

Research and Application of Workflow-based Modeling Approval in Dispatching Automation Master System

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Abstract

Dispatching automation system is the nerve center of power grid. When using the system, it usually needs grid model diagrams, such as plant station wiring diagram, flow calculation diagram, etc. In addition, the model files are used for grid monitor, dispatching analysis, etc. Thence before use, these files need to be approved strictly for ensuring the security of the running power grid system. This paper briefly describes the dispatching automation master system iES600Pro of Integrated Electronic Systems Lab Co. Ltd. (iESLab). Moreover, it proposes a system optimization scheme based on workflow technology, thus the system can implement complete approval process of model files. The process is flexible, convenient and customizable. Furthermore, it presents the implementation of scheme including the architecture of system after the optimization, the description of interfaces between system components, the design of business data table, a sample of approval process, and finally the testing platform and results. The results show that the proposed scheme improves the system function and approval efficiency. It is more conducive to the security of grid dispatching.

Keywords: *Dispatching automation master system; Workflow; Modeling approval; jBPM(java Business Process Management)*

1. Introduction

Power system consists of generation, transmission, transformation, distribution and consumption link. It is a critical infrastructure to guarantee the steady growth of the national economy and social harmony and stability. Now many companies are interested in the research and development of power management and smart grid technology [1]. As the nerve center of the power grid, dispatching automation system achieves the monitor and control of power equipments to ensure the reliable, economic and high quality operation of power system through collecting and processing information [2].

When using dispatching automation system, users first need to make model diagrams of grid or power station. The model files are used for power flow calculation, real-time monitor, dispatching analysis, etc. There is no doubt that the correctness of graphic files is very important [3]. In fact, a strict approval process is required for ensuring the security of power system. No modification is allowed to be applied directly to the running system. Paper [4] presented that although these existing dispatching automation systems can fulfill the application requirements, they are limited in dealing with process-oriented tasks. Furthermore, these systems usually don't have approval process in software system, but instead they complete the approval by manual data transmission, or just have hard-coded

approval processes [3]. The iES600Pro of iESLab, OPEN3000 and PCS-9001 of NARI, CC-2000A of Kedong and other dispatching systems are all using “polymorphism” grid model unified maintenance means. The “polymorphism” usually includes research state, real-time state, planning state, training state, etc. It protects the safety of power grid to a certain extent. But such approval methods are not strict, flexible, efficient and convenient.

The main function of workflow is to realize the automation of business process, which has advantages over other technologies in aspects of business process description, process automatic flow and process tracking management [4, 5]. At present, workflow management system has been widely used in office automation, telecommunications, manufacturing, financial services, scientific experiments, power dispatching system and many other fields [6], while the workflow engine provides a process execution environment and manages the overall processing and execution of workflow instances [7, 8]. Of course it also has been used in power system such as workflow scheduling given in [9, 10]. Therefore, this paper puts forward a system optimization scheme, which embeds workflow engine in the power grid dispatching automation master system iES600Pro. The system can implement complete approval process of collaborative modeling. Moreover, the process is flexible, convenient and customizable.

The rest of this paper is organized as follows. Section 2 introduces the workflow technology. Section 3 describes the iES600Pro system, including the cartography module and the place that can be optimized. Then the optimization scheme and the implementation of optimization are respectively presented in Section 4 and Section 5. Finally, conclusion is given in Section 6.

2. Workflow Technology

2.1. Workflow

The definition for workflow given by the Workflow Management Coalition (WfMC) is as follows: The computerized facilitation or automation of a business process, in whole or part [11]. It is concerned with the automation of procedures where documents, information or tasks are passed between participants according to a set of predefined rules to achieve or contribute to an overall business goal. In order to promote the development of workflow technology and make the management of workflow industry convenient, the WfMC issued the workflow reference model, which describes the main components, mutual interface and so on.

