SOFTWARE PACKAGES:
STATUS AND COMMISSIONING PLANS

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Abstract

The many modifications of the software packages that have been done during LS1 will be reported. Based on the issues and requirements that have been presented in the 2012 Evian workshop [1], the solutions implemented and their impact on operation will be explained, the status of these different upgrade projects will be presented. Without doing a complete inventory of the control room applications, those with important functional modifications or presenting issues will be covered.

INTRODUCTION

During the three years of LHC operation, several issues and limitations have been discovered concerning the control system [1]. With the operational experience, new requirements have come out to optimize the operational procedures and improve the LHC performance. The LHC operation's schedule includes short technical stops during which such issues and requests are addressed. But due to the time constraint, the implementation has to be done fast, and only backward compatible changes are allowed. As a consequence, the new developments are not always implemented in the cleanest way.

The technology used by the LHC control system is frozen during the accelerator run, while outside the software world is moving fast, with new performant hardware replacing obsolete product, new libraries version with less bugs and new features, etc…

LS1 is the opportunity for all control systems to be refactored and cleaned. It is time to integrate the latest version of the third party libraries and implement the new requirements. The users have time to adapt to the non-backward compatible changes, and a testing period is allocated.

COMMON MIDDLEWARE [2]

The common middleware is composed of several modules that ensure and secure the communication from the control system to the hardware devices.

The communication layer Corba is facing technical limitations: this was a solution chosen 15 years ago and the software is not actively maintained anymore, this is a big risk for the project. In addition much better products exist now on the market. After a careful evaluation, ZeroMq was chosen for Corba replacement.

Several issues were highlighted during beam operation with the RDA layer, in particular

- Insufficient protection against bad or slow clients: the subscription reliability affected, i.e. issue with the software interlock system subscriptions that lead to several spurious beam dumps.
- Poor client number scalability: stability issues when client number was above 200.

The new RDA3 layer, based on zeroMq, will provide a new subscription mechanism and a priority system for the clients. It also supports new data structures requested by the users like multi-dimensional arrays.

RAD3 has been integrated with the middleware libraries: new extension of JAPC and new CMW proxy for RDA3 server.

The JAPC core library has been improved both for RDA2 and RDA3 extension to solve the stability and performance problems.

Status

RDA3 is ready and deployed in operation for FGCD gateway in PSB and Linac2, the next deployment will be for the FGCD in CPS. In June FESA will have a new version based on RDA3. During the summer and until the LHC start-up, several equipment classes will migrate to this new version, and RDA3 should be deployed massively for the LHC operation. Nevertheless RDA2 will be maintained until LS2.

FESA3

The Front-End Software Architecture (FESA) framework is a comprehensive environment for equipment specialists to design, develop, test and deploy real-time control software for front-end computer. FESA 3 is the latest evolution of the tool and brings new features that will optimize the classes' development and maintenance. The major technical improvement is that the new version can handle the multicore CPUs.

Many critical LHC systems are planned to restart with FESA3 like QPS, cryogenic, power converters, kickers and collimators [3]. The equipment's responsible have already started the migration from FESA2 to FESA3.

Some systems like Beam Interlock System, RF and beam instrumentation will migrate later. FESA2 will be supported until the end of 2015.

LSA [4]

Core software

The LSA platform consists of a server, a database and an application suite used to operate particle accelerator and transfer lines. The development of LSA started ten years ago, based on SPS and LHC requirements. With operational experience, many requirements and fixes have been implemented on top of the first design. In addition LSA has been extended to the PS complex to renovate their control system, with necessary adaptations and additional functionality. The software modifications were applied in the context of running machines, with quick fixes and new features deployed during the short stops. The complexity of the API and design increased in such a way that it was difficult to stay flexible and add new functionality to the system.

During LS1 it was then mandatory to operate a major refactoring of LSA that would make it easier to maintain and extend:

- The software structure has been simplified with a reduction of the number of modules and a simpler package hierarchy.
- The services responsibility has been reorganised in a more coherent way, with less exposed methods.
- Common concepts have been factored out of LSA to a generic package for re-use by any software package (timber, applications…).

LSA Database

The LSA database had known performance problems in 2012 with the access of the settings. This was explained by the rapidly growing number of settings that doubled during 2012. The number of clients increased with the extension of LSA to PS complex, and some application needed frequent access to a lot of settings. Actions were immediately taken to optimize the data access, but their efficiency was limited by the huge amount of data and the hardware performance.

During LS1, the hardware has been replaced by a new CPU, a new disk and a bigger data cache that will provide a much faster access to the data. A data cleaning campaign has been started, only the last operational settings for each type of LHC operation will be kept (Pb/Pb, Pb/p,p/p), the rest will be deleted. A back-up database with data frozen on April 2013 is kept and will be accessible via 2012 LSA version in case old settings needs to be retrieved.

Status

LSA version has been released as pro in March 2014. All software using LSA needs to be adapted to the new API. This is not simple and trivial and can be time consuming, a web site is provided by the LSA support team to help the user. Today most of the operational applications have been adapted. Most of LSA software is being tested and debugged with the start-up of the injectors, and the dry-runs organized for the LHC.

