The design and implement of alarm processing system for large-scale railway maintenance equipment diesel engine combustion control based on multi-agent

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Abstract

The Alarm Processing System reference model for large-scale railway maintenance equipment diesel engine combustion control, which is based on multi-agent, is an important system for high speed and automation. Alarm Processing System are vital aspects in M large-scale railway maintenance equipment diesel engine combustion control, in this sense, alarm processing system should support decision-making tools as known as decision support system(DSS), new maintenance approaches and techniques, the enterprise thinking and flexibility. In this paper a Multi-agents based alarm processing System reference model for large-scale railway maintenance equipment diesel engine combustion control is presented which combines the existing models and multi-agents. This model is based on a generic framework using multi-agent systems for the diesel engine combustion control the diesel engine combustion control on-line monitoring system. In this sense, the alarm processing system is viewed like a feedback control process and the actions are related to the decision-making in the scheduling of the preventive maintenance task and the running of preventive and corrective specific maintenance tasks. The result of an evaluation of the Multi-agents based alarm processing system reference model for the diesel engine combustion control are presented. This new model is compared to some important existing models and applied to a real investigation.

Keywords: diesel engine combustion control, alarm processing systems, multi-agent system, automation

1 Diesel engine combustion control technology

In the innovation progress of diesel engine, new technology such as turbocharger technology, the three element catalytic processing, the lean combustion, homogeneous charge compression ignition (HCCI) comes out. In the conventional altitude conditions, the engine has reached a higher level of technology. But in the plateau and the special circumstances, the engine is still weak. In addition, with the requirements of increasingly stringent emission regulations, to explore a new combustion control method has become a necessity. Figure 1 shows the Schematic Structure of the diesel engine combustion.

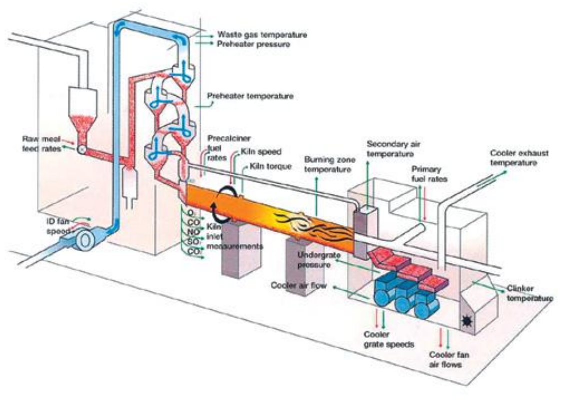

FIGURE 1 Schematic Structure of the diesel engine combustion.

With development of the catalytic converter processing technology, gasoline engine emissions are reduced, however, HC at starting stage is a major obstacle to achieve ultra-low emission [1]. To solve the problem of NO2 diesel engine emissions has been facing challenges; there are contradictions and difficulties in the trade-off between NO2 and particle. Although the existence of complex factors of engine combustion process, but the combustion is using oxygen as oxidant, controlling the share of air intake oxygen combustion control is the most fundamental way.

During combustion a control system must therefore maintain the following conditions:

1) Control of the O2 concentration in the flue gas to keep it at a constant figure.
2) Maintenance of a uniform thermal output.
3) Maintenance of optimum flow conditions in the furnace and the first boiler pass with as little variation as possible so that the desired conditions for attaining the lowest possible degree of emissions and thus preventing corrosion are always maintained [2].

These conditions can only be fulfilled by optimized combustion at a stable operation point. Conventional control systems are incapable of reacting to the inevitable local and intermit and inhomogeneity of the refuse fed to the grate, which are attributable to varying calorific values and

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ignition properties. It is as a result impossible to avoid pronounced variations in the combustion process and such variations are always associated with unfavorable emission figures.

The engine combustion is mainly controlled by the contents of oxygen, nitrogen [3,4]. One is the intake combustion, the other is flame retardant, the two shares become the basic elements of the combustion process control. To implement the combustion and emission control is by the way of reforming the intake charge component. Oxygen Enriched Air (OEA) can significantly reduce the non-full combustion emissions (except NO2), can enhance the power performance and shorten the ignition delay period, which is conducive to low quality fuel [5,12]. Nitrogen Enriched Air (NEA) can inhibit the combustion process, can be beneficial to relieve the No emission, which is considered to be an effective method.

