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INTERLOCK SUPER AGENT: ENHANCING MACHINE EFFICIENCY AND PERFORMANCE AT CERN'S SUPER PROTON SYNCHROTRON

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Abstract

In the CERN Super Proton Synchrotron (SPS), finding the source of an interlock signal has become increasingly unmanageable due to the complex interdependencies between the agents in both the beam interlock system (BIS) and the software interlock system (SIS). This often leads to delays, with the inefficiency in diagnosing beam stops impacting the overall performance of the accelerator. The Interlock Super Agent (ISA) was introduced to address this challenge. It traces the interlocks responsible for beam stops, regardless of whether they originated in BIS or SIS. By providing a better understanding of interdependencies, ISA significantly improves machine efficiency by reducing time for diagnosis and by documenting such events through platforms such as the Accelerator Fault Tracking system. The paper will discuss the practical implementation of ISA and its potential application throughout the CERN accelerator complex.

INTRODUCTION

The CERN Super Proton Synchrotron (SPS) has recently implemented a new Interlock Super Agent (ISA). ISA presents the complete chain of logic that has led to these beam dumps, providing the operator with a powerful diagnostic tool and systematic guidance during the setup phase for the different beams. Using so-called exporters, a variety of follow-up actions can be initiated automatically via the agent, such as automated logbook entries or fault registration in the CERN Accelerator Fault Tracking (AFT).

BEAM INTERLOCK SYSTEM

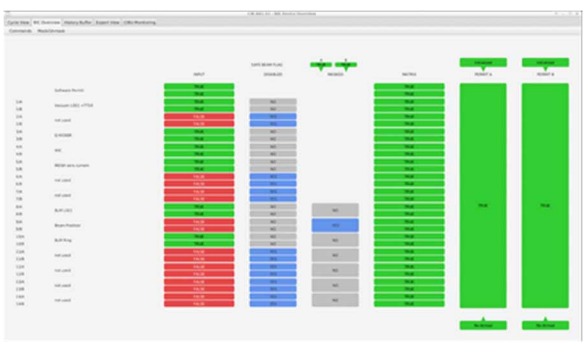

Figure 1: Inputs Beam Interlock System.

The Beam Interlock System [1] (BIS) is a global beam interlocking system at CERN. It is responsible for monitoring the parameters of the particle beam in the accelerators and experiments in real time. If abnormal or dangerous conditions are detected, the BIS activates safety measures to stop the beam and protect equipment. The BIS system is based on several Beam Interlock Controllers (BIC) receiving signals from various equipment (Fig. 1), each client must be decoded via a database.

SOFTWARE INTERLOCK SYSTEM

The Software Interlock System [2] (SIS) is a key component of operation with over 1000 parameters monitored (at the SPS) to ensure optimum protection in all the different systems that are linked by equations (Fig. 2). Over time it has become an assistant that helps the operation team to achieve its mission, providing high quality beams and thus in a safe way.

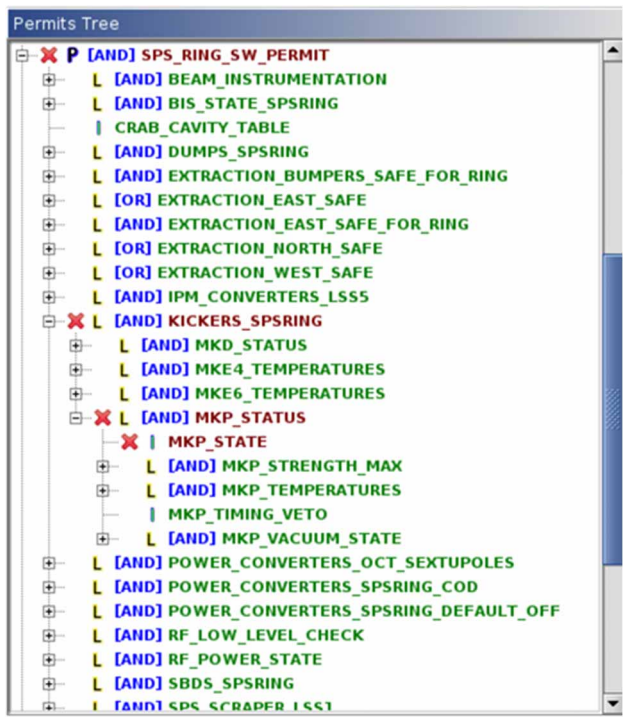

Figure 2: Tree structure with logic function AND and OR with as final result a permit.

LOGBOOK

The logbook is used by the operator to record all the information needed to operate the machine, and to distribute the information to the machine coordinators and other team members. Information such as beam stops (Fig. 3) and masks applied to interlock systems are also recorded in the logbook.

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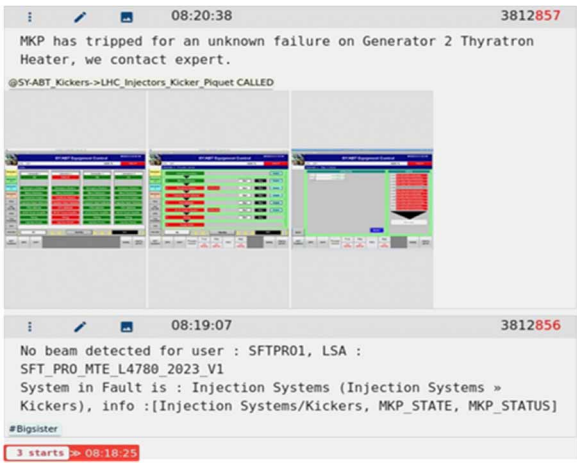

Figure 3: Information in Logbook, an example

ACCELERATOR FAULT TRACKING

The Accelerator Fault Tracking [3, 4] (AFT) platform is used to record, identify, and track system failures (Fig. 4). And enables actions to be taken to increase accelerator availability and efficiency.

