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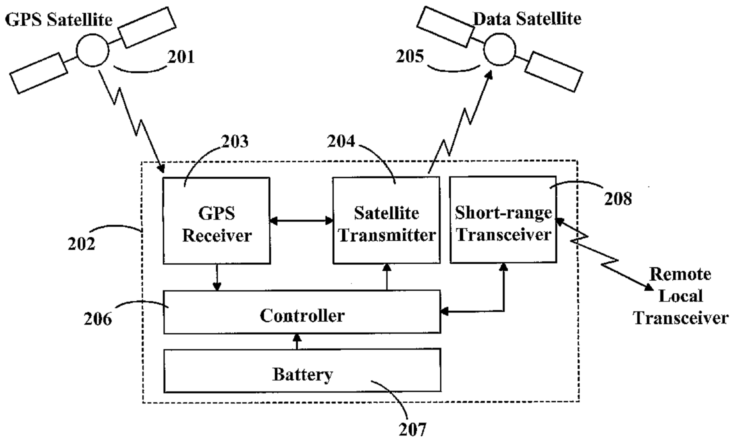
(54) Title: ASSET MANAGEMENT DEVICE AND METHOD USING SIMPLEX SATELLITE TRANSMITTER AUGMENTED WITH LOCAL AREA TRANSCEIVER



(57) Abstract: A device, method, and computer program product for monitoring and transmitting a location and a local status of a remote device using a satellite transmitter is provided. The monitoring device includes a position location unit, a satellite transmitter, a power source, a controller, and a short-range radio transceiver. The position location unit is configured to determine a location of the remote device. The satellite transmitter is configured to transmit the location to one or more satellites in low earth orbit. The controller includes a power management unit configured to control a power state of the position location unit and the satellite transmitter, and to periodically enable and disable power from the power source to the position location unit and the satellite transmitter. The short-range radio transceiver is used to configure and remotely manage the monitoring device and is used by the monitoring device to monitor local sensors wirelessly.

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ASSET MANAGEMENT DEVICE AND METHOD USING SIMPLEX SATELLITE TRANSMITTER AUGMENTED WITH LOCAL AREA TRANSCEIVER

FIELD OF THE INVENTION

The present invention relates to the monitoring of mobile and remote endpoint devices over a very large area of service.

BACKGROUND OF THE INVENTION

Asset management is a critical part of any business entity engaged in the transfer of raw or finished goods. It is important to carefully manage re-supply of raw materials to ensure that the manufacturing or service element of an industry does not halt and to carefully manage transportation of finished goods to minimize inventory held for sale. Those companies that do not optimize manufacturing and materials handling are at a significant disadvantage.

The proliferation of location based services, devices, and methods in the past decade is a testimony to the market need for an effective means for locating and managing remote assets that are fixed or mobile. There exist several methods for collecting remote data wirelessly, including terrestrial and satellite based communications systems. The problem arises in collecting data from assets that do not have readily available power, such as cargo trailers, rail, and remote fixed assets such as pipelines, shear sensors, and the like.

The uncertainty associated with raw materials and finished goods in transit presents a problem in asset management. Companies generally operate with an element of uncertainty as to the exact time of delivery or location of pending delivery for products and raw materials in transit. Unforeseen conditions impacting the arrival of truck, rail, or other vessel deliveries are impossible to predict and difficult to model. Real-time information about materials in transit can be used to forecast deliveries, schedule manpower and other materials, and predict finished goods inventory supply.

The transportation industry suffers from in-transit cargo theft and loss. Loss of cargo happens in a wide variety of ways, from employee/driver theft to the organized capture of entire fleets of trailers and rail-cars. The transportation industry has been struggling to limit loss through radio communication means. The cellular telephone industry has enabled a host of communications products that are making an impact. These products provide many functions such as standard voice communication, data services, and real-time position reporting and status of vehicle operations such as speed, temperature, or brake conditions.

Conventional solutions typically rely on cellular communication systems or satellite communication systems. Existing technology solutions that rely on cellular coverage are generally not ubiquitous in coverage. Cellular coverage may be adequate for urban and major interstate routes but becomes unreliable in rural or sparsely populated regions. Additionally, a cellular network implemented primarily for voice communications is a poor solution for rail or vessel data communication. Also, as cellular technology advances, the protocols have transitioned from analog to digital and now to tri-band Global System for Mobile Communication (GSM). Thus, some communication systems developed only a few years ago are already obsolete.

Cellular communication asset management systems are inherently two-way in nature and thus require continuous line power for operation. This type of system does not operate effectively on battery power without periodic reconnection to line power such as an automotive power system.

Satellite based communication systems mitigate some of the problems associated with cellular asset management devices. For instance, satellite modems are not limited to the service coverage area of cellular telephone corridors. Instead, the area of service is related to the satellite system selected for use and thereby solves the problem of rural and vessel coverage.

Satellite asset management systems are preferred if the communication system can provide adequate information bandwidth to support the application requirements. Generally, satellite asset management systems are the successors of cellular systems and offer broadband feature sets such as Internet and voice over Internet-Protocol. Broadband satellite services are typically expensive and generally prone to communication failures due to weather and obstruction. Most asset management systems which utilize broadband satellite must package broadband services such as voice or Internet in order to justify the cost of the data bandwidth, even though the information for asset management is generally low-bandwidth in nature. This drives the cost of satellite-based asset management systems up.

The transmit power required to communicate to geo-stationary satellites imposes power system problems for a remote asset management device. Existing satellite asset management systems generally must incorporate transmit power amplifiers of up to 10 Watts to adequately operate. As most satellite communication systems impose tightly controlled spectral masks, digital communication systems must incorporate linear or nearly linear (Class A or Class AB) power amplifier architectures to prevent spectral re-growth. As a result, the transmit device must be designed to produce up to 10 Watts with amplifier architectures which are typically only 40% efficient. This creates difficult design limitations which require sufficient line power or high-density bulky battery systems to function.

Most satellite-based asset management systems use satellite architectures that are duplex in nature. In order to send data over a satellite, the remote device must generally negotiate a data channel. Even if the data is only one-way in nature, the communication modem must contain both receive and transmit capability to implement this negotiation. Remote asset management devices must both listen and transmit in order to facilitate data transfer to and from a remote device.

Both cellular and two-way satellite asset management systems require available line power or extensive battery systems to operate. Even existing systems equipped with low power operational states must utilize excessive power to manage two-way communications as well as transmit with sufficient energy to operate within the communications infrastructure.

Existing asset management devices are generally located on the tractor-cab of the truck, train, or vessel. This serves to locate the cargo while the load is attached. Unfortunately, when a load such as the trailer, rail-car, or barge is disconnected, the important information that provides value for asset management is lost. Trailers that get dropped-off by a driver may become lost for hours or days, resulting in the total loss of perishable loads or missing deadlines for non-perishable loads. Thus, inventory management becomes difficult and highly labor intensive to minimize misplaced loads.

Rail-car tracking systems generally lag in capability behind truck tracking systems. Since rail-cars remain on class 1 lines, the owners typically know when the rail-cars have passed checkpoints using barcode or visual identification systems. However, once the rail-cars are placed on class 2 or class 3 lines there is generally no real-time tracking. Additionally, customers often use rail-cars as temporary storage to delay offloading goods and maintain an average amount of storage of goods at the cost of the rail-fleet owner. Rail-fleet owners have a difficult time assessing demurrage charges because they may not know if the rail-car has been offloaded on schedule or where the rail-car is currently located. As a result, the only solution generally applied is to add new cars to the fleet to satisfy logistic problems of moving goods.

Barge and vessel owners generally are dependent on river pilots and deep-sea vessel operators for the location of goods using voice communication only. As such, commodity traders usually maintain a staff of logistics personnel to voice-track products as they are moved. A radio-telemetry product that works without a cellular infrastructure and without the requirement of available power can thus dramatically reduce the reliance of pilots and logistics staff.

There is thus an unmet need in the art for an asset management device that operates on an internal battery and provides years of service, utilizes satellite communication with a world-wide footprint, integrates Global Positioning Satellite service (GPS) providing world-wide location determination, utilizes remote configuration, and which provides for external data such as alarms and raw user data, enabling sophisticated endpoint monitoring.

SUMMARY OF THE INVENTION

It is a first object of this present invention to enable simplex transmitters for remote configuration through the use of an external interface, which can be a wired or a wireless interface such as a short-range radio transceiver interface. The present invention provides a system and method whereby the introduction of an external interface is extremely power efficient while providing utility of function. The present invention also provides a system and method whereby use of the external interface is extremely power efficient, and does not significantly impair the overall service life of the battery operated remote asset management device.

The introduction of an external interface introduces many new utilities as well as overcomes a significant shortcoming of the prior art. Since a simplex satellite transmitter is one-way, it is dependent on internally or locally initiated stimuli to engage alternate functional modes. For example, since it is not possible to talk to a remote asset management device that is field deployed, it is impossible to instruct such a device to alter a report schedule or initiate an extended low power state. Thus, it is an additional object of the present invention to provide an external interface to provide configuration, sensor monitoring, group detection and control, and long-range detection and control of host satellite asset management devices. The addition of the external interface, operating in a power efficient mode, serves to overcome deficiencies in the art.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other advantages and features of the present invention will become more apparent from the detailed description of exemplary embodiments of the invention given below with reference to the accompanying drawings.

Fig. 1 is a block diagram of a battery powered remote endpoint asset management device capable of ascertaining its location and relaying the location to an external satellite network.

Fig. 2 is a block diagram of a battery powered remote endpoint asset management device with additional functionality including the external interface shown as a short-range radio transceiver interface according to one embodiment of the present invention.

Fig. 3 is a block diagram of a battery powered remote endpoint asset management device with the additional functionality of a power efficient mode of operation for the short-range radio transceiver interface of one embodiment of the present invention.

Fig. 4 is an operational illustration of the use of a configuration tool enabled with a short-range radio transceiver interface used to configure one or more remote host satellite asset management devices according to one embodiment of the present invention.

Fig. 5 is an operational illustration of the use of a configuration tool enabled with a short-range radio transceiver interface used to configure one or more remote sensors to be monitored by a host satellite asset management device according to one embodiment of the present invention.

Fig. 6 is an operational illustration of the use of a gateway device enabled with a short-range radio transceiver interface used to configure one or more remote host satellite asset management devices or one or more remote sensors according to one embodiment of the present invention.

Fig. 7 is an operational illustration of the use of a remote controller used to control one or more gateway devices, each with a short-range radio transceiver interface used to configure one or more remote host satellite asset management devices according to one embodiment of the present invention.

Fig. 8 is an operational illustration of the use of an interrogator device used to initiate a satellite transmission from of one or more remote host satellite asset management devices according to one embodiment of the present invention.

Fig. 9 is an operational illustration of the use of one or more gateway devices to relay data from one or more remote host satellite asset management devices in one embodiment of the present invention.

Fig. 10 depicts the communication method for a power efficient short-range radio transceiver interface used in the remote host satellite asset management device of one embodiment of the present invention.

Fig. 11 depicts the communications interface between a remote host satellite asset management device and a slave device in one embodiment of the present invention.

Fig. 12 further defines the control registers used for managing the interface described in the embodiments of Figs. 10 and 11.

Fig. 13 depicts operation of the short-range transceiver link using gateway and repeater devices in one embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to the drawings, wherein like reference numerals designate identical or corresponding parts throughout the several views, preferred embodiments of the present invention are described.

Fig. 1 illustrates the functional blocks of a battery operated endpoint device for remote asset management as described in U.S. Patent Application Publication Number 20050171696, which in turn references U.S. Patent No. 4,977,577 and U.S. Patent No. 5,987,058, each assigned to the assignee of the present application, Axonn LLC, and each incorporated by reference herein.

Enclosure 102 depicts the physical enclosure of the asset management device. Internal to the enclosure 102 is a battery 107 used to power the location determination device 103. The location determination device 103 may be any means in the art for ascertaining the location of the endpoint device. For example, the location determination device 103 may derive the location using inertial navigation, barcode scan for waypoints, radio telemetry for fixed waypoints, or satellite data. Once the location has been ascertained by a location determination function, the location information is transmitted using a satellite transmitter 104 to the satellite system 105. This transmission function may be accomplished using any number of satellite communications means, such as a simplex satellite transmitter. Simplex communication as known in the art is a form of one-way communication that provides for a transmit or a receive path between two network components. The efficiencies of a simplex one-way satellite transmitter may be utilized to send data to a satellite constellation for relay to a ground receiver or network. The data may be distributed from the receiver gateways to end users using a variety of other terrestrial communication networks, such as the Internet. Battery 107 is a power source local to the device and provides power to the remote asset management device.

The embodiment of the present invention as shown in Fig. 2 adds several capabilities to the remote asset management device of Fig. 1. The addition of an external interface having a short-range radio transceiver overcomes many obstacles associated with use of a simplex satellite transmitter to manage assets. While an external interface having a radio frequency transceiver is described in various embodiments of the present invention, one of skill in the art will understand that the external interface can use any wireless frequency. One of skill in the art will also realize that the host controller 307 can be connected to one or more external interfaces, which can be collectively referred to as the "external interface." As described in various embodiments of the present invention, the external interface can have one or more wired or wireless interfaces, including a wireless external interface using radio frequency such as the short-range transceiver 308. For convenience only and to help illustrate the novelty of various embodiments of the present invention, the short-range transceiver external interface 308 may be discussed or illustrated as a separate physical or logical unit, such as item 308 in Fig. 3. Thus, while illustrated or discussed separately, one of skill in the art will realize that the short-range transceiver 308 is simply one type of external interface useable with embodiments of the present invention.

In Fig. 2, the remote asset management device 202 contains a location determination device such as a GPS receiver 203 which receives signals from the GPS satellite constellation 201. Location determination may also be accomplished in a variety of ways, with GPS employed in various embodiments. The satellite transmitter 204 relays information about the remote asset management device 202 to the satellite constellation 205. The satellite transmitter can be a two-way transmitter. The current embodiment utilizes a simplex transmitter. The short-range radio transceiver 208 is used by the asset management device 202 to communicate terrestrially to a remote device similarly enabled with a compatible radio transceiver.

