US008979363B2

(12) **United States Patent**
Groeneweg et al.

(10) **Patent No.: US 8,979,363 B2**
(45) **Date of Patent: Mar. 17, 2015**

(54) **INTEGRATED RAIL EFFICIENCY AND SAFETY SUPPORT SYSTEM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/560,829**

(22) Filed: **Jul. 27, 2012**

(65) **Prior Publication Data**

US 2012/0290251 A1 Nov. 15, 2012

Related U.S. Application Data

(63) Continuation of application No. 12/347,695, filed on Dec. 31, 2008, now Pat. No. 8,231,270.

(60) Provisional application No. 61/018,796, filed on Jan. 3, 2008, provisional application No. 61/030,822, filed on Feb. 22, 2008, provisional application No. 61/140,539, filed on Dec. 23, 2008.

(51) **Int. Cl.**

B61L 23/04	(2006.01)
B61L 27/00	(2006.01)
B61K 9/08	(2006.01)

(52) **U.S. Cl.**

CPC ***B61L 23/042*** (2013.01); ***B61L 27/0088*** (2013.01)

USPC **374/141**; 374/109; 701/19

(58) **Field of Classification Search**

USPC 374/16, 109, 120, 121, 124, 129, 141, 374/142, 143; 701/19, 20; 702/130, 184; 340/905

See application file for complete search history.

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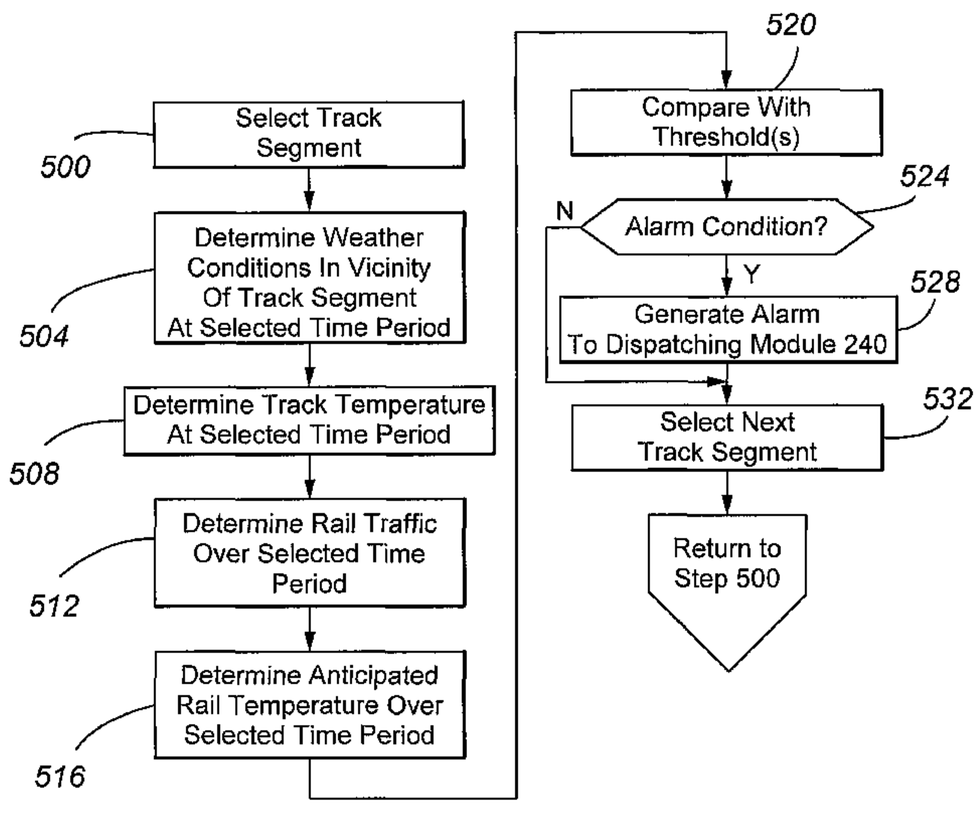
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(57) **ABSTRACT**

Embodiments of an integrated rail efficiency and safety support system and method are shown comprising a server operable to receive a plurality of sets of collected information, each of the sets of collected information comprising a consist physical location and weather conditions and rail temperatures in an area of the respective consist and to process a predictive rail temperature algorithm for predicting a rail temperature and/or a trend in rail temperature for a selected section of track; and wherein the predictive rail temperature algorithm factors the information provided to it and provides a predicted rail temperature and/or trend in rail temperature for the selected section of track.

16 Claims, 6 Drawing Sheets



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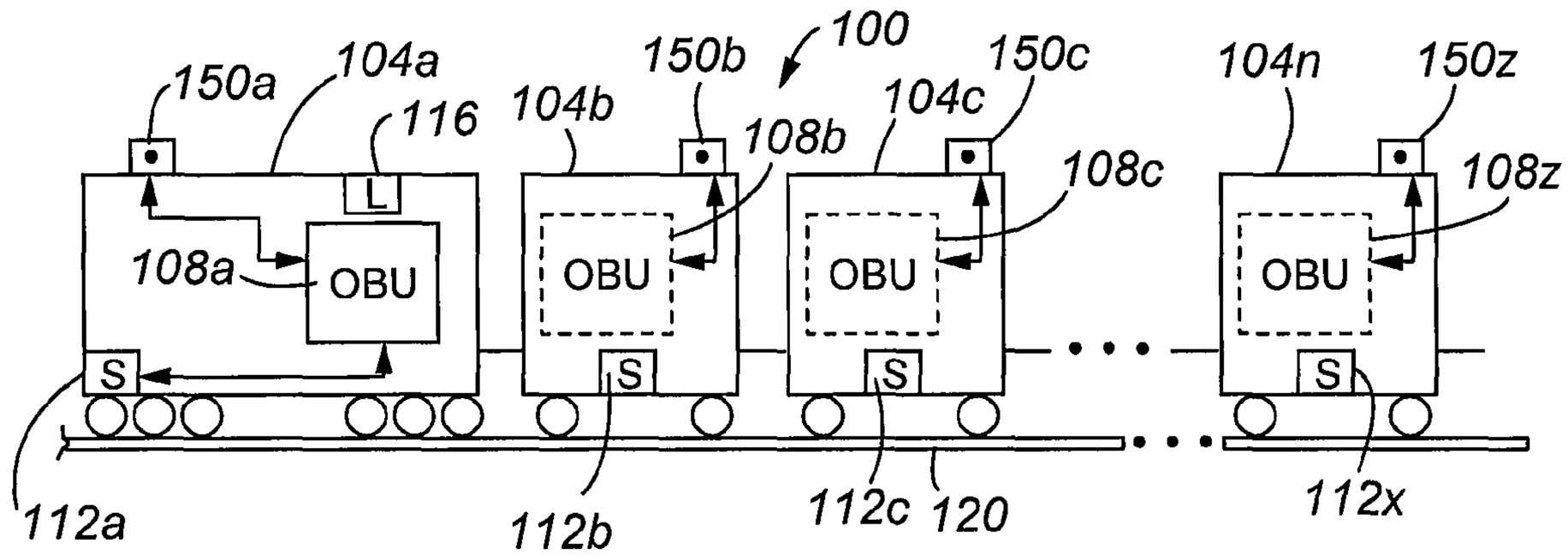

100
150a
104a
116
104b
150b
108b
104c
150c
108c
104n
150z
108z
108a
OBU
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S
S
112a
112b
112c
120
112x

Fig. 1A

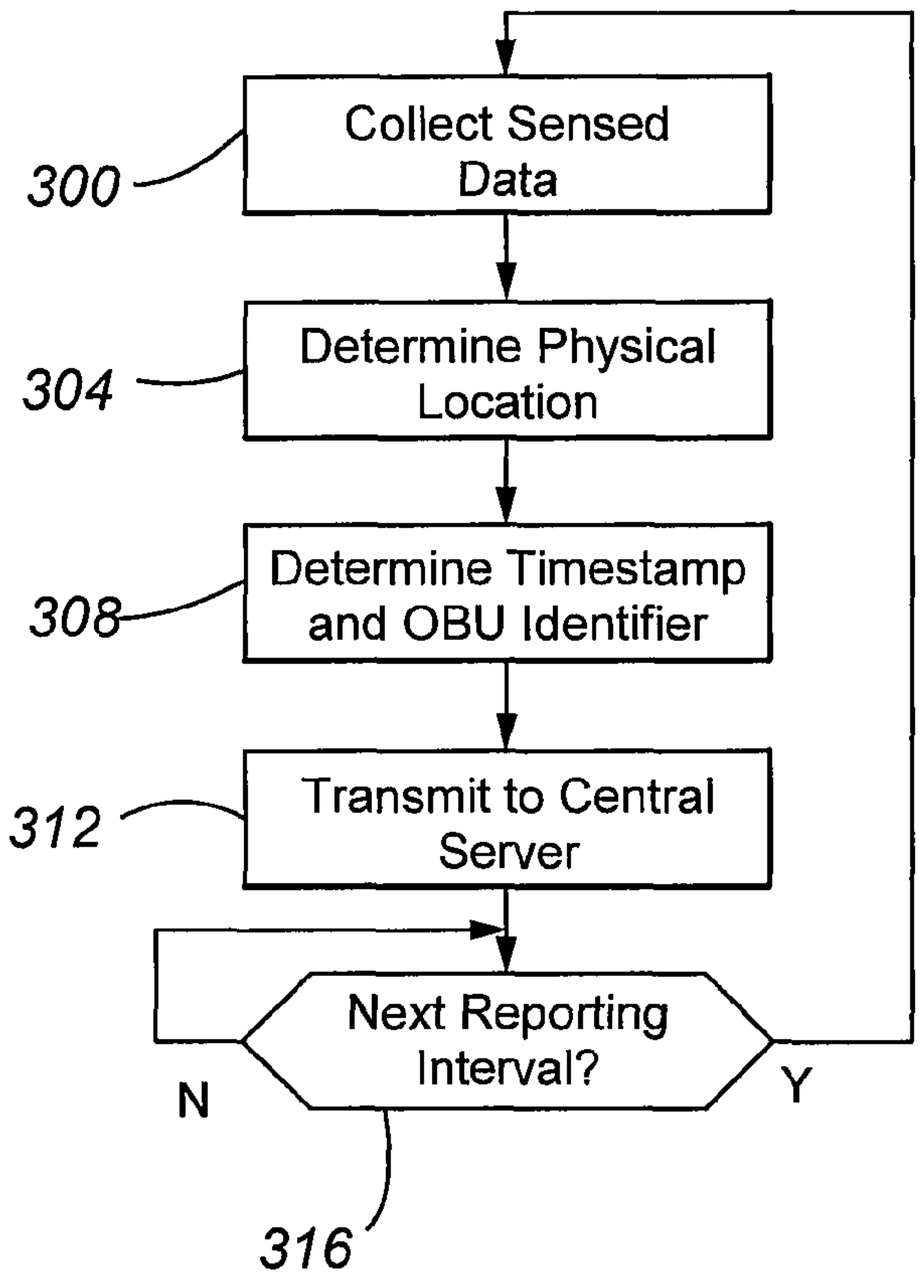

Collect Sensed Data
300
Determine Physical Location
304
Determine Timestamp and OBU Identifier
308
Transmit to Central Server
312
Next Reporting Interval?
N
Y
316