A possible method of automating this process is the registration of combustion by infrared thermography. This offers the immediate advantage that the plant operator is in a position to observe combustion directly from the control room [6,9]. Because of the geometry of the furnace in the plant under consideration the area which must be observed lies mainly in grate zone 3, but also to some extent in zones 2 and 4, which cannot be so completely observed.

This is however more than adequate in order to determine the position of the fire. Additionally it is possible, by statistical evaluation of the infrared picture, to determine the width of the combustion zone and derive from this information on asymmetric positions of the fire or secondary combustion zones.

Even if all the information given above is available it is still necessary to development an adequate mathematical model which will allow the information the information to be applied to a conventional control system. However combustion processes as a rule are of a highly non-linear nature and represent multi-variant problems. For conventional control system strategies the only feasible method is therefore to influence controllers by heuristic programming [8,10].

New solutions to problems of that kind are offered by the use of advanced control techniques. In particular fuzzy logic control has been applied to similar combustion processes [7,13]. Complex interactions between the various items of information evaluated require a methodology of structured information analysis.

Diesel engine combustion control is a capital intensive process due to increasingly severe environmental regulations. Complying with the environmental rules demands the adoption of new and expensive technologies for both the combustion process and treatment of the residues (gaseous, liquid). The investment and operation costs have to be regained through adoption of a number of measures, primarily more efficient combustion, which should minimize the residues and maximize the energy recovery.

With the advent of Diesel engine combustion control's facilities toward high speed and automation, the online monitoring becomes important [11]. Since a facility of the Diesel engine combustion control may break down unexpectedly, the unscheduled shutdown will cause the losses and deteriorate of the environment. The traditional time-based maintenance strategy does not take into account the practical machine condition and only performs the maintenance practice at a fixed time interval from local personnel. Therefore, accidental breakdowns will unavoidably happen, when the chosen time interval is too long. Otherwise, it will lead to over-maintenance, when the chosen time interval is too short.

In order to increase automation in Diesel engine combustion control, an on-line monitoring system for facilities based on computer's technology gains popularity. In general, facilities monitoring or supervision is carried out by measuring some parameters from some facilities of Diesel engine combustion control. The justification for on-line facility monitoring is prompted by the needs to achieve the availability of facilities and to protect facilities from some problems of running.

A five level's architecture is considered, in general, for MSW incineration automation schemes: process, local control, supervision, planning and administrative management, each one with specific tasks. In general, the couple model–control has constrained suppositions about the process' dynamic and its causes are not thoroughgoing modelled, thus, in case of not well working, the process performance should be deteriorated. These modelling suppositions put up with the development of Alarm processing system proposing fault detection, diagnosis and prediction tasks, and preventive maintenance plans; these tasks living together in the supervision and control levels. A multi-agent based automation model is proposed, taking into account the general objects of the production processes: production planning, production factors management, processes control, Alarm processing and abnormal situations management. The agents-based reference model for distributed control systems (DCS) has provided a generic conceptual framework permitting to see any system like a feedback control systems [14].

Alarm processing and maintenance are vital aspects in industrial process. They not only include the knowledge about the failure modes and their causes, but an awareness of the extent to which equipment failure affects safety, product quality, costs and plant availability. Changes in the maintenance approaches, recent knowledge, skills of maintenance people, and so on, must be incorporated into the maintenance systems in order to attain high performances. In this sense, maintenance systems should be developed in an open framework permitting to take into account the changes in the maintenance paradigms. In the maintenance framework, the challenges are related to the selection of the appropriate techniques for fault detection, isolation and diagnosis; the building of the appropriate models for detection, isolation, diagnosis and prediction; the decision-making in the design of feasible preventive maintenance plans; the decision-making in the emergency situations.

In this work, a multi-agents based Alarm Processing System (APS) reference model for MSW incineration process is proposed. This model outlines the management of the preventive maintenance plans permitting to perform detection, isolation and diagnosis tasks. This model takes into account the following tasks: local or global abnormal behavior detection of the controlled process; fault isolation and diagnosis; fault causes identification; preventive and corrective maintenance task running; maintenance task planning; fault prediction models development.

The APS objectives are achieved by the coordinated interaction of the agents. Reasoning aspects as well as adaptive and learning aspects are incorporated into the multi-agent behavior, helping in the interpretation of available data from different sources and characteristics. This way, the agent-based APS provides the assistance in the detection-diagnosis-decision process, as well as in the planning and running of maintenance tasks.

