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REVOLUTION OF REMOTE DIAGNOSIS IN AUTOMOBILE SECTOR

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ABSTRACT

The modern automobiles are intelligent and equipped with inter and intra-communication tools. Electronics had found its own logical space in an automobile, making it more controllable and driver-friendly. With the onset of solutions like Remote Diagnostic Server (RDS), Gateways etc., the remote diagnosis for safety critical systems has become very easy, enabling the needed vigilance of a particular item under observation round the clock. This paper would bring out the trends and updates of this technology with the focus on automobile.

Keywords: reliability, vigilance, embedded, diagnostics, etc...

INTRODUCTION

As electronic systems in cars become more complex, reliability becomes harder to achieve. The more complex a system, the more failure points it offers—and today's separate systems are being networked together in ever more complicated arrangements. With point-to-point wiring giving way to control and power buses, the possibility of massive failures that affect the whole car, not just individual functions, arises. New functions often require new technologies, which in the beginning may be less reliable than more developed ones [1].

The growing reliance on software raises more issues. Every software professional knows, software is far more likely than hardware to fail, and rebooting is impractical and tedious. Hence automotive software modules must communicate and coordinate with one another. For hardware, the environment is more demanding. Space constraints place Electronics near heat generating elements. Two decades before, the highest junction temperatures recorded were 150 °C and those systems required higher reliability. So IC manufacturers began qualifying their products for 175 °C to meet the variations across average [2]

The temps deep inside vehicle may raise further, driving IC makers toward devices qualified for 200 °C operation. Should even higher temperatures be required, liquid-cooling systems may be added to electronic modules. More electronics means more risk from externally generated electromagnetic interference (EMI) and from EMI generated by systems in the vehicle that are adjacent or interconnected. The effects can be quite serious: some reports say that on certain highway overpasses in Europe, the engines of some vehicles have been shut off when their control units encountered high EMI levels from, among other things, high-voltage lines beneath the roadway [3].

These problems must be identified and corrected before the vehicle goes into production. Because of these risks, the auto industry is re-evaluating its requirements and testing for new sources of EMI. Suppliers are increasingly relied upon to develop expertise in managing potential risks during the early stages of engine control unit development. And the growing use of optical-fiber data buses is eliminating one possible source of EMI problems. Voltages will rise in the next decade or so, as vehicles move up from 14 V provided by today's 12-V car battery to 42 V from a 36-V battery, or to dual voltage systems. But voltage spikes, surprisingly, may become less troublesome [4].

Even with equipping an Automobile with ECUs connected with a high-speed, EMI immune bus; it requires the continuous monitoring of the Electronics built inside for various controls. The post fault maintenance taking to Garage has become outdated with the onset of Telematics and Remote Diagnosis. One of the major benefits of remote diagnostics is the ability to collect important data about how the vehicle is operating on the road. Each year the world's carmakers spend billions of USD to satisfy warranty claims. Timely diagnostic data would lead to better forecasting of oncoming service problems. Rather than basing regularly scheduled maintenance on mileage alone, service could be more accurately targeted towards known problems before they occur, possibly reducing the number of service visits required.

This paper brings out the various facets of this technology and service providers in the market with relevant data.

• Brakes
• Suspension
• Oil & other fluid levels
• Steering
• Air conditioning
• Engine
• Lights & exhaust
• Tire pressure
• Coolant

REMOTE DIAGNSOIS USING BLUETOOTH

For short-range diagnostics, Blue tooth technologies provides a boon. From Technician point of view, the front-end of the network is a Telematics control unit (TCU) that bridges together the various networks in an integrated networked vehicle (INV). The automotive industry is moving toward a centralized service gateway model for the INV, and Blue tooth technology [1] provides a connectivity solution for links in this network. The details of Gateway are described in following sections. It complements the established controller area network (CAN) bus by providing wireless links and ad hoc networking.