Fig. 3

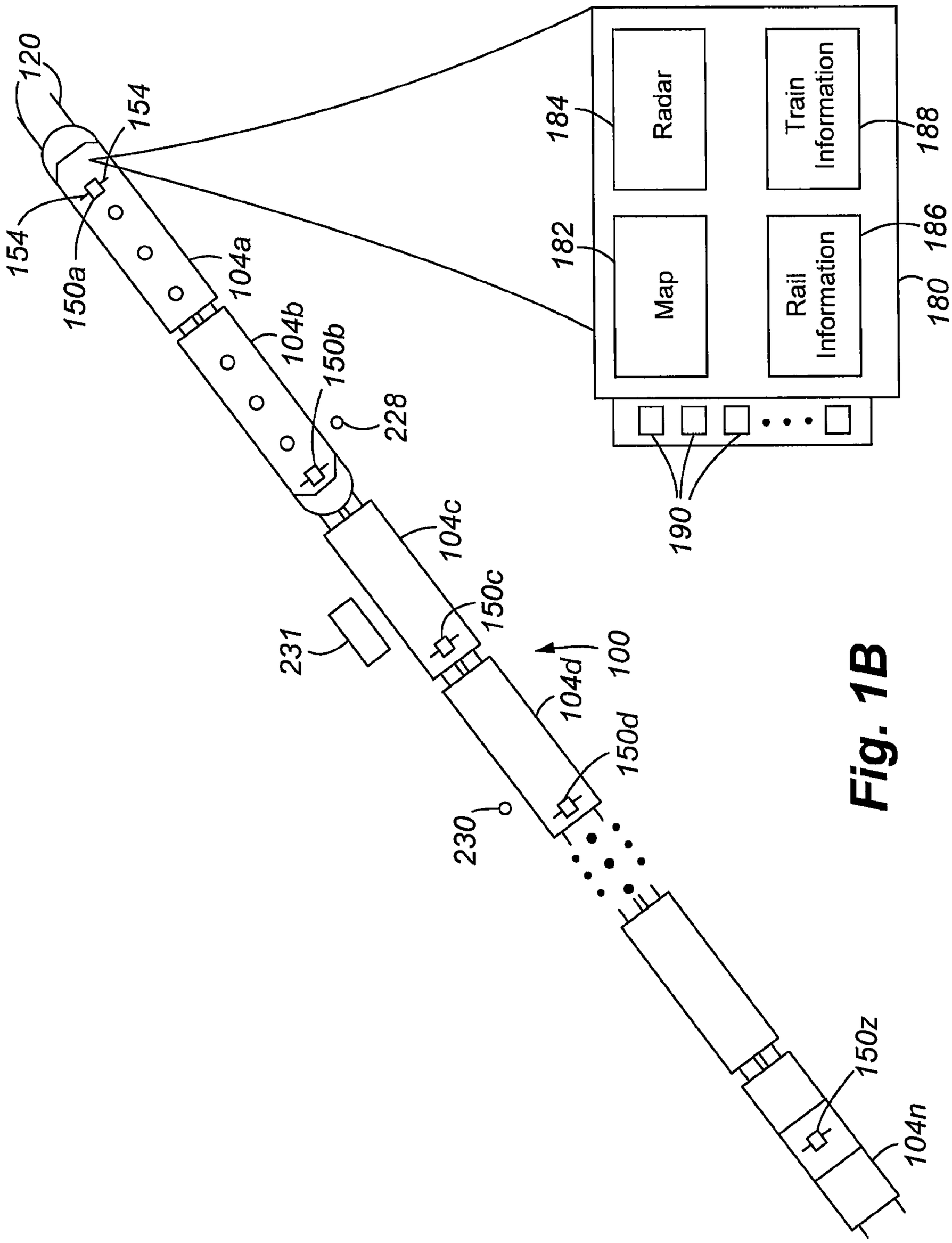

120
154
154
150a
104a
104b
150b
228
104c
150c
231
104d
100
150d
230
150z
104n
184
Radar
Train Information
188
182
Map
Rail Information
186
180
190

Fig. 1B

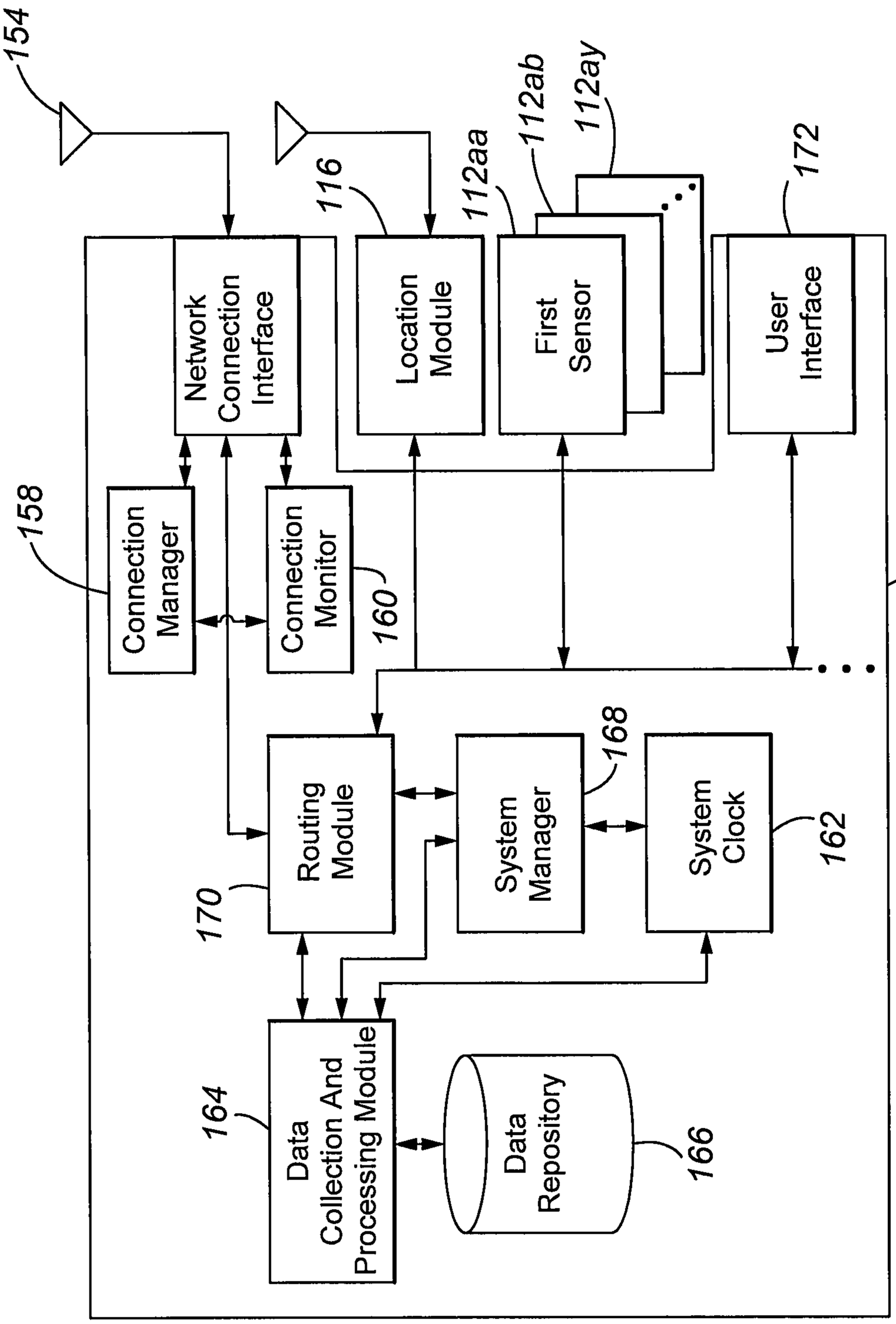

154
116
112aa
112ab
112ay
172
Network Connection Interface
Location Module
First Sensor
User Interface
158
Connection Manager
Connection Monitor
160
108
168
Routing Module
System Manager
System Clock
170
162
164
Data Collection And Processing Module
Data Repository
166

Fig. 1C

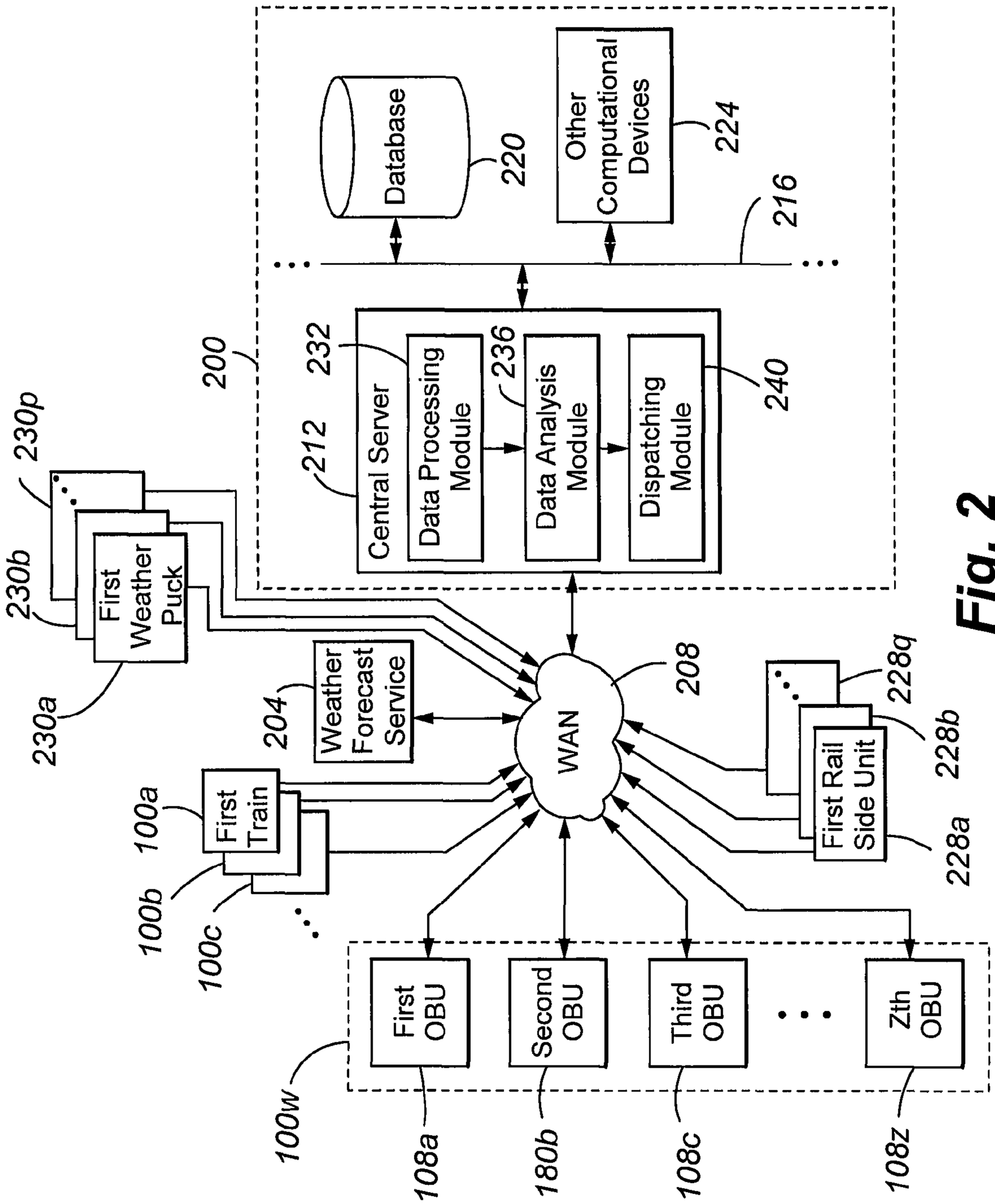

Database
220
Other Computational Devices
224
216
200
232
212
Central Server
Data Processing Module
236
Data Analysis Module
Dispatching Module
240
230p
230b
First Weather Puck
230a
204
Weather Forecast Service
208
WAN
228q
228b
First Rail Side Unit
228a
100a
First Train
100b
100c
100w
First OBU
Second OBU
Third OBU
Zth OBU
108a
180b
108c
108z

