronically coupled with each of the plurality of end devices and is always on so as to be able to receive the sent RF assert signals from the coordinator; said method comprising:

performing by the RF transmitter to send the RF assert signals to the end devices;

performing by the RF receivers to receive the sent RF assert signals; and

activating the end devices from a power saving mode to a ready mode for data transmission to the coordinator if the sent RF assert signals are intended for the end devices;

whereby the end devices are in power saving mode when they are not activated by the sent assert signals, reducing the energy consumption of the wireless network.

19. The method of claim 18, wherein the RF assert signal is an n-bit serial data including the codes for activation of end devices and the identification of each end device; wherein the n is an even number.

20. The method of claim 19, wherein the end device comprises a serial-to-parallel converter for converting the n-bit serial data into parallel form, a comparator for comparing the identification code in the serial data with the address of the end device set by a DIP switch, and an AND gate for activating the end device when there is a match between the identification code and the end device address.