CONFIGURATION MANAGEMENT SYSTEM FOR THE LHC SUPERCONDUCTING MAGNET TEST BENCHES

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Abstract

The configuration management system for the Large Hadron Collider (LHC) superconducting magnet test facility has been integrated with the already existing software enforcing quality assurance procedures of the LHC - the Manufacturing and Test Folder (MTF). Such a solution provides one common access point to all the data relevant to each of the tested magnets. The MTF software was developed at CERN in order to capture the design, manufacturing and test data for equipment in the LHC project. Being an integral part of CERN's Engineering/Equipment Data Management System (EDMS), MTF is a web-based application built on top of two commercial software packages: Axalant from Eigner and Datastream's MP5 asset tracking tool. The CERN developed part of MTF complements the MP5 software with an easy-to-use web interface. Within the framework of the configuration management project, new modules have been developed to store parameter settings and to ease the task of the test operators and minimize error-prone keyboard data introduction. Test bench hardware configuration can now be fully recorded using an industrial portable PC and a barcode reader. The configuration data stored in MTF can be read by the actual control systems in the test bench facility in an automatic way.

INTRODUCTION

Terminology

The term configuration can be used in various contexts, often resulting in ambiguity. Throughout this paper *hardware configuration* will refer to a position of a piece of equipment used in a bench at a given moment in time with respect to its parent equipment; whereas all the data relevant to calibration, gains, on/off switches etc. will be called *parameter configuration.* Furthermore, we will refer to the equipment composing the test benches as *tools*.

Information Systems Context

As the commissioning of the LHC approaches, industrially produced dipole and quadrupole magnets are starting to arrive at CERN in large quantities. Prior to their installation in the tunnel, all the magnets must undergo a series of tests, both warm and cold (1.9 K). These tests are part of the official quality assurance plan of the LHC project. Test result data is stored in dedicated databases, while a synthesis of the most important results of each production, delivery and test step for every magnet is stored in the MTF system which offers wide ranging traceability features [1]. The long lifetime and complexity of the LHC accelerator require a project-wide coherent approach to the life-cycle management of engineering and equipment data. This implies that a wide range of data such as information about the manufacturer, manufacturing procedures, test results, non-conformance reports and other related documentation have to be stored and retrieved from nearly any place in the world. While the test results, dates, equipment identifiers and other similar data are stored in the underlying asset tracking system - MP5 from Datastream Inc., the documents, whether they be non-conformance reports, test reports etc. are managed by the CERN-developed EDMS system and the underlying commercial software - Axalant [2]. Both the EDMS and MTF services have been in production for several years now and have proven their usefulness.

After the first tests of pre-series magnets it became evident that it is not only the test results that should be stored in a well established and maintained information system, but also data describing the configuration for each of the cold tests that are both complex and expensive to perform. With 1232 dipole and over 400 quadrupole magnets to test in the superconducting magnet test facility, the configuration of the 12 test benches may evolve as hardware is upgraded, new modules added, parameter settings changed etc. Being able to trace the exact configuration both in terms of hardware used as well as the parameter settings of tools is extremely important in the results analysis phase. The configuration management of the test benches has become an issue on its own.

Proposed Solution

The parameter configuration tool is closely coupled with the data acquisition (DAQ) system used. Although parts of the DAQ hardware and software systems in the superconducting magnet test facility and in the adjacent String 2 experiments are similar, reusing the existing String 2 configuration tool [3] implied a considerable amount of programming work in order to adapt it to the bench specific requirements. Moreover, this tool lacked the capability of tracking hardware configuration changes as in the String 2 experiment the hardware configuration *a priori* did not change.

The capability of storing structures of equipment together with their history is one of the core functionalities of MTF. Hence, traceability of hardware configuration could be provided by the MTF, just as traceability of the tested magnets is assured. However, tracking changes in the parameter configuration of tools posed a problem, as the parameters stored within MTF did not have their history recorded. Nevertheless, given the general interest in enhancing this functionality, it was decided to use MTF as a hardware and parameter configuration tool for the superconducting magnet test benches. Management of not only the test results data, but also of the test-bed configuration within the same information system means that the entire history of manufacturing and testing process is kept in one location, with one access point and one authorization mechanism, thus assuring maximum data coherency and security.

NEW DEVELOPMENTS

Parameter Configuration Module

The original design of MTF included the concept of properties - each category of equipment had a certain number of properties associated with them. E.g. for a dipole magnet, where a number of power tests is conducted, this could be the value of the first quench level. Since the test results do not change with time - there is one value for each test step, the history of property values was not taken care of. In the case of parameter configuration, it is important to store the complete history of parameter settings through the entire lifetime of the test benches.

