Organizational Level Cloud Diagnostics System of Complex Electromechanical System Based on SOA

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Abstract. In order to better solve the problem of insufficient support ability of high-tech electromechanical system, the cloud computing model was introduced into fault diagnostics system of electromechanical system. An open, loose-coupled architecture of Integrated Diagnostic System (IDS) for electromechanical system is put forward basing on Service-Oriented Cloud Computing Architecture (SOCCA). Test and diagnosis resources of repair shop at all levels and total life cycle information resources of electromechanical system were integrated by Portable Maintenance Aid (PMA) with cloud diagnostics platform. According to different demands, Test and diagnosis resources can be divided into data, software, platform and infrastructure, which can be provided on demand to maintainer of all levels as a service. This allows more complex maintenance issues to be accomplished at Forward Operating Locations (FOLs) by better utilizing the most relevant diagnostic information to enable direct, real-time, and engineering assistance when needed. Organizational Level (O-Level) IDS can effectively improve O-level maintainer support ability of complex electromechanical system.

1. Introduction
With the development in technologies, the performance of electromechanical system has become more and more advanced. At the same time, modern electromechanical system often include a large number of working units or sub-components, which are subject to failures or malfunctions during operations. The complexities and interactions of these components lead to increased difficulties in ensuring the safe and reliable operation of the systems[1,2]. The diagnostic complexity of critical electromechanical system, coupled with the on-going need to support the repair and diagnosis at O-Level yields a demanding set of requirements for O-Level IDS. The Integrated Diagnosis of the electromechanical system is one kind of configurable design and management process that it considers all related diagnosis factor (such as testability, diagnosis, test software and hardware, technical data, training and so on), so as to obtain the best efficiency diagnosis potency[3,4].The proposed O-Level IDS that has the real-time, remote diagnosis capability can improve maintenance practices and support of the O-Level maintainer[5]. The O-Level IDS employs a combination of PMA with net-centric maintenance paradigm to provide the ability for an O-level maintainer to have access to expert knowledge and needed information on-platform[6]. This allows more complex on-platform maintenance issues to be accomplished at FOLs by better utilizing the most relevant diagnostic information to enable direct, real-time, and engineering assistance when needed. In recent years, the developments and achievements in the field of the model-based diagnostics[7], human-machine interfaces[8], electronics and embedded system technologies[9] have investigated the feasibility and commenced development for an innovative and advanced O-Level IDS.
This paper is organized as follows: Section II, basing on Service Oriented Cloud Computing Architecture, test and diagnosis resources are divided into four categories, an open, loose-coupled Architecture of O-Level Integrated Diagnostics is put forward. In Section III, the model of O-Level IDS for electromechanical system is presented. Finally, some concluding remarks are made.

2. O-Level Integrated Diagnostics Architecture

2.1. Service Oriented Cloud Computing Architecture
Service-Oriented Architecture (SOA) is one of the latest architectural style whose goal is to achieve loose coupling among interacting software agents. SOA is a system architecture model consisting of standardized components such as web services[10]. A service is a unit of work done by a service provider to achieve desired end results for a service consumer. Both provider and consumer are roles played by software agents on behalf of their owners. In an SOA, resources are made available to other participants in the network as independent services that are accessed in a standardized way[11,12].

SOA and cloud computing are related, specifically, SOA is an architectural pattern that guides business solutions to create, organize and reuse its computing components, while cloud computing is a set of enabling technology that services a bigger, more flexible platform for enterprise to build their SOA solutions. In other words, SOA and cloud computing will coexist, complement, and support each other. Together SOA and cloud can provide a complete services-based solution[13]. Service-Oriented Cloud Computing Architecture (SOCCA) is proposed so that clouds can interoperate with each other. SOCCA supports easy application migration from one cloud to another and service redeployment to different clouds by separating the roles of service logic provider and service hosting/cloud providers[14,15]. It promotes an open platform on which open standards, ontology are embraced. More specifically, SOCCA can be developed and deployed in NCSEs to enable electromechanical system to perform closed-loop diagnostics across levels of maintenance.