Fig. 2

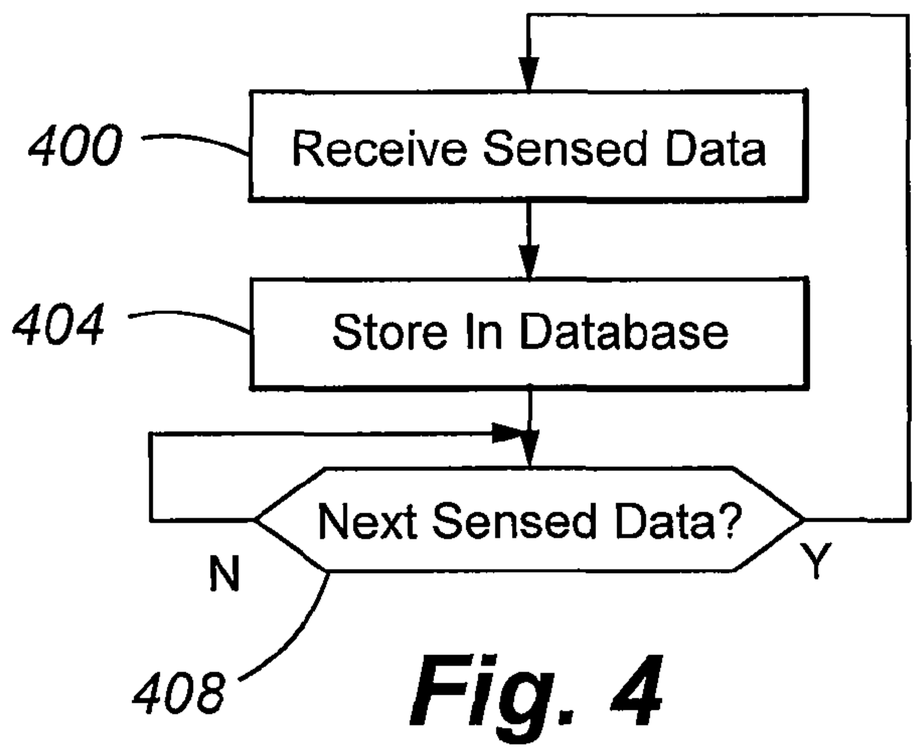

400
Receive Sensed Data
404
Store In Database
Next Sensed Data?
N
Y
408

Fig. 4

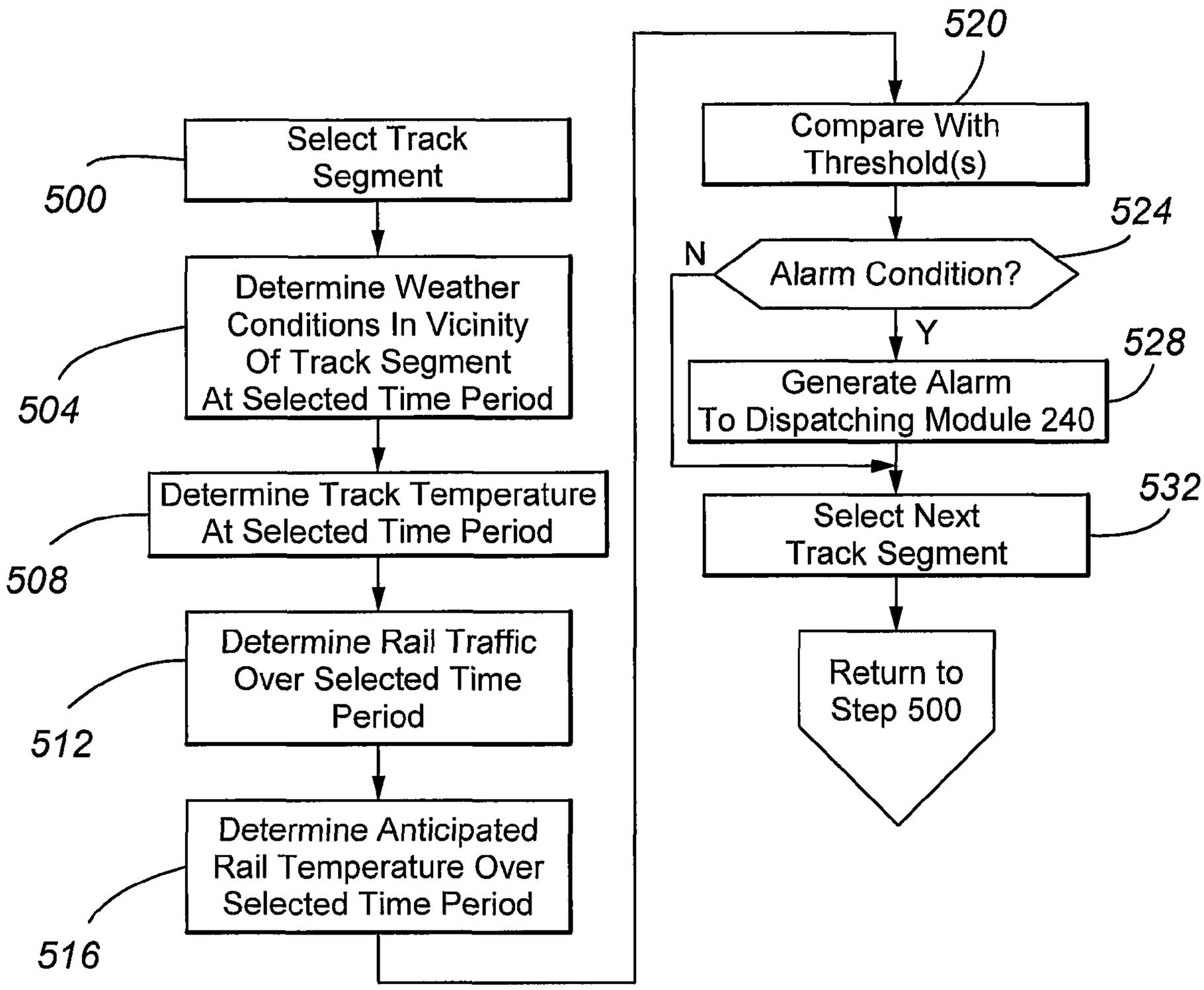

500
Select Track Segment
504
Determine Weather Conditions In Vicinity Of Track Segment At Selected Time Period
508
Determine Track Temperature At Selected Time Period
512
Determine Rail Traffic Over Selected Time Period
516
Determine Anticipated Rail Temperature Over Selected Time Period
520
Compare With Threshold(s)
524
N
Alarm Condition?
Y
528
Generate Alarm To Dispatching Module 240
532
Select Next Track Segment
Return to Step 500

Fig. 5

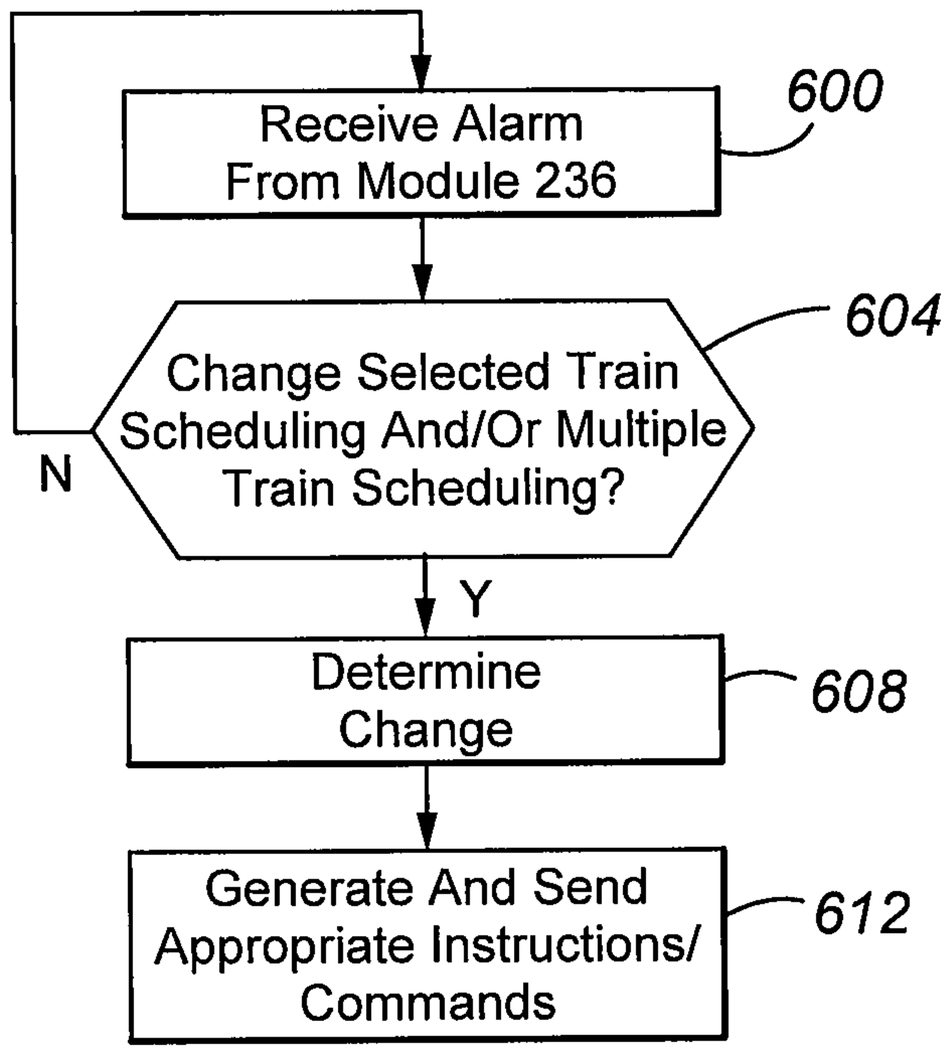

Receive Alarm From Module 236
600
Change Selected Train Scheduling And/Or Multiple Train Scheduling?
604
N
Y
Determine Change
608
Generate And Send Appropriate Instructions/ Commands
612

Fig. 6

INTEGRATED RAIL EFFICIENCY AND SAFETY SUPPORT SYSTEM

CROSS REFERENCE TO RELATED APPLICATION

The present application claims the benefits of U.S. Provisional Application Ser. Nos. 61/018,796, filed Jan. 3, 2008, 61/030,822, filed Feb. 22, 2008, and 61/140,539, filed Dec. 23, 2008, each of which is incorporated herein by this reference in its entirety. This application is a continuation of U.S. Ser. No. 12/347,695, now U.S. Pat. No. 8,231,270, filed on Dec. 31, 2008, and hereby incorporates that application in its entirety.

