Research on PLC Information Model Based on UML Class Diagram

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Abstract. In the industrial control system, there are a variety of PLC, which are made of different manufacturers and with various types, working in the operation line for different enterprises. Due to the different communication protocols and information exchange standards, it is difficult to achieve information sharing and unified management, and easily leading to "information island". In this paper, the PLC information model is put forward to design the information standard, and further to realize the standardization of data collection and industrial information, system integration and information sharing, and then set up the industrial control information standard. The modeling and drawing principle of PLC information model based on UML is introduced, and the modeling and drawing method of PLC information model based on EA UML modeling tool is presented.

1. Introduction
PLC has high reliability and strong anti-interference ability, and has been widely used in industrial control field, having become one of the three pillars of modern industrial automation [1]. In the industrial control system, there may be cases where various types of PLCs produced by various manufacturers operating in production lines of different enterprises. Since various PLCs adopt different communication protocols and information exchange standards, and the compatibility is poor, it is difficult to achieve information sharing and unified management, and it is easy to form an "information island" [2]. The current problem of non-opening, non-interworking, and difficult interconnection of PLC has become a paradox or bottleneck restricting the development of smart manufacturing. To this end, it is necessary to follow the unified standards and build a unified industrial control information platform for the development of sensing, measurement, control, communication, network, cloud computing, and big data in PLC and even industrial control fields. The compilation of information standardization standards in the industrial control field includes information standards, interface specifications, information security rules, and so on. The PLC information model proposed in this paper is to design information standards, standardize data collection, standardize industrial control information, and facilitate system integration and information sharing.

The existing industrial control information related standards mainly describe the system structure system, but lack the information system architecture, information modeling and communication interface standards. Take the national standard "GB/T 15969 Programmable Controller" as an example. This standard only reflects the basic elements and usage methods of the equipment, but does not explain the information representation between PLC and equipment, PLC and network, PLC and MES system. Methods, information exchange methods, information security and other issues.
2. Material and Methods

UML provides a set of graphical symbols for modeling object-oriented systems [3]. Class Diagram is the most common and important diagram in object-oriented system modeling. It is the basis for defining other graphs. It is mainly used to display the classes, interfaces and static structures and relationships between them. a static model. The relationships between classes are generalized, related, dependent, and implemented.

2.1 Several relationships between classes

2.1.1 Generalization. Generalization is an inheritance relationship that represents a general and special relationship, and the sub-class inherits all the details of the parent class. In the class diagram, a solid line with a hollow arrow is used, and the arrow points from the subclass to the parent class.

2.1.2 Implementation (Realization). Implementation is a relationship between a class and an interface, indicating that the class is the implementation of all the features and behaviors of the interface. In the class diagram, the dotted line with a hollow arrow is indicated, and the arrow points to the interface.

2.1.3 Association. An association is a connection between a class and a class. It makes a class know the properties and methods of another class and indicates the connection between the objects of the thing. The class diagram is represented by a solid line with a common arrow. The two-way association can have two arrows or no arrows, and the one-way association has an arrow.

The aggregation relationship is a relationship between the whole and the part. Even if there is no whole, the part can exist separately. The class diagram is represented by a hollow diamond, and the diamond points from the local to the whole.

Combinations are whole and part, but parts cannot exist separately and exist separately. The class diagram is represented by a solid diamond, and the diamond points from the local to the whole.

Multiplicity is often used in associations, aggregations, and combinations to represent how many associated objects exist. Expressed by "number: asterisk (number)".

2.1.4 Dependency. A dependency is a dependency between two or more classes. The class diagram is represented by a dashed line with an arrow pointing to the dependent element.

2.2 PLC information model

In UML modeling, class diagrams can be used to represent how different entities are related to each other. UML modeling can make it easier to abstract the relationship between classes and classes by using forms such as class diagrams. The information model proposed in this paper is based on the analysis of PLC data collection requirements. Based on the object-oriented thinking, seven classes are abstracted from the basic properties of PLC, and the relationship between these classes is analyzed and determined.

Based on the object-oriented technology, the UML class diagram is used to build the PLC information model. This paper proposes the information model modeling flow chart shown in Figure 1, and divides the UML class diagram modeling into six steps. The first four steps are detailed as follows.

