MAXIMIZING THE EFFICIENCY OF LHC MAINTENANCE DURING OPERATION TIMES USING A MOBILE TOOL

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Abstract

The operation of the Large Hadron Collider (LHC) imposes minimum maintenance time, when needed corrections to all systems are to be carried out. Today's maintenance management tools at CERN are seen as too slow and cumbersome for such a challenge. The short duration of the technical stops (72 h/month) requires preparation of jobs in advance, and coordination of all involved teams; at the same time, the radio-protection of personnel in the LHC underground areas imposes a strict "As Low As Reasonably Achievable"(ALARA) policy for the works' duration. In order to perform a maximum of tasks in a short time, a mobile tool for the manipulation of job and equipment data has been created. The ability to signal a new job to a team in the field will avoid unnecessary trips to the tunnel; the signalling of a job's completion (and its details) will allow subsequent jobs to start promptly and with more information; finally, the possibility to consult equipment's full manufacturing and installation data "in situ" will help with the investigation of unforeseen situations. In a 27 km environment with scarce Wi-Fi connectivity, an online light tool is now available, covering the essentials of asset maintenance tasks.

CHALLENGE

The maintenance of the LHC presents a series of challenges that make interventions complex and hard to coordinate. The different operations, trades and specialities of the work to be done, the interaction between different systems sharing a limited space, the very short time windows where all critical maintenance is to be performed, allied to the complex nature of the machine (where thousands of components are not accessible) make the required work a non trivial matter to plan, execute and document.

Even though a lot of the work to be done can and will be prepared beforehand, the experimental nature of a large part of the LHC's components require an access to equipment's data in the field, in order to access its technical properties, past maintenance history, manufacturing steps, assembly structure and so on.

Scheduling tools will provide the sequences of work to be done, where one job may only start when required previous ones are finished. Also, the radiation ALARA principle is to be observed as well as the limitation of the number of people that may be in a safety area at any given time.

In what concerns connectivity, the LHC's tunnel has serious restrictions in the sense that most areas do not have a wireless data network, but only a mobile telephone network, with General Packet Radio Service (GPRS) with limited bandwidth (40 Kbps). Finally, the system is to be operated in a rough environment, by people who are not used to computing desktop environments, and where the ease of data input is highly appreciated.

APPROACH

CERN's Maintenance Management System is Infor's EAM (Enterprise Asset Management); it is an off the shelf product, widely used for more than 20 years at CERN for the maintenance of the technical infrastructure. Infor EAM is also a building block of MTF (Manufacturing and Test Folder) [1], an in-house application used to collect and store manufacturing, test and commissioning data of the LHC's scientific equipment.

Practical tests showed that the off the shelf commercial package from Infor was unusable in CERN's environment. In fact, it downloads the whole database to the mobile device - which may be possible in very small installations, but unusable for a database as big as CERN's with over 1 million assets – making a full synchronisation of the mobile device take more than 8 hours.

Other commercially available packages to access Infor EAM also proved unsuitable, as they require both a huge bandwidth - which is not available when using GPRS - and high degree of customized development.

The adopted solution was to use standard and commercially available technologies from Infor as much as possible, and create an application that only serves as a graphical interface layer to the EAM system. The availability of a Web Services Toolkit from Infor made this solution possible, as it allows the separation between all technicalities dealing with the database and system functionality, which are Infor's core competence, and the presentation layer, which can be developed and maintained at CERN.

A serious handicap of the web services provided by Infor's Web Services Toolkit is their extreme verbosity, of particular concern in a GPRS network; in fact the time required for the execution of a simple operation made it unsuitable; the solution was to get away from the classic 3-tier architecture model (Database Server – Application Server - Mobile client) and create an extra tier – we have called it Mobile Middle Tier - between the Application server and the Mobile frontend. This extra tier not only reduces the time required to encapsulate and de-capsulate the relevant information, but by compressing the data sent, also implicitly makes the communication more reliable by shortening the period of time required to carry it.

