CONFIGURATION SYSTEM OF THE NSLS-II BOOSTER CONTROL SYSTEM ELECTRONICS

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Abstract

The National Synchrotron Light Source II is under construction at Brookhaven National Laboratory, Upton, USA. NSLS-II consists of linac, transport lines, booster synchrotron [1] and the storage ring. The main features of booster are 1 or 2 Hz cycle and beam energy ramp from 200 MeV up to 3 GeV in 300 msec. EPICS is chosen as a base for the NSLS-II Control System. The booster control system covers all parts of the facility such as power supplies, timing system, diagnostics, vacuum system and many others. Each part includes a set of various electronic devices and a lot of parameters which shall be fully defined for the control system software.

This paper considers an approach proposed for defining some equipment of the NSLS-II Booster. It provides a description of different entities of the facility in a uniform way. This information is used to generate configuration files for EPICS IOCs. The main goal of this approach is to put information in one place and elimination of data duplication. Also this approach simplifies configuration and modification of the description and makes it clearer and easily usable by engineers and operators.

INTRODUCTION

NSLS-II Booster magnetic system contains 68 power supplies of 6 types. It is controlled [2] by EPICS, which is used on booster as well as on all other NSLS-II subsystems. For convenience of development, debugging and operation all direct control is performed by 6 IOCs, one for each type of power supplies (including similar ones). All IOCs run on one dedicated Linux server.

Table 1: Amount of PS' channels

	ai		ao	bi	bo	PSs	sum		
	1k wf	10k wf	10k wf				wf	bin	all
bend	10	2	1	16	3	3	39	57	96
quad	9	2	2	11	2	3	39	39	78
corr/ sext	3	2	1	1	1	52	312	104	416
pulsed sept.	5	2	1	10	2	3	24	36	60
kicker	7	2	1	15	3	6	60	108	168
dc-sept.	5	2	1	7	3	1	8	10	18
						Total	482	354	836

Each power supply contains analog inputs for control, analog outputs for measurement, digital inputs for control and digital outputs for status. Table 1 lists channel groups for each PS type. Titles have following meaning (in EPICS style): *ai* – analog input, *ao* – analog output, *bi* – binary input (status), *bo* – binary output (control), *wf* – waveform (an array of values by regular intervals).

Power supplies are controlled via special electronic hardware bundle: PSC and PSI [3]. These devices were developed in BNL specifically for NSLS-II PSs. From control system's point of view they compose a single device, separated in space for convenience of use and because of electro-technical reasons. So, below we'll consider only PSC, since it implements all devices' logic and interacts with control system software.

Each PSC contains 2 DAC channels, 18 ADC channels, 8 binary outputs and 16 binary inputs. So, depending on a power supply type, some subset of available channels is used. Each PSC channel is patched to a definite PS's channel, depending on PS type.

Booster employs 44 PSCs, with over 800 channels involved. Additionally, some artificial software channels are required for system operation; such as PS stability monitoring channels, channels with processed data from ADCs, etc. So, resulting number of channels is several times larger. Obviously, it is hardly possible to describe such big set of channels (and keep it up to date!) "by hand". Particular difficulties are caused by changes in configuration, e.g. renaming or re-patching of PS to a different PSC.

To solve this task a PyCDB [4] configuration system has been used. It was designed specifically to store and edit configuration information for control systems of various scales.

DATA MODEL

PyCDB is a graph database, which allows storing configuration data for experimental facilities in optimal way. To use it the data model (schema) should be described first; this is similar to table structure in relational databases.

Data model describes a set of entities with attributes, their links, types of links, directions and multiplicity of links.

A data model designed for NSLS-II Booster magnetic subsystem is presented on Fig. 1.

