A remote home monitoring system (100) for monitoring a utility meter (108) and a home device (118) located in a dwelling (102) and for communicating with a remotely located host computer (130) having programs (306–330) for performing a prescribed function related to a purpose served by the host computer. The system includes a home control unit (116) having a receiver (82) for receiving a sensor status signal from the home device, a transmitter (82) for transmitting information to the home device, and a control module (83). A utility meter reading unit (120) is attached to a standard consumption meter (e.g. electric meter) and includes a sensing system (218) for reading consumption data from the utility meter; an interface module (302) for transmitting the consumption data; and a control module (304) for storing the consumption data from the utility meter and for controlling the transmission of the consumption data by the interface module. The utility meter reading unit is in communication with a concentrator (122) that includes a transmitter (650, 302) for transmitting a concentrator polling request signal to the interface module of the utility meter reading unit, a receiver (650, 304) for receiving the consumption data from the interface module of the utility meter reading unit in response to the concentrator polling request signal, a concentrator interface module (654) for packaging the consumption data into an automatic meter reading (AMR) packet having a destination host address, and a transceiver (658) for transmitting the AMR packet to the host computer. The system provides a home (including apartments etc.) to fully integrate and control utility meters and any number of home devices within the home that can be monitored by remotely located computers.
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REMOTE HOME MONITORING SYSTEM

TECHNICAL FIELD
This invention relates to the field of remote monitoring systems to monitor activities in a dwelling, and more particularly to a system for measuring the amount of energy consumed by the dwelling, for monitoring sensors (such as smoke, carbon monoxide, alarm switches etc.) in the dwelling, and for providing a home based interactive interface that allows the occupant to review and distribute information to and from a central facility.

BACKGROUND ART
Many of these functions (energy consumption monitoring, alarm/sensor monitoring, and home based access and control to this information) have been traditionally implemented separately requiring specialized hardware and software for each component with limited integration. For example, traditional home alarm systems that are connected to a central monitoring facility cannot be easily adapted to read and report on energy consumption in the home.

In addition, measuring energy consumption such as electrical power consumption is a difficult task due to the requirement for a utility company to periodically read the meters of every power user. It has long been recognized that automatic reading of meters, such as electric and gas utility meters, would be highly desirable. To take full advantage of automatic reading, it is desirable for the meter to be able to transmit its readings to a remote location.

Many systems having these capabilities have been proposed of which the first systems used telephone or power lines as the preferred communications method between the utility meter and the central facility. Unfortunately, these systems were difficult to install and as a result none have been widely adopted. One such

It would be desirable to provide a fully integrated remote home monitoring system that can support remote meter reading and reporting functions to monitor energy consumption in a dwelling together with integrated sensor/alarm support and to provide a home based facility to monitor all of this activity interactively with a remote site.

Recent advances in the field of wireless technology have prompted many proposals using this technology in remote monitoring systems. However, none of these recent proposals attempts to integrate utility and sensor monitoring into one system. Additionally, these systems have not been designed with intelligent routing capabilities resulting in the requirement that a single central facility receive and route all information to the appropriate parties. Not only does this create a delay in the arrival of information to the secondary party but also causes a very strong dependency on the central facility. One such system is shown in United States Patent No. 5,553,094 issued on September 3, 1996.

This patent (U.S. Patent No. 5,553,094) has the further disadvantage of an absence of a data integrity check. This prior art system specifies the use of additional, redundant intermediate data carriers to ensure information is received at the final destination, thereby increasing the cost of the system. Additionally, the prior art specifies the use of a clock in each data collection device reducing the synchronousness of data collection across the network and increases the cost and complexity of each data collection device.
DISCLOSURE OF THE INVENTION

An object of the present invention is to provide a system and method of automatically sending usage information from a utility meter monitored by a utility meter reading unit to at least one of a plurality of remotely located host computers.

Another object of the present invention is to provide a system and method of sending usage information from a utility meter monitored by a utility meter reading unit to a remotely located utility host computer.

Another object of the present invention is to provide a system and method of sending an alarm message from a home device having a sensor monitored by a home control device and a meter reading unit to a remotely located alarm host computer.

Another object of the present invention is to provide a remote home monitoring system capable of automatic meter reading, sensor/alarm monitoring and reporting information in relation thereof to at least one of a plurality of a remotely located host computers.

In accordance with the invention, there is provided a remote home monitoring system for monitoring a utility meter and a home device located in a dwelling and for communicating with a remotely located host computer having means for performing a prescribed function related to a purpose served by the host computer, said system comprising: a home control unit having a receiver for receiving a sensor status signal from the home device, a transmitter for transmitting information to the home device, and a control module; a utility meter reading unit having sensing means for reading consumption data from the utility meter; an interface module for transmitting the consumption data, said interface module being in electrical communication with the home control unit; and a control module for storing the consumption data from the utility meter and for controlling
the transmission of the consumption data by the interface module; and a
concentrator in communication with the utility meter reading unit, said
concentrator having a transmitter for transmitting a concentrator polling request
signal to the interface module of the utility meter reading unit, a receiver for
receiving the consumption data from the interface module of the utility meter
reading unit in response to the concentrator polling request signal, a concentrator
interface module for packaging the consumption data into an automatic meter
reading (AMR) packet having a destination host address, and a transceiver for
transmitting the AMR packet to the host computer.

In accordance with another aspect of the present invention there is provided a
remote home monitoring system for monitoring a utility meter and a home device
located in a dwelling, said system comprising: a home control unit having a
receiver for receiving a sensor status signal from the home device, a transmitter
for transmitting information to the home device, and a control module; a utility
meter reading unit having sensing means for reading consumption data from the
utility meter; an interface module for transmitting the utility consumption data and
for receiving signals, said interface module being in electrical communication with
the home control unit; and a control module for storing the consumption data from
the utility meter and for controlling the transmission of the consumption data by
the interface module; a concentrator in communication with the utility meter
reading unit, said concentrator having a transmitter for transmitting a concentrator
polling request signal to the interface module of the utility meter reading unit, a
receiver for receiving the consumption data from the interface module of the utility
meter reading unit in response to the concentrator polling request signal, a
concentrator interface module for packaging the consumption data into an
automatic meter reading (AMR) packet having a destination host address, a base
station in communication with the concentrator, said base station having a
transmitter and a receiver for receiving the AMR packet sent from the transceiver
of the concentrator, routing means for routing the AMR packet based on the
destination host address information; and a plurality of host computers, each of
said plurality of host computers having a network interface, whereby at least one
of said plurality of host computers adapted to receive the AMR packet from the
transmitter of the base station and for transmitting a host polling request signal to
the utility meter reading unit through the transmitter of the base station and the
transceiver of the concentrator to request receipt of the consumption data, and
means for performing a prescribed function related to the purpose served by the
host computer once the AMR packet has been received.

In accordance with another aspect of the present invention there is provided a
method of automatically sending usage information from a utility meter monitored
by a utility meter reading unit to at least one of a plurality of remotely located host
computers through a concentrator and a base station, said method comprising the
steps of: (a) said meter reading unit generating consumption data (CD) based on
utility usage; (b) said concentrator generating a concentrator polling request
signal (CPRS) at a pre-set time interval; (c) said concentrator transmitting the
CPRS to the meter reading unit; (d) said meter reading unit sending the CD to the
concentrator based on the CPRS of step (c); (e) said concentrator framing the CD
of step (d) to form an automatic meter reading (AMR) packet that includes host
address information; (f) said concentrator transmitting the AMR packet of step (e)
to the base station; and (g) said base station routing the AMR packet to the
appropriate destination host computer for processing.

In accordance with another aspect of the present invention there is provided a
method of sending usage information from a utility meter monitored by a utility
meter reading unit to a remotely located utility host computer through a
concentrator and a base station, said method comprising the steps of: (a) said
meter reading unit generating consumption data (CD) based on utility usage; (b)
said utility host computer generating a utility polling request signal (UPRS) and
transmitting the UPRS to the base station; (c) said base station receiving the UPRS and transmitting the UPRS to the concentrator; (d) said concentrator receiving the UPRS and generating a concentrator polling request signal (CPRS); (e) said concentrator transmitting the CPRS to the meter reading unit; (f) said meter reading unit sending the CD to the concentrator based on the CPRS of step (e); (g) said concentrator framing the CD of step (f) to form an automatic meter reading (AMR) packet that includes host address information; (h) said concentrator transmitting the AMR packet of step (g) to the base station; and (i) said base station routing the AMR packet to the utility host computer for processing.

In accordance with another aspect of the present invention there is provided a method of sending an alarm message from a home device having a sensor monitored by a home control device and a meter reading unit to a remotely located alarm host computer through a concentrator and a base station, said method comprising the steps of: (a) said sensor indicating the presence of an alarm situation; (b) said home device transmitting a sensor status signal (SSS) to the home control device and the meter reading unit responsive to the presence of the alarm situation; (c) said meter unit processing said SSS to form a sensor status data (SSD) that includes a control field specifying the type of alarm situation; (d) said meter unit transmitting the SSD to the concentrator; (e) said concentrator framing the SSD received from step (d) to form a home device (HD) packet containing destination host information; (f) said concentrator transmitting the HD packet of step (e) to the base station; and (g) said base station routing the HD packet to the alarm host computer for processing.