Controls configuration database

With the migration to FESA3 and the upgrade of equipment, the device-types, the properties and fields and sometime device names are updated in the controls configuration database (CCDB). The LSA database configuration needs to be synchronised with the CCDB. In case of backward compatible changes or addition of new devices, this is trivial and the task will be automated soon. In cases of non-backward compatible modification on existing devices, this is more complicated when the settings need to be kept. A migration map that give the mapping between old and new configuration need to be given to the database responsible, and according to the complexity several iteration may be needed, this is not an immediate process.

RENOVATION OF CENTRAL TIMING [5]

The LHC central timing will be renovated during LS1. The front-end design will be simplified, only one front-end will be used instead of three. LynxOS will be replaced by Linux SLC5, and the FESA classes upgraded to FESA3 to handle the multi-core CPU.

A new communication protocol with the CBCM (central timing for the injector) will be designed for the injection request. It will be simpler, more flexible and robust. The limitation of 1.2s for the injection time in the SPS cycle will disappear. This will solve the dynamic destination issue encountered in 2012.

The protocol has been already implemented in the CBCM side. The new LHC central timing with the new protocol and new hardware will be deployed at the end of October 2014.

LOGGING

SDDS eradication [4]

Until LS1, the logging service offered two options: logging of data in the measurement and logging database (Oracle) or logging of data in SDDS files. For

maintainability and simplification reason, the SDDS logging will be eradicated. It is replaced by a full parameter logging that stores the same data in the measurement database instead of SDDS files. Parameter logging is ready and already configured for more than 8000 devices.

The SDDS logging is now disabled and no more SDDS files are generated by the logging process. Old data can be transferred in the logging database on demand.

Logging Data extraction API renovation

The logging data extraction API is the API used by timber application and more than one hundred other custom applications to extract the data from the measurement and logging database.

The actual API started to be developed 10 years ago, and has evolved a lot. Refactoring and cleaning was necessary to improve the flexibility and efficiency of the code and allow the addition of new functionality. The new API is under development and will include new features, particularly in the data analysis domain:

- Extraction of data from multiple sources, not only from the logging database but also from the LSA settings, the logbook, the post-mortem or new PVSS database.
- Possibility to store analysis results related to events in the past.
- Increase data aggregation and alignment options.
- Extracting data based on other signals
- Data value distribution analysis and histograms
- Extraction of vector elements over time as time series

DIAMON AND CONNECTION VIEWER

There is a recurrent complain that the Diamon application doesn't always give the correct status of a process or a front-end. Most of the time, this is the consequence of a configuration problem. During LS1, Diamon software has been refactored and improved to facilitate the configuration of the front-ends, i.e. the limits for temperature, CPU load or memory can now be adjusted directly from the application. Nevertheless an effort is required from operation team and equipment owners to adjust the configuration to get reliable information on Diamon: the equipment owner has to be informed by operation team in case the process or front-end status is not right and act on the limits and detection points to solve the issue. The cold check out is the period to make sure that everything is well configured before the start-up.

To help with the front-end and process diagnostics and complete diamond information, a new application called "connection viewer" has been created. It retrieves and displays all the connections between CO processes.

ALARMS

The alarm screen has never been fully used in LHC operation, because with the actual alarms configuration it was permanently overloaded with yellow or red alarms with no direct meaning for LHC operation. A complete review of the alarms configuration would require a huge and time consuming effort from OP and equipment's group that one can't afford.

To improve the situation anyway, it was decided to remove all the alarms from the laser configuration for LHC-OP. Once the laser screen is empty, OP in collaboration with the equipment group and laser team will decide on the alarms that are useful for operation and add them to the LHC-OP configuration.

OTHER OPERATIONAL TOOLS

QPS software tools

The QPS software will be widely renovated after LS1, with a new set of java applications (QPS Swiss knife) for piquet and operation teams to perform basic and safe operations on the QPS. For example the power cycling of a QPS crate will be done by this tool, replacing the Labview application used during run 1.

The QPS settings management will be migrated to LSA, using standard LSA functionalities for storing and loading/cross-checking of parameters and settings in the QPS cards. That will allow improving the security by using RBAC and a systematic settings consistency check will be performed from the sequencer.

Accelerator test framework (ACCTEST)

The accelerator test framework is the software used for hardware commissioning tests and it is envisaged to be used in the future as well for machine checkout and machine protection system commissioning. In view of the large campaign of tests that have to be done after LS1, the software was reviewed and improved for better tests and analysis efficiency.

New analysis modules have been integrated directly in the Java framework. All sequences and analysis steps for the commissioning of the 60A and 120A circuits will be fully automated; the expert will be needed only in case of doubts or problems. Gradually the automated analysis will be extended to more complex circuits. This will represent a consequent gain of time and mean fewer dependability on the expert presence during the commissioning campaigns.