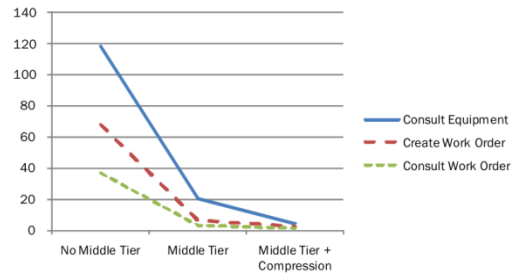

Figure 1: Reduction in the message size due to the middle tier and compression (in kB).

The advantage of the chosen architecture is even more evident by the fact that the computational effort required to process the business logic takes now place on the fast Mobile middle tier server.

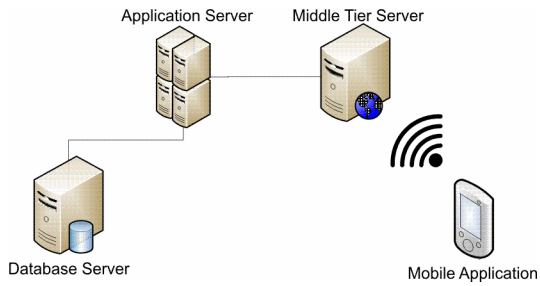

Figure 2: Architecture of the system.

The mobile platform chosen was Windows Mobile 6.1 which ships with a powerful collection of runtime libraries - Microsoft .NET Compact Framework 3.5.

As for the device, the choice was Psion Teklogix rugged PDA with barcode scanner, RFID reader, with GPRS and wireless connectivity, which provides enough choice of input methods and the required flexibility.

SYSTEM FUNCTIONALITY

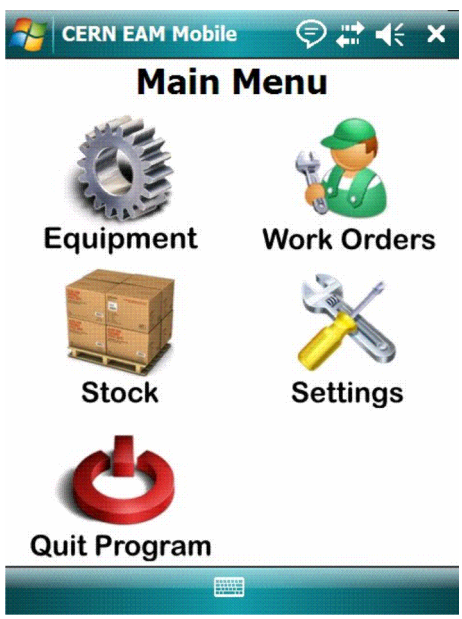

Figure 3: Main Menu screen.

The interface has been developed in order to allow it, as much as possible, to be operated with the fingers, e.g. using large icons and sparse menus. Data input has been reduced to the minimum, by allowing barcode scanning in all input fields and proposing relevant selections from pre-calculated lists, e.g. "My Work Orders". In order to present a certain amount of data on such a small screen, other techniques were implemented, like a tab scroll function that allows to change tab by simply swiping it with a finger.

Three sets of functionality have been implemented on a first phase. The first deals with Equipment, the second with Work Orders and the third with Stock.

Equipment

The ability to consult the existing data about any equipment online, through a search function was the first to be implemented. It fetches all relevant data, and displays it in a convenient, compact format. Data such as equipment's class, category, Maintenance Responsibility Centre (MRC), status, manufacturer, model, serial number, structure, etc is available for consultation and update. Also, a piece of equipment's technical characteristics may be consulted just by changing the active tab of the interface.

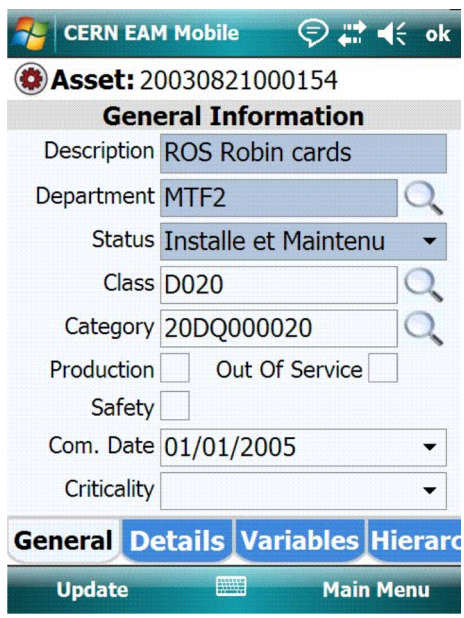

Figure 4: Equipment main screen.