2.2. JBPM

JBPM (Java Business Process Management) is a Jboss workflow and business process management engine in Java and it can execute processes described in BPEL (Business Process Execution Language) or its own process definition language jPDL (Jboss jBPM Process Definition Language). The business process model of jBPM is based on activity diagram, and the construction of its engine considers the theories of FSM (Finite State Machine) and Petri-Net [6]. Its competitiveness edge relative to other workflows lies in the short development cycle, strong portability and good expansibility [12]. In addition, jBPM has the following two characteristics.

- JBPM uses a lightweight XML structure process description language jPDL. Compared to XPDL (XML Process Definition Language) and BPEL standards, jPDL language is simpler and easier to read.

- JBPM uses Hibernate to manage the database. Hibernate is a very popular data storage layer solution in java field. JBPM supports all databases supported by the Hibernate. And it isolates the data management function and concentrates on business logic processing.

Therefore, jBPM was chosen in the system optimization scheme.

3. IES600Pro System

IES600Pro of iESLab is a dispatching automation master system which has the C/S (Client/Server) structure. It uses SoftBus-based communication architecture loosing the coupling between modules. This communication architecture increases the robustness of the system and makes the system easy to expand. It is positioned on the net, provincial and large area grid and it can also be configured according to user's requirements to apply to dispatching automation system of small and medium-sized regional grid. This system can well meet the application requirements of grid dispatching. The focus here is the graphic modeling tool and the place of this module that can be optimized.

3.1. Graphic Modeling Tool

The graphic modeling tool of iES600Pro is mainly used for drawing and filling in the basic components of database to construct the grid topology model. In addition, it has many convenient and special functions, such as topological connectivity check, automatically combining into a diagram, generating interval graphs, etc. It relies on the security proxy service of system, SoftBus service, oracle database service and so on. The model files obtained are used by other function modules for dispatching and analyzing of the running grid. The quality of model files has a very important influence on grid dispatching operation.

3.2. Place can be Optimized

IES600Pro supports many kinds of application conditions of grid model, data and so on. This is also known as "polymorphism" or "context support". The "polymorphism" that iES600Pro achieved includes training state, planning state, real-time state, and historical state. The corresponding software operation patterns are called training pattern, planning pattern, real-time pattern, and historical pattern. Multiple instances of the same software modules running in different pattern can exist in the system without any effect. For example, the module of training state won't send the control commands of power equipments to the software module running in real-time state; the software module of real-time state won't send real-time data to the software module running in training state. The online switch of application conditions can be realized through human-machine software module of iES600Pro. This enables the grid models or data to change from one state to another. The "polymorphism" mechanism is actually an approval process guaranteeing the reliable operation of power system to a certain extent. However, the so called approval process here is hard-coded. It is not streamlined, automated and flexible. Consequently, the process can't be changed according to the actual situations and customer's requirements at any time.

4. System Optimization Scheme

JBPM can only provide a workflow engine and a set of mechanisms of business flow. It cannot deal with business issues and manage business data for the staff. So it needs to make iES600Pro (business system) and jBPM (workflow system) run together. In the final analysis, the integration of the two systems is the association of task instance (*e.g.*, approval and

review) and business instance (*e.g.*, model file). According to the research, there are two ways as follows:

- a) Saving process task instance index in iES600Pro system. Then the system is business-oriented. Through the index of the task instance saved in business system, the context data such as location data of business task in the process can be gotten.
- b) Saving business instance index in jBPM subsystem. The system is process-oriented. Providing users with business tasks through workflow task list and getting the binding specific business data according to the business instance index.

The first method has no invasion to the workflow system. It only needs to modify the business system and save the process instance index in business data tables. But this step is generally pre-designed in the business system design stage. Furthermore, the implementation of the second method also has two kinds of ideas:

- Taking business instance indexes as process variables and saving them in jBPM system database, without creating new data tables. The existing database tables of jBPM can save any object, which can be serialized, even the whole business instance object, such as model files. As a result, it doesn't need to modify the original database structure of jBPM. However, this does affect the efficiency of the whole system, because database gain binary data and serialization or deserialization of the object affects the efficiency.
- Modifying the jBPM original table structure, creating new table, and expanding its source code. It is a good habit to expand the jBPM source code without any modification. And it is the idea recommended by jBPM official.

