Software Architecture for the LHC Beam-based Feedback System

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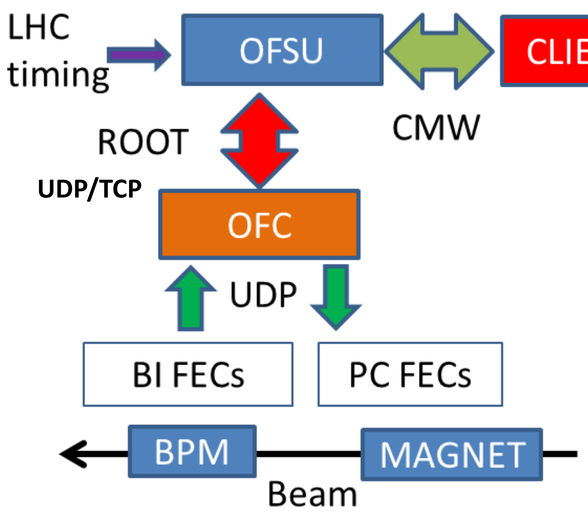
Abstract

This poster presents an overview of beam based feedback systems at the LHC at CERN. It will cover the system architecture which is split into two main parts – a feedback controller (OFC) and a service unit (OFSU). The paper presents some issues encountered during beam commissioning and lessons learned including follow-up from a recent review which took place at CERN

System Overview

LHC timing events are used to signal updates to acquisitions and parameters

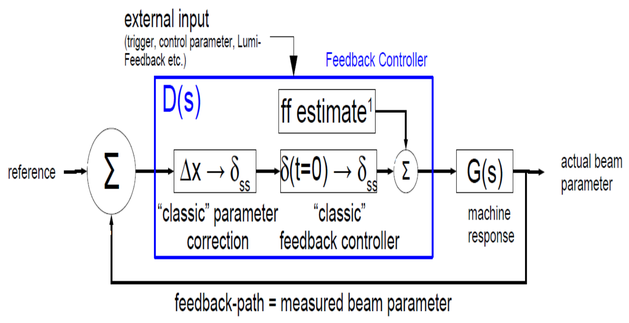
Real-time data input from ~70 distributed front-end computers (BI FEC) provide the signals on which the feedback server (OFC) reacts to produce corrections. There are 500 position readings per beam and per plane.

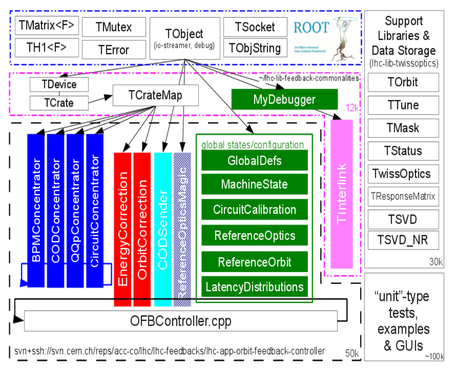


Slowly changing parameters and acquisitions typically updated at 1Hz are handled by the service-unit (OFSU) server over CMW (RDA2). The OFSU also triggers optics and critical reference orbit changes (~10 changes / cycle).

The OFC provides real-time corrections (trims) to LHC power converters (PC FEC) affecting the beam through ~500 orbit corrector magnets for each of the 2 LHC beams.

Feedback server (OFC)





Principle feedback loop as implemented in the OFC server

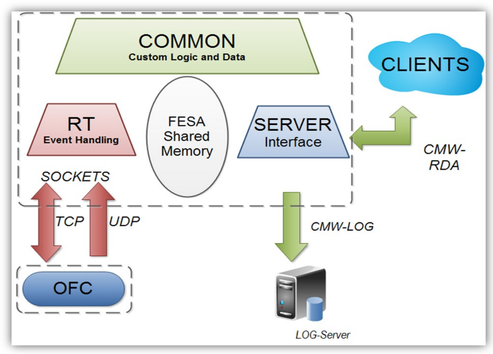
ΔX = deviation from reference value which for the betatron tunes is a single value per plane

