

Internet-Based Marine Maintenance Information System

T. T. Wong

The Hong Kong Polytechnic University, Hong Kong

W. K. Chan

The Hong Kong Police Force, Hong Kong

INTRODUCTION

The Marine Region of the Hong Kong Police Force is responsible for policing the waters and 262 islands that lie within the 1,651 square kilometers of the Hong Kong Special Administrative Region (HKSAR). In addition to routine policing, the Marine Region has responsibilities in other diverse areas like quarantine, immigration, conservancy, and also port and maritime regulations (Hong Kong Police Force, 2005). The Region is now managing a police fleet of over 140 vessels of various classes. A modern police vessel is a complex, technologically advanced, and highly automated machine. As such, the Marine Region Support Bureau (MRSB) insisted that it must be maintained at the highest possible levels of operational availability while its life cycle operating and maintenance costs should be kept at a minimum. To achieve this aim, this article addresses the need to effectively implement a marine maintenance information system.

Traditionally, the defects and maintenance data of the fleet were collected and recorded by the crew in writing, and then the maintenance records were used as the basis for maintenance decisions by the MRSB and the Hong Kong Government Dockyard. With the paper-based recording procedure, the following problems often occur:

- There are missing data due to unintentional negligence or uncertainty about the nature of the equipment failure or damage,
- errors occurred during the coding of failure information, and
- there is difficulty in deciding whether repair tasks performed were routine servicing or corrective maintenance.

To minimize such problems, it was decided that the processes of crew logbook entry and failure coding procedures would be replaced by direct input to the desktops of MRSB and the Government Dockyard through portable communication devices such as personal digital assis-

tants (PDAs) and laptops, which can easily be obtained at reasonable costs locally.

Currently, virtual private networks (VPNs) provide one of the most cost-effective ways for users to access organization networks while in Hong Kong waters. They are also an effective way of joining together the main office with remote depots using the public Internet. Three types of VPNs are being used.

1. **Intranet VPN:** This VPN can securely connect the desktops of the MRSB and the HKSAR Government Dockyard over the intranet, with all data traffic being encrypted.
2. **Extranet VPN:** Besides the functions provided by the intranet VPN, this network provides access to the MIS to preferred maintenance contractors. Data are accessible only over secure encrypted connections, with all contractor users authenticated.
3. **Remote-Access VPN:** For this network, authorized users are able to access the MRSB and HKSAR Government Dockyard MIS anytime from anywhere. With the aid of wireless PDAs, this facilitates decision making on the spot and is limited to decision makers such as the police superintendent.

A preliminary attempt at developing a Web-based maintenance management information system was carried out for a small fleet of patrol vessels (Wong & Chan, 2002), and due to the nonmodular structure, a major difficulty was found in the modification and extension of the system framework. Recent advances in VPN technology indicate that VPN WANs (wide area networks) are now faster, cheaper, and more reliable than traditional WAN technologies. For a successful implementation of the IMIS, an efficient framework is needed to achieve the automation of diagnostic processes and the integration of inspection and maintenance information under a secure communication infrastructure. Prior to an elaboration on the design of the proposed model, a brief review of object-oriented technologies (OOTs) is shown in the following section.

OBJECT-ORIENTED TECHNOLOGIES

Many object-oriented methods have been proposed over the years. In an object-oriented paradigm, a system is defined in terms of objects. The object-oriented method represents a model of a system that is based on real-world entities. Objects can represent systems, defects, or functions that individuals or organizations play. OOTs employ the principle of inheriting characteristics or attributes from superclass objects. The inheritance mechanism of an OOT supports the reusability of software and simplifies design. In the literature, various object-oriented approaches to design, model, and develop management information systems have been noted.

The concepts and methodology of an architecture for developing agroenvironmental models based on reusable components are proposed by Papajorgji, Beck, and Braga (2004). The unified modeling language (UML) is used to specify the system model and components at a high level of abstraction. UML interfaces are used to define the behavior of components that can be implemented using standard object-oriented programming languages such as Java. Distributed components can be created using the common object broker architecture (CORBA), remote method invocation (RMI), or Web-services technologies, which enable components at different geographic locations to communicate.

Accumulated information about design and process failures recorded through failure mode and effect analysis (FMEA) provides detailed knowledge for future product and process design. However, the way the knowledge is captured poses considerable difficulties for reuse. Teoh and Case (2004) have contributed to the reuse of FMEA knowledge through a knowledge-modeling approach. An object-oriented approach has been used to create an FMEA model. The FMEA model is assisted by functional reasoning techniques to enable automatic FMEA generation from historical data. The reasoning technique also provides a means for the creation of new knowledge.

Dynamic simulations of energy systems are essential when it comes to the transient analysis and design of complex plants. In their work, Wischhusen and Schmitz described the advantages of the transient simulation method in the optimization process of energy systems (Wischhusen & Schmitz, 2004). The object-oriented model of a heat exchanger is presented utilizing the modeling language Modelica.

In software reuse, which is an important approach to improving the practice of software engineering, many factors may hinder reusing software artifacts. Among those factors are the availability of software artifacts at a different level of abstraction and a method to classify and retrieve them. Ali and Du (2004) proposed an approach based on a faceted classification scheme for the classifi-

cation and retrieval of software design artifacts, namely object-oriented design (OOD) models, thus facilitating their reuse. Six facets—domain, abstractions, responsibilities, collaborations, design view, and asset type—have been defined to constitute the classification and retrieval attributes. Each of the facets describes one aspect of an OOD model. It contains a number of predefined terms chosen through the analysis of various software systems specifications. The selected terms of each facet are arranged on a conceptual graph to aid the retrieval process.

Amongst all possibly desired endeavors for e-commerce, research has shown that the effective management of customer relationships is a major source for keeping competitive differentiation. In their work, Lin and Lee (2004) has proposed an object-oriented analysis method for the development of such a customer-relationship management information system (CRMIS). The approach starts with the identification of prospect customers and their desired behaviors under preferable execution environments, and ends with the specification of the system—the internal objects and entities that collaborate to satisfy these behaviors and environments. The method used is the case-driven approach with UML utilized and extended as its tool.

Role-based access control (RBAC) provides flexibility to security management over the traditional approach of using user and group identifiers. In RBAC, access privileges are given to roles rather than to individual users. Users acquire the corresponding permissions when playing different roles. Roles can be defined simply as labels, but such an approach lacks the support to allow users to automatically change roles under different contexts; using a static method also adds administrative overhead in role assignment. In e-commerce and other cooperative computing environments, access to shared resources has to be controlled in the context of the entire business process; it is therefore necessary to model dynamic roles as a function of resource attributes and contextual information.

Afgan, Coelho, and Carvalho (1998) describe the development of an expert system for detecting boiler-tube leakage. The leakage-detection expert system is designed in a knowledge-base environment, comprising the knowledge base containing facts, information on how to reason with these facts, and inference mechanisms able to convert information from the knowledge base into user-requested information. The knowledge base is based on the object-oriented structure with the definition of the object Leakage. The object class Leakage is composed of subclasses Sensor and Cases. The inference procedure uses a set of procedural processes in the preparation of diagnostic variables reading for the decision-making pro-

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