In situation that iES600Pro is basically fixed, if the first method is used to embed workflow in the system, other function modules of the system as well as the database structure need to be amended accordingly. Thus, it doesn't meet the requirement that the invasion to original system is least.

Considering the factors above, the second way of the second method was finally applied in the optimization of system. In addition, some essential modifications to the original system were needed as well.

5. Implementation and Testing

5.1. New System Architecture

Figure 1 shows the new system architecture after introducing the workflow engine into iES600Pro. These areas inside the box are the modules added or modified. This system can achieve the automatic flow of approval process based on workflow technology.

- **Process definition tool.** Used for the definition and deployment of process according to business requirements. It is developed by java-based, open-source, and free jgraph package. And it relies on jBPM development kit. Each process definition includes a PNG format image file and an XML file, which meets the jPDL language specification. Both the image and XML file need to be deployed in database.
- **Model and workflow client.** Used for human-machine interaction. The new workflow client is embedded in model client. It provides interfaces of startup flow, query tasks and other operations related to the execution and management of approval process. It also provides convenient interfaces for editing and managing models.
- **Workflow service.** It is the core of process control and management. It is responsible for controlling process instances flow according to the process predefined rules and

providing service interfaces for the current task query, historical data query, process startup, process stop etc. It depends on the *jbpmwrapper.jar* which is the package of open-source workflow development kit, according to specific business requirements. As using C++, this part needs to implement JNI (Java Native Interface) call in order to interact with *jbpm.jar*, which uses java.

- **Workflow database.** It stores workflow related data tables and new business data table, which saves model file index for approval, process instance index, version, approval state and other information.
- **Model service.** Providing making graphic models related services such as check-in, check-out, file management, topology connectivity check etc.

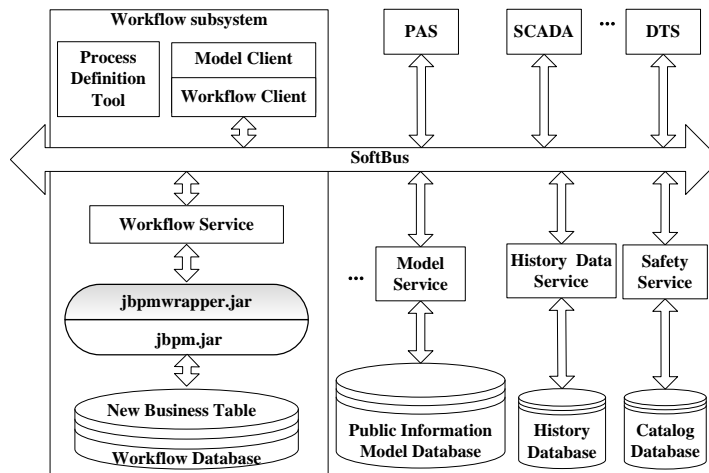


Figure 1. System Architecture

The whole scheme relies on iES600Pro system of iESLab. The jBPM source code uses java, while iES600Pro uses C++. Therefore, for the realization of the system optimization scheme, both java and C++ are used. The development tools are Eclipse, VS2005 and Qt3.3.8.

5.2. Interaction between Components

The smooth flow of a workflow instance depends on the interaction of system module components, as shown in Figure 2. Model service and workflow service don't interact directly, but interact with the corresponding human-machine interface through the SoftBus service.