Inside the vehicle, the high-reliability communications among systems that affect vehicle performance and safety is securely handled by the CAN bus. High speed CANs are used to connect engine control units (ECUs), Antilock Braking Systems (ABSes), Yaw Stability Control and other critical systems. Low-speed CANs are often used to implement multiplex wiring, in which lamp clusters, power windows and power seats, are nodes on a CAN bus, rather than being connected by traditional point-to-point wiring with large and expensive harnesses. The architecture for a short range remote-access diagnostic interface based on Blue tooth technology, where Blue tooth networking protocols provide the underlying transport (physical) medium from an HTTP to CAN gateway. With an embedded HTTP server running on the TCU, a service technician can monitor and control nodes on the INV from a Web browser running on a Blue tooth-enabled laptop computer. The operational Range could be extended upto 100 m with transmitter power value 100 mW (20dBm) .

DIAGNOSIS BASICS

Remote Diagnosis is a method of monitoring of real time Vehicle Parameters from distance using advanced Telematics, to ensure Vehicle Health status and condition. The remote diagnostics station equipped with Telematics Service Providers (TSP) equipment, that analyses the data to make sure vehicle are in the good condition, else an automated maintenance & repair report will be issued. There are various TSPs in the market to support the Remote Diagnosis for an automobile.

The following are the various vehicle parameters monitored by Remote Diagnostic Station (RDS).

The wireless interface provides convenient access from beneath the vehicle, under the hood or inside the passenger compartment. The system described here uses Blue tooth's dial-up networking profile to emulate an external modem and support a Web browser that dials into the vehicle's CAN. By using standard communication protocols such as TCP/IP and embedding the vehicle-specific software in the HTTP server, the technician's hardware and software would be completely scalable across vehicle designs even if the maintenance and repair procedures were radically different among manufacturers and model years.

Figure 2 shows the network architecture of a car's in vehicle network accessed using a Blue tooth-based diagnostic system. A Web browser on a conventional Blue tooth-enabled computer is used to access the TCU, which provides a user interface to the car's networks. By embedding the diagnostic interface in the vehicle itself, the manufacturer can customize the presentation of data and procedures presented to the technician. Diagnostic procedures that are specific for the set of option installed in a particular vehicle can be provided.

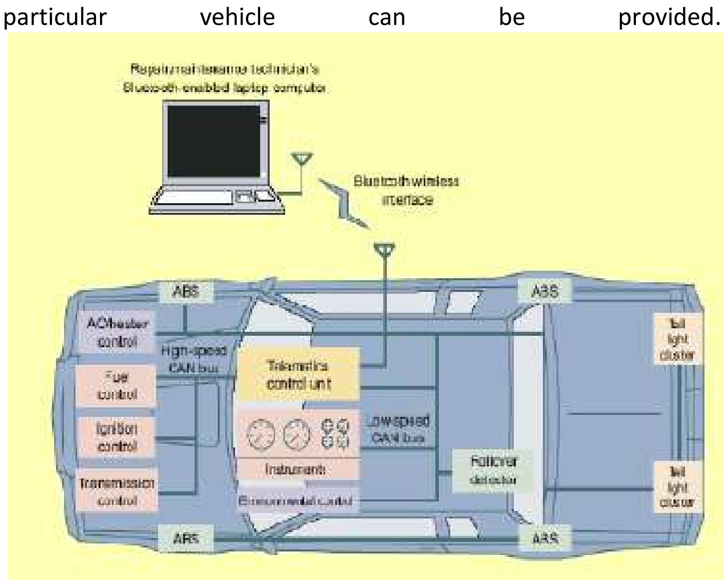

Fig.2 Network Architecture of a Car's in Vehicle Network Accessed Using a Blue Tooth-Based Diagnostic System