Alarm processing refers to the interpretation of a large number of alarms in a computerized control system. It is one of the important functions of the computerized supervisory control and data acquisition (SCADA) systems. An alarm is a structured signal from the SCADA system which is used in distribution power substation control centers [15].

Alarm processing thus relies on status information or measurements gathered at a large number of points distributed throughout those substations. The advances in computer and communications technology in the last three decades have made it possible for a large SCADA system to scan 20,000 to 50,000 points every few seconds. Such a SCADA system will have the ability of displaying 500/1000 or even more alarm messages per minute.

The enormity of the system and rate at which messages are displayed on the console increases the complexity of the problem multifold. This complexity leaves an operator in the control center that has to analyze these alarm messages a highly constrained time frame suffering from high stress and cognitive overload. In early years, prioritizing the alarms and arranging alarm messages have been used to reduce the number of alarms listed to the operator's console [16]. However, the operator still needs to analyze the real-time messages to diagnose the system problem. In general, alarms can be caused by different events and an event can result in multiple alarms.

Uncontrollable events such as sudden load fluctuations, equipment failures and atmospheric perturbations can propel the system from a stable and secure state to an insecure and unstable state. The operator in these circumstances has to take immediate action in order to pull back the system into an acceptable state. Failure to respond quickly, can lead to catastrophic circumstances like the state of the system may continue to deteriorate with some loads getting disconnected or in extreme cases, and the entire system may collapse, leading to a blackout for hours. Under abnormal conditions, trigged alarms responsive to abnormal conditions will disturb the operator to take corrective actions in handling the fault. Therefore, alarm processing issues are worth studying and have received significant interests of many researchers.

In this paper, an agent-based alarm processing architecture is presented to solve the alarm problems inherent in computerized and centralized SCADA systems. For operations that require timely action, the proposed intelligent alarm processor is an ideal way to assist operators to take corrective actions.

The definition of an alarm is described as follows:

a. A measured analogue value exceeds the preset level.

b. A measured digital value changes the status.

2 The multi-agent technology

2.1 ORIGINS AND CONCEPTION OF MULTI-AGENT

The direct reason for MAS (Multi-Agent System) coming into being is that the ability of MAS in dealing with problems is better than that of single Agent, and MAS can communicate with current systems and software, it can enhance the efficiency and robustness of systems, and it is distributed. MAS are Agents that can work together or act autonomously in their environment to complete a set of goals. An Agent as well as a Multi-Agent system can be developed efficiently [17]. The study on Multi-Agents technology mainly lies in two fields: studying the architecture, communication and learning mechanism of MAS in theory, and studying scientific computing, computer network, robot and traffic controlling in application.

2.2 THE FRAME OF MULTI-AGENT SYSTEM

2.2.1 Centralized multi-agent system

The center is responsible for the control and cooperation of the system. This frame would keep the information coherent in the system; it can be managed, controlled and maneuvered easily. The disadvantage is that as every Agent becomes complicated and dynamic; the bottleneck in controlling becomes outstanding. The deadly shortcoming is that, once the Agent that controls the local part or all parts collapses, all parts will collapse.

2.2.2 Distributed multi-agent system.

This frame contains many service organizations, it offers services when Agents cooperate with others, and every Agent is equal. The virtue is to increase the flexibility and stability of the system, and thus the bottleneck in controlling is abated [18]. The shortcoming is that since every Agent is restricted by local and incomplete information, it is hard to implement the coincident behavior.

A multi-agent system is a system where multiple agents are acting in the same environment. Running in the same environment implies that they get the same inputs and that there actions affect the same environment. This automatically leads to more complex issues as soon as there are multiple agents in the same environment the action of one action affects all the other agents in the system as well. This clearly shows the need for some sort of communication between these agents. There are two basic modes of multi-agent systems: cooperation and competition. In a cooperative mode, agents cooperate to reach a common goal. Agents in such a system might for example each have a very specialized function so that they can only together achieve a goal that requires several of specialized functions. In competitive MAS, on the other hand, agents compete with each other for limited resources like computation time [19]. MASIAP is designed as a cooperative one. Agents in MASIAP are specialized agents that are each pursuing their own goals. To reach these design objectives those agents most cooperate with other agents in the system because they can't achieve their goal without cooperation.

