Outsourcing of the New Wave Form Acquisition, Surveillance and Diagnostic System for the LEP Injection Kickers

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Abstract

In 1996, a project has been launched to improve the acquisition, surveillance and diagnostic system of the LEP injection kickers. The technical solution is formed by a VXI acquisition hardware and a Windows NT / LabVIEW software environment. The realisation has been entirely outsourced to industry. This paper discusses the different phases of the project, from market survey over technical specification to acceptance tests, explains the technical choices and evaluates the results, presents the point of view of both parties on the collaboration and concludes with the experiences learned from this project.

1 Introduction

In 1996, a project has been set up to provide better acquisition, surveillance and diagnostics facilities for all SPS and LEP kickers at CERN, in the first instance for the LEP injection kickers [1]. This comprises tools to select, acquire, log, retrieve, and visualise signals from the beam pickup and the kicker magnets, to analyse them, and to compare them with stored reference pulses. These tools must be applicable either on request for on-line diagnostic and adjustment or run continuously in the background for automatic equipment surveillance.

The desired functionality has been specified and the realisation of the project subcontracted to the Spanish company CRISA. The system has meanwhile been delivered to CERN. Its integration into the real application and the evaluation with kicker magnet measurement signals are underway.

2 Technical Solution

One of the project goals was to use solely proven industry standards for hardware and software. In fact, no specific development was necessary to realise the project.

The hardware consists of a VXI acquisition system and the software is based on a LabVIEW [2] environment running either under Windows NT on the PC embedded in the VXI crate or under HP/UX on a remote workstation, using the Open Software Foundation (OSF) Remote Procedure Call in the Distributed Computing Environment (DCE).

Such hardware and software are already in use at CERN and fully integrated into the controls environment.

2.1 Hardware

The acquisition hardware is lodged in a Tektronix VX1410 IntelliFrame VXI crate and composed of an 'acquisition controller' as shown in Figure 1, consisting of an embedded VXI PC (National Instruments VXIpc-745, 486 processor at 100 MHz with 32 MB of memory) and one to four 'acquisition systems'. Each acquisition system consists of a Tektronix TVS641 4-channel waveform analyser with external trigger facility and a Tektronix TX4320 RF multiplexer allowing each acquisition channel to be selected among 4 sources and the trigger among 8 sources.

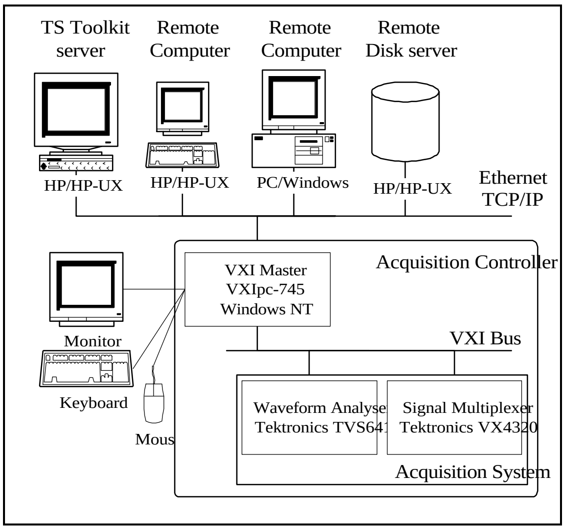

Figure 1: Hardware layout

2.2 Software

Figure 2 gives an overview of the software layout. The software, entirely developed using LabVIEW, is organized in a client/server scheme and is composed of three client applications: the acquisition, the analysis, and the presentation task.

The data exchange between the different applications is performed through a remote disk server in a HP workstation. All clients use a fixed data file format. HP-UX clients access data files through NFS and Windows 95 or Windows NT clients access them through the SAMBA software suite [3].

The acquisition and analysis tasks run in the acquisition controller. The presentation task can either be executed in the acquisition controller or in any remote computer connected to the accelerator control system, under HP-UX, Windows 95 or Windows NT, using iden-tical LabVIEW application code.

