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CLERK, U.S. DISTRICT COURT
NORTHERN DISTRICT OF CALIFORNIA
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Attorneys for Plaintiff
GENX MOBILE INCORPORATED.

UNITED STATES DISTRICT COURT

FOR THE NORTHERN DISTRICT OF CALIFORNIA

GENX MOBILE INCORPORATED,
a Delaware corporation,

Plaintiff,

vs.

HTI IP, LLC,
a Delaware corporation,

Defendant.

Case No. C 08 00374 HRL

COMPLAINT FOR DECLARATORY JUDGMENT OF PATENT NON-INFRINGEMENT AND INVALIDITY

PARTIES, JURISDICTION, AND VENUE

1. Plaintiff GenX Mobile Incorporated ("GenX") is a corporation organized under the laws of the state of Delaware, with a principal place of business at 1955 Concourse Drive, San Jose, California, 95131.

2. GenX is in the business of making and selling mobile data processing devices and systems, including but not limited to the GenX Location Unit, model GNX-10.

3. On information and belief, defendant HTI IP, LLC ("HTI") is a limited liability company organized under the laws of Delaware, and has a principal place of business at 41 Perimeter Center East, Suite 400, in Atlanta, Georgia 30346.

4. On information and belief, HTI is closely affiliated with and/or part owned by Hughes Telematics, Inc., a company whose principal place of business is the same building, with the same address, as HTI. Hughes Telematics, Inc. has an additional office at 4510 Executive Drive, Suite 315, San Diego, CA 92121.

5. On information and belief, HTI, its owner Hughes Telematics, and their associated companies do business within California, and have otherwise purposefully availed themselves of the laws of California, including this District.

6. HTI has purposefully directed its patent infringement claims against GenX, a resident of this District, knowing that GenX was a resident of this District and knowing that at least some of the business activities of GenX that it was challenging were transacted in and from this District.

7. On information and belief, HTI is the current assignee and owner of United States Patent No. 6,636,790 ("the '790 patent"), a true copy of which is attached as Exhibit A.

8. On information and belief, HTI is the current assignee and owner of United States Patent No. 6,732,031 ("the '031 patent"), a true copy of which is attached as Exhibit B.

9. On information and belief, HTI is the current assignee and owner of United States Patent No. 6,611,740 ("the '740 patent"), a true copy of which is attached as Exhibit C.

10. This action arises under the patent laws of the United States (Title 35 of the United States Code).

11. This Court has subject matter jurisdiction pursuant to 28 U.S.C. §§ 1331, 1338(a) and 2201–02.

12. Venue in this district is proper pursuant to 28 U.S.C. §§ 1391(b)–(c) and 1400(b), because HTI and its related companies do business in the Northern District of California, and therefore HTI is a resident of this District for venue purposes.

13. There exists a case of actual controversy between GenX and HTI regarding the alleged infringement of the '790 patent, the '031 patent, and the '740 patent. Actions by HTI have caused and created an actual, immediate and substantial controversy between the parties, regarding the issue of non-infringement of any valid claim of the patents in suit.

14. In particular, HTI has filed suit against GenX in the Eastern District of Texas, Civ. Action No. 07-00466, alleging that GenX infringes the '790, '031, and '740 patents. GenX has filed a motion to dismiss that action for lack of personal jurisdiction in that action, which is currently pending.

COUNT 1: DECLARATION OF PATENT NON-INFRINGEMENT

15. Paragraphs (1) through (14) are incorporated by reference herein.

16. On information and belief, HTI owns the '790 patent, the '031 patent, and the '740 patent.

17. Actions by HTI have caused and created an actual controversy between the parties, regarding the issue of whether the '790, '031, or '740 patents are infringed by GenX.

18. GenX has never infringed and does not currently infringe any valid claim of the '790, '031, or '740 patents.

19. GenX is entitled to a declaration that it does not infringe any valid claim of the '790, '031, or '740 patents.

COUNT TWO: DECLARATION OF PATENT INVALIDITY

20. Paragraphs (1) through (14) are incorporated by reference herein.

21. Actions by HTI have caused and created an actual controversy between the parties, regarding the issue of whether the '790, '031, or '740 patents are valid.

22. One or more claims of the '790, '031, or '740 patents is invalid for failure to meet the conditions of patentability of 35 U.S.C. § 101 et seq., including without limitation those of sections 102, 103, and 112.

23. GenX is entitled to a declaration that one or more claims of the '790, '031, or '740 patents is invalid.

PRAYER FOR RELIEF

WHEREFORE, GenX requests:

A. a declaration that GenX has not infringed any valid claim of the '790, '031, or '740 patents;

B. a declaration that HTI and each of its officers, employees, agents, alter egos, attorneys, and any persons in active concert or participation with it be restrained and enjoined from further prosecuting or instituting any action against GenX claiming that the '790, '031, or '740 patents are infringed, or from representing that the products or services provided by GenX, or use of those products or services by others, infringe the '790, '031, or '740 patents.

C. an award to GenX of reasonable attorneys' fees under 35 U.S.C. § 285; and

D. such other relief as the Court deems just and proper.

Dated: January 18, 2008

THELEN REID BROWN RAYSMAN & STEINER

By: Christopher Ogden

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Exhibit A

US006636790B1

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

(10) **Patent No.: US 6,636,790 B1**
(45) **Date of Patent: Oct. 21, 2003**

(54) **WIRELESS DIAGNOSTIC SYSTEM AND METHOD FOR MONITORING VEHICLES**

(75) Inventors: **Bruce Lightner**, La Jolla, CA (US); **Diego Borrego**, San Diego, CA (US); **Chuck Myers**, La Jolla, CA (US); **Larkin Hill Lowrey**, La Jolla, CA (US)

(73) Assignee: **Reynolds and Reynolds Holdings, Inc.**, Dayton, OH (US)

(*) 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.: **09/776,106**

(22) Filed: **Feb. 1, 2001**

Related U.S. Application Data

(60) Provisional application No. 60/222,152, filed on Aug. 1, 2000, provisional application No. 60/222,213, filed on Aug. 1, 2000, and provisional application No. 60/220,986, filed on Jul. 25, 2000.

(51) **Int. Cl.**[7] **G06F 7/00**
(52) **U.S. Cl.** **701/33**; 701/29
(58) **Field of Search** 701/29, 30, 33, 701/35; 73/116, 117.2

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,442,553	A	8/1995	Parrillo	364/424.04
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5,574,427	A	11/1996	Cavallaro	340/430
5,732,074	A	3/1998	Spaur et al.	370/313
5,758,300	A	5/1998	Abe	701/33
5,797,134	A	8/1998	McMillan et al.	705/400
6,064,970	A	5/2000	McMillan et al.	705/4
6,295,492	B1	9/2001	Lang et al.	701/33

FOREIGN PATENT DOCUMENTS

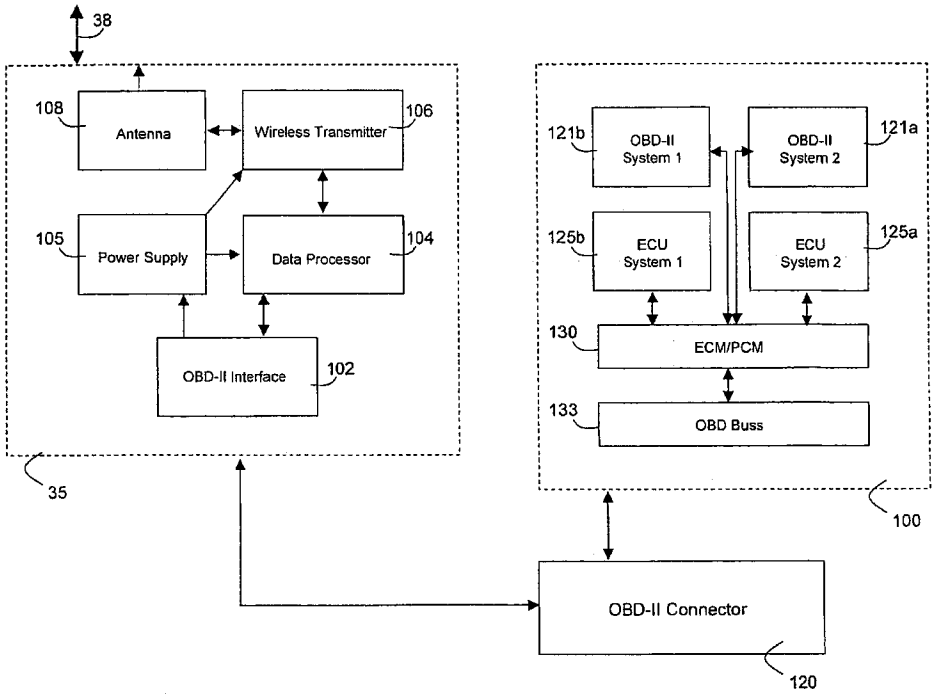
WO	WO 00/79727	12/2000

Primary Examiner—Yonel Beaulieu
(74) *Attorney, Agent, or Firm*—Hale and Dorr LLP

(57) **ABSTRACT**

A method and apparatus for remotely characterizing a vehicle's performance is described. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink to a wireless communications system and then to a host computer; and iv) analyzing the data packet with the host computer to characterize the vehicle's performance.

36 Claims, 4 Drawing Sheets



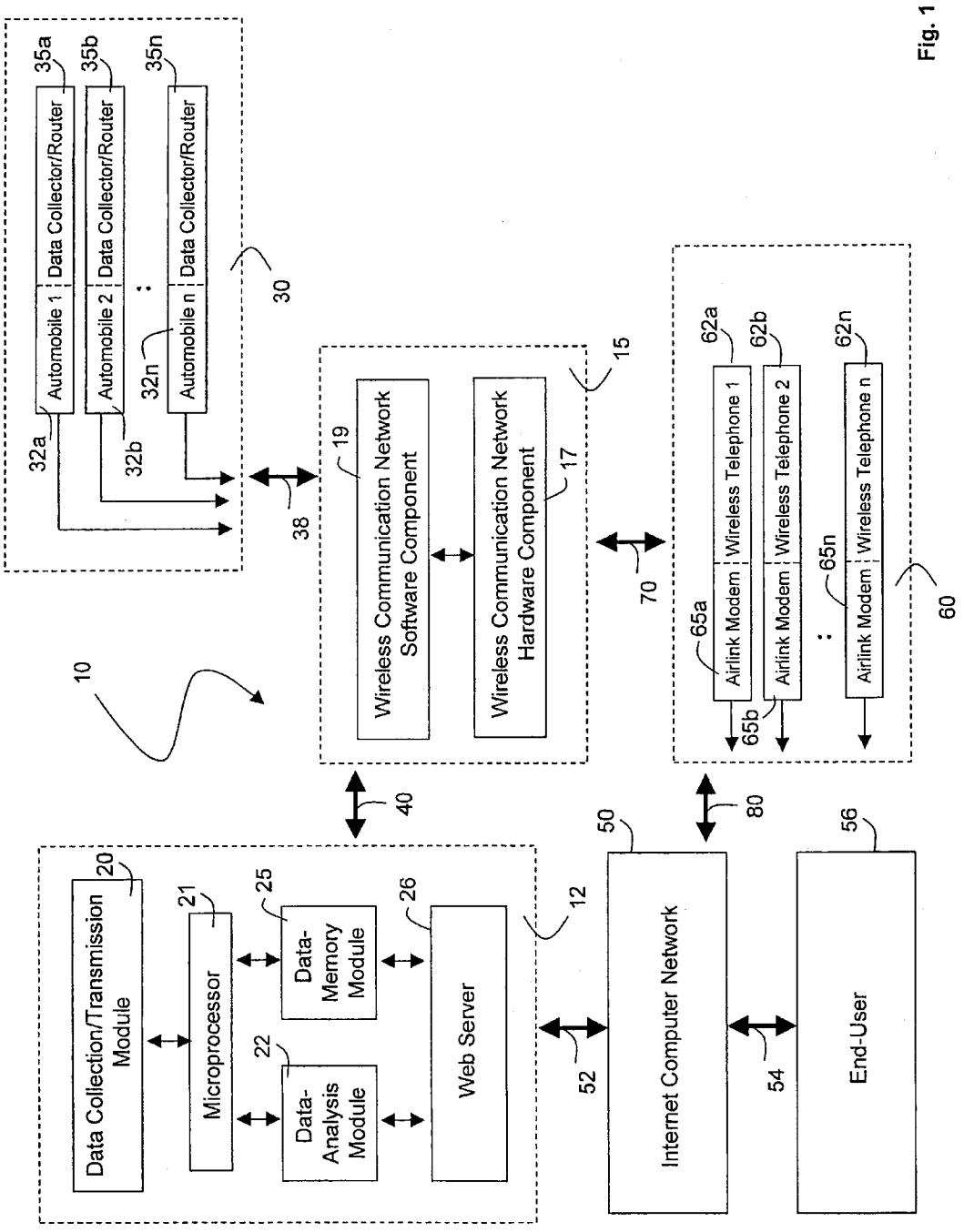

Automobile 1
Data Collector/Router
Automobile 2
Data Collector/Router
Automobile n
Data Collector/Router
35a
35b
35n
32a
32b
32n
30
38
Wireless Communication Network Software Component
Wireless Communication Network Hardware Component
19
17
15
70
Airlink Modem
Wireless Telephone 1
Airlink Modem
Wireless Telephone 2
Airlink Modem
Wireless Telephone n
62a
62b
62n
65a
65b
65n
60
10
40
80
Data Collection/Transmission Module
20
Microprocessor
21
Data-Analysis Module
22
Data-Memory Module
25
Web Server
26
12
50
52
Internet Computer Network
54
End-User
56

Fig. 1

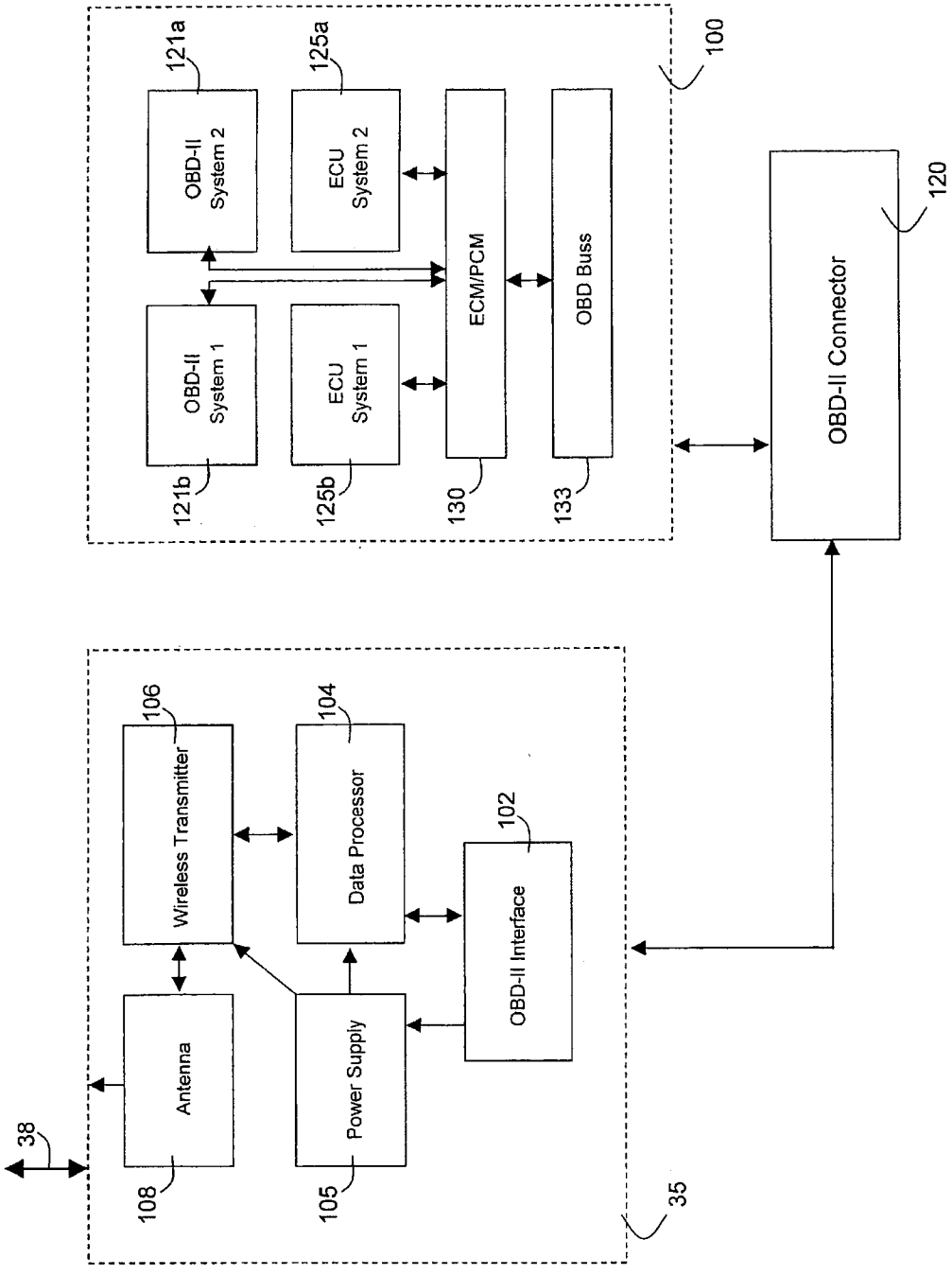

121a
OBD-II System 2
125a
ECU System 2
ECM/PCM
OBD Buss
100
OBD-II System 1
ECU System 1
121b
125b
130
133
OBD-II Connector
120
106
Wireless Transmitter
104
Data Processor
102
OBD-II Interface
Antenna
Power Supply
38
108
105
35

Fig. 2

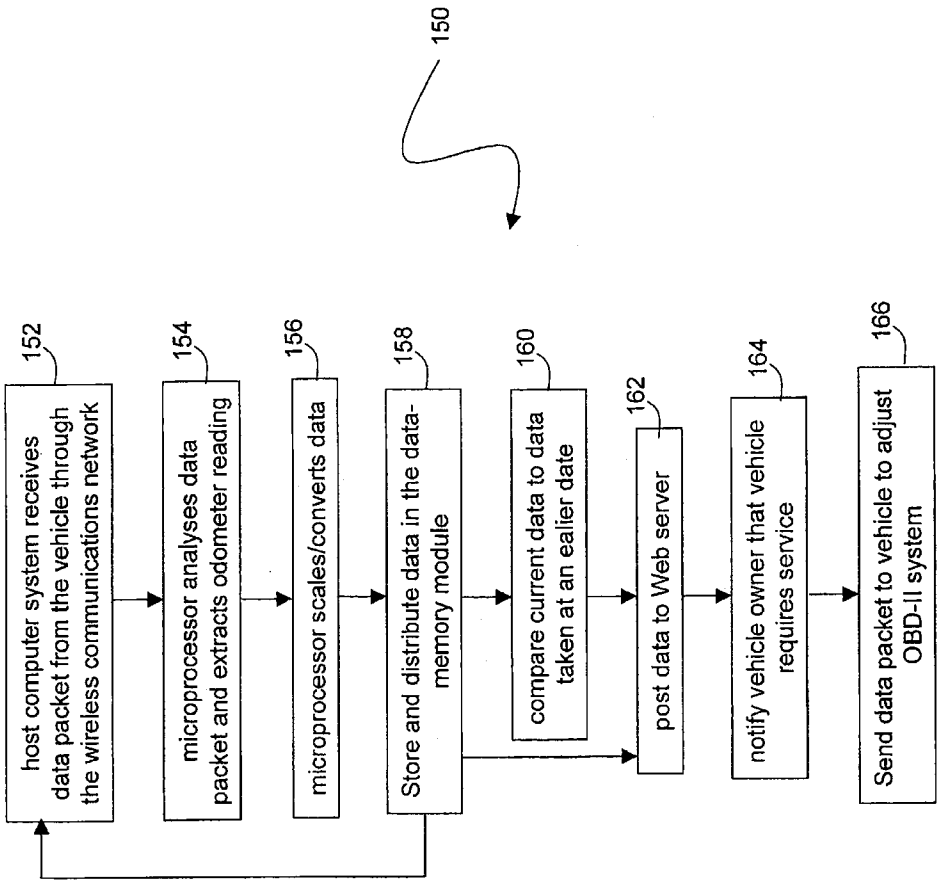

150
152
host computer system receives data packet from the vehicle through the wireless communications network
154
microprocessor analyses data packet and extracts odometer reading
156
microprocessor scales/converts data
158
Store and distribute data in the data-memory module
160
compare current data to data taken at an ealier date
162
post data to Web server
164
notify vehicle owner that vehicle requires service
166
Send data packet to vehicle to adjust OBD-II system

Fig. 3

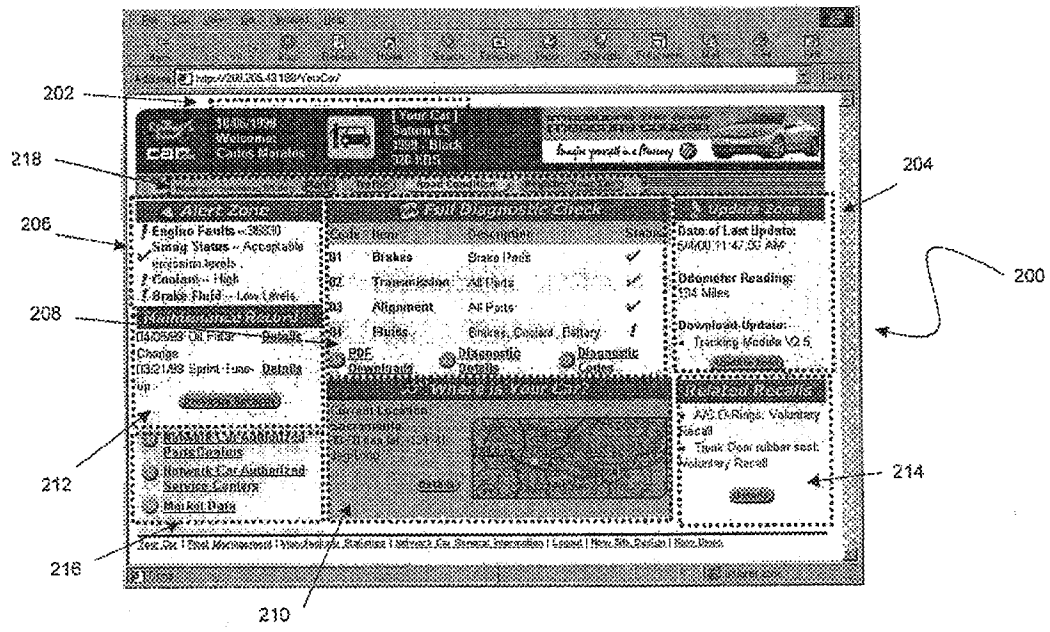


Fig. 4

WIRELESS DIAGNOSTIC SYSTEM AND METHOD FOR MONITORING VEHICLES

RELATED APPLICATION

Under 35 U.S.C. §119(e)(1), this application claims benefit of prior U.S. Provisional Applications No. 60/222,152, entitled "Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" filed Aug. 1, 2000; and No. 60/222,213, entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" filed Aug. 1, 2000, both of which are incorporated herein by reference; and it claims benefit of prior U.S. Provisional Application No. 60/220,986 entitled "Wireless Diagnostic System for Vehicles" filed Jul. 25, 2000.

In addition, this application is related to the following U.S. Patent Applications that were filed on the same day as the present application: (1) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (U.S. Ser. No. 09/776,033); and (2) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (U.S. Ser. No. 09/776,083), both of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the use of wireless communications and diagnostic systems in automotive vehicles.

BACKGROUND OF THE INVENTION

The Environmental Protection Agency (EPA) requires vehicle manufacturers to install on-board diagnostics (OBD) for emission control on their light-duty automobiles and trucks beginning with model year 1996. OBD systems (e.g., computer, microcontrollers, and sensors) monitor the vehicle's emission control systems to detect any malfunction or deterioration that causes emissions to exceed EPA-mandated thresholds. Such a system, for example, is an oxygen sensor located in the vehicle's exhaust manifold and tailpipe.

The EPA requires that all information monitored or calculated by OBD systems is made available through a standardized, serial 16-cavity connector referred to as the ALDL (Assembly Line Diagnostic Link) or OBD connector. All physical and electrical characteristics of this connector are standard for all vehicles sold in the United States after 1996. The EPA also mandates that, when emission thresholds are exceeded, diagnostic information characterized by OBD systems must be stored in the vehicle's central computer so that it can be used during diagnosis and repair.

A second generation of OBD systems ("OBD-II" systems) monitors a wide range of data that indicate the performance of the host vehicle. For example, these data can be analyzed to infer the vehicle's emission performance. In addition to emissions, OBD-II systems monitor vehicle speed, mileage, engine temperature, and intake manifold pressure. OBD-II systems also query manufacturer-specific data, such as data relating to the vehicle's engine, transmission, brakes, alarm, entertainment systems. OBD-II systems also monitor codes called diagnostic trouble codes, or "DTCs", which indicate a mechanic or electrical problem with the vehicle. DTCs are the codes that typically light a vehicle's 'service engine soon' light. In total, OBD-II systems typically access more than 300 segments of data relating to the performance and make of the host vehicle.