The Server is a computer which runs IOC. Since each computer can run more than one IOC, the relation between Server and IOC has multiplicity 1 - 0…n (one-to-many), and type of relation is Logical, meaning that IOC is logically related to (ran on) Server. Then, each

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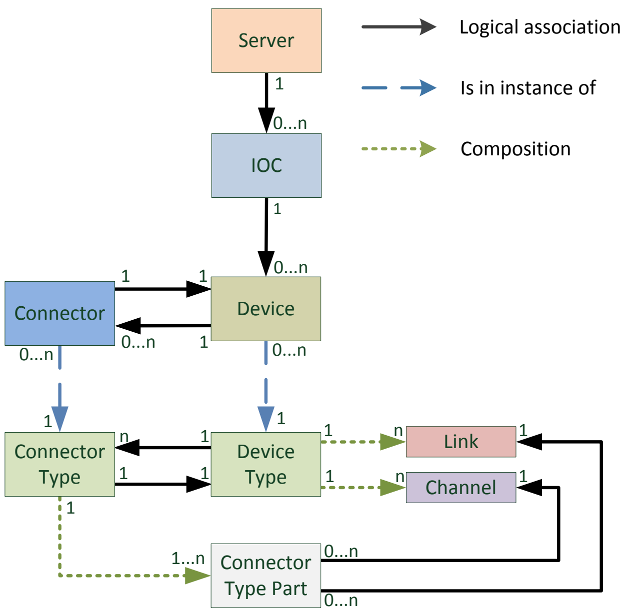

Figure 1: Data model of NSLS-II Booster magnetic subsystem.

IOC serves a number of Devices (1 - 0…n relation, of Logical type). Each Device has its own type (Device Type), and multiple devices of each type are possible (0…n - 1 relation); type of this relation is Types. Each Device Type describes a "device template", specifying which Channels this device includes and which Links to other devices are possible. In other words, Channel is similar to socket, while Link is similar to plug.

Since links between two devices is often not limited to a single link, an additional Connector Type concept was introduced, which describes a way to connect two given device types. And Connector Type is related (Composition) to Connector Type Part – elementary entity which accounts for relation of one channel to one link. Thus, we can define an arbitrary number of ways to connect channels to links between two any device types. This is useful in case when the same control device can be connected to different controllable devices (for example, different PSCs are connected to different types of PSs, with different sets of channels; and even to same type PSs, but using different channels).

CONFIGURATION OF MAGNETIC SYSTEM

Fig. 2 shows a part of configuration information graph for NSLS-II Booster magnetic subsystem. This graph is based on scheme shown on Fig.1 and contains two PSCs (PSC01 and PSC02) and two bend magnets' PSs (Bend01 and Bend02). PSC01 controls Bend01, PSC02 controls Bend02. First pair is connected via PSC01-Bend01 connector, while second one is via PSC02-Bend02; both connectors are of the same type PSC-Bend (i.e., these two device pairs are connected in a same way). This type of connection supposes that PSC channels DAC01, ADC02 and ADC06 are connected to links AI01, AO05 and AO07, respectively.

All of these four devices are served by ps-br-bend IOC, which runs on psioc-br-rgb server.

Example above shows that DB contains both PSC devices and PS devices. Such description forms two layers [5]:

1. Controllers' (hardware) layer, required for engineer screens for PSCs.
2. Power supplies ("logical") layer, used by higher-level applications for "direct" control of PSs.

DATA EXPORT

Access to configuration information is provided by a dedicated API, which allows convenient node-to-node traversal over graph, search for nodes by specific criteria, create/delete/modify nodes and links. To enable data export from central DB to local storages (as described in [4]) PyCDB includes a flexible modular-extensible mechanism.

In the course of Booster magnetic subsystem control system development a PyCDB module was created which extracts data from DB and creates a configuration file required for IOC start. To solve this task special parameterizable .db-files for EPICS were made, which are reused during automatic generation of IOC start scripts. The module's algorithm traverses a graph, extracts parameters from nodes and substitutes their values into prearranged templates using .db-files. At final stage resulting start script is copied to an appropriate directory at IOC-running server.

There are plans to extend this approach to other NSLS-II subsystems.

PyCDB web-interface allows to edit data in table-text mode. Currently a visualization and editing module is under development, which will present both data schema and data in a more demonstrative way.

CONCLUSION

Configuration information for control systems comprises a large amount of data with non-trivial relations and dependencies. It is obvious on NSLS-II Booster magnetic system, which consists of 44 controllers, 68 power supplies, 836 control and measurement channels. The total size of IOC start scripts is 762kb. Obviously, creation and support of such amount of information is problematic without some means of automation.

