ISBN: 978-3-95450-168-7 doi:10.18429/JACoW-IPAC2015-WEPTY057

ADAPTABLE MACHINE PROTECTION ARCHITECTURE FOR CW, HIGH INTENSITY ACCELERATORS

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Abstract

An adaptable architecture of a machine protection system (MPS) suitable for continuous wave (CW), high intensity accelerators like those proposed for Accelerator Driven Systems (ADS) for subcritical reactor strategies and heavy ion accelerators for the production of rare isotopes is presented. A system of databases, networks and nodes that can systematically and flexibly be reconfigured to rebalance the required metadata is used. Additional features include reconfigurable machine setup templates that can rigorously be tested with mirror redundant online backups, the utilization of external reconfigurable geometric algorithms for the data channels and the network distribution, and the inclusion of initial system requirements as well as envisioned upgrades.

BACKGROUND

High power, high intensity proton drivers (Fig. 1) for nuclear fuel transmutation are required to have *High Availability* (Table 1) or better performance - otherwise the electric utilities do not consider these drivers as a viable solution. The implementation progress has been steady- however it has stalled at low 90%. The driving forces behind fourth generation superconducting accelerator machine protection system [MPS] is avoid incremental gain but structural.

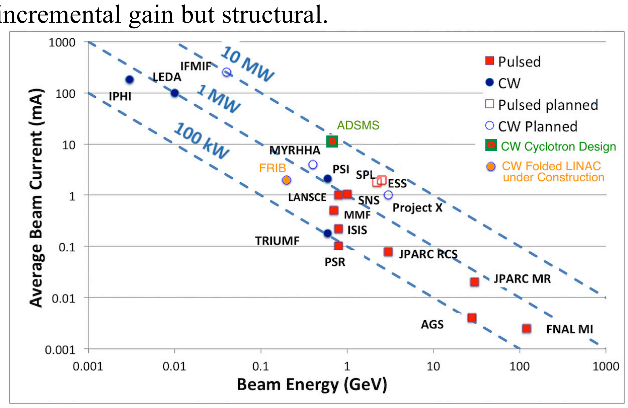

Figure 1: High Power Accelerator History

Table 1: Beam Availability Score

System Type	Availability	Unavailability
Fair	90%	37 days/year
Well-managed	99.9%	526 (min/year)
Fault-tolerant	99.99%	53 (min/year)
High-availability	99.999%	5 (min/year)

The generations are based on beam interaction with accelerator surrounding, beam power, technology and management mandate as systems have come to existence from the Tevatron and PSI to SNS and LHC. Although the MPS of each of these accelerators has significantly improved from its predecessor, the up time is in ~92% after four decades of operations, and cannot be sustained due to the complexity of tens of thousands of variables without a complete overhaul. Databases have become overwhelmed, and at times have become mere warehouses of information, that often provides valuable information, after accidents to discover a catastrophe in developing from days. In this paper I address one systematic approach that all MPS designers have considered but its implementation has fallen short due to cost, available technology and or integration framework factors. Data management is one aspect of high availability accelerator operation, automation, instrumentation and control, which are integral parts of forming the framework of MPS as machine performance manager.

METHODOLOGY

To achieve much better than 99% availability, one cannot simply attempt to squeeze efficiency without major architectural re-evaluation, and the bottom up systematics of running accelerators is even more model-driven with beam-hardware dynamic feedback. Moreover, the MPS has to provide reliable, redundant valid information from the start of the commissioning, rather than relying on limited physics studies to debug massive MPS on reliability, as it's failure will be the demise of an

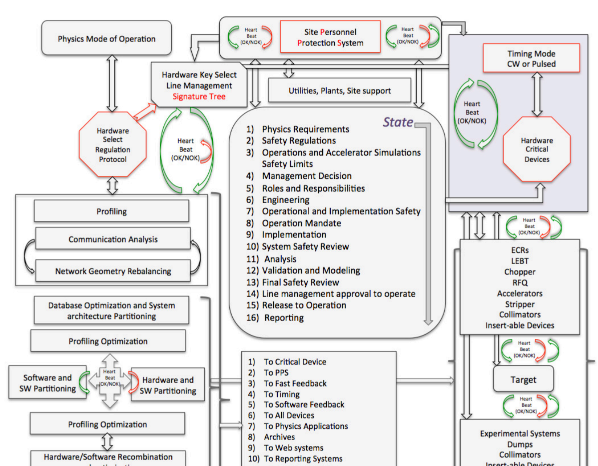

Figure 2: Database foundation setup for project dynamic integrated MPS in advance of hardware selection and parameterization.

Accelerator, such as the Texas A&M 800 MeV, Accelerator Driven Subcritical Molten Salt [ADSMS] or Facility for Rare Isotope Beam designed by Professor Richard York at FRIB. The first step is to integrate

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existing legacy work, equipment, technology, and resources to minimize cost and to prevent duplication (figure 2).