In addition to the OBD-II systems, most vehicles manufactured after 1996 have electronic control units (ECUs) that control internal electromechanical actuators. Examples include ECUs that control fuel-injector pulses, spark-plug timing, and anti-lock braking systems. Most ECUs transmit status and diagnostic information over a shared, standardized electronic buss in the vehicle. The buss effectively functions as an on-board computer network with many processors, each of which transmits and receives data. The primary computers in this network are the vehicle's electronic-control module (ECM) and power-control module (PCM). The ECM typically accesses computers and microcontrollers that monitor or control engine functions (e.g., the cruise-control module, spark controller, exhaust/gas recirculator). The PCM typically controls or monitors ECUs associated with the vehicle's power train (e.g., its engine, transmission, and braking systems).

When a vehicle is serviced, data from the standardized buss can be queried using external engine-diagnostic equipment (commonly called 'scan tools') that connect to the above-described 16-cavity electrical connector (called an OBD-II connector for vehicles made after 1996). The OBD-II connector is typically located under the vehicle's dashboard on the driver's side. Data transferred through the connector to the scan tool yields data that identify a status of the vehicle and whether or not a specific component of the vehicle has malfunctioned. This makes the service process more efficient and cost-effective.

Some manufacturers include complex electronic systems in their vehicles to access and analyze the above-described data. These systems are not connected through the OBD-II connector, but instead are wired directly to the vehicle's electronic system. This wiring process typically takes place when the vehicle is manufactured. In some cases these systems transmit data through a wireless network.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to address the limitations of the conventional engine-diagnostic systems discussed above. Specifically, it is an object of the invention to both access and send data over the ODB-II connector using a remote, wireless system that connects to the Internet using an airlink. The device used for accessing and transmitting the data is simple, low-cost, and easy-to-install.

In one aspect, the invention features a method and apparatus for remotely characterizing a vehicle's performance. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink, to a wireless communications system, and then to a host computer; and iv) analyzing the data packet with the host computer. Once analyzed, the data can be used to characterize the vehicle's performance, e.g. evaluate the vehicle's electrical and mechanical systems. The data can also be used for other purposes, such as for insurance-related issues, surveys, and vehicle tracking.

The terms 'microcontroller' and 'microprocessor' refer to standard electronic devices (e.g., programmable, silicon-

based devices) that can control and/or process data. For example, a sensor disposed in the vehicle (e.g., an oxygen sensor) would be a microcontroller. "Airlink" refers to a standard wireless connection between a transmitter and a receiver.

In the above-described method, steps i)–iv) can be performed at any time and with any frequency, depending on the diagnoses being performed. For a 'real-time' diagnoses of a vehicle's engine performance, for example, the steps may be performed at rapid time or mileage intervals (e.g., several times each minute, or every few miles). Alternatively, other diagnoses (e.g. a 'smog check' that includes inferring the concentrations of hydrocarbons, oxides of nitrogen, or carbon monoxide) may require the steps to be performed only once each year or after a large number of miles are driven. Steps i)–iii) (i.e. the 'generating', 'transferring', and 'transmitting' steps) may be performed in response to a signal sent from the host computer to the vehicle. Alternatively, the vehicle may be configured to automatically perform these steps at predetermined or random time intervals.

The generating step typically includes generating data encoded in a digital format using the vehicle's electronic control unit (ECM) and/or power control unit (PCM). The data, for example, describes the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, engine-performance tuning parameters, alarm status, accelerometer status, cruise-control status, fuel-injector performance, spark-plug timing, and/or a status of an anti-lock braking system. The data can also be a DTC or related code. The analyzing step features extracting data from the transmitted data packet, and then storing the data in a computer memory or database.

Once stored, the data is processed in a variety of ways. For example, the processing can simply involve determining the vehicle's odometer reading, and then comparing this reading to a schedule that lists recommended, mileage-dependent service events (e.g., a 5000-mile tune-up). Other algorithms include those that compare current data with data collected at an earlier time to dynamically characterize the performance of the vehicle. In another example, the algorithms compare the data with a predetermined numerical value or collection of values. For example, the data can correspond to a level of the vehicle's exhaust emissions or mileage; these values can then be compared to predetermined values for the particular vehicle to characterize its performance. More complex processing can include, for example, analyzing the data with a mathematical algorithm to predict the electrical or mechanical performance of the vehicle or a failure of a particular component.

After the processing step, the method can also include the step of sending an electronic text, data, or voice message to a computer, cellular telephone, personal digital assistant or wireless device to alert the end-user of a potential problem. The results from the analysis can also be displayed on similar devices connected to the World-Wide Web or the Internet.

In another embodiment, the method additionally includes the step of sending a second data packet from the host computer system over an airlink to the wireless communications system and then to the vehicle's data collector/router. In this case, the second data packet is processed by the microprocessor in the data collector/router to generate a signal that is sent to at least one of the vehicle's microcontrollers. There, the signal is processed and used, for example to adjust a setting in the particular microcontroller. The signal can also be used to update or distribute new software or firmware configurations to one or more of the vehicle's microcontrollers. In still other embodiments, the signal can be used to make 'tailored' readings of the vehicle's diagnostic information, e.g. to perform complex diagnoses (sometimes called 'drilling down') and isolate malfunctioning components in the vehicle's mechanical or electrical systems.

In another aspect, the invention features a method for sending data to an electrical system in a vehicle. The method features the steps of: i) generating with a host computer a data packet that affects at least one microcontroller disposed within the electrical system of the vehicle; ii) transmitting the data packet from the host computer over an airlink to a wireless communications system and then to a data collector/router (containing a microprocessor and wireless transmitter similar to that described above) disposed in the vehicle; iii) receiving the data packet with the wireless transmitter and sending it to the microprocessor; iv) processing the data packet with the microprocessor to generate data; and v) transmitting the data through an OBD, OBD-II or equivalent electrical connector to the microcontroller disposed within the vehicle's electrical system.

The invention has many advantages. In particular, wireless transmission of a vehicle's diagnostic data makes it possible to remotely identify potential problems without bringing the vehicle to a conventional service center. For example, the system can be configured so that when a DTC is generated by a vehicle the code associated with it is automatically sent to the web sites of a service center and the vehicle owner. This way, the service center can diagnose the problem, order the required parts, and schedule the service before the vehicle owner actually brings in the vehicle for service. In certain situations, potential problems with the vehicle can be remotely predicted and addressed before they actually occur. Moreover, data from the vehicle can be queried, stored and analyzed frequently and in real-time (i.e., while the vehicle is actually in use) to provide a relatively comprehensive diagnosis that is not possible in a conventional service center.

The device used to access and transmit the vehicle's data is small, low-cost, and can be easily installed in nearly every vehicle with an OBD-II connector in a matter of minutes. It can also be easily transferred from one vehicle to another, or easily replaced if it malfunctions.

Communication with the vehicle's OBD buss can also be bi-directional, making it possible to actually repair certain problems remotely. This, of course, means that in some cases the vehicle's problem can be both diagnosed and repaired in a completely remote and unobtrusive manner.

Data transmitted from the vehicle can also be analyzed for purposes unrelated to mechanical or electrical problems. For example, the data can be collected and analyzed in real-time to characterize driving patterns (e.g. a vehicle's speed), automotive part reliability, and emission characteristics. Lessors and renters of vehicles can remotely track mileage for billing purposes. Smog and emission certifications can be easily done in a completely remote manner. Data can also be analyzed to determine the vehicle's approximate location as a safety or anti-theft measure.

Another advantage of the invention is that data transmitted from a particular vehicle over a wireless airlink can be accessed and analyzed through the Internet without the need for expensive diagnostic equipment. Software used for the analysis can be easily modified and updated, and then used by anyone with access to the Internet. This obviates the need

for vehicle service centers to upgrade their diagnostic equipment for next-generation vehicles. The resulting data, of course, have many uses for vehicle owners, surveyors of vehicle performance (e.g., J. D. Power), manufacturers of vehicles and related parts, and vehicle service centers.

Sophisticated analysis of the above-mentioned data yields information that benefits the consumer, vehicle and parts manufacturers, vehicle service centers, and the environment.

These and other advantages of the invention are described in the following detailed disclosure and in the claims.

BRIEF DESCRIPTION OF DRAWINGS

The features and advantages of the present invention can be understood by reference to the following detailed description taken with the drawings, in which:

FIG. **1** is a schematic drawing of a wireless diagnostic system in wireless contact with a system of vehicles and the Internet;

FIG. **2** is a schematic drawing of a data collector/router used in each of the vehicles of FIG. **1**;

FIG. **3** is a flow chart describing analysis of data transmitted by the data collector/router by the host computer of FIG. **1**; and

FIG. **4** is a screen capture of a page from the Web server of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a wireless diagnostic system **10** that communicates with a collection of vehicles **30** using a host computer system **12** and a standard wireless communications system **15**. The wireless communications system **15** is, e.g., a conventional wireless telephone or paging system (e.g., Bell South's 'Mobitex' System). Each vehicle **32***a*, **32***b*, **32***n* in the collection of vehicles **30** features a data collector/router **35***a*, **35***b*, **35***n* that queries data generated by each vehicle's ECU and OBD-II systems through an OBD buss. After the query, each data collector/router **35***a*, **35***b*, **35***n* receives data from the host vehicle **32***a*, **32***b*, **32***n* and sends it as a data packet over a wireless airlink **38** to the wireless communication system **15**. The wireless communication system **15** features a standard hardware component **19** (e.g. a system of transmission 'base stations', computers, and switching and routing hardware) and software component **17** (e.g., a paging or cellular network) that relay the data packet through a digital line **40** to the host computer system **12**.

A data collection/transmission module **20** (e.g., a digital transmission line) in the host computer system **12** receives the data packet and then routes it to a microprocessor **21**. The microprocessor controls a data-analysis module **22** (e.g., hardware and software for statistical analysis) that processes the data packet, and a data-memory module **25** (e.g., a computer memory or database) that stores it. A web server **26** receives the processed data from the data-analysis **22** and data-memory modules **25** and makes it available to an Internet computer network **50** through a first network connection **52**. An end-user **56** accesses the data on the web server **26** through a second network connection **54** using the Internet computer network **50**.

Data packets from each data collector/router **35***a*, **35***b*, **35***n* can also be accessed directly over an airlink **70** by wireless telephones **62***a*, **62***b*, **62***n* in a wireless telephone network **60**. In this case each wireless telephone **62***a*, **62***b*, **62***n* has an airlink modem **65***a*, **65***b*, **65***n* that allows the data packet to be accessed directly. Alternatively, using the airlink modem **65***a*, **65***b*, **65***n*, the wireless telephones **62***a*, **62***b*, **62***n* can access processed data from the web server **26**, provided they have the appropriate software (e.g., web-browsing capabilities). In this case, the web server **26** formats the data in a manner suitable to wireless browsing (e.g. wireless access protocol).

The host computer system **12** typically works bi-directionally, i.e. it can both send data to and receive data from the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*. For example, following a query, the host computer system **12** receives a data packet from a particular data collector/router. The system typically runs a real-time operating system (e.g., Windows NT® or Unix®) that manages multiple software programs conducting different functions (e.g. data processing and storage).

Data is typically sent from the host vehicle **32***a*, **32***b*, **32***n* to each data collector/router **35***a*, **35***b*, **35***n* at a predetermined time interval (e.g. a random or periodic time interval) that is programmed in either the data collector/router or the actual vehicle. For example, data can be sent on a daily basis. Alternatively, data can be queried in response to a signal sent from the host computer system **12** to the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*.

Depending on the make and model of the vehicle, the data packet can contain hundreds of datum that describe, e.g.: i) basic properties of the power train (e.g., emission levels, fuel-system status, engine temperature, speed and odometer readings, anti-lock brake status, RPMs, fuel and intake manifold pressure); and ii) manufacturer-specific information (e.g., status of the door locks, airbags, and entertainment center). In total, for most vehicles there are typically more than 300 datum that can be included in the data packet.

Certain vehicle functions can also be controlled by sending a data packet to the vehicle. Data in the data packet can adjust, for example, settings in the ECUs and OBD-II sensors, certain engine properties, and indicator lights on the vehicle's dashboard. They can also be used to open door locks and reconfigure the vehicle's entertainment system.

In addition, data packets routed through the wireless communications system **15** can be analyzed to determine the vehicle's approximate location. This can be done with relatively low accuracy (within a few miles) by simply recording the location of a specific cellular tower in the hardware component **17** of the wireless communications system **15** that routes the data packet to the host computer system **12**. Recording the location of multiple base stations within range of the vehicle, and then analyzing these data using conventional algorithms (e.g., triangulation), increases the accuracy to which the vehicle's location is determined.

FIG. **2** shows a data collector/router **35** in electrical contact with a vehicle's OBD/ECU system **100**. The two systems connect through a conventional OBD-II connector **120** typically located under the vehicle's dashboard. The data collector/router **35** is contained in a small, portable housing that plugs directly into the connector **120** and can be easily installed and replaced.

The connector **120** has a serial, 16-cavity layout, with specific electrical connections in separate cavities supplying data and electrical power from the OBD/ECU system **100**. The connector electrically and mechanically matches an OBD-II interface **102** in the data collector/router **35**. Although the OBD-II connector **120** has a standard mechanical interface, data transmitted through it may have a format and pass through cavities that depend on the

vehicle's make and model. For example, Ford and General Motors vehicles use an OBD data format called J1850; data in this format pass through cavities **2** and **10**. Chrysler and most European and Asian manufacturers use a data format called ISO 9141-2 and pass data through cavities **7** and **15**. In a third format, called J2284, data is passed through cavities **6** and **14**.

The connector **120** also passes battery power (cavity **16**), automobile chassis ground (cavity **4**), and signal ground (cavity **5**) from the OBD/ECU system **100** through the OBD-II interface **102** to the data collector/router **35**. Using these connections, a power supply **105** receives the battery power, regulates it, and in turn drives a data processor **104** and wireless transmitter **106** within the data collector/router **35**.

Once received, data is passed to the data processor **104** (e.g., a microprocessor) that processes and formats it to form a data packet. As an example, a data packet and specifically formatted for Bell South's wireless 900 MHz mobitex MPAK system is described in Table below. Actual data describing the host vehicle is contained in the 516-byte data area described in Table 1.

TABLE 1

description of Mobitex MPAK data packet

Bytes	General Description	
3	source MAN (unique 24-Bit modem number)	
3	destination MAN (unique 24-Bit modem number)	
1	when sending:	Bit 0 = use mailbox Bit 1 = return positive acknowledgment Bit 2 = use address list Bits 3–7 = 0
	when receiving:	Bit 4 = may be ignored Bits 5–7 = traffic state
1	MPAK type	
0 or 22	address list	
0 to 512	data payload	

Once properly formatted as described in Table 1, the data packet is passed from the data processor **104** to the wireless transmitter **106**. The transmitter **106** transmits the data packet through a conventional wireless antenna **108** over an airlink **38** to a wireless communications system (**15**) shown in FIG. **1**. The data processor **104** formats the data packet according to the wireless communications system that transmits it.

Once transmitted, the data packet propagates through the wireless communication software and hardware components (**17** and **19** in FIG. **1**) of the communication network (e.g., the Mobitex network). Typically in this case the data packet is routed to a 'point of presence' or 'POP' in the network, where it is then transferred over a digital line (e.g., **40** in FIG. **1**) to the host computer system.

The data area described in Table 1 contains data generated by the vehicle's OBD/ECU system **100**. As described above, this system **100** functions effectively as an on-board computer network that generates, transmits, and receives data. For simplicity, the system **100** in FIG. **2** contains two OBD-II systems **121***a*, **121***b* and two ECU systems **125***a*, **125***b;* it is analogous to more complex OBD-II and ECU systems employed in actual vehicles. The OBD-II systems **121***a*, **121***b* are microcontrollers that monitor the various vehicle-related properties described above. The ECU systems **125***a*, **125***b* receive and send data to electromechanical actuators that control, e.g., fuel-injector pulses, spark-plug timing, and anti-lock braking systems.

The OBD-II systems **121***a*, **121***b* and ECU systems **125***a*, **125***b* are controlled by the vehicle's ECM/PCM **130**. In some cases, the ECM/PCM **130** receives data from these systems and routes it over a shared electronic OBD buss **133**. Alternatively, after receiving the data the ECM/PCM **130** converts it to "fail" or "malfunction" codes that are then routed over the shared electronic buss **133**. In both cases, the OBD buss serially transmits data to the data collector/router **35** through the electrically connected OBD connector **120**.

Once collected and sent to the host computer system (**12** in FIG. **1**), the data packet can be analyzed in a variety of different ways. As an example, FIG. **3** shows a flow chart describing one method **150** of how data is analyzed and then made available to end-users through the Internet. A wide number of different data-analysis methods are possible; the one shown in FIG. **3** was chosen because of its simplicity.

In the data-analysis method **150**, the host computer system receives a data packet from the vehicle through the wireless communications network (step **152**). The data packet has a format shown, e.g., in Table 1 above, and contains a wide range of information that characterizes the vehicle's performance. Once received, the packet is analyzed and an odometer reading (e.g., mileage) from the vehicle is extracted (step **154**). If necessary, the microprocessor then scales the odometer reading (e.g., converts kilometers to miles) or converts the format used in the data packet (e.g., a manufacturer-specific format) to one that is easily recognized by the end-user (step **156**). At this point the odometer reading and other data within the data packet are distributed and stored in the data-memory module (e.g. a database) of the host computer system (step **158**). Some data may be simply disregarded during this step. This portion (steps **152**, **154**, **156**, and **158**) of the method may be repeated at this point to generate additional data.

All the data (e.g. the vehicle's mileage collected at different time or mileage intervals) can be posted directly on a Web page on the Web server (step **162**) where it is accessible by the end-user through the Internet. The data can also be analyzed further. For example, a current odometer reading can be compared to one recorded at an earlier date (step **160**) to determine how many miles the vehicle has traveled since its last oil change. If this value exceeds that recommended for the particular vehicle, the host computer system can notify the user through electronic mail that the vehicle requires service (step **164**). The method **150** can also be used to remotely adjust settings in the vehicle's OBD-II systems. For example, at this point the host computer system could send a data packet to the vehicle to reset the trip odometer to a new value (step **166**).

FIG. **4** shows a sample Web page **200** from a Web server that displays data processed using a method similar to that shown in FIG. **3**. Access to Web page is typically password-protected, thereby only allowing end-users with the correct password to access data for a particular vehicle.

The Web page **200** features a region **202** that describes the owner of the vehicle and its make and model. The page **200** also has a region **204** that describes the time, date, and odometer readings registered at its last update. Data describing vehicle problems (e.g., engine faults, coolant and brake fluid levels, emission status) that may require immediate attention are displayed in region **206**. Data used to diagnose the overall condition of the vehicle (e.g., brake and transmission status, wheel alignment) are displayed in region **208**. More data relating to these properties can be obtained by clicking the appropriate buttons ("Diagnostic Details", "Diagnostic Codes") in this region. The page **200** also

includes a region **210** that provides the approximate location of the vehicle. As described above, the vehicle's location is determined by recording the location of one or more base stations used to send the latest data packet through the wireless communications system. The page also includes a region **212** that features data describing the general history and maintenance of the vehicle. A related region **214** describes parts for the particular vehicle that have been recently recalled. A region **216** describes the locations of parts dealers and local service stations for the particular vehicle, while the region **218** provides access to features that may affect travel, such as weather, traffic, road conditions, and the status of the vehicle's registration.

Other embodiments are within the scope of the invention. For example, the components used in the data collector/router (particularly the wireless transmitter) may be optimized for different types of wireless communications systems. These systems include wireless telephone and paging systems, Bluetooth®, and similar systems. Similarly, the format of the data packet may also be adjusted for transmission over different types of networks. In general, any components in the data collector/router, and any format of the data packet, can be used to accomplish the general method of the invention.

Likewise, a wide range of mathematical algorithms can be used to analyze data once it is extracted from the data packets. These algorithms range from the relatively simple (e.g., lessors and renters determining the mileage on a vehicle for billing purposes) to the complex (e.g., predictive engine diagnoses using 'data mining' techniques). Data analysis may be used to characterize an individual vehicle as described above, or a collection of vehicles. Algorithms used to characterize a collection of vehicles can be used, for example, for remote vehicle or parts surveys, to characterize emission performance in specific geographic locations, or to characterize traffic.

Other embodiments of the invention include algorithms for analyzing data to characterize vehicle accidents and driving patterns for insurance purposes; algorithms for determining driving patterns for use-based leasing; and algorithms for recording vehicle use and driving patterns for tax purposes. In general, any algorithm that processes data collected with the above-described method is within the scope of the invention.

Similarly, the temporal or mileage frequency at which data is collected can be adjusted to diagnose specific types of problems. For example, characterization of certain types of vehicle performance indicators, such as emissions, may need to be monitored relatively frequently. Other properties, such as mileage and fluid levels, may only need to be monitored every few days, or in some cases just a few times each year.

Once the data is analyzed, the Web page used to display the data can take many different forms. Different Web pages may be designed and accessed depending on the end-user. For example, individual users may have access to Web pages for their particular vehicle. Conversely, vehicle service providers (e.g. providers that change oil or certify a vehicle's emissions) may have access to Web pages that contain data (e.g., mileage and emissions data) from a wide range of vehicles. These data, for example, can be sorted and analyzed depending on vehicle make, model, and geographic location. Web pages may also be formatted using standard wireless access protocols (WAP) so that they can be accessed using wireless devices such as cellular telephones, personal digital assistants (PDAs), and related devices.

In other embodiments, additional hardware can be added to the in-vehicle unit. For example, hardware for global-positioning systems (GPS) may be added so that the location of the vehicle can be monitored along with its data.

In other embodiments, data from the data collector/router in the vehicle can be analyzed and used for: remote billing/payment of tolls; remote smog and emissions checks; remote payment of parking/valet services; remote control of the vehicle (e.g., in response to theft or traffic/registration violations); and general survey information.

Still other embodiments are within the scope of the following claims.

What is claimed is:

1. A method for characterizing a vehicle's performance, comprising the steps of:

retrieving data representative of the vehicle's performance through the vehicle's OBD or OBD-II connector according to a communication protocol at a predetermined time interval with a data collector/router comprising:

i) an electrical connector that connects to the OBD or OBD-II connector;

ii) a microprocessor configured to retrieve and transmit data at the predetermined time interval, and

iii) a wireless transmitter in electrical contact with the microprocessor;

wirelessly transmitting the data with the wireless transmitter to a wireless communications system and then to a host computer; and

analyzing the data with the host computer.

2. The method of claim **1**, wherein the data is serially transferred through an OBD-II connector to the data collector/router.

3. The method of claim **2**, wherein the protocol used to transfer data through the OBD-II connector is J1850, ISO 9141-2, J2284, or equivalents thereof.

4. The method of claim **1**, wherein the generating step further comprises generating data encoded in a digital format using an electronic control unit and/or power control unit.

5. The method of claim **4**, wherein the generating step further comprises generating data that describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, and a status of an anti-lock braking system.

6. The method of claim **1**, wherein the analyzing step further comprises extracting data from the data packet corresponding to a specific property of the vehicle and storing the data in a computer memory or database.

7. The method of claim **6**, wherein the analyzing step further comprises processing the data stored in the computer memory or database with an algorithm.

8. The method of claim **7**, wherein the processing further comprises analyzing the data with a mathematical algorithm to characterize or predict the electrical or mechanical performance of the vehicle.

9. The method of claim **7**, wherein the processing further comprises comparing the data with data collected at an earlier time to characterize or predict the performance of the vehicle.

10. The method of claim **7**, wherein the processing further comprises comparing the data with a predetermined numerical value or collection of values to characterize the performance of the vehicle.

11. The method of claim 7, wherein the data corresponds to a level of exhaust emissions for the vehicle, and the processing comprises comparing the level of exhaust emissions to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

12. The method of claim 7, wherein the data corresponds to a mileage for the vehicle, and the processing comprises comparing the mileage to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

13. The method of claim 1, further comprising sending an electronic text, data, or voice message to a computer, cellular telephone, or wireless device after the data is analyzed.

14. The method of claim 1, further comprising displaying results from the analysis on a computer, cellular telephone, or wireless device connected to the World-Wide Web or the Internet.

15. The method of claim 1, wherein the results are displayed on a page on the World-Wide Web or the Internet.

16. The method of claim 1, wherein the method further comprises the step of wirelessly sending a second data packet from the host computer system to the wireless communications system and then to the data collector/router disposed in the vehicle.

17. The method of claim 16, wherein the second data packet is processed by the microprocessor in the data collector/router to generate a signal, and the signal is sent to at least one microcontroller disposed within the vehicle.

18. The method of claim 17, wherein the signal is processed by the microcontroller and used to adjust it.

19. A system for characterizing a vehicle's performance comprising:

a data collector/router comprising:

an electrical connector configured to connect to the vehicle's OBD or OBD-II connector;

a microprocessor in electrical contact with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit it to a network;

a first computer system comprising a processor configured to receive the data from the network; and

a second computer system configured to analyze the data.

20. The system of claim 19, wherein the data collector/router is configured to serially transfer data through an OBD-II connector to the data collector/router.

21. The method of claim 19, wherein the data collector/router is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

22. The system of claim 19, wherein the processor in the host computer system is configured to analyze the data with a mathematical algorithm to predict or characterize the performance of the vehicle.