Remote asset management device 202 includes a host interface controller 206 which performs several functions that add utility to the endpoint device. The primary function of the host interface controller 206 is power management. Thus, the host interface controller 206 can contain an algorithmic engine capable of enabling and disabling the functional blocks of the remote asset management device 202. The host interface controller 206 can therefore connect the battery 207 of the remote asset management device 202 to the GPS receiver 203, the satellite transmitter 204, and the short-range transceiver 208 to perform power management functions as necessary, such as disabling all functionality to set the unit 202 into a low power state. While in a low power state, the host interface controller 206 will use a variety of means to resume active power mode to perform the asset management function.

Fig. 3 provides another embodiment of the present invention useful for asset management. As in Fig. 2, the present embodiment is contained in an enclosure 302 suitable for numerous applications. The enclosure 302 in the present embodiment is designed to withstand the harsh environment of outdoor use for extended periods of time. The device retains the principal functions of location determination 303 derived from the satellite system 301, a satellite transmission means 304, a short-range radio transceiver 308, a battery 306, and a host controller 307. The host controller 307 includes hardware or algorithmic means to accomplish the functions depicted in the controller block. The controller 307 performs power management functions, placing the asset management device in reduced power states and resuming operational functions. The controller 307 may use the timer function to periodically or randomly engage operation. It may also use the event table or alternate event table or a combination of each to schedule operational functions. The controller 307 may include alarm detection means to initiate an unscheduled operational function. The controller 307 may include an external interface used by an external device to initiate an unscheduled operational function. Finally, the controller 307 may use a motion detection means to initiate an operational function. These controller 307 functions may also be used in various combinations to enable complex operational functions. The controller 307 functions can include a satellite transmission event and a local communication event via the short-range transceiver 308 means.

The current embodiment of the present invention can include external interfaces 309 used to bridge the communication between the controller 307 and any combination of external alarms, configuration devices, or communications devices. Additionally, the present invention may also include an optional power input 310 used to extend or replace the internal battery 306 function.

The short-range radio transceiver can be power managed to prevent undue degradation of service life through exhaustion of battery 306. Fig. 3 also depicts a data storage element 311 which provides for data logging of the asset management device 302. Data may be generated by the controller or received from remote sensors or data interfaces via the wired serial interface or over the wireless short-range transceiver interface 308.

Fig. 4 shows one embodiment of the present invention which does not require physical connection to an asset management device 403 for configuration. Fig. 4 depicts this function where the asset management device 403 incorporates the internal means and functions enclosed in 302. The short-range radio transceiver function 403 can be used to communicate with a configuration tool 405. The configuration tool 405 need only be in relative proximity to the asset management device 403 to configure it. Since the radio link is bidirectional, the configuration tool 405 can query the asset management device identification information to determine the precise device being configured. Similarly, the configuration tool 405 can communicate with one or more asset management devices 403, 404 within range of the short-range radio transceiver link. The configuration tool 405 can query each unique identification term and present them to the operator for individual or group selection. In this way, an operator may configure devices at depot maintenance while still in the packing crate, or individually in the initial configuration. The operator also has the ability to perform query or configuration functions in the field after the units have been deployed. Once configured, each unit resumes the operational functions of asset management as before, using the GPS satellite network 401 to determine location and relaying long-range data over the data satellite network 402. The present embodiment can use a LEO Data Satellite network.

Additionally, it is an object of the present invention to utilize a wireless external interface to enable use of wireless sensors, thus removing the need to install connecting wiring. Fig. 5 depicts both the use of wireless sensors 506 and 507 with asset management devices 503 and 504 as well as the use of the configuration tool 505 to properly configure each device. The sensors 506 and 507 may be any one of a variety of sensors including door switches, temperature, pressure, volume, dry contact closure, data logger sensors, and the like. These sensors operate on their own power, and upon determination of need to relay data to the asset management device 503 or the system, the sensors pass sensor data to the asset management device 503. The sensor may be tightly bound to a specific asset management device using identification data for each sensor and the asset management device. Tightly bound sensors send their data only to one asset management device.

Alternatively, the sensor may be loosely bound, enabled to communicate to any asset management device 503, 504 in range of the transceiver link 506, 507. In this mode, the sensor may be portable between asset management devices 503, 504. Examples of the utility provided would be a sensor affixed to a palette or mobile load that is transferred between trailers, each tagged with an asset management device 503. The portable sensor would therefore acquire any suitable asset management device 503 and thus relay data to the data satellite 502 while in transit. Other similar applications exist where the sensor must be portable.

The asset management device 503 may also support a multiplicity of wireless sensors. The current embodiment can support many wireless sensors as each sensor can contain a unique identification data term. The protocol implemented in one embodiment of the present invention supports up to 32 unique sensors, allowing for many palettes of cargo tagged with portable sensors to be monitored by one asset management device 503. Each sensor such as 506 or 507 would logically connect to a given asset management device 503 and use that device 503 to relay sensor data to the data satellite network 502.

The configuration tool 505 can be used to configure the sensors 506, 507 for operation either at time of deployment or subsequently in field use. The configuration tool 505 can configure an asset management device 503 as described previously by initiating a communication link and acting as a slave device. The configuration tool 505 can configure a sensor 506, 507 by initiating a communication link while acting as a master device with a reserved identification code that the sensors detect. Under normal operation the sensor monitors the master communications node of the asset management device, but can also detect the presence of the unique identification code of the configuration tool 505, and upon determining a tool is present could slave to the configuration tool 505. The configuration tool 505 could then configure the operational setting of each sensor 506, 507 and then release them to re-acquire the asset management device serving as the master communications node for that sensor network. Alternatively, a local stimulus to the sensor such as a switch or magnet activated relay switch could trigger the sensor 506 to engage configuration mode with the configuration tool 505.

Another object of an embodiment of the present invention is to provide for automated monitoring and configuration of asset management devices and sensors through the use of a gateway device 605 as depicted in Fig 6. The gateway device 605 can be a fixed asset used to monitor a specific region for the presence of assets that are equipped with the asset management device 603 or 604. The gateway device 605 can also be mobile. A single gateway device 605 can monitor one or more asset management devices and also the sensors 606, 607 that are bound to them. The gateway device 605 can be an asset management device with an external interface in various embodiments of the present invention.

The gateway device 605 may be configured to locally monitor a region, such as a depot service yard, and to detect the presence of assets as they arrive in the yard. Upon such detection, the gateway device 605 can alter the configuration of any or all detected assets. Such configuration changes may be a change in reporting, internal functions such as motion detection, mapping, frequency, or any other operational function local to the asset management device 603. It may also instruct the asset management device 603 to enter a low power state, thus reducing the power utilization and data messaging to the data satellite network 602. The gateway device 605 may also instruct the asset management device 603 to engage a low power state while in the presence of the gateway communications link, and then automatically resume operation upon detection of removal from the gateway device 605. In this way, the asset management device 603 can engage a low power mode and then resume normal reporting functions when the asset management device is relocated away from the gateway device 605.

The gateway device 605 may be used in a stand alone operation for managing short-range transceiver equipped assets 603 within a local region. Alternatively, the gateway device 605 could include a long-range communications function 608 to enable remote communications between the gateway device 605 and a remote controller. A gateway device 605 equipped with a long-range communications means may be connected to a local network containing local controllers or other gateway devices. In such a way, the effective range of the short-range transceiver could be extended through the use of a multiplicity of gateway devices communicating over a local network in order to more effectively provide short-range transceiver capability over an expanded range of service. A local controller function also connected to the network could manage each gateway device 605 to properly manage the remote asset management devices 603, 604 and sensors 606, 607 within range of the collective gateway devices. This controller function could reside in either a stand alone controller, or in one or more of the gateway devices 605 themselves acting as a network master.

Similarly, the long-range communications interface 608 could interface to a distant network, interfacing the gateway device 605 to a distant controller or network of controllers. The long-range communications interface can be a dedicated hard-wired line, public or private telephone, Internet, long-range wireless such as cellular, RF data link, satellite, or other similar means. The gateway device 605 can be controlled by a distant controller monitoring and controlling the operations of the asset management devices 603, 604 in range of the gateway device 605. The distant controller can be an asset management device with an external interface in various embodiments of the present invention.

Fig. 7 depicts an embodiment of the present invention for using local and distant networks and controllers to better manage and control widely distributed assets tagged with asset management devices enabled with short-range wireless transceivers. The long-range communications means of the gateway 705 can enable a private network where an asset manager could remotely monitor and control assets abroad. In this embodiment, the network 708 can be the public telephone network, the Internet, or other means to connect the distant controller 709 to a local network of asset management devices 703, 704 within the short-range transceiver operational range 706. The distant controller 709 can operate on multiple private and local networks 706, 707.

Another embodiment of the present invention provides for public or shared use of widely distributed gateway devices 705, each networked using the long-range communications means of each gateway device 705 in each gateway region 706, 707 over a long-range network 708 to a distant controller 709. In this embodiment, an asset manager could distribute posted commands for specific assets to a multiplicity of widely distributed gateway devices 705. Upon detection of the presence of the desired asset via the short-range transceiver link to any gateway device 705, the gateway device 705 can effect a change of configuration in the remote asset, and subsequently report the change to the central controller and asset manager. In such an embodiment, multiple asset managers could use the same network and same distributed gateway devices 705, accessing shared or unique sets of endpoint assets to gain widely distributed access to mobile assets. In such a way, gateway devices 705 widely distributed but networked using their intrinsic long-range communications means could act as a back-channel communications means not present in simplex communications. By intelligently selecting locations for networked gateway devices 705 such as truck stops, rail yards, interstate crossings, and high density asset nodes, the asset management device of the present invention becomes capable of receiving reconfiguration commands abroad for the majority of operating devices of a fleet.

Since each local network can operate with encryption, it is possible to use the gateway networks in a public manner. Gateway regions may be established and connected into a central network controller for use by a multiplicity of separate users or companies to collectively gain broader regional coverage than attainable using privately installed networks. Gateways 705 that are used in this manner can use the encryption keys tied to specific master identifications to access their own local master networks over any installed public gateway device 705.

For example, customers that install their gateway devices 705 to manage their own depot storage regions may connect to a public network accessible through a web-site over the Internet. Other companies similarly enrolling in the approach could add their gateway regions to the public network, such as interstate weigh stations and truck stops. Both companies may post commands at all connected gateway devices to perform specific functions for a unique master identification device upon detection. Once the local network master is in range of any of the public gateway devices, the gateway will use the customer supplied encryption key, secured by the network controller as private to the customer, and access the local network master to perform the specified function. In this way, the introduction of other gateway devices to the public network enables broader and broader control access to mobile asset management devices. The same architecture discussed as private using Fig. 7 applies to public use of gateways 705. If the controller depicted has broad public use, such as a user login with security, the users may access all gateways 705 connected to the network independent of the location or real ownership of the hardware box. The controller and gateways 705 would safeguard the encryption keys for each user and each local network master identification using standard user access control.

Another embodiment of the present invention uses the short-range transceiver capability of each asset management device to initiate a solicited transmission through an active interrogation function. Fig. 8 depicts the use of an interrogator device 801 which is a device enabled with a compatible short-range transceiver suitable for engaging a compatible asset management device 803. The interrogator device 801 operates within the effective range of the short-range transceiver 802. Assets 803 that enter this effective range are detected by the interrogation device 801, which in turn establishes a slave communication link to the asset management device 803. Using the slave communication link, the interrogator 801 can collect data from the asset management device 803 or trigger it to initiate a satellite function, such as transmit data to the data satellite 807 or ascertain location using the GPS satellite 806 and relay that information to the data satellite 807. The interrogation device 801 therefore functions as a local alarm input upon detection of an asset management device. The interrogation device 801 can also contain some history record to determine if the device in range is a new arrival. One mode of operation can use the history information to initiate an interrogation function upon new detection of an asset management device 803. Another mode of operation would be to interrogate periodically while an asset 803 is in range 802. Still another mode of operation would be to interrogate at a range of input power level or a range based on GPS location to make an entry and exit interrogation. The interrogator can be an asset management device with an external interface in various embodiments of the present invention.

As depicted in the embodiment of Fig. 8, the in-range asset management device 803 can be mobile, traveling down a path such as a road 805. The interrogation device 801 can be a roadside mounted device, detecting and initiating a GPS location message to the data satellite network 807. An out of range asset management device 804 would only perform a similar function upon entry into the range 802 of the interrogation device 801. A system as described here would provide a location and time tag for assets passing a fixed gate or checkpoint.

Another embodiment of the present invention enables extensions of range for the short-range transceiver function through the use of repeat enabled gateway devices. Fig. 9 depicts a gateway device 905 functioning in a repeater mode and relaying data between a multiplicity of asset management devices 903, 904 and the gateway device 906. In such a manner, the gateway device 906 may be able to access a wider distribution of asset management devices than is provided for by the range of the short-range transceiver function. This capability provides utility for assets that are disadvantageously positioned, such as stacked or loaded in the holds of ships or strung in lines such as loaded on a train. The repeater capability allows for a gateway device 906 or devices to stay in positive communications contact with the distributed asset 903, 904 management devices. The protocol of the short-range transceiver function incorporates repeat level data to ensure that repeated messages eventually terminate and thus a repeater will not continue to repeat a repeated message. Similarly, multiple repeaters can be used to further extend the effective range and provide multiple paths for data flow to provide better network integrity.

In embodiments of the present invention, the addition of a wireless interface to the short-range transceiver of the asset management tool provides powerful enhancements to existing functions and enables new capabilities. In order for the short-range transceiver function to work properly, it is necessary for the power utilization to be minimized in order to preserve the service life of the battery operated endpoint asset management devices and sensors. An efficient and innovative protocol is implemented in the present invention that enables the functions described herein while minimally impacting the battery life of the asset management device. The protocol described below causes a degradation of the product life of a few months over 8 years of service and requires approximately 10 uA of average current draw on the primary battery.

Figs. 10, 11, and 12 disclose embodiments of the protocol in use. The protocol and method provide for the creation of local networks, coexisting open local networks, coexisting closed local networks, distributed local and closed networks, bound and unbound sensors, configuration tools, interrogation, repeater, and gateway devices. A key aspect for each local network is that all devices on the network may operate predominately in the dormant or off mode.