FIELD OF THE INVENTION

The invention relates generally to vehicular data collection/transmission systems and particularly to rail vehicle data collection/transmission systems.

BACKGROUND OF THE INVENTION

Weather related problems, such as rail buckling and derailments, pose a significant problem. In addition to the direct loss of equipment and possible personal injury, there are significant consequential costs to commerce and society in terms of lost use of that line, the need to reroute traffic, delays, etc. The reduction of average speeds even of as little as 1 mph, has been estimated to involve millions of dollars in societal costs.

Extreme temperatures (high or low) and adverse weather (e.g., flooding or extreme cold or snow or ice) can force train services to slow down, or, in some cases, stop and/or reroute. Most methods of monitoring rail temperatures to date have involved equipment affixed to rails in limited, specific, static locations. Such fixed sites typically involve significant spatial gaps, are relatively expensive to deploy, require significant site preparation and infrastructure, and are difficult to install and/or maintain, especially in remote stretches.

SUMMARY OF THE INVENTION

The present invention is directed generally to vehicular data collection/transmission systems and particularly to rail vehicle data collection/transmission systems.

In a first embodiment, a rail vehicle includes a sensor to measure a temperature of a rail in proximity to the rail vehicle. The rail vehicle normally travels on the rail. An example of a sensor is an infrared sensor, though other types of temperature sensors may be employed.

In a second embodiment, a central control system, such as a central control system for a rail network, includes a server to receive, from a number of consists located at different parts of a rail network, rail temperature measurements and use the rail temperature measurements to determine one or more of speed restrictions, consist routes, current of traffic, traffic mode, consist schedules, timetables, number of trains per hour, consist length restrictions, and consist weight restrictions.

In a third embodiment, a method includes the steps of:

(a) determining, based on sensed data received from a mobile sensor, a rail temperature at a selected physical location; and

(b) generating, by a processor, a command to adjust one or more of a velocity, acceleration, and route of a train based on the rail temperature.

In a fourth embodiment, a method includes the steps of:

(a) receiving, from a number of different consists and by a server, a number of datasets, each dataset including a rail temperature, a timestamp, and a physical location; and

(b) based on the datasets, determining, by the server, one or more of a speed restriction, consist route, current of traffic, traffic mode, consist schedule, timetable, number of trains per hour, consist length restriction, consist type restriction, and consist weight restriction.

The invention can allow temperatures and other track and train information to be collected on a mobile basis along entire rail lines. In one configuration, data from a given train, or consist, is combined with that of other trains, or consists and with current and forecasted weather and other information to better monitor and predict potential problematic stretches of line, provide alerts and recommendations to help improve routing/rerouting, maximize efficiency, and facilitate safety and commerce.

These and other advantages will be apparent from the disclosure of the invention(s) contained herein. For example, the invention can realize significant mile/hour improvements in train speed. While not wishing to be bound, it is believed that the invention can improve train speeds anywhere from 0.25 to 1 mile/hour in overall routing during the year, particularly during summer months. It has been estimated that each mile/hour improvement in train speed translates into a savings of $50 to $100 million/year. The invention can generate, in real-time, maps showing train locations, speeds, and statuses and rail conditions and profiles. This can further improve existing computer-aided dispatch systems providing network-wide visibility and thereby permit railroad operators to manage traffic proactively, thereby maximizing capacity and increasing productivity. The invention can provide rail temperatures and/or weather conditions to dispatchers in a separate display and/or input projected delays and problem areas into automated dispatching systems to permit the system's schedules to be adjusted and/or refined.

As used herein, "at least one", "one or more", and "and/or" are open-ended expressions that are both conjunctive and disjunctive in operation. For example, each of the expressions "at least one of A, B and C", "at least one of A, B, or C", "one or more of A, B, and C", "one or more of A, B, or C" and "A, B, and/or C" means A alone, B alone, C alone, A and B together, A and C together, B and C together, or A, B and C together.

It is to be noted that the term "a" or "an" entity refers to one or more of that entity. As such, the terms "a" (or "an"), "one or more" and "at least one" can be used interchangeably herein. It is also to be noted that the terms "comprising", "including", and "having" can be used interchangeably.

The term "automatic" and variations thereof, as used herein, refers to any process or operation done without material human input when the process or operation is performed. However, a process or operation can be automatic even if performance of the process or operation uses human input, whether material or immaterial, received before performance of the process or operation. Human input is deemed to be material if such input influences how the process or operation will be performed. Human input that consents to the performance of the process or operation is not deemed to be "material".

The term "block" refers to a section of track of defined limits for train movement, the use of which is governed by, for example, rules and/or block signals. Not all sections of track on a main line are considered to be part of a block.

The term "block signal" refers to a signal at an entrance of a block to govern trains entering and using that block.

The term "computer-readable medium" as used herein refers to any tangible storage and/or transmission medium that participate in providing instructions to a processor for execution. Such a medium may take many forms, including but not limited to, non-volatile media, volatile media, and transmission media. Non-volatile media includes, for example, NVRAM, or magnetic or optical disks. Volatile media includes dynamic memory, such as main memory. Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, or any other magnetic medium, magneto-optical medium, a CD-ROM, any other optical medium, punch cards, paper tape, any other physical medium with patterns of holes, a RAM, a PROM, and EPROM, a FLASH-EPROM, a solid state medium like a memory card, any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read. A digital file attachment to e-mail or other self-contained information archive or set of archives is considered a distribution medium equivalent to a tangible storage medium. When the computer-readable media is configured as a database, it is to be understood that the database may be any type of database, such as relational, hierarchical, object-oriented, and/or the like. Accordingly, the invention is considered to include a tangible storage medium or distribution medium and prior art-recognized equivalents and successor media, in which the software implementations of the present invention are stored.

A "consist" is a train including one or more cars or rail vehicles. A consist and train are synonymous terms.

The terms "determine", "calculate" and "compute," and variations thereof, as used herein, are used interchangeably and include any type of methodology, process, mathematical operation or technique.

The term "home signal" refers to a signal at an entrance of a route or block to govern trains entering and using that route or block.

The term "main line" means trackage in a rail network that is outside of a maintenance yard. For example, main line refers to a principal line or lines of a rail network or railway.

The term "module" as used herein refers to any known or later developed hardware, software, firmware, artificial intelligence, fuzzy logic, or combination of hardware and software that is capable of performing the functionality associated with that element. Also, while the invention is described in terms of exemplary embodiments, it should be appreciated that individual aspects of the invention can be separately claimed.

A "speed restriction" refers to a voluntary or mandatory maximum or minimum speed along a section of track or block. An example of a speed restriction is a restricted speed.

"Train" is a series of connected railroad freight or passenger cars or vehicles pulled or pushed by one or more locomotives or propelled by an on-board motor, such as a light rail vehicle.

"Train state" refers to a condition, function, location, or operation of a train or a component or accessory thereof.

The preceding is a simplified summary of the invention to provide an understanding of some aspects of the invention. This summary is neither an extensive nor exhaustive overview of the invention and its various embodiments. It is intended neither to identify key or critical elements of the invention nor to delineate the scope of the invention but to present selected concepts of the invention in a simplified form as an introduction to the more detailed description presented below. As will be appreciated, other embodiments of the invention are possible utilizing, alone or in combination, one or more of the features set forth above or described in detail below.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a functional block diagram of a train, such as a consist, according to an embodiment;

FIG. **1**B is a plan diagram of a train according to an embodiment;

FIG. **1**C is a functional block diagram of an on board unit according to an embodiment;

FIG. **2** is a network architecture according to an embodiment;

FIG. **3** is a flow chart depicting a data collection operation according to an embodiment;

FIG. **4** is a flow chart depicting an operation of the data processing module according to an embodiment;

FIG. **5** is a flow chart depicting an operation of the data analysis module according to an embodiment; and

FIG. **6** is a flow chart depicting an operation of the dispatching module according to an embodiment.

DETAILED DESCRIPTION

The following exemplary embodiments will generally be discussed in relation to a railway embodiment, and in particular to rail monitoring sensors and equipment. However, in general, the system, methodologies and techniques described herein can be applied to other industries, environments, types of vehicles and sensors. As such, there may be a corresponding change in one or more of the type(s) of data depending on the operational environment and a corresponding change in the type(s) and format of information displayed on the various devices.

In one embodiment, a system for rail temperature prediction modeling and warning, as well as the more general collection of rail and other train and track-related information is provided. The collected information can be monitored dynamically onboard, transferred to central computers, and combined the same with weather information and forecasts. The processed information can be inputted into rail temperature prediction modeling and algorithms, which can generate alerts, recommendations, and commands for central dispatchers, engineers and others.

The System Components

With reference to FIGS. **1**A and **1**B, the information collection and dissemination architecture according to an embodiment includes rail-side units **228**, weather pucks or pods **230**, stationary equipment **231** (such as a rail-side deicing sprayer, rail-side sign, rail-side friction enhancer (such as a device that applies sand to the selected section of track), and a train **100**. Each train **100** includes a plurality of (motorized or unmotorized) rail vehicles **104***a-n*, one or more of which is equipped with an OnBoard data collection Unit(s) (OBU(s)) **108***a-z*, one or more sensor(s) **112***a-x*, and a spatial location module **116**. The OBUs communicate with one another and with remote servers via transceivers **150** and associated antennas **154**. The railway vehicles **104***a-n* can be engines, passenger cars, freight cars, and other types of motorized and unmotorized rail vehicles. Although the train **100** is shown as a multi-car consist, it is to be understood that the train can be a single-car consist and can be supported by one or multiple rails **120**. For example, the train **100** can be a manually and/or automatically operated passenger train (e.g., a commuter, inter-city, high-speed, or long-distance passenger train) and/or a freight train.

Referring to FIG. **1**C, each of the OBUs **108***a-z* commonly are software-controlled devices having processing capabilities and the ability to transmit data on a wired or wireless basis to other points on the train (if more than one OBU **108** is onboard) and/or to a dislocated central server. More than one OBU **108** can be used per train **100** and more than one OBU **108** on a given train **100** can transmit collected information, or sensed data, to the central server. Each OBU **108** can be capable of monitoring and reporting applicable temperatures, periodically transmitting existing temperatures, transmitting special alerts when parameters are exceeded, receiving commands, recommendations, and other information (such as weather forecast information (e.g., Doppler radar and/or satellite images of weather conditions in the vicinity of the OBU) and expected rail conditions and profiles) from the central servers for presentation, via a user interface (e.g., a voice, graphical, audio, or other type of interface) to train operators. The OBUs may be incorporated into, or interface with, the communication control unit (which controls communications between cars in a consist) and/or electronic control unit (which controls all electronic functions and operations of the train). As will be appreciated, each car in a consist has its own electronic control unit, which communicates with other electronic control units in the consist.