23. The system of claim 19, wherein the processor in the host computer system is configured to compare the data with other data from a data packet collected from the vehicle at an earlier time to characterize the performance of the vehicle.

24. The system of claim 19, wherein the processor in the host computer system is configured to compare the data with a predetermined numerical value or collection of values to characterize the performance of the vehicle.

25. The system of claim 19, wherein the data corresponds to a level of exhaust emissions for the vehicle, and the processor in the host computer system is configured to compare the level of exhaust emissions to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

26. The system of claim 25, wherein the data is analyzed to infer the concentration of hydrocarbons, oxide of nitride, or carbon monoxide emitted from the vehicle.

27. The system of claim 19, wherein the data corresponds to a mileage for the vehicle, and the processor in the host computer system is configured to compare the mileage to a predetermined value for the particular vehicle to characterize the performance of the vehicle.

28. A system for characterizing a vehicle's performance comprising a data collector/router comprising:

an electrical connector configured to connect through the vehicle's OBD or OBD-II connector;

a microprocessor in electrical contact with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit it to a network.

29. The system of claim 28, wherein the microprocessor is additionally configured to serially transfer data through the OBD, OBD-II or equivalent electrical connector.

30. The method of claim 29, wherein the microprocessor is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

31. A system for characterizing a vehicle's performance comprising a data collector/router comprising:

an on-board diagnostic connector configured to connect to a serial connector located in the vehicle's interior;

a microprocessor in electrical contact with the on-board diagnostic connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval;

a wireless transmitter integrated in the data collector/router configured to receive the data from the microprocessor and wirelessly transmit it to a network; and

a housing containing the microprocessor and the wireless transmitter.

32. The system of claim 31, wherein the serial electronic connector is located underneath the vehicle's steering column.

33. The system of claim 31, wherein the microprocessor is additionally configured to serially transfer data through the serial connector.

34. The method of claim 33, wherein the microprocessor is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol, or an equivalent thereof.

35. A method for sending data to an electrical system in a vehicle, comprising the steps of:

generating with a host computer data that affects at least one microcontroller disposed within the electrical system of the vehicle;

wirelessly transmitting the data from the host computer to a wireless communications system and then to a data collector/router disposed in the vehicle, the data collector/router comprising:

i) an electrical connector that connects to an OBD or OBD-II connector and comprises electrical connections for multiple vehicle models;

ii) a microprocessor, and

iii) a wireless transmitter in electrical contact with the microprocessor;

receiving the data with the wireless transmitter;

sending the data from the wireless transmitter to the microprocessor;

processing the data with the microprocessor to generate processed data; and

transmitting the processed data through the electrical connector to the microcontroller disposed within the vehicle's electrical system.

36. A method for characterizing a vehicle's performance, comprising the steps of:

retrieving data representative of the vehicle's performance through an OBD or OBD-II connector at a predetermined time interval with a data collector/router comprising:

i) an electrical connector that connects to the OBD or OBD-II connector and comprises electrical connections for multiple vehicle models;

ii) a microprocessor, and

iii) a wireless transmitter in electrical contact with the microprocessor;

generating data representative of the vehicle's location with a global positioning system disposed within the vehicle;

wirelessly transmitting a first set of data representative of the vehicle's performance with the wireless transmitter to a wireless communications system and then to a host computer;

wirelessly transmitting a second set of data representative of the vehicle's location with the wireless transmitter to a wireless communications system and then to a host computer;

analyzing the first and second sets of data with the host computer to generate analyzed data; and

displaying the analyzed data on one or more web pages accessible on the internet.

* * * * *

Exhibit B

US006732031B1

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

(10) **Patent No.: US 6,732,031 B1**
(45) **Date of Patent: *May 4, 2004**

(54) **WIRELESS DIAGNOSTIC SYSTEM FOR VEHICLES**

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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.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **10/447,713**

(22) Filed: **May 29, 2003**

Related U.S. Application Data

(63) Continuation of application No. 09/776,106, filed on Feb. 1, 2001, now Pat. No. 6,636,790.
(60) Provisional application No. 60/222,152, filed on Aug. 1, 2000, provisional application No. 60/222,213, filed on Aug. 1, 2000, and provisional application No. 60/220,986, filed on Jul. 25, 2000.

(51) **Int. Cl.**[7] **G06F 7/00**
(52) **U.S. Cl.** **701/33**; 701/29
(58) **Field of Search** 701/33, 29, 30, 701/35; 73/116, 117.2

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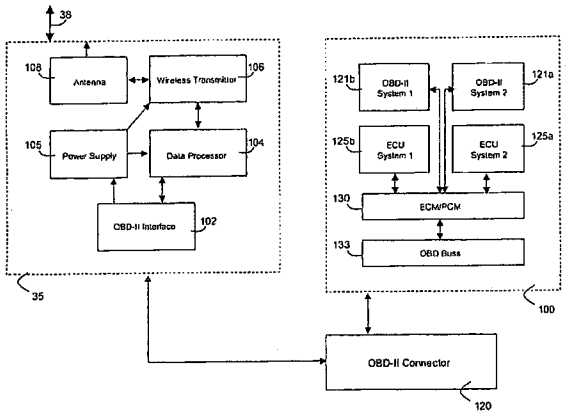
(57) **ABSTRACT**

The invention features a method and apparatus for remotely characterizing a vehicle's performance. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink to a wireless communications system and then to a host computer; and iv) analyzing the data packet with the host computer to characterize the vehicle's performance.

116 Claims, 4 Drawing Sheets



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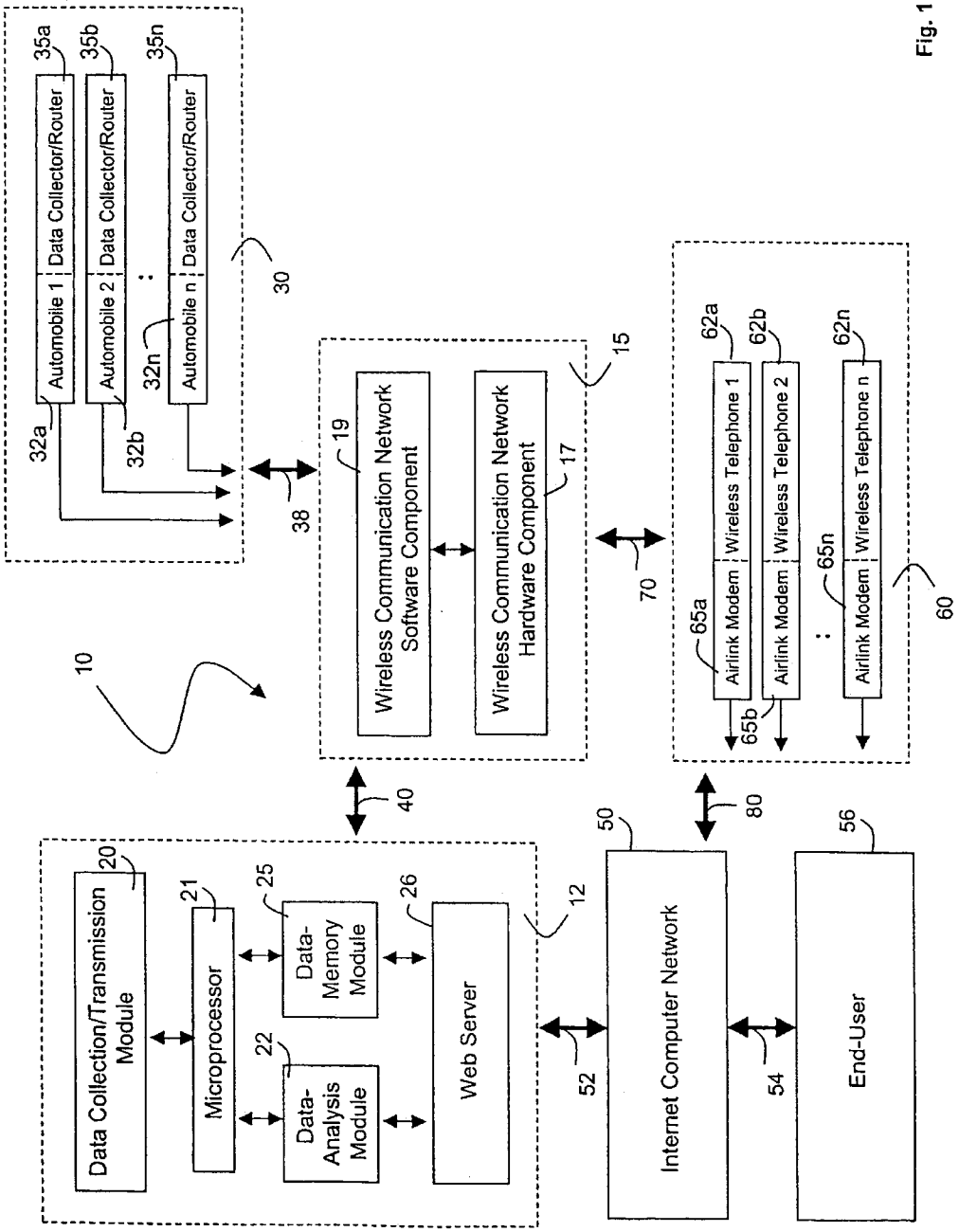
Automobile 1
Data Collector/Router
Automobile 2
Data Collector/Router
Automobile n
Data Collector/Router
32a
32b
32n
35a
35b
35n
30
38
Wireless Communication Network Software Component
Wireless Communication Network Hardware Component
19
17
15
70
Airlink Modem
Wireless Telephone 1
Airlink Modem
Wireless Telephone 2
Airlink Modem
Wireless Telephone n
65a
65b
65n
62a
62b
62n
60
10
40
80
Data Collection/Transmission Module
Microprocessor
Data-Memory Module
Data-Analysis Module
Web Server
20
21
22
25
26
12
50
52
Internet Computer Network
54
56
End-User

Fig. 1

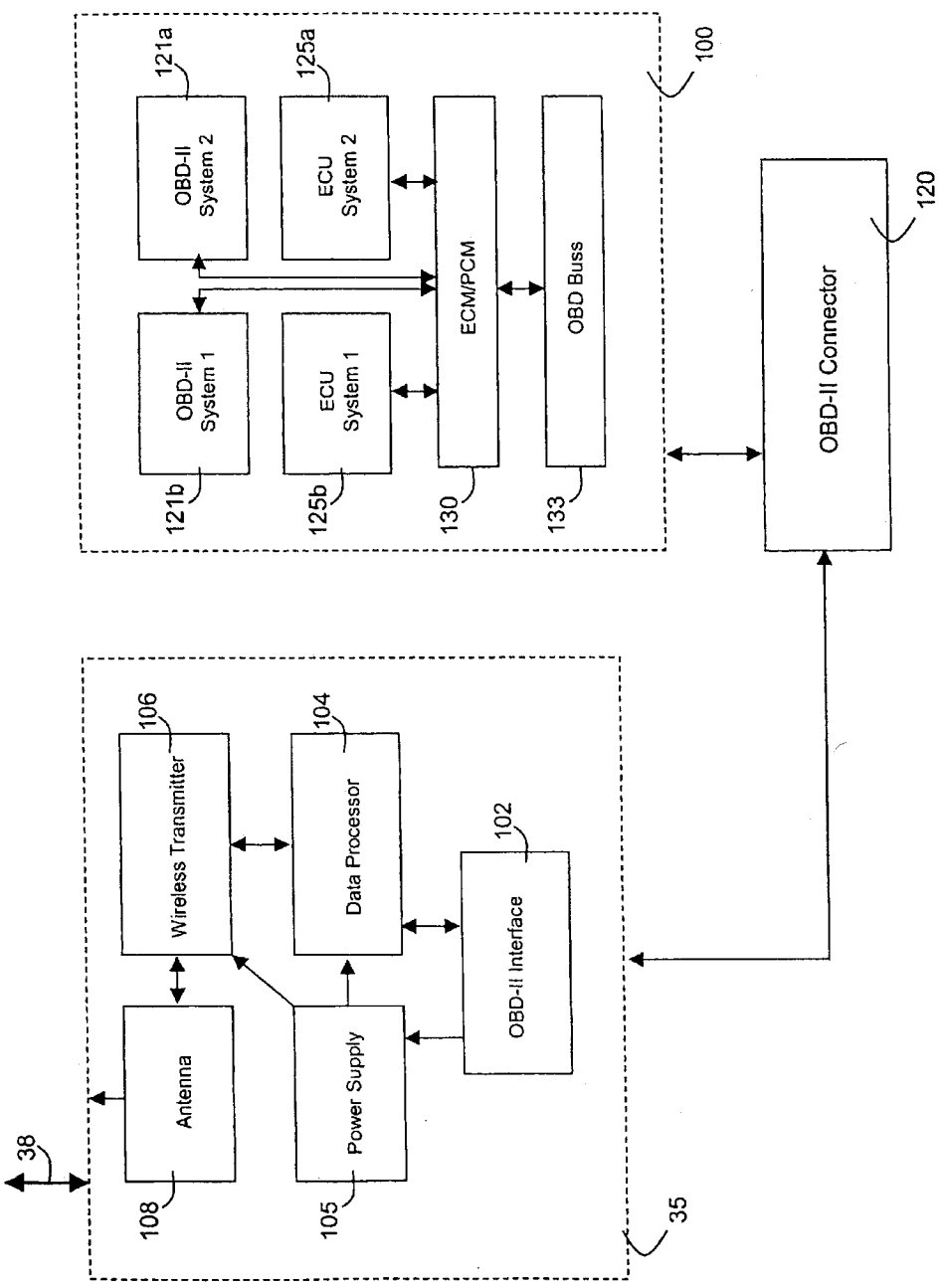
121a
OBD-II System 2
125a
ECU System 2
ECM/PCM
OBD Buss
100
OBD-II Connector
120
OBD-II System 1
ECU System 1
121b
125b
130
133
106
Wireless Transmitter
104
Data Processor
102
OBD-II Interface
Antenna
Power Supply
38
108
105
35

Fig. 2

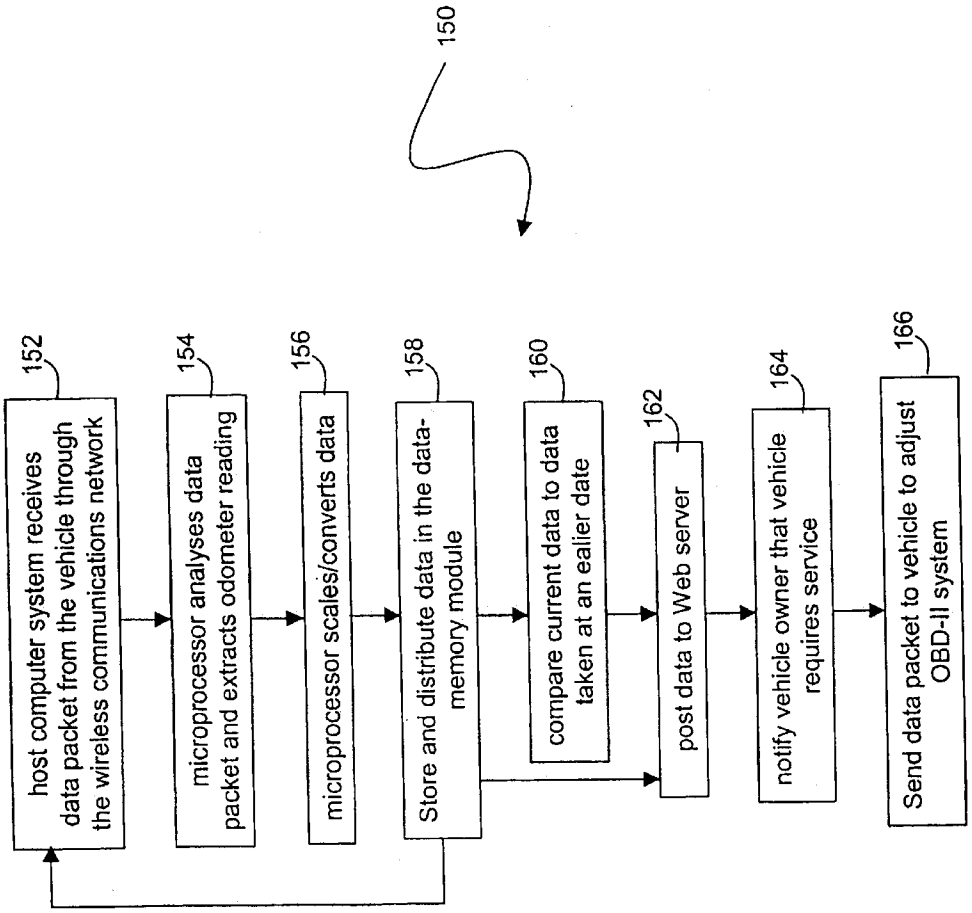
150
152
host computer system receives data packet from the vehicle through the wireless communications network
154
microprocessor analyses data packet and extracts odometer reading
156
microprocessor scales/converts data
158
Store and distribute data in the data-memory module
160
compare current data to data taken at an ealier date
162
post data to Web server
164
notify vehicle owner that vehicle requires service
166
Send data packet to vehicle to adjust OBD-II system

Fig. 3

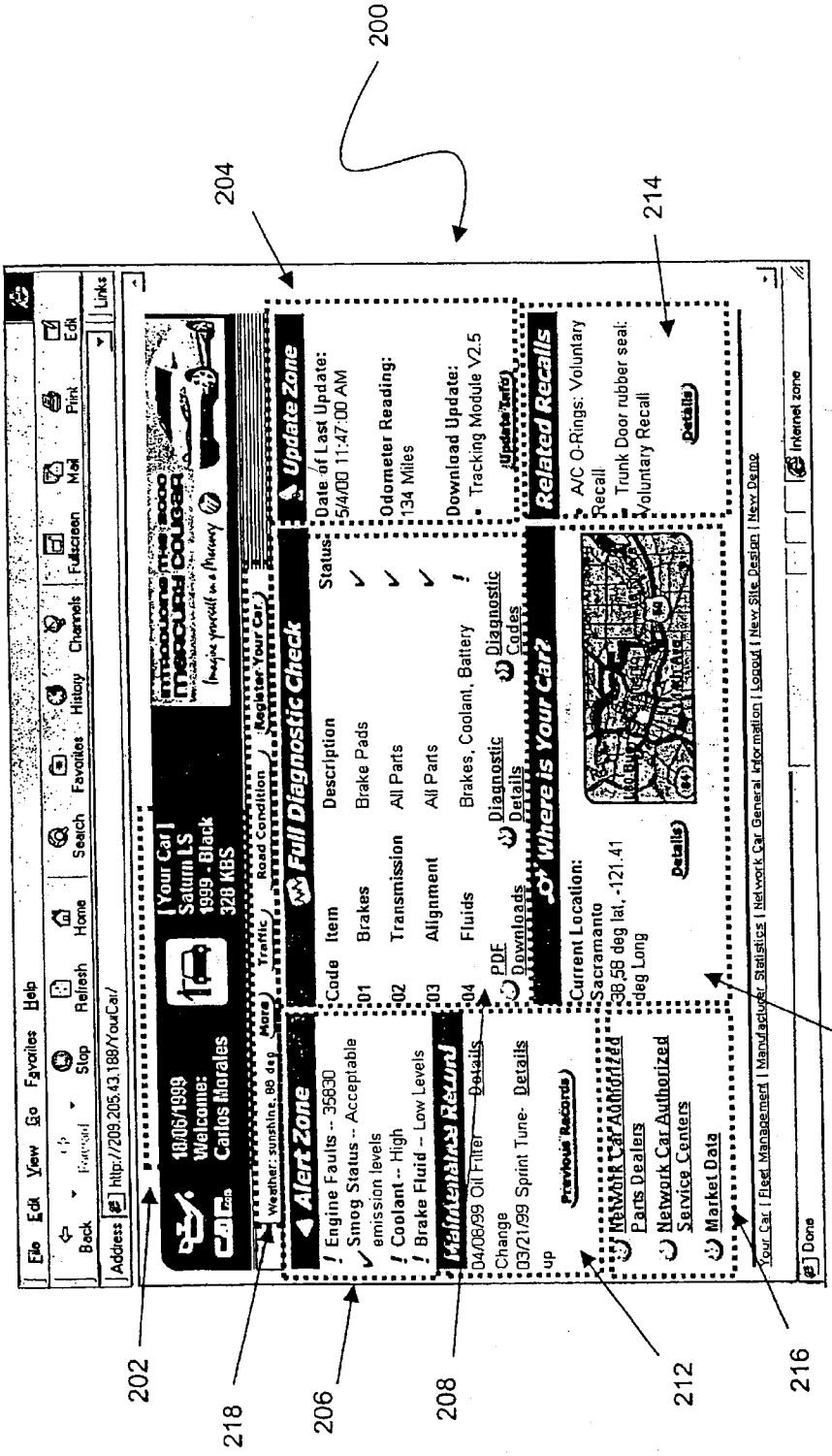
200
204
214
202
218
206
208
212
216
210
Alert Zone
Full Diagnostic Check
Update Zone
Related Recalls
Maintenance Record
Where is Your Car?
Your Car
Saturn LS
1999 - Black
328 KBS
Engine Faults -- 35830
Smog Status -- Acceptable emission levels
Coolant -- High
Brake Fluid -- Low Levels
Code
Item
Description
Status
Brakes
Brake Pads
Transmission
All Parts
Alignment
All Parts
Fluids
Brakes, Coolant, Battery
Date of Last Update:
5/4/00 11:47:00 AM
Odometer Reading:
134 Miles
Download Update:
Tracking Module V2.5
A/C O-Rings: Voluntary Recall
Trunk Door rubber seal: Voluntary Recall
Current Location:
Sacramento
38.58 deg lat, -121.41 deg Long
Network Car Authorized Parts Dealers
Network Car Authorized Service Centers
Market Data

Fig. 4

WIRELESS DIAGNOSTIC SYSTEM FOR VEHICLES

This application is a continuation application of U.S. patent application Ser. No. 09/776,106, filed Feb. 1, 2001, now U.S. Pat. No. 6,636,790, the contents of which are incorporated herein by reference, which claims the benefit of U.S. provisional patent applications Ser. Nos. 60/222,152, filed Aug. 1, 2000, 60/222,213, filed Aug. 1, 2000, and 60/220,986, filed Jul. 25, 2000, the contents of which are incorporated herein by reference.

RELATED APPLICATIONS

Under 35 U.S.C. §119(e)(1), this application claims benefit of prior U.S. Provisional Applications No. 60/222,152, entitled Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" filed Aug. 1, 2000; and No. 60/222,213, entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" filed Aug. 1, 2000, both of which are incorporated herein by reference.

In addition, this application is related to the following U.S. Patent Applications that were filed on the same day as the present application: (1) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing a Vehicles Exhaust Emissions" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (Client/Matter No. 12170/003001); and (2) U.S. Patent Application entitled "Wireless Diagnostic System for Characterizing One or More Vehicles' Mileage, Fuel Level, and Period of Operation" with inventors Matthew J. Banet, Bruce Lightner, Diego Borrego, Chuck Myers, and Larkin H. Lowrey (Client/Matter No. 12170/004001), both of which are hereby incorporated by reference.

FIELD OF THE INVENTION

The present invention relates generally to the use of wireless communications and diagnostic systems in automotive vehicles.

BACKGROUND OF THE INVENTION

The Environmental Protection Agency (EPA) requires vehicle manufacturers to install on-board diagnostics (OBD) for emission control on their light-duty automobiles and trucks beginning with model year 1996. OBD systems (e.g., computer, microcontrollers, and sensors) monitor the vehicle's emission control systems to detect any malfunction or deterioration that causes emissions to exceed EPA-mandated thresholds. Such a system, for example, is an oxygen sensor located in the vehicle's exhaust manifold and tailpipe.

The EPA requires that all information monitored or calculated by OBD systems is made available through a standardized, serial 16-cavity connector referred to as the ALDL (Assembly Line Diagnostic Link) or OBD connector. All physical and electrical characteristics of this connector are standard for all vehicles sold in the United States after 1996. The EPA also mandates that, when emission thresholds are exceeded, diagnostic information characterized by OBD systems must be stored in the vehicle's central computer so that it can be used during diagnosis and repair.

A second generation of OBD systems ("OBD-II" systems) monitors a wide range of data that indicate the performance of the host vehicle. For example, these data can be analyzed to infer the vehicle's emission performance. In addition to emissions, OBD-II systems monitor vehicle speed, mileage, engine temperature, and intake manifold pressure. OBD-II systems also query manufacturer-specific data, such as data relating to the vehicle's engine, transmission, brakes, alarm, entertainment systems. OBD-II systems also monitor codes called diagnostic trouble codes, or "DTCs", which indicate a mechanic or electrical problem with the vehicle. DTCs are the codes that typically light a vehicle's 'service engine soon' light. In total, OBD-II systems typically access more than 300 segments of data relating to the performance and make of the host vehicle.

