THE LHC EXPERIMENTS' JOINT CONTROLS PROJECT, JCOP

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Abstract

The Large Hadron Collider, LHC, is the next large accelerator being built at CERN, Geneva, for operation from 2005. Four experiments are being prepared to use the LHC, namely ALICE, ATLAS, CMS and LHCb, and each has over a thousand collaborating physicists world-wide. The LHC experiments are on an unprecedented scale; data acquisition channels are numbered in units of 10**6 and controls channels in units of 10**5. The experiments have actively been looking for ways to make common developments and avoid duplication. Hence, at the beginning of 1998, a Joint Controls Project, JCOP, was set up to provide common solutions for a control system for all four experiments, including supervisory software, field buses, PLCs, OPC servers and so forth. This paper will report on the goals of the project and how far these have been achieved by the date of the conference. In particular, we shall review the outcome of the second JCOP Workshop which took place in September 1999.

1 WHY A JOINT CONTROLS PROJECT?

CERN is currently being pulled in two directions. On the one hand it is building the Large Hadron Collider, the world's most powerful particle accelerator. On the other hand the budget is being severely squeezed and the staff numbers cut by 30%. All this whilst continuing to run existing experiments which occupy half the world's experimental particle physicists and collaborating in the construction of two large and two extremely large experiments for LHC (the ATLAS and CMS experiments have up to 2000 participating physicists each). This is certainly a challenge.

To cope with the severe reductions in manpower an increasing amount of work is being out-sourced, but there are mission-critical areas where this is not possible, and experiment controls is one of them. However, another means of increasing efficiency is to try to reduce duplication of effort by the use of common developments, and a committee composed of members of the four LHC experiments and the Information Technology (IT) division was set up in 1997 to find areas where common development between the four LHC experiments could be feasible. Experiment control was thought to be such an area, and thus the LHC Experiments' Joint Controls Project, JCOP, was started in January 1998 with these five partners [1].

2 GOALS AND ORGANIZATION

Clearly, each of the four experiments must have its own control system. However, the goal of JCOP is to ensure that the tools and components used to build these systems are the same wherever possible. Thus, the JCOP project definition specified the goals to be:

- Understand the needs of the experiments;
- Evaluate the technology and commercial products;
- Produce guidelines for hardware interfaces and communications protocols;
- Select a control system or SCADA tool kit capable of supporting the experiments' hardware and software components and subsystems;
- Evaluate, select and support an interim solution.

The day-to-day management of the project is handled by bi-weekly meetings of the Controls Co-ordinator of each experiment, the leader of the IT Controls Group, and the JCOP Project Leader. However, as much as possible, an attempt is made to proceed by consensus after discussion at Project Team meetings where all those people working on the project are present. Project Team meetings also serve as a forum for presentations on technical issues, reviews of sub-projects, and so forth.

Apart from technical issues, a joint project of this nature must also deal with the questions of scope, timing, and resource allocation. Problems related to the scope of the project are due to differences in how each experiment sees its internal architecture. Thus, one experiment might see the domain of JCOP covering mainly industrial controls, whilst another wishes to have an integrated control system covering also trigger and data acquisition (not including fast real-time hardware control). As the four experiments all have different schedules, the timing of when decisions must be made has to be a compromise, as must be the allocation of resources.

Technical issues are tackled by a series of sub-projects, described below, which are staffed by members of IT/CO group along with representatives of the experiments. In June 1998, not long after JCOP was started, a large workshop was organised at CERN [2] at which all these points were debated and presentations were made by a range of existing experiments on how they had dealt with some of these questions.

3 JCOP TECHNICAL PROJECTS

Technical issues are dealt with by sub-projects, each with a designated sub-project leader. Sub-projects have a short proposal to define the goals, time scale and resources, and produce one or more reports. All the documentation is on the Web [4], although commercially sensitive information is protected by a password.

Whilst unfortunately not complete, a substantial amount of effort went into producing a document on architectural design [5]. This helped a great deal to fix ideas and for everyone to use a common vocabulary. The document deals separately with hardware and software design, and looks at issues such as system partitioning, integration and configuration, device servers, access control and so forth.