Each OBU **108** includes a number of internal logic modules for performing various operations. The modules are normally implemented in processor executable software but may additionally or alternatively be implemented as logic circuits.

The logic modules include one or more connection managers **158** to configure the OBU as required by the particular communications network provider and interact with the service provider to establish a communication session with the remote server, and one or more connection monitors **160** to monitor the health and/or state of the connection. When the health is unacceptable (e.g., the connection has too much interference or the Quality of Service is unacceptable) or the link used by the connection is down, the monitor **160** causes the manager **158** to reestablish the communication session by setting up another connection. Typically, a set formed by one connection manager and monitor corresponds to each wireless network service provider.

A system clock **162** is synchronized to a universal time clock and provides internal timing information to control OBU operations and timestamp collected data.

A data collection and processing module **164** receives sensed data and other information from the on board sensors **112**, location module **116**, weather pods **230** and stations, and third party sources, processes the sensed data and other information to form processed information derived from the collected data, and stores the raw and processed information in a data repository **166**. The raw and processed information is then transmitted, over an established network connection, to and stored on a remote central server. The data repository **166** is used during normal processing operations and as a buffer for data collected when the network connection is either unhealthy or down.

A routing module **170** identifies the types of digital incoming signals (e.g., by sensor type), based on the type of incoming signal, translates the digital signals received from the sensors to a selected language or format, and directs the communications to the data collection and processing module; directs incoming communications from other OBUs or third parties (such as the central server) to the data collection and processing module **164** or system manager **168**, as appropriate; handles outgoing communications such as by packetizing the collected data (with a data-type identifier included in the payload) and applying headers to packets for uploading onto the network; and otherwise handles mail and messaging functions.

A user interface **172** provides information to and receives input from the engineers.

A system manager **168** oversees and controls overall operations of the OBU **108**, responds to alarms, interrupts, and other alerts received from the data collection and processing module **164**, generates internal commands to control OBU operations, responds to external commands received from remote servers, and performs remote system maintenance and troubleshooting functions, and other functions.

The OBU further includes drivers and programming for the user interface **172**.

In one configuration, the data collection and processing module **164** processes multimedia information. For example, the module **164** uses the following parameters to process video information: a URI address of the remote server, an imaging device name, a time interval between snapshots, a Boolean value for whether images should have a current date/time stamp, a Boolean value for whether attachments should be sent as DIME or MIME attachments, a temporary file storage location, and an identifier of the OBU sending the video information.

Each OBU and/or train has a unique identifier. The identifier of the OBU is used, by the data collection and processing module, to associate the received information with a corresponding rail vehicle and respective local host OBU. The data collection and processing module in the local master OBU receives the received information from each OBU on the train. The identifier of the train or master OBU identifier is used by the remote data processing network to associate received information with a set or collection of OBUs.

The train **100** includes one or more location sensor(s) **116**. The location sensor(s) **116** can determine location by any type of mechanism, such as by a Global Navigation Satellite System (GNSS) or other satellite navigation system (that provides autonomous geo-spatial positioning with global coverage), Radio Frequency Identification Detection (RFID) (with an RFID reader and tag being used to determine device location), and Internet connectivity via a connection, such as a wi-fi hot spot, controlled by a resource provider. As will be appreciated, GNSS allows small electronic receivers to determine their location (longitude, latitude, and altitude) to within a few meters using time signals transmitted along a line of sight by radio from satellites. Exemplary GNSS include the NAVSTAR Global Positioning System (GPS), the Russian GLONASS, the European Union's Galileo positioning system, the Chinese regional Beidou navigation system, and India's IRNSS. Typically, the location module forwards digital location signals (e.g., GPRMC NMEA sentences) to the respective OBU **108**. The timing of the signals is typically controlled by the location module **116**. A preferred location module **116** integrates the antenna and a GPS module into a puck positioned on the exterior of the train. The location module **116** can be plugged into various available ports on the OBU, including specially created ports such as a special five-pin DIN connection. The location module can also be separated from the antenna and collocated inside of the OBU.

One or more of the OBUs could be configured with a user interface **172** and/or be interfaced directly with other onboard system(s) and data collection device(s). Such OBUs could provide audible or visual alerts and provide other information. The user interface can include a variety of devices, such as a keyboard and/or monitor. The monitor is preferably a touchscreen. The monitor can provide the engineer with various options to control operations or configurations of the train

(e.g., number of engines in consist and the like), provide commands and recommendations from central control (e.g., recommended speed and/or acceleration for a section of track, provide data input regarding the train state (e.g., stopped for loading, stopped for unloading, stopped due to malfunction, and in motion or transit) or environmental conditions, transmit text messages to the remote server, receive text messages from the remote server, and provide the engineer with views of the data transmitted and/or received. While the OBU is discussed with reference to displaying commands to engineers, it is to be understood that specified operational aspects for many trains will be controlled remotely rather than locally.

Sensors **112***a-n* can be any suitable sensor for collecting desired data. For example, the sensors can be infrared sensors currently available on the market or other specially created sensors. Examples of other sensors include humidity sensors (e.g., hygrometers), barometers, anemometers, light sensors (e.g., photodetectors and pyranometers), thermometers configured to measure ambient temperature, video imaging devices; wind vanes, and rain gauges. The rail sensors **112** are commonly attached to the underbody of the train **100** to monitor rail **120** and ambient temperatures, as the train moves along the rail lines. The sensors can also collect other train-related information, such as, for example, engine temperature, oil and/or fuel pressure, revolutions per minute of a motor, engine, or rotating member, train speed, train mileage (e.g., by an odometer), train direction of travel (e.g., by a compass), and train acceleration. Other wired or wireless sensors can be stationary and positioned near the track, such as in pods or rail-side units. In one configuration, the sensors include a still and/or motion video imaging device to provide still or full motion images to the remote server. In one configuration, the sensors include a microphone to provide audio to the remote server. Analog-to-digital conversion is employed, as needed, to convert analog signals from sensors to digital format. The sensors can also collect/transmit touch and sensor inputs, including camera images and security information (including, without limitation, facial recognition hits and time, location and details with or without images).

Other data could also be collected from engineers by means of manual inputs using the user interface.

Sensed or inputted data would be location-, date- and time-stamped as collected onboard and as later received at the central servers.

One or more such sensors per train can be used with one or more OBUs.

Examples of sensed and manually inputted data include ambient temperature, rail **120** temperature, selected video images, ambient humidity, ambient pressure, visibility, rail bed temperatures, current train velocity and/or acceleration, cloud conditions, wind bearing and velocity, train bearing, train physical location, operational state or status of the train, engine parameters (e.g., oil pressure, engine temperature, fuel levels, and the like), number of cars in the consist, weights of the cars, and the like.

Sensors and OBUs installed at the front of the train can provide early warnings as to current conditions and, in the case of hot tracks, employ appropriate algorithms to provide localized and/or system-wide alerts when the length and weight of the train are expected to raise rail temperatures to dangerous or otherwise undesirable levels. OBUs farther back on the train **100** can monitor actual temperature rises, and provide data to help refine and enhance the algorithms.

For example, sensors can be positioned at the front and rear of the train to measure rail temperature. The sensor at the front of the train would provide ambient rail temperature while that at the rear of the train would provide the elevated temperature after passage of the train. The difference of the two temperatures provides the delta temperature caused by passage of the train. The delta temperature can be used to evaluate the thermal effect of the train's passage on the rail temperature of a selected block, route, or other defined section of rail. The delta temperature can be significant for long freight haulage trains.

In addition to train-specific data, train vehicles so equipped may also be used for detailed rail profiling, manually and/or through cameras and other equipment, while the train passes over sections of track. This may include collecting data regarding shaded and windblown rail segments during various times throughout the year, positions of nearby buildings along the section of track, positions of bridges, viaducts, tunnels, portals, and other features that can impact rail temperature; marking sections of track so that very specific information can be recorded and relayed; and noting maintenance activities such as rail, tie, and rail bed repairs, debris clearance, weed spraying, or other maintenance actions needing to be performed. Times, locations, and other conditions and information can be recorded with such events to preserve and generate appropriate reports and records, as well as for separate processing and analysis, accounting, materials inventory, purchasing, etc.

Referring to FIG. **1**B, an exemplary display **180** of the user interface **172** is shown. The display **180** can be mounted in the cab of a rail vehicle and can include associated speakers as well as communication capabilities such that cameras, microphones, and other devices can be associated with the OBU. The display **180** includes one or more display portions **182**, **184**, **186**, and **188** and one or more buttons **190**. The exemplary display portions include a map **182** (displaying rail lines, blocks, or sections of tracks, rail grades, and/or rail profiles, and surrounding features in a selected area), radar **184** (displaying current (Doppler) radar, weather statistical information, and other weather information, such as by a feed (e.g., streaming media) from a selected weather service), rail information **186** (displaying, such as in a color-coded map, sections of rail and current rail temperatures and/or profiles) and train information **188** (displaying, such as in a color-coded map, the trains in a selected area and their statuses, operations, and directions of travel, audio and/or video feeds from a selected train, and the like).

In one configuration, the train information **188** can depict the locations of the subject train as well as the other trains in a selected area relative to the subject train, using an icon denoting each train. The icon color can be varied to indicate differing rail vehicle states. Text and/or visual (camera) information can be depicted on the map adjacent to or associated with each icon. The text information can describe selected state information associated with the train, such as a train identifier, direction of train travel, train speed, status of the train's location signal, train status and activity, and timestamp of the last data update for the identified train. The map can also depict, for one or more selected rail vehicles, a trace route over a selected period of time. A trace route indicates the path of travel of the train over the selected time period. The map can also display reported condition(s) and status of the train. Additionally, the display can show the operation recommendations or commands for the specific train, which the engineer may accept and, in some configurations, modify. Such modifications and actual applications implemented throughout a route would then be transmitted back to the central server **212** and saved as part of the history of actions taken in the relevant area or region or section of track.

This display **180** allows for relatively unrestrained, dynamically generated, train and location-specific information to be accessible to the train or, in general, to any location. This is in contrast to the relatively limited capabilities previously available through text messaging or oral communications via phone or radio.

A dynamically generated webpage at a respective Universal Resource Indicator or Locator (URI or URL) has the versatility to display one or more of images and multimedia (and audio through an associated speaker) and provide information that is as current as possible, depending of course on the availability of network connections in the area.

The display of information can include without limitation a seamless integration of various types of information, such as weather radar loops, weather forecasts as well as current conditions, projected, historic, and current rail conditions (as determined by other trains), rail grades, rail profiles, and camera images. It also allows the rail vehicle to directly communicate with one or more of central dispatch or control and other engineer(s) through messaging as well as communicate with other trains through the remote server. More than one server may be joined to enhance processing power and capabilities, as well as to integrate data from multiple states and other entities.