In addition to the OBD-II systems, most vehicles manufactured after 1996 have electronic control units (ECUs) that control internal electromechanical actuators. Examples include ECUs that control fuel-injector pulses, spark-plug timing, and anti-lock braking systems. Most ECUs transmit status and diagnostic information over a shared, standardized electronic buss in the vehicle. The buss effectively functions as an on-board computer network with many processors, each of which transmits and receives data. The primary computers in this network are the vehicle's electronic-control module (ECM) and power-control module (PCM). The ECM typically accesses computers and microcontrollers that monitor or control engine functions (e.g., the cruise-control module, spark controller, exhaust/gas recirculator). The PCM typically controls or monitors ECUs associated with the vehicle's power train (e.g., its engine, transmission, and braking systems).

When a vehicle is serviced, data from the standardized buss can be queried using external engine-diagnostic equipment (commonly called 'scan tools') that connect to the above-described 16-cavity electrical connector (called an OBD-II connector for vehicles made after 1996). The OBD-II connector is typically located under the vehicle's dashboard on the driver's side. Data transferred through the connector to the scan tool yields data that identify a status of the vehicle and whether or not a specific component of the vehicle has malfunctioned. This makes the service process more efficient and cost-effective.

Some manufacturers include complex electronic systems in their vehicles to access and analyze the above-described data. These systems are not connected through the OBD-II connector, but instead are wired directly to the vehicle's electronic system. This wiring process typically takes place when the vehicle is manufactured. In some cases these systems transmit data through a wireless network.

BRIEF SUMMARY OF THE INVENTION

It is an object of the present invention to address the limitations of the conventional engine-diagnostic systems discussed above. Specifically, it is an object of the invention to both access and send data over the ODB-II connector using a remote, wireless system that connects to the Internet using an airlink. The device used for accessing and transmitting the data is simple, low-cost, and easy-to-install.

In one aspect, the invention features a method and apparatus for remotely characterizing a vehicle's performance. The method features the steps of: i) generating data representative of the vehicle's performance with at least one microcontroller disposed within the vehicle; ii) transferring the data through an OBD, OBD-II or equivalent electrical connector to a data collector/router that includes a microprocessor and an electrically connected wireless transmitter; iii) transmitting a data packet representing the data with the wireless transmitter over an airlink, to a wireless communications system, and then to a host computer; and iv) analyzing the data packet with the host computer. Once

analyzed, the data can be used to characterize the vehicle's performance, e.g. evaluate the vehicle's electrical and mechanical systems. The data can also be used for other purposes, such as for insurance-related issues, surveys, and vehicle tracking.

The terms 'microcontroller' and 'microprocessor' refer to standard electronic devices (e.g., programmable, silicon-based devices) that can control and/or process data. For example, a sensor disposed in the vehicle (e.g., an oxygen sensor) would be a microcontroller. "Airlink" refers to a standard wireless connection between a transmitter and a receiver.

In the above-described method, steps i)–iv) can be performed at any time and with any frequency, depending on the diagnoses being performed. For a 'real-time' diagnoses of a vehicle's engine performance, for example, the steps may be performed at rapid time or mileage intervals (e.g., several times each minute, or every few miles). Alternatively, other diagnoses (e.g. a 'smog check' that includes inferring the concentrations of hydrocarbons, oxides of nitrogen, or carbon monoxide) may require the steps to be performed only once each year or after a large number of miles are driven. Steps i)–iii) (i.e. the 'generating', 'transferring', and 'transmitting' steps) may be performed in response to a signal sent from the host computer to the vehicle. Alternatively, the vehicle may be configured to automatically perform these steps at predetermined or random time intervals.

The generating step typically includes generating data encoded in a digital format using the vehicle's electronic control unit (ECM) and/or power control unit (PCM). The data, for example, describes the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, engine-performance tuning parameters, alarm status, accelerometer status, cruise-control status, fuel-injector performance, spark-plug timing, and/or a status of an anti-lock braking system. The data can also be a DTC or related code. The analyzing step features extracting data from the transmitted data packet, and then storing the data in a computer memory or database.

Once stored, the data is processed in a variety of ways. For example, the processing can simply involve determining the vehicle's odometer reading, and then comparing this reading to a schedule that lists recommended, mileage-dependent service events (e.g., a 5000-mile tune-up). Other algorithms include those that compare current data with data collected at an earlier time to dynamically characterize the performance of the vehicle. In another example, the algorithms compare the data with a predetermined numerical value or collection of values. For example, the data can correspond to a level of the vehicle's exhaust emissions or mileage; these values can then be compared to predetermined values for the particular vehicle to characterize its performance. More complex processing can include, for example, analyzing the data with a mathematical algorithm to predict the electrical or mechanical performance of the vehicle or a failure of a particular component.

After the processing step, the method can also include the step of sending an electronic text, data, or voice message to a computer, cellular telephone, personal digital assistant or wireless device to alert the end-user of a potential problem. The results from the analysis can also be displayed on similar devices connected to the World-Wide Web or the Internet.

In another embodiment, the method additionally includes the step of sending a second data packet from the host computer system over an airlink to the wireless communications system and then to the vehicle's data collector/router. In this case, the second data packet is processed by the microprocessor in the data collector/router to generate a signal that is sent to at least one of the vehicle's microcontrollers. There, the signal is processed and used, for example to adjust a setting in the particular microcontroller. The signal can also be used to update or distribute new software or firmware configurations to one or more of the vehicle's microcontrollers. In still other embodiments, the signal can be used to make 'tailored' readings of the vehicle's diagnostic information, e.g. to perform complex diagnoses (sometimes called 'drilling down') and isolate malfunctioning components in the vehicle's mechanical or electrical systems.

In another aspect, the invention features a method for sending data to an electrical system in a vehicle. The method features the steps of: i) generating with a host computer a data packet that affects at least one microcontroller disposed within the electrical system of the vehicle; ii) transmitting the data packet from the host computer over an airlink to a wireless communications system and then to a data collector/router (containing a microprocessor and wireless transmitter similar to that described above) disposed in the vehicle; iii) receiving the data packet with the wireless transmitter and sending it to the microprocessor; iv) processing the data packet with the microprocessor to generate data; and v) transmitting the data through an OBD, OBD-II or equivalent electrical connector to the microcontroller disposed within the vehicle's electrical system.

The invention has many advantages. In particular, wireless transmission of a vehicle's diagnostic data makes it possible to remotely identify potential problems without bringing the vehicle to a conventional service center. For example, the system can be configured so that when a DTC is generated by a vehicle the code associated with it is automatically sent to the web sites of a service center and the vehicle owner. This way, the service center can diagnose the problem, order to required parts, and schedule the service before the vehicle owner actually brings in the vehicle for service. In certain situations, potential problems with the vehicle can be remotely predicted and addressed before they actually occur. Moreover, data from the vehicle can be queried, stored and analyzed frequently and in real-time (i.e., while the vehicle is actually in use) to provide a relatively comprehensive diagnosis that is not possible in a conventional service center.

The device used to access and transmit the vehicle's data is small, low-cost, and can be easily installed in nearly every vehicle with an OBD-II connector in a matter of minutes. It can also be easily transferred from one vehicle to another, or easily replaced if it malfunctions.

Communication with the vehicle's OBD buss can also be bi-directional, making it possible to actually repair certain problems remotely. This, of course, means that in some cases the vehicle's problem can be both diagnosed and repaired in a completely remote and unobtrusive manner.

Data transmitted from the vehicle can also be analyzed for purposes unrelated to mechanical or electrical problems. For example, the data can be collected and analyzed in real-time to characterize driving patterns (e.g. a vehicle's speed), automotive part reliability, and emission characteristics. Lessors and renters of vehicles can remotely track mileage for billing purposes. Smog and emission certifications can be easily done in a completely remote manner. Data can also be analyzed to determine the vehicle's approximate location as a safety or anti-theft measure.

Another advantage of the invention is that data transmitted from a particular vehicle over a wireless airlink can be accessed and analyzed through the Internet without the need for expensive diagnostic equipment. Software used for the analysis can be easily modified and updated, and then used by anyone with access to the Internet. This obviates the need for vehicle service centers to upgrade their diagnostic equipment for next-generation vehicles. The resulting data, of course, have many uses for vehicle owners, surveyors of vehicle performance (e.g., J. D. Power), manufacturers of vehicles and related parts, and vehicle service centers.

Sophisticated analysis of the above-mentioned data yields information that benefits the consumer, vehicle and parts manufacturers, vehicle service centers, and the environment.

These and other advantages of the invention are described in the following detailed disclosure and in the claims.

BRIEF DESCRIPTION OF DRAWINGS

The features and advantages of the present invention can be understood by reference to the following detailed description taken with the drawings, in which:

FIG. **1** is a schematic drawing of a wireless diagnostic system in wireless contact with a system of vehicles and the Internet;

FIG. **2** is a schematic drawing of a data collector/router used in each of the vehicles of FIG. **1**;

FIG. **3** is a flow chart describing analysis of data transmitted by the data collector/router by the host computer of FIG. **1**; and

FIG. **4** is a screen capture of a page from the Web server of FIG. **1**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. **1** shows a wireless diagnostic system **10** that communicates with a collection of vehicles **30** using a host computer system **12** and a standard wireless communications system **15**. The wireless communications system **15** is, e.g., a conventional wireless telephone or paging system (e.g., Bell South's 'Mobitex' System). Each vehicle **32***a*, **32***b*, **32***n* in the collection of vehicles **30** features a data collector/router **35***a*, **35***b*, **35***n* that queries data generated by each vehicle's ECU and OBD-II systems through an OBD buss. After the query, each data collector/router **35***a*, **35***b*, **35***n* receives data from the host vehicle **32***a*, **32***b*, **32***n* and sends it as a data packet over a wireless airlink **38** to the wireless communication system **15**. The wireless communication system **15** features a standard hardware component **19** (e.g. a system of transmission 'bay stations', computers, and switching and routing hardware) and software component **17** (e.g., a paging or cellular network) that relay the data packet through a digital line **40** to the host computer system **12**.

A data collection/transmission module **20** (e.g., a digital transmission line) in the host computer system **12** receives the data packet and then routes it to a microprocessor **21**. The microprocessor controls a data-analysis module **22** (e.g., hardware and software for statistical analysis) that processes the data packet, and a data-memory module **25** (e.g., a computer memory or database) that stores it. A web server **26** receives the processed data from the data-analysis **22** and data-memory modules **25** and makes it available to an Internet computer network **50** through a first network connection **52**. An end-user **56** accesses the data on the web server **26** through a second network connection **54** using the Internet computer network **50**.

Data packets from each data collector/router **35***a*, **35***b*, **35***n* can also be accessed directly over an airlink **70** by wireless telephones **62***a*, **62***b*, **62***n* in a wireless telephone network **60**. In this case each wireless telephone **62***a*, **62***b*, **62***n* has an airlink modem **65***a*, **65***b*, **65***n* that allows the data packet to be accessed directly. Alternatively, using the airlink modem **65***a*, **65***b*, **65***n*, the wireless telephones **62***a*, **62***b*, **62***n* can access processed data from the web server **26**, provided they have the appropriate software (e.g., web-browsing capabilities). In this case, the web server **26** formats the data in a manner suitable to wireless browsing (e.g. wireless access protocol).

The host computer system **12** typically works bi-directionally, i.e. it can both send data to and receive data from the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*. For example, following a query, the host computer system **12** receives a data packet from a particular data collector/router. The system typically runs a real-time operating system (e.g., Windows NT® or Unix®) that manages multiple software programs conducting different functions (e.g. data processing and storage).

Data is typically sent from the host vehicle **32***a*, **32***b*, **32***n* to each data collector/router **35***a*, **35***b*, **35***n* at a predetermined time interval (e.g. a random or periodic time interval) that is programmed in either the data collector/router or the actual vehicle. For example, data can be sent on a daily basis. Alternatively, data can be queried in response to a signal sent from the host computer system **12** to the data collector/routers **35***a*, **35***b*, **35***n* present on each vehicle **32***a*, **32***b*, **32***n*.

Depending on the make and model of the vehicle, the data packet can contain hundreds of datum that describe, e.g.: i) basic properties of the power train (e.g., emission levels, fuel-system status, engine temperature, speed and odometer readings, anti-lock brake status, RPMs, fuel and intake manifold pressure); and ii) manufacturer-specific information (e.g., status of the door locks, airbags, and entertainment center). In total, for most vehicles there are typically more than 300 datum that can be included in the data packet.

Certain vehicle functions can also be controlled by sending a data packet to the vehicle. Data in the data packet can adjust, for example, settings in the ECUs and OBD-II sensors, certain engine properties, and indicator lights on the vehicle's dashboard. They can also be used to open door locks and reconfigure the vehicle's entertainment system.

In addition, data packets routed through the wireless communications system **15** can be analyzed to determine the vehicle's approximate location. This can be done with relatively low accuracy (within a few miles) by simply recording the location of a specific cellular tower in the hardware component **17** of the wireless communications system **15** that routes the data packet to the host computer system **12**. Recording the location of multiple bay stations within range of the vehicle, and then analyzing these data using conventional algorithms (e.g., triangulation), increases the accuracy to which the vehicle's location is determined.

FIG. **2** shows a data collector/router **35** in electrical contact with a vehicle's OBD/ECU system **100**. The two systems connect through a conventional OBD-II connector **120** typically located under the vehicle's dashboard. The data collector/router **35** is contained in a small, portable housing that plugs directly into the connector **120** and can be easily installed and replaced.

The connector **120** has a serial, 16-cavity layout, with specific electrical connections in separate cavities supplying data and electrical power from the OBD/ECU system **100**.

The connector electrically and mechanically matches an OBD-II interface **102** in the data collector/router **35**. Although the OBD-II connector **120** has a standard mechanical interface, data transmitted through it may have a format and pass through cavities that depend on the vehicle's make and model. For example, Ford and General Motors vehicles use an OBD data format called J1850; data in this format pass through cavities **2** and **10**. Chrysler and most European and Asian manufacturers use a data format called ISO 9141-2 and pass data through cavities **7** and **15**. In a third format, called J2284, data is passed through cavities **6** and **14**.

The connector **120** also passes battery power (cavity **16**), automobile chassis ground (cavity **4**), and signal ground (cavity **5**) from the OBD/ECU system **100** through the OBD-II interface **102** to the data collector/router **35**. Using these connections, a power supply **105** receives the battery power, regulates it, and in turn drives a data processor **104** and wireless transmitter **106** within the data collector/router **35**.

Once received, data is passed to the data processor **104** (e.g., a microprocessor) that processes and formats it to form a data packet. As an example, a data packet and specifically formatted for Bell South's wireless 900 MHz Mobitex MPAK system is described in Table below. Actual data describing the host vehicle is contained in the 516-byte data area described in Table 1.

TABLE 1

description of Mobitex MPAK data packet

Bytes	General Description	
3	source MAN (unique 24-Bit modem number)	
3	destination MAN (unique 24-Bit modem number)	
1	when sending:	Bit 0 = use mailbox
		Bit 1 = return positive acknowledgment
		Bit 2 = use address list
		Bits 3–7 = 0
	when receiving:	Bit 4 = may be ignored
		Bits 5–7 = traffic state
1	MPAK type	
0 or 22	address list	
0 to 512	data payload	

Once properly formatted as described in Table 1, the data packet is passed from the data processor **104** to the wireless transmitter **106**. The transmitter **106** transmits the data packet through a conventional wireless antenna **108** over an airlink **38** to a wireless communications system (**15**) shown in FIG. **1**. The data processor **104** formats the data packet according to the wireless communications system that transmits it.

Once transmitted, the data packet propagates through the wireless communication software and hardware components (**17** and **19** in FIG. **1**) of the communication network (e.g., the Mobitex network). Typically in this case the data packet is routed to a 'point of presence' or 'POP' in the network, where it is then transferred over a digital line (e.g., **40** in FIG. **1**) to the host computer system.

The data area described in Table 1 contains data generated by the vehicle's OBD/ECU system **100**. As described above, this system **100** functions effectively as an on-board computer network that generates, transmits, and receives data. For simplicity, the system **100** in FIG. **2** contains two OBD-II systems. **121***a*, **121***b* and two ECU systems **125***a*, **125***b*; it is analogous to more complex OBD-II and ECU systems employed in actual vehicles. The OBD-II systems **121***a*, **121***b* are microcontrollers that monitor the various vehicle-related properties described above. The ECU systems **125***a*, **125***b* receive and send data to electromechanical actuators that control, e.g., fuel-injector pulses, spark-plug timing, and anti-lock braking systems.

The OBD-II systems **121***a*, **121***b* and ECU systems **125***a*, **125***b* are controlled by the vehicle's ECM/PCM **130**. In some cases, the ECM/PCM **130** receives data from these systems and routes it over a shared electronic OBD buss **133**. Alternatively, after receiving the data the ECM/PCM **130** converts it to "fail" or "malfunction" codes that are then routed over the shared electronic buss **133**. In both cases, the OBD buss serially transmits data to the data collector/router **35** through the electrically connected OBD connector **120**.

Once collected and sent to the host computer system (**12** in FIG. **1**), the data packet can be analyzed in a variety of different ways. As an example, FIG. **3** shows a flow chart describing one method **150** of how data is analyzed and then made available to end-users through the Internet. A wide number of different data-analysis methods are possible; the one shown in FIG. **3** was chosen because of its simplicity.

In the data-analysis method **150**, the host computer system receives a data packet from the vehicle through the wireless communications network (step **152**). The data packet has a format shown, e.g., in Table 1 above, and contains a wide range of information that characterizes the vehicle's performance. Once received, the packet is analyzed and an odometer reading (e.g., mileage) from the vehicle is extracted (step **154**). If necessary, the microprocessor then scales the odometer reading (e.g., converts kilometers to miles) or converts the format used in the data packet (e.g., a manufacturer-specific format) to one that is easily recognized by the end-user (step **156**). At this point the odometer reading and other data within the data packet are distributed and stored in the data-memory module (e.g. a database) of the host computer system (step **158**). Some data may be simply disregarded during this step. This portion (steps **152**, **154**, **156**, and **158**) of the method may be repeated at this point to generate additional data.

All the data (e.g. the vehicle's mileage collected at different time or mileage intervals) can be posted directly on a Web page on the Web server (step **162**) where it is accessible by the end-user through the Internet. The data can also be analyzed further. For example, a current odometer reading can be compared to one recorded at an earlier date (step **160**) to determine how many miles the vehicle has traveled since its last oil change. If this value exceeds that recommended for the particular vehicle, the host computer system can notify the user through electronic mail that the vehicle requires service (step **164**). The method **150** can also be used to remotely adjust settings in the vehicle's OBD-II systems. For example, at this point the host computer system could send a data packet to the vehicle to reset the trip odometer to a new value (step **166**).

FIG. **4** shows a sample Web page **200** from a Web server that displays data processed using a method similar to that shown in FIG. **3**. Access to Web page is typically password-protected, thereby only allowing end-users with the correct password to access data for a particular vehicle.

The Web page **200** features a region **202** that describes the owner of the vehicle and its make and model. The page **200** also has a region **204** that describes the time, date, and odometer readings registered at its last update. Data describing vehicle problems (e.g., engine faults, coolant and brake fluid levels, emission status) that may require immediate attention are displayed in region **206**. Data used to diagnose

the overall condition of the vehicle (e.g., brake and transmission status, wheel alignment) are displayed in region **208**. More data relating to these properties can be obtained by clicking the appropriate buttons ("Diagnostic Details", "Diagnostic Codes") in this region. The page **200** also includes a region **210** that provides the approximate location of the vehicle. As described above, the vehicle's location is determined by recording the location of one or more bay stations used to send the latest data packet through the wireless communications system. The page also includes a region **212** that features data describing the general history and maintenance of the vehicle. A related region **214** describes parts for the particular vehicle that have been recently recalled. A region **216** describes the locations of parts dealers and local service stations for the particular vehicle, while the region **218** provides access to features that may affect travel, such as weather, traffic, road conditions, and the status of the vehicle's registration.

Other embodiments are within the scope of the invention. For example, the components used in the data collector/router (particularly the wireless transmitter) may be optimized for different types of wireless communications systems. These systems include wireless telephone and paging systems, Bluetooth®, and similar systems. Similarly, the format of the data packet may also be adjusted for transmission over different types of networks. In general, any components in the data collector/router, and any format of the data packet, can be used to accomplish the general method of the invention.

Likewise, a wide range of mathematical algorithms can be used to analyze data once it is extracted from the data packets. These algorithms range from the relatively simple (e.g., lessors and renters determining the mileage on a vehicle for billing purposes) to the complex (e.g., predictive engine diagnoses using 'data mining' techniques). Data analysis may be used to characterize an individual vehicle as described above, or a collection of vehicles. Algorithms used to characterize a collection of vehicles can be used, for example, for remote vehicle or parts surveys, to characterize emission performance in specific geographic locations, or to characterize traffic.

Other embodiments of the invention include algorithms for analyzing data to characterize vehicle accidents and driving patterns for insurance purposes; algorithms for determining driving patterns for use-based leasing; and algorithms for recording vehicle use and driving patterns for tax purposes. In general, any algorithm that processes data collected with the above-described method is within the scope of the invention.

Similarly, the temporal or mileage frequency at which data is collected can be adjusted to diagnose specific types of problems. For example, characterization of certain types of vehicle performance indicators, such as emissions, may need to be monitored relatively frequently. Other properties, such as mileage and fluid levels, may only need to be monitored every few days, or in some cases just a few times each year.

Once the data is analyzed, the Web page used to display the data can take many different forms. Different Web pages may be designed and accessed depending on the end-user. For example, individual users may have access to Web pages for their particular vehicle. Conversely, vehicle service providers (e.g. providers that change oil or certify a vehicle's emissions) may have access to Web pages that contain data (e.g., mileage and emissions data) from a wide range of vehicles. These data, for example, can be sorted and analyzed depending on vehicle make, model, and geographic location. Web pages may also be formatted using standard wireless access protocols (WAP) so that they can be accessed using wireless devices such as cellular telephones, personal digital assistants (PDAs), and related devices.

In other embodiments, additional hardware can be added to the in-vehicle unit. For example, hardware for global-positioning systems (GPS) may be added so that the location of the vehicle can be monitored along with its data.

In other embodiments, data from the data collector/router in the vehicle can be analyzed and used for: remote billing/payment of tolls; remote smog and emissions checks; remote payment of parking/valet services; remote control of the vehicle (e.g., in response to theft or traffic/registration violations); and general survey information.

Still other embodiments are within the scope of the following claims.

What is claimed is:

1. A method for characterizing a vehicle's performance, comprising:

(a) retrieving data representative of the vehicle's performance, through the vehicle's OBD or OBD-II connector, according to a communication protocol, at a predetermined time interval, and with a data collector, the data collector comprising,

i) an electrical connector configured to connect to the OBD or OBD-II connector,

ii) a microprocessor interfaced with the electrical connector and configured to retrieve and transmit data at the predetermined time interval, and

iii) a wireless transmitter interfaced with the microprocessor; and

(b) wirelessly transmitting the data with the wireless transmitter.

2. The method of claim **1**, wherein the data is serially transferred through an OBD-II connector to the data collector.

3. The method of claim **2**, wherein the protocol used to transfer data through the OBD-II connector is J1850, ISO 9141-2, or J2284.

4. The method of claim **1**, wherein the retrieving data comprises retrieving data encoded in a digital format using an electronic control unit or power control unit.

5. The method of claim **1**, wherein the retrieved data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

6. The method of claim **1**, further comprising wirelessly receiving data configured to adjust a setting in a diagnostic system of the vehicle.

7. The method of claim **1**, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

8. The method of claim **1**, further comprising wirelessly transmitting location data representative of the vehicle's location with the wireless transmitter.

9. The method of claim **8**, wherein the location data includes global positioning system (GPS) data.

10. The method of claim **1**, wherein the predetermined time interval is programmable.

11. The method of claim 1, wherein the retrieving data or wirelessly transmitting data is automatically performed at a configurable predetermined or random time interval.

12. The method of claim 1, further comprising wirelessly receiving data configured to modify a software or firmware configuration in the vehicle.

13. A system for characterizing a vehicle's performance, comprising:

(a) a data collector/router comprising,

(i) an electrical connector configured to connect to the vehicle's OBD or OBD-II connector;

(ii) a microprocessor interfaced with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

(iii) a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit the data; and

(b) a location-determining component configured to determine location data representative of the vehicle's location, wherein the wireless transmitter is configured to receive the location data and wirelessly transmit the location data; and

(c) a wireless receiver configured to receive (1) data configured to adjust a setting in a diagnostic system of the vehicle and (2) data configured to modify a software or firmware configuration in the vehicle,

wherein the retrieved data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system,

wherein the microprocessor is configured to retrieve data at a configurable predetermined or random time interval,

wherein the wireless transmitter is configured to transmit data at a configurable predetermined or random time interval,

wherein the location data includes global positioning system (GPS) data,

wherein the data collector/router is configured to serially transfer data through an OBD-II connector to the data collector/router, and

wherein the data collector/router is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol.

14. A system for characterizing a vehicle's performance, comprising:

(a) a data collector/router comprising,

(i) an electrical connector configured to connect to the vehicle's OBD or OBD-II connector;

(ii) a microprocessor interfaced with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval; and

(iii) a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit the data.

15. The system of claim 14, wherein the data collector/router is configured to serially transfer data through an OBD-II connector to the data collector/router.

16. The system of claim 15, wherein the data collector/router is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol.

17. The system of claim 14, further comprising a wireless receiver configured to receive data configured to adjust a setting in a diagnostic system of the vehicle.