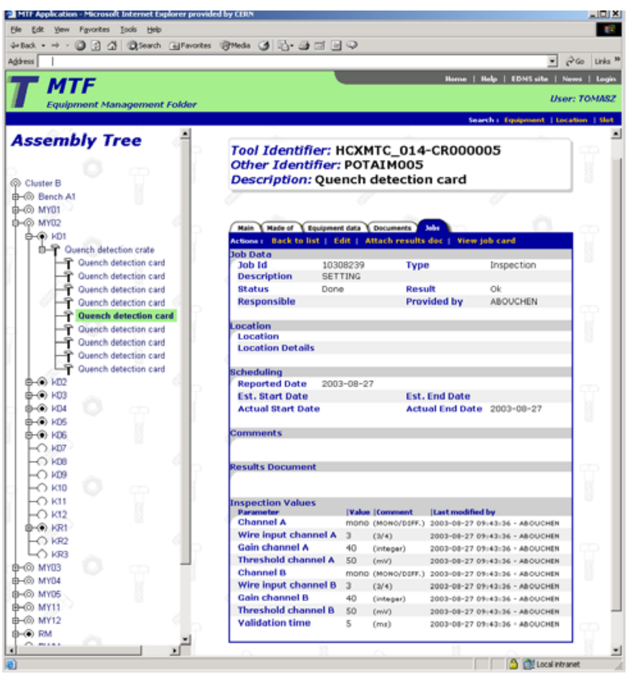

Figure 1: Inspection job page.

A new concept of inspection jobs was introduced into MTF, relying on the MP5 Inspection Management Module. For each tool category a number of parameters to inspect may be introduced in the system. Whenever there is a need to change the values of parameters, a new job is created. The new parameter configuration is recorded together with all the 'administrative' variables of each job - who and when performed the operation, what was its status etc. (Figure 1).

Hardware Configuration Wizard

Each test of a magnet requires the presence of specific tools in the test bench. Most of the tools are in fact permanently attached to each bench - e.g. power converters, cold feed boxes, quench heater power supplies etc. However, some sophisticated tools can be shared between several benches. These can be, for example, mobile racks with magnetic measurement pre-amplifiers.

Prior to each test, a complete examination of all the tools is necessary, followed by the recording of what is present for a particular test run. Although this operation is straightforward, it is prone to human errors when large quantities of equipment identifiers must be recorded. In order to guarantee unique identifiers for equipment throughout the CERN environment, some general rules of how to compose these alphanumerical codes have been defined and specified in the LHC quality assurance procedures [4]. Depending on the type of equipment and its project or machine origin, different prefixes are being attributed, after which locally managed coding conventions are applied. Within the LHC project two different kinds of identifiers are being used. A 19-character long descriptive code for all the equipment specially manufactured for the LHC and a 10-character long, partially randomly generated, code for all off-the-shelf components.

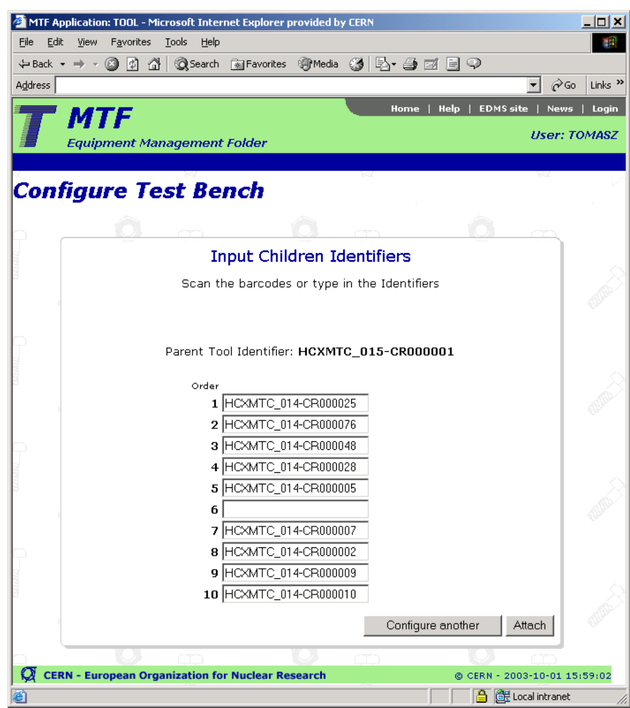

Figure 2: Hardware configuration page: the parent is a VME crate, the children correspond to electronics cards.

