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Preliminary design of ECCO: Experimental control system which is cloud oriented

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HIGHLIGHTS

- ECCO is a self-organized and de-centralized control system software.
- *ECCO integrates ECCO-SDD and ECCO-REST..*
- ECCO network protocol is based on HTTP protocol and RESTful design practice, implements Hypermedia, automatic discovery, and event.
- ECCO is flexible, plug-and-play, and provides a series of unified toolkits.

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ABSTRACT

As the development of the Tokamak, the scale of the facility is getting bigger and bigger. It is a great challenge to design, manage and operate a control system of such big scale. So we developed a new control system software: Experimental Control System which is Cloud Oriented (ECCO).

ECCO consists two parts, ECCO-SDD and ECCO-REST. ECCO-SDD is used to design, manage and describe the whole control system, configure every subsystem statically. There is a SDD editor which is a human machine interface for control system designer to design by simply drag and drop, and it can be easily extended using plug-in. The ECCO-SDD translator is used to generate different outputs. All the system design and configuration is stored in the MongoDB database using an object relational mapping dedicated designed for ECCO-SDD.

ECCO-REST mainly defines a control network protocol based on HTTP RESTful service, it also implements automatic discovery using Zero-configuration (Zeroconf) networking standard. Since this protocol is based on industrial standard and transparent protocol, it is open enough and it can be easily implemented by others. ECCO-REST application is the core of ECCO-REST, it is a cross platform control software running on distributed control units just like the EPICS IOC. It can be extended by user created models. It is configured by human readable JSON file which can be generated by ECCO-SDD translator.

ECCO is a self-organized and de-centralized control system software. Based on the same protocol, every part of the system can discover each other, thus the controllers which ECCO-REST application running on can constitute a cloud control system, and each controller can operate autonomously.

1. Introduction

The integrated control system is to operate the whole control system by a unified way. The control system software can provide the software design standards, the related toolkit and the control network protocol. A well designed control system software can make the integrated control system much more flexible and maintainable.

Experimental Physics and Industrial Control System (EPICS) [1] and TANGO [2] are widely used integrated control system software. EPICS use Channel Access (CA) network protocol to communicate between the various computers via process variables (PV) and it is signal-oriented. EPICS version 4 [3] extended EPICS with complex data structures, a new network-accessible application framework,

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and Service Oriented Architecture (SOA). New pvAccess protocol in EPICS version 4 is designed to support the structured data types which called pvData, optimized interoperability of control system endpoints. TANGO is a device-oriented controls toolkit which uses two network protocols: the omniorb implementation of CORBA and Zeromq.

ITER employs EPICS as integrated control software framework and develops ITER SDD as its static configuration to describe control system. ITER SDD [4] is designed according to EPICS. KSTAR has performed a standard framework of control system which based on EPICS. [5]

ECCO is designed to build a de-centralized and self-organized control system. ECCO consists two relatively independent parts: ECCO-SDD and ECCO-REST. ECCO-SDD just like ITER SDD for static configuration, and ECCO-REST is similar to EPICS, but ECCO-REST is based on HTTP network protocol. All the nodes running ECCO-REST forms a cloud. Each ECCO-REST node can consume the services in the cloud without pre-knowing about the nodes in the cloud. Using Hypermedia and Zeroconf, the nodes can discover the services provided by the cloud and realize plug-and-play, thus it is cloud oriented. ECCO is flexible, and provides a series of unified toolkits, thus it can be in more common use.

2. ECCO-SDD

ECCO-SDD is used to design, manage and describe the control system, and configure every sub system statically [6]. ECCO-SDD defines the model of static control system and saves all the information to database. ECCO-SDD can also generate control system configuration file by using translator.

2.1. ECCO-SDD model

ECCO-SDD model is defined to describe the control system and its components in a universal way.

There are interconnections among control system components, in other words, a control system should be organized as a hierarchical structure. There are no isolated components, every component link to its upper or lower component.

ECCO-SDD regards every relatively independent control system element as an ECCO-SDD Entity. Entities are divided into two types: ECCO-SDD Component and ECCO-SDD Connection. There are also ECCO-SDD Link and ECCO-SDD Port for the purpose of link.

ECCO-SDD Entity is the basic control system element which is logical independent. ECCO-SDD stores every Entity in the database. Entity class is the superclass that Component and Connection inherit from. ECCO-SDD Link is the connection or relation-ship in control system. ECCO-SDD Port is the physical or logical slot that Entity can link to. ECCO-SDD Component is the fundamental element of the ECCO-SDD which inherits from the Entity. ECCO-SDD Connection is the optional element which also inherits from the Entity. ECCO-SDD provides the base classes of these models, users can create their own model inheriting from the base.

In order to store all the heterogeneous ECCO-SDD Entity, Link and other information, ECCO-SDD database is implemented based on MongoDB [7] which is a cross-platform document-oriented NoSQL (Not Only SQL) database.

2.2. ECCO-SDD editor and translator

ECCO-SDD editor is the HMI (Human Machine Interface) that users can design control system by simple drag-and-drop. The editor is based on NShape [8] which is an open-source diagram designing framework for .NET WinForms. The editor supports plug-and-play models, control system developers can create their own ECCO-SDD model, and the only thing they need to do is to place the compiled models to the editor folders as the plug-in. Thus the editor will find and load these models, get their attributes, initialize them with corresponding templates automatically. Users can find all the models in the toolbox and can use them to develop control system.

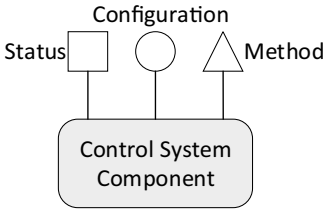

Fig. 1. Abstracted control system component.

ECCO-SDD translator is to generate different outputs when users complete the design in editor, the translator is integrated into the editor currently. The translator can generate ECCO-REST application configuration file, assembly drawings, equipment list which can be basis of equipment purchase, and so on.

3. ECCO-REST

3.1. ECCO-REST model

For a control system component, we need a unified software interface to gain the internal status when it running, control the component and respond to an event. We abstract the control system component into three attributes: Status, Configuration, and Method. We can achieve general function by means of the three attribute, but the particular function is implemented by its internal logic. The ECCO-REST protocol is based on HTTP RESTful service, it is used to access resources. All the three attributes are ECCO-REST resources.

Status is a collection of properties contains the control system component's internal information that external need to know. It can be achieved on the hiding and encapsulation of the internal control system component by using Status. Status only accepts HTTP GET method. Configuration is a collection of contains a series of parameters which can be modified by other components in the control system by using ECCO-REST protocol. The behavior of the control system components are determined by these parameters. It is recommended that Configuration can be modified by others rather than the control system component itself, but that is not mandatory. Configuration seems to be similar to the input of traditional control system, but it will affect the behavior of the control system. Configuration accepts HTTP GET, PUT and POST method. Method is an instructions with no parameters, just like the event in discrete event system.

The abstract of a control system component is shown in Fig. 1. Any control system component can interact with each other by unified interface. The whole control system consists of these components. Status is the synthesis of its internal information; therefore it can neither show the whole internal status, nor complete input of the system. Hence external cannot calculate the control system's output or the next status by this integrated controlling interface. This satisfies the encapsulation of control system component. A control system component should not depend on other component's internal status. It can be a component when several components make up to a control system, but the Status, Configuration, Method must be redefined.

Every ECCO-REST model must combines the function itself and the Status, Configuration, Method. Control system developer only need to mark the attribute provided by ECCO-REST in the code to declare them.

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