A customized vehicle-specific diagnostic interface reduces the chance of a technician becoming confused and applying incorrect procedures. The interface can be used to access real-time operational data while the car is running and historical data from controllers that logs unusual events, such as engine misfires and out of-range sensor data. The controller can also be used to override the vehicle's sensors for testing purposes—e.g. to verify that the emission control mechanisms react correctly to sensor input. The diagnostic system could also recover data for the auto manufacturer and develop models of indicators of a failure. By uploading data logs from flash memory and correlating those logs with failure reports from technicians, learning algorithms could optimize automatic diagnostic tools. The incentive for maintenance and repair facilities to provide this information is assistance in vehicle diagnosis. Uploading the flash data should be the first action to take when a problem is encountered because the manufacturer's soft- ware tools will often be able to diagnose it (or provide useful suggestions) before the costly services of a skilled technician are employed.

USAGE OF GATEWAYS IN REMOTE VEHICLE DIAGNOSIS

The Automotive industry felt the need of a device which takes care of software application downloading and diagnostics of various Electronic Control Units (ECUs), connected over CAN bus in a vehicle.

The typical gateway device is a portable module with embedded applications built in it, for handling the software download and diagnostic sessions. Figure 3 shows the block schematic of Gateway connected to a Test bay and a Vehicle.

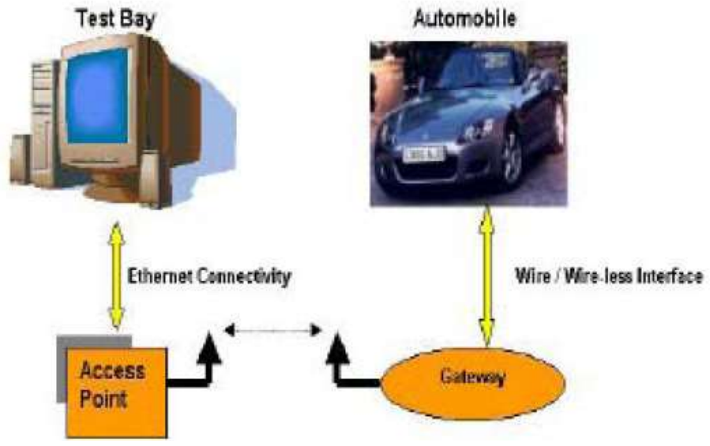

Fig.3 Block Schematic of Gateway Connected to a Test Bay and a Vehicle.

The Gateway allows a Test engineer to directly download the required applications to ECUs in the vehicle and monitor the success and failure of various parametric functions in an automobile. The gateways have the RF interface to Test bay as well as the automobile.

REMOTE DIAGNOSIS TOOLS AND ARCHITECTURES

TEAMS TOOL SET

QSI's integrated toolset [2] comprising of TEAMS™ (Testability Engineering and Maintenance System), TEAMS-RT™, TEAMATE™ and TEAMSKB/ KB-lite™ captures the users' knowledge of the system in terms of models to automate the testability and reliability analyses, and to perform on-line monitoring and off-line diagnosis tasks. TEAMS is a graphical software tool for diagnostic model development and analysis that integrates a unique multi-signal flow graph modeling methodology and various analysis techniques for performing testability analysis and design for testability. Various testability figures of merit (TFOMS) are also generated. TEAMS has been used for testability analysis of large systems containing as many as 50,000 faults and 45,000 test points. TEAMS minimizes the life-cycle cost of a system by aiding the system designer and test engineer in embedding testability features, including "built-in-test" requirements, into a system design; and by aiding the maintenance engineer by developing near optimal diagnostic strategies.

TEAMS KEY FEATURES

- Separation of the system-specific knowledge, captured in terms of models, from the fault isolation methods. This allows for the same tool to be used on multiple systems using different models.
- Ability to diagnose multiple failures in fault-tolerant systems with multiple modes of operation.
- Ultra-compact memory requirements: only about 2 MB for two subsystems with 1000 failure sources and 1000 test points each.
- Excellent performance using low-end microprocessors (e.g., less than 200ms for the above-mentioned system on a 75MHz Pentium processor).

