Development of ADS virtual accelerator based on XAL

WANG Peng-Fei(王鹏飞)^{1,2;1)} CAO Jian-She(曹建社)¹ YE Qiang(叶强)¹

 1 Institute of High Energy Physics, Chinese Academy of Sciences, Beijing 100049, China 2 University of Chinese Academy of Sciences, Beijing 100049, China

Abstract: XAL is a high level accelerator application framework that was originally developed by the Spallation Neutron Source (SNS), Oak Ridge National Laboratory. It has an advanced design concept and has been adopted by many international accelerator laboratories. Adopting XAL for ADS is a key subject in the long term. This paper will present the modifications to the original XAL applications for ADS. The work includes a proper relational database schema modification in order to better suit the requirements of ADS configuration data, redesigning and re-implementing db2xal application, and modifying the virtual accelerator application. In addition, the new device types and new device attributes for ADS online modeling purpose are also described here.

Key words: XAL, ADS, relational database, db2xal, virtual accelerator PACS: 89.20.Ff, 29.20.Ej DOI: 10.1088/1674-1137/38/7/077006

1 Background

The Accelerator Driven Sub-critical System (ADS) takes the spallation neutrons as a external neutron source to drive the sub-critical blanket system [1]. Consequently, it has an inherent safety and has been universally regarded as the most effective approach to dispose of long-lived nuclear wasted. In 2011, the Chinese Academy of Sciences launched the "Strategic Priority Research Program" named "Future Advanced Nuclear Fission Energy" [1]. This program has two subprograms, one of which is the ADS Project.

XAL [2–4] is a mature framework for the rapid development of applications. It is written in Java, and provides users with a hierarchal view of the accelerator, which is shown schematically in Fig. 1. The features include database configuration of the accelerator structure, a common look-and-feel graphical user interface (GUI), an online envelope model that is configurable from design or live machine values, a scripting interface for algorithm development, and many other utility packages.

2 ADS accelerator database

The decision to use MySQL was made easily and early. MySQL is the world's most popular open source database, it is widely used in the world by many of the largest organizations (including Facebook, Google and Adobe), it is extremely easy to use, it has scalability and flexibility, high performance, high availability, robust transactional support, strong data protection, easy management, and the MySQL relational model is well known and understood. Compared with relational database, OO databases have some stabilityrelated "early adopter" problems. These factors led us to choose MySQL.

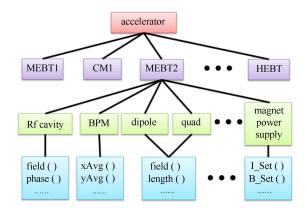


Fig. 1. Schematic of the XAL accelerator class hierarchy.

The ADS virtual accelerator database that is shown in Fig. 2 uses the standard relational model. It is redesigned and implemented by referencing the SNS [5] and CSNS [6] virtual accelerator database.

Database - a brief introduction

1) BEAM_LINE_DVC: Information of beam line devices such as the measured misalignments, aperture shape and size.

Received 22 September 2013

¹⁾ E-mail: wangpf@ihep.ac.cn

 $[\]odot$ 2014 Chinese Physical Society and the Institute of High Energy Physics of the Chinese Academy of Sciences and the Institute of Modern Physics of the Chinese Academy of Sciences and IOP Publishing Ltd

2) DVC: Information of all devices including standby equipment.

3) BEAM_LINE: Version information of beam line.

4) DVC_WS_SFTW: The WS device is profile monitor or wire scanner.

5) DVC_SET: Information of the device settings for beam line devices.

6) CHANNEL: The master list of valid EPICS PVs and its handler, classified by device type.

7) BPM_DVC: Unique information of the BPM device.

8) DVC_SEQ: Information of accelerator sequences.

9) RF_GAP: Unique information of the RF cavity gap.

10) RF_DVC: Unique information of the RF cavity.

11) MAG_DVC: Unique information of the magnet.

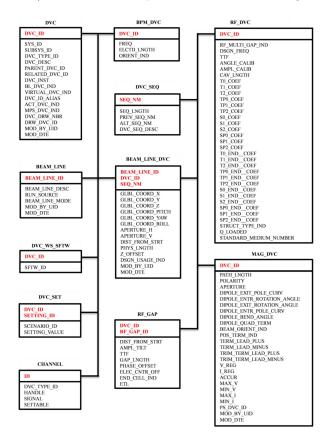


Fig. 2. ADS virtual accelerator database.