18. The system of claim 14, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

19. The system of claim 14, further comprising a location-determining component configured to determine location data representative of the vehicle's location, wherein the wireless transmitter is configured to receive the location data and wirelessly transmit the location data.

20. The system of claim 19, wherein the location data includes global positioning system (GPS) data.

21. The system of claim 14, further comprising a wireless receiver configured to receive data configured to modify a software or firmware configuration in the vehicle.

22. The system of claim 14, wherein the microprocessor is configured to retrieve data at a configurable predetermined or random time interval.

23. The system of claim 14, wherein the wireless transmitter is configured to transmit data at a configurable predetermined or random time interval.

24. The system of claim 14, wherein the retrieved data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

25. A method executed by a programmable host computer to characterize a vehicle's performance, the method comprising:

(a) wirelessly receiving, by the host computer, a first set of data representative of the vehicle's performance;

(b) wirelessly receiving, by the host computer, a second set of data representative of the vehicle's location;

(c) analyzing the first and second sets of data with the host computer to generate analyzed data, wherein the analyzing includes applying at least one algorithm to at least a portion of the first and second sets of data; and

(d) displaying the analyzed data on at least one web page accessible on the Internet,

wherein the displayed analyzed data includes at least one map representation depicting a current location of the vehicle, and

wherein the at least one web page includes a plurality of regions associated with respective analyzed data.

26. The method of claim 25, wherein the displayed analyzed data includes vehicle location information in degrees latitude and longitude.

27. The method of claim 25, wherein the second set of data is provided, at least in part, from a global positioning system (GPS) component in the vehicle.

28. The method of claim 25, wherein the at least one web page is associated with an individual user or vehicle service provider.

29. The method of claim 25, wherein the at least one web page displays analyzed data associated with a plurality of vehicles.

30. The method of claim 25, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

31. The method of claim 25, wherein the analyzing the data includes extracting data from a data packet corresponding to a specific property of the vehicle and storing the data in a computer memory or database.

32. The method of claim 25, wherein the algorithm is used to at least in part characterize or predict electrical or mechanical performance of the vehicle.

33. The method of claim 25, wherein the analyzing the data includes comparing the data with data collected at an earlier time to characterize or predict performance of the vehicle.

34. The method of claim 25, wherein the analyzing the data includes comparing the data with a predetermined numerical value or collection of values to characterize performance of the vehicle.

35. The method of claim 25, wherein the data corresponds at least in part to a level of exhaust emissions for the vehicle, and the analyzing the data comprises comparing the level of exhaust emissions to a predetermined value for the particular vehicle to characterize performance of the vehicle.

36. The method of claim 25, wherein the data corresponds to a mileage for the vehicle, and the analyzing the data comprises comparing the mileage to a predetermined value for the particular vehicle to characterize performance of the vehicle.

37. The method of claim 25, further comprising sending an electronic text, data, or voice message to a computer, cellular telephone, or wireless device after the analyzing of the data.

38. The method of claim 25, further comprising wirelessly transmitting data to the vehicle, the transmitted data configured to adjust a setting in a diagnostic system of the vehicle.

39. The method of claim 25, wherein the first set of data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

40. The method of claim 25, further comprising storing the analyzed data in at least one database, the database associated with at least one of insurance, vehicle driving pattern monitoring, emission characteristics, a performance or reliability survey, vehicle tracking, and billing of a user of the vehicle.

41. The method of claim 25, wherein the analyzing the data includes inferring a concentration of hydrocarbons, oxides of nitrogen, and carbon monoxide emitted from the vehicle.

42. The method of claim 25, wherein the analyzing the data includes:

(i) estimating the vehicle's odometer reading;

(ii) comparing the odometer reading to a schedule indicative of at least one service event associated with mileage; and

(iii) based on the comparing, sending a notification if a service event is recommended for the vehicle.

43. The method of claim 25, further comprising wirelessly transmitting data configured to modify a software or firmware configuration in the vehicle.

44. The method of claim 25, wherein the at least one web page provides access to analysis software executable by a user, wherein the analysis software is remote from the user.

45. The method of claim 25, wherein the analyzing the data includes:

(i) remotely identifying a problem condition in the vehicle, wherein the vehicle is located at a location remote from a service entity; and

(ii) sending a message to at least one of the service entity and an owner of the vehicle, wherein the message is associated with the identified problem condition.

46. The method of claim 45, wherein the sending a message comprises updating a web page associated with the service entity or owner.

47. The method of claim 45, wherein the problem condition relates to an existing problem.

48. The method of claim 45, wherein the problem condition relates to a predicted problem.

49. The method of claim 25, wherein the analyzing the data comprises:

(i) remotely identifying a problem condition in the vehicle; and

(ii) remotely repairing the vehicle to correct the problem condition,

wherein the vehicle is located at a location remote from a service entity.

50. The method of claim 25, wherein the analyzing the data comprises:

(i) determining a location of the vehicle; and

(ii) activating a safety or anti-theft function associated with the determined location.

51. A programmable host computer for characterizing a vehicle's performance, comprising:

(a) a data collection component configured to receive data sent wirelessly by the vehicle, the received data including a first set of data representative of the vehicle's performance and a second set of data representative of the vehicle's location;

(b) a data transmission component configured to wirelessly transmit data;

(c) a data analysis component configured to analyze the first and second sets of data to generate analyzed data, wherein the data analysis component is configured to apply at least one algorithm to at least a portion of the first and second sets of data; and

(d) a web display component configured to provide the analyzed data for display on at least one web page accessible on the Internet,

wherein the displayed analyzed data includes at least one map representation depicting a current location of the vehicle, and

wherein the at least one web page includes a plurality of regions associated with respective analyzed data.

52. The programmable host computer of claim 51, wherein the web display component comprises a web server.

53. The programmable host computer of claim 51, further comprising a data memory component configured to store at least a portion of the received or analyzed data.

54. The programmable host computer of claim 53, wherein the data memory component comprises a database.

55. The programmable host computer of claim 51, wherein the displayed analyzed data includes vehicle location information in degrees latitude and longitude.

56. The programmable host computer of claim 51, wherein the second set of data is provided, at least in part, from a global positioning system (GPS) component in the vehicle.

57. The programmable host computer of claim 51, wherein the at least one web page is associated with an individual user or vehicle service provider.

58. The programmable host computer of claim 51, wherein the at least one web page displays analyzed data associated with a plurality of vehicles.

59. The programmable host computer of claim 51, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

60. The programmable host computer of claim 51, wherein the data analysis component is configured to extract data from a data packet corresponding to a specific property of the vehicle and to store the data in a computer memory or database.

61. The programmable host computer of claim 51, wherein the algorithm is used to at least in part characterize or predict electrical or mechanical performance of the vehicle.

62. The programmable host computer of claim 51, wherein the data analysis component is configured to compare at least a portion of the received data with data collected at an earlier time to characterize or predict performance of the vehicle.

63. The programmable host computer of claim 51, wherein the data analysis component is configured to compare at least a portion of the received data with a predetermined numerical value or collection of values to characterize performance of the vehicle.

64. The programmable host computer of claim 51, wherein at least a portion of the received data corresponds at least in part to a level of exhaust emissions for the vehicle, and the data analysis component is configured to compare the level of exhaust emissions to a predetermined value for the particular vehicle to characterize performance of the vehicle.

65. The programmable host computer of claim 51, wherein at least a portion of the received data corresponds to a mileage for the vehicle, and the data analysis component is configured to compare the mileage to a predetermined value for the particular vehicle to characterize performance of the vehicle.

66. The programmable host computer of claim 51, wherein the data transmission component is configured to send an electronic text, data, or voice message to a computer, cellular telephone, or wireless device responsive to an output of the data analysis component.

67. The programmable host computer of claim 51, wherein the first set of data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

68. The programmable host computer of claim 51, further comprising a data storage component configured to store the analyzed data in at least one database, the database associated with at least one of insurance, vehicle driving pattern monitoring, emission characteristics, a performance or reliability survey, vehicle tracking, and billing of a user of the vehicle.

69. The programmable host computer of claim 51, wherein the data analysis component is configured to infer a concentration of hydrocarbons, oxides of nitrogen, and carbon monoxide emitted from the vehicle.

70. The programmable host computer of claim 51, wherein the data analysis component is configured to:

(i) estimate the vehicle's odometer reading;

(ii) compare the odometer reading to a schedule indicative of at least one service event associated with mileage; and

(iii) based on the comparing, send a notification if a service event is recommended for the vehicle.

71. The programmable host computer of claim 51, wherein the data transmission component is configured to wirelessly transmit data configured to modify a software or firmware configuration in the vehicle.

72. The programmable host computer of claim 51, wherein the at least one web page provides access to analysis software executable by a user, wherein the analysis software is remote from the user.

73. The programmable host computer of claim 51, wherein the data analysis component is configured to:

(i) remotely identify a problem condition in the vehicle, wherein the vehicle is located at a location remote from a service entity; and

(ii) send a message to at least one of the service entity and an owner of the vehicle, wherein the message is associated with the identified problem condition.

74. The programmable host computer of claim 73, wherein a web page associated with the service entity or owner is updated.

75. The programmable host computer of claim 73, wherein the problem condition relates to an existing problem.

76. The programmable host computer of claim 73, wherein the problem condition relates to a predicted problem.

77. The programmable host computer of claim 51, wherein the data analysis component is configured to:

(i) remotely identify a problem condition in the vehicle; and

(ii) remotely repair the vehicle to correct the problem condition,

wherein the vehicle is located at a location remote from a service entity.

78. The programmable host computer of claim 51, wherein the data analysis component is configured to:

(i) determine a location of the vehicle; and

(ii) activate a safety or anti-theft function associated with the determined location.

79. The programmable host computer of claim 51, wherein the wireless transmission component is configured to transmit data to the vehicle which adjusts at least one setting in a diagnostic system of the vehicle.

80. A machine-readable medium including instructions for performing a method for a programmable host computer to characterize a vehicle's performance, said medium comprising:

(a) instructions for wirelessly receiving, by the host computer and from the vehicle, a first set of data representative of the vehicle's performance;

(b) instructions for wirelessly receiving, by the host computer and from the vehicle, a second set of data representative of the vehicle's location;

(c) instructions for analyzing the first and second sets of data with the host computer to generate analyzed data, wherein the analyzing includes applying at least one algorithm to at least a portion of the first and second sets of data; and

(d) instructions for displaying the analyzed data on at least one web page accessible on the Internet,

wherein the displayed analyzed data includes at least one map representation depicting a current location of the vehicle, and

wherein the at least one web page includes a plurality of regions associated with respective analyzed data.

81. The machine-readable medium of claim **80**, wherein the displayed analyzed data includes vehicle location information in degrees latitude and longitude.

82. The machine-readable medium of claim **80**, wherein the second set of data is provided, at least in part, from a global positioning system (GPS) component in the vehicle.

83. The machine-readable medium of claim **80**, wherein the at least one web page is associated with an individual user or vehicle service provider.

84. The machine-readable medium of claim **80**, wherein the at least one web page displays analyzed data associated with a plurality of vehicles.

85. The machine-readable medium of claim **80**, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

86. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include instructions for extracting data from a data packet corresponding to a specific property of the vehicle and storing the data in a computer memory or database.

87. The machine-readable medium of claim **80**, wherein the algorithm is used to at least in part characterize or predict electrical or mechanical performance of the vehicle.

88. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include instructions for comparing the data with data collected at an earlier time to characterize or predict performance of the vehicle.

89. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include instructions for comparing the data with a predetermined numerical value or collection of values to characterize performance of the vehicle.

90. The machine-readable medium of claim **80**, wherein the data corresponds at least in part to a level of exhaust emissions for the vehicle, and the instructions for analyzing the data comprise instructions for comparing the level of exhaust emissions to a predetermined value for the particular vehicle to characterize performance of the vehicle.

91. The machine-readable medium of claim **80**, wherein the data corresponds to a mileage for the vehicle, and the instructions for analyzing the data comprise instructions for comparing the mileage to a predetermined value for the particular vehicle to characterize performance of the vehicle.

92. The machine-readable medium of claim **80**, further comprising instructions for sending an electronic text, data, or voice message to a computer, cellular telephone, or wireless device after analysis of the data.

93. The machine-readable medium of claim **80**, further comprising instructions for wirelessly transmitting data to the vehicle, the transmitted data configured to adjust a setting in a diagnostic system of the vehicle.

94. The machine-readable medium of claim **80**, wherein the first set of data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

95. The machine-readable medium of claim **80**, further comprising instructions for storing the analyzed data in at least one database, the database associated with at least one of insurance, vehicle driving pattern monitoring, emission characteristics, a performance or reliability survey, vehicle tracking, and billing of a user of the vehicle.

96. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include instructions for inferring a concentration of hydrocarbons, oxides of nitrogen, and carbon monoxide emitted from the vehicle.

97. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include:

(i) instructions for estimating the vehicle's odometer reading;

(ii) instructions for comparing the odometer reading to a schedule indicative of at least one service event associated with mileage; and

(iii) instructions for, based on the comparing, sending a notification if a service event is recommended for the vehicle.

98. The machine-readable medium of claim **80**, further comprising instructions for wirelessly transmitting data configured to modify a software or firmware configuration in the vehicle.

99. The machine-readable medium of claim **80**, wherein the at least one web page provides access to analysis software executable by a user, wherein the analysis software is remote from the user.

100. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data include:

(i) instructions for remotely identifying a problem condition in the vehicle, wherein the vehicle is located at a location remote from a service entity; and

(ii) instructions for sending a message to at least one of the service entity and an owner of the vehicle, wherein the message is associated with the identified problem condition.

101. The machine-readable medium of claim **100**, wherein the instructions for sending a message comprise instructions for updating a web page associated with the service entity or owner.

102. The machine-readable medium of claim **100**, wherein the problem condition relates to an existing problem.

103. The machine-readable medium of claim **100**, wherein the problem condition relates to a predicted problem.

104. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data comprise:

(i) instructions for remotely identifying a problem condition in the vehicle; and

(ii) instructions for remotely repairing the vehicle to correct the problem condition,

wherein the vehicle is located at a location remote from a service entity.

105. The machine-readable medium of claim **80**, wherein the instructions for analyzing the data comprise:

(i) instructions for determining a location of the vehicle; and

(ii) instructions for activating a safety or anti-theft function associated with the determined location.

106. A graphical user interface for displaying performance and location information for a vehicle, the interface comprising:

a plurality of regions, each region displaying analyzed data for the vehicle,

wherein at least one region includes data representative of the vehicle's performance,

wherein at least one region includes data representative of a location of the vehicle, and

wherein the plurality of regions are displayed on at least one web page accessible on the Internet.

107. The graphical user interface of claim **106**, wherein the displayed analyzed data includes at least one map associated with the location data.

108. The graphical user interface of claim **106**, wherein the displayed analyzed data includes vehicle location information in degrees latitude and longitude.

109. The graphical user interface of claim **106**, wherein the displayed analyzed data includes data representing at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system.

110. The graphical user interface of claim **106**, wherein the at least one web page is associated with an individual user or vehicle service provider.

111. The graphical user interface of claim **106**, wherein the at least one web page displays analyzed data associated with a plurality of vehicles.

112. The graphical user interface of claim **106**, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

113. The graphical user interface of claim **106**, wherein access to the graphical user interface is password-protected.

114. The graphical user interface of claim **106**, wherein the displayed analyzed data includes information associated with at least one problem condition.

115. A motor vehicle for use in cooperation with a programmable central computer, comprising:

(a) an engine;

(b) a transmission;

(c) a braking mechanism;

(d) an onboard diagnostic system having an OBD or OBD-II connector, the diagnostic system configured to query at least data relating to the engine, transmission, and braking mechanism;

(e) a data collector/router comprising,

(i) an electrical connector configured to connect to the OBD or OBD-II connector,

(ii) a microprocessor interfaced with the electrical connector, the microprocessor configured to retrieve data generated by the vehicle at a predetermined time interval, and

(iii) a wireless transmitter configured to receive the data from the microprocessor and wirelessly transmit the data; and

(f) a location-determining component configured to determine location data representative of the vehicle's location, wherein the wireless transmitter is configured to receive the location data and wirelessly transmit the location data; and

(g) a wireless receiver configured to receive (1) data configured to adjust a setting in a diagnostic system of the vehicle and (2) data configured to modify a software or firmware configuration in the vehicle,

wherein the retrieved data describes at least one of the vehicle's mileage, exhaust emissions, engine performance, engine temperature, coolant temperature, intake-manifold pressure, vehicle-identification number, engine-performance tuning parameters, alarm status, accelerometer status, fuel-injector performance, spark-plug timing, odometer reading, and a status of an anti-lock braking system,

wherein the microprocessor is configured to retrieve data at a configurable predetermined or random time interval,

wherein the location data includes global positioning system (GPS) data,

wherein the data collector/router is configured to serially transfer data through an OBD-II connector to the data collector/router, and

wherein the data collector/router is configured to transfer data using a J1850, ISO 9141-2, or J2284 protocol.

116. The motor vehicle of claim **115**, wherein the vehicle is selected from a group comprising an automobile, truck, wheeled commercial equipment, heavy truck, power sport vehicle, collision repair vehicle, marine vehicle, and recreational vehicle.

* * * * *

Exhibit C

US006611740B2

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

(10) **Patent No.: US 6,611,740 B2**
(45) **Date of Patent: Aug. 26, 2003**

(54) **INTERNET-BASED VEHICLE-DIAGNOSTIC SYSTEM**

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(73) Assignee: **NetworkCar**, San Diego, CA (US)

(*) 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.: **09/808,690**

(22) Filed: **Mar. 14, 2001**

(65) **Prior Publication Data**

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(51) **Int. Cl.**[7] **G01M 17/00**; G06F 7/00; G06F 17/00; G06F 19/00

(52) **U.S. Cl.** **701/29**; 709/200; 709/260; 702/182; 702/183; 707/1; 707/102; 379/1.01; 379/219

(58) **Field of Search** 701/35, 29, 115, 701/33, 32, 102, 114; 709/200, 207, 240; 340/439, 438, 459; 700/29; 123/436; 702/187, 184, 185, 183, 182; 707/203, 1, 100, 102; 379/1.01, 219; 370/313, 401, 328; 455/457, 404, 563

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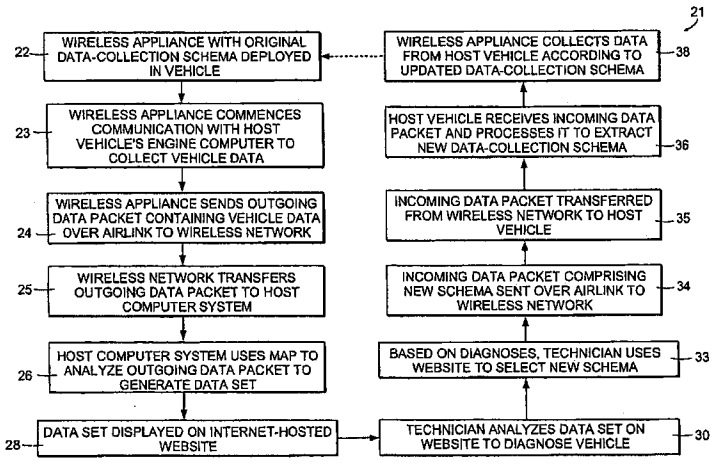
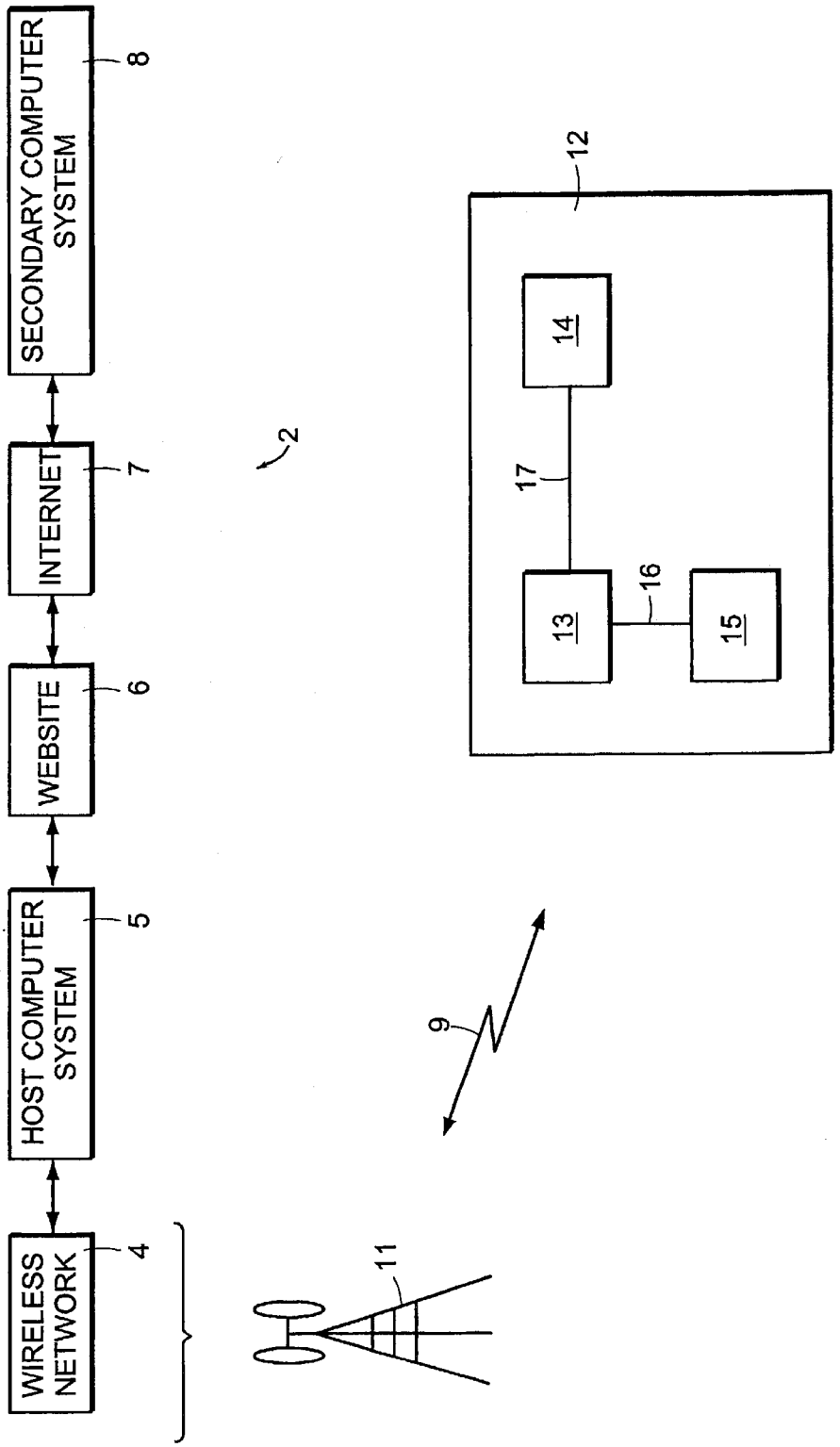
(57) **ABSTRACT**

The invention provides a system for monitoring a vehicle that includes a wireless appliance in electrical contact with an in-vehicle computer. The wireless appliance features: 1) a data-collection component that supports communication software that collects diagnostic data from the computer; and 2) a data-transmission component, in electrical communication with the data-collection electronics, configured to transmit an outgoing data packet comprising the diagnostic data over a network and receive over the same network an incoming data packet that modifies the communication software. The wireless appliance communicates with a host computer system that is configured to: 1) receive the outgoing data packet from the network; 2) process the outgoing data packet to generate a set of vehicle diagnostic data; 3) host a web site on the Internet that displays the vehicle diagnostic data; and 4) send out the incoming data packet over the same network to modify the communication software.