δ (t) = response value which for the LHC orbit feed-back leads to handling large matrices due to the number of possible inputs and outputs

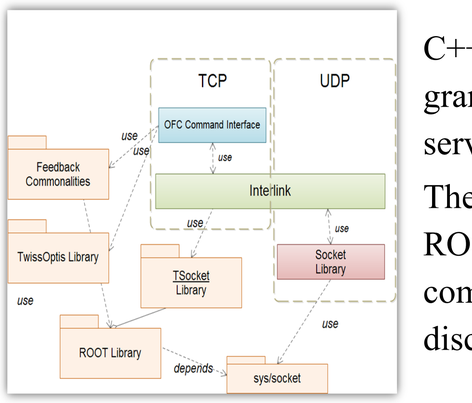
C++ class diagram for the OFC server

A rationalization effort has been started looking at the different classes and their dependencies for long-term maintenance

Service Unit server (OFSU)

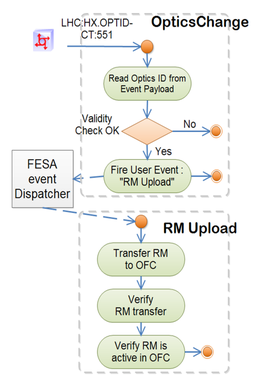


Software interfaces implemented by the OFSU server. The next FESA frame-work released is presently being investigated offering access to the new CMW middleware (RDA3 based on ZeroMQ) provided by CERN-BE/CO as an alternative to the present RDA2 (CORBA-based)



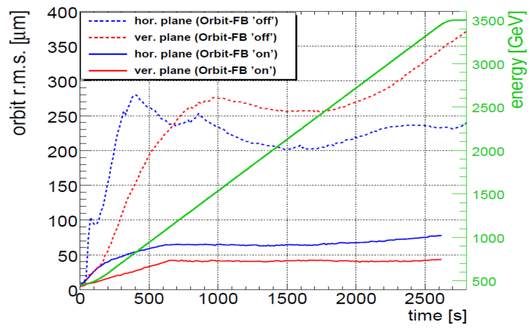
C++ dependency diagram for the OFSU server.

The use of TCP and ROOT/TInterlink based communication is being discussed

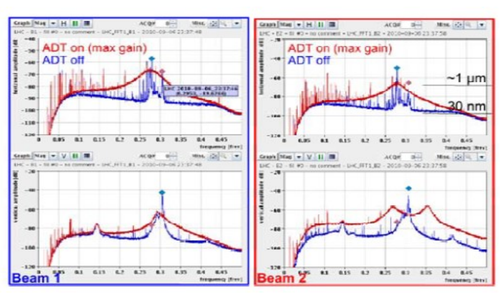


Implementation details concerning a change of LHC optics

Performance and issues



The orbit feedback is essential for LHC operation with high intensity as the required stability cannot be obtained by feed-forward alone. Its performance is better than initially specified.



The performance of the LHC tune feedback is limited by the quality of the tune signal. With high beam intensity, the transverse feedback (ADT) as well as non-linear fields strongly degrade the signal quality.

On-going investigation during LS1

- Improvements will be made to cope with future operation mode involving more dynamic reference changes (by cycle): high level JAVA layer (LSA)
- The optics manipulations and matrix inversions will be moved to a high level JAVA server. Only the results will be transmitted by the OFSU
- Optics and reference changes will be handled directly inside the OFC
- Gain/bandwidth management to be looked into while running at higher energy after LS1 (reduced margin on the correction circuits)
- Some diagnostics and error-checking will be made at the level of the front-ends
- BPM front-end software to RT Linux for improved RT performance

Conclusions and outlook

The OFC/OFSU server combination has allowed running the LHC beam-based feedback reliably allowing rapid setting-up of new running scenarios. This has allowed subsequent feed-forward reducing the required real-time corrections to deal with slowly drifts of position and betatron tunes. During LS1, a small team has been put in place with an aim of looking critically at performance, design and implementation decisions and propose alternative solutions for running feedbacks in the years to come.