TEAMS is used basically to:

- Model individual subsystems and integrate them into system models,
- Analyze and quantify testability of systems and subsystems, visually pinpoint the diagnostic inefficiencies of a system, and make recommendations towards the design of completely testable systems,
- Provide a comprehensive aid to automate the generation of FMECA reports,
- Generate near-optimal diagnostic procedures for a variety of realistic testing options.

TEAMS Remote Diagnostic Server (RDS) can be used for remote health management and tele-maintenance in enterprise applications such as maintaining a fleet of vehicles, or in support of an aftermarket service contract. Running across the world or across the room, over the Internet or a local intranet, TEAMS-RDS collects diagnostic information gathered from the equipment, performs diagnostics, serves the intelligent (dynamic) procedure, and manages the health of the system. The RDS solution scales-up to hundreds, even thousands of clients and it scales-down to run embedded on a PC controller, stand-alone laptop, or tablet PC.

RDS users can upload sensor/test data over the Internet, have it automatically processed through the intelligent model based reasoner and see the resulting diagnostics on a web page in a matter of seconds. They can launch intelligent, dynamic procedures to isolate faults, perform maintenance, and verify the operational integrity of the system.

All the diagnostic results, test outcomes, and procedure steps taken during the maintenance are logged in RDS for later analysis or display during future maintenance activities. This dynamic procedure can be optimized for cost and time and it will account for any resource constraints (e.g., availability of test equipment) either listed in a stored site profile or input by the technician. All these automatic capabilities are based on TEAMS model of the system, thus eliminating the need for the group of experts offline as required by some current remote diagnostic/monitoring systems.

Thus, TEAMS is mainly a design for testability (DFT) tool, but its (pre-computed, and, hence, static) diagnostic procedures can be embedded into Interactive Electronic Technical Manuals (IETMs) and Automatic Test Equipment (ATE).

Figures 4 and 5 depict the screen shots of TEAM RDS system.

Fig.4 The Screen Shots of TEAM RDS System.

RDS ARCHITECTURE

The RDS is built around Broker Architecture. The reason is; real-time fault detection and isolation solution is essential to faster, cheaper and better operations of complex systems. In an effort conducted with NASA-ARC in 1996, development of a model-based reasoning engine, TEAMS-RT, for the detection and isolation of multiple faults took place. The key features of TEAMS-RT are described in the above section.

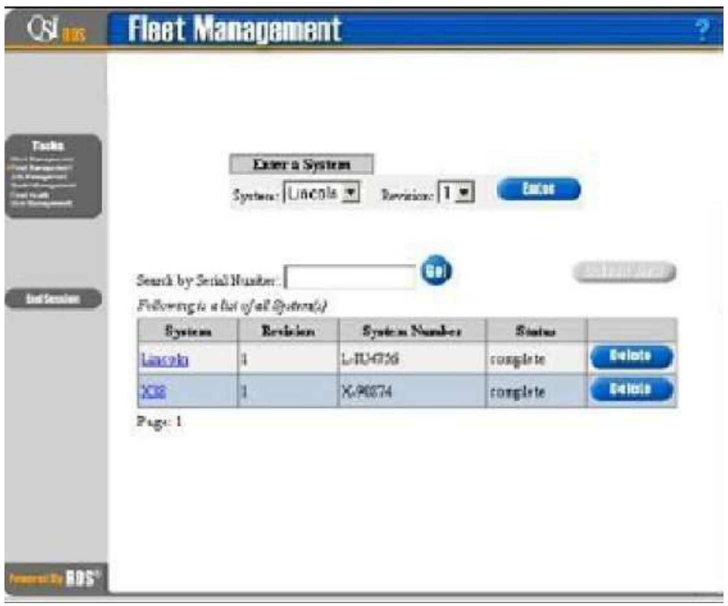

Fig. 5 The Screen Shots of TEAM RDS System.

