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EVALUATION OF MODEL BASED REAL TIME FEEDBACK CONTROL SYSTEM ON PLASMA DENSITY*

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Abstract

The KSTAR plasma control system has very powerful monolithic software architecture that has dedicated centralized system architecture. However, due to increasing of real time functionality on distributed local control system, we need a flexible high-performance software framework. A new real time core engine program inherited design philosophy from the Very Large Telescope (VLT) control software. A new Tool for Advanced Control (TAC) engine was based on C++ standard run on Linux. It is a multithreaded core engine program for execution of real time application. The elemental building blocks are chained together to form a control application. A control application dictated as a single xml file, and it is parsed when the core engine initializing. The core engine is realized inside EPICS IOC as a standard library together with KSTAR common framework library. The IOC is automatically linked with Pulse Automation System, and performs sequential plasma operation.

INTRODCUTION

Since the KSTAR facility has similar engineering characteristics to ITER, the KSTAR control team is carrying out an evaluation tasks for the ITER control system element technology for the past several years [1]. The results of the collaboration are also reflected in the upgrade of the KSTAR control system. An additional time synchronization and real time network which were derived from ITER have been adopted as a complementary network infrastructure [2]. The SDN is based on UDP/IPv4 multicast over 10Gb Ethernet. TCN is based on Precision time Protocol (PTP version 2, IEEE-1588-2008). Besides the basic network infrastructure, KSTAR adopted design philosophy of the ITER Real Time Framework (RTF) [3] for the next generation of plasma control system. As a result of solid collaboration, new real-time core programs have been implemented and are under constant development to increase functionality and reliability. The new application performs a real-time feedback control of the plasma density and performs gas puffing.

REAL TIME CORE PROGRAM

Real time core program inherit from the TAC [4]. The TAC-engine provides a mechanism for a user to specify the structure and behaviour of a digital control algorithm on a high abstraction level. It provides over 40 numbers of elemental processing blocks which have a user defined processing role. The engine is implemented using the standard C++ language and compiled into a static and a shared libraries to support portability for various applications, including EPICS. Fig. 1 shows fundamental libraries and basic structure.

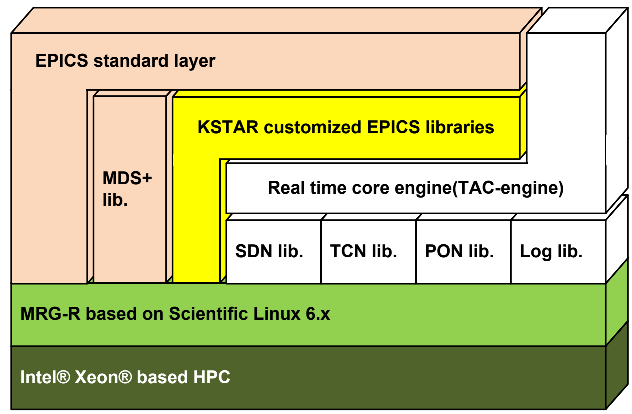

Figure 1: Software Components and architecture of EPICS IOC for real time processing.

An application designer links existing blocks for appropriate configuration. The IOC initiates the engine program according to the KSTAR sequential operation flow.

Applied Software Component

- KSTAR standard software framework library (sfwLib): Provides customized libraries, template, EPICS DB files and system environment files. It is similar to EPICS native ASYN library and supports common functions for DAQ and control systems [5].
- sdn-coreLib: base library to process SDN topics both subscribe and publish.
- TCN Lib: 3rd party deamon from ITER provides high precison time synchronization.
- PON Lib: provides EPICS CA function with external IOC.
- IOC Lib: provides PV connection inside IOC.
- Log Lib: propagates error and trace logging information to local file. The library can be safely used inside real-time portions of software.

APPLICATION CONFIGURATION FILE

The core program uses a single configuration file. The control application file describes all the libraries, threads, blocks, and link information for each function block used. The IOC indicates an appropriate filename, and the engine initializes the class instance with given configuration. The example of file is shown in Fig. 2. Fig. 3 depicts the basic software components inside the IOC and connections.

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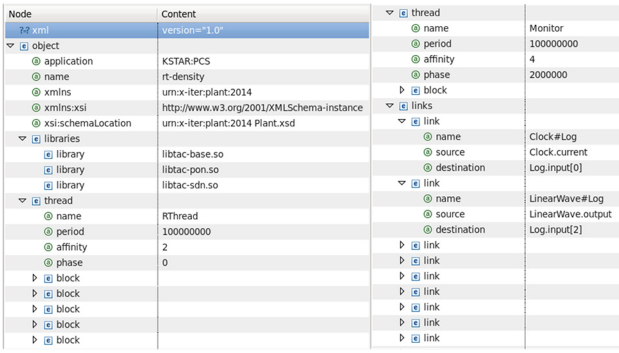

Figure 2: Contents of the control application configuration file by using general xml viewer.