This paper describes an approach to configuration information management on NSLS-II Booster magnetic subsystem using PyCDB – a specialized tool, enabling centralized creation, editing and automated export to local storages of information required for control system operation. PyCDB use significantly decreases control system maintenance costs and minimizes human factor-related problems.

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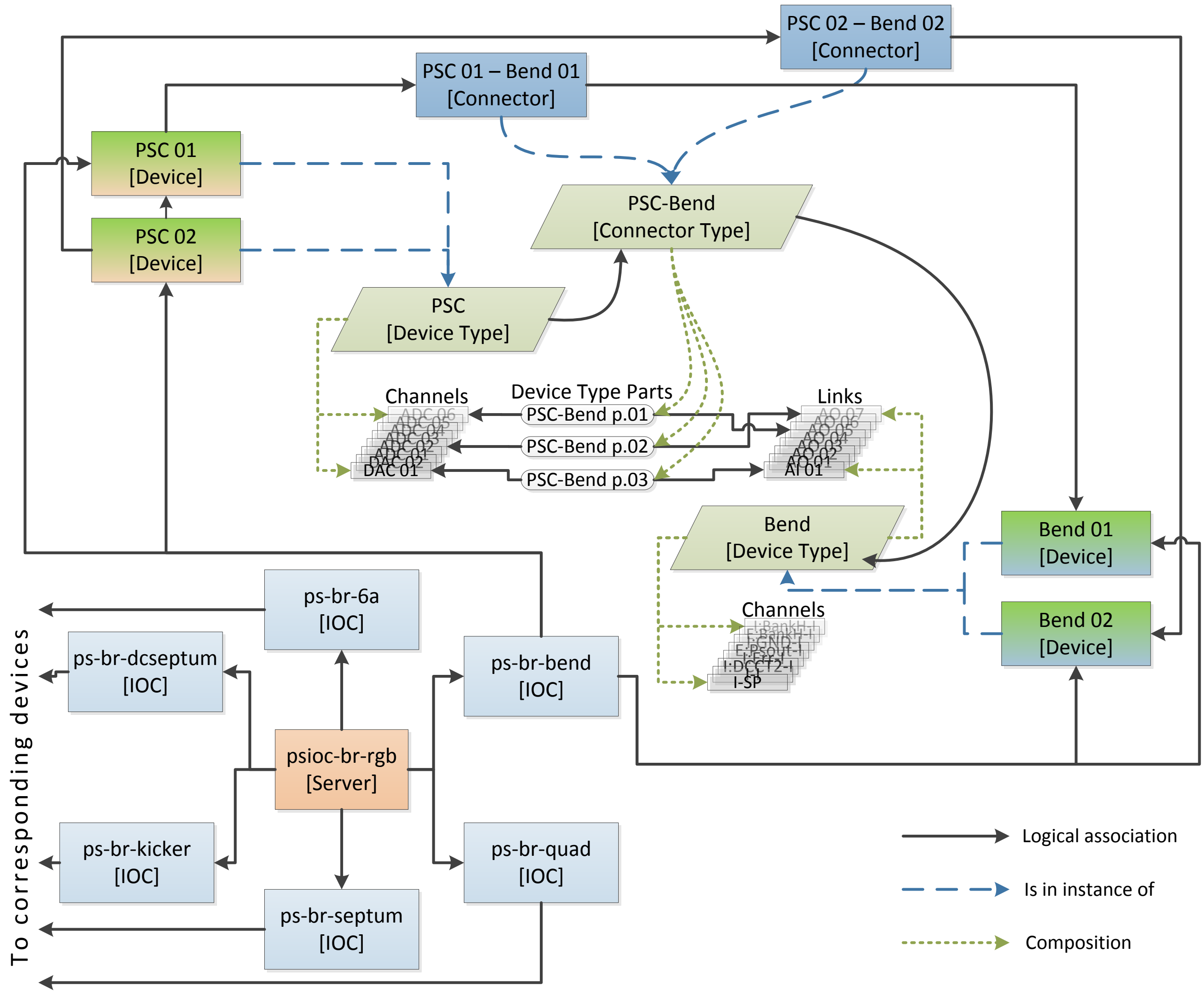

Figure 2: Simplified part of configuration information graph for NSLS-II Booster magnetic subsystem.

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