Interoperability Optimization and Service Enhancement in Vehicle Onboard Infortainment Systems

***Abstract*—This paper presents an overview on optimizing interoperability between different applications for enhanced return-on-investment through utilization of business intelligence in conjunction with prognostics and health management methodology. Such implementation is particularly suitable for deployment in mass-produced vehicle onboard diagnostics system.**

I. Introduction

Onboard diagnostics (OBD) systems become an integral part of modern motor vehicles. While OBD serves the main purpose of vehicle health monitoring and diagnosis, numerous additional features are also supported for both vehicle service centers and owners. The formal benefit from additional revenue generated from enhanced servicing efficiency and reduction in spare parts stock inventory and the latter enjoy a wide range of multimedia infotainment services as well as drivers' health monitoring [1].

The OBD is configured to simultaneously support .different applications for both vehicle service centers and end users on optimizing return on investment (ROI) and health management for both driver and motor vehicle. A prognostics framework using data collected from sensors mounted in different parts of the vehicle and accompanying accessories is proposed to analyze the actual use profile to more thoroughly address the optimization of operational reliability [2]. The proposed framework is optimized for mass-produced vehicle onboard diagnostics systems with a focus on maximizing return-on-investment (ROI) for vehicle service centers.

II. Prognosis and Diagnosis

A. Vehicle health

The condition of a motor vehicle has a direct influence on the operation of a service center. Prognosis allows services parts to be ordered in advance so that inventory can be kept to a minimum without overstocking parts that may eventually become obsolete [3]. An OBD is connected to a sensing network that continuously monitors vehicle health and safety parameters.

B. Driver health

Using a range of biosensors and wearable devices, various signs that may impair driving capability such as drowsiness, blackout and intoxication of the driver can be monitored [4].

C. Business intelligence

The OBD collects failure codes from individual vehicles, and generate a detailed description of the associated fault so that the health of the vehicle can be remotely assessed. Necessary replacement parts are ordered based on diagnostic information. Any anomaly triggers an alarm for emergency response. Prognostics is carried out by continually monitoring components that are subject to tear and wear and are measured against certain predefined baselines. This facilitates the service center track individual vehicle's use conditions and suggest the optimal service interval based on actual usage profile. The collected data can also can provide more customized service solutions to their clients through business intelligence technology and supports the development of a systematic approach to customer relationship management (CRM) [5].

D. System layout

The overall infotainment system consists of several wireless communication subsystems for both intra-vehicular and vehicle-to-infrastructure communications as shown in Fig. 1.

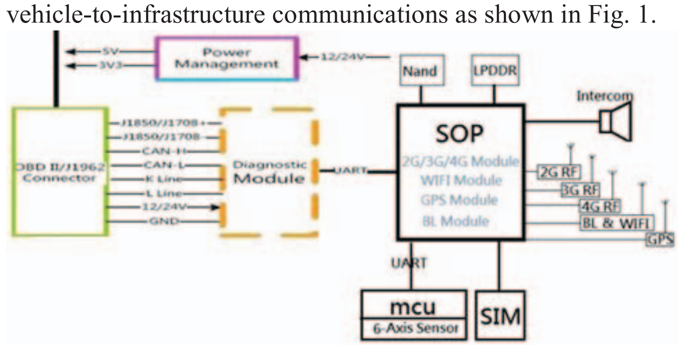

Fig. 1 OBD and infotainment system

.One of the major functions of the OBD is to obtain failure codes from various key modules of an individual vehicle, and generate a detailed description of the associated fault so that the driver can be well-informed of health of the vehicle. Any abnormal readings received by onboard sensors can be sent back to the service center for problem identification and isolation. Interoperability possess great challenges for OBD service integration since different infotainment services provided by different entities may have different QoS requirements while collecting and delivering information through the same system [6]. Both wireless and wired sensors connected to different subnetworks in the vehicle share the same OBD system resources.