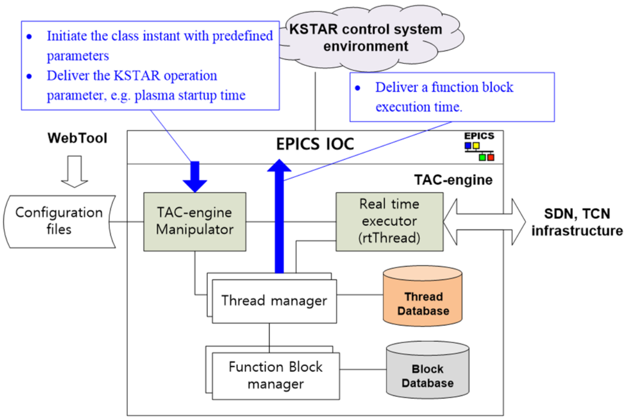

Figure 3: Basic software components and connections inside EPICS IOC.

WEB BASED CONTROL LOGIC DESIGNER

We prototyped an interactive JavaScript based design tool for control application developers. The "WebTool" provides drag-and-drop method for the Function Block placement. Users can interconnect each FB using mouse movement. The tool uses three DBMS to translate connection information as a final xml configuration file.

Graphic User Interface and Explanation of "WebTool" per each Sector

- Function Block selector: Repository of all formal FBs and Thread block. Provide classified layer interface according to characteristic of FB.
- WebTool Menu bar: provide basic file operation menu and system control function.
- FB Placement & Route (P&R): workspace for the definition of FB connectivity where is placed in by drag-and-drop interface
- FB attribute editor: modify the properties of each function block. Add new property field. Change attributes.
- Static Editor: provide integrated edit function from configured FB list. Edit a generated XML file directly.
- Information Viewer: Log display, shot information, statistics, integrated data viewer with KSTAR Data Integration System.

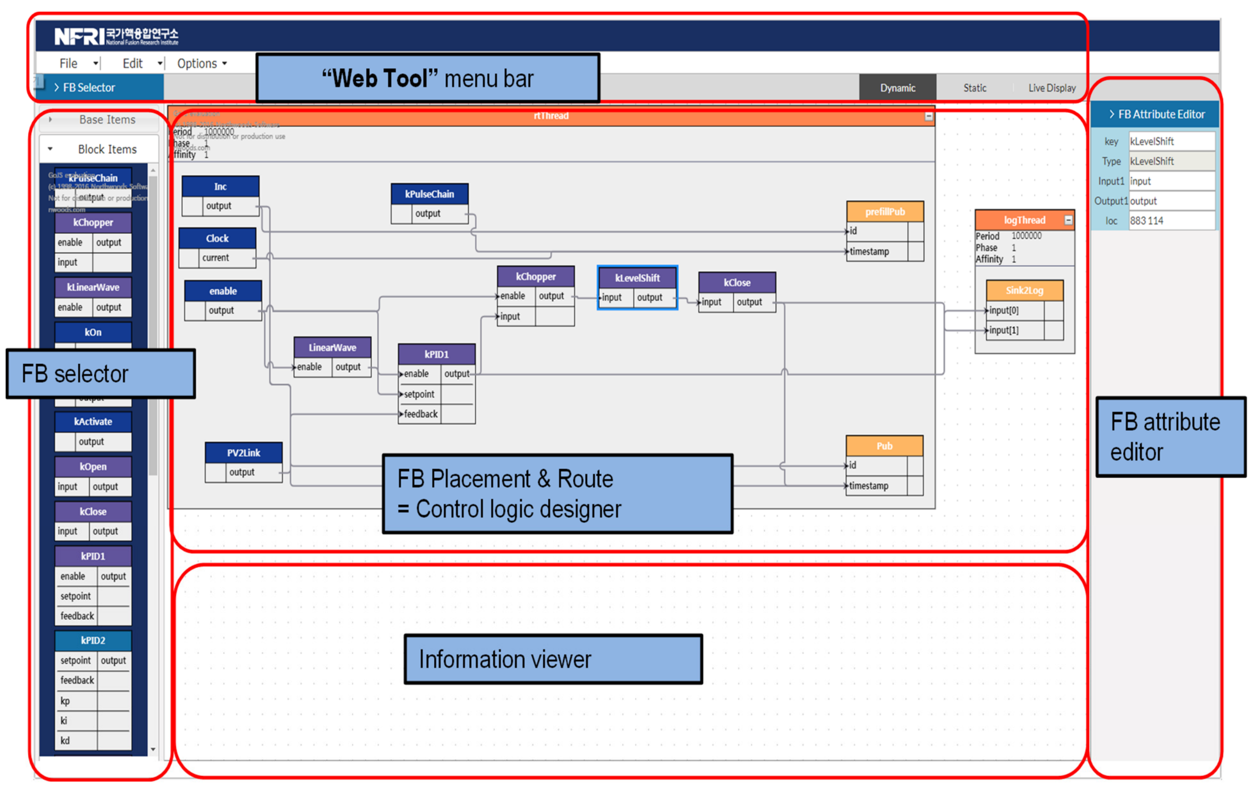

Figure 4: Present view of *WebTool*. It is under develop to reflect from the application designers requirements.