One or more of the OBUs would be designated the "master" OBU and therefore be responsible and configured to send data back to central servers for more in depth processing with data from other sources. In one configuration, the OBUs collect sensed data along the rail lines as the host train moves along the lines and periodically or continuously transmits the sensed data to the central server and, if out of range of the central server, buffers the sensed data for later transmission when the master OBU is again within central server range. Information collected from third party sources may include weather data, for example from the National Weather Service, forecasts, and local and regional radars and related information such as front location, snow depth, wind conditions, as well as current rail conditions. Information collected from weather stations and weather pods can include current surface and ambient temperatures, humidity, wind speed and direction, wind chill, rain, drizzle, freezing rain, snow, frost, clear, and fog, and in general any weather condition, trend, forecast or information. Other types of information that can be gathered or otherwise calculated from gathered data include historic, projected and/or current rail conditions or profiles, physical location, recommended and/or maximum train speed and/or acceleration, video images of a selected train's exterior environment or the train's interior or exterior, and audio of the selected train's interior. Such information can be displayed and updated manually or on an automated basis.

Information from other sources may be collected through server-to-server links. All information can then be stored and processed on the remote server or a combination of the servers working together. The stored and processed information can be accessed locally and directly by central dispatch or control room (such as for automatic train control) and internal personnel, by dispatch assistants or related offices or through mobile devices such as cell phones and PDAs, or remotely by rail vehicles and other in-vehicle systems through, for example, a wireless connection.

A Distributed Processing Network Embodiment

Referring now to FIG. **2**, a distributed processing network architecture according to an embodiment is presented. The architecture includes an enterprise network **200**, weather forecast service **204**, a plurality of trains **100***a-w*, a plurality of weather pucks (or pods) **230***a-p*, and a plurality of rail side units **228***a-q* in communication with one another via Wide Area Network (WAN) **208**. Each of the trains will, in turn, include location modules, sensors, and OBUs. For example, the train **100***w* includes first, second, third, . . . nth OBUs **108***a-z*.

The enterprise network **200** includes a central server **212** in communication via Local Area Network (LAN) **216** with one or more database(s) **220** and other computational devices **224**.

The central server **212** can be any suitable communications server and receives sensed data from and provides information to the first, second, third, . . . zth OBUs **108***a-z*. In one configuration, the WAN **208** is a wireless network, and the server **212** is capable of wirelessly communicating with the various OBUs **108**.

The database **220** can include a variety of information. The database **220**, in one configuration, includes a plurality of identifiers and, for each identifier, current and historic data sensed by an entity corresponding with the identifier. The identifier can be associated with a train, a rail vehicle, and/or a specific OBU **108**. When the identifier is associated with a train or an OBU on a train, the stored data can further include the train parameters, such as train velocity, acceleration, and travel direction and location, for each train engine, engine revolutions-per-minute, engine temperature and oil pressure, fuel level, battery amperage, battery voltage, mileage per gallon, and other onboard warning systems and sensor readings, the number and types of rail vehicles in the train or consist, the length and type of the train, the cumulative weight of the train or individual rail vehicles, the type of freight carried by the train, whether the train is loaded or unloaded, the number of passengers being carried by the train, video images of the train's exterior environment or the train's interior or exterior, audio of the train's interior, engineer identifications, instructions, directions, and other information that can be displayed, sensed, and/or input manually or on an automated basis. Whether the OBU is rail-side or mounted on a train, the database includes, for the train or OBU identifier, currently sensed weather conditions (such as temperature, humidity, wind speed and direction, wind chill, raining, snowing, blowing snow, foggy, clear, overcast, cloudy, and barometric pressure), rail conditions (e.g., rail temperature, icy, snow-packed, snow depth, frosty, wet, dry, rail coefficient of friction, rail in flooded location or flood plain, black rail conditions, etc.), train or OBU spatial location (e.g., Global Positioning System or GPS-based location), sensed airborne chemicals or particulates and radiation levels, thermal and/or infrared imaging, and other information that can be displayed, sensed, and/or input manually or on an automated basis. The database can further include current and historic weather forecast information for specific days and times and a description of the rail lines providing, for example, topological information, rail line mapping coordinates, rail bed type and composition (e.g., rail road tie type and underlying bed (e.g., ballast) type and composition), information regarding nearby features (e.g., road crossings, bodies of water, buildings, foliage, and the type), and the like, and train schedules and traffic information along various rail routes (as the amount of traffic can impact significantly the temperatures on a given line).

The other computational devices **224** can include personal computers, laptops, and the like. In one configuration, the computational devices are workstations for human operators or monitors.

The weather forecast service **204** can be one or more services providing weather forecasting information. An example

is the National Weather Service and general or regional weather forecasting services. As discussed below, the weather information is used to better predict short term and even longer predictions for anticipated rail temperatures and to thus help identify problematic stretches, best routing alternatives, calculate updated schedules, etc. Alternatively, the weather forecast service refers to weather stations.

The rail side units **228** are stationary units positioned adjacent to the rail lines at strategic locations. The rail side units are similar, if not identical, to the OBUs **108**. They are frequently positioned along less frequently traveled sections of tracks and/or at frequent problem areas of the tracks.

The weather pucks **130***a-p* are available for use in areas where there are no full weather stations and installing one would be impractical and cost-prohibitive. The application involves a fixed, instead of a mobile, application of similar technology and processes to provide an inexpensive alternative for regions that currently do not have full weather stations, making accurate data collection possible in areas that have historically been void of such data collection. These devices generally contain an infrared sensor capable of measuring ambient and surface temperatures, and a modem that allows the device to transmit the collected data back to the information management system **100**. It is possible to add additional sensors, cameras, and/or other related equipment to the weather pods in order to enhance the accuracy. The data is sent back to the central server **212** where it is displayed or directly used, or where it is applied to algorithms or modeling software with other known or separately collected weather characteristics to enhance interpretation and generate warnings, monitoring alerts, e.g., to one or more of a rail vehicle, rail-side sign, central dispatch, etc, and information enhanced maps on the display **180**.

Temperatures could be recorded in the field with a corresponding time stamp. The time stamp of the in-field system, as with the in rail vehicle system, can be automatically synchronized to UTC. The information could then be transmitted to the central server **212**. If the system were unable to establish a network connection, the data could be stored in the OBU and transceiver **150** and transmitted once a connection could be established.

One exemplary purpose of the weather pods is to collect basic information (e.g. ambient and surface temperatures) and transmit the data to the central server **212** to be processed with other known or collected information to provide a more enhanced and accurate depiction of the different weather conditions at various locations which will ultimately aid to better predict weather conditions and increase ability to effectively monitor rail condition and profile and control rail traffic speeds over sections of track.

The WAN **208** can be any wired and/or wireless network employing suitable communication protocols. The data collected from various sources and the corresponding reports and recommendations and commands sent back to the trains can be transmitted to the OBU in the cab through a variety of public and private wireless networks as well as land-lines and/or wired networks or via satellite or via the rails themselves (such as in the automatic train protection system). Commonly, the WAN **208** is a wireless network. The wireless network **708** can be any type of wireless service and/or air interface, such as Advanced Mobile Telephone Service or AMPS, Digital Advanced Mobile Telephone Service or D-AMPS, Digital Communication Service or DCS1800, Global System for Mobile Communications/General Packet Radio Service or GSM/GPSR, North American Digital Cellular, Personal Communications Services, Personal Digital Cellular, Total Access Communication System, High Speed Downlink Packet Access or HSDPA, Enhanced Data GSM Environment or EDGE, 1xRTT CDMA, CDMA2000, Evolution Data Optimized or EVDO, Digital Enhanced Network or iDEN, Specialized Mobile Radio or SMR, 802.11x, WiMAX or 802.16, and other public and private networks, with Frequency Division Multiple Access or FDMA, Time Division Multiple Access or TDMA, Code Division Multiple Access or CDMA, Cellular Digital Packet Data or CDPD, Wideband CDMA or WCDMA/UMTS, or others. The public or private network **708** can be either landline or wireless. Wireless networks can be operated by one or more private or public networks, including carriers, such as Sprint™, Nextel™, Verizon™, Cingular™, Alltel™, Western Wireless™, AT&T Wireless™, Unicell™, Westlink™ and others, as well as affiliates thereof. If commercial wireless carriers, such as Sprint™, Nextel™, and Verizon™, are utilized, the information delivery system has the ability to accommodate and work with different types of IP addresses, including static, dynamic, and spoofed addresses. Dynamic and spoofed IP addresses are typically assigned to mobile devices. However, this system does not require carriers separately to provide dedicated lines and/or fixed IP addresses. Bandwidth and/or transmission speeds, and/or the frequency and method of data transmissions, may be intentionally limited (by setting appropriate modem parameters) to qualify for favorable telemetry rates.

In one configuration, information is typically converted into a selected form, packetized, and transmitted over the wireless network. The form of the information can be in accordance with any selected language, such as the eXtensible Markup Language or XML, the HyperText Markup Language or HTML, Remote Method Invocation or RMI, or Direct Socket Connections. The packets can be transported using any suitable protocol, such as the Transport Control Protocol/Internet Protocol suite of protocols, Simple Object Access Protocol, or User Datagram Protocol.

The OBU and transceiver **150** check for updates from the central server **212** and download the same when present. These updates can be downloaded as the engineer requests or on an automated basis. The OBU can be used for example to send information to the rail vehicle or to change programming and/or remotely access the rail vehicle, even when otherwise protected by dynamic and spoofed IPs. One example of this would involve updates to menu items and/or applications, which can be posted to a central server **212**. The OBU can then be set to periodically or upon certain conditions check the central server for updates and if present, download and install the same to itself or other onboard systems and/or run applications. This can be done despite the inability of a central computer to communicate with the trains.

The OBU is also compatible with 3G and other wireless technologies. 3G technologies are the third-generation technology in the context of mobile-phone standards and are associated with wide-area wireless voice telephony and broadband wireless data.

Included in the memory of the central server(s) **212** ("data collection server(s)" may also serve as the "central processing system") are a data processing module **232**, data analysis module **236**, and dispatching module **240**.

The data processing module **232** stores sensed data from a given train in the database **220**.

The data analysis module **236** combines, in one configuration, the stored sensed data with one or more of the following: data from other trains, current and forecasted weather information, historical data and trends, and track profiles to create specialized prediction models for rail conditions along the applicable lines. The prediction models can be used to

select the current of traffic, traffic mode (e.g., freight mode, rail passenger only mode, etc.), schedules (e.g., the direction, number, and movement of one or more trains), timetables, number of trains per hour, average, mean, median, lowest or highest train length, average, mean, median, lowest or highest train speed, average, mean, median, lowest or highest train acceleration, and train routes.

In one configuration, the data analysis module **236** applies predictive models to the stored data to determine, for a given month and/or day of the year and given weather conditions and selected section of track, predicted temperatures along the selected track segment and/or rail temperature trends. In making these predictions, the model can include the type and composition of the ties and rail bed along the section of track, the likely sun exposure of the tracks in the section of track in view of nearby sun blocking features (e.g., foliage and buildings), the length and weight of a selected train passing over the section of track, and expected and/or actual traffic from other rail vehicles passing over the section of track. The data analysis module **236** can even predict rail temperature increases over the length of the train. The predictive models, in one configuration, resemble modeling software used for predicting road conditions based on ambient weather conditions and road parameters (e.g., type and composition of road surface and bed).