33 Claims, 11 Drawing Sheets




SECONDARY COMPUTER SYSTEM
8
INTERNET
7
WEBSITE
6
HOST COMPUTER SYSTEM
5
WIRELESS NETWORK
4
2
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11
12
14
17
13
16
15

FIG. 1

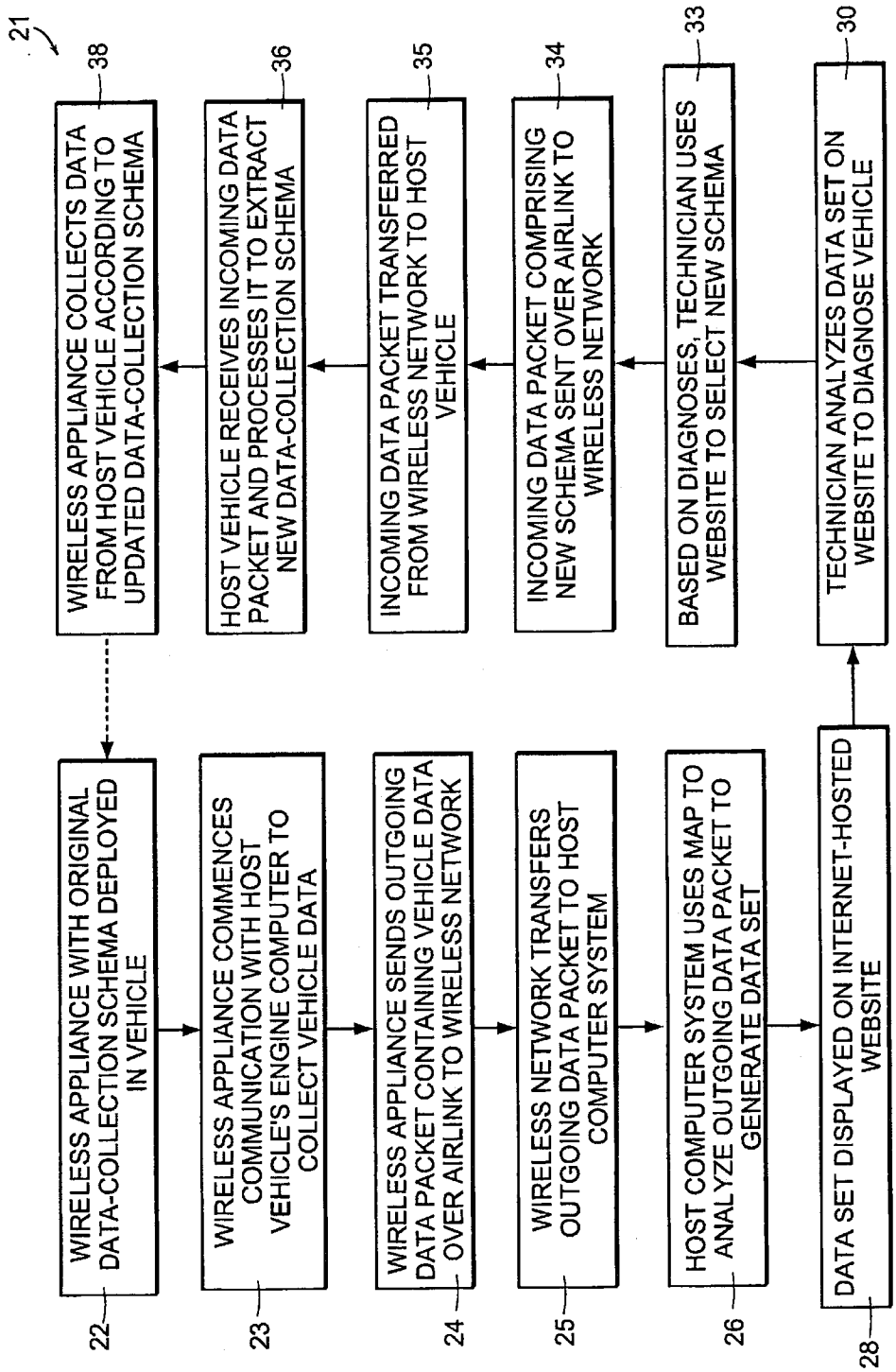
21
WIRELESS APPLIANCE WITH ORIGINAL DATA-COLLECTION SCHEMA DEPLOYED IN VEHICLE
22
WIRELESS APPLIANCE COMMENCES COMMUNICATION WITH HOST VEHICLE'S ENGINE COMPUTER TO COLLECT VEHICLE DATA
23
WIRELESS APPLIANCE SENDS OUTGOING DATA PACKET CONTAINING VEHICLE DATA OVER AIRLINK TO WIRELESS NETWORK
24
WIRELESS NETWORK TRANSFERS OUTGOING DATA PACKET TO HOST COMPUTER SYSTEM
25
HOST COMPUTER SYSTEM USES MAP TO ANALYZE OUTGOING DATA PACKET TO GENERATE DATA SET
26
DATA SET DISPLAYED ON INTERNET-HOSTED WEBSITE
28
TECHNICIAN ANALYZES DATA SET ON WEBSITE TO DIAGNOSE VEHICLE
30
BASED ON DIAGNOSES, TECHNICIAN USES WEBSITE TO SELECT NEW SCHEMA
33
INCOMING DATA PACKET COMPRISING NEW SCHEMA SENT OVER AIRLINK TO WIRELESS NETWORK
34
INCOMING DATA PACKET TRANSFERRED FROM WIRELESS NETWORK TO HOST VEHICLE
35
HOST VEHICLE RECEIVES INCOMING DATA PACKET AND PROCESSES IT TO EXTRACT NEW DATA-COLLECTION SCHEMA
36
WIRELESS APPLIANCE COLLECTS DATA FROM HOST VEHICLE ACCORDING TO UPDATED DATA-COLLECTION SCHEMA
38

FIG. 2

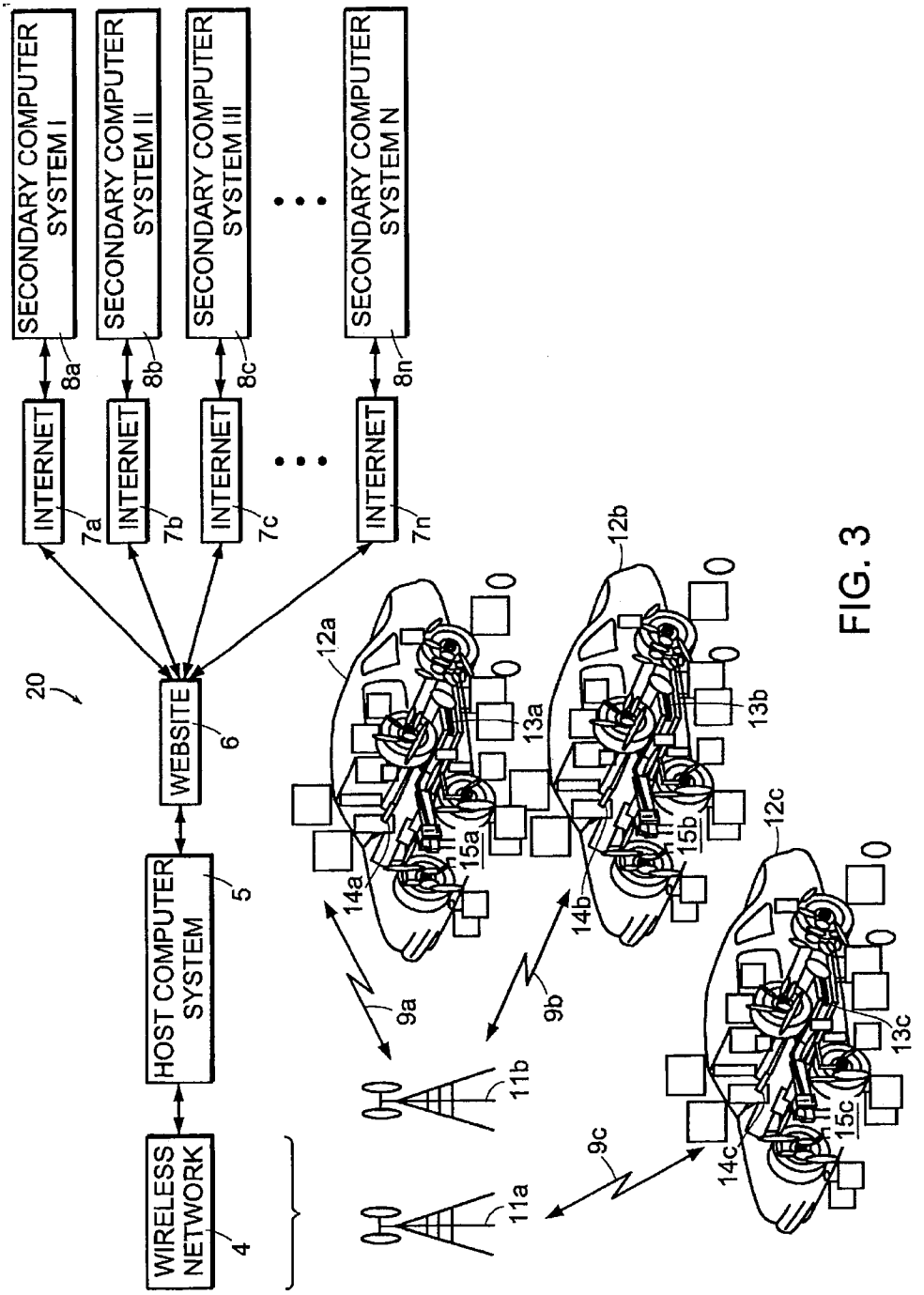
SECONDARY COMPUTER SYSTEM I
SECONDARY COMPUTER SYSTEM II
SECONDARY COMPUTER SYSTEM III
SECONDARY COMPUTER SYSTEM N
8a
8b
8c
8n
INTERNET
7a
7b
7c
7n
20
WEBSITE
6
HOST COMPUTER SYSTEM
5
WIRELESS NETWORK
4
12a
12b
12c
13a
13b
13c
14a
14b
14c
15a
15b
15c
9a
9b
9c
11a
11b

FIG. 3

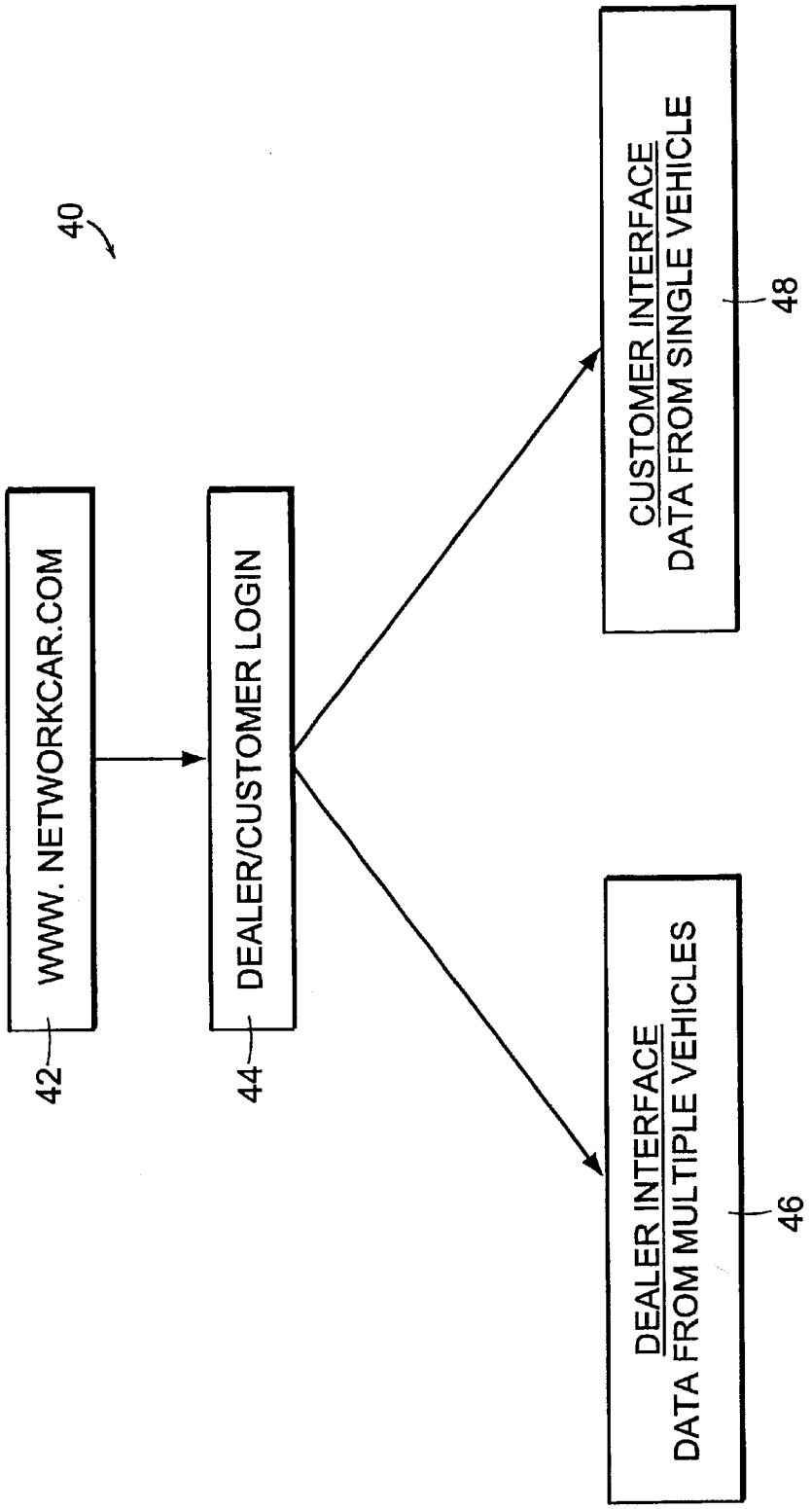
40
WWW. NETWORKCAR.COM
42
DEALER/CUSTOMER LOGIN
44
CUSTOMER INTERFACE
DATA FROM SINGLE VEHICLE
48
DEALER INTERFACE
DATA FROM MULTIPLE VEHICLES
46

FIG. 4

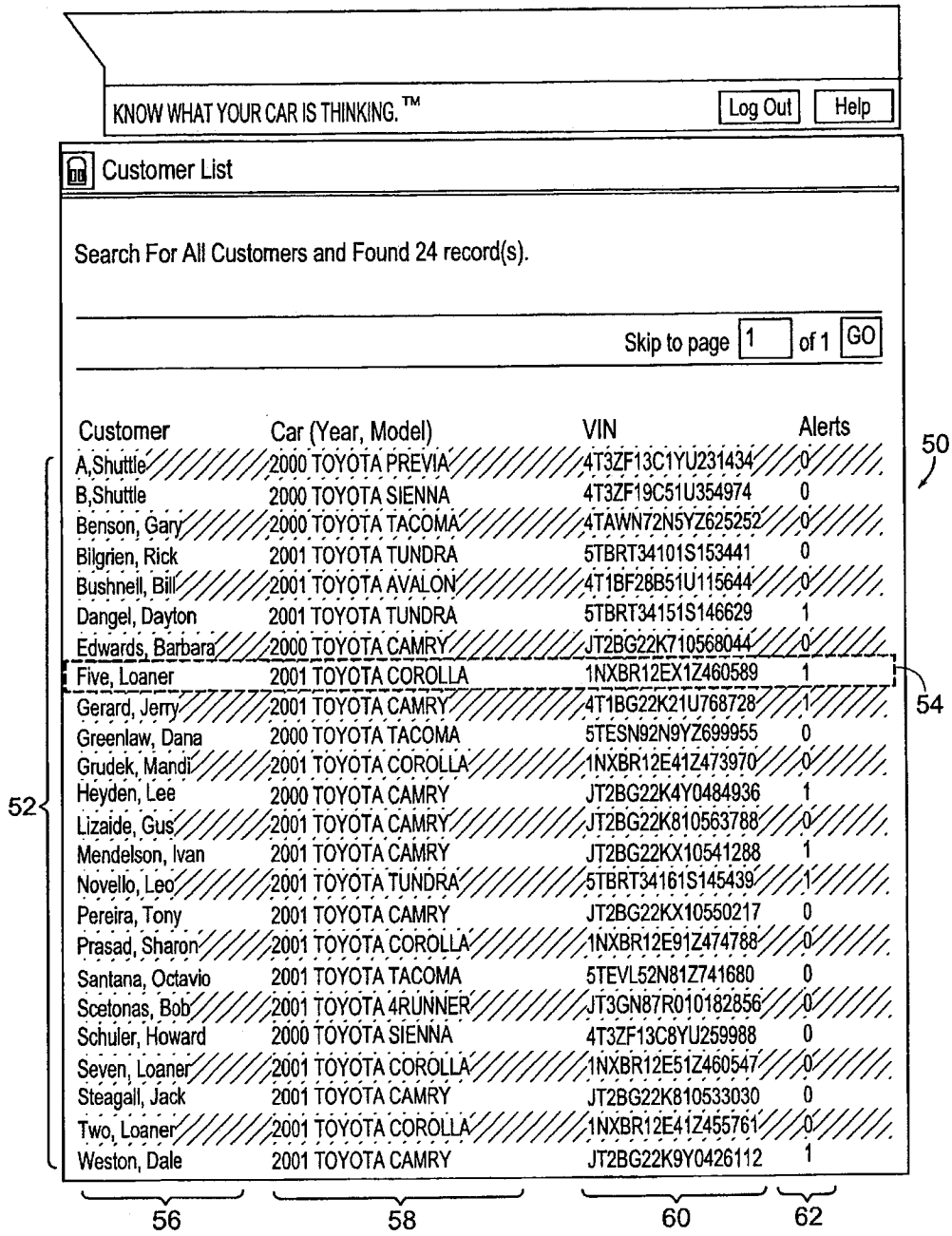
KNOW WHAT YOUR CAR IS THINKING.™
Log Out
Help
Customer List
Search For All Customers and Found 24 record(s).
Skip to page 1 of 1 GO
Customer
Car (Year, Model)
VIN
Alerts
A,Shuttle 2000 TOYOTA PREVIA 4T3ZF13C1YU231434 0
B,Shuttle 2000 TOYOTA SIENNA 4T3ZF19C51U354974 0
Benson, Gary 2000 TOYOTA TACOMA 4TAWN72N5YZ625252 0
Bilgrien, Rick 2001 TOYOTA TUNDRA 5TBRT34101S153441 0
Bushnell, Bill 2001 TOYOTA AVALON 4T1BF28B51U115644 0
Dangel, Dayton 2001 TOYOTA TUNDRA 5TBRT34151S146629 1
Edwards, Barbara 2000 TOYOTA CAMRY JT2BG22K710568044 0
Five, Loaner 2001 TOYOTA COROLLA 1NXBR12EX1Z460589 1
Gerard, Jerry 2001 TOYOTA CAMRY 4T1BG22K21U768728 1
Greenlaw, Dana 2000 TOYOTA TACOMA 5TESN92N9YZ699955 0
Grudek, Mandi 2001 TOYOTA COROLLA 1NXBR12E41Z473970 0
Heyden, Lee 2000 TOYOTA CAMRY JT2BG22K4Y0484936 1
Lizaide, Gus 2001 TOYOTA CAMRY JT2BG22K810563788 0
Mendelson, Ivan 2001 TOYOTA CAMRY JT2BG22KX10541288 1
Novello, Leo 2001 TOYOTA TUNDRA 5TBRT34161S145439 1
Pereira, Tony 2001 TOYOTA CAMRY JT2BG22KX10550217 0
Prasad, Sharon 2001 TOYOTA COROLLA 1NXBR12E91Z474788 0
Santana, Octavio 2001 TOYOTA TACOMA 5TEVL52N81Z741680 0
Scetonas, Bob 2001 TOYOTA 4RUNNER JT3GN87R010182856 0
Schuler, Howard 2000 TOYOTA SIENNA 4T3ZF13C8YU259988 0
Seven, Loaner 2001 TOYOTA COROLLA 1NXBR12E51Z460547 0
Steagall, Jack 2001 TOYOTA CAMRY JT2BG22K810533030 0
Two, Loaner 2001 TOYOTA COROLLA 1NXBR12E41Z455761 0
Weston, Dale 2001 TOYOTA CAMRY JT2BG22K9Y0426112 1
50
52
54
56
58
60
62

FIG. 5

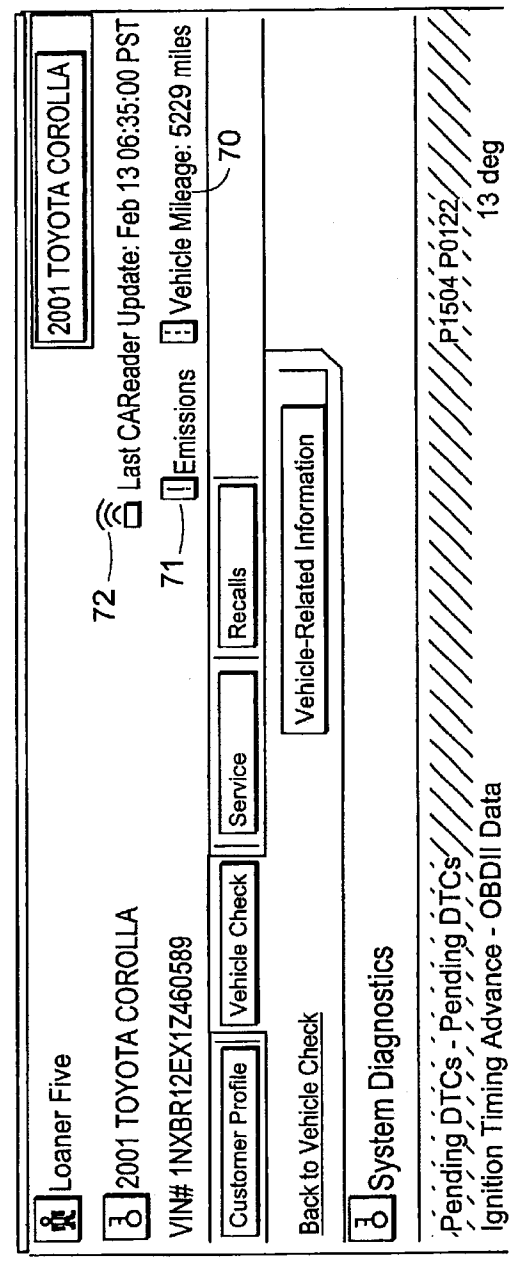

FIG. 6A

FIG. 6

FIG. 6A
FIG. 6B
FIG. 6C

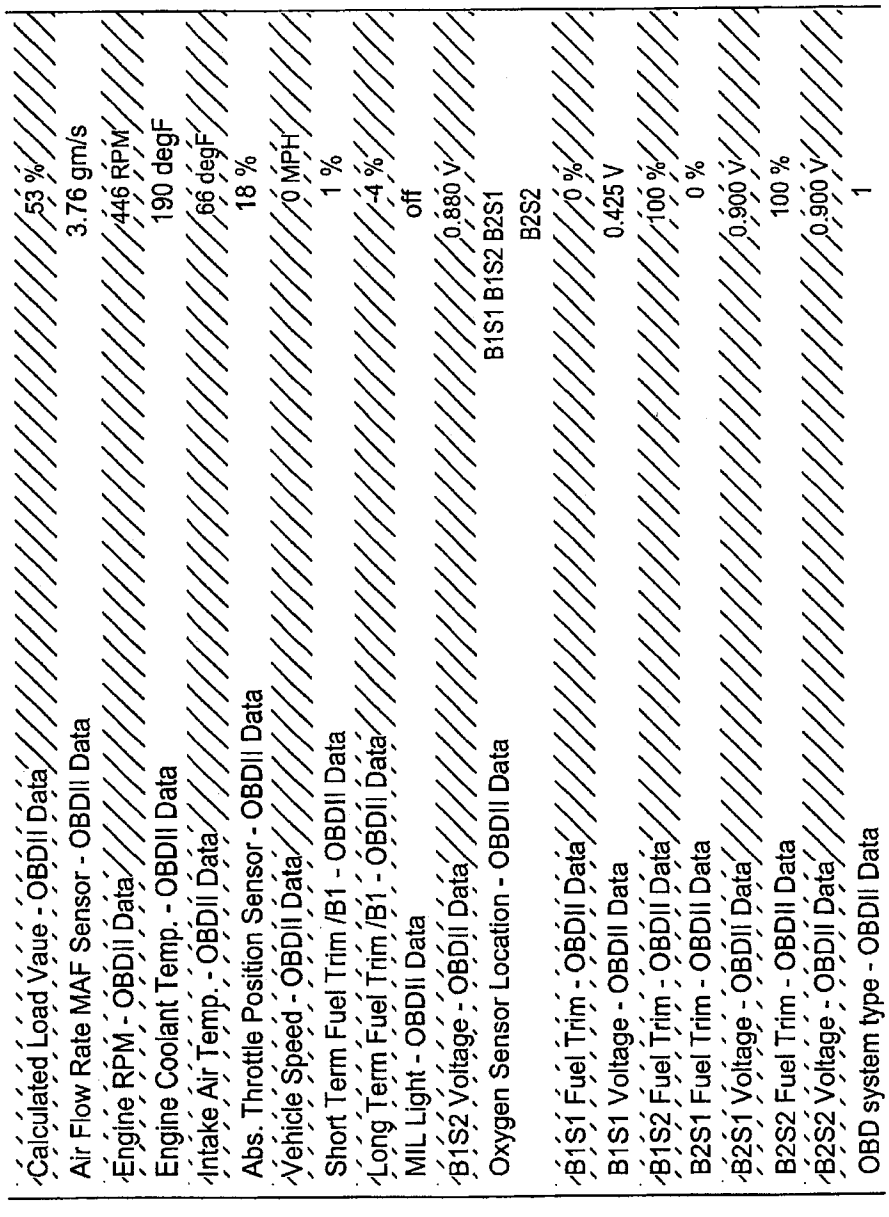
122
Calculated Load Value - OBDII Data
53 %
Air Flow Rate MAF Sensor - OBDII Data
3.76 gm/s
Engine RPM - OBDII Data
446 RPM
Engine Coolant Temp. - OBDII Data
190 degF
Intake Air Temp. - OBDII Data
66 degF
Abs. Throttle Position Sensor - OBDII Data
18 %
Vehicle Speed - OBDII Data
0 MPH
Short Term Fuel Trim /B1 - OBDII Data
1 %
Long Term Fuel Trim /B1 - OBDII Data
-4 %
MIL Light - OBDII Data
off
B1S2 Voltage - OBDII Data
0.880 V
Oxygen Sensor Location - OBDII Data
B1S1 B1S2 B2S1
B2S2
B1S1 Fuel Trim - OBDII Data
0 %
B1S1 Voltage - OBDII Data
0.425 V
B1S2 Fuel Trim - OBDII Data
100 %
B2S1 Fuel Trim - OBDII Data
0 %
B2S1 Voltage - OBDII Data
0.900 V
B2S2 Fuel Trim - OBDII Data
100 %
B2S2 Voltage - OBDII Data
0.900 V
OBD system type - OBDII Data
1

