ReDi2Service (Remote Diagnostics Tools and Services)
Technical research

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There is a high demand for better tools for wear and maintenance prediction on vehicles and services connected with these. The ReDi2Service project is aimed towards developing distributed embedded agents for fault detection, fault isolation, diagnostics and wear prediction. This abstract describes the technical part of the research conducted in this project.

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1. Background and Motivation

The last decades have seen a very strong development in vehicle electronics. A modern car, truck or bus has a large number of embedded processors and computers on-board. The vehicles have field buses (e.g. CAN) where system signals (sensors, control commands, fault codes, etc.) are communicated all the time. Software agents embedded into the hardware on the vehicles can listen to these signals and learn the typical patterns of these signals and detect deviations from the normal, provided that the vehicles have a possibility to represent and communicate their signal patterns with each other or with back-office applications that can summarize the fleet behavior. The back-office application can be connected to maintenance databases and thus learn how different deviation patterns are associated with specific faults.

Traditional approaches to condition monitoring of vehicles (and other equipment) have all very much the same approach; a reference model is built off-line, based on expert knowledge and data from test runs, verified and then implemented on-board. Building such models is expensive in terms of man hours and experiments and compromises have to be made since it is not economically possible to model all usage profiles and all climate conditions. Also, the traditional approaches require that faults are thought of beforehand and that accurate models of the systems can be built – models that are accurate also under faulty conditions. Utilizing telematic technologies it is possible to envision a solution where a large number of vehicles are monitored in real-time, with embedded software agents on the vehicles, and thus can fleets of vehicles be used as a "real time laboratory" where the operation of the equipment is monitored under real usage conditions and "normal" behavior is determined from groups of similar vehicles. The idea is to have a self-discovering system; a system that learns how equipment wears and breaks, by observing the equipment over a long time.

2. Methodology

The project has both a hardware and software aspect. The hardware aspect is the development of a hardware (VACT) that listens to the data streams on the vehicles (city buses and/or heavy load trucks) and the telematics gateway for transmitting the information to a back-office application. The software aspect is both the software running on the "clients" (i.e. in each VACT module), the embedded agents and the software in the back-office application.

The technical algorithmic methodology is a mixture of machine learning and statistical methods. The fault detection problem can be split into three separate (or semi-separate) parts:

- finding the interesting signals and relationships to monitor (not requiring an overview of all vehicles);
- comparing these relationships (with an overview of all vehicles);
- and then to determine which systems that don't behave normally.

These issues were explored in a previous project, Remote Diagnostics and Monitoring (RDM), that lead to the ReDi2Service project. The diagnostics and wear monitoring problem can be approached with both an active and a passive approach:

- passive – observe parameter relationships over time (on the fleet, on test vehicles, in simulations) and build up a knowledge base that is then used for, e.g., case based reasoning, pattern recognition, etc.;

- active – download software onto the vehicle for specific fault finding, or start a simulation off-board (at the back-office) and try to replicate the observed deviation. The latter requires high quality simulation models and it is questionable if these exist today.

There are several research questions in this, e.g. how to autonomously determine "interesting" relationships to monitor without knowing what a fault looks like, how to determine which systems that deviate, analyzing if this could replace traditional (expert driven) monitoring approaches, how to do the diagnostics with a distributed intelligence approach (i.e. how a fleet of vehicles can be used to build diagnostic models and aid in the search for a fault).

3. Results

A new hardware system (VACT) for listening to signals on-board vehicles has been designed and built, intended to be used for an approximately 2-year longitudinal study on city buses (end of 2011 until end 2013). The system is currently installed and logging data from 16 buses at a bus operator in Kungsbacka. Service records are collected continuously for these vehicles for matching with observed deviations in onboard data. Observed deviations on some components have so far been noted manually, and there is current ongoing work with validating the deviations (i.e. determining the true cause). A fault injection experiment is planned to be conducted on a separate bus during the Spring of 2013 to further help verify the behavior of certain components when they are exposed to wear or damage.

PARTNERS AND SPONSORS

The project is done in cooperation with Volvo Technology, and the project manager is Niclas Karlsson. The project external sponsors are Volvo GIB-T, VINNOVA and the Knowledge Foundation.

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