**BRIEF DESCRIPTION OF THE DRAWINGS**

Embodiments of the invention will be described by way of example with the drawings in which:
Fig. 1A illustrates a block diagram of a remote home monitoring system according to an embodiment of the present invention;

Fig. 1B illustrates a block diagram of another embodiment of the remote home monitoring system wherein the concentrator is in direct wireline communication to the base stations;

Fig. 2 is a block diagram illustrating the integration of various modules of the system of Fig. 1;

Fig. 3A is a block diagram illustrating the components of the home control unit shown in Fig. 1;

Fig. 3B is a block diagram illustrating the components of a smoke detector system as one of the home devices shown in Fig. 1;

Fig. 4 illustrates the software architecture of a general host shown in Fig. 1;

Fig. 5 illustrates the software architecture of the AMR module of Fig. 2;

Fig. 6 illustrates the software architecture of the sensor/alarm module of Fig. 2;

Fig. 7 illustrates the software architecture of the interactive display module of Fig. 2;

Fig. 8 illustrates an exploded perspective view of the meter reading unit of the present invention incorporated into a standard hydro electric meter;

Fig. 9 illustrates a block diagram of the electronic architecture of the meter reading unit of Fig. 8;

Fig. 10 illustrates a schematic frontal view of the sensor and rotating disk shown in Fig. 8;

Fig. 11 illustrates the connection detail between the sensor and the microcontroller of Fig. 9;

Fig. 12 illustrates a software partitioning diagram for the meter reading unit;

Fig. 13 illustrates a detailed schematic of the electronic architecture of the meter reading unit of Fig. 8 shown in general block form in Fig. 9;

Fig. 14 illustrates a front view of an antenna mounted on the meter reading unit according to an embodiment of the present invention;

Fig. 15 illustrates a side view of the antenna of Fig. 14;
Fig. 16 illustrates a top view of the antenna of Fig. 15;

Fig. 17 illustrates a top view of the antenna of Fig. 14 illustrating its radiation pattern;

Fig. 18 illustrates a schematic side view of the radiation pattern of the antenna shown in Fig. 14;

Fig. 19 illustrates a circuit diagram of the antenna of Fig. 14;

Fig. 20 illustrates a block diagram of the electronic architecture of the concentrator of Fig. 1;

Fig. 21 illustrates a schematic diagram of the electronic architecture of the concentrator of Fig. 1 shown in general block form in Fig. 20;

Fig. 22 illustrates a software partitioning diagram for the concentrator of Fig. 1;

Fig. 23 illustrates a block diagram of the electronic architecture of the base station of Fig. 1;

Fig. 24 illustrates a flow chart of the process of automatically sending a meter reading from a utility meter to a host computer according to an embodiment of the present invention;

Fig. 25 illustrates a flow chart of the process of sending a meter reading from a utility meter to a host computer on the request of the host computer according to an embodiment of the present invention; and

Fig. 26 illustrates a flow chart of the process of sending an alarm message from a home device to a host computer according to an embodiment of the present invention.

BEST MODE(S) FOR CARRYING OUT THE INVENTION

System

Fig. 1A illustrates a remote monitoring system 100 that includes dwellings 102 (such as homes, apartments, office buildings and the like) that consume utilities such as electric power, water and natural gas. The consumption of a utility is monitored by a utility meter 108. The utility meter 108 is connected to a meter reading unit 120 that communicates with a concentrator 122. The meter unit 120 interfaces with a home
control unit 116, which provides wireless communications to additional home devices 118 within the dwelling 102. The home devices 118 include smoke/alarm based monitoring devices that will be discussed in more detail below.

The concentrator 122 is in communication with at least one of a plurality of base stations 124, which relay consumption information from the meter reading unit 120 and status signals from the home control unit 116 to at least one host 130 including: a utility host 126, a system host 128 and a sensor/alarm monitoring host 132. The sensor/alarm monitoring host 132 receives updates on the status of sensors (i.e. home devices 118) in the dwellings 102 and in the case of an alarm signal from a security sensor for example, notifies the appropriate service provider (e.g. fire or police department). The utility host 126 produces invoicing and other outsourced data 133 to be sent to the occupant of the dwellings 102 to report and bill utility consumption.

The system host 128 uses information from the utility host 126 and the sensor/alarm monitoring host 132 to keep track of the status of all components (118, 120) in the dwelling 102. While the utility host 126, the system host 128, and the sensor/alarm monitoring host 132 all serve different functions, each is composed of essentially the same components and as such the general term host 130 will be used interchangeably to describe shared architecture.

The host 130 interfaces with at least one of the base stations 124 by an X.25 link into a wireless data packet (WDP) network 90, such as Mobitex™. The drawings only show one link between a base station 124 and the hosts 130 for simplicity. The link between each host 130, the base stations 124 and the concentrator 122 use an account numbering scheme that is analogous to telephone numbers to route messages. Each host 130 has a list of concentrator account numbers it communicates with and the concentrator 122 has a list of each host's 126, 128, 132 account numbers it uses to return data from various dwellings 102. The base station
124 acts as the router for the data transferred between the concentrator 122 and the hosts 130. The details of this interaction will be described in further detail below.

The concentrator 122 provides an interface to the next wireless link down to the meter unit 120 at the dwelling 102. Typically, a concentrator 122 would service about 50 meter units 120 (or dwellings 102). Therefore, in a given community a plurality of concentrators 122 would be located at predetermined locations (for example, on light standards) to service the homes and business in the entire community.

Fig. 1B illustrates a remote home monitoring system 101 according to an alternative embodiment of the present invention in which the concentrator 122 is in direct wireline communication to the base stations 124 using telephone lines or fibre optic cable for example. The subsequent discussion of the interaction between various components of the home monitoring system apply equally to the wireless system 100 of Fig. 1A and the direct wireline system 101 of Fig. 1B.

Fig. 2 illustrates the interaction of the various in-home components (118, 120, 139) with the application software modules that co-ordinate communications between the in-home components and the concentrator 122, the base stations 124 and the hosts 130.

**Automatic Meter Reading (AMR) Module**

An AMR module 134 performs functions related to gathering meter consumption data and demand readings from the meter reading unit 120 located at the utility meter 108. The module 134 also provides for polling of this data during special situations such as service opening and closing.

**Sensor/Alarm Monitoring Module**

An sensor/alarm monitoring module 136 performs functions related to the receipt of sensor and alarm data from the home device 118 within the dwelling 102. The
data transfer is initiated by the home control unit 116 and continues to the meter reading unit 120 then through the concentrator 122, base station 124 and ultimately to the sensor/alarm monitoring host 132.

*Interactive Display Module*

An interactive display module 138 performs functions related to the downloading of display text from the system host 128 to a device control/display unit 139 (such as a set-top box connected to a television) in the dwelling 102 and the return of any messages initiated by an operator in the dwelling 102. The text and messaging is used for services such as electric billing information and the return of payment actions.

*Home control unit*

The home control unit 116 is electrically connected to the meter reading unit 120 and is detailed in Fig. 3A. The control unit 116 includes a power supply 80 to provide prescribed levels of voltage to a receiver/transmitter module 82 and a control module 83. The receiver/transmitter module 82 is used to transmit and receive information from home devices 118 and the meter reading unit 120. The control module 83 includes a processor 84 to interface with the meter reading unit 120 and receiver/transmitter 82, and a latches module 86 to store data and to include address locations for processing of data.

*Home Devices- General*

The home devices 118 referred to in the present application include smoke detectors, alarm based sensors (e.g. for doors and windows), carbon dioxide sensors and the like. In general, all home devices 118 communicate with the control unit 116 and report to the sensor/alarm monitoring host 132 through the meter reading unit 120. A detailed description is provided for smoke detectors, however, it is understood that similar hardware/software would be implemented for other types of sensors.
In particular, in order to connect and communicate with the control unit 116 the home device 118 matches the specification of a typical pinout for the home device 118 as summarized in Table A1, where MEZ represents the home control unit 116.

**TABLE A1**

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<tr>
<th>PIN</th>
<th>NAME</th>
<th>USAGE</th>
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<tr>
<td>1</td>
<td>FROM_MEZ</td>
<td>Serial data from the MEZ to the connected device</td>
</tr>
<tr>
<td>2</td>
<td>TO_MEZ</td>
<td>Serial data from the connected device to the MEZ</td>
</tr>
<tr>
<td>3</td>
<td>MEZ_REQ</td>
<td>Active low request from MEZ to the connected device</td>
</tr>
<tr>
<td>4</td>
<td>VCC</td>
<td>5V power supply provided by the connected device</td>
</tr>
<tr>
<td>5</td>
<td>spare</td>
<td>--</td>
</tr>
<tr>
<td>6</td>
<td>GND</td>
<td>ground</td>
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</table>

In operation, the home device 118 connected to the home control unit 116 (or MEZ in Table A1) can initiate communications with the home control unit 116 by sending it serial messages on the TO_MEZ line. This line is connected to a general purpose I/O pin on the home device 118.

When the home control unit 116 needs to communicate with the connected home device 118, it asserts the active low MEZ_REQ signal. This signal is normally pulled up on the connected home device 118, so that if no home control unit 116 is connected, the device 118 will operate correctly.
When the falling edge of the MEZ_REQ occurs, the connected home device 118 is placed in such a state as to wait for characters to be received from the home control unit 116 on the FROM_MEZ line. The MEZ_REQ need not be asserted before each character is sent. The home device 118 continues to poll the FROM_MEZ line until either a complete message has been received, or a time-out occurs.

The data structure for the home device 118 is summarized in Table A2. Field 6 is a variable length of data for data payload for particular devices that require long data strings.

