APPLICATION OF MODEL INDEPENDENT ANALYSIS WITH EPICS-DDS*

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Abstract

Model Independent Analysis (MIA) is an essential approach for measuring optical properties of accelerators. In this paper, we present a prototype of its online implementation based on the new NSLS-II high-level application environment.

INTRODUCTION

Commissioning and operation of the modern accelerator facilities depends highly on the performance and capability of the high-level applications. This paper presents the first NSLS-II online application based on the new EPICS-DDS three-tier consolidating environment [1]. The selection of Model-Independent Analysis as the first candidate was determined by two major factors. First, MIA has become one of the important practical tools in commissioning and operation of several accelerator facilities [2]. Second, it represents a complex test bed for the different technical decisions introduced and implemented in the new high-level application framework.

MIA is a spatial-temporal mode analysis technique used for processing turn-by-turn data measured at a large number of beam position monitors. The approach is based on Singular Value Decomposition (SVD) which decomposes the spatial-temporal variations of beam motion into a few orthogonal modes. As a result, MIA is able to provide the different types of important information, such as optical properties of accelerators and the performance of a BPM system, in an efficient and comprehensive way. Moreover, the level of mismatch between the design optics and MIA-based measurements can serve as quantitative criteria and guidance for a machine commissioning. This feature was especially appealing for developing and evaluating this application in the context of the new consolidating environment using both the Online Design Model and Virtual Accelerator, a simulation engine for generating turn-by-turn data.

EPICS-DDS ARCHITECTURE

The EPICS-DDS high-level accelerator application environment is designed after a typical three-tier architecture illustrated in Fig. 1. In this approach, front end computers controlling physical devices form the bottom tier. Middle layer servers, such as Virtual Accelerator or Online Model, maintain common data structures and algorithms which are shared and used by an open collection of top tier thick and thin client applications.

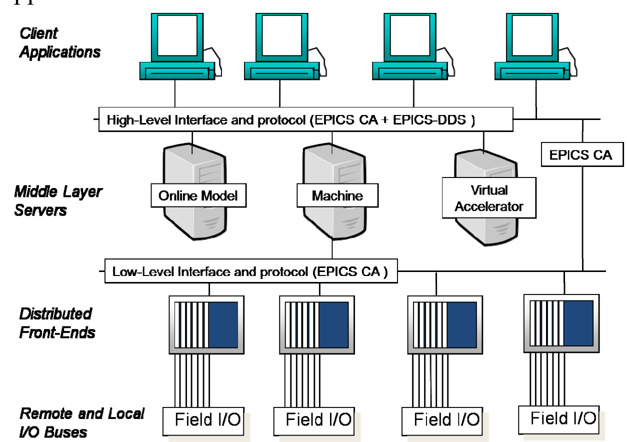

Figure 1: EPICS-DDS three-tier high level application environment.

Despite the common environment, requirements of each layer are different. As a result, the modern accelerator facilities are using at least two different technologies: low-level control infrastructures like RHIC ADOs and high-level middleware, like JLAB CDEV, OMG CORBA, and Java JMS. The EPICS-DDS project addressed this problem by providing a consolidated approach based on the Experimental Physics and Industrial Control System (EPICS) and the OMG Data Distribution Service specification.

EPICS is an open source framework and a rich collection of tools are developed collaboratively and used worldwide for building distributed real-time control systems in large-scale scientific projects: accelerators, detector systems, telescopes and others. Its base infrastructure consists of two layers: distributed Input/Output Controllers (IOC) and Operator Interface applications. IOC provides uniform interfaces to heterogeneous physical devices which can be accessed and monitored by clients via the Channel Access (CA) communication protocol.

DDS is the next generation of industrial standards, bringing a data-centric publish-subscribe architecture to the broad spectrum of distributed environments ranging from small networked embedded systems to large-scale information backbones. Similar to the OMG CORBA specification, DDS addresses the middleware and middle layer tasks including the support of high-level structured data types. In contrast with CORBA, the DDS interface is protocol neutral, facilitating its deployment and integration with different systems like EPICS.