Each local network is managed by a network master. The asset management device serves as the local network master in one embodiment of the present invention. Network slaves are devices that communicate only with the network master. Slave devices in the present invention are typically sensors, but can be asset management devices in various embodiments of the present invention. A key aspect in the present invention is that sensors are intelligent, performing the prescribed sensing function and using the network master most often as a communications conduit to the data system, which is a satellite system in one embodiment of the present invention. The network master predominately provides for the easy acquisition of slave devices.

To accomplish these goals, the network master as depicted in Fig. 10 continually generates a series of Network Master Idle Messages 1004 on a periodic basis. Each Network Master Idle Message 1004 contains one or more of the following data terms:

LEADER: data term used by the receiving device (network slave) to detect a message start.

MASTER ID: data term specific and unique to a network master device. This is the electronic serial number (ESN) of the asset management device.

CONTROL REGISTER: contains a set of data terms used to manage the local network. The Network Master Idle Message Control Register 1202 is further described in Fig. 12 where the specific terms contained include one or more of the following:

CNTRL/Type: a term denoting the device type acting as a network master.

CNTRL/Carton Manifest: a term denoting the network master holds a shipping carton data manifest in memory (used in product manufacturing packaging and shipping).

CNTRL/D: a term denoting the network master holds data in a local data store for collection by external network controller such as a repeater or gateway device.

RF Sequence Number: a term that enumerates the specific time window allocated to the Network Master Idle Message. The network master increments this sequence number between 0 to 31 and then repeats the sequence indefinitely. The range of sequence numbers is not critical to the operation of the method. 32 individual time slots can be used in one embodiment of the present invention to facilitate up to 32 different slave devices per network master. Each slave device may seize an available RF sequence number Time Division Multiple Access (TDMA) slot for responding to the master idle message and predominately use this slot for all communications to the network master. Optionally, a slave device may simply attempt to communicate on any channel time slot.

DITHER: a term that denotes the time period till next Network Master Idle Message. The messages generally occur periodically and are modified slightly with a randomization term to prevent adjacent network masters from locking and jamming each other.

ECRC: or checksum (CRC) term is a data validation term used to qualify the data integrity of the message for the receiver.

The network master repeatedly transmits the Network Master Idle Message, modifying the RF Sequence number. Following transmission of the message, the network master listens for any slave device to send a message as depicted on timeline expansion 1003. If no slave device message is detected, the network master resumes low power or sleep mode. The typical duty cycle for active versus inactive is 1:1000. The precise duty cycle is a tradeoff between response time for a slave device and battery live of the master device.

A slave device monitors the idle messages of the network master. When it needs to communicate to the master, it will respond in the time window immediately following the master idle message as shown in 1003. Optionally, in one embodiment of the present invention there is a subsequent acknowledgement from the master to the slave immediately following the slave response. If implemented, this acknowledgement confirms the message was received by the master device.

The network slave device transmits data to the network master using a Network Slave Response Message 1005 protocol. This message contains one or more of the following data terms:

LEADER: data term used by the receiving device (network master) to detect a message start.

MASTER ID: a repeat of the master ID received. This is the electronic serial number (ESN) of the master asset management device.

SLAVE ID: data term specific and unique to a network slave device. This is the electronic serial number (ESN) of the slave device.

CONTROL REGISTER: contains a set of data terms used to manage the local network. The Network Slave Response Message Control Register 1204 is further described in Fig. 12, where the specific terms include one or more of the following:

CNTRL/TX: a term instructing the network master to relay the information in a subsequent transmission to the data satellite network or short-range transceiver interface. This term is set to no-transmit for supervisory and data log type messages.

CNTRL/DEV TYPE: a term denoting the device type acting as a network slave.

CNTRL/GPS: a term that instructs the network master to perform a GPS function, and/or pass payload verbatim, and/or then replace a specific field of data in the payload with location data prior to transmission or data store.

CNTRL/D: a term instructing the network master to store data for collection by an external network controller such as a repeater or gateway device.

RF Sequence Number: a term that enumerates the specific time window allocated to the Network Master Idle Message. The network master increments this sequence number between 0 to 31 and then repeats the sequence one or more times. The range of sequence numbers is not critical to the operation of the method. 32 individual time slots were chosen for the present embodiment to facilitate up to 32 different slave devices per network master. Each Slave device may seize an available RF sequence number Time Division Multiple Access (TDMA) slot for responding to the master idle message and predominately use this slot for all communications to the network master, or alternatively simply attempt communication on any time receive window of the master device. The method for timeslot selection can be established during Slave setup mode.

Payload: a term that contains sensor or remote slave data to be acted upon by the network master. The payload field is further defined for use in the asset management device to include specific sensor types, data logging functions, data relay, and location determination commands.

CRC: or Cyclic Redundancy Checksum (CRC) term is a data validation term used to qualify the data integrity of the message for the receiver.

Two types of slave devices are supported, bound or unbound. Additionally, a slave device can operate in one of three modes, acquire, track, and alarm. In acquire mode, the slave device listens for all Network Master Idle Messages observable.

If a bound sensor in acquire mode detects and decodes the message, it will confirm that the Master ID matches the master ID configured in the sensor, and thus the sensor has found the master it is logically bound with. If the Master ID does not match the configured term, it ignores the message and continues monitoring additional messages. Upon detection of the appropriate Network Master Idle Message, the slave will transmit to the network master with a Network Slave Response Message 1005 time coincident to the network master listen interval. The slave device can then transition from acquire mode to track mode. The network master may optionally be configured to engage a function upon determination of a lost sensor or slave device that fails to report in a specified period of time. For example, the network master may send a data message to the satellite data network notifying the detection of a lost sensor. This enables a security notification for a locally disabled sensor such as a door switch.

In track mode, the sensor will resume a low power state coincident with the master low power state and awaken each master sync message to track and stay in sync with the network master. The slave need not transmit each wake interval, but merely track to follow the randomized Dither parameters. If the slave misses a sync message, it merely resumes acquire mode. The slave will periodically transmit a supervisory message to the network master to keep the master from timing out and transmitting a lost sensor message, if the function is enabled.

If a sensor determines it is time to perform the designed function, such as detection of an door open, a temperature alarm, or a wired input alarm, the sensor will engage alarm mode. In this mode the sensor will initiate a Network Slave Response Message on the next TDMA window coincident with the RF Sequence number detected when the unit engaged tracking mode, or alternatively simply transmit in the receive time window following any master idle message.

An unbound sensor operates as a bound sensor except that it will engage any network master available, ignoring the Master ID field match that the bound sensor performs. Unbound sensors operate as slave devices that can relay sensor data through any conduit available, generally with the purpose of relaying to the satellite data network the sensor data independent of the asset management device used. Examples of use for unbound sensors include cargo tags, security switches, industrial data sensors etc. In each of these cases, the sensor data itself is the valuable item, and the asset management device used to relay this data is relatively unimportant. The data may be relayed to the satellite data network or a local recipient via the short-range transceiver interface. Additionally, the data may be logged to local data storage 311 of the asset management device.

A sensor may remain in track mode until it is time to perform a transmit function and then wait until the desired RF Sequence number occurs, or it may remain totally dormant, then engage acquire mode to initiate a data transmission. If a sensor is logging or monitoring data or is monitored by the system for a lost sensor, it is usually configured to remain in track mode, generating periodic supervisory messages to the network master. If a sensor is very infrequently used, it is probably dormant, and will acquire only upon sensor event. In this case the acquisition cycle would appear as depicted in the embodiment of Fig. 11.

When the sensor event occurs coincident to 1103 in the diagram, the sensor engages listen mode waiting to hear the next master idle message 1101 with an embedded RF sequence number (4 in the case of the diagram). Decoding the transmitted master idle message, the sensor may notice another sensor transmitting in the slot or simply not successfully complete the communication link through active acknowledgement on the Slave Response fail. The sensor may reschedule a second attempt, noting the DITHER term, denoting the next event window and resuming low power mode to awaken at the end of the sleep interval. On waking, the sensor may again fail to finish the communication exchange as depicted, and again reschedule for the next time window. The sensor would continue this process until it successfully communicates 1104 with the network master with the successful slave response message 1105.

A similar approach is used for sensors that are experiencing difficulty in reliably communicating as determined by a CRC test. The sensor would simply track to the next available slot and operate within that TDMA sequence number slot. In this way, high densities of sensors and masters will dynamically adjust to operate correctly, with the network master merely monitoring and collecting data. The network master sets up the structure for sensors to adjust and collects data from any TDMA slot without priority or weight of position. This pushes down the network management to sensors that are equipped with a mechanism to automatically adjust and acquire communication channels of the master.

Data security remains a concern over any communication link, especially wireless links. The short-range transceiver interface can incorporate three levels of encryption in the master idle messages 1004 and the network slave response messages 1005. The encryption is designed to allow for friendly (owner devices) and foreign (other party's devices) cooperation without enabling misuse of the communication link.

The lowest level of encryption is disabled. Disabled encryption allows for any person to observe, configure, or copy the communication of a given local network. A network operating without encryption allows for any sensor to operate over any network manager in bound or unbound modes.

The next level of encryption is moderate. Moderate encryption, as depicted in 1004, uses an encryption key that scrambles the data following the leader. The encryption key is generally provided to a given user of the network hardware. All master and slave devices will use the same key allowing all devices of a given user (friendly) to operate together and ignore any other similar devices (foreign) of another party. This prevents unbound sensors of a user from using a foreign master to relay data over the data satellite network (and also the battery usage associated with the master function). Moderate encryption allows for the detection of communication in a local region but not the interpretation of the communication. The CRC checksum could be redundantly encrypted (ECRC) as shown in 1004 or un-encrypted (CRC) as shown in 1005.

The last level of encryption is high. High encryption scrambles all the data of the message including the leader. As with moderate encryption, only friendly devices have access to the communication network. But unlike moderate encryption, high encryption mode makes it impossible for a foreign observer to detect or intercept communications in a local region. Without the encryption key, the operation of the network is undetectable.

The short-range transceiver interface as described above is also suitable for use with other slave devices such as configuration tools, data logging interfaces, gateway, and repeater devices. Configuration tools can initiate a communication link with a master device by connecting as a slave device and then passing a payload command that engages configuration mode. Similarly, configuration tools can initiate a communication link with a slave device by connecting as a master device with a pre-defined master ID of a configuration tool. Slave devices within range of the configuration tool would receive the configuration master idle message and abort following any previously bound network master and rebind to the configuration tool. The tool then communicates the desired configuration changes and releases the slave to resume operation with the specified network master.

Gateway devices can similarly connect to master and slave devices within range of the short-range transceiver link. The embodiment of Fig. 13 depicts the operation of gateways and repeaters retrieving data from a network master. Line 1301 represents a time line for a sensor or slave device connected or bound to a local network master 1302. As described above, the slave device listens to the network master 1305 awaiting his RF Sequence TDMA window to pass sensor data to the master. Once the slave decodes the desired RF Sequence number 1306, it responds to the master with a slave response message 1307. The slave response message may command the network master (as a term in the payload field) to send the payload to the data satellite network, short-range transceiver network, store in data storage, or any combination thereof. If the master contains any data in data storage, it sets the CNTRL/S term 1202 which is transmitted in each subsequent master idle message. This is denoted as a solid rectangle on the master timelines of Fig. 13.

Operating as slave devices, a gateway device can link to any network master and effect configuration changes and pass and collect data. Operating as a network master, the gateway device can connect to a slave device and effect configuration changes and pass and collect data.

A repeater is a gateway device that connects to a local network master to relay data from that network to a nearby gateway using a short-range transceiver interface. Time line 1303 represents the operation of a repeater in collecting data from a local network master.

The repeater device monitors the master idle messages 1308 and notes the presence of the CNTRL/S flag 1309 indicating the master is holding data that can be collected. The repeater device then delays a randomized time interval 1310 and initiates a dialog with the network master by issuing a slave response message 1311 with the Type field of the Control Register denoting Transparent Modem. The network master and repeater device engage a point-to-point communications link 1312 where the gateway retrieves the held information, clearing the CNTRL/S flag of the network master. The network master resumes sending periodic idle messages 1313 with the CNTRL/S flag cleared.

The repeater then changes modes and becomes a new local network master 1314, transmitting the Idle message with a CNTRL/S flag set. The repeaters also incorporate use of the Repeat Level term to either bit-mask by installed repeater instance or by incrementing count to ensure the message will not be repeated indefinitely. Subsequent repeaters or gateways can pull the data from the repeater operating as a master. In this way, slave response messages stored in a local network masters may propagate through repeaters to distant gateway devices for collection.

A gateway monitors all network masters 1304, including the repeater operating in slave mode. Upon the detection of a CNTRL/S bit in either a network master or a repeater 1314, the gateway will delay a random time interval 1315 before responding with a slave response message 1316 to engage transparent modem mode and retrieve the data 1317. Once the data has been retrieved from a repeater, it will resume slave mode 1319, again searching for data to retrieve.

Similarly, a local network master may perform the logical functions of a repeater by alternating as a master and a slave to another nearby master. In this mode of operation, a group of network masters may collectively network to build a bridge for local sensor and other master data to hand off data to a regionally configured gateway or fixed repeater.

In yet another embodiment of the present invention, a local device may incorporate both master and slave operation to serve as a local repeater to extend the range of a sensor to a local master. This type of a device has value for sensors that are disadvantageously placed relative to the monitoring master, such as sensors inside metal containers with the associated master outside the container. A single local repeater can penetrate the metal enclosure using a master node on the inside to monitor sensors inside the container, and using a slave node on the outside that communicates to the local asset management master device. The local repeater simply incorporates both communication methods to monitor the slaves that would otherwise not be operable to the local network master. In this case, the local repeater may use a unique identification or it could simply mimic the identification of the local master to the slaves.

The local network master may be configured to redundantly store to local data storage any transmitted data satellite message, setting the CNTRL/S term. In this way, messages that may be dropped by the simplex satellite network are augmented through gateway devices, often later as the device comes within range of a gateway or repeater. The data through the gateway may be collected using a long-range communication link and merged with data collected from the data satellite system to create a more complete set of data.