3 ADS virtual accelerator configuration files

The XAL configuration mechanism is driven by five main files and two auxiliary files, as shown in Fig. 3. The main.xal file contains the names and locations of other four main files, which are: ads.impl, ads.xdxf, model.params, timing_pvs.tim. The two auxiliary files are ADSMEBT1Entr. probe and xdxf.dtd.

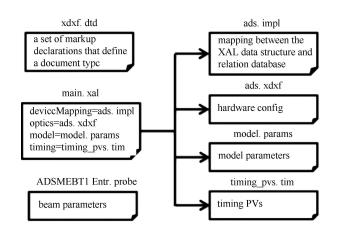


Fig. 3. XAL configuration files.

4 Db2xal

Among the XML configuration files, the ads.xdxf file has tens of thousands of lines. Consequently, it is difficult to manually generate this file. Db2xal is an XAL general purpose application that is able to do this tedious task, but the original db2xal has much SNS specific information embedded in the code, which leads to bad performance in ADS. ADS also has specific elements, like the solenoid element. Besides, the bunchers in MEBT1 and RF cavities in CM1 use the new attribute ETL instead of the separate properties—the longitudinal electric field (E), the transit time factor (T) and the gap length (L). In addition, the original db2xal application has poor interaction. Redesigning and re-implementing db2xal application to better suit ADS configuration data requirement is needed. The flowchart of db2xal is shown in Fig. 4.

4.1 Implementing

1) Three main classes

(1) Main. This is a subclass of Application Adaptor base class.

(2) Db2XalDocument. As a general purpose application, the Db2XalDocument class subclass the XalDocument base class. It typically implements the actions for the views defined in the gui.bricks file and the menu definitions file.

(3) Db2XalExtractDataFromDB. This is the main class responsible for extracting data from the database to generate corresponding optics configuration information.

2) Four auxiliary classes

(1) Db2XalMyTableModel. This is an inner class of Db2XalDocument and is used to generate the data of the table, as shown in the left part of Fig. 5, and handle the button event.

(2) MyTimerTask. This is an inner class of Db2Xal-Document and is used to update the information of the status bar and the status of the progress bar.

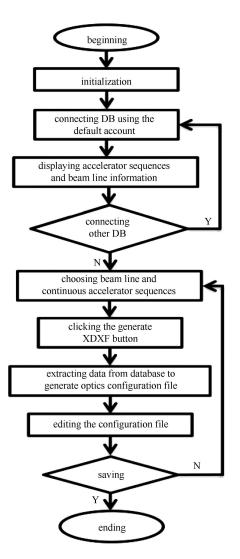


Fig. 4. Flowchart of db2xal [10].

(3) Db2XalBeamlineIDTableDialog. This is used to pop up a dialog box and handle the button event.

(4) Db2XalBeamlineIDTableModel. This is an inner class ofDb2XalBeamlineIDTableDialog and is used to generate the data of the table in the dialog box.

3) GUI file [7]

Gui.bricks, which resides in the "resources" subfolder of Db2XAL, is generated by the Bricks application. It describes the views within the document's associated main window. The main interface of Db2xal include title bar, menu bar, toolbar, workspace and status bar, as shown in Fig. 5. The title bar and toolbar is provided by the XAL framework. The menu bar is defined in the menu definition file, which resides in the same folder as Gui. bricks. Gui.bricks describes the layout of the views within the workspace and status bar.

4.2 Program function

The ADS initial design development stage wherein,

it is possible that errors will be discovered that will require design changes. The version information of the beam line, such as beam line ID and beam line info, is used to record these changes. The read-only textbox shown in the upper part of Fig. 5 is used to display the version information. The beam line ID can be changed by clicking the "Change ID" button. In order to generate a configuration file, it is necessary to select the appropriate beam line ID and continuous sequences. A warning message-"You must select continuous sequences!" appears when discontinuous sequences are selected. When the user clicks on the "Generate XDXF" button, the main process of db2xal will extract data from development database or production database, and display the result in the textarea control. A development database that mainly used by programming staff is used to test the new device or sequence. The production database, which is the db2xal's default database, is used in the daily operations. The user can change the default database by selecting the "Database" menu item. Meanwhile, some measures are taken to promote interactivity, such as using a status label to display messages during different phases of the application's life cycle or using a progress bar to show an approximate percentage of completion of the main process. The final result displayed in textarea control can be edited according to customer needs or it can be exported to "ads.xdxf" should the user click the "Save" button.