Traditional SCADA system attempts to monitor and control everything from a control center. Remote Terminal Units (RTUs) are widely used for centralized monitoring and control. A fixed communication channel has to be established for data exchange between control center and remote terminal units, and the failure of a remote terminal unit or of the centralized monitoring server could cause the whole system to fail. To conquer the limitations of centralized monitoring, a multi-agent approach is employed. The rationale and justification for the choice of multi-agents for distributed transformers on-site monitoring is the capability of an agent to respond to changes in its environment, act in anticipation of such changes, and interact with other agents to solve problems in a cooperative manner. Multi-agent systems are ideally suited to the characterization or design of distributed computing systems. With reference to the presentation of information and resource control in the distributed monitoring system, agents are appropriate because:

1) They are intelligent agents.
2) The autonomy of an agent enables it to encapsulate the identity of a particular user, and tailor its response to reflect the user's responsibilities, such as monitoring the state of relays.
3) Agents allow the integration of existing systems. Therefore agents can negotiate with each other to obtain required information.

2.3 THE FRAME OF MULTI-AGENT DECISION-MAKER

Agent Decision-Maker is used to hold the diesel engine combustion control of DSS, which is based on A-Team (asynchronous team) agent interaction structure. As shown in Figure 2, all of the diesel engine combustion control tasks which are need to process are store in a "Population". The sub-agents of the Decision-Maker are discussed as below:

1) Analyzer, which is used to analyze the diesel engine combustion control tasks and target the attributes of all the tasks.
2) Inquirer, which acquires the information from the system source database to support Analyzer for analyzing and targeting the attributes.
3) Updater, which updates the information changed by Analyzer to the system source database.
4) Specilizer, which constructs the rules of tasks from "Population".
5) Decomposer, which decomposes the tasks from Specilizer.

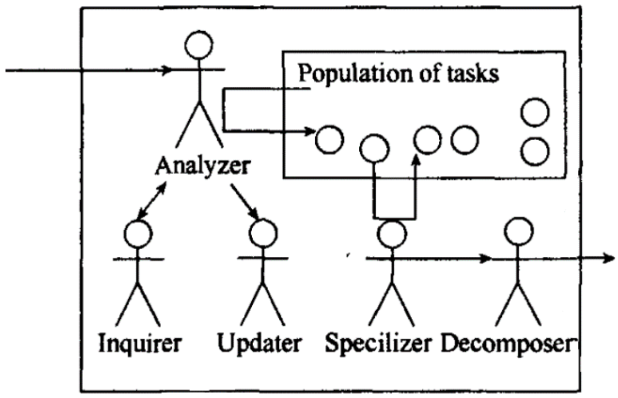

FIGURE 2 The frame of decision-maker

3 The proposed architecture of multi-agent based alarm processing system

This section will outline the general architecture of the multi-agent based alarm processing system (MASAPS). The architecture is presented from two perspectives: one is the software perspective and the other is the system perspective. The system perspective shows the relationship between different parts of the system and the physical location of the different software parts. The software perspective describes the way in which the system is embedded into different agents and the style in which they interact with each other [20]. The MASAPS mentioned above has been evaluated in the simulation experiment. The MASAPS is under development using the Java language and can run under any computational platform that supports Java byte code and GUI.

The system is under development using the Java language and can run under any computational platform that supports Java byte code and GUI (Graphic User Interface). The system architecture is depicted in Figure 3. It consists of five major components, Java-based human machine interface (HMI), data analysis agent, monitoring agent, control agent and database agent. We choose JADE (Java Agent Development framework) as development tools because it can provide an agent environment to communicate with each other and migrate from one substation to another. We will discuss the function of these components in the following sections.

In each substation, there exists database used for persistent storage of historical real-time data which connected to database agent. The real-time information is gathered from substation remote terminal units by monitor agent over serial RS232 or TCP/IP. The data analysis agent is not only responsible for analyzing the receiving measured values, but also can generate diagnosis information via its reasoning process. One of the advantages to detect data directly from each local remote terminal unit is the ability to suppress redundant alarms. After perceiving information from substation remote terminal units, the monitoring agent provides a copy of the receiving information to database agent for persistent data storage. Each user can access the system information through the Java-based HMI. In order to effectively analysis system alarms, all agents are capable of communicating with other agents in different substations.