Similarly, gateways, repeaters, or configuration tools could monitor the CNTRL/M and/or CNTRL/U flags to detect and retrieve data created by the asset management device itself or remote users who uploaded data for storage. A logistics manager may seal a container with an asset management device affixed, then upload user data to storage data for later retrieval at container destination. The destination manager could monitor the idle message of the local master and detect it by using the CNTRL/U flag if user data exists for extraction and review.

Repeaters can retrieve data from a local network master upon detection of a CNTRL/S flag after a random delay of several Idle message cycle intervals. This delay allows a time window where any local gateway will have ample opportunity to be the first to retrieve data directly from a network master. The repeater can randomize the Idle Sequence TDMA slot to minimize the probability that multiple repeaters will attempt to retrieve data from a local network master at the same Idle Sequence TDMA interval. The delays in retrieving the data from a local network master are relatively small compared to the standard time to resolve a GPS location determination. Gateway devices differ from repeaters in that they contain computation controllers, typically microprocessor based and custom algorithms and software to perform a variety of functions.

The ability of embodiments of the present invention to establish private or public networks to control battery powered remote simplex asset management devices is unique. Other two-way type devices do not incorporate a wireless architecture that will support battery operation, let alone provide for the additional capability of supporting wireless sensors. The present invention discussed herein provides utility in container security, rail, marine, fixed and mobile security, trailer tracking and more on a global scale, operable using batteries for years of service.

Many of the algorithmic operations and functions described herein may be implemented using a conventional general purpose computer or microprocessor programmed according to the teachings of the present invention, as will be apparent to those skilled in the art. Appropriate software can readily be prepared by programmers of ordinary skill based on the teachings of the present disclosure as will be apparent to those skilled in the art.

A general-purpose computer may be used to implement the method of the present invention, wherein the computer housing houses a motherboard which contains a CPU, memory (e.g., DRAM, ROM, EPROM, EEPROM, SRAM, SDRAM, and Flash RAM), and other optional special purpose logic devices (e.g., ASICS) or configurable logic devices (e.g., GAL and reprogrammable FPGA). The computer also includes plural input devices, (e.g., keyboard and mouse), and a display card for controlling a monitor. Additionally, the computer may include a floppy disk drive; other removable media devices (e.g. compact disc, tape, and removable magneto optical media); and a hard disk or other fixed high density media drives, connected using an appropriate device bus (e.g., a SCSI bus, an Enhanced IDE bus, or an Ultra DMA bus). The computer may also include a compact disc reader, a compact disc reader/writer unit, or a compact disc jukebox, which may be connected to the same device bus or to another device bus.

As stated above, the system includes at least one computer readable medium. Examples of computer readable media are compact discs, hard disks, floppy disks, tape, magneto optical disks, PROMs (e.g., EPROM, EEPROM, Flash EPROM), DRAM, SRAM, SDRAM, etc. Stored on any one or on a combination of computer readable media, the present invention includes software for controlling both the hardware of the computer and for enabling the computer to interact with a human user. Such software may include, but is not limited to, device drivers, operating systems and user applications, such as development tools. Computer program products of the present invention include any computer readable medium which stores computer program instructions (e.g., computer code devices) which when executed by a computer causes the computer to perform the method of the present invention. The computer code devices of the present invention can be any interpretable or executable code mechanism, including but not limited to, scripts, interpreters, dynamic link libraries, Java classes, and complete executable programs. Moreover, parts of the processing of the present invention may be distributed (e.g., between (1) multiple CPUs or (2) at least one CPU and at least one configurable logic device) for better performance, reliability, and/or cost.

The invention may also be implemented by the preparation of application specific integrated circuits or by interconnecting an appropriate network of conventional component circuits, as will be readily apparent to those skilled in the art. Numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced otherwise than as specifically described herein.

We Claim:

1. A monitoring device configured to monitor a remote status of mobile assets, comprising:

a position location unit to determine a location of a remote device;

a simplex satellite transmitter configured to transmit the location to one or more satellites;

a power source;

an external interface for communicating with one or more devices;

a controller in communication with the external interface and including a power management unit configured to control a power state of the position location unit and of the simplex satellite transmitter; and wherein

the controller is further configured to control the position location unit to determine the location and to control the simplex satellite transmitter to transmit the location based on the interval schedule.

2. The monitoring device of claim 1, wherein the position location unit comprises a GPS receiver subsystem.

3. The monitoring device of claim 1, wherein the power management unit is further configured to control a power state of the external interface and to periodically enable and disable power from the power source to the external interface.

4. The monitoring device of claim 1, wherein the external interface includes at least one of a plurality of alarm inputs.

5. The monitoring device of claim 1, wherein the external interface includes a configuration interface configured to receive modifications to configuration parameters.

6. The monitoring device of claim 5, wherein the power management unit is further configured to control a power state of the configuration interface and to periodically enable and disable power from the power source to the configuration interface.

7. The monitoring device of claim 1, wherein the external interface includes an external data unit configured to receive external data.

8. The monitoring device of claim 7, wherein the power management unit is further configured to control a power state of the external data unit and to periodically enable and disable power from the power source to the external data unit.

9. The monitoring device of claim 1, wherein the external interface includes at least one of a wired or wireless interface.

10. A monitoring device for monitoring a remote status of a mobile asset, the monitoring device comprising:

a position location unit to determine a location of a remote device;

a satellite transmitter to transmit the location to one or more satellites;

an external interface for communicating with one or more devices;

a power source; and

a controller in communication with the external interface and including a power management unit configured to control the supply of power from the power source to the satellite transmitter on an interval schedule.

11. The monitoring device of claim 10, wherein the position location unit comprises a GPS receiver subsystem.

12. The monitoring device of claim 10, wherein the external interface includes at least one of a wired or wireless interface.

13. The monitoring device of claim 10, wherein the power source comprises a battery.

14. The monitoring device of claim 10, wherein at least one of the one or more satellites operate as a bent-pipe relay device.

15. The monitoring device of claim 10, wherein the external interface includes at least one of an alarm input, a configuration interface configured to receive modifications to configuration parameters, and an external data unit configured to receive external data.

16. The monitoring device of claim 10, wherein the external interface is periodically enabled by the power management unit to communicate with one or more devices.

17. The monitoring device of claim 10, wherein the external interface is used to modify an operating configuration of the monitoring device.

18. The monitoring device of claim 10, wherein the external interface is used to monitor one or more sensor devices.

19. The monitoring device of claim 10, wherein the external interface is used to relay information received from one or more devices.

20. The monitoring device of claim 18, wherein a sensor is at least one of a door sensor, a cargo sensor, a dry contact circuit closure sensor, a temperature sensor, an analog voltage sensor, an analog measurement sensor, a volume sensor, a pressure sensor, or a humidity sensor.

21. The monitoring device of claim 10, wherein the external interface detects a remote sensor and initiates a satellite transmission.

22. The monitoring device of claim 21, wherein the satellite transmission contains data from at least one of the remote sensor, the monitoring device, and the position location unit.

23. The monitoring device of claim 10, wherein the controller is further configured to control the position location unit to determine the location and to control the satellite transmitter to transmit the location based on the interval schedule.

24. The monitoring device of claim 10, wherein the interval schedule is at least one of a repeated fixed interval, a set of fixed intervals sequentially executed and repeated as a set, or an interval which is randomly or pseudo-randomly adjusted over time.

25. The monitoring device of claim 15, wherein the controller is configured to detect at least one of the plurality of alarm inputs, and upon detection of an alarm input, to cause the satellite transmitter to transmit alarm data.

26. The monitoring device of claim 15, wherein the controller is configured to detect at least one of the plurality of alarm inputs, and upon detection of an alarm input, to enable power to the satellite transmitter and to the position location unit, and to cause the position location unit to determine the location and to cause the satellite transmitter to transmit the location and alarm data.

27. The monitoring device of claim 15, wherein the controller is configured to detect at least one of the plurality of alarm inputs, and upon detection of an alarm input, to enable power to the external interface.

28. The monitoring device of claim 10, wherein the controller is configured to detect modifications to a configuration parameter, and upon detection of modifications to the configuration parameter, to modify operation in accordance with the configuration parameter.

29. The monitoring device of claim 10, wherein the controller is configured to detect external data from a device, and upon detection of external data, to cause the satellite transmitter to transmit the external data.

30. The monitoring device of claim 10, wherein the controller is configured to queue transmissions to the satellite transmitter and to control the satellite transmitter to transmit the queued transmissions as a block.

31. The monitoring device of claim 10, wherein the controller is configured to control the satellite transmitter to periodically transmit a health status of the remote device.

32. The monitoring device of claim 10, further comprising a motion detection unit.

33. The monitoring device of claim 32, wherein the controller is configured to cause the position location unit to determine the location and to cause the satellite transmitter to transmit the location upon detection of motion by the motion detection unit.

34. The monitoring device of claim 32, wherein the controller is configured to cause the satellite transmitter to transmit a motion detection message upon a determination by the motion detection unit of a stop of motion followed by a start of motion.

35. The monitoring device of claim 32, wherein the controller is configured to cause the satellite transmitter to transmit a motion cease message upon a detection by the motion detection unit of a start of motion followed by a stop of motion.

36. The monitoring device of claim 10, wherein the power management unit is configured to disable power and then enable power to the satellite transmitter on a duty cycle of less than a 1% power-on to power-off ratio

37. A method for monitoring a remote device with an asset management device, the method comprising the steps of:

enabling power to an external interface of the asset management device;

transmitting a synchronization message through the external interface, the synchronization message containing a device identification data field associated with the asset management device;

enabling receive mode on the external interface for a period following transmission of the synchronization message and awaiting a potential response message from one or more remote devices; and

disabling power to the external interface.

38. The method of claim 37, wherein the enabling power step comprises the step of enabling power to an external interface of the asset management device on at least one of a predetermined interval, a predetermined set of intervals, or an interval adjusted randomly or pseudo-randomly over time.

39. The method of claim 37, wherein the remote device is a sensor.

40. The method of claim 37, wherein the synchronization message contains a time data term instructing one or more remote devices of the next scheduled interval.

41. The method of claim 37, further comprising the steps of:

receiving by the asset management device a message from one or more remote devices; and

transmitting data using a satellite transmitter to one or more satellites.

42. The method of claim 41, wherein the transmitted data contains data from at least one of the remote device or the asset management device.

43. The method of claim 37, further comprising the step of logically binding the remote device to the asset management device, whereby the remote device exclusively communicates with the asset management device for a period of time.

44. The method of claim 37, further comprising the step of roaming and temporarily binding by the remote device to one or more asset management devices.

45. The method of claim 37, wherein the external interface is at least one of a wired interface or a wireless interface.

46. A configuration tool for configuring one or more host satellite asset management devices using a wireless interface, wherein a host satellite asset management device includes a position location unit to determine a location of a remote device, a satellite transmitter to transmit the location to a satellite, and an external interface for communicating with the configuration tool.

47. The configuration tool of claim 46, wherein the configuration tool provides for the configuration of a reduced set of host satellite asset management devices, with the reduced set based on data derived from the whole set of detected host asset management devices.

48. The configuration tool of claim 46, wherein the configuration tool configures at least two of the host satellite asset management devices simultaneously.

49. The configuration tool of claim 46, wherein the configuration tool configures one or more remote sensor devices.

50. A gateway device for controlling one or more host satellite asset management devices, the gateway device comprising:

a wireless interface compatible with at least one of a host satellite asset management device or a remote sensor device; and

a controller device to control the wireless interface for communicating with a host satellite asset management device or a remote sensor device.

51. The gateway device of claim 50, wherein at least one of a host satellite asset management device or the gateway device comprises:

a position location unit to determine a location of a remote device;

a satellite transmitter to transmit the location to one or more satellites;

an external interface for communicating with one or more devices; and

a power source.

52. The gateway device of claim 50, wherein the controller device is further configured to detect new and exiting host satellite asset management devices and to communicate a change of device configuration based on proximity to the gateway device.

53. The gateway device of claim 50, wherein the controller device is further configured to detect a host satellite asset management device and to configure the detected host device for low power operation while in proximity to the gateway device.

54. The gateway device of claim 50, wherein the gateway device announces its presence to a host satellite asset management device and wherein the host satellite asset management device alters its mode of operation while in proximity to the gateway device.

55. The gateway device of claim 50, wherein the controller device is further configured to relay information from nearby host satellite asset management devices to other gateway devices.

56. The gateway device of claim 50, wherein the gateway device further comprises a communication interface for communicating with a remote system controller interface.

57. The gateway device of claim 56, wherein the controller device is further configured to monitor nearby host satellite asset management devices and to relay data from the nearby host devices to the communication interface.

58. The gateway device of claim 56, wherein the communication interface is at least one of a wired or wireless interface.

59. An interrogator device comprising:

a wireless interface; and

a controller which monitors and detects the presence of one or more host asset management devices, and upon detection of a host device binds to and initiates a function that results in the host device transmitting a satellite message.

60. The interrogator device of claim 59, wherein the transmitted satellite message contains at least one of location information, interrogator identification information, or interrogator information.

61. The interrogator device of claim 59, wherein at least one of the interrogator device or the host satellite asset management device comprises:

a position location unit to determine a location of a remote device;

a satellite transmitter to transmit the location to one or more satellites;

an external interface for communicating with one or more devices; and

a power source.

62. A method for modifying a configuration of a host satellite asset management device using a gateway device, wherein the host satellite asset management device comprises a position location unit, a satellite transmitter, a wireless interface, a power source, and a

controller, and wherein the gateway device comprises a controller, a wireless interface, and a communication interface, the method comprising the steps of:

detecting by the gateway device the presence of the host satellite asset management device using the wireless interface of the gateway device;

establishing a wireless communication channel between the gateway device and the host satellite asset management device; and

modifying by the gateway device the configuration of the host satellite asset management device using the wireless communication channel, wherein the configuration is modified based on instructions received through the communication interface from a remote controller.

63. A method for communicating data using one or more nodes, the method comprising the steps of:

transmitting from a master communication node a Network Master Idle Message comprising a Leader, Master Identification, Control register, Sequence Number, Dither parameter, and a checksum; and

initiating by the master communication node a period of input message detection during which the master communication node awaits a Network Slave Response Message from a slave communication node.

64. The method of claim 63, further comprising the steps of:

transmitting by the slave communication node a Network Slave Response Message;

receiving the Network Slave Response Message by the master communication node; and

performing by the master communication node a function designated in the Network Slave Response Message.