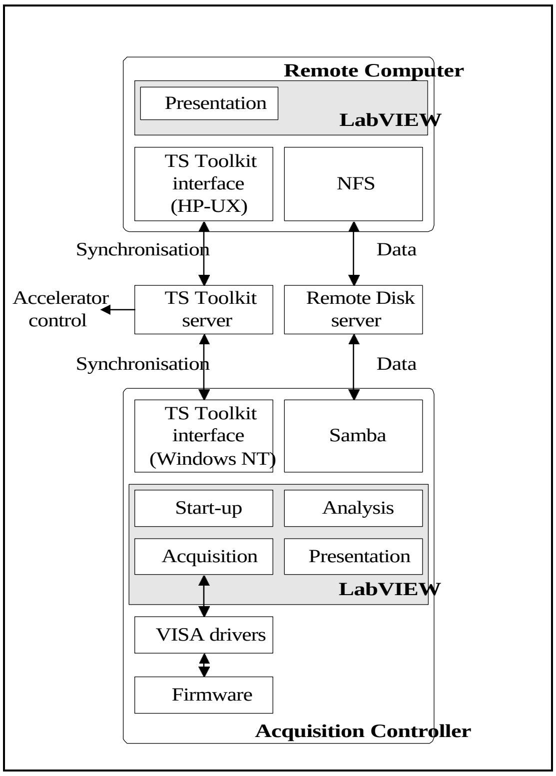

Figure 2: Software layout.

Inter-task synchronisation is performed through the TS Toolkit [4] which also implements the kicker control system and serves as interface to the higher levels of the accelerator control chain, e.g. for alarms. The interface to the TS Toolkit is formed either by a shared library (HP-UX environment) or through a dynamic link library (Windows environment).

The hardware is accessed via VISA drivers and is VXI*plug&play* compatible in the WIN framework.

2.3 Performance

Using one acquisition system with all four channels employed and all tasks (acquisition, analysis and presentation) running on the embedded VXI a sustained repetition rate of 0.2Hz has been achieved (sampling rate : 1Gs/s, vertical resolution : 8bits) which is well beyond the required rate.

3 Project organisation

The project life cycle has been divided into three main phases: the tendering, the development and the acceptance phase, as shown in Figure 3. At the beginning, each phase has been planned with fixed deadlines and a progress meeting at its end.

The tendering phase comprised the market survey, the specification and the call for tender. The development phase was divided into the detailed software requirements specification, the software production and the software integration. The acceptance phase included acceptance tests at the contractor's premises and at CERN.

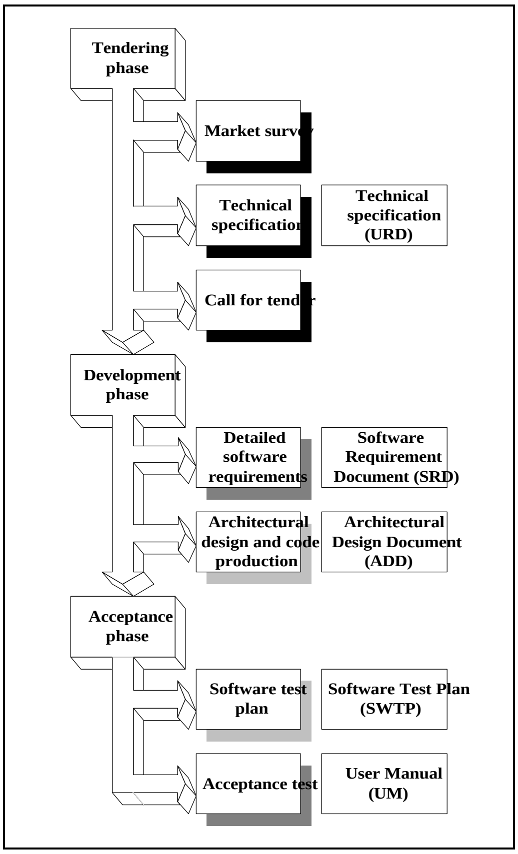

Figure 3: Project life cycle.

3.1 Tendering phase

At the beginning of the project, a market survey has been carried out in order to qualify a first set of companies able to realise the project. This phase has also been used to identify the industry standards in this kind of applications. 40 companies have been consulted resulting in 25 replies of which 15 were considered valid.

In the technical specification, care has been taken to describe the project in terms of the desired functionality rather than to specify detailed hardware and software requirements. The main reason for this approach was to stay as close as possible to industry standards and to reduce development costs.

The call for tender has finally been sent to 7 companies resulting in 6 valid quotations. The contract has been awarded to CRISA. The hardware has been directly purchased by CERN and sent to CRISA for system integration.

Even if the tendering phase took considerable time, (50 % of the total project), it contributed significantly to its success. The market survey, which was not mandatory, was really useful to pre-select the most competent companies for the call for tender, reducing cost and improving product quality.

3.2 Development phase

In the first part of this phase the project has been presented in detail to the contractor and the detailed software requirements were identified. As a result a Software Requirements Document (SRD) has been provided which permitted to link the various user requirements to measurable functions. The SRD also contained a traceability matrix between the technical specifications and the software requirements which was used at the end of the project to prove that all desired functions could be achieved.