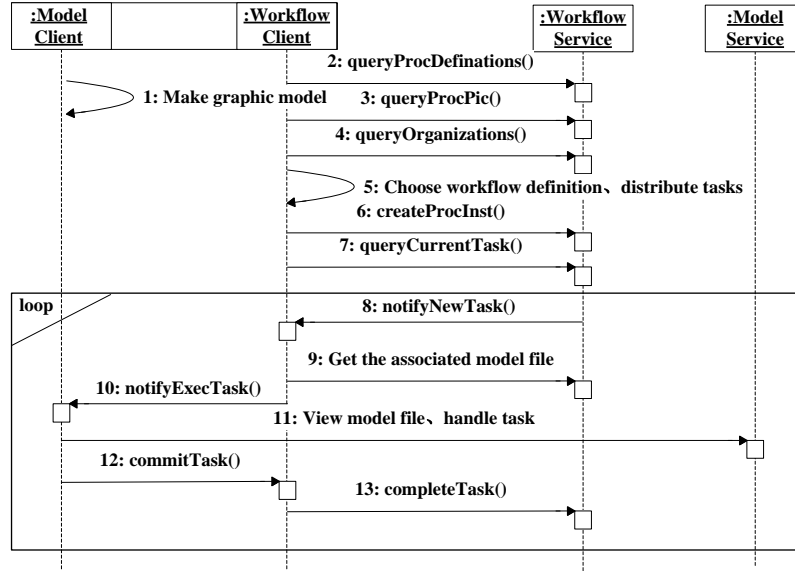


Figure 2. Interaction between Components

5.3. New Business Data Table

In view of the system integration scheme and in order to facilitate the management of data, the original structure of the database of iES600Pro system is not changed while a new table space IES-jBPM-TABLESPACE is separately created, which is used to store workflow related data tables and new business data table. The information of new business data table is shown in Table 1. In order to make the table managed by Hibernate like other workflow data tables, the jBPM source code was expanded. The corresponding java entity class *IesLob* and Hibernate mapping files required were designed. Figure 3 shows the expanded Hibernate mapping files. *IesLob* contains the interfaces for CRUD operations. When starting an approval process and handling “Submit” task, model file index, process instance index, editor, version and other information will be saved in the table. Along with the flow of process instance, the values of some fields will be changed.

Table 1. IesLob

| Field | Type | Note |
|---------------|--------------------|---------------------|
| DBID_ | NUMBER(19) | number |
| DBVERSION_ | NUMBER(19) | version |
| EXECUTION_ | VARCHAR2(255 char) | process instance id |
| NAME_ | VARCHAR2(255 char) | file name |
| LOBID_ | VARCHAR2(255 char) | file version |
| STATE_ | VARCHAR2(255 char) | file approve state |
| EDITOR_ | VARCHAR2(255 char) | file editor |
| APPROVER_ | VARCHAR2(255 char) | file approver |
| REAPPROVER_ | VARCHAR2(255 char) | file reviewer |
| TIMEMARK_ | VARCHAR2(255 char) | file submit time |
| MACHINE_ | VARCHAR2(255 char) | machine |
| APPOPINION_ | CLOB | approval opinion |
| REAPPOPINION_ | CLOB | review opinion |