(1) Analyze the problem domain and determine the requirements:

The standard is formulated with reference to the IEC information model, which describes the information model in an object-oriented manner and abstracts the information through classes. The basic components of the PLC [4] include the central processing unit (CPU), memory, input/output interfaces (I/O, including input interfaces, output interfaces, external device interfaces, expansion interfaces, etc.), external device programmers, and power modules. The internal components of the PLC are connected by the power bus, the control bus, the address bus and the data bus, and the external device is configured according to the actual control object to form the PLC control system [5].
The demand is mainly to obtain the classes required for modeling, the parameters of the class, the attributes, methods, and the relationships between the classes from the basic components of the PLC and the basic attribute information. Then, verify the information needed for modeling according to the existing standard specifications, and make the necessary supplements, and finally classify the information into 7 standard classes.

(2) Find the class and determine the meaning and responsibilities of the class:

Based on the functions of the system, these functions are analyzed and summarized, and the relationship between the functions is clarified. The basic attributes of the PLC are divided into seven categories, namely CPU module, temperature control module, I/O port module, I/O expansion module, register module, power module, and communication module.

(3) Define the properties and operations of the class:

The I/O port module mainly realizes the input interface to convert various control signals input from the field control or detection component to the PLC into signals that the CPU can receive and process, and output interface circuit converts the weak electric control signal sent by the CPU into a strong electric signal required in the field [6]. Its properties and operations are shown in Figure 2.

**Figure 1. Information model modeling flow chart.**

**Figure 2. The properties and operation of I/O extended module.**
Figure 3. The properties and operation of power module.

The power module mainly converts the externally supplied AC power into DC power required for the CPU, memory, etc., and its attributes and operations are shown in Figure 3.

The communication module [7] is used for program and data exchange between the programmable controller and other programmable controllers or any devices in an external device or automation system. It provides functions such as device verification, data acquisition, alarm reporting, program execution and I/O control, application transfer, and connection management between external devices and PLC signal processing units. Its properties and operations are shown in Figure 4.

Figure 5. The properties and operation of register module.

Programmable controllers require a variety of logic devices and computing devices with different functions in software design, called programming components. These programming components are used to complete the logic operations, arithmetic operations, timing, counting functions given by the program, and the name of the relay [8] is used and named according to their functions, such as input relays, output relays, timers, counters. Wait. However, these devices are not real physical devices, but...
are composed of electronic circuits and memories. Each programming device corresponds to a memory cell of the component image register in the PLC memory, such as timer T, counter C, auxiliary relay M, The state device S and the like are all composed of memories. When the PLC is working, the data in the register is read by changing the state of the register. Its properties and operations are shown in Figure 5.

The I/O expansion module is used to connect the expansion module to the basic unit, so that the configuration of the PLC is flexible to meet the needs of different control systems. When each function module is connected to the PLC host, it can be simply plugged in, which is flexible and convenient. When the host I/O point does not meet the requirements of the control system, various I/O modules can be expanded as needed. Its properties and operations are shown in Figure 6.

Figure 7. The properties and operation of temperature module.

The temperature measurement module is used to measure and display the temperature of the process control, including the thermocouple temperature measurement module TC and the platinum resistance temperature measurement module RTD, and the temperature measurement input signal from the process control is converted into a digital quantity of a certain number of bits for PLC operation and processing. Its properties and operations are shown in Figure 7.

(4) Determine the relationship between the classes.

The CPU module is the core class of the whole model. The power supply, I/O port, register module and CPU module are combined. The temperature control, communication, I/O expansion module and CPU module are related, thermocouple, platinum resistance temperature control module. It is a generalization relationship with the total temperature control module.

3. Results

An example of a UML class diagram of the PLC information model is shown in Figure 8. The CPU module is the core class of the entire model, which processes the signals acquired from the sensors and
the internal data memory according to the application, generating signals to the actuator and the internal data memory.

**Figure 8. UML Class Diagram Example of PLC Information Model.**
4. Conclusions
The PLC information model proposed in this paper describes the information model in an object-oriented manner, and abstracts the information through the class to complete the design of the information standard in the industrial cloud platform. The unified information representation mode in the constructed industrial control information platform is compatible with various PLCs, which is convenient for industrial system integration and information sharing. Based on this, the definition of information interface between modules, the design interface specification can be further clarified, the PLC information model can be realized, and the standardization of information exchange can be realized, which provides basic conditions for interoperability and information fusion of industrial control cloud terminals in the future.

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