2.2. Integrated Diagnostics Architecture
In order to overcome problem of existing equipment support information systems technology architecture diversification, tight coupling between the parts and poor information sharing and reuse, an open system, net-centric architecture is desired. Basing on Service Oriented Cloud Computing Architecture, an open, loose-coupled architecture of O-Level integrated diagnostics is put forward. It is four-layer structure as shown in Figure 1, including the physical resource layer, service resources layer, service bus layer and service application layer.

(1) Physical resources layer: this is the basic layer which provides hardware support for the architecture, including physical resources such as PMA, remote cloud diagnostics platform and communication network systems.

(2) Service resources layer: this is the layer that includes many fine-grained services. The services can be packaged as a single service or integrated into a coarse-grained service. According to different levels and different demands of services, the services can be divided into four categories: Data as a Service, Software as a Service, Platform as a Service and Infrastructure as a Service.

① Data as a Service (DaaS): Data such as product data, use information, fault knowledge, test data can be provided on demand to maintainer of all levels as a service. It can effectively support troubleshoot and optimize design of equipment by increasing effective accumulation, sharing, reuse of information of the full life cycle.

② Software as a Service (SaaS): Software such as test program, fault diagnosis software, IETM, data analysis software can be provided on demand to O-Level maintainer as a service. The software are shared by multiple users, automatically updated from the clouds. The maintainers can log in cloud diagnostics platform to download and install according to requirement. It saves the maintainers from the troubles of software deployment and maintenance.
Platform as a Service (PaaS): It provides a development platform with a set of services to assist application design, development, testing, deployment, monitoring, hosting on the cloud. It can support geographically distributed O-Level maintainer to work on projects collaboratively.

Infrastructure as a Service (IaaS): It virtualizes computing power, storage and network connectivity of the data centers, and offers it as provisioned services to O-Level maintainer. The maintainer can scale up and down these computing resources on demand dynamically. Typically, multiple users coexist on the same infrastructure resources.

The dividing lines for the four services are not distinctive. Components and features of one service can also be considered to be in another service. For example, data storage service can be considered to be either in IaaS or PaaS.

(3) Service bus layer: this is system connecting hub, is an essential element to build the nervous system of a maintenance organization. It is mainly to complete the functions of service management, information transformation, information routing, protocol conversion involved in service publication, request and offer.

(4) Service application layer: this is provide maintainers of all levels, technical support center, spare parts warehouse, production units and other client with specific service, such as test data analysis, fault diagnosis, remote expert diagnosis and decision-making services.

![Figure 1. O-Level Integrated Diagnostics Architecture](image-url)
levels and total life cycle information resources of electromechanical system were integrated by PMA with cloud diagnostics platform. The model of O-Level IDS for electromechanical system was developed as illustrated in Figure 2.

![Diagram](image.png)

**Figure 2.** The model of O-Level Integrated Diagnostics System

When an electromechanical system is subject to failure, the first approach for fault diagnostics and trouble shooting is the analysis of self-monitoring data that acquire by Built In Test Equipment (BITE). The fault diagnostics can be support by Interactive Electronic Technical Manual (IETM), maintenance information database, fault diagnosis case database. If maintenance personnel can’t locate and isolate failure, further functional signal acquisition and data analysis can be carried out by Portable Instrument Pack. If necessary, request support remote technical support as quickly and accurately detect the presence of electromechanical system hidden faults, fault isolation replaceable unit. Direct, real-time, and engineering assistance can be enabled when needed.

O-Level IDS that seeks to coordinate distance support with real-time test data, permitting local domain experts to assist forward deployed technicians. Hence, ready availability of information referenced resources, such as a collaborative historical maintenance data, usage data, the latest test methodologies and repair techniques, along with the latest experience can provide necessary leverage to execute a timely repair and return a problem electromechanical system to service more quickly.

4. Conclusion
In this paper, we put forward an open, loose-coupled architecture of O-Level IDS for electromechanical system basing on Service-Oriented Cloud Computing Architecture (SOCCA). The model of O-Level IDS was developed. Test and diagnosis resources that are integrated by PMA with cloud diagnostics platform are divided into four categories: data as a service, software as a service, platform as a service and infrastructure as a service. This allows more complex maintenance issues to be accomplished at FOLs by better utilizing the most relevant diagnostic information to enable direct, real-time, and engineering assistance when needed. O-Level IDS is capable of assisting O-Level maintainer to make accurate and timely decision, so it can effectively improve O-level maintainer support ability of complex electromechanical system.

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