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<class name="org.jbpm.pvm.internal.lob.IesLob" table="jbpm4_ies_lob" >
  <id name="dbid">
    <column name="DBID_" />
    <generator class="assigned"></generator>
  </id>
  <version name="dbversion" column="DBVERSION_" />
  <property name="procinstid" column="EXECUTION_" />
  </property>
  <property name="blob" type="blob">
    <column name="BLOB_VALUE_" />
  </property>
  <property name="name" column="NAME_" />
  </property>
  <property name="lobid" column="LOBID_" />
  </property>
  <property name="state" column="STATE_" />
  </property>
  <property name="editor" column="EDITOR_" />
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  </property>
  <property name="reapprover" column="REAPPROVER_" />
  </property>
  <property name="timemark" column="TIMEMARK_" />
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  <property name="bj" column="BJ_" />
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  </property>
  <property name="changzhan" column="CHANGZHAN_" />
  </property>
  <property name="approveOpinion" column="APPOPTNION_" />
  </property>
  <property name="reapproveOpinion" column="REAPPOPINION_" />
  </property>
</class>

```

Figure 3. Hibernate Mapping File

5.4. Sample Approval Process

According to the business requirement of model approval, a sample of the approval process as shown in Figure 4 is designed using the process definition tool. After completing making graphic model, it can't be issued directly. First, users need to start a process and get the process instance index. Then, they can submit the model file for approval. The process will flow according to the result of approval and review until the end of the process.

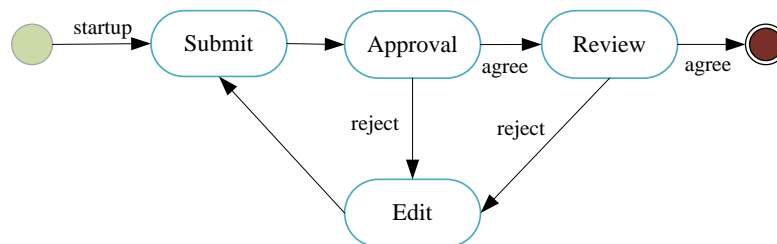


Figure 4. Sample of Approval Process

5.5. Testing and Application

The optimization scheme has been successfully achieved. The system has been tested and implemented as well. And the experiment has proven that the optimization scheme can improve the efficiency of model file approval.