65. The method of claim 63, further comprising the step of resuming by the master communication node, upon receipt of a Network Slave Response Message, a low power mode for a periodic interval indicated by the Dither parameter.

66. The method of claim 63, further comprising the step of resuming by the master communication node, upon failing to receive a Network Slave Response Message, a low power mode for a periodic interval indicated by the Dither parameter.

67. The method of 63, further comprising the steps of:

determining a communications need by the slave communication node;

initiating by the slave communication node a period of input message detection during which the slave communication node awaits a Network Master Idle Message;

receiving the Network Master Idle Message by the slave communication node; and

qualifying the master communication node as acceptable using the Master Identification.

68. The method of 67, further comprising the step of initiating by the slave communication node a transmit function to the master communication node.

69. The method of claim 67, further comprising the step of resuming by the slave communication node a lower power state until the slave communication node determines a communication need.

70. The method of claim 63, wherein the Network Master Idle Message is transmitted on a an interval being at least one of a repeated fixed interval, a set of fixed intervals sequentially executed and repeated as a set, or an interval adjusted with a randomization term to randomly vary the interval.

71. The method of claim 63, wherein at least one of the one or more nodes is a device comprising a position location unit to determine a location of the device, a satellite transmitter to transmit the location to one or more satellites, an external interface for data communications, and a power source.

72. The method of 71, wherein the external interface is at least one of a wired or wireless interface.

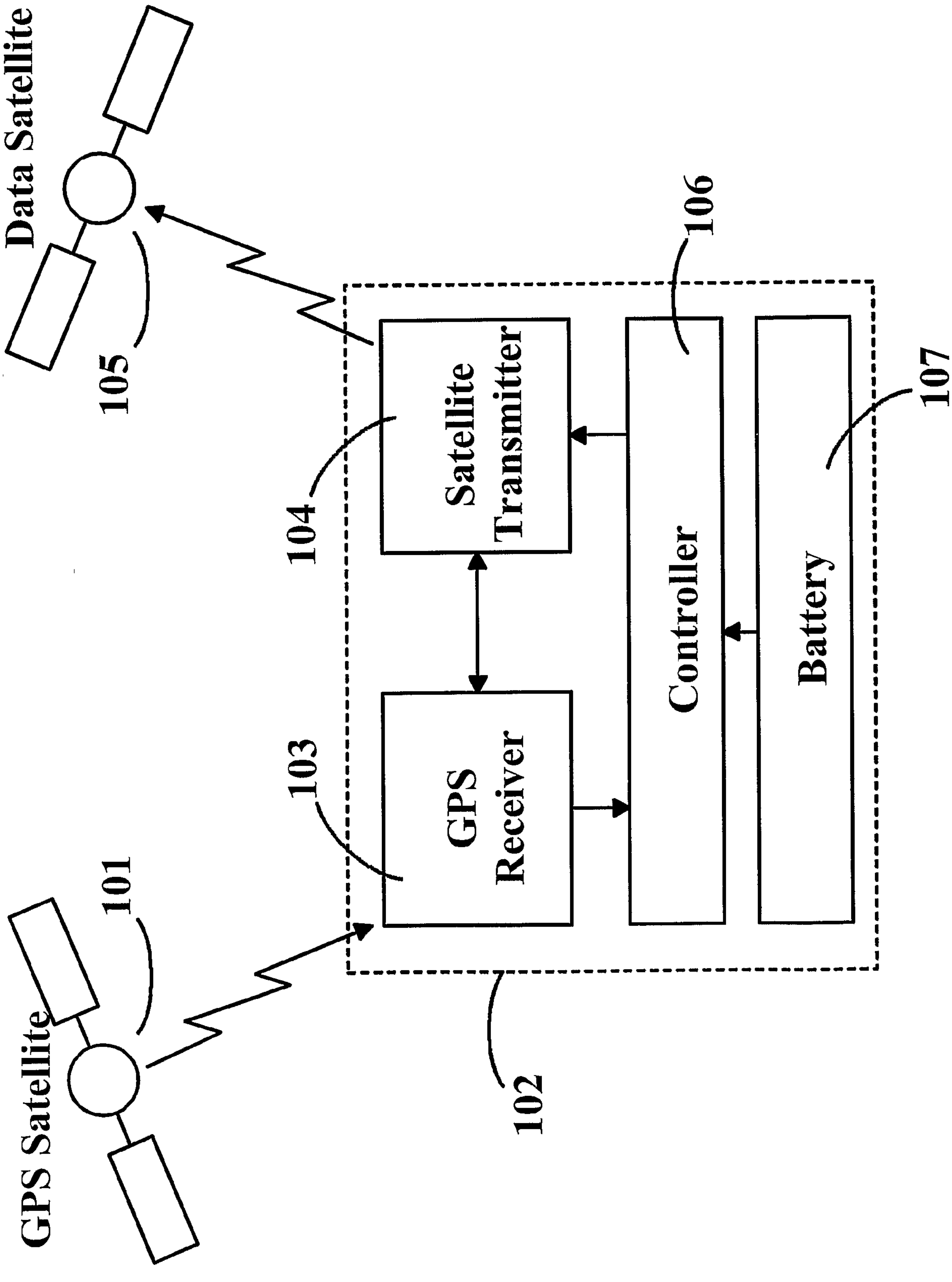

Figure 1 (Prior Art)

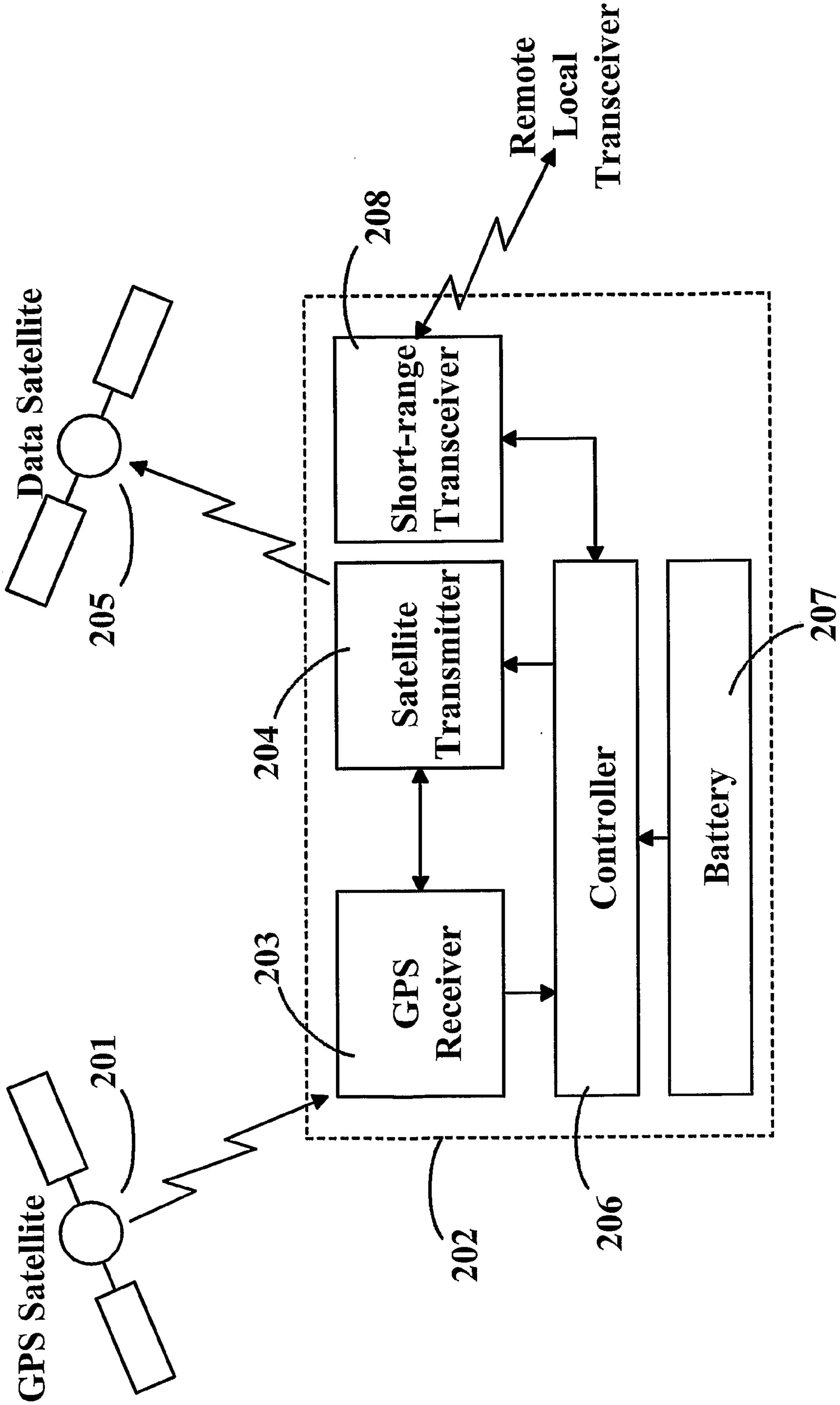
Data Satellite
205
Remote
Local
Transceiver
208
Short-range
Transceiver
Satellite
Transmitter
204
GPS
Receiver
203
Controller
Battery
207
GPS Satellite
201
202
206

Figure 2

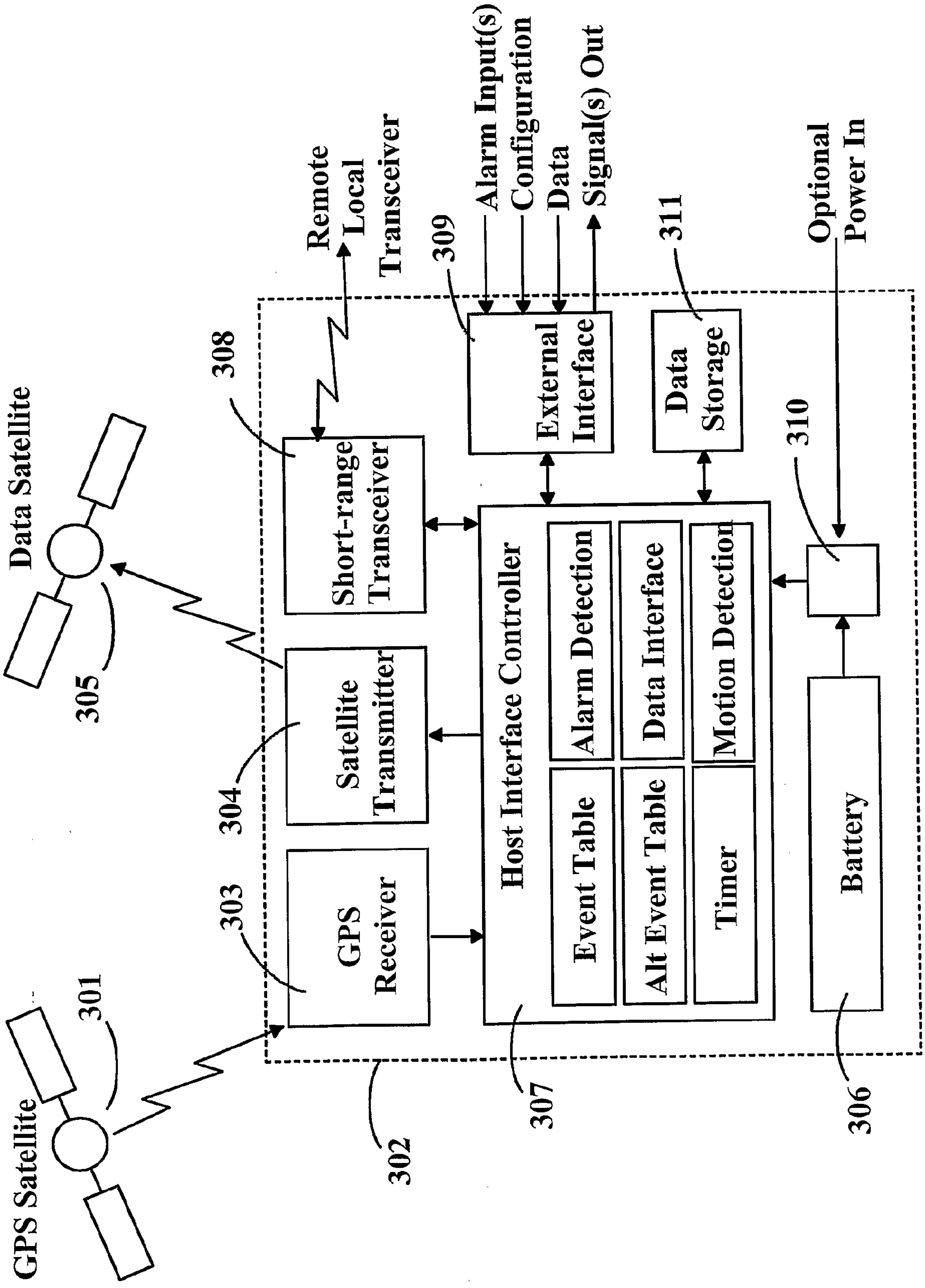
GPS Satellite
301
Data Satellite
305
302
303
GPS Receiver
304
Satellite Transmitter
308
Short-range Transceiver
Remote Local Transceiver
309
External Interface
Alarm Input(s)
Configuration
Data
Signal(s) Out
311
Data Storage
307
Host Interface Controller
Event Table
Alarm Detection
Alt Event Table
Data Interface
Timer
Motion Detection
310
Optional Power In
306
Battery