**TABLE A2**

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<tr>
<th>Number</th>
<th>Bytes</th>
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<tr>
<td>1</td>
<td>4</td>
<td>Device ID - unique identifier for all devices</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>Message Type</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>LAN Node ID (within catchment area)</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>Service function</td>
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<tr>
<td>5</td>
<td>1</td>
<td>Length</td>
</tr>
<tr>
<td>6</td>
<td>0-16</td>
<td>Variable length data payload</td>
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</table>

The device ID is a unique identifier that is tied to the serial number of the home devices 118 so that no duplicate ID exist. The message type is a two-byte identifier for the message sent by the device 118, for example installation, test (battery, device), emergency (fire, security), or status 1 - signal not forwarded.

The LAN node ID is a single byte reserved for identifying the meter unit 120 within a concentrator's 122 catchment area. The service function field is the byte
identifier for the type of service that is provided by a third party, such as fire, security, local loop detection, electric/gas/water utility, or television set-top box. The length field is a byte identifier that shows how long the variable data payload is for a particular message buffer. This field gives the flexibility to provide for longer or shorter messages depending on the application.

The variable length data payload is a buffer for messages that require longer data structures than most simple applications require. The data within this data payload can be in any format including ASCII or binary.

**Home device-Smoke detector**

A smoke detector system 70 is an example of a home device 118 in the systems 100 and 101. The smoke detector system 70 (as shown in Fig. 3B) includes a control interface 72 that monitors output signals from a smoke detector circuit 74 (such as the Motorola MC14467-1). The control interface 72 determines the operating condition of the detector 74 (i.e. test, alarm, battery low). When one of these conditions has been detected, a processor 76 transmits a message to the meter unit 120 for subsequent transmission to the concentrator 122 and ultimately to the appropriate host 130. The interface 72 also sends a system status message once per day to notify the home control unit 116 and eventually to the sensor/alarm monitoring host 132 that the detector system 70 is working properly.

**Home device- device control/display unit**

The device control/display unit 139 is another example of a home device 118. The display unit 139 is in communication with the interactive display module 138 and performs the following functions:

**Utility Message Handling**

(a) Electric meter readings - initiated by meter unit 120

(b) Electric meter readings - initiated by utility host 126
(c) Gas meter readings - initiated by meter unit 120, sent on a regular basis
(d) Water meter readings - initiated by meter unit 120, sent on a regular basis

5

Maintenance Functions

(a) Generated internally within the dwelling 102
   Test smoke detectors
   Low battery indication messages

10
(b) Generated from utility host 126
   External meter calibration

Status Message Handling

(a) Normal operation report on a regular basis

15
(b) Tamper message

Emergency Messages

All meter units 120 hearing an emergency message type will respond to the concentrator 122 with a message indicating an emergency. Emergency messages are categorized by life-safety messages as described below:

(a) smoke detector message;
(b) carbon monoxide detector message;
(c) fire detector message; and

25
(d) medical emergency message - initiated by any home device 118 or by the display unit 139 itself

Initializing new home devices 118

When an occupant/user purchases a new home device 118 the compatible device can easily be added to the system 100 (or system
101) by merely providing the interactive display module 138 with some basic information about the device (type, serial no) into the device control/display unit 139. The new home device then becomes a fully integrated component to the overall system 100 (or system 101).

**Host Architecture**

The host 130 describes the generic architecture of the utility host 126, the system host 128, and the sensor/alarm monitoring host 132. The host 130 interfaces with the network 90 through a wide area network communications interface 308 and an X.25 interface 306 shown in Fig. 4. The inter-process communications protocol (IPC) is a Dynamic Data Exchange (DDE) interface 310 to an application program module 311. The host 130 operates at a message level leaving details of the network 90 communications protocol to Datarec™ and RAD sock™ programs, which are known in the art. The program module 311 includes an application message delivery and reception module 312, a database manager 314 for storing and retrieving data from a database 320, an application data extraction/export forwarding module 316 and an application user interface 318. The interaction of these components will be described in detail in conjunction with the specific application programs (i.e. the AMR module 134, the sensor/alarm monitoring module 136 and the interactive display module 138).

In the case of the sensor/alarm host 132, an alarm service provider application 326 is included to interact with the application module 311 through an X.25 link 322 to provide monitoring and feedback information from the home devices 118 (discussed in more detail below).

In the case of the utility host 126, an electric utility application 328 interacts with the application module 311 through a file transfer interface 324 to provide
monitoring and feedback information from the meter reading unit 120 (discussed in more detail below.)

Examples of the communication protocol between the host 130 and the concentrator 122 are provided in Tables B1 to B3. Specifically, an example of the dialogue for an autonomous message generated by the concentrator 122 is summarized in Table B1.

### TABLE B1

<table>
<thead>
<tr>
<th>HOST 130</th>
<th>COMMUNICATION LAYERS</th>
<th>CONCENTRATOR 122</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;--open connection</td>
<td>send data</td>
</tr>
<tr>
<td></td>
<td>connection accept--&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--AMR ready</td>
<td></td>
</tr>
<tr>
<td>receive data</td>
<td>&lt;--incoming data message</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ack to message--&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--close connection</td>
<td></td>
</tr>
</tbody>
</table>

An example of the dialogue for a data download where the host 130 is initializing the concentrator 122 is summarized in Table B2.
### TABLE B2

<table>
<thead>
<tr>
<th>HOST 130</th>
<th>COMMUNICATION LAYERS</th>
<th>CONCENTRATOR 122</th>
</tr>
</thead>
<tbody>
<tr>
<td>send data</td>
<td>open connection--&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--connection accept</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--AMR ready</td>
<td></td>
</tr>
<tr>
<td></td>
<td>outgoing data message--&gt;</td>
<td>receive data</td>
</tr>
<tr>
<td></td>
<td>&lt;--ack to message</td>
<td></td>
</tr>
<tr>
<td></td>
<td>close connection--&gt;</td>
<td></td>
</tr>
</tbody>
</table>

An example of the dialogue for polling of the concentrator 122 by the host 130 for a meter reading is summarized in Table B3.
TABLE B3

<table>
<thead>
<tr>
<th>HOST 130</th>
<th>COMMUNICATION LAYERS</th>
<th>CONCENTRATOR 122</th>
</tr>
</thead>
<tbody>
<tr>
<td>send data</td>
<td>open connection--&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--connection accept</td>
<td></td>
</tr>
<tr>
<td></td>
<td>&lt;--AMR ready</td>
<td></td>
</tr>
<tr>
<td></td>
<td>outgoing data message--&gt;</td>
<td>receive request</td>
</tr>
<tr>
<td></td>
<td>&lt;--ack to request</td>
<td></td>
</tr>
<tr>
<td>receive data</td>
<td>&lt;--response to request</td>
<td>send data</td>
</tr>
<tr>
<td></td>
<td>ack to response--&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>close connection--&gt;</td>
<td></td>
</tr>
</tbody>
</table>

AMR Module Architecture

Fig. 5 shows the software architecture for the AMR module 134 of the utility host 126 for gathering the meter consumption and demand readings from the meter reading unit 120.

An incoming communications module 150 interacts with a communication module 140 to bring a message into the AMR module 134 and directs a copy of the traffic activity to an activity log 152. A message validation module 156 performs message level checks to ensure accuracy in the message. The message can be a request for information or meter reading consumption data transferred to the host 126 by the concentrator 122.

A field validation and splitter module 160 performs detailed checks on the fields to ensure that the data format is correct and tests some of the ranges against setup
parameters and from previously received data to ensure, for example, that consumption data for a utility is not completely erroneous. A command module 158 facilitates the real time issuance of initialization and polled reading commands to the meter unit 120 through the concentrator 122 and the display of the resulting message. Also, the command module 158 includes a batch file input process 162 for the issuance of large numbers of commands such as initializing blocks of meter units 120.

An outgoing communications module 146 interacts with the communication module 140 to send messages to the concentrator 122 plus copies traffic to the activity log 152 and display as enabled by setup parameters. Module 146 checks for errors in the command process where an acknowledgement from the concentrator 122 was expected but not received for example.

An activity log and display module 148 archives message traffic to a filing system and displays the activity. The activity log files 152 are retained but files older than indicated in the setup parameters will be deleted. A log replay utility module 144 facilitates the playback of logged message traffic into the incoming communications module 150.

A database manager module 164 handles message storage into a database 166 and retrieval of data. The module 164 also handles the meter unit 120 configuration database and consolidated network routing database.

A meter reading data extraction and conversion module 170 reads data from the database 166 through the manager module 164 according to selected criteria and converts the format of the data, storing it in a flat file 176 ready for a computer operator to transfer it through other processes. A startup file 172 is a text file that contains all startup parameters for the above modules. A exception and error
report file 174 is a text file that the above modules direct any exception and error reports.

As discussed above in conjunction with Fig. 4, interface of the utility application 328 to the application module 311 will be by the file transfer technique 324. The extraction and conversion module 170 will generate the flat file 176 in a format compatible with a final user’s (i.e. a hydro corporation) application software such as a billing package. The mechanisms used to transfer this file range from moving it to another directory on the drive if the final application is on the same computer, to using a disk, to using a file transfer protocol over a modem or local area network etc. as is well known in the industry.

**Sensor/Alarm Monitoring Module Architecture**

Fig. 6 shows the software architecture for the sensor/alarm monitoring module 136 of the sensor/alarm monitoring host 132 for the receipt of alarm data from within the dwelling 102 based on data received from the home devices 118 that monitor fire detectors, security devices and the like.

The modules having like reference numbers discussed in conjunction with Figs. 4 and 5 function in the same way in relation to the architecture of Fig. 6. Fig. 6 introduces an alarm message forwarding and format conversion module 330 for forwarding an alarm message to a service provider (i.e. alarm company, gas company etc.) through the X.25 interface 306 and the X.25 link 322. The module 330 also handles the message format conversion to match destination requirements.
Interactive Display Module Architecture

Fig. 7 shows the software architecture for the interactive display module 138 of the system host 128 for the downloading of display text from the system host 128 to the device control/display unit 139 connected to a television set in the dwelling 102. The modules having like reference numbers discussed in conjunction with Figs. 4 and 5 function in the same way in relation to the architecture of Fig. 7.