To test the system, a hardware system platform was designed according to the field application environment. The Figure 5 shows the test hardware system platform of the system optimized. And the program system has been successfully deployed in the hardware system.

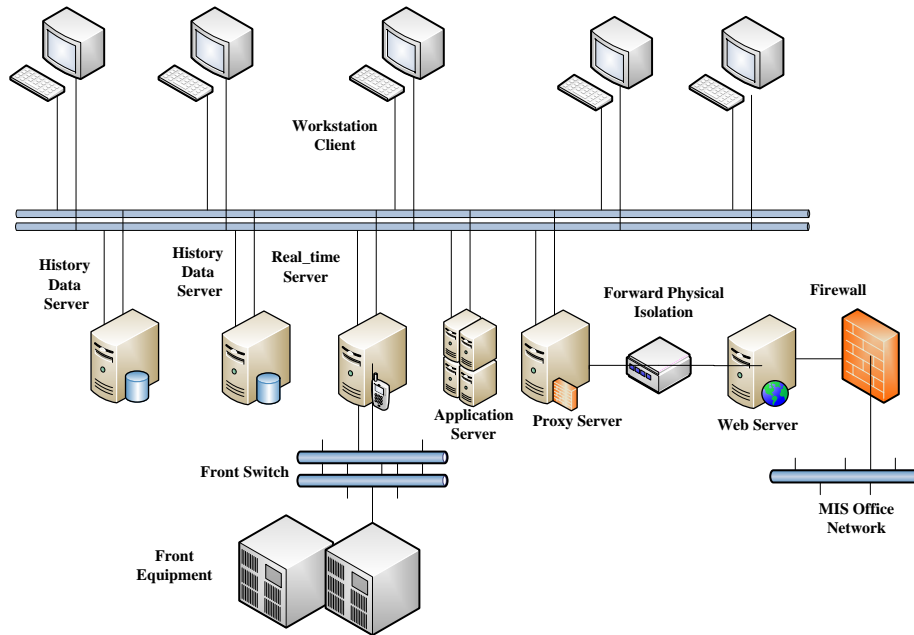


Figure 5. Hardware System Platform

Before using workflow, users need to start workflow service successfully and make sure that workflow service has registered to SoftBus correctly. The Figure 6 shows that the workflow service has started and registered to SoftBus successfully. Next, the model client should be started since the workflow client is embedded in it. The Figure 7 presents the new model client. The workflow client and workflow service can communicate through SoftBus.

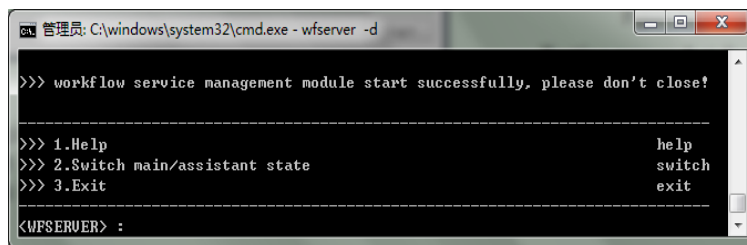


Figure 6. Service Startup Window

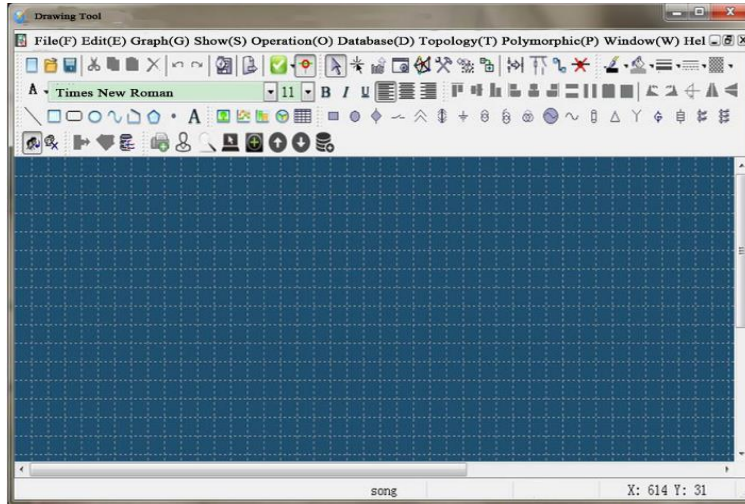


Figure 7. Model and Workflow Client

After completing making graphic model, users can start an approval process instance from workflow startup window by selecting appropriate process definition and submit the model file for approval. The workflow startup window is shown in Figure 8. When starting a flow, users need to allocate participants for each task based on their departments and roles. Each task can be allocated to all the personnel with a role of a department, also can be allocated to a specific person with a role of a department. In addition, the participants of each task can be changed during the flow of approval process. Then the approval process can execute automatically according to the definition. The whole work logic just likes Office Automation (OA).

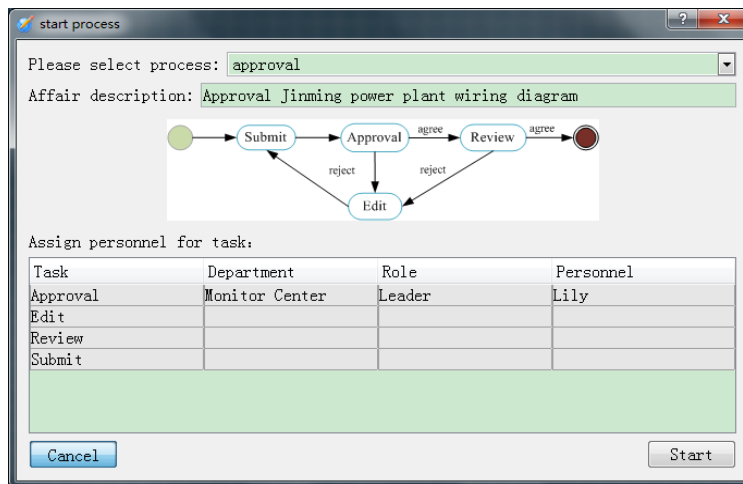


Figure 8. Process Startup Window