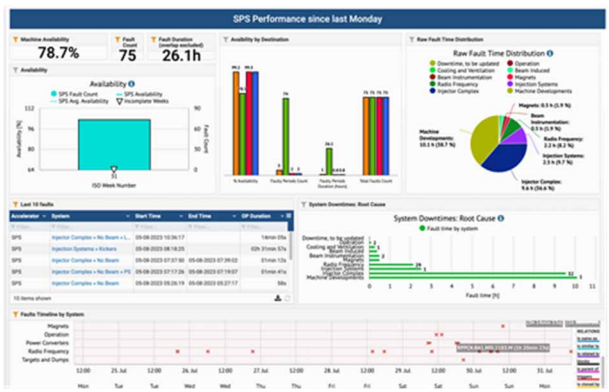

Figure 4: Accelerator Fault Tracking.

BIG SISTER

Big Sister is an SIS server instance that manages beam stops, based on a measurement of circulating intensity for each cycle used by the accelerator.

ISSUE TO BE ADDRESSED

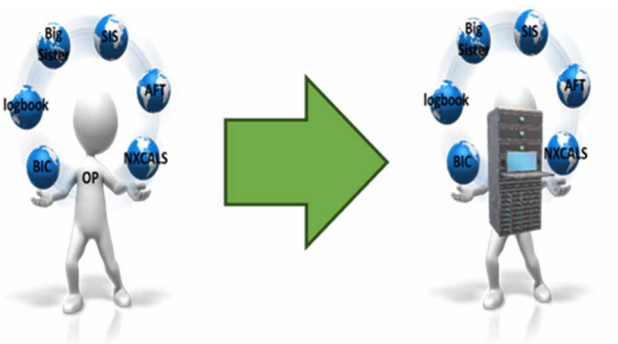

Figure 5: Interlock Super Agent Schema.

Operators have to interact with multiple systems (Fig. 5), Beam Interlock System (BIS), Software Interlock System (SIS), Logbook, Accelerator Fault Tracking (AFT), Big Sister, that are not interconnected, which could result in efficiency issues and unnecessary downtime.

THE INTERLOCK SUPER AGENT

The Interlock Super Agent [5] (ISA, Fig. 6) solution was implemented at the SIS server level in the Java programming language to display the logic that stop the beam from being injected into the SPS or LHC. It takes into account the fact that the accelerator is ready for beam to be injected, but that the injectors are unable to produce the beam, connecting the different faults between accelerators. This tool also publishes the faulty system, using APIs on the logbook and AFT clients. Furthermore, the SIS is not simply a client for the BIS, but also supervises the BIC inputs to identify the faulty system that is not monitored by the standard SIS. The status of SIS masks and BICs are also recorded in the logbook. The ISA project is now integrated into the SIS core library for standard use in any CERN accelerator using the SIS. It is used at the SPS and LHC (for injection diagnostics) and is designed to assist the operational teams with the possibility for future development of the handling of recurring tasks.

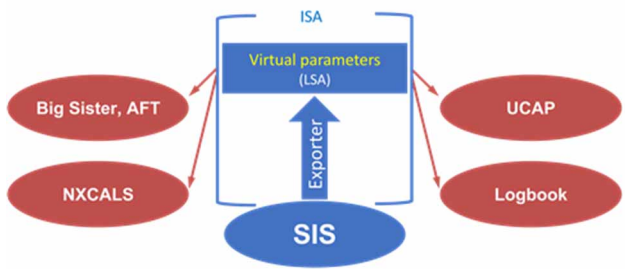

Figure 6: Interlock Super Agent Schema.

LOGGING

Once the information has been extracted from the SIS server with the crucial information on the faults that caused the accelerator to stop, the logging comes for free with the infrastructure provided by the virtual parameters used within CERN via the Control Middle Ware (CMW). This data can be consulted using the Next generation CERN Accelerator Logging Service [6] (NXCALS).

SPS ANNOUNCER

The fault detection system has made it feasible to reuse ISA for transmitting messages through a web interface with a vocal 'announcer', and to improve the diagnosis of beam failures for operators.

GRAPHICAL USER INTERFACE

A web interface (Fig. 7) has been developed to extract only the results of the SIS logic tree.

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Figure 7: Interlock Super Agent on.

WRAP (Web-based Rapid Application Platform [7])

CONCLUSIONS AND PERSPECTIVES

The ISA project has significantly increased operational efficiency and reliability, and provides automation to relieve operators of routine tasks, allowing them to focus on the actual operation and performance of the accelerator complex. The project uses the existing framework and infrastructure at CERN, minimising development time and costs. The modularity of the software enhances simplicity and functionality and simplifies maintenance. Together with the diagnostic power of the system, it provides the perfect environment and topology required by the operators to achieve their mission and machine performance goals.

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