Meter Unit-system

Fig. 8 illustrates an exploded perspective view of the meter reading unit 120 incorporated into a standard hydro electric meter assembly 200. The electric meter 200 includes a base assembly 202 having a set of sockets 204 and a meter face 206 containing a rotating disk 207 having a black indicator mark 226 on the outer edge thereof. The meter face 206 includes a set of prongs 208 that correspond to the sockets 204 of the base assembly 202. The meter 200 also includes spacer rings 210 and 212. The meter reading unit 120 includes a plurality of prong extension members 214 that are positioned between the sockets 204 of the base 202 and the prongs 208 of the meter face 206.

A central processing module 216 integrated into a retaining ring 217 is connected between the spacer rings 210 and 212. A sensor system 218 is connected to the meter face 206 and the processing module 216. The sensor system 218 includes a sensor 220 a reflective disk 222 and a retention arm 224 having an access cover 225. The retention arm 224 holds the sensor 220 and the disk 222 in contact with the meter face 206 to detect movement of the rotating disk 207.

Fig. 9 illustrates a block diagram of the electronic architecture of the meter unit 120. The central processing module 216 of the meter unit 120 includes a power supply 300, a LAN interface module 302 connected to an antenna 303 and a
control module 304. Details of each of these components will be discussed in conjunction with Figs. 12 and 13.

**Sensor-meter unit-system**

The sensor 220 shown in more detail in Fig. 10 is a disk rotation sensor (such as the Sharp GP2A22™ photo interrupter) having a TTL-compatible output used to read the black mark 226 on the edge of the rotating disk 207 of the meter 200. The sensor 220 includes a differential optic emitter 230 and receiver 232. As the black mark 226 on the edge of the rotating disk passes the emitter 230 beam, light is absorbed instead of reflected. Circuitry in the sensor 220 detects an open connection. The control module 304 senses a pulse and stores this as a digital increment, which is recorded. The electrical consumption is determined by equation (1):

\[
\text{kWh} = \frac{\text{pulses counted}}{\text{(meter constant (kh) \times 1000))} \times \text{meter multiplier}} ...
\]  

Fig. 11 details the connection between the sensor 220 and the control module 304 that includes three wires: P represents a power wire, S represents a signal wire, and G represents a ground wire.

**Control Module-meter unit-system**

A data flow diagram of the control module 304 is shown in Fig. 12. In general, the meter unit 120 counts the meter disc 207 revolutions; responds to polling signal messages from the concentrator 122; detects power failures; and transfers messages from and to the AMR module 134.

The key execution units are shown as bubbles, interconnected with arrows to show the information exchanged among them. Data storage for key items are indicated as rotation count module 402, demand module 404, and non-volatile storage unit 406 such as Flash RAM.
Constant values such as meter identifiers and meter constants are stored in the non-volatile storage unit 406. In this arrangement, the variables stored in memory unit 406 can be easily modified, but are saved without a constant power requirement. The rotation count module 402 stores pulse count data in volatile RAM and is powered at all times.

In operation, the meter unit 120 signals the assertion of dial rotation of the disk 207 to a detect-rotation-event (DRE) function 408. The DRE function 408 increments a counting semaphore, the rotation count module 402, and writes to the demand module 404 using the meter unit’s 120 time base. A transit-consumption (TC) function 410 reads both the rotation count module 402 and the demand module 404, initiating transmission via a service-LAN module 412. The criteria for invoking the transmission of consumption data can be based on the meter unit’s 120 time base and/or requested from the concentrator 122, the choice of which depends on the network protocol.

The service-LAN module 412 performs transactions for the system 100, including transmission of consumption data and receipt of new software in support of its programmable functions.

A detect-power-fail (DPF) function 414 is used to detect a drop in the power line sensed by integrated circuit (IC) logic in the power supply 300. The DPF function 414 responds to a loss of power by running an alarm subroutine.

A watchdog timer reset (WDT) function 416 is a timer that is set in motion when a power drop is sensed by the DPF function 414. A full power outage is indicated when the timer expires. If the timer does not expire then this would indicate that the power drop is merely a brown out.
A load-software (LS) module 418 handles changes to the non-volatile storage unit 406 if a new configuration must be setup by the system host computer 128. The changes can include updates to the real-time clock and usage rates.

The service-LAN function 412 provides the protocol between the concentrator 122 and the meter reading unit 120 and is a packet based protocol. Each packet transfer actually consists of the following items:

(a) preamble: a period of time in which the RF carrier is present but no data is sent;

(b) packet: asynchronous serial data (8 bits, no parity, 1 stop bit); and

(c) postamble: period of time in which the RF carrier is present but no data is being sent.

The packet consists of the following fields:

(a) header: every packet starts with a header whose format is the same for all packet types. The header consists of:

(i) STX: a one byte synchronization character used to indicate the start of the packet;

(ii) concentrator address: a three byte field identifying the concentrator 122 involved in the message transaction. For a packet to be received by the meter, the concentrator address must be equal to the meter unit’s 120 address, or equal to 0xFFFFFE. This address is used to allow any concentrator to talk to a specific meter;

(iii) meter address: a one byte field identifying the meter unit 120 involved in the message transaction. For a packet to be received by the meter, the meter address must match the address stored in the meter, or be equal to 0xFF. This is a broadcast address to allow the concentrator 122 to talk to all of its meters 120;

(iv) control: a one byte field specifying the type of packet; and
(v) length: a one byte field holding the packet length in bytes from the STX up to and including the ETX.
(b) payload: this field has various lengths depending on the control field;
(c) trailer: including:

5

(i) CRC: a two byte field containing a Cyclic Redundancy Check. The standard CRC-16 polynomial is used to calculate the CRC. The ETX character is not used in the calculation; and
(ii) ETX: a one byte end of message character.

10

The CRC virtually assures that packet with bit errors or missing bytes will be received and considered as valid by the receiver. The packet format is limited to at most 41 bytes in length to keep down the length of time required to send a message, which reduces the susceptibility to interference. The CRC check on the packet provides a collision detect mechanism. For example, if two nodes are transmitting at the same time the signal interference at the intended receiver will cause the packet to fail its CRC check. If the CRC check specifies that a collision has occurred the data integrity check will fail and the receiving end will transmit a request for retransmission of the data.

20

Encoder and decoder hardware provides for a 4 bit unbuffered data path to the software system and a channel capacity of 2.4kbps. This data path will be discussed in further detail in conjunction with Fig. 13. Provided the channel is half-duplex, this translates to an event being presented to the service-LAN function 412 every 1.67ms. The service-LAN function 412 uses interrupt service for both transmit and receive functions, and is attributed a relatively high priority to accomplish its task. As such, the function detect-rotation-event 408 is capable of tolerating latencies introduced by service-LAN processing.

30

To characterize the processing requirements of service-LAN function 412, the receive function is summarized in Table C1.
<table>
<thead>
<tr>
<th>Function</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>receive header</td>
<td>...</td>
</tr>
<tr>
<td></td>
<td>load message length</td>
</tr>
<tr>
<td></td>
<td>reset buffer address</td>
</tr>
<tr>
<td></td>
<td>clear count</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td>receive data</td>
<td>load count address</td>
</tr>
<tr>
<td></td>
<td>load buffer address</td>
</tr>
<tr>
<td></td>
<td>test low bit of count</td>
</tr>
<tr>
<td></td>
<td>jump to “odd” if set</td>
</tr>
<tr>
<td>even</td>
<td>read input port</td>
</tr>
<tr>
<td></td>
<td>rotate 4 bits</td>
</tr>
<tr>
<td></td>
<td>store at buffer address</td>
</tr>
<tr>
<td></td>
<td>jump to “next”</td>
</tr>
<tr>
<td>odd</td>
<td>read input port</td>
</tr>
<tr>
<td></td>
<td>mask data bits</td>
</tr>
<tr>
<td></td>
<td>“or” to byte at buffer address</td>
</tr>
<tr>
<td>next</td>
<td>increment buffer address</td>
</tr>
<tr>
<td></td>
<td>increment count</td>
</tr>
<tr>
<td></td>
<td>compare count to message length</td>
</tr>
<tr>
<td></td>
<td>jump to “done”, if not equal</td>
</tr>
<tr>
<td></td>
<td>set messageIn signal</td>
</tr>
<tr>
<td>done</td>
<td>...</td>
</tr>
</tbody>
</table>
The detect-rotation-event function 408 executes in response to the assertion of the meter dial event, indicating the occurrence of one complete rotation. Table C2 summarizes the rotation count function 402. The hardware interface includes edge-detect circuitry. Alternatively, the input can be polled (level sensitive rather then edge sensitive). The polled method is suitable for relatively slow transitions of the input signal where its duty cycle is sufficiently long to guarantee detection by the software.