When logging in the system, users can view the tasks that need to be handled from task list window which is shown in Figure 9. It can be seen from the task list window that the personal task is shown in red and the group task is shown in blue. After one task is handled, the approval process will flow to the next node until the end of the process. Moreover, users also can delegate task to other people or view task detail from

the task list window. Note that only personal task can be delegated to other people. And before handling group task, users need to extract the task first. Once the group task is extracted by one of the candidates, other people cannot extract it again.

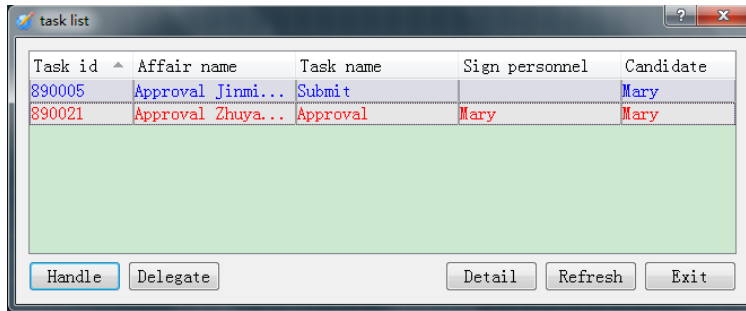


Figure 9. Task List

These users with workflow management authority can monitor and control the execution of all processes from workflow management window, which is shown in Figure 10. They can terminate a process according to the actual situation. In addition, they can query history process instances for analysis. The query is based on user name and time period as shown in Figure 11.

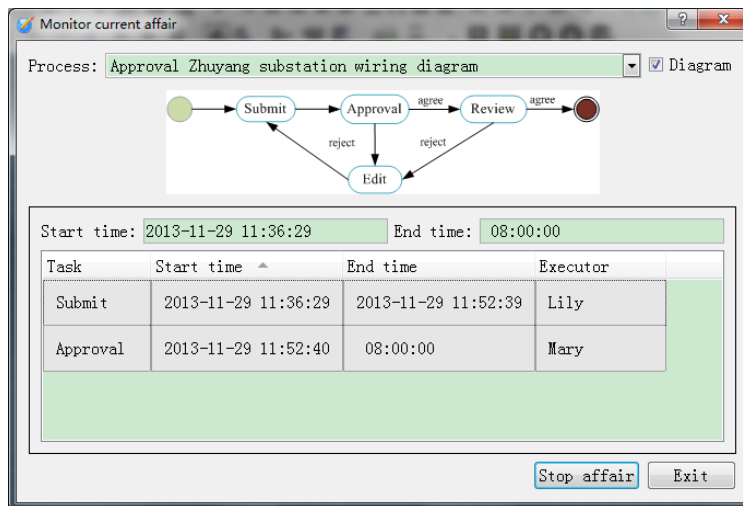


Figure 10. Workflow Management Window

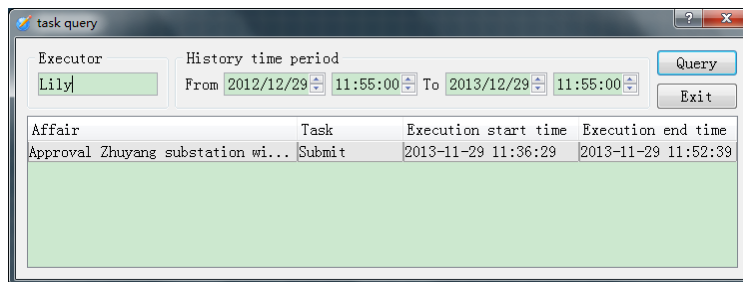


Figure 11. History Task Query Window

The experiment has proven that the new iES600Pro system can be well applied for approval graphics files with workflow and other related operations. And it is convenient and efficient.

6. Conclusion

This paper proposes a dispatching automation master system optimization scheme, which embeds workflow engine in the system. So the dispatching system can implement complete approval process of modeling. And the process is flexible, convenient and customizable. Accordingly, the proposed scheme has been successfully achieved. This paper also describes the implementation of scheme including the architecture of system after the optimization, the design of business data table, the sample of approval process, development tools as well as the testing platform and testing results.

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