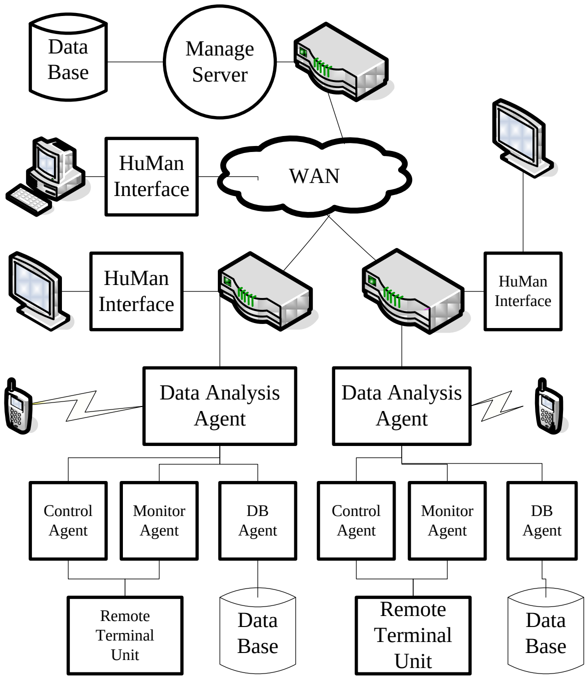

FIGURE 3 The proposed architecture multi-agent based alarm processing system

4 The function of the multi-agent

4.1 DATA ANALYSIS AGENT (DAA)

The Data Analysis Agent (DAA) plays an important role in the multi-agent systems. Hich task is to gather information from substation remote terminal unit and perform data analysis, and here the control task is executed by the control agent. Hile exist three software agents: messenger agent, fault analyzer agent, and learner agent. The messenger is an information centre that allows sending and receiving messages to other agents via FIPA compliant agent communication language. The incoming real-time data which come from monitoring agent is analyzed and fault sections using cause-effect networks to determine the relevant event is identified by the fault analyzer agent. The learner agent plays the role for enhancing accuracy of event identification by using the post experiences from interaction with user.

4.2 MONITORING AGENT (MA)

The main function of monitoring agent is to continuously monitor measured analogue values that exceed the preset limitation and/or digital values that change state from remote terminal unit. The collected data will be sent to data analysis and store in the database via database agent.

4.3 CONTROL AGENT (CA)

The control agent is responding to manages and performs a low-level control action in a secure way. By clicking a component for operation requests in the diagram window, a pop-up dialog box is displayed for confirming an executable operation. Through check before execution and software interlock functions to avoid critical operation process.

4.4 DATABASE AGENT (DA)

Several reasons lead us to make the decision that data about the activity in the substations, its environment and the systems activity should be logged.

These reasons were:

1) Requirement to make statistical tests about the behavior of the system.
2) To have a learning base, where the system could learn from experience.
3) An ability to plot charts about the behavior of the system.

4.5 USER INTERFACE AGENT (UIA)

The User Interface Agent is fully implemented by using Java, which provides a graphic operation interface with cross-platform feature that can run under different platforms with Java Virtual Machine (JVM).

4.6 MANAGEMENT SERVER

The management server, located in control center, contains a facilitator that provides with agent service lookup, user authentication, ontology database. The directory facilitator, connected to a recovery database, is designed for system recovery and migrate information from each substation. User authentication is the way of restricting access to database by asking for a username and password. Ontology is a description of a conceptualization and has properties for knowledge sharing. For pragmatic reasons, we choose to provide an ontology database as a set of definitions of formal vocabulary.

The proposed approach adopts a rational agent model as human practical reasoning and to represent human's mentalist attitudes. Belief, desire, and intention, representing the informative, motivational, and deliberative states of the agent, respectively, are the three attitudes of an agent.

When an event occurs, the goal of the proposed agent system will try to reach the event from overwhelming alarm messages by agent cooperation in related substations. The definition of events and their corresponding alarms, according to substation configuration, is used as the beliefs. The plan, which is deliberative attitude, is the way that agents achieve their goal. Each agent has to store the facts as beliefs that make up the agent's knowledge.

5 Conclusions

This Multi-agent based alarm processing system for MSW incineration could better realize heterogeneous enterprise data, application systems and business processes. Due to a distributed system, MAS modular design not only reduces the complexity of the system, but also is easy to expand, as well as has good robustness and reliability. It also can be integrated to the existing SCADA system. We have designned and implemented a multi-agent based alarm processing system framework, MASAPS, Which has cross-platform architecture, distributed computing capability, and intelligent inference mechanism. The system may be a suitable training simulator for system operators in the future.

Acknowledgments

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