**TABLE C2**

<table>
<thead>
<tr>
<th>Function</th>
<th>Steps</th>
</tr>
</thead>
<tbody>
<tr>
<td>detect rotation count</td>
<td>load rotationcount address</td>
</tr>
<tr>
<td></td>
<td>increment low order bits</td>
</tr>
<tr>
<td></td>
<td>jump to rotationdone, if carry=0</td>
</tr>
<tr>
<td></td>
<td>increment address</td>
</tr>
<tr>
<td></td>
<td>increment next to low order bits</td>
</tr>
<tr>
<td></td>
<td>jump to rotationdone, if carry=0</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
<tr>
<td>Rotation done</td>
<td>load timer source address</td>
</tr>
<tr>
<td></td>
<td>load demand destination address</td>
</tr>
<tr>
<td></td>
<td>read source low order bits</td>
</tr>
<tr>
<td></td>
<td>write destination low order bits</td>
</tr>
<tr>
<td></td>
<td>increment source address</td>
</tr>
<tr>
<td></td>
<td>increment destination address</td>
</tr>
<tr>
<td></td>
<td>read source next-to-low-order bits</td>
</tr>
<tr>
<td></td>
<td>write destination next-to-low-order bits</td>
</tr>
<tr>
<td></td>
<td>...</td>
</tr>
</tbody>
</table>
The data item rotation count is implemented as a counting semaphore (accumulator), incremented by detect-rotation-count and decremented by the function transmit-consumption. The meter unit 120 does not debit the rotation count until successful communication to the concentrator 122 has been confirmed.

The rotation count is required to be preserved across power cycles and is written to a storage medium, such as a non-volatile storage implemented as EEPROM or flash EPROM have programming cycles on the order to 10ms.

The detect-power-fail function 414 and the WDT-reset function 416 are peripheral to the meter unit's 120 normal operating mode. The DPF function 414 input to the control module 304 provides sufficient warning to allow a non-volatile programming cycle to be completed before power is completely lost.

The load-software function (LSF) 418 is responsible for the procedure of validating, installing and activating software received from the hosts 130. The load-software function 418 is a 'boot strap' module that uses information from the billing host computer 126 to configure each meter unit 120. The LSF module 418 also programs the storage module 406 with meter specific information. Configuration changes from the host computers 126 and 128 are accomplished by downloading new programs to the concentrator 122, or to the meter units 120 via the concentrator 122.

To ensure the integrity of the new program in either case, it is downloaded using a boot loader program. The boot loader program, which is not alterable in the field, handles the reception and validation of packets containing the new program. The new program code is stored at the appropriate space in memory, and then verified using a checksum when complete. If the checksum passes, the meter unit 120 begins to execute the new program.
LAN interface module-meter unit-system
A more detailed schematic representation of the components of the meter unit 120 is shown in Fig. 13. The LAN interface module 302 includes a transmit/receive switch 512 connected to the meter unit antenna 303. The switch 512 is electrically connected to a transmitter 502 and a receiver 504 through a pre-amplifier 503.

Control module-meter unit-system
The control module 304 includes a microcontroller 505 connected to an encoder 506, which is connected to the transmitter 502, and a decoder 508, which is connected to the receiver 504. The encoder 506 (for example, an MC145026™) encodes 9 lines of information (either trinary or binary data) and transmits them twice to increase security.

The decoder 508 (for example, an SC41343™) receives the serial stream and interprets five of the trinary digits as an address code. Therefore, 243 (3**5) are possible with trinary data (high, low, or open) or 32 addresses with binary data (high or low). Two conditions must be met by the receiving data before the decoder 508 will output it for the microcontroller 505. First, the received address must match the address inputs of the decoder 508, and second, the data must be received twice identically. Once these conditions are met, the decoder 508 asserts its valid transmission (VT) output and the microcontroller 505 can read the 4 data bits.

The transmission includes an address field that must match at the destination end. Consequently, the destination must know the address it is listening for. If the address were to be chosen from the meter unit’s 120 serial number, the concentrator 122 could only receive messages from meter units 120 it was expecting to hear from. This would preclude the meter unit 120 from autonomously sending to the concentrator 122. Therefore, a common address
value is chosen for all nodes in the systems 100 and 101 (i.e. meters 120 and
concentrators 122). This address field will provide an extra level of protection on
transmissions since it must match at both the sending and receiving nodes.

An address latch 514 sets the address lines from the microcontroller 505 to a
memory module 516. The memory 516 is also used for non-volatile storage of
operating software for the meter unit 120.

*Power Supply-meter unit-system*

The power supply 300 supplies power to the meter unit 120 using standard AC
main lines. A battery backup (not shown) is used to save the information in the
memory 516 in case of a power failure.

The power supply module 300 includes a surge protector 518 to protect circuitry
against voltage spikes. An isolation transformer 520 is used for de-coupling the
incoming line voltage from the circuitry to prevent current spikes.

A fuse 521, a diode bridge 522, and a capacitor 524 inverts AC voltage supply to
DC voltage supply to a DC supply module 528 to feed the appropriate voltage to
the microcontroller 505.

The power supply 300 is powered from the 120V AC mains, and a 12V sealed
lead acid battery. The main functions of the power supply 300 are summarized
below:

(a) to generate the DC supplies to power the other subsystems (i.e. 5V DC power
for the microcontroller 505; and 3V DC for the LAN interface module 302);
(b) to run from the battery when AC power is not available; and
(c) to provide the capability to turn the 3V DC power supply on and off.
Antenna-meter unit-system

Fig. 14 illustrates the antenna 303 of the meter reading unit 120 according to an embodiment of the invention. The antenna 303 can be used effectively when oriented either vertically or horizontally. Normally, the antenna 303 will be installed to the left of the meter face 206. In some installations, however, another meter 200 is adjacent, and the antenna 303 must be installed above or below the meter face 206.

It is likely that the signal path between the antenna 303 and the concentrator 122 is not free air, line of sight. For example, in many areas, the meters 200 on adjacent houses are facing each other for ease of reading. Consequently, the line-of-sight range of the antenna 303 is more than the range necessary in the general case to account for the difficulties in predicting multipath propagation of radio waves in unknown environments.

The antenna 303 is a hemispheric radiator type as shown in Figs. 15/16, and is connected to the meter unit 120 through a feed wire 612. The antenna 303 is mounted on a ground plate integrated circuit board 608 to provide stability and shielding from the control module 304. The antenna 303 is mounted on the underside of the board 608 and utilizes it as a signal radiation back plane as shown in Fig. 17.

A hemispheric type of antenna radiates omnidirectional in a half sphere, where the flat of the half sphere is along a wall 610 of the dwelling 102. This radiation pattern provides the following advantages: (a) the relative position and orientation of the meter unit 120 and concentrator 122 are unknown, as are the objects to be found between them, and (b) at a typical 900MHz frequency energy radiated back towards the dwelling 102 will be lost as it will not travel through the dwelling 102.
A half-duplex link is used so that both the receiver 504 and the transmitter 502 of the LAN interface module 302 can be connected to the antenna 303. A transmit/receive (T/R) switch 512 is used to connect the receiver 504 and the transmitter 502 to the antenna 303 as previously discussed. To save power, either the receiver 504 or the transmitter 502 will be powered up, but not both. For example, when transmitting, the receiver 504 can be powered down, and vice versa.

In general, half-duplex is a method of communication that supports 2-way communication, but only one device can transmit at a time. The half-duplex link applies between the meter unit 120 and the concentrator 122. If the two devices 120/122 attempt to transmit to each other simultaneously the devices 120/122 will back off transmitting for a random time and then re-transmit.

The plane of the antenna 303 is generally vertical when the meter unit 120 is installed as shown in Fig. 14, and oriented perpendicular to the side of the dwelling 102. The antenna 303 radiates in its plane as shown in Fig. 18. Schematically, the antenna 303 is a loop type having a high Q parallel resonant LC circuit as shown in Fig. 19. The inductance L1 is the self inductance of the wire loop. The capacitance C1 is typically a variable capacitor turned to make the antenna 303 resonate at the desired frequency. Since the antenna 303 is made from a short length of a conducting material, its impedance is very low, on the order of milliOhms.

To deliver power to the antenna 303, an impedance match between the typically 50 Ohm driver and the low impedance antenna 303 is needed. This is accomplished by using a smaller loop L2 inside the antenna loop L1. The mutual inductance of the two loops transforms the low antenna impedance to 50 Ohms to match to the driver.
Concentrator Unit-system

Figs. 20 and 21 illustrate schematic representations of the components of the concentrator 122. The concentrator 122 includes a LAN interface module 650 connected to an antenna 651, a control module 652, a WAN interface module 654 connected to a wide area network (WAN) antenna 655, and a power supply module 656. The WAN antenna 655 is a loaded coil antenna with high gain to receive and transmit signals to and from the hosts 130 through the network 90.

Power supply-concentrator unit-system

The power supply module 656 is powered from the 120V AC mains, and a 12V sealed lead acid battery (not shown). The components of the power supply 656 are identical to the components of the power supply 300 of the meter unit 120 as discussed in conjunction with Fig. 13, with the exception of the addition of a charger 526. The charger 526 incorporates an intelligent charging circuit for re-charging the lead-acid battery in the concentrator unit 122. The charger 526 will determine (by checking the battery strength) what strength of charge needs to be applied to the battery to charge it to full strength. If the battery has experienced a deep discharge, the charger 526 will apply a fast charge. If the battery has experienced little discharge, the charger 526 will apply a trickle charge.

The main functions of the power supply module 656 are summarized below:

(a) to generate the DC signals to power the subsystems: (i) 5V DC power for the control module 652; (ii) 3V DC for the LAN interface module 650; and (iii) 8V DC for the WAN interface module 654;

(b) to charge the battery when AC power is available; the battery charger 526 is a typical buck topology switching regulator that uses a constant current charging scheme to fast charge the battery. Once the battery is fully charged, the charger 526 switches to a constant voltage maintenance or trickle charge mode;

(c) to provide the microcontroller 660 with battery and charger status information;
(d) to run from the battery when AC power is not available;
(e) to provide the capability to turn the 3V DC power supply on and off; and
(f) to provide a way to prevent the battery charger 526 from operating. This is used to prevent the battery charger 526 from operating while the modules 650 and 654 are in their high current transmit state.