The automotive data stream is near real-time, and consists of detailed sensor data from multiple subsystems on board. A real-time remote monitoring solution can be realized that utilizes this telemetry data to monitor the health of the various subsystems. The benefits of an onboard solution could be demonstrated without having to actually install any software on. The modern automobile has plenty of sensors, and some models even have wireless communication links (e.g., OnStarTM systems).

All of these systems could benefit from a tele-diagnosis capability, where remote data-streams from multiple subsystems are processed by offsite analysts for diagnosis and prognosis of the remote system(s). Implementation of such a tele-diagnosis server system is significantly cheaper than embedding reasoners in the subsystems, and would pay for itself by the savings realized from reduction of service calls by technicians.

THE RDS FRAMEWORK/SCHEME

The scheme of basic RDS is shown below using TEAMS tools set [3].

The RDS framework or scheme is a three-tier scalable server architecture consisting of a middle layer (called "broker") that performs session management, flow control, message buffering and routing, and load balancing. The back ends are server products based on TEAMS-RT (for real-time diagnosis) and TEAMATE (for interactive diagnosis) and a database backend built around TEAMS-KB. The reasoning is model driven, utilizing multi signal models developed in TEAMS. Thus, the RDS framework makes QSI Integrated Diagnostic Toolset consisting of TEAMS, TEAMATE, TEAMS-RT and TEAMS-KB accessible over the Network to any communication capable system in need of diagnosis. Network to any communication capable system in need of diagnosis.

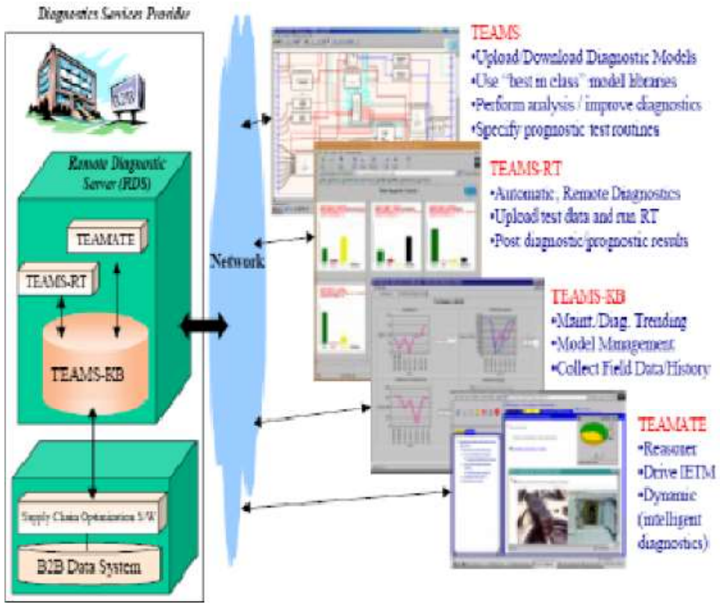

Fig.6 RDS Framework Makes QSI Integrated Diagnostic Toolset Consisting of TEAMS, TEAMATE, TEAMS-RT and TEAMS-KB

PROVIDERS OF REMOTE DIAGNOSTICS SERVICES IN GLOBAL MARKET

Toyota is providing customers who have opted for the G-Book Telematics service a simple remote diagnostics feature. When a trouble light comes on, data about which light is tripped is automatically sent to Toyota's G-Book call center. At that point the call center can send a message to the vehicle to let the driver know if there is a serious problem and suggest that the customer contact his dealer. G-Book sends the dealer's name, location and phone number to the vehicle display, including button that the customer can press to contact the dealer. The dealer could also be equipped to remotely access the diagnostics connector.

So far about 3,000 LS430 vehicles have been sold; 70% of the buyers have opted for G-Book. In the next five years, Toyota will add more remote diagnostics capabilities."Remote diagnostics is one of the most important Telematics functions," as, told by Mr. Keiji Yamamoto, general manager of Electronics Engineering Division. The names given below are the major players in the global market [4].

