

Development of Pulse Fault Sequence Analysis Application with KSTAR Data Integration System

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The Korea Superconducting Tokamak Advanced Re-search (KSTAR) interlock related systems are configured with various system such as fast interlock, supervisory interlock, plasma control, central control, and heating using various types of hardware, software, and interface platforms. For each system, monitoring and analysis tools are already well-developed. However, for the analysis of system fault behavior, these heterogeneous platforms do not help finding the relation of failure. When the inter-lock events are latched or pulse is stopped by PCS, events are transmitted to different actuators and it could make other events via various interface. In other words, it could lead another factor of fault causes on different system. Through this application, we will figure out sequence of fault factor during the pulse-by-pulse KSTAR operation. The KSTAR Data Integration System (KDIS) is configured with KSTAR event-driven architecture and data processing environment. This application will be developed on the KDIS environment and synchronized with KSTAR event. This paper will present the development of shot fault sequence analysis application and its environment configured with KDIS.

Introduction to the Application

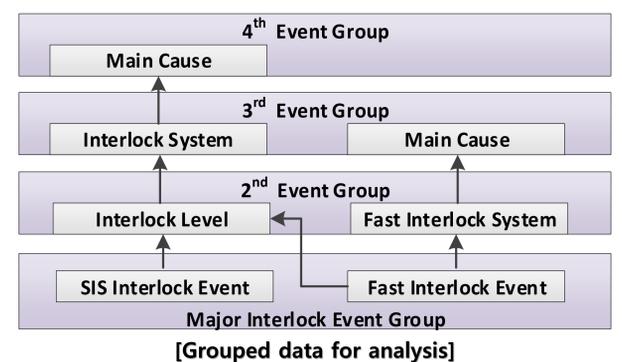
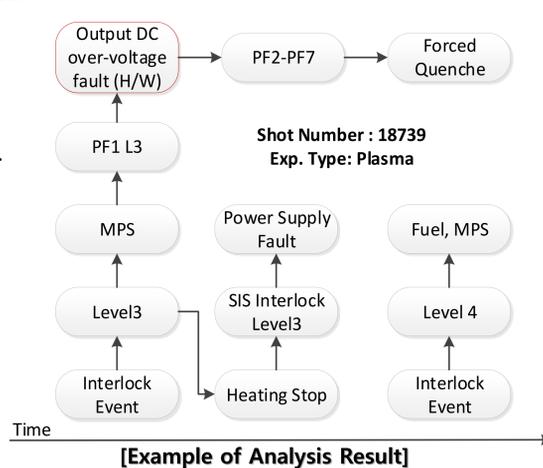
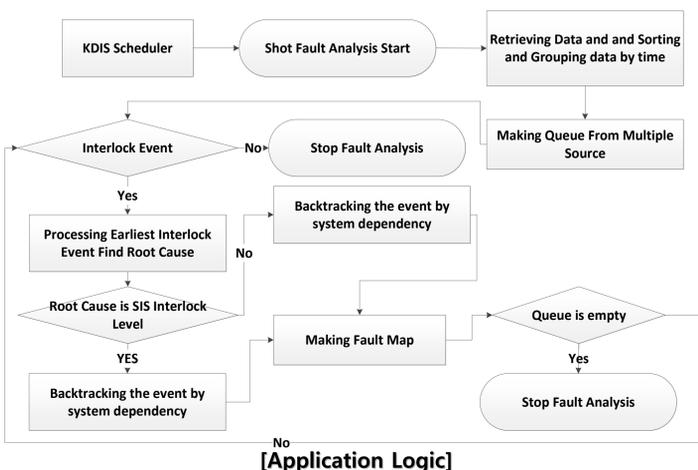
- The main purposes of this application are generating meaningful fault analysis data by providing information
 - Providing information to the operator between pulse operation time
 - Identifying cause and effect of the fault
 - Supporting statistical analysis through accumulated results.

Pre-processing Interlock Related Event

- Integrating and analyzing log during specific KSTAR pulse stage.
- Data is coming from various interface such as EPICS, MDSPlus and sorting it according to the timestamp.
- Aggregated data will be divided as part of groups to be analyzed.

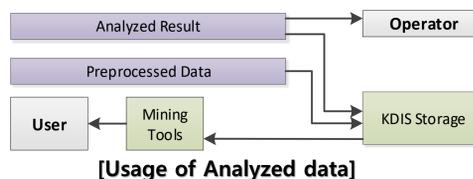
Application Logic

- Based on the pre-processed data, the application performs analysis logic.
- The beginning of the analysis is the search for the first major event that occurred. (FIS and SIS)
- Interlock event could occur chained by previous event and relation between SIS and Fast Interlock.



Analysis Result and Data Archiving

- The result of analysis and filtered pre-processed logs will go to the storage and operator