LAN interface-concentrator-system
The LAN interface module 650 implements a low power unlicensed narrowband wireless local area network (LAN). The LAN interface module 650 transmits and receives digital packet data to and from the meter units 120. The transmission scheme is on-off keying (OOK) of a 916.5 Mhz carrier. The bit rate is typically in the 1-2KBAud range depending on range. The components of the interface module 650 are identical to the components of the interface module 302 of the meter unit 120 as discussed in conjunction with Fig. 9

The meter unit 120 signal radiation pattern is directional using the wall 610 of the dwelling 102 as a ground plane as discussed previously in conjunction with Figs. 17 and 18. The concentrator unit 122 signal radiates in all directions. The data packets contain both the sender's and recipient's addresses. The packets contain an identifier for the type of application sending the message. The packet reserves a variable length data payload for the message data. The concentrator 122 has the ability to address multiple meter units 120 through a broadcast signal in the data packet.

WAN interface-concentrator-system
The WAN interface module 654 uses a transceiver 658 and the WAN antenna 655 to provide the interface to the public packet data radio network 90 such as Mobitex™. The Mobitex packet data network 90 acts as a wide area communications link between the concentrator unit 122 and the host computer 130. The radio 658 is a digital radio modem (such as the RIM900™ Mobitex™
radio supplied by Research in Motion™). The radio 658 acts as a serial connection between the microcontroller 660 and the network 90.

The Mobitex network provides for message re-tries and message error correction transparently with respect to the user. Mobitex is provided by a public data carrier where coverage by the carrier exists.

A cellular telephone interface version of the WAN module 654 provides for communication where Mobitex coverage is not available. This version simply acts as a telephone modem device for wireless telephone service. The concentrator 122 establishes a connection with the host 130 or vice versa, data is transmitted and the connection is then taken down.

*Control Module-concentrator-system*

The control module 652 manages the messages to and from the meter units 120 and to and from the host computers 126, 128, 132. The control module 652 buffers meter readings from the various meters 120 in a cache in the concentrator 122 until requested by the host computers 126, 128, 132 or until a particular time interval has elapsed.

The control module 652 includes a microcontroller 660 connected to an encoder 664, which is connected to the transmitter 502, and a decoder 662, which is connected to the receiver 504.

The decoder 662 (for example, an SC41343™) receives a serial data stream and interprets five of the trinary digits as an address code. Two conditions must be met by the receiving data before the decoder 662 will output it for the microcontroller 660. First, the received address must match the address inputs of the decoder 662, and second, the data must be received twice identically. Once
these conditions are met, the decoder 662 asserts its valid transmission (VT) output and the microcontroller 660 can read the 4 data bits.

The transmission includes an address field that must match at the destination end. Consequently, the destination must know the address it is listening for. If the address were to be chosen from the meter unit’s 120 serial number, the concentrator 122 could only receive messages from meter units 120 it was expecting to hear from. This would preclude the meter unit 120 from autonomously sending to the concentrator 122. Therefore, a common address value is chosen for all nodes in the system 100 (i.e. meters 120 and concentrators 122). This address field will provide an extra level of protection on transmissions since it must match at both the sending and receiving nodes.

An address latch 666 sets the address lines from the microcontroller 660 to memory modules 668. The memory modules 668 are also used for non-volatile storage of operating software for the meter unit 120.

In summary, the control module 652 determines whether data must be forwarded either from the meter unit 120 to the hosts 126, 128, 132 or from the hosts 126, 128, 132 to the meter unit 120, depending on the nature of the data. For example, utility meter readings may be buffered but certain smoke detector messages must be forwarded immediately.

Software-concentrator-system

Fig. 22 shows the major software components and data exchanges that are required to implement the concentrator 122. The concentrator 122 provides a first-in-first-out (FIFO) scheduling mechanism. This mechanism simplifies the integration of I/O (input/output) service, where the nature of message arrival and departure rates are asynchronous.
The queuing mechanism supports the requirement for multiple outstanding requests, including those issued by the host 130 and those resulting from dialog with one or more meter units 120.

A WAN-input 706 function and a WAN-output 708 function provide for receipt and transmission respectively of messages on the network 90. For example, when the software's interface to the network 90 is a half-duplex, 8 bit data path, service is required to receive or transmit at approximately 1 millisecond intervals. The number of operations required to be performed at each service interval is estimated at 200.

The requirement for several outstanding requests is provided by the FIFO queues labelled IP_REQS 710 and OP_REQS 712. The number of outstanding requests is limited by the capacity to these queues.

Service to the meter reading units 120 is provided by a service-LAN function 714. The function 714 monitors data traffic from the meter units 120 to receive incoming messages and transmit outgoing messages and communicates with a meter unit database 715. The sequence of operation of the function 714 is summarized below:

Concentrator 122 SENDING/Meter reading unit 120 RECEIVING

The microcontroller 660 of the concentrator 122 asserts a transmit enable signal to switch the T/R switch 512 to transmit and turns on the RF field. This period of time acts as a message preamble that is detected by the receiver 504 of the meter reading unit 120. Following the preamble, the microcontroller 660 then sends serial data on a transmit data line. When the message has been transmitted, the microcontroller 660 dissents the transmit enable signal. This event returns the T/R switch 512 to receive mode.
The meter reading unit 120 microcontroller 505 running the LAN service module 412, is interrupted by the preamble from the concentrator 122 and asserts a pass-through signal (an output line on the microcontroller 505) to allow data to pass through to receive data input. The control module 304 receives the data packet and checks the data integrity. The control module 304 decodes the message and, if necessary, will respond with a message where the meter reading unit 120 places a message in the return packet to the concentrator 122.

**Meter reading unit 120 RECEIVING/Concentrator 122 SENDING**

The reverse of the above procedure occurs. The concentrator 122 then sends the consumption data from the meter reading unit 120 through the network 90 to the hosts 130. The concentrator 122 receives the packet from the meter reading unit 120 using the LAN service module 412. The control module 652 forwards the data to the WAN interface module 654. The microcontroller 660 creates an AMR (automatic meter reading) packet and includes in the data of the packet to be sent, the meter pulse count, the time stamp from the real-time clock, a meter data transfer message type ID, and the meter reading unit 120 ID.

The concentrator 122 is driven by the meter unit 120 specified in network messages and requests. These components are shown in Fig. 22 as a timed-response-subsystem 718, a computer-Kwh function 720 and a configure-meter-dial function 722. The computer-Kwh function 720 is executed on demand or at timed intervals and requires simple arithmetic functions (such as multiply and divide). In support of these functions the concentrator 122 includes a timebase subsystem 724 to provide a single clock source for functions requiring timing service. A software time of day clock or a real time clock device can be used.
A detect power fail module 726 is a voltage monitoring integrated circuit that
detects a rate of fall in the supply voltage. If the supply voltage decreases beyond
a set threshold (e.g. less than 10% of the normal supply voltage level), the
module 724 will initiate a switch of power source. Within a few milliseconds, the
module 724 can assert an interrupt with the concentrator 122 indicating that a
switch to battery power is necessary.

Base Station-system
The base station 124 is part of the wide area network 90. The base station 124
sends and receives messages to and from the concentrator 122. The base
station 124 routes the packets it receives from the concentrator 122 to the
appropriate host 130.

The base station 124 also receives packets from the host 130 via the network 90
(as in system 100) or via a wire-line digital telephony switch (as in system 101).

The base station 124 is composed of a transmitter/receiver 804, a router 802, and
a network interface 800.

Base Station - Transmitter/Receiver
The base station transmitter/receiver 804 serves as an interface with the network
90 and allows the base station 124 to communicate with the concentrator 122 in
the embodiment of Fig. 1A or using a direct wire-line connection as in the
embodiment of Fig. 1B. The transmitter/receiver 804 receives data packets from
the meter reading unit 120 via the concentrator 122 and sends polling signals
from the hosts 126, 128, 132 to the meter reading unit 120 via the concentrator
122.
Base Station - Router
The base station router 802 is an intelligent routing system capable of forwarding a data packet directly to appropriate host 130. From the control field of the data packet the subject matter of the message contained therein can be determined and the packet can be forwarded to the appropriate host 126, 128, 132 based on this information.

Base Station - Network Interface
The base station network interface 800 acts as an interface to the X.25 network to which the hosts 126, 128, 132 are connected. The network interface 800 forwards messages from the router to the appropriate host via the X.25 network.

EXAMPLE 1
The first example details the process of automatically sending a meter reading from the utility meter 108 to one of the hosts 130 (illustrated in Fig. 24).

Step 850 - Track utility usage
The sensor 220 detects the presence of the black mark 226 on the edge of the rotating disk 207 using the differential optic emitter 230 and receiver 232. The control module 304 of the meter reading unit 120 senses the transition of state between the emitter 230 and the receiver 323 and stores this event as a digital increment or pulse. Each pulse is directly proportional to the amount of electricity consumed by the user. The control module 304 retains the cumulative value of pulses in memory.

Step 852 - Concentrator sends CPRS to meter reading unit
The concentrator 122 retains a real-time clock as part of the control module 652. When the concentrator 122 is interrupted by a pre-set time interval for delivering a meter reading to the utility host 126, the concentrator 122 sends a concentrator polling request signal (CPRS) to the meter reading unit 120. The control module
652 of the concentrator 122 asserts a transmit engage signal to switch the T/R switch 512 to transmit and turns on an RF field. This period of time acts as a message preamble that is detected by the receiver 504 of the meter reading unit 120. Following the preamble, the microcontroller 660 of the concentrator 122 then sends the CPRS. When the CPRS has been transmitted, the microcontroller 660 disengages the transmit engage signal. This event returns the T/R switch 512 to receive mode.