A significant change from previous experiment control systems will be the adoption wherever possible of industry-standard field buses to connect hardware to the supervisory layer. A CERN working group has recommended the use of three standards [6] which cover the complete range of applications. These are CANbus, Profibus and WorldFIP.

The use of field buses, along with the *de facto* adoption of OPC as a software interface standard (OLE for Process Control [7, 8]), should make it much easier to provide an upgrade path from an intermediate to a long-term software solution. The intermediate software tool chosen, which is BridgeView from National Instruments [9], can ultimately be replaced by a more-sophisticated SCADA (Supervision, Control And Data Acquisition) system without the necessity to modify anything at the hardware or middleware level as BridgeView and the SCADA systems all have OPC clients. Whilst BridgeView is not suitable for large applications, it is certainly sufficient for prototyping and testing sub-detector components.

Also starting to appear in experiments are Programmable Logic Controllers (PLCs [10]). There are over a thousand of these at CERN in industrial applications, but it is now understood that they can also be applied usefully within experiments. After a tendering procedure, CERN has negotiated contracts for the supply of PLCs from several major manufacturers. Thus, CERN-wide supported solutions are available for both PLCs and field buses. In the latter case, because in general field bus nodes are low-density, a development driven by the ATLAS experiment has produced a high-density multiplexed connection for CANbus, called the LMB [11], to which a large number of I/O devices can be connected cheaply.

In order to test both hardware and software devices a Test Bench [12] has been set up. This provides an assortment of PCs, field buses, PLCs, and other equipment in a lab which can be used for testing software, measuring performance and so forth. OPC servers exist or have been written for an assortment of devices, which makes it straight forward to try out different software solutions. However, the Test Bench may also be used to test new hardware sensors or larger pieces of equipment, such as multi-channel power supplies.

Yet other work items or sub-projects have been concerned with trying out the technology in a production environment, such as for experimental “Test Beams” [13, 14], and this topic is covered by another ICALEPCS’99 paper [15]. We are also looking into controls for common services, such as gas and safety systems [16, 17], as well as collaborating with a CERN-wide working group set up to provide a common communications system between the experiments, accelerator, safety, cryogenics and other systems. In addition, an attempt is being made to standardising interfaces to High Voltage power supplies [18]. It may be that there are technical reasons why not all these projects can standardise on common solutions, but we are hopeful that we can succeed in most cases.

The major issue currently being tackled by JCOP is the choice of supervisory and control software. An evaluation of the EPICS system [19] in 1997/1998 suggested that whilst this had certain strengths, it would not be appropriate for experiments as complex as those for LHC which would not start until 2005 and then run for 10 to 20 years. This led to a decision by the CERN Controls Board [20] to sponsor an in-depth survey of the SCADA market, and this survey will be described in detail during the present conference [21, 22]. In excess of 40 companies world-wide were found to be producing possibly suitable SCADA software and new products continue to be discovered all the time. A selection procedure was put in place which cut down the number of candidates to twenty and then to five or six, and the remaining products have been evaluated in detail over the previous twelve months.

The evaluation has turned out to be an enormous amount of work as each product is complex and may have deficiencies one can only discover by making detailed tests. Criteria used in these evaluations included scalability to the order of 10**6 I/O points, performance, openness and adaptability. If there is one thing we know, it is that we don't know now what our applications will look like in 10 years time! Thus, the primary goal was to convince ourselves that indeed commercial SCADA systems would be suitable for control of LHC experiments and then, if we believed this to be true, to select which products were the most appropriate. Along with reports and discussions on all the other JCOP activities, the result of these investigations was presented at a second workshop at the beginning of September 1999 [3].

4 THE FUTURE

The conclusion of the SCADA evaluation, as presented at the workshop was that in all likelihood a commercial SCADA system could be used for LHC experiments so long as it belongs to the latest generation of device-oriented products. Earlier SCADA systems are tag-based and these were felt to be inappropriate for modelling the large number of complex devices to be found in an LHC experiment.