Figure 3

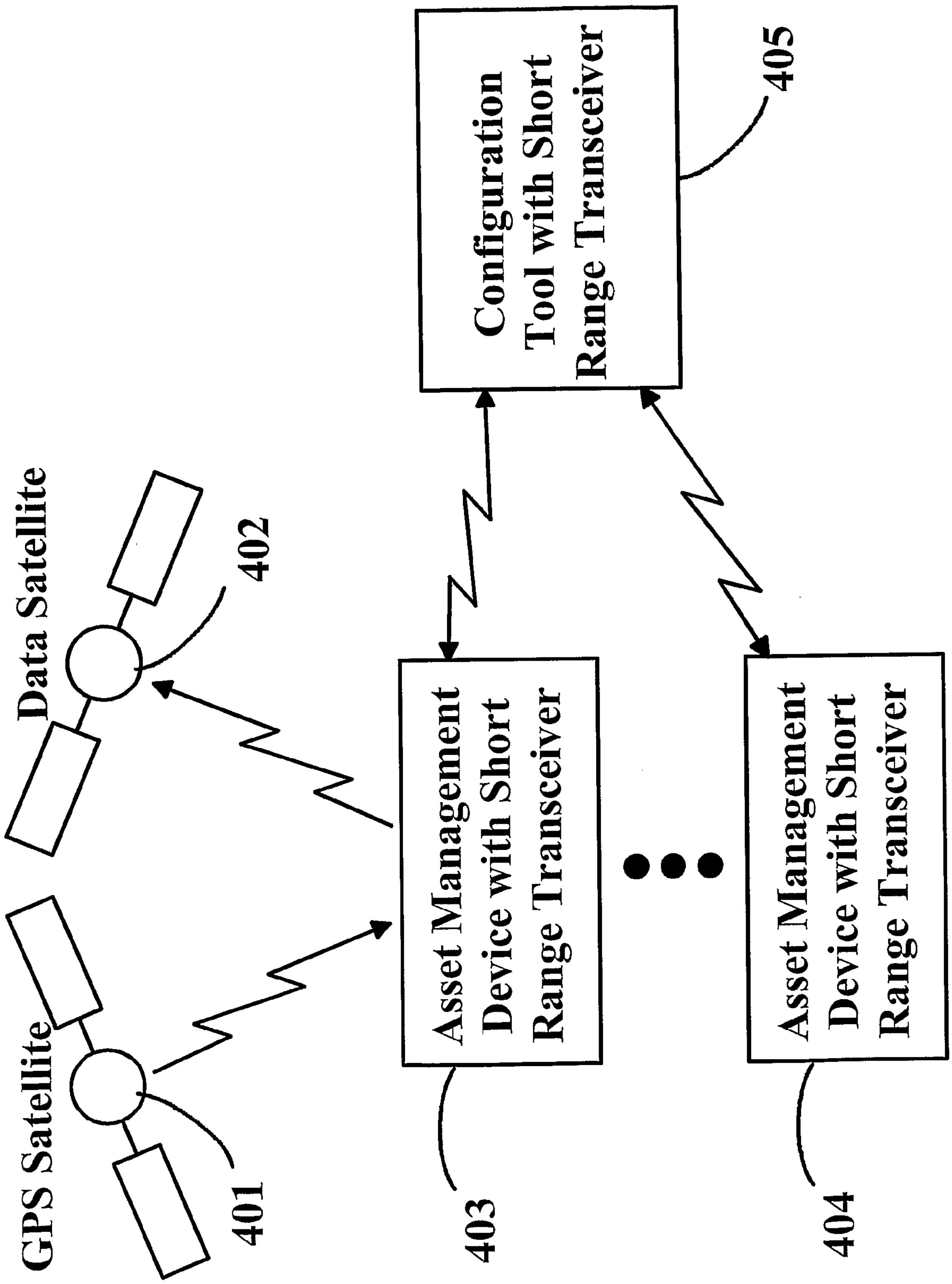
GPS Satellite
401
Data Satellite
402
Asset Management Device with Short Range Transceiver
403
Asset Management Device with Short Range Transceiver
404
Configuration Tool with Short Range Transceiver
405

Figure 4

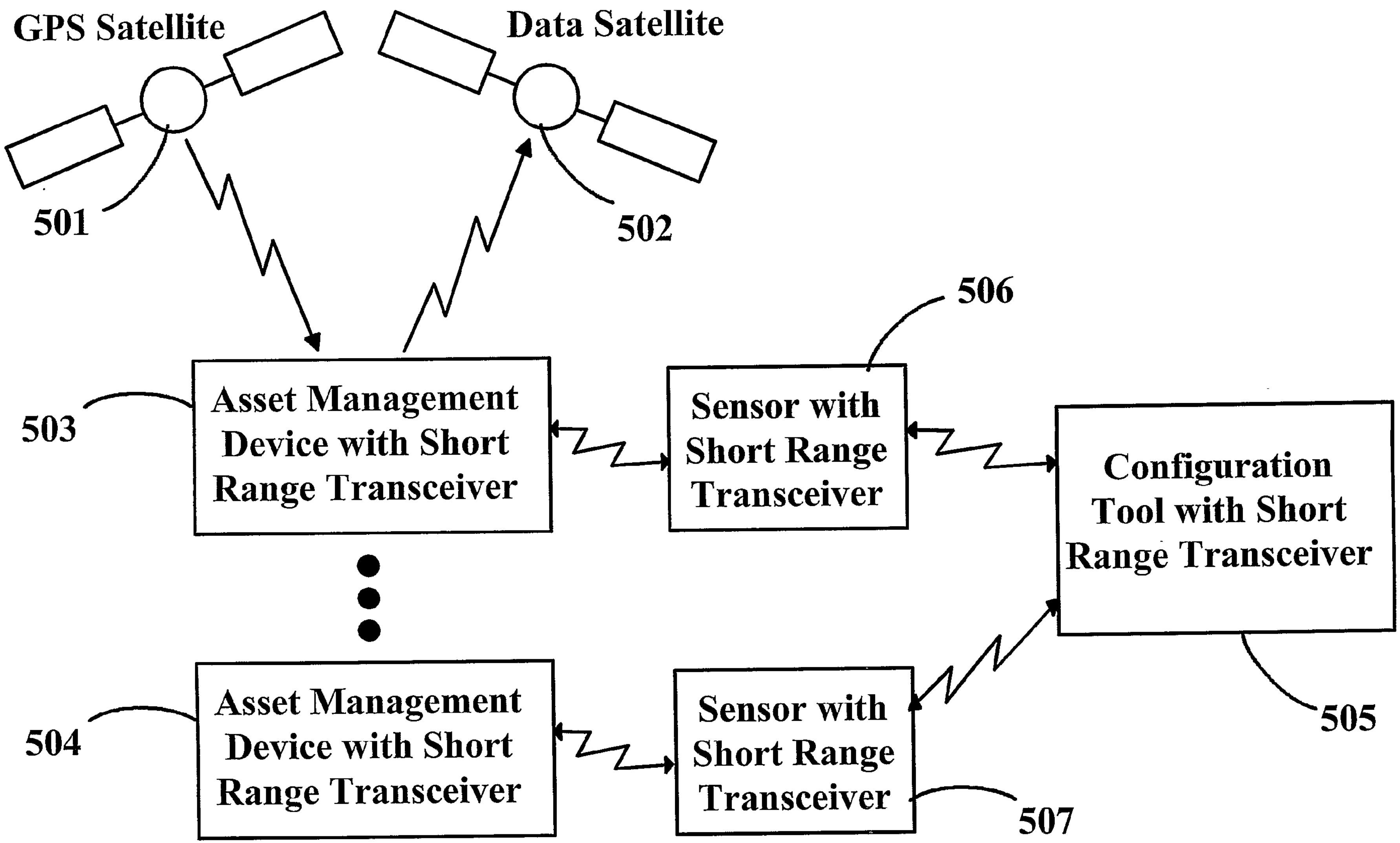
GPS Satellite
Data Satellite
501
502
503
Asset Management Device with Short Range Transceiver
506
Sensor with Short Range Transceiver
Configuration Tool with Short Range Transceiver
504
Asset Management Device with Short Range Transceiver
Sensor with Short Range Transceiver
505
507

Figure 5

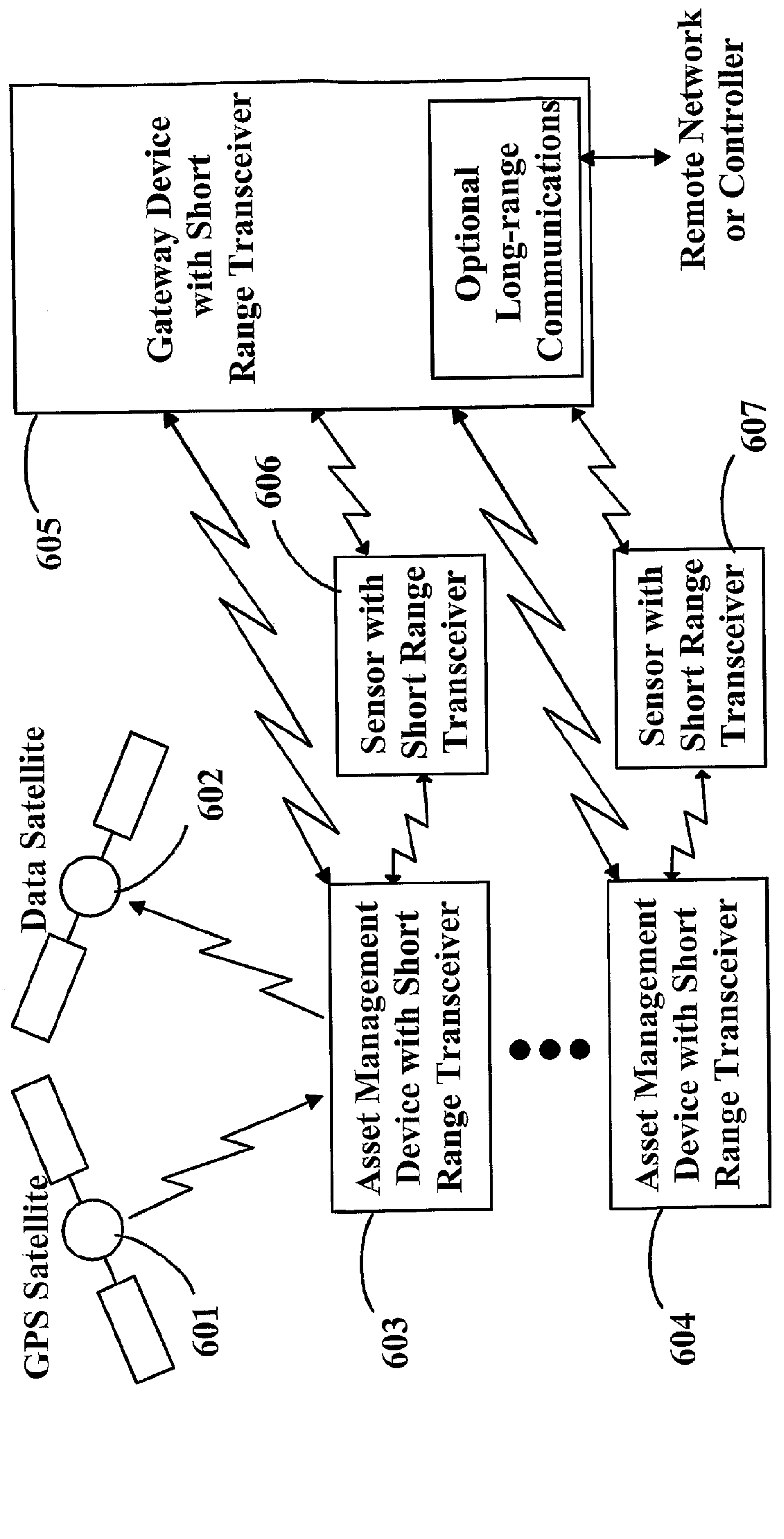
Gateway Device with Short Range Transceiver
Optional Long-range Communications
Remote Network or Controller
605
606
607
Sensor with Short Range Transceiver
Sensor with Short Range Transceiver
Data Satellite
602
GPS Satellite
601
Asset Management Device with Short Range Transceiver
Asset Management Device with Short Range Transceiver
603
604

Figure 6

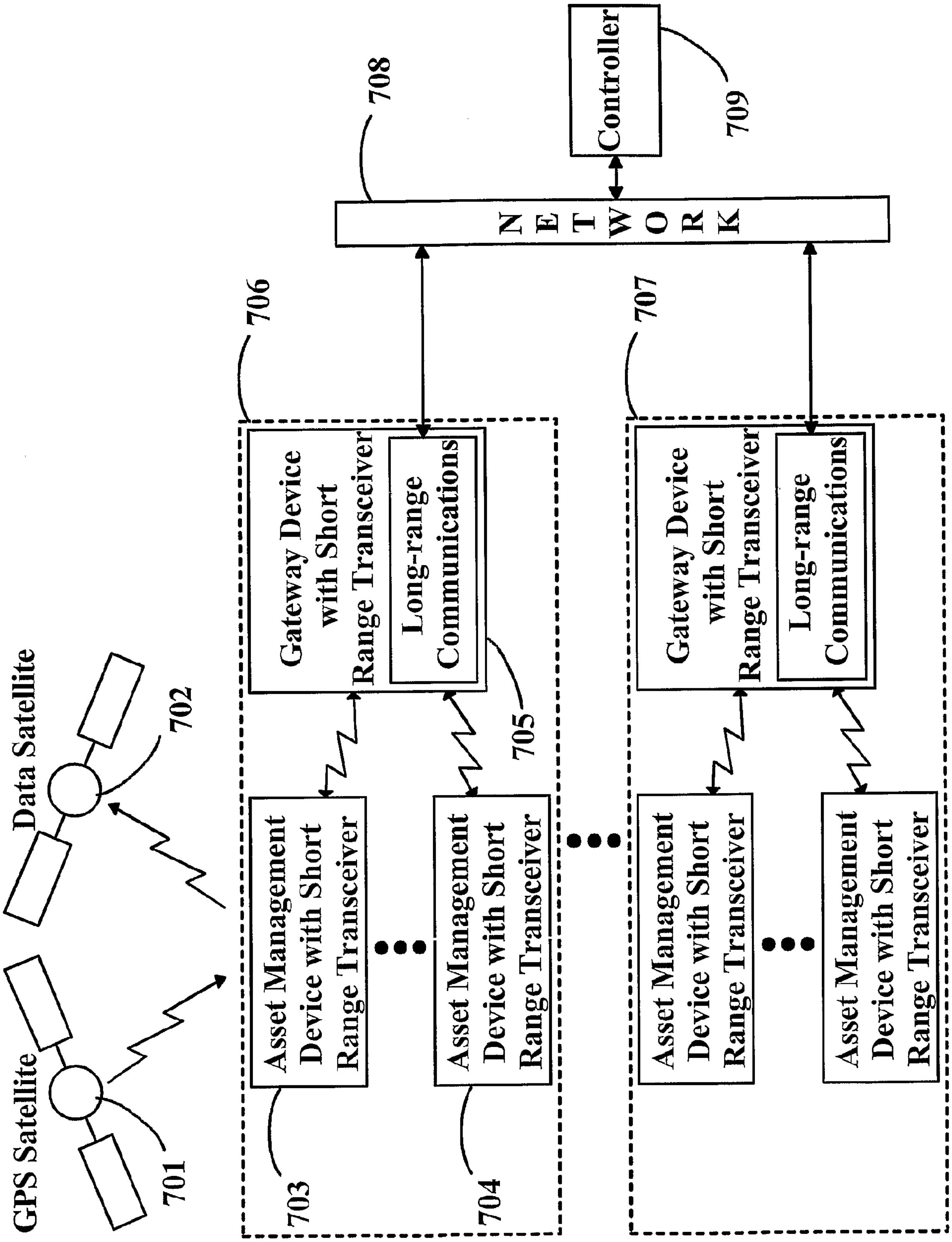
GPS Satellite
701
Data Satellite
702
Asset Management Device with Short Range Transceiver
703
Asset Management Device with Short Range Transceiver
704
Gateway Device with Short Range Transceiver
Long-range Communications
705
706
Asset Management Device with Short Range Transceiver
Asset Management Device with Short Range Transceiver
Gateway Device with Short Range Transceiver
Long-range Communications
707
NETWORK
708
Controller
709

