SELECTION AND EVALUATION OF COMMERCIAL SCADA SYSTEMS FOR THE CONTROLS OF THE CERN LHC EXPERIMENTS

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Abstract

Considering its continuously shrinking resources, CERN is increasingly focusing its efforts more on physics activities at the cost of more technology-oriented developments. Along these lines, commercial Supervisory Controls And Data Acquisition (SCADA) systems [1] are now being given serious consideration for the Detector Control Systems (DCS) of the LHC experiments. Indeed, such systems are generally used for industrial processes whose characteristics in terms of scale, distributed nature and functionality resembles those of detector controls to a significant extent. Therefore, an in-depth analysis of such systems has been carried out at CERN in the Research Sector. This paper describes this procedure and shows how the initial definition of the user requirements (à la ESA-PSS-05) led to a detailed set of criteria against which the SCADA products were checked. Some of the more promising products have undergone a sequence of more detailed evaluations related to scalability, openness, development facilities, etc. The paper will also highlight that the use of such SCADA systems is most beneficial if complemented by proper engineering activities.

1 INTRODUCTION

Due to the reasons given in the abstract above, as well as the stated aim to have a common controls solution for the four LHC experiments, it was decided in 1997 to start a project, called the Technology Survey, to look at commercial SCADA systems. The aim was to evaluate whether commercial SCADA tools would be suitable for use as the basis of a common controls solution for the LHC experiments. This activity was later incorporated into the Joint Controls Project (JCOP) [2] when this was started in January 1998 and has since been performed under the auspices of it.

2 MAJOR CRITERIA

Prior to commencing with this Technology Survey, a User Requirements Document was prepared in co-operation with two of the LHC experiments following the methodology PSS-05 from the European Space Agency (ESA) [3]. This was used as the basis to develop an extensive list of criteria against which the SCADA systems could be evaluated. These criteria were grouped into a number of categories:

- Scalability – considers any built-in limits that would prevent the product being applied to a control system with the number of channels of an LHC experiment, e.g. limits on the number of variables, historians or alarm handlers in one system, as well as the possibilities that exist to extend the system, e.g. to add additional client or server stations
- Architecture and openness – aspects of the product architecture that would e.g. impact on the performance, such as polling or event driven, central or distributed database, central or distributed archiving, as well as the ease of adding functionality or interfacing to external systems
- Functionality – suitability of the standard SCADA development and run-time facilities, as related to an HEP application
- Support for the configuration of large applications – the capabilities of tools provided for the configuration of very large applications
- Company and commercial considerations – aspects including cost and company stability

Each of these criteria was assigned a relative weight within its category and the categories were themselves also weighted amongst each other. These criteria and the associated weighting factors were discussed and agreed with the four LHC experiments.

3 INITIAL SELECTION

At the beginning of the Technology Survey activity it was not known how many products existed on the market nor what their relative capabilities might be. Therefore, an initial request for information, including a detailed questionnaire, was sent to a large number of companies (>150), which had been identified to be involved in the area of industrial controls. From the forty or so responses received, a first selection was made. This was based on the questionnaire responses, on any additional technical documentation provided as well as on the responses to a number of additional questions sent for clarification. This initial sorting was effectively done to eliminate products that were clearly seen to be unsuitable, e.g. not adequately scalable or that were based upon the use of proprietary hardware. This first selection reduced the number of products to around 20.

In order to reduce further the number of products, and to come up with a short-list to be evaluated in a 'hands-on' fashion, the remaining companies were visited to obtain more detailed information on the capabilities of the products. The purpose of these visits was threefold:

- To meet representatives from the company to better understand each others terminology, whilst also obtaining a view into the company's organisation and facilities
- To go through a set of more detailed technical questions relating to the architecture and functionality of the products as well as addressing commercial issues
- To see a demonstration of the product

On the basis of this detailed information a comparison of the products was made by applying the detailed criteria mentioned in Section 2 above. This led to a ranking of the products and the top five were selected for further evaluation.

4 EVALUATION STEPS

It was decided to perform the 'hands-on' evaluation of the short-listed products in two phases and special evaluation licenses were obtained from the companies. The first evaluation phase was intended to look at the basic functionality of the products and to assess their ease of use, both in development as well as during run-time, whilst the second phase was intended to look in more depth at a number of specific issues related to using such a system in an HEP environment.

In addition to performing this 'hands-on' evaluation, the market watch was continued and this led to the identification of a number of additional products of interest, one of which was eventually added to the short-list of products to be evaluated.

Finally, to better understand some technical issues not generally covered in the product documentation, and to discover the intended evolution path for the products, a set of meetings were set up with engineers from each of the companies.

4.1 Phase 1

The Phase 1 evaluation of each product was preceded by a week's training course to shorten the learning curve for the users. This proved to be a successful approach and it was possible to commence the evaluation in an effective manner immediately after the course. This phase of the evaluation concentrated on the basic SCADA features such as the configuration tools, the Human Machine Interface (HMI), alarm and event handling, logging and archiving as well as the access control mechanisms. These were evaluated from both a functional, as well as, from a usability point of view, e.g. were the various facilities of the product well integrated or was the user presented with a number of independent tools, how consistent and intuitive were the provided facilities to use, how good was the on-line help, etc.