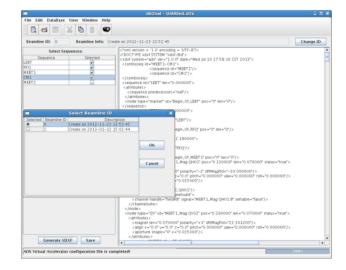


Fig. 5. The main interface of db2xal.

5 Virtual accelerator

With the Virtual Accelerator, it is possible for an operator to judge whether the setting parameters should be justified or not, examine the control system of the machine, and practice the commissioning without a beam. The original virtual accelerator application does not support solenoid PVs and ADS new attribute—ETL, so proper modification is needed in order to better suit the ADS online modeling purposes.

5.1 Modification

1) Adding support for solenoid PVs

Modifying the registerNodeChannels method in VAServer.java to register PVs for the node type of solenoid.

2) Addingnew attribute–ETL

(1) Adding new attribute–ETL to the RfGapBucket class which define a set of RF gap attributes.

(2) Adding definitions and functions in the RfGap class to handle the new attribute of ETL.

(3) Modifying the definition of METHOD_LIVE_ETL and METHOD_DESIGN_ETL in the RfGapPropertyAccessor class.

(4) Modifying the putSetPVs method, the configureReadbacks method and the SelectedSequenceChanged method in VADocument.java to suit the new attribute of ETL.

5.2 Program test result

The main process of the ADS virtual accelerator will be held in a recurrent state after the user starts the simulation. The built-in EPICS portable channel access server broadcasts all PVs, as shown in Fig. 6, which are defined in the selected sequence or sequence combo within the LAN. Any computers in the same network segment can get and set the value of virtual PVs. The final result shown in Fig. 7 validates that the solenoid PVs and the new PV–cavETL work normally. It also

References

- 1 ZHAN Wen-Long, XU Hu-Shan. Bulletin of the Chinese Academy of Sciences, 2012, **27**(3): 375 (in Chinese)
- 2 http://xaldev.sourceforge.net.
- 3 https://wiki.ornl.gov/sites/xaldocs/default.aspx.
- 4 Galambos J et al. XAL Application Programming Structure. Proceedings of 2005 Particle Accelerator Conference.

proves that the ADS configuration files generated by the application of db2xal are correct and that the ADS virtual accelerator runs normally.