Controls, Network and Diagnostics

Although EPICS has served SNS well (Fig. 3 right side), the underlying communication techniques are not fault tolerant for CW operations (Fig. 4). The last decade has witnessed increased interest in the study of higher order interactions of objects languages to geometric objects: nodes, lines, surfaces, etc.) Interesting from scientific viewpoint as well as from technical development in database design. In one particular aspect, cell phone tower technology, the idea of data fusion based on interaction (overlap) of nearby cell towers has led to significant advances in transmission that can be adapted in high-energy physics (Fig. 5). These recent developments have led to the speedup in data accessing, and have generated robust transmission. The CERN experience handing large data warehousing, with the use of ORACL let to our implementing heterogeneous ORACL tools to rapidly prototype using EPICS client-server for testing. I chose heterogeneous distributed databases with heterogeneous services in order to prevent future redesigning databases in the MPS framework [1,2]. In distributed processing (such as the EPICS), we used local speed advantage and shared memory, in the logical database processing of shared resources at sensor levels among two or more physically independent sites (i.e. lattice coordinates) that are connected though a network to pre-process and generate meta databases with tags associated with severity of required response from the supervising Machine AI Performance System. These steps are shown in (Fig. 6). For example, input/output (I/O), data selection and data validation can be performed on one computer and a report based on that data might be created on locally defined redundant servers. Sensors, local virtual databases, and redundant low level sensor servers are highly integrated with the timing system.

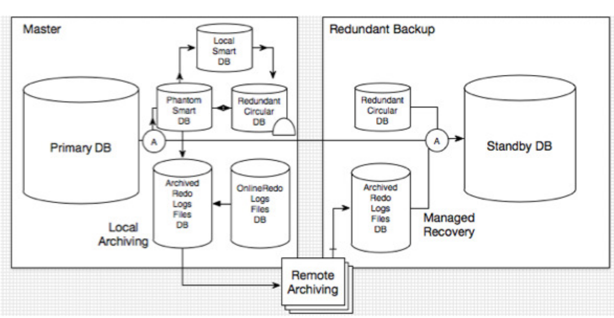

Figure 3: Database at sensor level (left) redundant DB at server level.

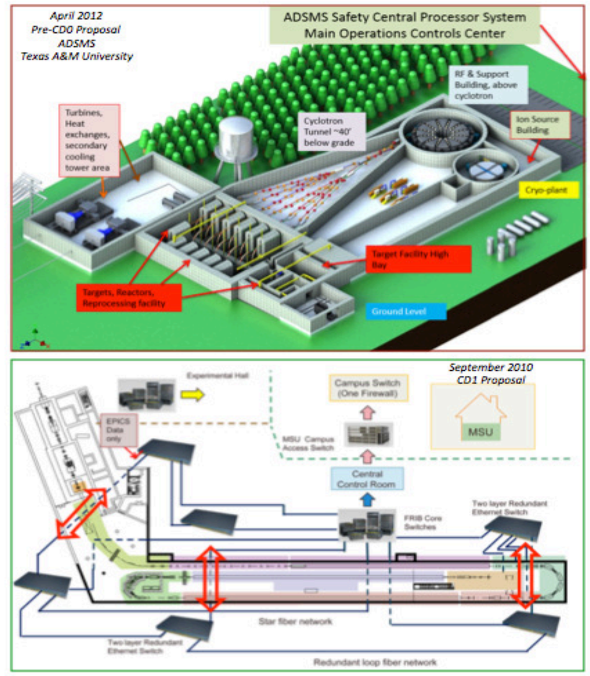

Figure 4: Top: The 10-MW ADSMS beam is split in 12 beam-lines, targeting 12 fast molten salt reactor cores with 43 critical devices for global MPS. In this regard 2010, I proposed designing a similar redundant Machine Protection System with only six critical devices, distributed in star-loop geometrics designed for the CW model-driven supervised machine performance system.

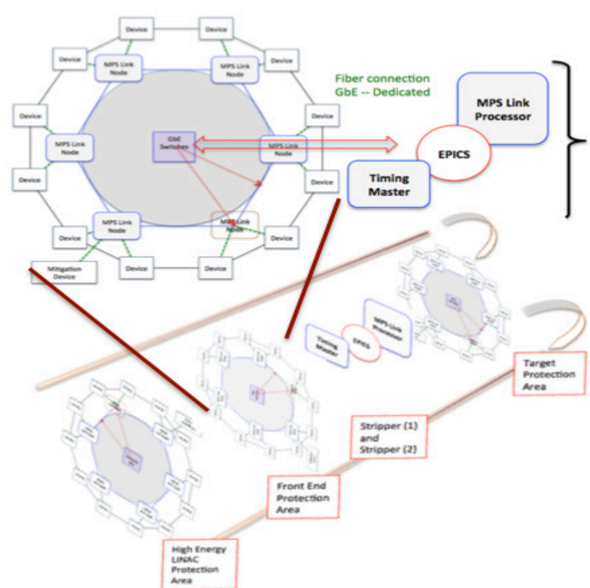

Figure 5: the periodic chirping of every sensor's timing link guarantees the synchronization of sensors within a clock cycle.