III. RELIABILITY AND INTEROPERABILITY

Consumer electronics part suppliers usually carries out qualification tests in the design and development phases of the product development cycle [7]. Tests for automotive applications entail environmental tests of reflow soldering test, thermal shock test and temperature cycle test that may take months to complete. Further, different quality of service (QoS) standards may apply to different components and subsystems where interoperability is considered. Mainstream method for predicting the future reliability of automotive electronics is by conducting accelerated life tests at high temperature for continuous operation in the engine bay to estimate the time-dependent degradation functional curve fitting under various test conditions [8]. Interoperability may also require certain subsystems to comply with the ISO/TS 16949 and/or 26262 standards. Using a combination of physics-of-failure (PoF) and data-driven approach as shown in Fig. 2, reliability assessment facilitates utilization of data-driven approach for anomaly detection and isolation of the attributes associated with interoperability that can be used in the relevant PoF models for degradation profiling [9]. Correlation between the fused data and impeding failure can be used to forecast any failure that may affect the operation of other subsystems.

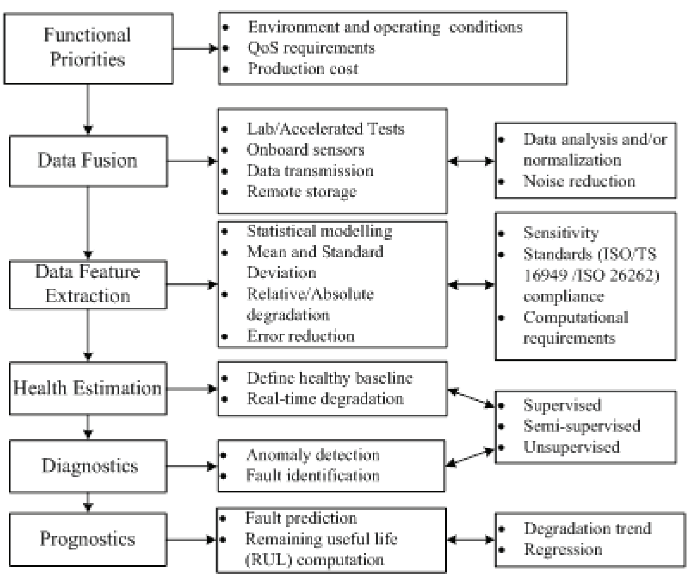

Fig. 2 Continuous reliability assessment process

IV. BUSINESS INTELLIGENCE

TABLE I
BUSINESS INTELLIGENCE FOR INFOTAINMENT SYSTEM

Automobile Manufacturer	After-Sales Service Center
Intermittent failures isolation	Condition-based Maintenance
ROI optimization	Manpower utilization
Reliability qualification	Service appointment scheduling
Root cause analysis	Spare parts management
RUL computation	Warranty

Data collected from the onboard infotainment system allows motor vehicle manufacturers and service centers to provide more customized service and enhanced business opportunities.

Prognostics provides servicing information on necessary spare parts to be scheduled for replacement based on the actual condition that leads to the reduction of spare parts required to be stocked. Information on spare part replacement schedule reduces stockholding as parts are replaced as they are arrived. Business intelligence (BI) yields substantial simplification of the supply chain for inventory [10]. As a result, one can have a better estimation of system redundancy requirements. Data fused from the infotainment system also facilitates condition-based monitoring for the motor vehicle to minimize the need for unscheduled maintenance and redundant inspections due to no fault found. BI will optimize reliability and enhance maintainability by analyzing data for accurate fault diagnostics thereby enhances maintenance effectiveness and operational costs. Any fault developed can be isolated and RUL assessment of vehicle parts can be computed.

With better awareness of individual vehicle's health state, service centers will handle less unscheduled repair that translates better resource management and warranty planning.

V. CONCLUSIONS

Vehicle onboard infotainment systems not only provide useful information for consumers while operating their vehicle but also provide important information that enhances profitability through effective utilization of business intelligence technology and reliability analysis. The mutual benefits brought to both consumers and automotive industry minimizes vehicle downtime while improves customer satisfaction as well as return-on-investment.

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