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PLATFORM HEALTH MANAGEMENT INFORMATION SHARING VIA SERVICE ORIENTED ARCHITECTURE

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ABSTRACT

Sharing platform health information in a disconnected environment requires the use of design strategies that consider the various systems that must participate in the creation, processing, and consuming of component health information. Using a common representation of a vehicle structure, platform health can be calculated, predicted, and communicated to end users at all levels of the enterprise. Implementing a Service Oriented Architecture (SOA) using a Grid Services approach enables a central application to manage and share data as needed; performing data integration, data cleansing, and data normalization. This design pattern facilitates holistic collaboration for platform health management on-platform, at-platform, within the tactical domain, at the national level, and at the OEM location.

INTRODUCTION

Platform Health Management (PHM) is most effective when viewed as a collaboration of engineering activities, system responses, operator interaction, support operations (e.g. maintainers and logisticians), and lifecycle fleet management decision analysis. Each of these key inputs affect the readiness and up-time of a system, however information sharing between organizations is often hampered by temporal, spatial, and informational context gaps that dilute the integrity, usefulness, or understanding of critical information. Following the Department of Defense (DOD) Modular Open Systems Approach (MOSA) [1] and enacting principles of a Net-Centric Architecture provides an enabling environment to overcome the barriers of current stove-piped systems for a collaborative approach to platform health management (see Figure 1).

PLATFORM HEALTH INFO SHARING

Reliability Centered Maintenance (RCM) [2] has been adopted by the US Army as a means for improving the overall availability of Army assets in the field, thereby creating a more effective force presence. RCM begins as an engineering activity, but must be embraced as a culture for lifecycle sustainment to be most effective – it requires the participation of all those who support the warfighter in assuring that their equipment is available to perform each mission.

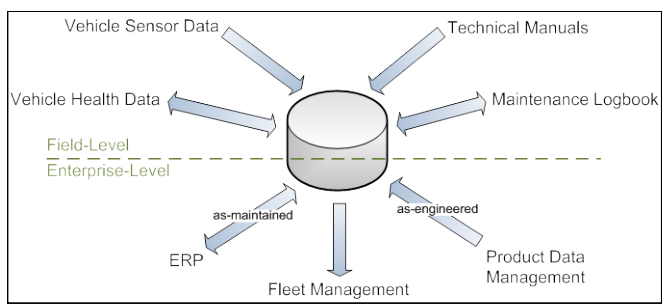

Figure 1: Integration of RCM enabling data

Many techniques have been attempted to implement RCM, from vehicle-level diagnostics to fleet-level analysis and manufacturing improvements from the OEMs. However, in order to effectively perform RCM, all of these efforts must be tied together in a seamless information sharing environment to provide near real-time analysis opportunities of failure and diagnostics data. Until now, the ability to bring these information sources together has been hampered by a lack of connectivity and disparate data representations on vehicle platforms. Several complementary initiatives within the Army over the past few years have converged within the Common Logistics Operating Environment (CLOE) Threshold Capabilities Implementation (TCI) effort. This activity has developed an approach for a common platform health information sharing environment that solves many of the problems that have persisted and provides a framework to enable the development of RCM-focused applications.

Inconsistent Data Representation

One of the primary issues with sharing platform health information has been that each platform and embedded system collects and uses its own representation of the data. Aside from a small number of standards in use by a limited set of systems, most vendors create their own data representation tailored to the needs of their system, and optimized for their operating environment. While this provides efficient processing at each individual component, it does not lend itself well to the sharing of this information with other stakeholders.

Limited Connectivity

Due to the mobile nature of vehicle platforms, a connectivity problem arises when attempting to share platform data with other systems in the enterprise. Unless data can be effectively transmitted, full RCM capabilities cannot be realized. In addition to dealing with the limited connectivity nature of vehicle platforms, a communication solution must also take into account security and efficiency when dealing with the information coming from the platforms. At times, the information being collected by vehicles and fielded maintenance systems may be considered sensitive or classified and the system must ensure all information assurance requirements are met with data isolated or sequestered where necessary. Additionally, due to the small bandwidths available in the deployed environment, the solution must be able to compress data and identify the most important changes to information in order to prioritize data transfer.

INTEGRATED RCM APPLIED

A solution for sharing platform health management data that overcomes the above obstacles uses a combination of software and architecture design patterns that have a proven track record in industry. This approach is compliant with current Army regulations and guidance and has been proven in lab environments and demonstrations for the Army.