4.2 Phase 2

The aim of the second phase of the evaluation was to look into a number of critical issues:

- Multi-user/multi-location development support – the control systems for the LHC experiments will be developed by multiple teams located all around the world and therefore a SCADA product would need to be able to support this distributed development approach, including the possibility to conveniently integrate these developments into a coherent system
- Configuration – the facilities provided to support the configuration of very large applications (n*10**5 I/O channels)
- Application Programming Interface (API) and openness – whether it would be possible to extend easily the functionality provided by the product, as well as to interface it to other applications e.g. a Finite State Machine (FSM), an Expert System, as well as to a central experiment configuration database
- Scalability and performance – how large an application could one build with the product (in terms of the number of I/O channels) and what would the performance for such an application be?
- Partitioning and hierarchy – it must be possible to operate the various components of a detector control system with different levels of abstraction either in an integrated mode or individually for instance during maintenance periods

4.3 Evaluation Results

The results of the evaluation were presented regularly to the LHC experiment communities during the course of the evaluation and then summarised during a workshop held at the beginning of September 1999. The goal of this workshop, in terms of SCADA, was to provide the experiments with sufficient information to be able to make a decision on whether or not to use SCADA for the their detector controls. Although the experiment collaborations have not yet reached an official decision, it would be fair to say that the general consensus during the workshop was favourable to the use of SCADA.

5 SUMMARY OF INITIAL RESULTS

It is not the intention of this paper to give detailed information on individual SCADA systems, nor any ratings of particular systems. Anyone interested in finding out more detailed information on the evaluation, and the results obtained, is requested to contact one of the authors. Furthermore, there is a wide range of documentation on this activity available via the web[1]. However, for reasons of confidentiality much of this is password protected.

[1] http://itcowww.cern.ch/jcop/subprojects/TSurvey/

Nonetheless, a number of general results can be presented here:

- SCADA systems are used extensively in industry including for large (up to 450,000 I/O) and complex applications
- Current SCADA systems are very powerful in terms of provided functionality and openness, and as such provide many of the features required by LHC experiments
- SCADA systems are very open and support many industrial standards but generally run only under NT
- The products are evolving very rapidly and indeed most of the companies have brought out new versions, containing significant enhancements, during the course of our evaluation
- Device-oriented system provide significant advantages over channel-based systems
- New generation device-oriented products are emerging on the market and typical application sizes are increasing (we are aware of planned system with approximately 1 million I/O channels)

6 IMPORTANCE OF ENGINEERING

During the various discussions with the product vendors, as well as during the visits to many reference sites, the topic of engineering and its importance to a project was raised repeatedly. Especially in large projects, and particularly in the case of the LHC detectors where the development will be performed in many locations around the world, the importance of proper engineering cannot be stressed enough. Engineering has the aim of not only ensuring a successful project leading to a high quality homogeneous control system but also of reducing to a minimum the effort required by the individual development teams. It is not possible in the space available to cover all the aspects of engineering but some of the more important issues are highlighted below:

- Development of templates and symbol libraries, e.g. power supply, rack, etc.
- Guidelines on 'look and feel' i.e. the use of colours, fonts, page layout, naming, ...
- Guidelines on partitioning
- Guidelines for alarm priority levels, access control levels, etc.
- Modelling of standard device behaviour
- Definition of system architecture (split of functionality between SCADA and other systems e.g. FSM)
- Development of configuration tools
- Implementation of standard interface methods to other systems

7 LESSONS LEARNT

The effort involved in such a process should not be underestimated as this can easily add up to many man-years if performed thoroughly. This is due to the fact that there are a large number of products on the market, which all provide a set of common basic facilities. Therefore, in order to understand the differences and to be able to find the better products, it is necessary to look into each of these products in some depth. Furthermore, this is complicated by the fact that each product has its own terminology, which is often based on the specific product's architecture, and it is first necessary to understand this. Then, having made an initial short-list based on the responses to any prepared questionnaire, technical documentation and discussions with the companies, it is definitely necessary to use the products. We can quite clearly say that our impression of the products changed, sometimes significantly, once we actually used them. Reading the documentation, listening to presentations, holding discussing with the companies is not sufficient. It is essential to try out the products to assess their usability, to investigate how well the functionality is provided, to evaluate performance and reliability, as well as to assess the provided technical support, documentation and training.

8 CONCLUSIONS

There are very many SCADA products on the market that are used in many large and complex industrial applications. Therefore, the process to select suitable products for evaluation and then to evaluate them in sufficient detail was a major exercise. To reach the point to be able to say whether such products would be suitable for the controls of the LHC experiments or not, has taken about two years and has involved the efforts of many people. However, the conclusion of this activity is that commercial SCADA systems would in general provide significant benefits [1] and that more specifically the new generation of products, which are currently emerging and which are device-oriented, would provide a feasible technical solution for the controls of the LHC detectors. However, the selection of a product is not the end of the story. In order to minimise the development effort by the end-users, and to achieve a homogeneous final system, a detailed engineering phase will need to be performed.

9 REFERENCES

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