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PROTOTYPING FOR REAL TIME FEEDBACK CONTROL OF PLASMA DENSITY.

Intend to evaluate new technologies, we have developed a feedback control system that complies with the ITER standards and have used plasma density control experiments. As complementary extension of KSTAR control environments for the next generation experiment, TAC-engine based new real time control infrastructure is under constructing. Over two types of diagnostics, fuel systems, and Supersonic Molecular Beam Injection (SMBI) system will be installed inside new control zone. Fig. 5 shows basic interconnection inside new control infrastructure.

We have done feasibility check for new conceptual controllability using RT core engine and Fuelling system, which has Piezo electric valve at 2017 campaign. Fig. 6 shows the test result.

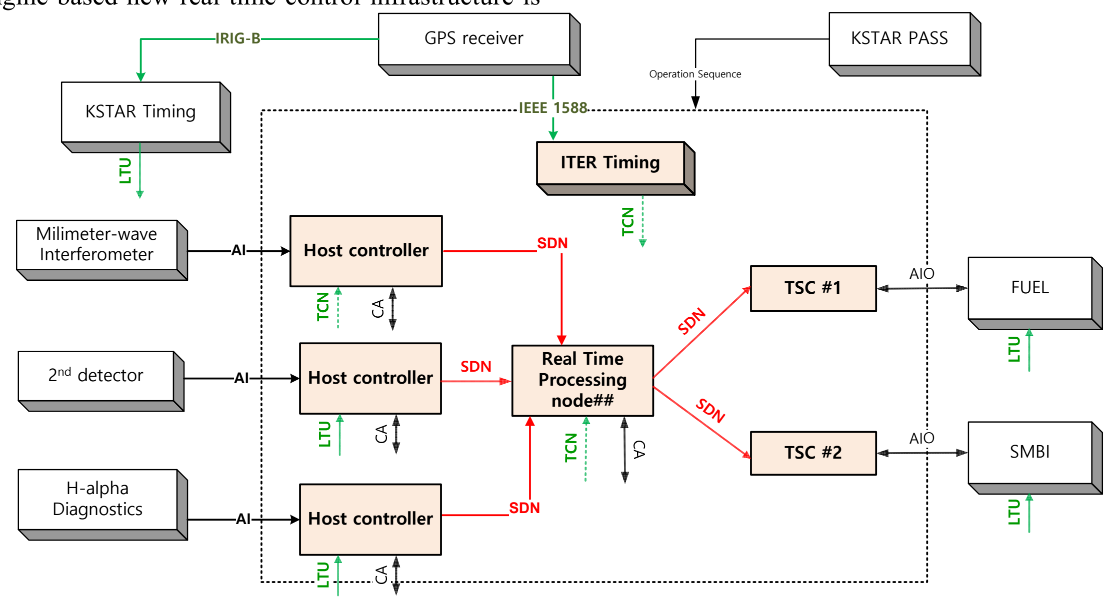

Figure 5: Entire system layout for real time feedback control on plasma line density. Each host controller calculates the plasma line integrated density and transmits the density data to a remote processing node through the SDN interface. The RTP node publishes the final control command so that the Topic to Signal Convertor (TSC) generates voltage value for local devices.

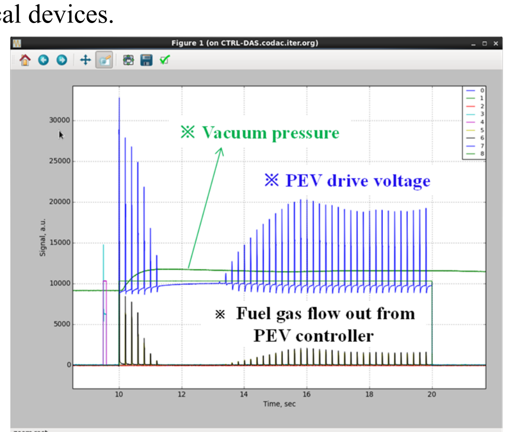

Figure 6: Feasibility check through the vacuum pressure control. Chop the control signal to cope with the slow response time on the pressure sensor.

CONCLUSION

KSTAR control system renovation is progressing utilize ITER CODAC standard network infrastructure. Function Block based control application design concept is prototyped and evaluated at KSTAR fuel system.

Integrated control system for advanced plasma control and the second Neutron Beam Injection system will be implemented based on a high performance clustered processing node include TAC-engine.

ACKNOWLEDGEMENT

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