The next stage will be for the experiments to try out several of these products intensively in small production systems, or test beams, in order that everyone is completely convinced of their efficacy before a final decision is taken to purchase one. A major issue here is the lack of people from the physics community with sufficient time and experience to carry out this work. Assuming a satisfactory conclusion, it is likely that we shall continue with a call for tender.

Of course, the purchase of such a system is only the beginning of a long process. Many engineering issues will need to be resolved and standards defined in order to ensure that the different pieces of each experiment, developed at sites scattered throughout the world, will work after their integration. For example, essentially all SCADA systems lack support for Finite State Machines, and so such a facility would need to be added by members of the joint project [24].

Other areas which we are only starting to touch are the joint provision of common services. As previously mentioned, JCOP is already collaborating with the LHC Experiments' Gas Working Group, but this could well be extended to such things as electrical power control, as well as cooling and ventilation.

There are several problems particular to the area of controls. For one thing it touches all aspects of an experiment, and so one must collaborate with a very large number of people. We would also like those people to use standard hardware items and interfaces where ever possible in order to reduce the complexity of the control systems and increase their reliability. However, perhaps the biggest problem is that so much effort is necessary to make such complex detectors work at all, that there tends to be very little man-power left for controls. Nevertheless, if insufficient thought is now given to control systems then there is a high risk that the LHC experiments will not produce physics results reliably.

5 ACKNOWLEDGEMENTS

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6 REFERENCES

[1] JCOP: The LHC Experiments' Joint Controls Project, http://itcowww.cern.ch/jcop/

[2] The First JCOP Workshop, June 1998, http://itcowww.cern.ch/jcop/JCOPworkshop1/

[3] The Second JCOP Workshop, September 1999, http://itcowww.cern.ch/jcop/JCOPworkshop2/

[4] JCOP Sub-Projects, http://itcowww.cern.ch/ jcop/subprojects/

[5] An Architecture for LHC Experiment Controls, http://itcowww.cern.ch/jcop/subprojects/Architecture/

[6] Recommendations for the use of field buses at CERN, http://itcowww.cern.ch/fieldbus/report1.html

[7] Results of the OPC evaluation, R. Barillère, et al, ICALEPCS'99, October, 1999.

[8] JCOP and OPC, http://itcowww.cern.ch/jcop /subprojects/OPC/welcome.html

[9] BridgeView, http://www.natinst.com/

[10] Programmable Logic Controllers, R. Rausch, J. Brahy and D. Blanc, http://itcowww.cern.ch/ JCOP/ProjectTeam/PTMinutes/dblanc/index.htm.

[11] Front-End I/O of the ATLAS DCS, H. Burckhart, ICALEPCS'99, October, 1999.

[12] The JCOP Test Bench, http://itcowww. cern.ch/jcop/subprojects/TestBench/

[13] ALICE HMPID Liquid distribution prototype, http://itcowww.cern.ch/jcop/subprojects/hmpid/

[14] ATLAS TRT GAS Prototype, http://itcowww. cern.ch/jcop/subprojects/ATLAS_TRT/

[15] Applying Industrial Solutions to the Control of Experiments, Paul Burkimsher, Herve Milcent, ICALEPCS'99, October, 1999.

[16] Gas Control, http://itcowww.cern.ch/jcop/ subprojects/GASControl/

[17] Interface to Experimental Area Safety, http:// itcowww.cern.ch/jcop/subprojects/Area-Safety/

[18] High Voltage Power Control, http://itcowww. cern.ch/jcop/subprojects/Highvoltage/

[19] JCOP Sub-project on EPICS, http://itcowww. cern.ch/jcop/subprojects/EPICS/

[20] The CERN Controls Board http://www.cern.ch/Controls/

[21] SCADA Technology Survey, http://itcowww.cern.ch/jcop/subprojects/TSurvey/

[22] What is SCADA?, Axel Daneels, ICALEPCS'99, October, 1999.

[23] Selecting and Evaluating SCADA Systems, Wayne Salter et al., ICALEPCS'99, October, 1999.

[24] SMI++, A Finite State Machine Tool Kit, Clara Gaspar, http://itcowww.cern.ch/jcop/projectteam/ minutes/smi_jcop/index.htm.