FIG. 6B

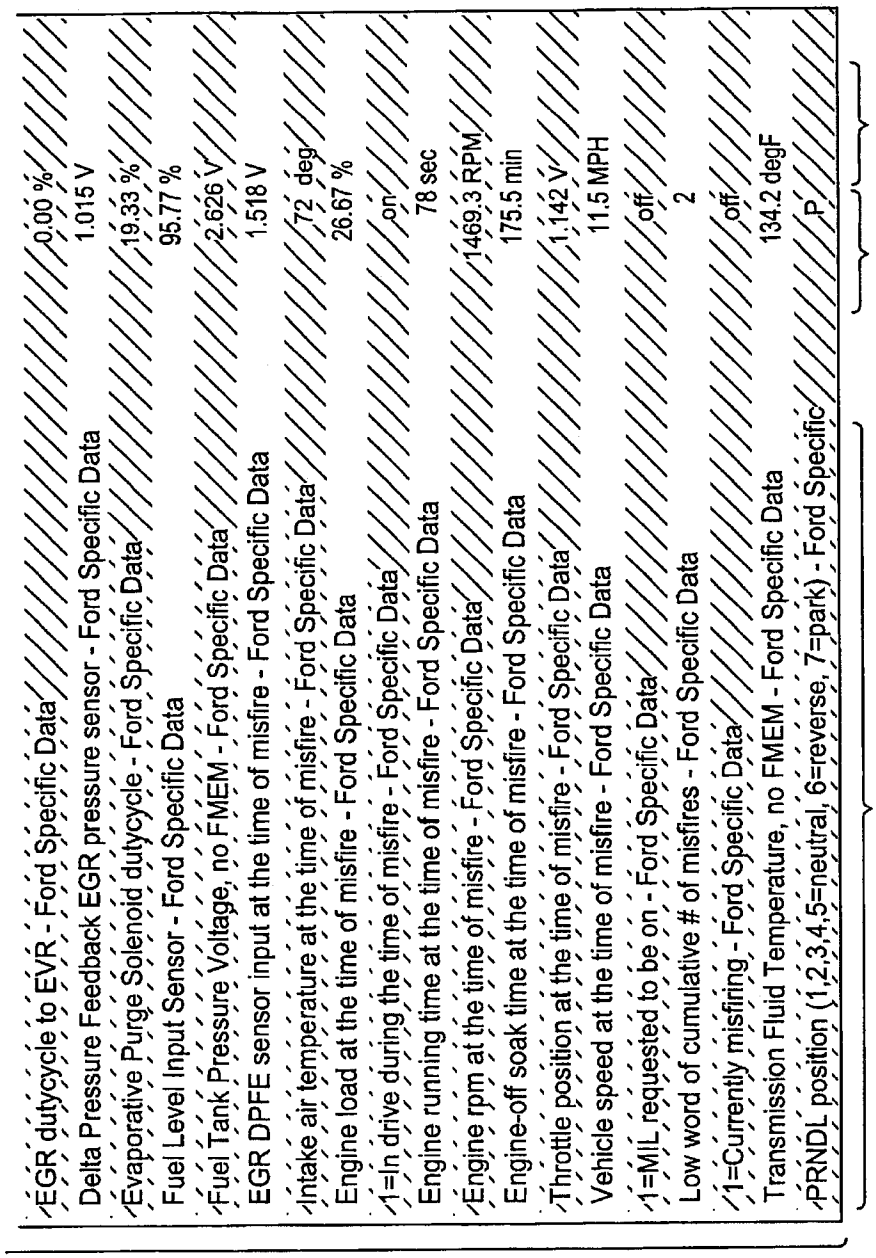
EGR dutycycle to EVR - Ford Specific Data 0.00 %
Delta Pressure Feedback EGR pressure sensor - Ford Specific Data 1.015 V
Evaporative Purge Solenoid dutycycle - Ford Specific Data 19.33 %
Fuel Level Input Sensor - Ford Specific Data 95.77 %
Fuel Tank Pressure Voltage, no FMEM - Ford Specific Data 2.626 V
EGR DPFE sensor input at the time of misfire - Ford Specific Data 1.518 V
Intake air temperature at the time of misfire - Ford Specific Data 72 deg
Engine load at the time of misfire - Ford Specific Data 26.67 %
1=In drive during the time of misfire - Ford Specific Data on
Engine running time at the time of misfire - Ford Specific Data 78 sec
Engine rpm at the time of misfire - Ford Specific Data 1469.3 RPM
Engine-off soak time at the time of misfire - Ford Specific Data 175.5 min
Throttle position at the time of misfire - Ford Specific Data 1.142 V
Vehicle speed at the time of misfire - Ford Specific Data 11.5 MPH
1=MIL requested to be on - Ford Specific Data off
Low word of cumulative # of misfires - Ford Specific Data 2
1=Currently misfiring - Ford Specific Data off
Transmission Fluid Temperature, no FMEM - Ford Specific Data 134.2 degF
PRNDL position (1,2,3,4,5=neutral, 6=reverse, 7=park) - Ford Specific P
125
127
129

FIG. 6C

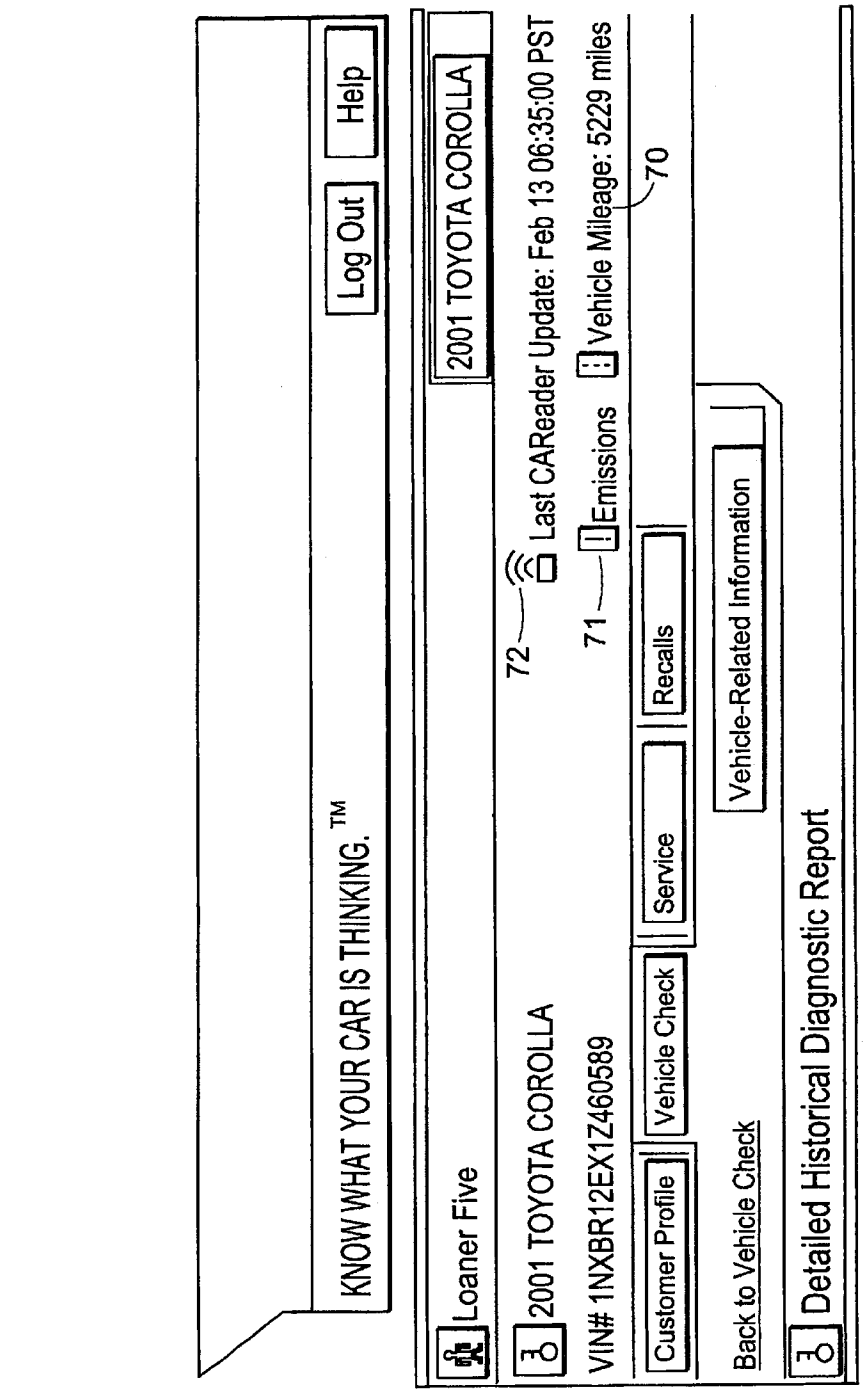

FIG. 7A

FIG. 7B

FIG. 7C

FIG. 7

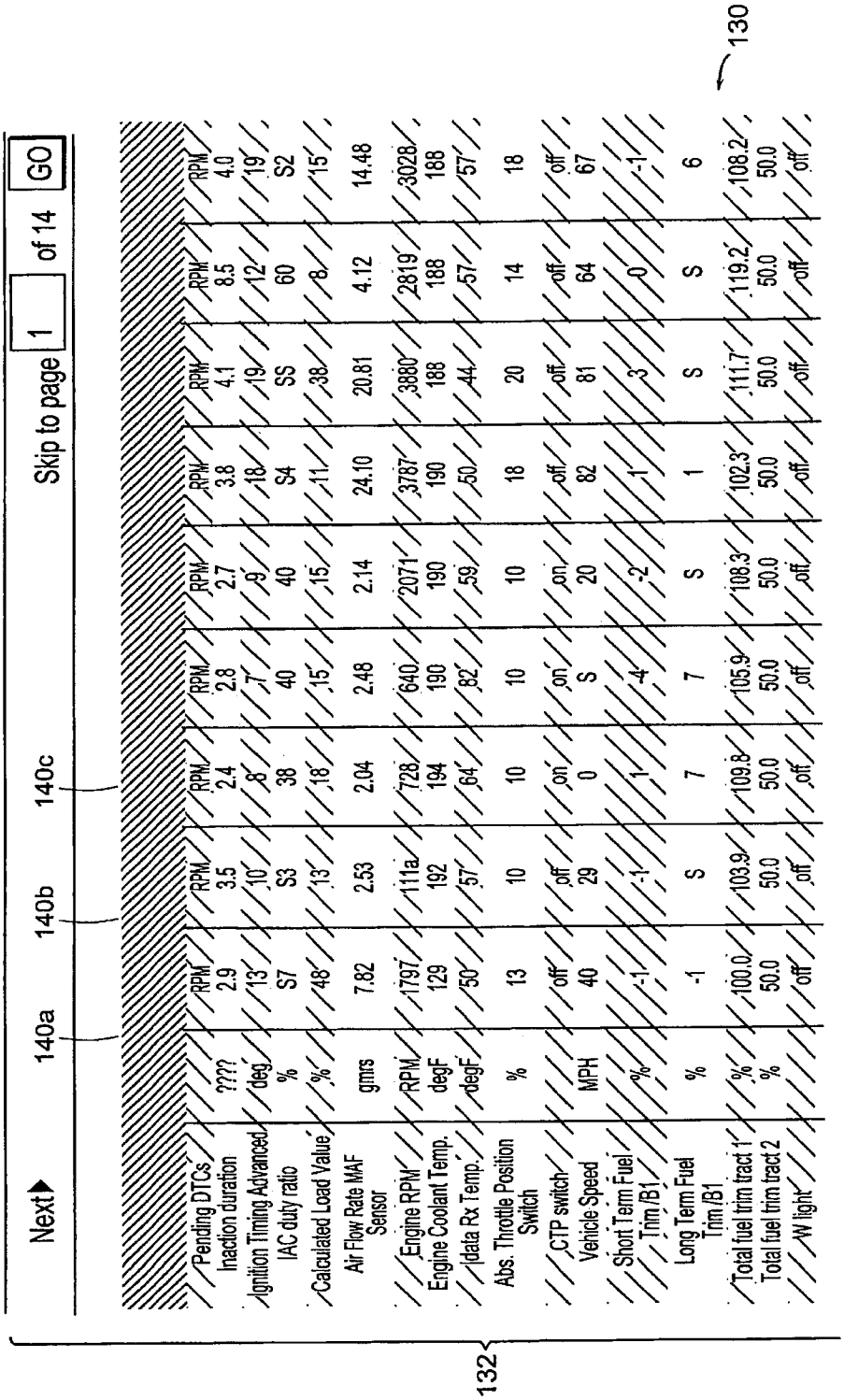
Next
140a
140b
140c
Skip to page 1 of 14
GO
Pending DTCs
Inaction duration
Ignition Timing Advanced
IAC duty ratio
Calculated Load Value
Air Flow Rate MAF Sensor
Engine RPM
Engine Coolant Temp.
Idata Rx Temp.
Abs. Throttle Position Switch
CTP switch
Vehicle Speed
Short Term Fuel Trim /B1
Long Term Fuel Trim /B1
Total fuel trim tract 1
Total fuel trim tract 2
W light
????
deg
%
gmrs
RPM
degF
%
MPH
off
on
S
132
130

FIG. 7B

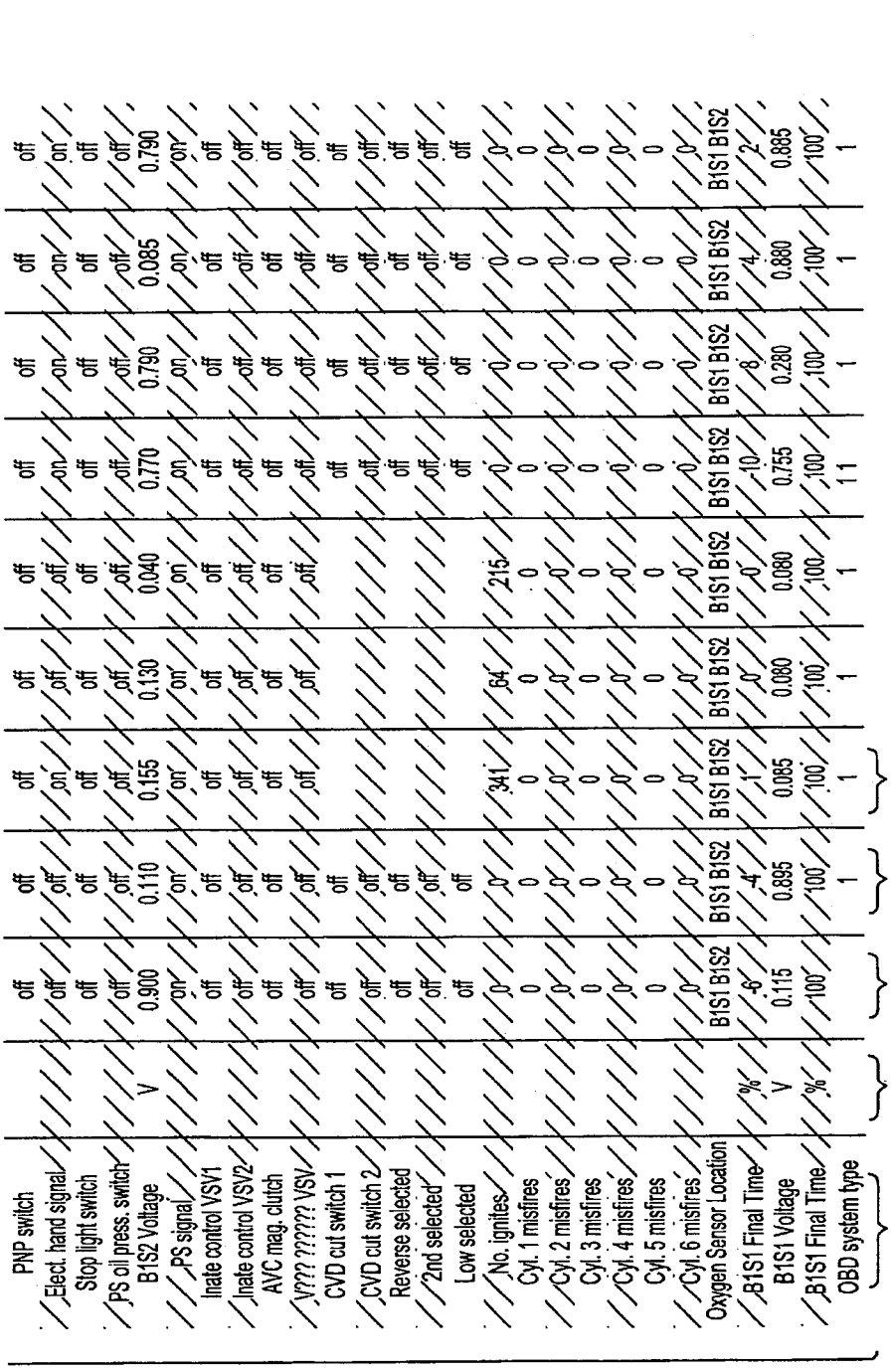
PNP switch
Elect. hand signal
Stop light switch
PS oil press. switch
B1S2 Voltage
PS signal
Inate control VSV1
Inate control VSV2
AVC mag. clutch
V??? ?????? VSV
CVD cut switch 1
CVD cut switch 2
Reverse selected
2nd selected
Low selected
No. ignites
Cyl. 1 misfires
Cyl. 2 misfires
Cyl. 3 misfires
Cyl. 4 misfires
Cyl. 5 misfires
Cyl. 6 misfires
Oxygen Sensor Location
B1S1 Final Time
B1S1 Voltage
B1S1 Final Time
OBD system type
125'
129'
127a
127b
127c

FIG. 7C

INTERNET-BASED VEHICLE-DIAGNOSTIC SYSTEM

TECHNICAL FIELD

The present invention relates to use of an internet-based system for diagnosing a vehicle's performance.

BACKGROUND

The Environmental Protection Agency (EPA) requires vehicle manufacturers to install on-board diagnostics (OBD-II) for monitoring light-duty automobiles and trucks beginning with model year 1996. OBD-II systems (e.g., microcontrollers and sensors) monitor the vehicle's electrical and mechanical systems and generate data that are processed by a vehicle's engine control unit (ECU) to detect any malfunction or deterioration in the vehicle's performance. Most ECUs transmit status and diagnostic information over a shared, standardized electronic buss in the vehicle. The buss effectively functions as an on-board computer network with many processors, each of which transmits and receives data. The primary computers in this network are the vehicle's electronic-control module (ECM) and power-control module (PCM). The ECM typically monitors engine functions (e.g., the cruise-control module, spark controller, exhaust/gas recirculator), while the PCM monitors the vehicle's power train (e.g., its engine, transmission, and braking systems). Data available from the ECM and PCM include vehicle speed, fuel level, engine temperature, and intake manifold pressure. In addition, in response to input data, the ECU also generates 5-digit 'diagnostic trouble codes' (DTCs) that indicate a specific problem with the vehicle. The presence of a DTC in the memory of a vehicle's ECU typically results in illumination of the 'Service Engine Soon' light present on the dashboard of most vehicles.

Data from the above-mentioned systems are made available through a standardized, serial 16-cavity connector referred to herein as an 'OBD-II connector'. The OBD-II connector typically lies underneath the vehicle's dashboard. When a vehicle is serviced, data from the vehicle's ECM and/or PCM is typically queried using an external engine-diagnostic tool (commonly called a 'scan tool') that plugs into the OBD-IL connector. The vehicle's engine is turned on and data are transferred from the engine computer, through the OBD-II connector, and to the scan tool. The data are then displayed and analyzed to service the vehicle. Scan tools are typically only used to diagnose stationary vehicles or vehicles running on a dynamometer.

Some vehicle manufacturers also include complex electronic systems in their vehicles to access and analyze some of the above-described data. For example, General Motors includes a system called 'On-Star' in some of their high-end vehicles. On-Star collects and transmits data relating to these DTCs through a wireless network. On-Star systems are not connected through the OBD-II connector, but instead are wired directly to the vehicle's electronic system. This wiring process typically takes place when the vehicle is manufactured.

SUMMARY

Embodiments of the invention can provide a wireless, internet-based system for monitoring a vehicle. For example, embodiments of the invention can access data from a vehicle, analyze it, and make it available to organizations (e.g. an automotive dealership or service center) over the internet so that the vehicle's performance can be analyzed accurately and in real-time. Data are accessed through the same OBD-II connector used by conventional scan tools. In this way, the invention collects data similar to those collected by scan tools, only they are collected in real-time while the vehicle is actually being driven. The invention also provides an Internet-based web site to view these data. The web site also includes functionality to modify the type of data being collected, e.g. the type of diagnostic data or the frequency at which it is collected. The data can be collected and viewed over the Internet without having to bring the vehicle in for service. The data include, for example, DTCs and mechanical and electrical data stored in the vehicle's engine computer.

In one aspect, the invention features a system for monitoring operational characteristics of a vehicle. The system includes a computer in the vehicle, and a wireless appliance in electrical contact with the computer. The wireless appliance includes a data-transmission component configured to transmit data associated with the operational characteristics over a network to a host computer system, and to receive over the network data from the host computer system.

In another aspect, the invention features a device for monitoring operational characteristics of a vehicle. The device includes a wireless appliance including a data transmission component configured to communicate data associated with the operational characteristics over a network to a host computer.

In another aspect, the invention features a device for monitoring operational characteristics of a vehicle. The device includes a wireless appliance including a data transmission component configured to receive data associated with the operational characteristics over a network from a host computer.

In a further aspect, the invention features a system for monitoring operational characteristics of a vehicle. The system includes a host computer and a wireless appliance including a data transmission component configured to communicate data associated with the operational characteristics over a network to the host computer. In some embodiments, the wireless appliance is in the vehicle. In certain embodiments, the host computer is external to the vehicle.

In one aspect, the invention features a system for monitoring operational characteristics of a vehicle. The system includes a host computer and a wireless appliance including a data transmission component configured to receive data associated with the operational characteristics over a network from the host computer. In some embodiments, the wireless appliance is in the vehicle. In certain embodiments, the host computer is external to the vehicle.

Embodiments of the invention can include one or more of the following features and/or advantages.

The 'wireless appliance' used in the above-described invention features a data-transmitting component (e.g. a radio or cellular modem) that sends out the data packet over an existing wireless network (e.g., Cingular's Mobitex network). Such a wireless appliance is described in the application WIRELESS DIAGNOSTIC SYSTEM FOR VEHICLES, filed Feb. 1, 2001, the contents of which are incorporated herein by reference.

In embodiments, the communication software supported by the data-collection component features a schema component that identifies the diagnostic data to be collected from the vehicle's computer. The schema component features an address that describes a location of a diagnostic datum in the

vehicle's computer memory. It can also describe a time or frequency that the data-collection component collects data from the vehicle's computer, or a time or frequency that the data-transmission component transmits an outgoing data packet. The schema component is typically an ASCII or binary data file that is configured to be processed by the communication software.

In the above-mentioned description, the term 'supported' means that an executable version of the communication software can run as a computer program on a microprocessor, microcontroller, or comparable, semiconductor-based device resident on the data-collection component.

The host computer system typically features at least one web-hosting computer that hosts the web site, and at least one, separate gateway computer that receives the outgoing data packet and sends the incoming data packet. In this embodiment the web site features a first web page that displays at least a single vehicle diagnostic datum. For example, the first web page can include data fields describing: i) a name of the diagnostic datum; ii) units corresponding to the diagnostic datum; and iii) a numerical value corresponding to the diagnostic datum. Multiple sets of diagnostic data, each received by the host computer system at a unique time and date, can also be displayed on the web page. The page can also include a graphical representation of the sets of diagnostic data, e.g. a time-dependent plot of the data.

In typical applications the set of diagnostic data includes at least one of the following: diagnostic trouble codes, vehicle speed, fuel level, fuel pressure, miles per gallon, engine RPM, mileage, oil pressure, oil temperature, tire pressure, tire temperature, engine coolant temperature, intake-manifold pressure, engine-performance tuning parameters, alarm status, accelerometer status, cruise-control status, fuel-injector performance, spark-plug timing, and a status of an anti-lock braking system.

In other embodiments the web site further includes a login web page, in communication with a database component, where a user enters a user name and password. The database component is configured to verify if the user is associated with multiple vehicles. If this is the case, the web site includes a second web page that displays vehicle diagnostic data corresponding to each vehicle.

In still other embodiments the web site includes a third web page that features a mechanism for sending the incoming data packet over the network. For example, the third web page can include a mechanism for selecting a new schema wherein a list of parameters is provided, each of which can be extracted from the vehicle's computer.

The gateway computer that receives the outgoing data packet and sends the incoming data packet is connected to the network, typically through an Internet-based connection or a digital communication line.

The system can also include a secondary computer system that connects to the host computer system through the Internet to display the web site. Alternatively, the system includes a hand-held device, e.g. a cellular telephone or personal digital assistant, which connects to the host computer system through the Internet. The host computer system can also be configured to send an electronic mail message that includes all or part of the vehicle diagnostic data.