As the keyboard entry of several 19-character long identifiers can easily lead to erroneous data introduction, it was proposed to place equipment identifiers on each tool in the form of barcodes. The MTF web software was enhanced to read values not only from a keyboard, but also from a barcode reader. At the same time a market study was performed to analyse which device could be used by the field operator to enter data. The requirements were simple: a portable device with the capability to display web pages, interfaced to a barcode reader and to CERN's intranet via wireless LAN. The hardware chosen was an industrial portable PC from Siemens - MOBIC T8 – the Mobile Industrial Communicator, equipped with a CCD barcode reader.

The wizard to configure the test-bed is composed of three steps.

- Attaching a piece of equipment (magnet, tool) to a position. Positions can be seen as empty slots or placeholders for equipment that can be moved.
- Attaching sub-tools to a tool; in most cases this operation corresponds to insertion of cards into a crate (Figure 2).
- Configuring calibration parameters (if any) for the tools. This step includes automatic creation of an inspection job and setting of all the job parameters - the job responsible is the person logged in to perform the tool scan, the job actual date is set to current date etc. (Figure 3).

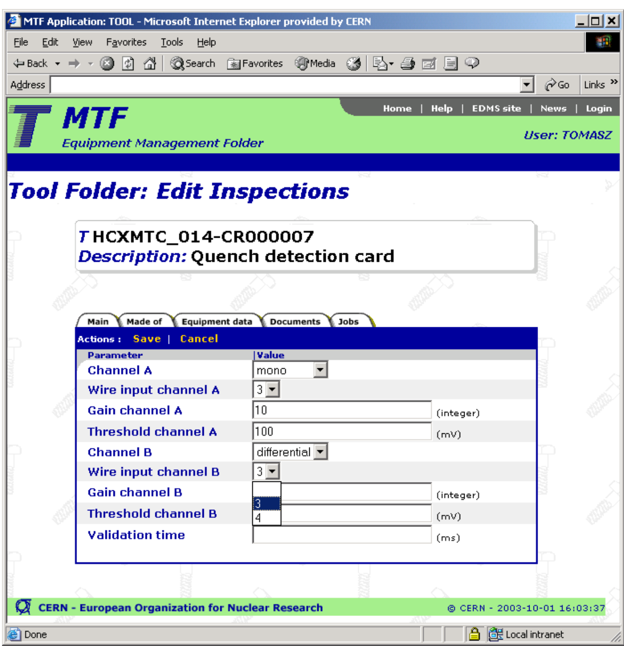

Figure 3: Parameter configuration page.

Although these steps are relatively simple, the real advantage of having a central DB repository lies in the verification procedures for each of the wizard tasks. Prior to actually performing an 'attach action' in the database, a large set of business and system rules is checked and sometimes corrective action is taken. For example: if a bench was used to test a magnet and this magnet's removal was not recorded, the wizard will automatically detach the magnet, before attaching a new one to the same bench.

Interface to the DAQ System

The configuration data stored in the MTF is of interest not only in the analysis phase, but also in the process of configuring the DAQ system. However, MTF has never before been considered as a tool to be interfaced with on-line control and data acquisition systems. The data structures of MP5 were designed with the goal of being generic and suitable to all forms of asset tracking, which may imply low performance compared to custom built DAQ configuration repositories. The access authorization mechanisms in MTF cannot be used at the MP5 table level. Therefore, consulting MP5 data from external software in an automatic way could not be provided, as it would neither be safe nor efficient.

Instead, a number of Oracle views were created. Data in the views is limited to the scope of interest of the test benches and its retrieval was optimized in terms of performance. There are 6 structure views with a parent-child relationship for each test cluster and one view with values of actual parameter configuration for each tool. A view with calibration data of cryogenic thermometers installed in the dipoles, which is also stored within MTF, was provided in addition. These views are accessed in an automatic way, whenever a new magnet test is being configured [5].

CONCLUSIONS AND OUTLOOK

The first version of the configuration management system has been tested in the field for the past few months. Integration with the DAQ system proved successful and no major problems were detected. Once the capacity of the magnet test benches increases and several magnets start being tested in parallel, full deployment of the system is foreseen.

Most of the original MTF web developments targeted users updating an individual piece of equipment or a document. The test bench operator was initially asked to register the entire configuration for every magnet tested - which meant scanning approximately 200 tools and for each scan operation a separate database transaction is necessary in the current software version. The test preparation procedure has since changed; nevertheless, specification for a more efficient wizard is under study.

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