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One of the basic ideas of the EPICS-DDS project is reuse of the EPICS waveform record for accommodating the serialized representation of structured data. The approach immediately creates a basis for developing the EPICS-based middle layer servers. According to the EPICS-DDS uniform scenario, these servers provide the states (the most current values) of the associated data structures shared by other servers and high-level client-subscribers. The majority of accelerator use cases require three data types: collection of the accelerator element parameters, design of linear and non-linear optics functions, and turn-by-turn data, measured or calculated in beam position monitors.

The description of the accelerator structure and accelerator devices is a key part of any accelerator program. The Accelerator Description eXchange Format (ADXF) represents one of the recent models addressing the different types of accelerator computational tasks. In the off-line environment, this object-oriented model has been mapped and deployed in several representations including the EPICS IRMIS relational database. Adherence to the DDS specification allows reuse of the same mapping procedure in defining the online interface of the Machine server for accessing a current state of the accelerator lattice. Other middle layer servers and high-level clients subscribe to the Machine server for synchronizing their own containers. Particularly, the Online Model and Virtual Accelerator servers recalculate and update their own states of the design optics and turn-by-turn beam data respectively.

The middle layer servers themselves were built on the EPICS Portable CA Server framework. By following the Service-Oriented Architecture principles, these online services can be configured with the different off-line accelerator programs. By this time, it was tested with two backends: Unified Accelerator Libraries and Numerical Transfer Matrix developed at Cornell University [3].

MIA APPLICATION

Model-Independent Analysis is a composite application requiring a connection with two middle layer servers, processing the SVD algorithm, and displaying the results with a graphical user interface. In principle, such functionality can be implemented in many different languages and the particular choice is usually the trade-off among several factors. We selected Java because it provided the clean and simple platform for writing the GUI-based clients. Moreover, Java Application Programming Interface can be directly called in the MATLAB environment. Finally, this application allows one to integrate and evaluate the different components of the next version of the EPICS communication protocol implemented in Java.

The application was tested with the NSLS-II booster lattice [4]. Figure 2 shows the horizontal and vertical beta functions calculated by the Online Model. According to the design, the turn-by-turn data will be measured in 24 BPMs. In the current application, this data is generated by the Virtual Accelerator. Figure 3 shows the MIA display with the comparison between design and measured values in the ideal case. As expected, they agree perfectly. These results conclude the development phase and establish a basis for the analysis of the MIA approach against the different conditions such as measurement noise, magnet errors, etc.

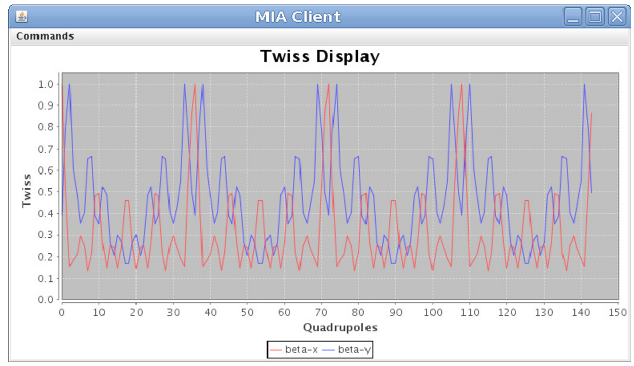

Figure 2: β-functions of the NSLS-II booster.

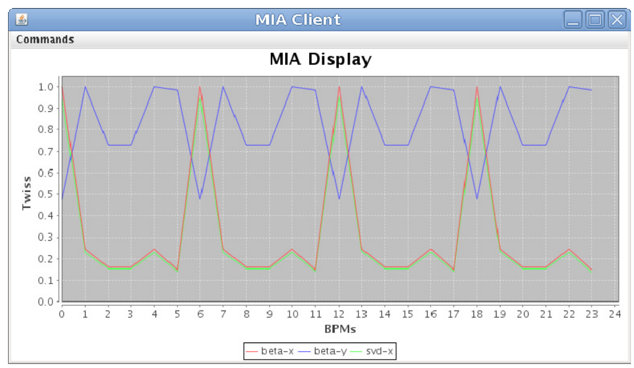

Figure 3: MIA display.

CONCLUSION

The Model-Independent Analysis application based on the new NSLS-II high-level application framework was implemented towards the comprehensive analysis of the NSLS-II booster. It demonstrates and confirms the architecture and major technical decisions introduced in this environment. The application will be tested for the robustness with realistic data sets (including offsets, non-linearity, errors in measurement, etc).

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