Another tab shows all maintenance history about a piece of equipment, with dates, description, status, comments, etc. of any associated work orders, currently open or already completed.

As Infor EAM is the asset tracking system behind the LHC's MTF, all data collected during the manufacturing, installation and commissioning of the equipment is also available for consultation and displayed in a similar way.

As the mobile device allows the reception of SMS (Short Message Service) via the telephone mobile network, a team may be warned while in the field, of a

new work order to be done, and eventually actually accept it, consult its information, fill in the work done and any other relevant data and close it without wasting time. The gains in productivity are remarkable.

Work Orders

Relevant data about a Work Order may be consulted and modified via the proposed interface; it includes its status, the MRC in charge, the description of the work, its location, priority problem code, etc. as well as its scheduling data, user defined properties and the break-down in activities of the work to be done. The system also proposes an audited comments insertion mechanism as well as the consultation and booking of hours passed working on each of a work order's activity.

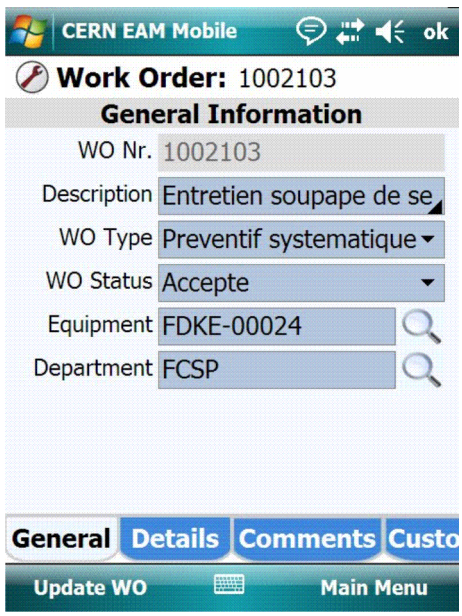

Figure 5: Work Order main screen.

The creation of Work Orders "on the fly" is also possible, as the execution of a work order may require and/or reveal unplanned work; once created, these work orders are equal to all others, and will follow the work flow defined for them.

Stock

Stock (and its associated Parts) management is also proposed as a set of functionality. In a first phase it allows the consultation of parts and current stock which in relation with the Work Orders functions, gives information on the stock situation and technical characteristics, manufacturers, etc of parts needed for a work order.

FUTURE DEVELOPMENTS

CERN's mobile solution will continue to evolve to fulfil new requirements and make the tool available to new areas of maintenance at CERN. In the near future, functionality to cover inspections done on equipment will be available, allowing the immediate collection of inspection data and automatic triggering of corrective work orders when inspected findings and values are outside the defined acceptable scope.

Another area where a mobile solution is required concerns meter readings; these operations are very repetitive in nature, with a huge effort dedicated to an operation with no great added value and prone to errors: the typing of hand written measured data into the system. The solution designed will allow the immediate capture of meter readings into the system, from the field, avoiding the manual transformation of paper notes to usable system data.

Store management, relating to stock transactions and inventories and the handling of pick tickets by the mobile solution is the third set of functionality foreseen for the near future.

CONCLUSIONS

CERN's mobile solution for Asset Management is a great step forward in maintenance management as it provides mobile and on-line access to CERN's asset management database, bringing efficiency to technicians in the field and streamlining the whole maintenance process.

The system provides the users with the means to enter and retrieve data, with efficient and adapted searching and browsing capabilities. It uses an "off the shelf" device which can be customized with barcode reading, physical keyboard, and other input facilitators. It can be used in remote places with scarce connectivity.

By using standard frameworks and toolkits from our software vendors, we have managed to very quickly provide a functional tool that will allow the maintenance of the LHC to be carried in a more efficient and fast way in the very short time windows available.

REFERENCES

[1] S. Mallón Amérigo, P. Martel, S. Petit, D. Widegren "CERN's Global Equipment Data Repository", ICALEPS'09, Kobe, October 2009, TUB004; http://www.JACoW.org.