Figure 7

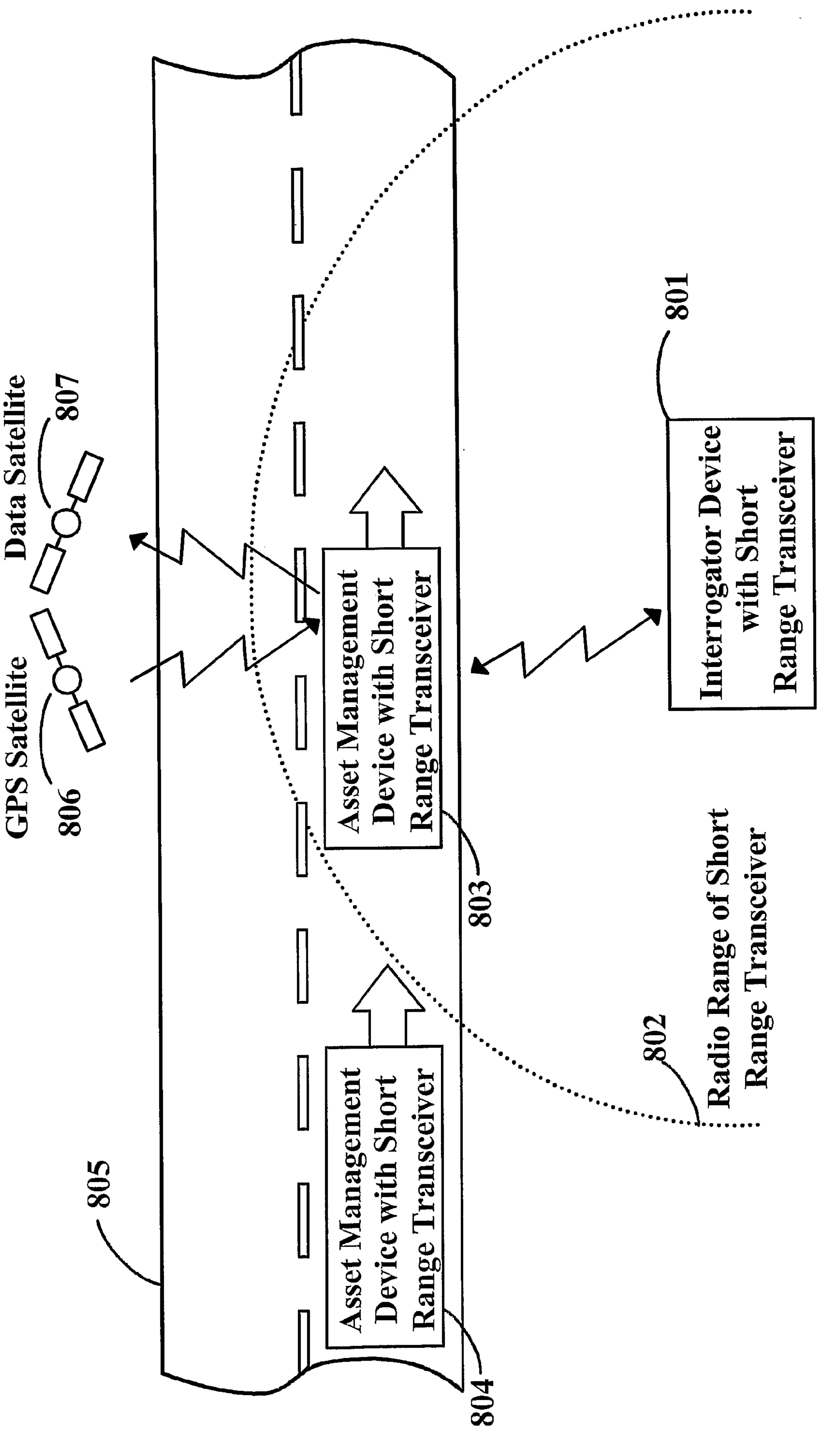
GPS Satellite
806
Data Satellite
807
805
Asset Management Device with Short Range Transceiver
803
Asset Management Device with Short Range Transceiver
804
Interrogator Device with Short Range Transceiver
801
802
Radio Range of Short Range Transceiver

Figure 8

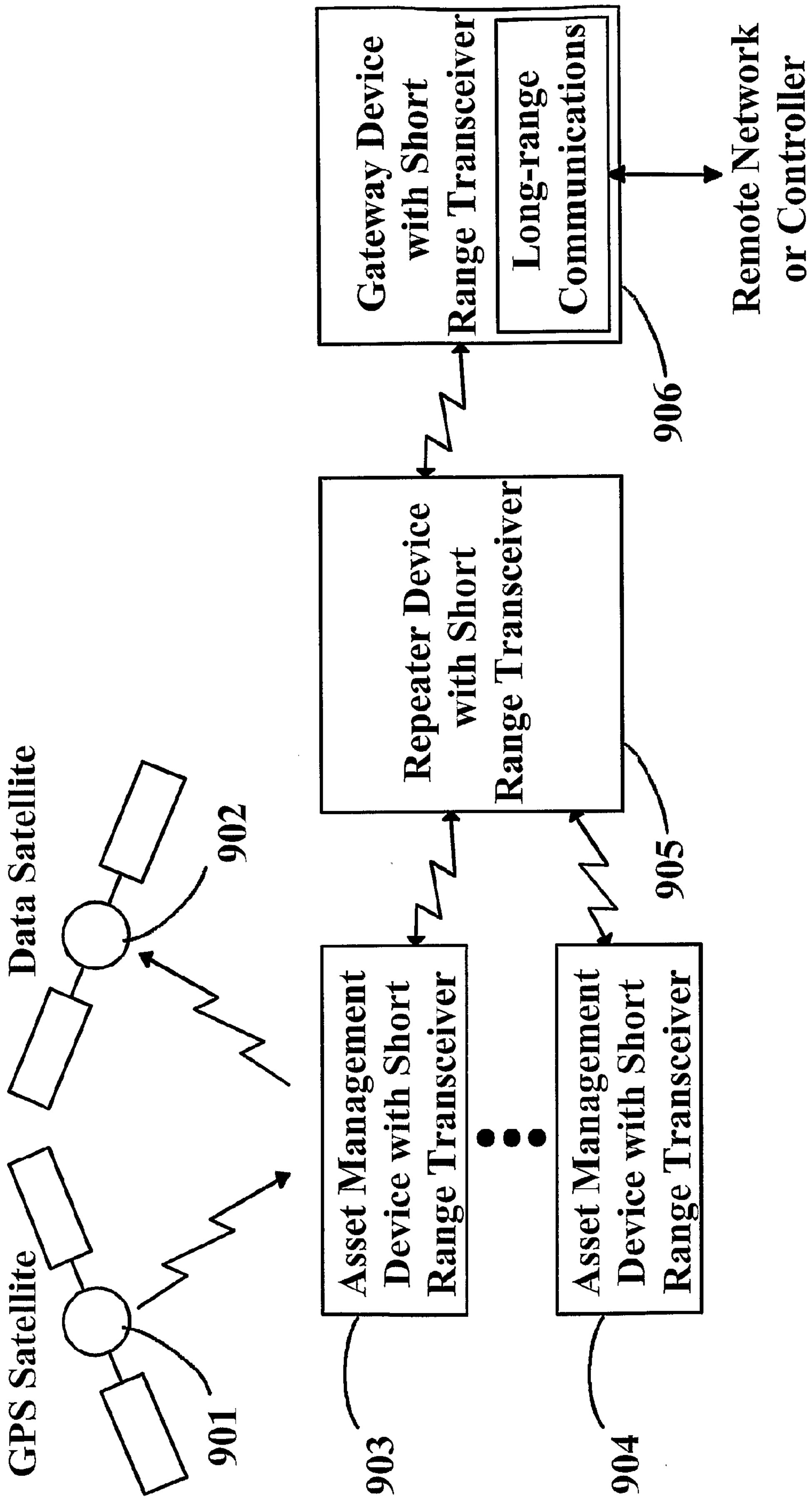
GPS Satellite
901
Data Satellite
902
Asset Management Device with Short Range Transceiver
903
Asset Management Device with Short Range Transceiver
904
Repeater Device with Short Range Transceiver
905
Gateway Device with Short Range Transceiver
Long-range Communications
906
Remote Network or Controller

Figure 9

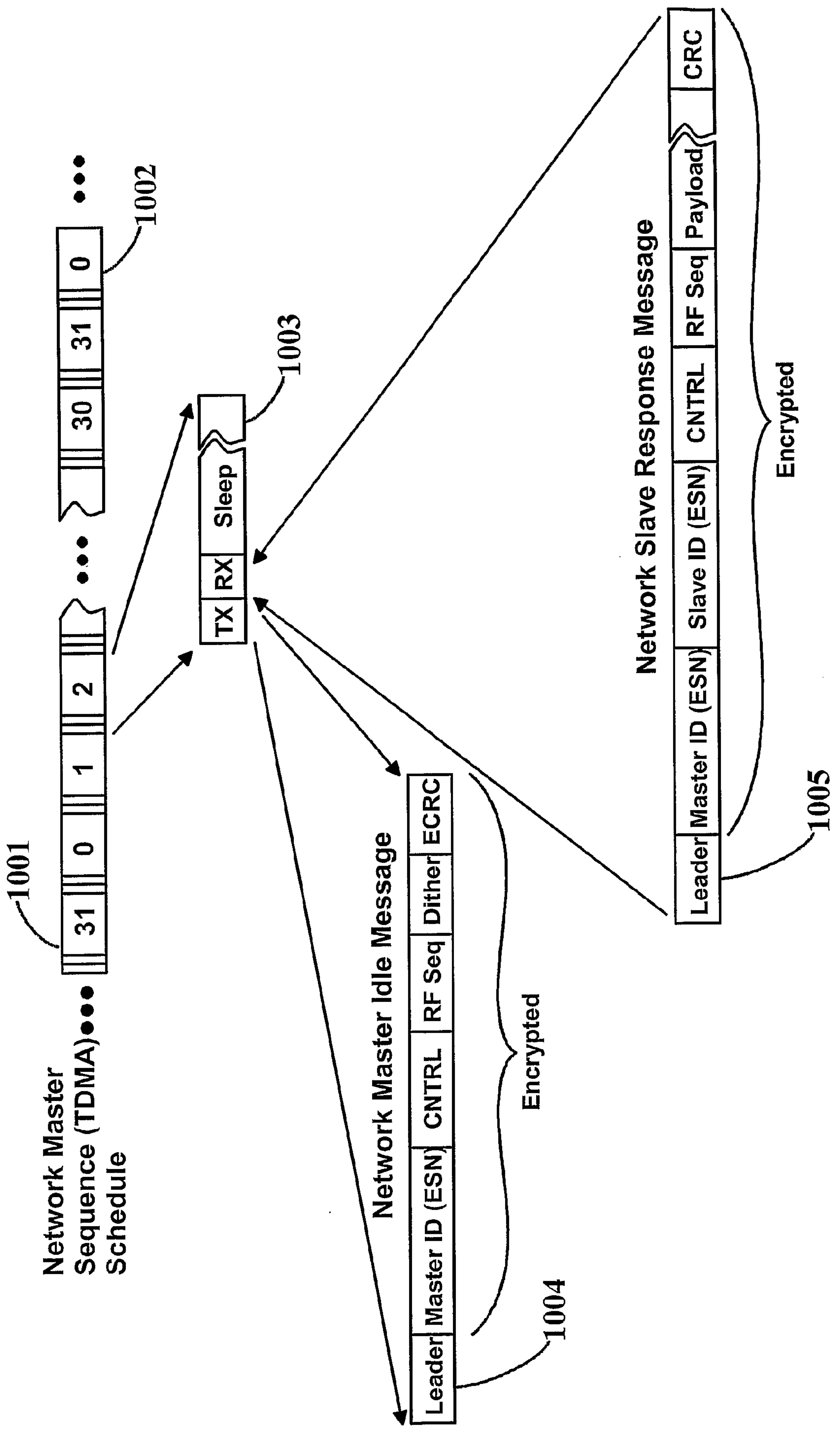
Network Master Sequence (TDMA) Schedule
1001
31
0
1
2
30
31
0
1002
1003
TX
RX
Sleep
Network Master Idle Message
Leader
Master ID (ESN)
CNTRL
RF Seq
Dither
ECRC
Encrypted
1004
Network Slave Response Message
Leader
Master ID (ESN)
Slave ID (ESN)
CNTRL
RF Seq
Payload
CRC
Encrypted
1005