The second part of the development phase consisted in the code production and in the software integration. In this phase, CERN has only been involved in review meetings.

3.3 Acceptance phase

Towards the end of the project the contractor has provided a Software Test Plan (SWTP). This contained a traceability matrix between the SRD, the technical specification and the different tests to be performed. All tests were carried out with an original hardware but simulated input signals at the contractor’s premises.

The hardware and software has been shipped to CERN. Its integration into the control system is underway.

It is noteworthy that the contract includes a two-year maintenance and the right to use as many copies of the software as needed which allows to use the software in other applications without extra development cost.

4 Viewpoints

4.1 Tenderer (CERN)

In this kind of collaboration the professional approach of the industry is a real advantage. Project management, planning, fixed deadlines and industry experience help to reach the scopes of the project and to obtain a ready to use product. The tenderer can concentrate on the functional aspect of the project as the management and the realisation become the responsibility of the contractor.

At the end of the collaboration a complete application is delivered and the required functional aspects are fully tested before acceptance and use in operation. The follow up of the project by the contractor and penalties for late delivery help to keep and reach the fixed deadlines.

The final product is completely documented. A User Manual (UM) and an Architectural Design Document (ADD) transmit the project know-how from the contractor to the tenderer.

This kind of approach is also more rigid. It becomes difficult to change or to add requirements once the detailed software requirements are agreed upon and the development has started.

Specifying this kind of software project is not too difficult when talking in terms of functionality. For this application, the specification of the acquisition and analysis processes is simple. On the other hand, the presentation application includes the man machine interface and it becomes really difficult not to specify its functionalities but the desired look-and-feel.

4.2 Contractor° (CRISA)

The usual activity of CRISA is hardware and software development and manufacturing for aerospace applications. CRISA designs and produces on-board computers, control equipment and DC/DC converters for satellites, and communications and test equipment for the ground segment.

The project described above has been the first one developed for CERN and the contract was awarded to CRISA in open competition. Our usual customers are the European Space Agency (ESA) and major European aerospace companies. Because of the new customer and application, the project has been a test of appliying our know-how outside the aerospace field.

Below we outline some of our initial concerns and how was later the reality of the development, and some lessons learned during the project:

- In order for the potential contractors to prepare the bidding it is mandatory for a software project to have a clear User Requirements Document (URD) made by the customer to start this phase. This has been the case in this project, and the document prepared by CERN has fulfilled the expectations.
- The project has been structured in a Software Requirements phase, followed by a design and coding phase for each of the software components. An Architectural Design Phase is necessary between these two stages. The software described above was made of 3 different software packages, but the coupling between them justified a common architectural design. We did it at the cost of a bigger effort in the early deliveries.
- CRISA is involved in aerospace field software projects where the Quality Assurance (QA) and project control standards are very demanding. The ESA Software Engineering Standard PSS-05 has proven its validity outside the aerospace field. The management uses of the aerospace industry have proven adequate for this project. This has been favoured by a highly technical customer with full understanding of the development process.
- LabVIEW has widely proven its suitability for command and control applications. However, when the software size and/or complexity start to grow, the problems of LabVIEW’s unsophisticated development environment arise. CRISA develops software mainly in Ada and C, and in both cases with the application of strict design and development rules (HOOD methodology, CASE tools and configuration control by CRISA’s Software QA). LabVIEW is used at CRISA because of its convenience (mainly for test equipment development), and a set of coding rules has been established for the use of LabVIEW in order to try to overcome these drawbacks.
- Meetings policy: the following meetings have been held along the project, all in the contractor’s premises: a Kick-Off meeting, a meeting at the end of the Software Requirements definition phase, and the Acceptance Review. 1-2 more meetings during the development and coding phase would have been useful.

- An engineering subcontractor like CRISA may be not fully aware of the complete system in CERN (the LEP Injection Kickers). A certain isolation is necessary between this complex high energy physics system and the waveform surveillance system software subject of the contract. This was CERN's responsibility and the performance was very good. CRISA saw only the aspects related to our software, while still a general perspective was provided by CERN that allowed us to understand the rational behind the decisions.

5 Conclusions

The present project was carried through in a pleasant and constructive atmosphere and successfully finished to specification within the predefined deadlines and cost frame.

Subcontracting an entire software project to industry is relatively straightforward if, like in the present case, the project and its boundaries are well defined and if the requirements can be fulfilled using industry standards. This reduces the duration and cost of the project.

Tenderers must be aware that outsourcing is not a means to save massively manpower, but to receive usually better tested and well documented products with a significant remaining in-house effort. The follow up of a project needs a continuous high attention and requires a permanent availability of the tenderer.

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