**Step 856 - Meter reading unit receives CPRS and sends CD to concentrator**

The microcontroller 505 of the meter reading unit 120 running the LAN service module 412, is interrupted by the preamble from the concentrator 122 and asserts a pass-through signal to allow data to pass through. The microcontroller 505 receives the CPRS and checks the data integrity using a checksum. The control module 304 decodes the CPRS and will respond with consumption data (CD) using the reverse process where the meter reading unit 120 places the cumulative pulse count in the return packet to the concentrator 122.

**Step 858 - Concentrator receives CD from meter reading unit**

The concentrator 122 receives the CD from the meter reading unit 120 using the LAN service module 412. The control module 652 forwards the CD to the WAN interface module 654. The control module 652 creates an automatic meter reading (AMR) packet from the CD and includes in the AMR packet, the meter pulse count, the time stamp from the real-time clock, a meter data transfer message type ID, and the meter reading unit 120 ID.

**Step 860 - Process AMR packet for transmission to base stations**

The WAN interface module 654 frames the AMR packet with packet framing information as defined by the WAN carrier network provider in standard Radio Open System Interconnect format. Included in the AMR packet prepared by the WAN interface module 654 is the concentrator 122 ID. The WAN interface
module 654 presents the AMR packet to the network 90 and then checks the AMR packet status byte that is returned by the network 90 to indicate successful receipt of the AMR packet. In the case of unsuccessful receipt of the AMR packet as defined by a lost data packet status, the concentrator 122 re-sends the AMR packet to the network 90.

**Step 862 - Base Station routing**

The base station(s) 124 route the AMR packet to the intended utility host 126 and the system host 128 based on destination information in the AMR packet. Sending the AMR packet to the system host 128 will enable the system host 128 to have the most recent utility usage information for each dwelling 102.

**Step 864 - Host Processing**

The communication module 140 of the utility host 126 handles the receipt and de-framing of the AMR packet. The activity log module 152 tracks the event of a received AMR packet and the message validation module 156 performs message level checks on the packet. In the message validation module 156, a field validation and splitter module 160 ensures that the data is correct and tests the meter reading ranges against setup parameters and previously received data. The database manager module 164 handles the storing of meter data into the database 166.

The meter reading data extraction and conversion module 170 reads data from the database 166 through the manager module 164 according to selected criteria and converts the format of the data, storing it in the flat file 176 ready for transfer to the billing module of the utility host computer 126. At this point, the utility host computer billing module (supplied by utility or third party) reads the AMR packet information and processes the bill according to the rate structure as set by the utility.
EXAMPLE 2

The second example details the process of sending a meter reading from the utility meter 108 on the request of the utility host 128 (illustrated in Fig. 25).

5  **Step 880 - Utility Host sends UPRS to base station**
When the utility host computer 126 receives a request to obtain a specific meter reading, the utility host computer 126 presents a flat file 176 to the manager module 164. The communication module 140 of the host computer 126 handles the framing of the utility polling request signal (UPRS). The communication module 140 then presents the UPRS to the network 90.

15  **Step 882 - Base station receives and processes UPRS**
The base station 124 receives the UPRS from the utility host computer 126 and forwards the UPRS to the intended concentrator 122. Included in the UPRS is the concentrator 122 ID.

20  **Step 884 - Concentrator receives and processes UPRS**
The WAN interface module 654 of the concentrator 122 receives the UPRS and de-frames the data. The control module 652 receives the UPRS from the WAN interface module 654. The control module 652 of the concentrator 122 determines from the data in the UPRS that a meter reading is requested by the utility host computer 126.

The concentrator 122 prepares a CPRS for the meter reading unit 120 using the LAN service module 412. The CPRS includes in the data to be sent, the meter data request message type ID, and the meter reading unit 120 ID.

25  **Step 886 - Meter unit receives CPRS and sends CD to concentrator**
The control module 304 of the meter reading unit 120 running the LAN service module 412, is interrupted by the preamble of the CPRS from the concentrator
122 and asserts a pass-through signal to allow data to pass through. The control
module 304 receives the CPRS and checks the data integrity. The control
module 304 decodes the CPRS and responds with a meter reading CD where the
meter reading unit 120 places the cumulative pulse count in the return packet to
the concentrator 122.

**Step 890 - Concentrator receives CD**
The concentrator 122 receives the CD from the meter reading unit 120 using the
LAN service module 412. The control module 652 forwards the CD to the WAN
interface module 654. The microcontroller 660 creates an AMR packet and
includes in the data of the packet to be sent, the meter pulse count, the time
stamp from the real-time clock, a meter data transfer message type ID, and the
meter reading unit 120 ID.

**Step 892 - Process AMR packet for transmission to base stations**
The WAN interface module 654 frames the AMR packet with framing information
as defined by the WAN carrier network provider in the standard Radio Open
System Interconnect format. Included in the AMR packet prepared by the WAN
interface module is the concentrator 122 ID. The WAN interface module 654
presents this AMR packet to the network 90 and then checks the packet status
byte that is returned by the network 90 to indicate successful receipt of the
packet. In the case of unsuccessful receipt of the AMR packet as defined by a
lost data packet status, the concentrator 122 re-sends the packet to the network
90.

**Step 894 - Base Station routing**
The base station(s) 124 route the AMR packet to the intended utility host 126 and
the system host 128 based on destination information in the AMR packet.
Sending the AMR packet to the system host 128 enables the system host 128 to
have the most recent utility usage information for each dwelling 102.
Step 896 - Host Processing

The communication module 140 of the utility host 126 handles the receipt and de-framing of the AMR packet. The activity log module 152 tracks the event of a received AMR packet and the message validation module 156 performs message level checks on the packet. In the message validation module 156, a field validation and splitter module 160 ensures that the data is correct and tests the meter reading ranges against setup parameters and previously received data. The database manager module 164 handles the storing of meter data into the database 166.

The meter reading data extraction and conversion module 170 reads data from the database 166 through the manager module 164 according to selected criteria and converts the format of the data, storing it in the flat file 176 ready for transfer to the billing module of the utility host computer 126. At this point, the utility host computer billing module (supplied by utility or third party) reads the meter data information and processes the bill according to the rate structure as set by the utility.

Example 3

The third example details the process of sending an alarm message from a home device 118, in this example a smoke detector, to the sensor/alarm monitoring host 132 (illustrated in Fig. 26).

Step 900 - Smoke detector triggered

The smoke detector 70 sounds an alarm in the presence of smoke prompting the control interface 72 to count the number of pulses per interval enabling the control interface 72 to determine the condition.
Step 902 - Transmit SSS to the home control unit

Once the condition has been deciphered the processor 76 of the smoke detector 70 serially transmits a sensor status signal (SSS) to the home control unit 116. The transmission of SSS will continue at a specified interval until the condition is no longer detected. The data packet sent to the home control unit 116 contains a unique serial device number, a service function and a sensor status message. This message details the condition detected by the smoke detector 70 (i.e. smoke present, low battery, etc.).

Step 904 - Home control unit and meter reading unit receive and process SSS

Once the SSS from the smoke detector 70 has been received, the processor 84 of the home control unit 116 forwards the message to the control module 304 of the meter reading unit 120. The control module 304 of the meter reading unit 120 packages the SSS as sensor status data (SSD) that is passed on to the LAN interface 302 to be sent to the concentrator 122. The SSD contains a control field in which the type of data contained therein is specified.

Step 906 - Concentrator receives and processes the SSD

The LAN service module 412 of the concentrator 122 receives the SSD from the meter reading unit 120. The microcontroller 660 determines the urgency of the message within the SSD and in the case of an alarm, immediately forwards the SSD to the WAN interface module 654. The WAN interface module 654 frames the SSD with framing information as defined by the WAN carrier network provider in standard Radio Open System Interconnect format to create a home device (HD) packet. Included in the HD packet prepared by the WAN interface module 654 is the concentrator 122 ID. The WAN interface module 654 presents this HD packet to multiple base stations 124.
Step 908 - Base Station and host process HD packet

The base station 124 deciphers the content of the HD packet based on the control field of the HD packet. In this example, where the message in the HD packet indicates the presence of smoke in a dwelling, the control field indicates an alarm type message. Based on this information the network interface 800 of the base station 124 forwards this message through the X.25 network to the sensor/alarm monitoring host 132. At this point the sensor/alarm monitoring host 132 notifies the service provider of an emergency situation. The base station 124 also forwards the HD packet to the system host computer 128. This allows the system host computer to have the most recent information on the status of each dwelling 102.