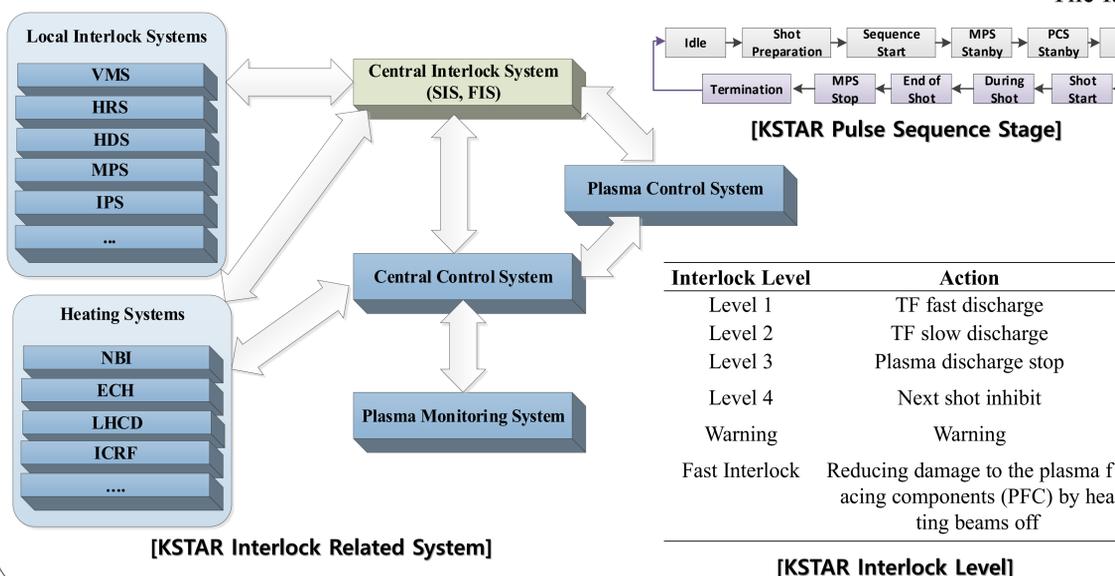
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    Shot Number = 18739, Shot Type = P-Shot
    System Fault Log between (Seq Start : 2017/06/12 12:59:00 ~ Seq End : 2017-06-12 12:59:55)
    -----Root Fault Event-----
    Heating Stop (NBI_FAULT [NBI_PLC_P52_FLT] > PCS [SOFT_LANDING])
    Shot Number = 18739, Shot Type = P-Shot
    System Fault Log between (Seq Start : 2017/06/12 16:09:00 ~ Seq End : 2017-06-12 16:09:43)
    -----Root Fault Event-----
    Interlock LV3 (MPS [PF1_L3] Output DC over-voltage fault H/W)
    Heating Stop (CCS [CCS_SET_PCS_INTL_LV3] > PCS [PS_FAULT])

    Shot Number = 18739, Shot Type = P-Shot
    System Fault Log between (Seq Start : 2017/06/12 16:09:00 ~ Seq End : 2017-06-12 16:09:43)
    -----Interlock Event Sequence-----
    2017-06-12 16:09:18.668644 PF1 Status : Output DC over-voltage fault (H/W)
    2017-06-12 16:09:18.892565 PF60 Status : Forced quench
    2017-06-12 16:09:18.906276 PF6L Status : Forced quench
    2017-06-12 16:09:18.924174 PF4L Status : Forced quench
    2017-06-12 16:09:19.858291 PF5L Status : Forced quench
    2017-06-12 16:09:19.228218 PF2 Status : Forced quench
    2017-06-12 16:09:19.331889 PF30 Status : Forced quench
    2017-06-12 16:09:19.423821 PF40 Status : Forced quench
    2017-06-12 16:09:19.597428 PF50 Status : Forced quench
    2017-06-12 16:09:19.673812 PF3L Status : Forced quench
    2017-06-12 16:09:19.716486 PF7 Status : Forced quench
    
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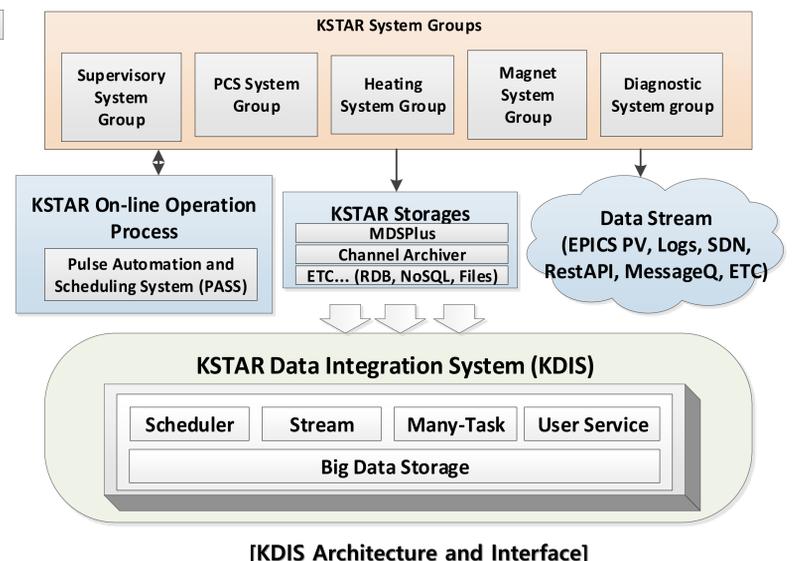
Background of Interlock Related Systems

- Fast Interlock System (FIS) - Protecting PFC from heating beams
- Supervisory Interlock System (SIS)
- Local interlock system, central control system, plasma control system, and plasma monitoring system



Background of KSTAR Data Integration System

- Scheduled processes on data according to KSTAR events with hardware and software infrastructures under the big data open source architecture
- The data cycle orchestration structure including functions such as data ingestion, analysis, and visualization with operational logics.
- The fault analysis application is developed under the KDIS environment



Summary and Future Plan

- This application has been developed for the analysis of operational fault event for the KSTAR machine operator and operated during the 2017 KSTAR campaign.
- Operation efficiency has been improved with making operation time shorter by saving fault detection time.
- For the future work, we will consider more about the data and interface quality.