In one configuration, the module **236** applies predictive modeling algorithms based on accumulated historical data (which will to some extent itself indirectly incorporate rail profile information, e.g., the profile for how a section of rail reacts will inherently reflect to some extent the rail profile in terms of rail bed type and composition and the like, even though profile details are not at this level recorded and incorporated). In this configuration, the bed type and composition and presence of nearby sun-blocking objects are ignored. The module **236** bases its rail temperature determinations purely upon historically and currently measured rail temperatures.

In one configuration, the module **236** incorporates into the predictive modeling algorithm of the prior configuration the effects rail profiles and other associated predictive modeling refinements (e.g., rail way characteristics, what the rail bed is composed of, whether the rail bed is over water, the height of the rail bed above the surrounding surface, time of day, time of year and angle of sun, weather forecasts from National Weather Service or NWS or other sources, historic trends, profiles and other available data, cloud conditions, fog conditions, shading, etc.). This is a more sophisticated algorithm than the prior configuration but is more computationally intensive.

In one configuration, the module **236** selects a length, segment, or section of track, determines, over a selected period of time, an (average, mean, median, lowest, or highest) temperature of the rail, such as in the presence or absence of rail traffic during the time period, compares the actual (average, mean, median, lowest, or highest) rail temperature against the (average, mean, median, lowest, or highest) ambient temperature over the time period to determine a delta value. The forecasted or actual ambient temperature can be mapped against historic (average, mean, median, lowest, or highest) ambient temperatures to provide the corresponding delta value, which when added to the forecasted or actual temperature approximates the rail temperature. The predictive algorithm may be made more sophisticated by adding a third variable, which is the average, mean, median, lowest or highest rail traffic over the selected time period. When mapping is performed for the track section or segment, a table is selected using not only the predicted or actual temperature but also the predicted or actual rail traffic over the segment.

In one configuration, the module **236** applies modeling algorithms that include the effects of natural events, such as actual or potential flooding, snow depth, and drifting of snow (which produces varying depths of snow over the tracks).

In one configuration, the module **236** uses modeling algorithms to make predictions of the impact of selected hypothetical train routing or dispatch scenarios on track conditions. For example, the module **236** models the effects on rail conditions from moving rail traffic from one line to another, or, for a given routing scenario, the effects from using selected combinations of shorter or longer or loaded or unloaded trains.

In one configuration, the module **236** compares current with historic images of objects and, based on the comparison, performs user authentication or identifies alarm conditions.

In one embodiment, historical and subsequent data is used by the data analysis module **236** to refine prediction models. Since data is collected along entire lengths of track, collected data is used to help generate automatically and continually refined profiles. Algorithms for heat buildup for various train lengths and weights are employed, along with other profile characteristics collected for various stretches of track. Profiles in surface transportation are often manually compiled and supplemented with accumulated data, but newer techniques involving optical and other equipment could also be employed. In the latter case, for example, onboard cameras and pixel analysis could aid in automated profiling for shaded areas, reflective surroundings, rail bed characteristics, and other area impacts relevant to analysis.

In one configuration, the module **236** compares information or a given sensed parameter to identify temporal trends or differences and, if necessary, generates appropriate alarms. The alarms can be logged internally and/or forwarded to the respective train via a modem system. The engineer and/or automated components thereof can then take appropriate remedial action to address the cause of the alarm. It can prepare selected reports on the information. It can log events. The enterprise network **710** can also provide communications to the modem system. The communications can, for example, provide instructions to the engineer, such as train operation and dispatch commands, and/or to automated components of the train itself to remotely control selected train operations.

The dispatching or central control module **240** generates dispatching instructions based on rail conditions provided by the data analysis module **236** and generates alarms and commands/instructions to specific trains based on the rail conditions. The module **240**, for instance, generates internal and external (OBU) client notifications and reports (e.g., internal alerts for problem areas along the rail line, client notifications (automate, email, mobile messages whatever) regarding delays or revised schedules, reports, commands/instructions regarding speed and acceleration levels to maintain selected rail conditions (e.g., block signals, cab signals, home signals, moving block train control signals, train protection signals, and the like). The dispatching module **240** and OBU **108**, collectively or individually, can provide visual and/or audible alerts when selected rail parameters are exceeded and on board access to updates and revised instructions, applicable weather and radar, messages and alerts, and other information. When actual or anticipated temperatures exceed specified thresholds (high or low), alerts and recommendations would be issued from the central server or servers to applicable dispatchers, engineers (via OBUs or otherwise) and other interested parties. Any and multiple available means of communication could be used, including without limitation, email and text messages, data transfers, visual displays via maps or otherwise, text to speech messages via cellular, radio

or/or other means. In one configuration, the dispatching module **240** receives, from the data analysis module **236**, information as to actual or recommended speed reductions and transfers the information to other systems or directly processes it to generate revised routing and schedules.

In one configuration, alerts are sent out by the OBU or central server **212** via email or text messages to the same devices, as well as via a call out for a voice alert via telephone or cell phone, or fax messages. Any of the devices can also be used to manually send a command to the stationary equipment **231**, if desired.

Once the central server **212** determines which train is requesting information by either manual or automated updates, a train-specific report or aggregate of information that will be most relevant for the requesting train as well as a train-specific combination of radar, forecasts and treatment recommendations are generated. Applying various techniques and software processes to the collected data produces this information and recommendation. The information and recommendation is then dynamically placed on a webpage or into another data format for transmission to the field systems.

In one embodiment, the architecture applies a similar architecture and modem technology to that described in U.S. patent application entitled "Smart Modem Device for Vehicular Roadside Applications", Ser. No. 11/363,581, filed Feb. 27, 2006, and U.S. patent application entitled "Information Delivery and Maintenance System for Dynamically Generated and Updated Data Pertaining to Road Maintenance Vehicles and Other Related Information", Ser. No. 12/147,837, filed Jun. 27, 2008, each of which is incorporated herein by this reference. As described in the applications for tired vehicles, the collected data may be used to populate, in real time, maps. In the maps, each engine or train would be indicated by an icon, the color of which could be related to a status of the corresponding train (e.g., idle, moving, pulling empty cars, pulling loaded cars), freight train versus passenger train, type of freight being pulled, whether or not on schedule, and other train-related parameters. Each icon can have a drop down description of these parameters. Additionally, icons can be used to represent track or weather conditions at selected points along the track. The icons can be generated when the conditions are unacceptable or exceed acceptable thresholds. Lines, routes and/or segments thereof can themselves be color coded for current temperatures, predicted problems, bottlenecks, and other parameters.

Module Operations

Selected operations of the various modules will now be discussed.

FIG. **3** depicts the data collection operation performed by the OBUs **108**.

In step **300**, the OBU **108** collects sensed data from one or more sensors **112** and/or from one or more other OBU's on the train.

In step **304**, the OBU **304** determines, from the location module **116** and when the sensed data is obtained directly from a sensor, a physical location of the train when the sensed data was measured.

In step **308**, the OBU determines, when the sensed data is obtained directly from a sensor, a timestamp when the sensed data was measured and OBU identifier for the train.

In step **312**, the OBU transmits the information to the central server **212** over WAN **208** or to a master OBU located elsewhere on the train, such as in the cab.

In decision diamond **316**, the OBU determines whether the next reporting interval has arrived. Decision diamond **316** is repeated until the next reporting time arrives. When the next reporting time arrives, the OBU returns to and repeats the foregoing steps **300**, **304**, **308**, and **312**.

An operation of the data processing module **232** will now be described with reference to FIG. **4**.

In step **400**, the module **232** receives sensed data from an OBU or rail-side unit **228**.

In step **404**, the module **232** stores the sensed data in the database **220** with reference to an identifier indicating a source of the sensed data. The identifier is used to locate the sensed data relative to a corresponding segment of track. This is done using the location information for train-mounted OBUs **108** or using known location information for rail-side units **228**.

In decision diamond **408**, the module **232** determines whether it has received further sensed data from another OBU or rail-side unit. Decision diamond **408** is repeated until the next reporting time arrives. When the next reporting time arrives, the module **232** returns to and repeats the foregoing steps **400** and **404**.

An operation of the data analysis module **236** will now be discussed with reference to FIG. **5**.

In step **500**, the module **236** selects a track segment or section.

In step **504**, the module **236** determines (average, mean, median, lowest, or highest) weather conditions in the vicinity of the selected track segment over a selected period of time.

In step **508**, the module **236** determines the (average, mean, median, lowest, or highest) track temperature for the selected segment over the selected time period.

In step **512**, the module **236** determines the actual and/or expected rail traffic over the selected rail segment over the selected time period.

In step **516**, the module **236** determines, based on the actual and/or expected rail traffic over the selected rail segment, an anticipated (average, mean, median, lowest, or highest) rail temperature for the selected track segment over the selected time period.

In step **520**, the module **236** compares the track temperature with one or more thresholds.

In decision diamond **524**, the module **236** determines whether the track temperature fails to satisfy the thresholds and an alarm condition therefore exists.

When an alarm condition exists, the module **236**, in step **528**, generates an alarm to the dispatching module **240**.

When there is no alarm condition or after step **528**, the module **236**, in step **532**, selects a next track segment for analysis and returns to and repeats step **500**.

An operation of the dispatching module **240** will now be discussed with reference to FIG. **6**.

In step **600**, the module **240** receives an alarm from the data analysis module **236**.

In decision diamond **604**, the module **240** determines whether or not to change a selected train's scheduling or operating parameters (e.g., speed, acceleration, and routing) and/or scheduling or operating parameters for multiple selected trains. If not, the module **240** returns to and repeats step **600**. If so, the module **240**, in step **608**, determines the change desired, and, in step **612**, generates and sends an appropriate instruction/command to the affected trains or other automated components (e.g., track switches to redirect trains onto a different route, etc.).

EXAMPLE

In one embodiment, ambient and surface temperatures are collected by an OBU **108** attached to a location module **116**, particularly a GPS puck, and an underbody infrared sensor

112 mounted over one or both rails 120. An optional monitor or display would be attached to the OBU, as would any other interfaces to other onboard systems and sensors.

Temperatures would typically be displayed on the monitor and/or applicable gauge, and would be periodically sent to the central servers via available communications (cellular, radio, or other wireless data collection/communication medium available along the tracks). Data not immediately transmitted (due to specification or lack of applicable communication coverage in a given location) would be stored and transmitted when later back in an area where coverage and connectivity permit.

When temperatures reach specified ranges, additional alerts and associated data would be displayed for the onboard engineers and be sent to the central server(s) as with the periodic information noted above.

The periodic information, along with any special alerts would be processed in conjunction with applicable weather, historic and other information to generate current and anticipated temperatures along various routes. Where temperatures are anticipated to be outside specified thresholds, the alerts and recommendations could be transferred electronically to applicable trains scheduled over such route(s) and map based displays could be provided showing projected problematic routes (with or without more granular detail regarding particular stretches within the route). Detailed data feeds could be set up to also relay such information to other systems. Recommended alternate routes based on other weather, speed, volumes and other factors could be generated. If/then functionality could be included as noted above.