A summary of the signal generation and processing of the main components of the system 100 is provided in Table D1.
<table>
<thead>
<tr>
<th>SIGNAL IN</th>
<th>COMPONENT</th>
<th>SIGNAL OUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>home device 118</td>
<td>sensor status signal (SSS)</td>
<td></td>
</tr>
<tr>
<td>SSS 116</td>
<td>home control unit 116</td>
<td></td>
</tr>
<tr>
<td>SSS CPRS 120</td>
<td>meter reading unit</td>
<td></td>
</tr>
<tr>
<td>SSD CD UPRS 122</td>
<td>concentrator 122</td>
<td></td>
</tr>
<tr>
<td>SSD CD UPRS 124</td>
<td>base station 124</td>
<td></td>
</tr>
<tr>
<td>HD packet AMR packet</td>
<td>HD packet AMR packet UPRS</td>
<td></td>
</tr>
<tr>
<td>HD packet AMR packet</td>
<td>host 130</td>
<td></td>
</tr>
<tr>
<td>utility polling request signal (UPRS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**INDUSTRIAL APPLICABILITY**

The apparatus and methods embodying the present invention are capable of being used in the utility consumption and alarm monitoring industry.
Claims:

1. A remote home monitoring system (100) for monitoring a utility meter (108) and a home device (118) located in a dwelling (102) and for communicating with a remotely located host computer (126, 128, 132) having means for performing a prescribed function related to a purpose served by the host computer, said system characterized by:
   a home control unit (116) having a receiver (82) for receiving a sensor status signal from the home device, a transmitter (82) for transmitting information to the home device, and a control module (83);
   a utility meter reading unit (120) having sensing means (218) for reading consumption data from the utility meter; an interface module (302) for transmitting the consumption data, said interface module being in electrical communication with the home control unit; and a control module (304) for storing the consumption data from the utility meter and for controlling the transmission of the consumption data by the interface module; and
   a concentrator (122) in communication with the utility meter reading unit, said concentrator having a transmitter (650, 502) for transmitting a concentrator polling request signal to the interface module of the utility meter reading unit, a receiver (650, 504) for receiving the consumption data from the interface module of the utility meter reading unit in response to the concentrator polling request signal, a concentrator interface module (654) for packaging the consumption data into an automatic meter reading (AMR) packet having a destination host address, and a transceiver (658) for transmitting the AMR packet to the host computer.

2. The remote home monitoring system of claim 1, wherein said host computer includes a network interface (308) for transmitting a host polling request signal (HPRS) to the transceiver of the concentrator to request transmission of the consumption data from the utility meter reading unit.
3. The remote home monitoring system of claim 1, further including a base station (124) in communication with the concentrator, said base station having a receiver (804) for receiving the AMR packet from the transceiver of the concentrator and a transmitter (804) for transmitting the AMR packet to the host computer.

4. The remote home monitoring system according to claim 3, wherein the concentrator is in wireless communication with the base station.

5. The remote home monitoring system according to claim 3, wherein the concentrator is in direct wire-line communication with the base station.

6. The remote home monitoring system according to claim 1, wherein the home device includes a receiver (72) for receiving signals from the home control unit, a transmitter (72) for transmitting the sensor status signal to the home control unit, and a detection module (74,76) for determining the operating condition of the home device.

7. The remote home monitoring system according to claim 1, wherein the home device is a smoke detector (70) having a detector circuit (74) for assessing and generating the status signal defining an operating condition of the smoke detector, a control interface (72) for transmitting the sensor status signal to the home control unit.

8. The remote home monitoring system of claim 1, wherein the means for performing the prescribed function for the host computer includes an application program module (311) having an application message delivery and reception module (312), a database manager (314) in communication with a database (320), an application data extraction forwarding module (316) and an application user interface (318).
9. The remote home monitoring system according to claim 8, wherein the host
computer is a utility host computer (126) functioning to monitor the consumption
of a single utility and wherein the application program module is an automatic
meter reading (AMR) module (134) for reading and processing the AMR packet
containing utility usage information.

10. The remote home monitoring system of claim 9, wherein said AMR module
includes an incoming communications module (150), a message validation
module (156) for performing message level checks, a command module (158) for
sending initialization commands and the HPRS to the concentrator, a meter
reading data extraction and conversion module (170) for reading data from the
database and converting it to a flat file format, and an outgoing communications
module (146) for sending messages.

11. The remote home monitoring system of claim 10, further including a utility
application (328) for interactively communicating with the AMR module of the
utility host to provide monitoring and feedback information from the utility meter
reading unit.

12. The remote home monitoring system according to claim 9, wherein the
single utility being monitored by said utility host computer is selected from the
group consisting of electricity, gas, water.

13. The remote home monitoring system according to claim 8, wherein the host
computer is a system host computer (128) functioning to keep track of the status
of the home control unit in the dwelling and wherein the application program
module is an interactive display module (138).
14. The remote home monitoring system according to claim 13, wherein said interactive display module includes an incoming communications module (150), a message validation module (156) for performing message validation checks, a command module (158) for sending initialization commands, a database manager module (164) for storing the messages into the database, and an outgoing communications module (146) for sending messages.

15. The remote home monitoring system of claim 14, further comprising a device control display unit (139) in wireless communication with the home control unit, said device control display unit displaying the consumption data for the utility meter reading unit and the sensor status signal for the home device.

16. The remote home monitoring system according to claim 8, wherein the host computer is an alarm host (132) functioning to monitor the home device and wherein the application program module is an alarm monitoring module (136).

17. The remote home monitoring system according to claim 16, wherein said alarm monitoring module includes an incoming communications module (150), a message validation module (156) for performing message level checks, a command module (158) for sending initialization commands to the meter reading unit, a database manager module (164) for storing the messages into the database, an alarm message forwarding and format conversion module (330) for forwarding an alarm message to a service provider and an outgoing communications module (146) for sending messages.

18. The remote home monitoring system according to claim 17, further including an alarm service provider application (326) for interactively communicating with the alarm monitoring module of the alarm host to provide monitoring and feedback information from the home device.
19. The remote home monitoring system of claim 18, wherein said service
provider is selected from the group consisting of fire department, police
department, security company, gas company.

20. The remote home monitoring system of claim 1, wherein the meter reading
unit is incorporated into the utility meter having a base assembly (202) having a
set of base sockets (204) and a meter face (206) having a set of prongs (208)
engagable with the set of base socket of the base assembly, said meter face
containing a rotating disc (207) having a position marking (226) that provides
information relating to utility usage, said meter reading unit comprising a set of
prong extension members (214) that are positioned between the set of base
sockets of the base assembly and the set of prongs of the meter face, a central
processing module (216) integrated into a retainer ring (217) positioned between
the base assembly and the meter face, and wherein the sensing means includes
a sensor module (218) connected to the meter face, said sensor system having a
sensor (220), a reflective disc (222) and a retention arm (224) for holding the
sensor and the reflective disc in contract with the meter face to detect movement
of the rotating disc.

21. The remote home monitoring system of claim 20, wherein the sensor
includes a differential optic emitter (230) generating an emitter beam, a receiver
(232) for receiving reflected light, said sensor being electrically connected to the
central processing module wherein as the position marking of the rotating disc
passes the emitter beam light is absorbed such that the emitter detects an open
connection that represents the consumption data.

22. The remote home monitoring system of claim 20, further including an
antenna (303) connected to the utility meter reading unit.
23. The remote home monitoring system of claim 22, wherein said antenna is a hemispheric radiator antenna.

24. A method of automatically sending usage information from a utility meter monitored by a utility meter reading unit to at least one of a plurality of remotely located host computers through a concentrator and a base station, said method characterized by the steps of:
   (a) said meter reading unit generating consumption data (CD) (850) based on utility usage;
   (b) said concentrator generating a concentrator polling request signal (CPRS) (852) at a pre-set time interval;
   (c) said concentrator transmitting the CPRS (852) to the meter reading unit;
   (d) said meter reading unit sending the CD to the concentrator (856) based on the CPRS of step (c);
   (e) said concentrator framing the CD of step (d) (858) to form an automatic meter reading (AMR) packet that includes host address information;
   (f) said concentrator transmitting the AMR packet of step (e) (860) to the base station; and
   (g) said base station routing (862) the AMR packet to the appropriate destination host computer for processing (864).

25. A method of sending usage information from a utility meter monitored by a utility meter reading unit to a remotely located utility host computer through a concentrator and a base station, said method characterized by the steps of:
   (a) said meter reading unit generating consumption data (CD) based on utility usage;
   (b) said utility host computer generating a utility polling request signal (UPRS) (880) and transmitting the UPRS to the base station;
   (c) said base station receiving the UPRS (882) and transmitting the UPRS to the concentrator;
(d) said concentrator receiving the UPRS (884) and generating a concentrator polling request signal (CPRS);

(e) said concentrator transmitting the CPRS (884) to the meter reading unit;

(f) said meter reading unit sending the CD to the concentrator (886) based on the CPRS of step (e);

(g) said concentrator framing the CD of step (f) (890) to form an automatic meter reading (AMR) packet that includes host address information;

(h) said concentrator transmitting the AMR packet of step (g) (892) to the base station; and

(i) said base station routing (894) the AMR packet to the utility host computer for processing (896).

26. A method of sending an alarm message from a home device having a sensor monitored by a home control device and a meter reading unit to a remotely located alarm host computer through a concentrator and a base station, said method characterized by the steps of:

(a) said sensor indicating the presence of an alarm situation (900);

(b) said home device transmitting a sensor status signal (SSS) (902) to the home control device and the meter reading unit responsive to the presence of the alarm situation;

(c) said meter unit processing said SSS (904) to form a sensor status data (SSD) that includes a control field specifying the type of alarm situation;

(d) said meter unit transmitting the SSD (904) to the concentrator;

(e) said concentrator framing the SSD (906) received from step (d) to form a home device (HD) packet containing destination host information;

(f) said concentrator transmitting the HD packet of step (e) (906) to the base station; and

(g) said base station routing (908) the HD packet to the alarm host computer for processing (908).
FIG. 4
FIG. 21
FIG. 23
METER READING UNIT (MRU) → TRACK UTILITY USAGE

CONCENTRATOR → SEND CPRS TO MRU

MRU → RECEIVE CPRS PROCESS AS CD SEND CD TO CONCENTRATOR

CONCENTRATOR → RECEIVE CD CREATE AMR PACKET

CONCENTRATOR → SEND AMR PACKET TO BASE STATIONS

BASE STATIONS → ROUTE AMR PACKET TO HOST

HOST → PROCESS AMR PACKET

FIG. 24
FIG. 26