The new Java analysis modules are conceived in a generic way such that they can be run after any circuit failure and not only after predefined current cycles. This will allow a regular check of the circuits during beam operation, increasing the chance to discover problems early on.

Accelerator Statistics and Data Analysis

The accelerator statistics and data analysis project will provide a coherent and maintainable solution for accelerator statistics. The implementation will be common for all accelerators. New interactive web interface will replace the current statistic web pages for LHC, SPS and PS complex.

The project is well on track for the statistic part; already the PSB data is being collected. For the other machines the data specifications are on-going. The development of the web interface will start in July.

For the data analysis, the requirements have been gathered and will be integrated in the new logging extraction API. Further input and requests are welcome.

Accelerator Fault Tracking

The actual system for fault tracking is based on the logbook and the post mortem database. The tools tracks only partially the faults: as only the faults that triggered a beam dump are recorded, but not necessary the parallel problems that could be source of more downtime. Furthermore, there is no consensual rule defined between operation and equipment team. The fault analysis was then difficult and incomplete.[6]

The new Accelerator Fault Tracking project should provide better tools. It will be a common solution for all accelerators, it will automate the fault tracking as much as possible thanks to links with logbook, post mortem and logging databases. It will provide functionalities to highlight inconsistency or missing information and will greatly facilitate the follow-up, update and analysis of a fault.

A prototype database is already in place with the data from previous years uploaded from the logbook. The persistence API is under development. User interfaces mock-ups have been created and the use-cases definition is on-going.

Interlocks

The Beam Interlock System (BIS) has been refactored and cleaned. The fast cycling machines will get a new GUI with cycle related information. The BIS GUI will be extended to include the views developed aside by Jorg Wenninger and all their functionality like group masking, display of hidden interlocks etc…

The software interlock system (SIS) will be upgraded mainly to facilitate the interlocks configuration. There will be a new easier language for the configuration (DSL), but xml can still be used, and effort will be made on user documentation.

More powerful hardware will replace the existing for LHC and SPS instances.

Power Converter Interlock

The power convertor interlock is an application that checks the current of the LHC correctors and compares it to a reference. If the difference is greater than the tolerance, a software interlock is generated and the beam is dumped.

The actual system provides a fixed tolerance for each corrector that is not flexible enough. The tolerance ideally should be a function of time and be calculated as a function of the beam energy. LSA parameter will be created with makerules and value generators for these tolerances management.

Later, the PC interlock will be extended to other circuits than only the correctors.

Reference Orbit Management

In the actual system, a reference orbit for the steering the addition of:

- the base reference orbit obtained by orbit measurements and corrections with all the separation and crossing bumps at zero
- the overlays obtained by calculation with MAD of the theoretical beam positions for given optic and crossing and separation bump values

The overlays have to be calculated manually for each optic and bump values of each beam processes. This is a time consuming process that will become quite laborious if we run with combined ramp and squeeze or collide and squeeze beam processes. For the start up a new orbit management system will be developed that will automate the creation of the references using LSA information.

Console Manager

A new tool for the menus configuration will be implemented to replace the databases views, it will be easier to use. An automatic update of the CCM on each console will be put in place for the end of 2014,

On OP request a mechanism to show or hide applications according to the beam mode will be created. It will improve the operational consoles ergonomic.

Sequencer

During LS1, a huge campaign of tasks and sequences cleaning has been performed. The sequencer has been updated to give the possibility to assign external arguments to a sequence, i.e. a sequence to reset and restart a power converter will have the power converter name given online by the operator.

Online model project

The online project model has been taken over by ABP. The aperture measurement application will be reviewed for November 2014.

There are many ideas of tools using online model that could be useful for machine set-up and model improvements. The requirements need to be listed an prioritized and the resources gathered before concrete work can be started.

The knob and optic upload that are part of the online model project had been taken over by OP. A new GUI has been developed to facilitate the upload of new optics and the management of elements in LSA. It replaces old Perl script by a java API for the upload into LSA database, and has facility to compare MADX and LSA information.

Heat load display

The heat load will be a major concern for 25ns beam operation and its monitoring will be crucial to maximize the scrubbing efficiency.

A new display of the heat load is under development [7]: data are extracted from the logging database to compute the heat load. Timber is for the moment used for the display, but should be replaced by a proper fixed display in the control room before the start-up.

In parallel another display will be created, heat load will be computed using the bunch by bunch energy loss measurement from the RF phase.

CONCLUSION

During LS1, developers have been very busy to upgrade, refactor, renovate and add functionalities to the accelerator control software. At every software layer, LS1 was the opportunity for major modifications, and software engineers are still struggling to come back to a stable situation before the start-up of the accelerators. The injectors' start-up will be a major test of the new control system and most of the issues will be caught and solved. On the LHC side, dry-runs have already started, it will allow solving as much as bugs and issues as possible well before the start-up of the LHC.

As the long shut down is over for the injectors, LHC beam is not foreseen before 2015 and there is still a lot to do for the LHC control in the coming months, but no major problem is anticipated.

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