Figure 10

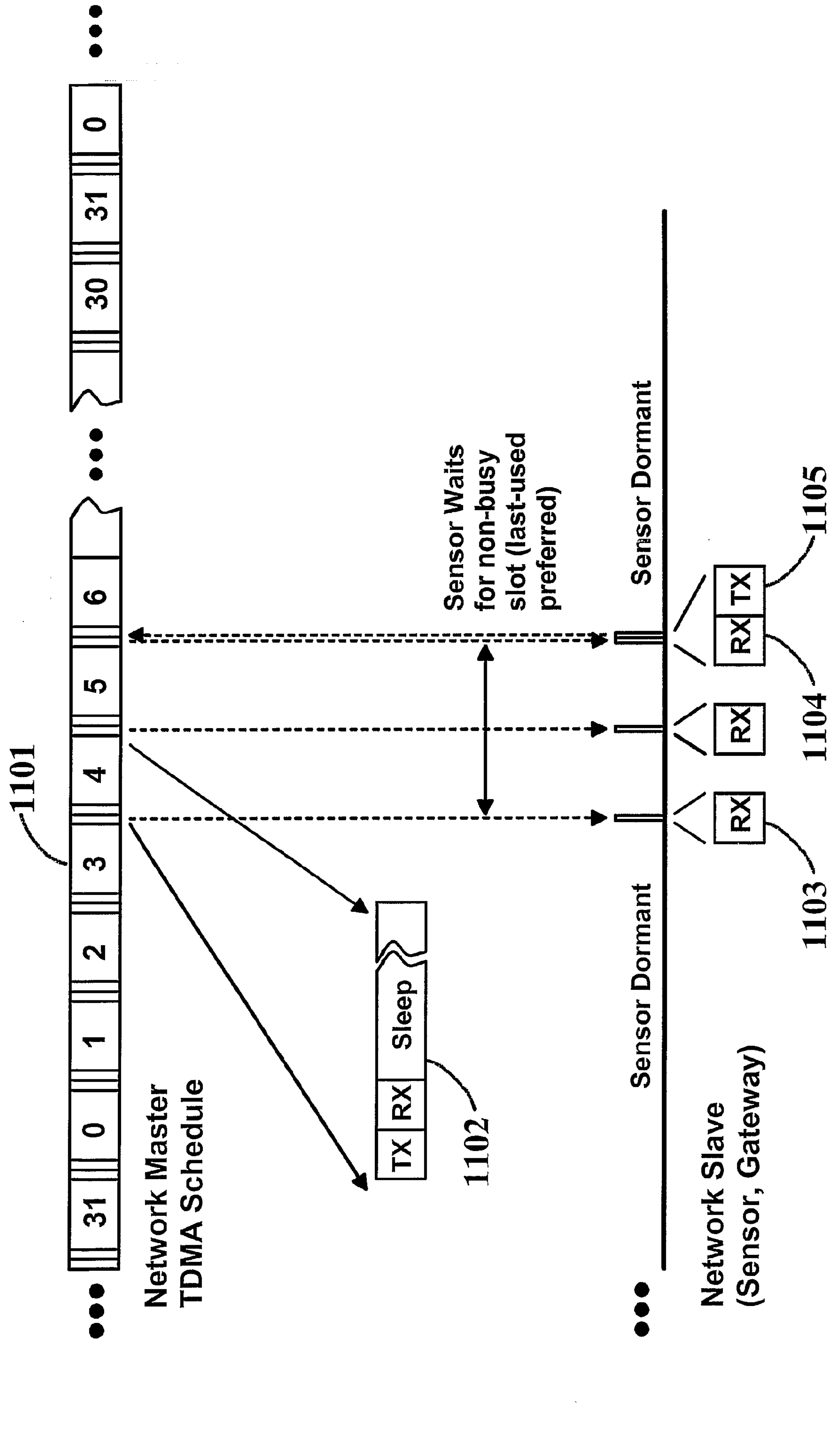
Network Master
TDMA Schedule
31
0
1
2
3
4
5
6
30
31
0
1101
TX
RX
Sleep
1102
Sensor Waits
for non-busy
slot (last-used
preferred)
Sensor Dormant
Sensor Dormant
RX
RX
RX
TX
1103
1104
1105
Network Slave
(Sensor, Gateway)

Figure 11

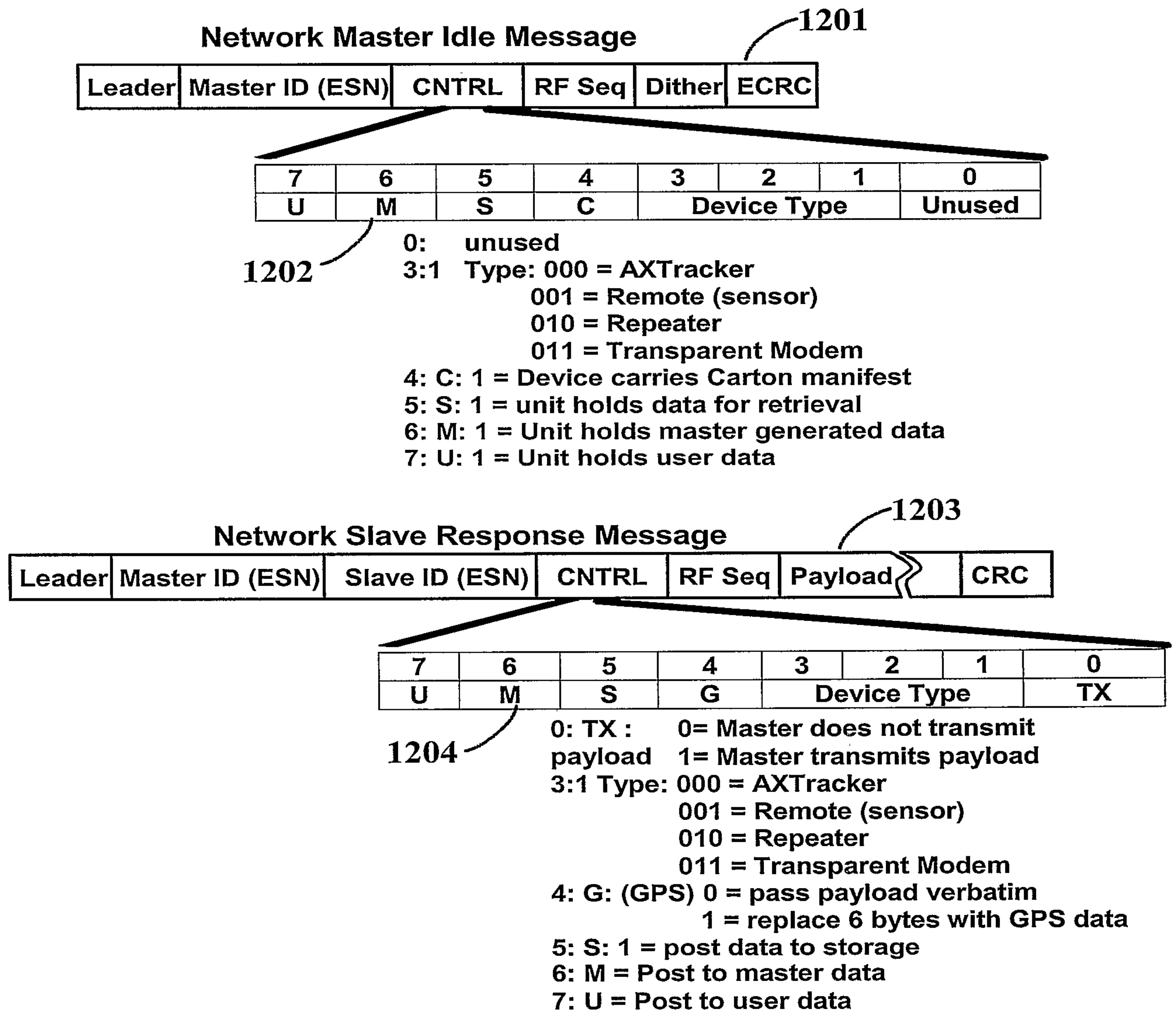
Network Master Idle Message
1201
Leader
Master ID (ESN)
CNTRL
RF Seq
Dither
ECRC
7 6 5 4 3 2 1 0
U M S C Device Type Unused
1202
0: unused
3:1 Type: 000 = AXTracker
001 = Remote (sensor)
010 = Repeater
011 = Transparent Modem
4: C: 1 = Device carries Carton manifest
5: S: 1 = unit holds data for retrieval
6: M: 1 = Unit holds master generated data
7: U: 1 = Unit holds user data
Network Slave Response Message
1203
Leader
Master ID (ESN)
Slave ID (ESN)
CNTRL
RF Seq
Payload
CRC
7 6 5 4 3 2 1 0
U M S G Device Type TX
1204
0: TX : 0= Master does not transmit
payload 1= Master transmits payload
3:1 Type: 000 = AXTracker
001 = Remote (sensor)
010 = Repeater
011 = Transparent Modem
4: G: (GPS) 0 = pass payload verbatim
1 = replace 6 bytes with GPS data
5: S: 1 = post data to storage
6: M = Post to master data
7: U = Post to user data

Figure 12

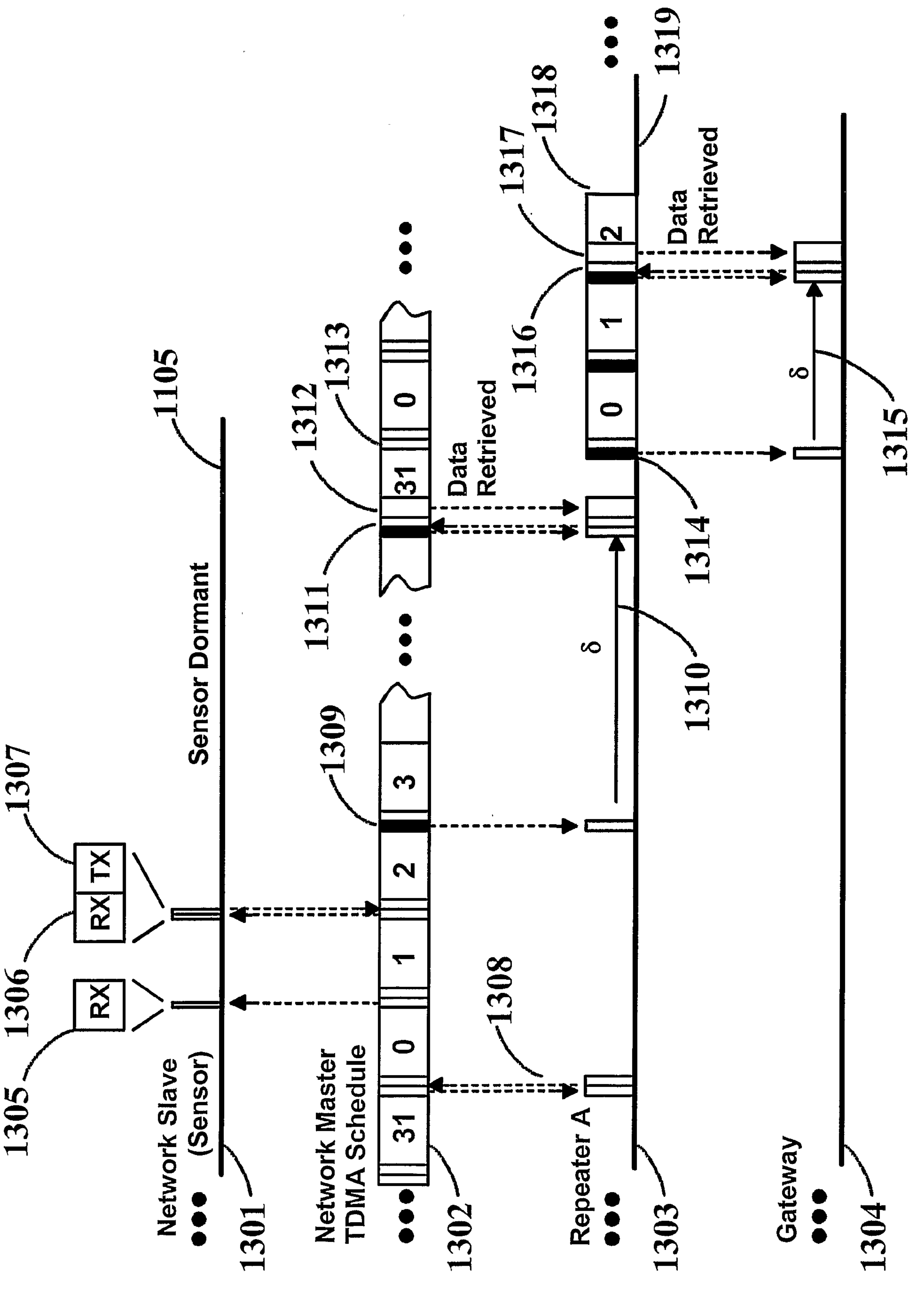
Network Slave (Sensor)
Network Master TDMA Schedule
Repeater A
Gateway
Sensor Dormant
RX
RX
TX
31
0
1
2
3
31
0
0
1
2
Data Retrieved
Data Retrieved
δ
δ
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1105

Figure 13

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US 06/26087

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) G01C 21/00 (2007.01)
USPC 701/214
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC(8) G01C 21/00 (2007.01)
USPC 701/214

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
342/357.1; 340/993

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
USPTO WEST (PGPB, USPT, EPAB, JPAB); DIALOG PRO; GOOGLE
Search Terms Used: simplex, network, interface, device, identification, synchronization, message, dither

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 2005/0171696 A1 (NADEN et al.) 04 August 2005 (04.08.2005), entire document	1-36, 46-62 --- 37-45, 63-72
Y	US 2005/0197059 A1 (NUMAKAMI et al.) 08 September 2005 (08.09.2005), para [0010]-[0011], [0039]- [0043], [0076]-[0077],	37-45, 63-72
A	US 6,907,346 B2 (TERANISHI et al.) 14 June 2005 (14.06.2005)	
A	US 2005/0068227 A1 (CASPI et al.) 31 March 2005 (31.03.2005)	

☐ Further documents are listed in the continuation of Box C. ☐

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
20 March 2007 (20.03.2007)

Date of mailing of the international search report
17 MAY 2007

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