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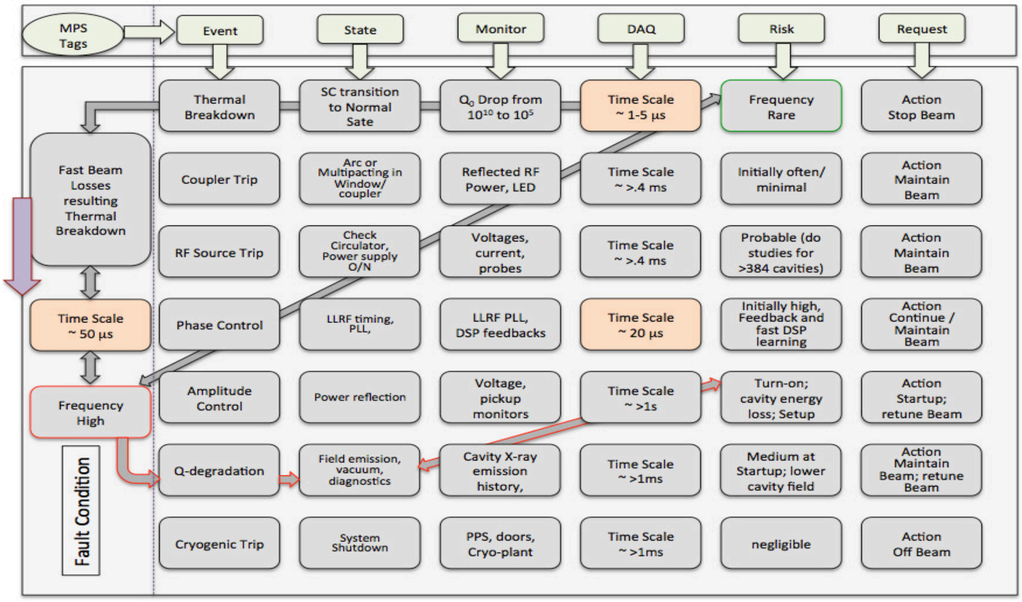

Figure 6: Distributed databases store logically related databases over many physically independent sensors, MPS severities (Tags), and fault scenarios to form agile input/output and data validations for machine feedback and real-time operation.

Back-propagation algorithms are used to supervise the learning approach. The target output vectors are defined earlier in the system per particle-material simulation codes such as GEANT4, combined with beam orbit trajectories model predictors and are downloaded to local real-time servers as shown above. For the BLM, we use a weighted Able inversion of fixed input beam loss monitors to produce virtual "real-time" loss monitors from the overlapped intersected domain of measured signals per highest probable simulated location from model. This layer has further dependencies of energy, and line of sight obstacles (Fig. 7) used as triangulation tags to speedup local processing. All the pre-processing is in real-time on a continuous rolling memory that can be triggered to send the "snapshot" to redundant backup.

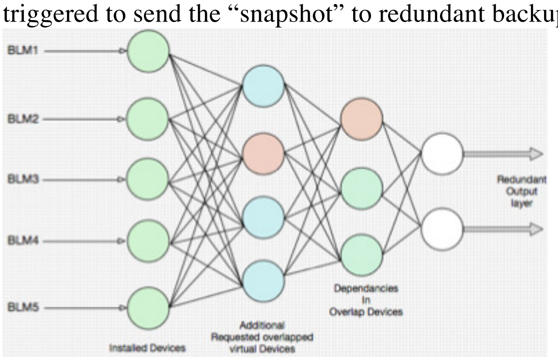

Figure 7: Sensors, model predicted signal and cross-domain produces redundant information.

Otherwise, all topologically predefined signals as "object DB" are tunnelled though the redundant layer for post processing. Basically, the new virtual Monitors and original monitors have unit cells that can lead to redistribute detector placement in the tunnel (Fig. 8).

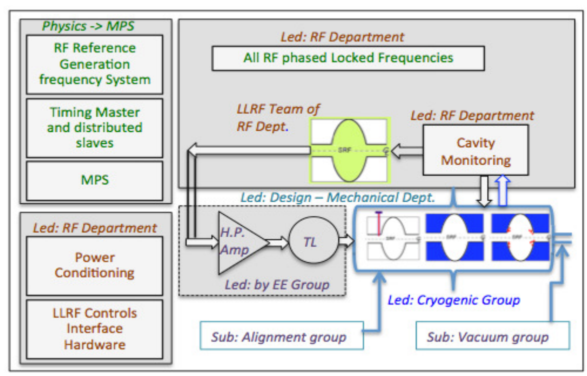

Figure 8: Subsystem MPS line-management feed unified and unique data to every user from construction to operation via MPS databases. This also adds verification of MPS data during testing and application development.

CONCLUSION

Recent developments in accelerator design without integrating new methodology and framework, result in ballooning cost.

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