If, in the above example, a mile long train of coal traveling south from the Powder River Basin mines in Wyoming begins running into high temperatures in Colorado in mid-morning, data being collected from that train would be both monitored by the OBU and transmitted to the central servers (communications permitting). If thresholds in the OBU are surpassed, the OBU itself could generate a warning. Assuming though for purposes of the example, the temperatures are high but not at or in excess of a threshold, the temperatures would nevertheless be analyzed at the central servers along with information from other trains ahead on the track, and the applicable weather and historic information, profiles, etc. Information from other trains will provide last reported information ahead, along with the rate of temperature increase. The weather information will provide applicable information as to whether and to what extent the rest of the line will be in the sun (maximum thermal heating) or whether and to what extent there will be shade or afternoon rain to cool the tracks and/or at least maintain satisfactory temperatures. Historic information from prior days and/or years, to the extent available, or over time compiled, can be used to help refine the algorithms, profiles and track characteristics. With trains on some tracks spaced relatively soon after each other, it will be possible to generate profiles, monitor entire stretches of track, and forecast rail temperatures more accurately and with more lead time than ever before or ever possible with limited, fixed location equipment.

As will be appreciated, OBUs and rail-side units could have full processing capabilities and functionality of an SMD as described in the above-referenced applications, but they could also be simpler datalogging/modem units, or a combination thereof.

A number of variations and modifications of the invention can be used. It would be possible to provide for some features of the invention without providing others.

For example in one alternative embodiment, the present invention is applied to a monorail transport system.

In another alternative embodiment, the invention is applied to sub-surface rail applications, such as a subway or mine haulage system.

The exemplary systems and methods of this invention have been described in relation to information management. However, to avoid unnecessarily obscuring the present invention, the description omits a number of known structures and devices. This omission is not to be construed as a limitation of the scope of the claimed invention. Specific details are set forth to provide an understanding of the present invention. It should however be appreciated that the present invention may be practiced in a variety of ways beyond the specific detail set forth herein.

Furthermore, while the exemplary embodiments illustrated herein show various components of the system collocated, certain components of the system can be located remotely, at distant portions of a distributed network, such as a LAN, cable network, and/or the Internet, or within a dedicated system. Thus, it should be appreciated, that the components of the system can be combined in to one or more devices, such as an information management system, or collocated on a particular node of a distributed network, such as an analog and/or digital communications network, a packet-switch network, a circuit-switched network or a cable network.

It will be appreciated from the preceding description, and for reasons of computational efficiency, that the components of the system can be arranged at any location within a distributed network of components without affecting the operation of the system. For example, the various components can be located in one or more of the information management system and information delivery system. Similarly, one or more functional portions of the system could be distributed between a communications device(s), such as a PDA, and an associated computing device.

Furthermore, it should be appreciated that the various links connecting the elements can be wired or wireless links, or any combination thereof, or any other known or later developed element(s) that is capable of supplying and/or communicating data to and from the connected elements. These wired or wireless links can also be secure links and may be capable of communicating encrypted information. Transmission media used as links, for example, can be any suitable carrier for electrical signals, including coaxial cables, copper wire and fiber optics, and may take the form of acoustic or light waves, such as those generated during radio-wave and infra-red data communications.

Also, while the flowcharts have been discussed and illustrated in relation to a particular sequence of events, it should be appreciated that changes, additions, and omissions to this sequence can occur without materially affecting the operation of the invention.

In yet another embodiment, the systems and methods of this invention can be implemented in conjunction with a special purpose computer, a programmed microprocessor or microcontroller and peripheral integrated circuit element(s), an ASIC or other integrated circuit, a digital signal processor, a hard-wired electronic or logic circuit such as discrete element circuit, a programmable logic device or gate array such as PLD, PLA, FPGA, PAL, special purpose computer, any comparable means, or the like. In general, any device(s) or means capable of implementing the methodology illustrated herein can be used to implement the various aspects of this invention. Exemplary hardware that can be used for the present invention includes computers, handheld devices, telephones (e.g., cellular, Internet enabled, digital, analog, hybrids, and others), and other hardware known in the art.

Some of these devices include processors (e.g., a single or multiple microprocessors), memory, nonvolatile storage, input devices, and output devices. Furthermore, alternative software implementations including, but not limited to, distributed processing or component/object distributed processing, parallel processing, or virtual machine processing can also be constructed to implement the methods described herein.

In yet another embodiment, the disclosed methods may be readily implemented in conjunction with software using object or object-oriented software development environments that provide portable source code that can be used on a variety of computer or workstation platforms. Alternatively, the disclosed system may be implemented partially or fully in hardware using standard logic circuits or VLSI design. Whether software or hardware is used to implement the systems in accordance with this invention is dependent on the speed and/or efficiency requirements of the system, the particular function, and the particular software or hardware systems or microprocessor or microcomputer systems being utilized.

In yet another embodiment, the disclosed methods may be partially implemented in software that can be stored on a storage medium, executed on programmed general-purpose computer with the cooperation of a controller and memory, a special purpose computer, a microprocessor, or the like. In these instances, the systems and methods of this invention can be implemented as a program embedded on personal computer such as an applet, JAVA® or CGI script, as a resource residing on a server or computer workstation, as a routine embedded in a dedicated measurement system, system component, or the like. The system can also be implemented by physically incorporating the system and/or method into a software and/or hardware system.

Although the present invention describes components and functions implemented in the embodiments with reference to particular standards and protocols, the invention is not limited to such standards and protocols. Other similar standards and protocols not mentioned herein are in existence and are considered to be included in the present invention. Moreover, the standards and protocols mentioned herein and other similar standards and protocols not mentioned herein are periodically superseded by faster or more effective equivalents having essentially the same functions. Such replacement standards and protocols having the same functions are considered equivalents included in the present invention.

The present invention, in various embodiments, configurations, or aspects, includes components, methods, processes, systems and/or apparatus substantially as depicted and described herein, including various embodiments, configurations, aspects, subcombinations, and subsets thereof. Those of skill in the art will understand how to make and use the present invention after understanding the present disclosure. The present invention, in various embodiments, configurations, and aspects, includes providing devices and processes in the absence of items not depicted and/or described herein or in various embodiments, configurations, or aspects hereof, including in the absence of such items as may have been used in previous devices or processes, e.g., for improving performance, achieving ease and/or reducing cost of implementation.

The foregoing discussion of the invention has been presented for purposes of illustration and description. The foregoing is not intended to limit the invention to the form or forms disclosed herein. In the foregoing Detailed Description for example, various features of the invention are grouped together in one or more embodiments, configurations, or aspects for the purpose of streamlining the disclosure. The features of the embodiments, configurations, or aspects of the invention may be combined in alternate embodiments, configurations, or aspects other than those discussed above. This method of disclosure is not to be interpreted as reflecting an intention that the claimed invention requires more features than are expressly recited in each claim. Rather, as the following claims reflect, inventive aspects lie in less than all features of a single foregoing disclosed embodiment, configuration, or aspect. Thus, the following claims are hereby incorporated into this Detailed Description, with each claim standing on its own as a separate preferred embodiment of the invention.

Moreover, though the description of the invention has included description of one or more embodiments, configurations, or aspects and certain variations and modifications, other variations, combinations, and modifications are within the scope of the invention, e.g., as may be within the skill and knowledge of those in the art, after understanding the present disclosure. It is intended to obtain rights which include alternative embodiments, configurations, or aspects to the extent permitted, including alternate, interchangeable and/or equivalent structures, functions, ranges or steps to those claimed, whether or not such alternate, interchangeable and/or equivalent structures, functions, ranges or steps are disclosed herein, and without intending to publicly dedicate any patentable subject matter.

The invention claimed is:

1. A system, comprising:

a server configured for two-way communication with a plurality of moving consists, each consist comprising at least one rail vehicle, wherein the server:

(a) receives over a network, from the plurality of consists, a plurality of sets of collected information, each of the sets of collected information comprising a consist physical location and observed real-time weather conditions and rail temperatures in an area of the respective consist;

(b) wherein the server is operable to process a predictive rail temperature algorithm for predicting a rail temperature and/or a trend in rail temperature for a selected section of track;

(c) wherein the predictive rail temperature algorithm factors the information provided to it, provides a predicted rail temperature and/or trend in rail temperature for the selected section of track and determines an instruction for each consist in the plurality of consists, wherein said instruction is calculated to influence the predicted rail temperature and/or trend in rail temperature for the selected section of track; and

(d) wherein the server sends, over the network, the respective instruction to each respective consist in the plurality of consists.

2. The system of claim **1**, wherein the network is a cellular network.

3. The system of claim **1**, wherein the network is a radio network.

4. The system of claim **1**, wherein a user of the system is at least one of an operator of one of the plurality of consists and a supervisor.

5. The system of claim **4**, wherein the supervisor is not located in any one of the plurality of consists.

6. The system of claim **5**, wherein the predicted rail temperature and/or trend in rail temperature for a selected section of track are communicated to the supervisor.

7. The system of claim **1**, wherein the plurality of sets of collected information are sent to the server over a first net-

work, and the predicted rail temperature and/or trend in rail temperature for a selected section of ack are sent to the consist over a second network.

8. The system of claim **1** wherein the predicted rail temperature and/or trend in rail temperature for a selected section of track are communicated to an operator of one of the plurality of consists orally via a radio signal.

9. A method, comprising:

(a) receiving over a network, from a plurality of moving consists, each consist comprising at least one rail vehicle, and by a server, a plurality of sets of collected information, each of the sets of collected information comprising a consist physical location and observed real-time weather conditions and rail temperatures in an area of the respective consist;

(b) processing, by the server a predictive rail temperature algorithm for predicting a rail temperature and/or a trend in rail temperature for a selected section of track;

(c) wherein the predictive rail temperature algorithm factors the information provided to it, provides a predicted rail temperature and/or trend in rail temperature for the selected section of track and determines an instruction for each consist in the plurality of consists, wherein said instruction is calculated to influence the predicted rail temperature and/or trend in rail temperature for the selected section of track; and

(d) sending, by the server and over the network, the respective instruction to each respective consist in the plurality of consists.

10. The method of claim **9**, wherein the network is a cellular network.

11. The method of claim **9**, wherein the network is a radio network.

12. The method of claim **9**, wherein a user of the method is at least one of an operator of one of the plurality of consists and a supervisor.

13. The method of claim **12**, wherein the supervisor is not located in any one of the plurality of consists.

14. The method of claim **13**, wherein the predicted rail temperature and/or trend in rail temperature for a selected section of track are communicated to the supervisor.

15. The method of claim **9**, wherein the plurality of sets of collected information are sent to the server over a first network, and the predicted rail temperature and/or trend in rail temperature for a selected section of track are sent to the consist over a second network.

16. The method of claim **9**, wherein the predicted rail temperature and/or trend in rail temperature for a selected section of track are communicated to an operator of one of the plurality of consists orally via a radio signal.

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