File Edit Accelerator Mode View Window Help					
Probe File Probe Editor	Set Noise Start VA	Stop VA			
ilten					
Node	Readback PV	Readback	Setpoint PV	Setpoint	
MEBT1,Mag:QH01	MEBT1_Mag:QH01:B	30.0		30.0	
MEBT1.Mag.QV02	MEBT1.Mag.QV02:8	23.3012	MEBT1_Mag PS_QV02:B_Set	23.301	
MEBT1.RF:Bnch01	MEBT1.LLRF.FCM1:cavPh	1aseAvg -90.093307	MEBT1_LLRF.FCM1:CUPhaseSet	-90.09330	
MEBT1.RF:Bnch01:Rg01	MEBT1.LLRF.FCM1:cavET	FL 0.081490995	MEBT1_ULRF_FCM1_CtIETLSet	0.081490995	
MEBT1.Mag QH03	MEBT1_Mag:QH03:B	13.6887		13.688	
MEBT1_Mag 0V04	MEBT1_Mag:QV04:B	16 8444	MEBT1_Mag PS_QV04:B_Set	16.844	
MEBT1_RF:Bnch02	MEBT1_LLRF:FCM2:cavPh	-90.060978	MEBT1_LLRF:FCM2:CtlPhaseSet	-90.05097	
MEBT1_RF:Bnch02:Rg01	MEBT1 LLRF:FCM2:cavET	L 0.087055899	MEBT1 LLRF:FCM2:CtIETLSet	0.08705589	
MEBT1 Mag OH05	MEBT1 Mag:OH05:B	14.0463	MEBT1 Mag PS OH05:8 Set	14.046	
MEBT 1. Mag. OV06	MEBT1.Mag:OV05:8	15.6612	MEBT1_Mag PS_QV06:B_Set	15.661	
CM1.RF:SCLCavity01	CM1.LLRF:FCM1:cavPhas	-39.98517		-39.9851	
CM1.RF:SCLCavitv01:Rg01	CM1.LLRF:FCM1:cavETL	0.2777626	CM1.LLRF:FCM1:CtIETLSet	0.277762	
CM1.Mag/SOLE01	CM1.MagSOLE01:8	-0.729994	CM1.Mag:PS.SOLE01.8.Set	-0.72999-	
CM1.RESCLCavity02	CM1.LLRF.FCM2 cavPhas			-37.9851	
CM1_RFSCLCavity02:Rg01	CM1_LLRF:FCM2:cavETL	0.32192882	CM1_LLRF:FCM2:CtIETLSet	0.3219288	
CM1_Mag/SOLE02	CM1_MagSOLE02:8	-0.755629	CM1_Mag PS_SOLE02:8_Set	-0.755621	
CM1_RFSCLCavity03	CM1_LLEF FCM3 cavPhas	-36.988708	CM1_LLRF_FCM3_CtiPhaseSet	-36.988708	
CM1_RFSCLCavity03:Rg01	CM1_LLRF:FCM3:cavETL	0.37006249	CM1_LLRF_FCM3_CtIETLSet	0.3700624	
CM1 Mag SOLE03	CM1 Mag SOLE03:B	-0.784701	CM1_Mag PS_SOLE03:8_Set	-0.78470	
CM1 RF:SCLCavity04	CM1 LLRF:FCM4:cavPhas	-34.990133	CM1 LLRF:FCM4:CtiPhaseSet	-34.99013	
CM1 RFSCLCavtty04 Rd01	CM1_LLRF:FCM4:cavETL	0.4415414	CM1.LLRF.FCM4:CtIETLSet	0.441541	
CM1.Mag/SOLE04	CM1.MagSOLE04:8	-0.819133	CM1.Mag PS.SOLE04:8.Set	-0.81913	
M1.RFSCLCavity05	CM1.LLRF FCM5 cavPhas	-32.991409	CM1.LLRF:FCM5:CtiPhaseSet	-32.99140	
M1.RF.SCLCavity05:Rg01	CM1.ULRF.FCM5:cavETL			0.534902	
CM1_Mag/SOLE05	CM1_MagSOLE05:8		CM1_Mag:PS_SOLE05:8_Set	-0.85759	
CM1_RESCLCavIty06	CM1_U.RF FCM6 cavPhas		CM1.LLRF:FCM6:CtiPhaseSet	-29.9926	
CM1_RFSCLCavity06:Rg01	CM1_LLRF_FCM6_cavETL		CM1_LLRF_FCM6_CtIETLSet	0.6828866	

Fig. 6. The main interface of virtual accelerator.

	The glocalitost.	~
文件(E) 编辑(E) 查看(V) 终端(T) 标签(B) 帮助(H)		
[WPF@localhost ~]\$ caget MEBT1_L	LRF:FCM1:cavETL	•
MEBT1_LLRF:FCM1:cavETL 0	.081491	
[WPF@localhost ~]\$ caput MEBT1_L	LRF:FCM1:Ct1ETLSet 0.080250	
01d : MEBT1_LLRF:FCM1:Ct1ETLSet	0.081491	
New : MEBT1_LLRF:FCM1:Ct1ETLSet	0.08025	
[WPF@localhost ~]\$ caget CM1_Mag	:SOLE01:B	
CM1_Mag:SOLE01:B -	0.729994	
[WPF@localhost ~]\$ caput CM1_Mag	:PS_SOLE01:B_Set750025	
01d : CM1_Mag:PS_SOLE01:B_Set	-0.729994	
New : CM1_Mag:PS_SOLE01:B_Set	-0.750025	
[WPF@localhost ~]S caget MEBT1_M	ag:QHO1:B	
MEBT1_Mag:QH01:B 3	0	
[WPF@localhost ~]\$ caput MEBT1 M	ag:PS QH01:B Set 33	
	30	
New : MEBT1_Mag:PS_QH01:B_Set	33	
		•

Fig. 7. Test result of virtual accelerator.

Knoxville, Tennessee, 2005. 79

- 5 http://snsapp1.sns.ornl.gov/SNS_Data_Model/index.htm
- 6 GAN Quan. Development of the CSNS Virtual Accelerator Based on XAL (Ph. D. Thesis). Beijing: Institute of High Energy Physics (IHEP), CAS, 2009 (in Chinese)
- 7 Thomas Pelaia II XAL Application Frameworkand Bricks GUI Builder. Proceedings of ICALEPCS07. Knoxville, Tennessee, USA, 2007. 105