In other embodiments, the wireless appliance is configured to send an outgoing data packet that indicates a location of a transmitting base station. In this case, the host computer system includes software that analyzes this location to determine an approximate location of the vehicle, which can then be displayed on a web page.

In the above-described method, the term "airlink" refers to a standard wireless connection (e.g., a connection used for wireless telephones or pagers) between a transmitter and a receiver. This term describes the connection between a data-transmission component and the wireless network that supports data transmitted by this component. Also in the above-described method, the 'generating' and 'transmitting' steps can be performed at any time and with any frequency, depending on the diagnoses being performed. For a 'real-time' diagnoses of a vehicle's engine performance, for example, the steps may be performed at rapid time or mileage intervals (e.g., several times each minute, or every few miles). Alternatively, other diagnoses (e.g. an emissions or 'smog' check) may require the steps to be performed only once each year or after a large number of miles are driven. Alternatively, the vehicle may be configured to automatically perform these steps at predetermined or random time intervals. As described in detail below, the transmission frequency can be changed in real time by downloading a new 'schema' to the wireless appliance through the wireless network.

The term 'web page' refers to a standard, single graphical user interface or 'page' that is hosted on the Internet or world-wide web. Web pages typically include: 1) a 'graphical' component for displaying a user interface (typically written in a computer language called 'HTML' or hypertext mark-up language); an 'application' component that produces functional applications, e.g. sorting and customer registration, for the graphical functions on the page (typically written in, e.g., C++ or Java); and a database component that accesses a relational database (typically written in a database-specific language, e.g. SQL*Plus for Oracle databases). A 'web site' typically includes multiple web pages, many of which are 'linked' together, that are accessed through a series of 'mouse clicks'.

The invention has many advantages. In particular, wireless transmission of data from a vehicle, followed by analysis and display of these data using a web site hosted on the internet, makes it possible to diagnose the performance of a vehicle in real-time from virtually any location that has internet access. This ultimately means the problems with the vehicle can be efficiently diagnosed, and in some cases predicted before they actually occur. Moreover, data from the vehicle can be queried and analyzed while the vehicle is actually in use to provide a relatively comprehensive diagnosis that is not possible using a conventional scan tool. An internet-based system for vehicle diagnoses can also be easily updated and made available to a large group of users simply by updating software on the web site. In contrast, a comparable updating process for a series of scan tools can only be accomplished by updating the software on each individual scan tool. This, of course, is time-consuming, inefficient, and expensive, and introduces the possibility that many scan tools within a particular product line will not have the very latest software.

The wireless appliance used to access and transmit the vehicle's data is small, low-cost, and can be easily installed in nearly every vehicle with an OBD-II connector in a matter of minutes. It can also be easily transferred from one vehicle to another, or easily replaced if it malfunctions.

The wireless appliance can also collect data that is not accessible using a scan tool. For example, data that indicates a vehicles performance can be collected while the vehicle is actually driven. For example, it may be required to collect

data while a vehicle is driving up a hill or pulling a load. Scan tools, in contrast, can only collect data from a stationary vehicle in a service bay. Service technicians using the wireless appliance, for example, can analyze DTCs and diagnostic data while the vehicle is being driven. The system described herein also makes data available in real-time, thereby allowing the technicians to order parts and schedule resources for service appointments before the vehicle is actually brought into the dealership.

Moreover, software schemas that update the type or frequency of the vehicle's data can be directly downloaded to specific wireless appliances or groups of wireless appliances (corresponding, e.g., to a fleet of vehicles or a group of vehicles having the same year, make, or model). This makes it possible to collect data that specifically elucidates a problem with the vehicle that may occur only under certain driving conditions.

The resulting data, of course, have many uses for automotive dealerships, vehicle-service organizations, vehicle-renting firms, insurance companies, vehicle owners, organizations that monitor emission performance (e.g., the EPA), manufacturers of vehicles and related parts, survey organizations (e.g., J.D. Power) and vehicle service centers. In general, these data yield information that benefits the consumer, vehicle and parts manufacturers, vehicle service centers, and the environment.

These and other advantages of the invention are described in the following detailed disclosure and in the claims.

DESCRIPTION OF THE DRAWINGS

The features and advantages of the present invention can be understood by reference to the following detailed description taken with the drawings, in which:

FIG. **1** is a schematic drawing of system of the invention featuring a single vehicle transmitting data across an airlink to an Internet-accessible host computer system;

FIG. **2** is a flow chart describing a method used by the system of FIG. **1** to diagnose vehicles;

FIG. **3** is a schematic drawing of the system of the invention featuring multiple vehicles, each transmitting data across an airlink to an Internet-accessible host computer system;

FIG. **4** is a schematic drawing of a web site with a login process that renders a series of web pages associated with either a dealer or customer interface;

FIG. **5** is a screen capture of a web page from the web site of FIG. **4** that shows a list of customers corresponding to a single dealership;

FIG. **6** is a screen capture of a web page related to the web page of FIG. **5** that shows diagnostic data for a customer's vehicle; and

FIG. **7** is a screen capture of a web page from the web site of FIG. **1** that shows several time-dependent sets of diagnostic data from a customer's vehicle.

DETAILED DESCRIPTION

FIG. **1** shows a schematic drawing of an Internet-based vehicle-diagnostic system **2** according to the invention. The system **2** measures diagnostic data from a vehicle **12** and transmits it over an airlink **9** to a web site **6** accessible through the Internet **7**. The system **2** functions in a bi-directional manner, i.e. in addition to receiving data from a vehicle, a user logged onto the web site **6** can specifically select the diagnostic data to be measured and the frequency at which it is measured. These properties are sent through the airlink **9** to the wireless appliance **13** that re-measures the diagnostic data from the vehicle **12**. In this way, the invention functions effectively as an Internet-based 'scan tool' that diagnoses any vehicle that includes a wireless appliance. The host vehicle can be diagnosed at any time it is being driven using an Internet-accessible web site.

The wireless appliance **13** disposed within the vehicle **12** collects diagnostic data from the vehicle's engine computer **15**. The engine computer **15** retrieves data stored in its memory and sends it along a cable **16** to the wireless appliance **13**. The appliance **13** typically connects to the OBD-II connector located under the dash in all vehicles manufactured after 1996. It includes a data-collection component (not shown in the figure) that formats the data in a packet and then passes the packet to a data-transmission component, which sends it through a cable **17** to an antenna **14**. To generate the data, the wireless appliance **13** queries the vehicle's computer **15** at a first time interval (e.g. every 20 seconds), and transmits a data set at a longer time interval (e.g. every 10 minutes). These time intervals are specified in a data-collection 'schema', described in more detail below.

The antenna typically rests in the vehicle's shade band, disposed just above the dashboard. The antenna **14** radiates the data packet over the airlink **9** to a base station **11** included in a wireless network **4**. A host computer system **5** connects to the wireless network **4** and receives the data packets. The host computer system **5**, for example, may include multiple computers, software pieces, and other signal-processing and switching equipment, such as routers and digital signal processors. Data are typically transferred from the wireless network **4** to host computer system **5** through a TCP/IP-based connection, or with a dedicated digital leased line (e.g., a frame-relay circuit or a digital line running an x0.25 protocol). The host computer system **5** also hosts a web site **6** using conventional computer hardware (e.g. computer servers for a database and the web site) and software (e.g., web server and database software). A user accesses the web site **6** through the Internet **7** from a secondary computer system **8**. The secondary computer system **8**, for example, may be located in an automotive service center.

The wireless appliance that provides diagnostic data to the web site is described in more detail in WIRELESS DIAGNOSTIC SYSTEM FOR VEHICLES, filed Feb. 1, 2001, the contents of which have been previously incorporated by reference. The appliance transmits a data packet that contains information of its status, an address describing its destination, an address describing its origin, and a 'payload' that contains the above-described diagnostic data from the vehicle, or a schema from the web site. These data packets are transmitted over conventional wireless network, such as Cingular's Mobitex network.

FIG. **2** shows a method **21** describing how the system **2** in FIG. **1** typically operates. As described above, the wireless appliance includes a data-collection component that, in turn, includes a microcontroller that has software and a data-collection 'schema' loaded in the microcontroller's memory. The schema is essentially a 'map' that describes the data that the wireless appliance collects from the vehicle's engine computer, and its corresponding location in the computer's memory. A schema specific to a given type of vehicle is typically loaded onto the microcontroller before the wireless appliance is installed in the vehicle (step **22** in FIG. **2**). During operation, the appliance communicates with the vehicle's engine computer as described above (step **23**). The appliance collects diagnostic data defined by the

schema, formats these data in a data packet, and then sends an outgoing packet over the airlink to a wireless network (step **24**). The network transfers the data packet to the host computer system as described above (step **25**). There, the host computer system analyzes the data packet using a 'map' that corresponds to the schema to generate a data set (step **26**). Every schema has a corresponding map. The map includes, for example, a list of the collected data, an acronym and unit for each datum. The data set, acronym, and units are then displayed on the web site (step **28**) where they can be viewed by any 'registered' user (i.e., a user with a username and corresponding password) with Internet connectivity.

In one mode of operation, a technician working at a vehicle-service center logs into the web site and analyzes the data set corresponding to a particular vehicle to diagnose a potential mechanical or electrical problem (step **30**). Specific web pages that display the data set are shown in FIGS. **5–7**, below. Based on the analysis, the technician may decide that additional data are required, or that data need to be collected and transmitted at a higher or lower frequency. In this case the technician uses the web site to select a new schema (step **32**) and then sends an incoming data packet that includes a new schema over the wireless network to the wireless appliance included in the vehicle being diagnosed (step **34**). In typical applications, the vehicle is specifically addressed using a serial number that corresponds to the data-transmitting component. This serial number is typically an 8 or 10-digit number that functions effectively as a 'phone number' corresponding to the data-transmitting component. This number is included in the data packet, and is used by the wireless network to transfer the packet to the host vehicle (step **35**). The host vehicle receives the packet and processes it to extract the new data-collection schema (step **36**). The wireless appliance uses the updated schema to extract a revised set of data from the vehicle's engine computer, or send out data at a revised frequency (step **38**). In other applications, the new schema can be used to query a set of data that is relevant to a DTC registered by the vehicle, or to 'clear' a DTC when it is deemed to no longer be problematic. Once these data are collected, the method **21** can then be repeated as described above to further diagnose the vehicle.

The above-described system is designed to work with multiple vehicles and multiple secondary computer systems, each connected to the web site through the Internet. FIG. **3** illustrates this point, showing a system **20**, similar to the system **2** of FIG. **1**, used to diagnose a set of vehicles **12***a–12c*. The system **20** operates similarly as that described above: a wireless appliance **13***a–13c* disposed in each vehicle collects data from the vehicles'respective engine computers **15***a–15c*, formats these data into data packets, and then sends the data packets using antennae **14***a–14c* over a series of airlinks **9***a–9c* to a base stations **11***a–11b* featured in a wireless network **4**. Each vehicle may include a unique schema. In this case, two vehicles **12***a*, **12***b* send their respective data packets to a single base station **11***b*, while a single vehicle **12***c* sends its data packet to a single base station **11***a*. The number and location of the base stations depends on the wireless network; in the Mobitex network there is typically one base station per zip code in most major cities. Once the data packets are received, the wireless network **4** routes them to the host computer system **5**. They are then processed with a corresponding map and consequently formatted as a series of data sets and displayed on the web site **6**. A series of secondary computer systems **8***a–8c*, **8***n* view the web site using separate connections over the Internet **7***a–7c*, **7***n*. Users of the secondary computer systems **8***a–8c*, **8***n* associated with organizations containing a series of vehicles (e.g., a vehicle dealership) can view data from all vehicles associated with the organization. In contrast, individual vehicle owners can only view data from their particular vehicle.

FIG. **4** illustrates this concept in more detail. The figure shows a schematic drawing of a login process **40** for a web site **42** that displays diagnostic data for a series of 'customer' vehicles associated with a vehicle 'dealership'. Within each vehicle is a wireless appliance that retrieves data from the vehicle's engine computer, and then sends these data, formatted in a data packet, through a wireless network. The data eventually are transferred from the network, through a host computer system, to the web site **42** where they are formatted, displayed and processed as described below.

A user 'logs' into the web site **42** through a login interface **44** by entering a username and password that, once entered, are compared to a database associated with the web site. The comparison determines if the user is a dealer or a customer. If the user is determined to be a dealer, the web site renders a dealer interface **46** that contains, e.g., diagnostic information for each purchased vehicle. Users viewing the dealer interface **46** do not have access to data corresponding to vehicles sold by other dealerships. If the user is determined to be a customer, the web site **42** renders a customer interface **48** that contains diagnostic information for one or more vehicles corresponding to the customer. Each customer using the web site **42** is associated with a unique customer interface.

FIG. **5** is a screen capture of a web page **50** included in the dealer interface indicated in FIG. **4**. The host computer system renders this page once the user is determined to be a dealer following the login process. The screen capture features a customer list **52** corresponding to a single dealership that includes: customer names **56** for each customer; a vehicle description **58** that includes the vehicle's year, make and model; a unique 17-digit vehicle identification number ('VIN') **60** that functions as the vehicle's serial number; and an 'alert' listing **62** that provides a number of alerts for each vehicle. The 'alerts' are described in more detail in the application entitled 'INTERNET-BASED SYSTEM FOR MONITORING VEHICLES', filed Mar. 15, 2001, the contents of which are incorporated herein by reference. In general, an alert is generated when data, sent from the vehicle's wireless appliance to the host computer system, indicates either 1) a mechanical/electrical problem with the vehicle; or 2) that a scheduled maintenance is recommended for the vehicle. For example, the customer list **52** includes a data field **54** that lists the user 'Five, Loaner' with an associated 2001 Toyota Corolla. The data field **54** also includes the number '1' in the alert listing **62**, indicating the presence of a single alert.

FIG. **6** shows a web page **120** that lists a detailed data set **122** transmitted from the vehicle-based wireless appliance to the host computer system. The host computer system receives the data set **122** at a time described by a time/date stamp **72** listed in the header **61**. The data set **122** includes a data parameter name **125**, a corresponding numerical value **127**, and a description of the units **129** of the numerical value **127**. As described above, these values are specified in the map corresponding to the data-collection schema used to extract the data from the vehicle. Some of the numerical values (e.g., the status of the 'MIL light' **131**) are dimensionless, i.e. they do not have units. To generate the numerical values **127**, the wireless appliance queries the vehicle's ECU at a set time interval (e.g. every 20 seconds),

and transmits a data set **122** at a longer time interval (e.g. every 10 minutes). Thus, the numerical values in the data set can represent 'instantaneous' values that result from a single query to the ECU, or they can represent 'average' values that result from an average from multiple sequential queries.

The data parameters within the set **122** describe a variety of electrical, mechanical, and emissions-related functions in the vehicle. Several of the more significant parameters from the set are listed in Table 1, below:

Pending DTCs
Ignition Timing Advance
Calculated Load Value
Air Flow Rate MAF Sensor
Engine RPM
Engine Coolant Temperature
Intake Air Temperature
Absolute Throttle Position Sensor
Vehicle Speed
Short-Term Fuel Trim
Long-Term Fuel Trim
MIL Light Status
Oxygen Sensor Voltage
Oxygen Sensor Location
Delta Pressure Feedback EGR Pressure Sensor
Evaporative Purge Solenoid Dutycycle
Fuel Level Input Sensor
Fuel Tank Pressure Voltage
Engine Load at the Time of Misfire
Engine RPM at the Time of Misfire
Throttle Position at the Time of Misfire
Vehicle Speed at the Time of Misfire
Number of Misfires
Transmission Fluid Temperature
PRNDL position (1,2,3,4,5=neutral, 6=reverse)
Number of Completed OBDII Trips
Battery Voltage

Table 1—Parameters Monitored from Vehicle

The parameters listed in Table 1 were measured from a Ford Crown Victoria. Similar sets of data are available for nearly all vehicles manufactured after 1996 that have an OBD-II connector. In addition to these, hundreds of other vehicle-specific parameters are also available from the vehicle's computer.

The data set **122** shown in FIG. **6** represents the most recent data sent from the vehicle's wireless appliance to the host computer system. Data sets sent at earlier times can also be analyzed individually or in a group to determine the vehicle's performance. These 'historical data', for example, can by used to determine trends in the vehicle's performance. In some cases data analyzed in this manner can be used to predict potential problems with the vehicle before they actually occur.

Referring to FIG. **7**, a web page **130** includes a historical data set **132** containing data parameter names **125'**, units **129'** and a series of data sets **127***a*–**127***c* transmitted at earlier times from the in-vehicle wireless appliance. Each of these data sets is similar to the data set **122** shown in FIG. **6**, but is received by the host computer system at an earlier time as indicated by a time stamp **140***a*–**140***c*. For example, the first two data sets **127***c*, **127***b* where transmitted with time stamps **140***b*, **140***c* of 11:42 and 11:52 on Feb. 12, 2001; the last data set **127***a* was transmitted the next morning with a time stamp **140***a* of 6:05.

Other embodiments are also within the scope of the invention. In particular, the web pages used to display the data can take many different forms, as can the manner in which the data are displayed. Web pages are typically written in a computer language such as 'HTML' (hypertext mark-up language), and may also contain computer code written in languages such as java for performing certain functions (e.g., sorting of names). The web pages are also associated with database software (provided by companies such as Oracle) that is used to store and access data. Equivalent versions of these computer languages and software can also be used.

Different web pages may be designed and accessed depending on the end-user. As described above, individual users have access to web pages that only show data for their particular vehicle, while organizations that support a large number of vehicles (e.g. dealerships or distributors) have access to web pages that contain data from a collection of vehicles. These data, for example, can be sorted and analyzed depending on vehicle make, model, odometer reading, and geographic location. The graphical content and functionality of the web pages may vary substantially from what is shown in the above-described figures. In addition, web pages may also be formatted using standard wireless access protocols (WAP) so that they can be accessed using wireless devices such as cellular telephones, personal digital assistants (PDAs), and related devices.

The web pages also support a wide range of algorithms that can be used to analyze data once it is extracted from the data packets. For example, the above-mentioned alert messages are sent out in response to a DTC or when a vehicle approaches a pre-specified odometer reading. Alternatively, the message could be sent out when a data parameter (e.g. engine coolant temperature) exceeded a predetermined value. In some cases, multiple parameters (e.g., engine speed and load) can be analyzed to generate an alert message. In general, an alert message can be sent out after analyzing one or more data parameters using any type of algorithm. These algorithms range from the relatively simple (e.g., determining mileage values for each vehicle in a fleet) to the complex (e.g., predictive engine diagnoses using 'data mining' techniques). Data analysis may be used to characterize an individual vehicle as described above, or a collection of vehicles, and can be used with a single data set or a collection of historical data. Algorithms used to characterize a collection of vehicles can be used, for example, for remote vehicle or parts surveys, to characterize emission performance in specific geographic locations, or to characterize traffic.

Other embodiments of the invention include algorithms for analyzing data to characterize vehicle accidents and driving patterns for insurance purposes; algorithms for determining driving patterns for use-based leasing; and algorithms for recording vehicle use and driving patterns for tax purposes. In general, any algorithm that processes data collected with the above-described method is within the scope of the invention.

In other embodiments, additional hardware can be added to the in-vehicle wireless appliance to increase the number of parameters in the transmitted data. For example, hardware for global-positioning systems (GPS) may be added so that the location of the vehicle can be monitored along with its data. Or the radio modem used to transmit the data may employ a terrestrial GPS system, such as that available on modems designed by Qualcomm, Inc. In still other embodiments, the location of the base station that transmits the message can be analyzed to determine the vehicle's approximate location. In addition, the wireless appliance may be interfaced to other sensors deployed in the vehicle to

monitor additional data. For example, sensors for measuring tire pressure and temperature may be deployed in the vehicle and interfaced to the appliance so that data relating the tires' performance can be transmitted to the host computer system.

In other embodiments, the antenna used to transmit the data packet is embedded in the wireless appliance, rather than being disposed in the vehicle's shade band.

In still other embodiments, data processed using the above-described systems can be used for: remote billing/payment of tolls; remote smog and emissions checks; remote payment of parking/valet services; remote control of the vehicle (e.g., in response to theft or traffic/registration violations); and general survey information.

Still other embodiments are within the scope of the following claims.

What is claimed is:

1. A system for interfacing with an on-board diagnostic computer in a vehicle, wherein the on-board diagnostic computer monitors a set of operational characteristics of a vehicle, the system comprising:

a wireless appliance which during use communicates with the vehicle's on-board diagnostic computer, said wireless appliance comprising a wireless communication component and a data-collection component, said wireless communication component configured to receive from a wireless network a schema identifying a subset of the set of operational characteristics that are monitored by the on-board diagnostic computer, said data-collection component configured to process the received schema and to collect from the vehicle's on-board diagnostic computer data for the subset of operational characteristics identified in the received schema, said wireless communication component being further configured to transmit said collected data over the wireless network to a host computer system.

2. The system of claim **1**, wherein the schema identifies an address of an operational characteristic for which data is to be collected from the vehicle's on-board diagnostic computer.

3. The system of claim **2**, wherein the schema comprises an address that describes a location of a diagnostic datum in a computer memory in the vehicle.

4. The system of claim **1**, wherein the host computer system is configured to transmit the schema.

5. The system of claim **1**, wherein the schema comprises a field that describes a time or frequency at which the data-collection component queries the vehicle's on-board diagnostic computer.

6. The system of claim **1**, wherein the schema comprises a field that describes a time or frequency at which the data-transmission component transmits data.

7. The system of claim **1**, wherein the schema is an ASCII or binary data file.

8. The system of claim **1**, wherein the system comprises a host computer system that includes at least one web-hosting computer that hosts an internet-based web site, and at least one, separate gateway computer that receives outgoing data and sends incoming data.

9. The system of claim **8**, wherein the internet-based web site comprises a first web page that displays a vehicle diagnostic datum.

10. The system of claim **9**, wherein the web site comprises a first web page that comprises data fields describing:

i) a name of a diagnostic datum;

ii) units corresponding to the diagnostic datum; and

iii) a numerical value corresponding to the diagnostic datum.

11. The system of claim **10**, wherein the first web page further comprises multiple sets of diagnostic data associated with a single vehicle.

12. The system of claim **11**, wherein the first web page further comprises a graphical representation of a set of diagnostic data.

13. The system of claim **9**, wherein the internet-base_ web site further comprises a database component.

14. The system of claim **13**, wherein the internet-base_ web site further comprises a login web page where a user enters a user name and password.

15. The system of claim **14**, wherein the database component comprised by the login web page is configured to verify if the user is associated with a first or second internet-based interface.

16. The system of claim **15**, wherein the web site comprises a web page that displays vehicle diagnostic data corresponding to multiple vehicles each associated with a single user.

17. The system of claim **8**, wherein the host computer hosts a web site on the Internet that displays the operational characteristics, wherein the web site comprises a web page that comprises a mechanism for sending the incoming data over the network.

18. The system of claim **17**, wherein the web page comprises a list of parameters that can be extracted from the vehicle's computer.

19. The system of claim **8**, wherein the gateway computer that receives the outgoing data packet and sends the incoming data packet is connected to the network.

20. The system of claim **19**, wherein the gateway computer is connected to a digital communication line that is connected to the network.

21. The system of claim **1**, wherein the operation characteristics include at least one of the following:

diagnostic trouble codes, vehicle speed, fuel level, fuel pressure, miles per gallon, engine RPM, mileage, oil pressure, oil temperature, tire pressure, tire temperature, engine coolant temperature, intake-manifold pressure, engine-performance tuning parameters, alarm status, accelerometer status, cruise-control status, fuel-injector performance, spark-plug timing, and a status of an anti-lock braking system.

22. The system of claim **1**, further comprising a secondary computer system that connects to the host computer system through the Internet and is configured to display the web site.

23. The system of claim **1**, further comprising a hand-held device that connects to the host computer system through the Internet and is configured to display the web site.

24. The system of claim **23**, wherein the hand-held device is a cellular telephone, computer or a personal digital assistant.

25. The system of claim **1**, wherein the host computer system is further configured to send an electronic mail message that comprises all or part of the vehicle diagnostic data.

26. The system of claim **1**, wherein the wireless appliance is configured to send an outgoing data packet that indicates a vehicle's location.

27. The system of claim **26**, wherein the host computer system comprises software that analyzes the vehicle's location and displays it on a map.

28. The system of claim **27**, wherein the web site comprises a web page that displays the map.

29. The system of claim **1**, wherein the data-collection component is configured to repeatedly collect said data from

the vehicle's on-board diagnostic computer data at times determined by a first schedule.

30. The system of claim **29**, wherein the first schedule is specified in the schema.

31. The system of claim **1**, wherein the wireless communication component is configured to repeatedly transmit the collected data over the wireless network to a host computer system at times determined by a first schedule.

32. The system of claim **31**, wherein the first schedule is specified in the schema.

33. A system for monitoring a set of vehicles, the system comprising:

a host computer that hosts a web site that receives operational characteristics transmitted wirelessly from the set of vehicles, said web site programmed to enable a user to display on a first web page the operational characteristics of a single vehicle selected from among said set of vehicles and to also display the operational characteristics of multiple vehicles among said set of vehicles on a second web page, said multiple vehicles associated with a single entity.

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