ONSTAR

Toyota. Launched in the fall of 1996, OnStar has been providing a limited remote diagnostics feature for years. OnStar remote diagnostics, re-branded GM Good wrench Remote Diagnostics in April 2003 to take advantage of Good wrench name recognition, is available to OnStar subscribers with model year 1997 and later vehicles. If the check engine light comes on or a strange sound is heard, with the press of a button subscribers can access a live operator at the OnStar call center, who can download the vehicle's trouble code and advise the driver whether she should continue driving or find a safe place to stop while waiting for assistance.

In the States, OnStar is available on 46 GM models plus an additional 22 models from Acura, Audi, Isuzu, Saab, Subaru and Volkswagen. OnStar receives roughly 15,000 remote diagnostics requests per month. At the end of 2003, OnStar had more than 2 million subscribers. Consumers pay a minimum of $16.95 per month for OnStar once the initial year of free service expires.

NETWORK-CAR

San Diego, California-based Networkcar is a remote diagnostics/location service serving both consumers and fleets. Consumers are reached through franchised car dealers, which sell Network car hardware and subscriptions. Service is provided by means of an embedded GPS receiver and thin-client communications device connected to the vehicle's OBD II connector. Network car automatically downloads trouble codes, location and other vehicle data from the vehicle for analysis and posting on a Web site that can be accessed by both the consumer and the car dealer.

VETRONIX

Founded in 1984 and located in Santa Barbara, California, Vetronix is a leading maker of service bay diagnostic tools. With customers including General Motors, Toyota, Honda and Nissan, Vetronix was one of the first companies in the world to develop scan tools, which plug into the vehicle and are used to read and interpret engine trouble codes and other diagnostic data. Forty percent of all vehicles manufactured worldwide are serviced by Vetronix products.

BMW

BMW is collaborating with Telematics service provider ATX Technologies in Germany and the States on the launch of Teleservice, a new BMW remote diagnostics program that informs the customer and the dealer when it is time to schedule a service appointment. Data from the vehicle— for example, that it needs an oil change, brake pads, and filters or is approaching a scheduled emissions check—are wirelessly sent to the ATX customer service center, which forwards the information to BMW. BMW then e-mails that data along with the vehicle's mileage, battery voltage, water temperature, and other status information to the customer's pre-selected dealer, who calls the customer to schedule an appointment.

With the advanced notice, the dealer can order any necessary components ahead of time so the customer gets his BMW back more quickly.

IBM

IBM, which develops software for both telematics devices and telematics infrastructure, is one of the major promoters of telematics applications worldwide. The company has been working on several pilot remote diagnostics programs in Europe and the States. For example, IBM is providing the underlying software architecture for a device (being manufactured by Celestica) that will be embedded in vehicles to collect data to help the U.K. auto insurer Norwich Union assess the insurance risk of cooperating drivers. Those drivers would pay insurance premiums adjusted to reflect the way they actually drive, so called "pay-as-you drive" insurance. Among the data collected for analysis: speed, time-of-day, location, and in the event of an accident, data from the airbag diagnostic module. In the initial stages of implementation, a total of 5,000 vehicles will be equipped with the telematics device.

CONCLUSION

Remote Vehicle diagnostics (RVD) is gradually emerging as a potentially inevitable next step in the technological progression of the automotive industry, with the promise of reduced outlay on warranty, product development and marketing.

Further benefits of the emerging RVD technology will be manifested in the creation of competitive advantage through product differentiation and the ability to provide improved after-sales service and support to customers.

However, due to the technology's nascency, vehicle manufacturers are cautious to announce ambitious plans concerning the introduction of RVD and associated services. A number of technical and commercial issues such as prohibitively high infrastructure costs (particularly telecoms), the management of technological obsolescence of component technologies and limited bandwidth, remain unresolved and must be addressed to enable the technology to fully evolve and flourish.

Apart from vehicle manufacturers, the vertical value chain participants are likely to drive the standardization of communication protocols, software components and in-vehicle networks.

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