Compliance with DOD Mandates and Regulations

The Army's Net-Centric Checklist [3] provides guidance on the open industry standards for net-centric information sharing that are articulated in the DOD Information Technology Standards Registry (DISR) [4]. The Modular Open Systems Architecture (MOSA) consists of establishing an enabling environment for modularity, identifying key interfaces, and determining which key interfaces should utilize open industry standards. Modularity around standard industry interfaces is essential to sharing information between systems without borders protected by proprietary boundaries. Additionally, modularity around open standards enables evolutionary replacement of material solutions without affecting all remaining applications in the system. All solutions described here utilize design patterns and technologies that have been approved by the DOD for use in Army vehicle fleets.

Common Information Representation

The first step in enabling the sharing and collaboration of this information is to develop a common representation of data across the stakeholders – i.e. employ a Canonical Data Model [5][6]. This model establishes associations between information gathered by stakeholders so that it can be analyzed in a manner that is useful to all stakeholders at all levels. This standard Canonical Data Model is a common ontology exposed to all stakeholders and must take into account the needs of each system at each node. It must be broad enough to incorporate all necessary data yet efficient enough to be used on systems with limited resources and communicated across channels with limited bandwidth. In today's world of "plug and play" components, the model must also be represented in a standard form that can be utilized by new systems as they become available.

The Army Logistics Innovation Agency (LIA) working with Program Executive Offices (PEOs) and Program Managers (PMs) in the ground, aviation, and enterprise business system communities under the Common Logistics Operating Environment (CLOE) initiative have coordinated the development of such a canonical model using an open, industry standards-based data schema. The schema can be used to store and communicate all types of information necessary to perform RCM, including Condition-Based Maintenance, at all levels of the Army environment. This provides a lifecycle view of data that encompasses engineering activities, system responses, operator interaction, support operations, and fleet management decision analysis in a cooperative effort.

The developed model incorporates all aspects of platform health management deploying answers to the seven questions of RCM[2] within an expression structure including: platform function tree, fault tree, fault impact data, physical product structure, failure detection details, reliability data, maintenance action information, supply data, parametric sensor data collection, unit/organization data, and more. Each of these elements contains well defined relationships to other elements where necessary so that the impact of any change to the data is known and communicated across the enterprise. Therefore, universal information context is established at the point of creation where it maintains original integrity. This model can be utilized efficiently throughout the enterprise, from the vehicle to a portable device to a data warehouse, and ensures that all stakeholders have a common view and understanding of the data contained therein.

Communication of RCM Data

In order to meet the needs of the communication environment in which these platforms operate, an effective solution leverages a Service Oriented Architecture (SOA) approach utilizing the Grid Service pattern [7]. The Grid Service pattern provides high scalability and fault tolerance by providing local copies of the state of data at all nodes on which it is deployed. This allows the business functions to remain available to users based on the last set of information prior to a connectivity loss

Under the CLOE TCI effort a distributed service application solution that implements this grid service has been shown to be deployable at any node in the architecture to provide data transformation, persistence, security, and synchronization with other nodes. The service is able to collect information from multiple local sources, translate messages from legacy systems into the canonical model, store the information locally, and then synchronize the locally stored information with other nodes as communication becomes available. The local cache of information enables business process operations to continue uninterrupted during the period of discontinuity.

CONCLUSION

In order to perform effective PHM in an environment that supports RCM initiatives, multiple data sources must be integrated in a manner that allows for analysis, correlation, and visibility of data across the enterprise. This sharing of platform health information must happen in an environment that is supported by current systems and is consistent with the prevailing Data Strategy (e.g. Army's approach to data sharing).

Establishing a localized information management service as a modular component within a PHM architecture facilitates indirect information sharing and collaboration between applications. Enforcing adherence to a Canonical Data Model as the official schema to expose data between applications provides consistent context and high integrity for information sharing. Employing a Grid Service to locally manage information simplifies the information sharing problem to a restricted set of applications, but provides visibility extensibility to a large population of nodes. The CLOE TCI effort has demonstrated a solution incorporating these three principles that addresses the major concerns with information sharing in a deployed mobile environment, enabling RCM to be truly implemented across the fleet in order to reduce overall costs and improve availability.

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