DevLore – A Firmware Library and Web-Based Configuration Control Tool for Accelerator Systems Under Constant Development

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ABSTRACT

The Free Electron Laser Project at Jefferson Lab is based on a comparatively small accelerator driver. As it's systems continues to grow and evolve, strict configuration control has not been a programmatic goal. Conversely, as the IR-Demo FEL and the 10kW IR FEL have been built and operated, hardware and software changes have been regular part of the machine development process. With relatively small component counts for sub-systems, changes occur without requiring much formal documentation and in-situ alterations are common-place in the name of supporting operations. This paper presents an overview of the web-based software tool called DevLore which was first developed to be a library for embedded programming and then became a tremendously effective tool for tracking all changes made to the machine hardware and software. This tool is maturing into an easy-to-access, common point-of access for the status of all of the installed system components, technical drawings, embedded firmware, procedures, operations notes, maintenance history, inventory tracking and computer-files associated with the FEL Project.

MOTIVATIONS

The need for a Programmable Device Code Revision Archive

Over the past ten years of installing, commissioning and operating various accelerator systems[1] at the Jefferson Lab FEL User Facility[2] and observing the common practices of the industrial controls community in general it was realized that, with regard to programmable devices (PLDs, PLCs, DSPs, etc…) although they have been used heavily in designs, they have not been included in the standard system of technical documentation that is required for every aspect of component and top-level system design. The most common practice is that the embedded programmer is usually found managing the embedded software project on their own. This is primarily due to the large variety of individually licensed embedded programming platforms and device types. But regardless, many systems have become critically dependant on those personnel who have been preserving (often times on their own) local copies of the device code that has been implemented in the system. As the capabilities of these devices continue to grow and the idea of "system-on-a-chip" becomes truer to its name, it is becoming increasingly easier for the field engineer to radically change the way a system performs without requiring a formal Engineering Change Order (ECO) or document revision change. As a result, It has become quite common lately to troubleshoot a system signal to where it enters a programmable system device, only to find that there is no available information about what process is generating or receiving it. There are two critical issues that must be addressed by every designer and system owner. The first issue is "what to do about all of the legacy device code that is currently in operation" and the second issue is "What can be done to solve the problem for our future designs". The "Devlore" system was created as an exact solution to this problem.

The need for a highly accessible Technical Documentation and related digital media

Although the need for an embedded code archive was the driving reason for developing a solution, it was also noted that access to the existing drawings and technical documentation was not straight-forward. It was found that the hard-copies of drawings kept on-hand could not be updated quick enough to be considered a definitive document. In real-terms, it is the collection of fragmented files and notes kept by the owner of the equipment that contained the most relevant information for trouble-shooting. It seemed to be a natural extension of a firmware archive to also provide a commonly accessible place to store the source files of any hard-copy text as well as any other files and photographs that are not adequate to be included in the formal documentation but are tremendously valuable to a field engineer or technician.

In coming to the decision to produce an online tool that would provide a firmware library for programmable device project files and also provide easy access to any other form of digital media associated with a given project, we decided that the interface needed to be designed with the field engineer/technician in mind as the primary user. This meant that the method of searching the archive would lend itself better to someone who knew the lay-out of the machine and its respective system rather than requiring a strict knowledge of drawing number or system identification code, etc.. The tool would allow searches to be done in the context of the region of the machine being considered. In order to accomplish this type of user interface, a listing of all of the systems, sub-systems and defined machine locations would need to be a integral part of the interface.

The Need for a User Editable List of Sensitive Machine Components

Beginning to develop the ideas expressed above was a process that occurred in the background, while the task of installing and commissioning the 10kW IR Free Electron Laser upgrade was the standard priority. In doing so, the FEL team routinely found themselves relying on the electronic logbooks and shift logs to keep track of any machine components that were placed in a "non-standard" and/or "less-than ideal" configuration. This is usually done in the interest of maintaining machine operations and it became know as "buggering" an item. We saw very quickly that there were too many of these "buggered" items to keep a working knowledge of them apart from a formal listing. After time, we saw that although a primitive "chalk-board" approach was good in that, it was easy to edit and was definitive it its purpose, however, it lacked any ability for someone to track the context or history of the "bugger" and the reasons for it. At the time when the earliest version of the firmware archive was made available, the list of buggered FEL components was added to database which served to track of the firmware projects in the library. In addition to adding the buggered items, a status field was added to the database table which then made it possible to search the firmware library for "buggered" projects and became our formal online list with the additional advantage that any authorized user could change the status of the item and/or update the information in the database. And with each change in status, the database was set-up to auto-log the changes.

From this point forward, it was clear what the online-archiving tool should do. I would host an interactive list of every namable aspect of the entire FEL project. Each item in the list would be categorized by type (hardware, software, document, etc…) and provide access to a common disk space which would serve as the library for all digital media associated with every level of system design as well as a respective physical location in the FEL facility. Furthermore, the list would be easily accessible and highly editable. It would also provide a statement of "item status" and keep track of the dates of any changes made to its content. This tool would serve as a "Configuration Control Database" which showed no preference for physical components versus technical documentation or data files (i.e. embedded systems project files).

SUMMARY OF THE UTILITY OF THE "DEVLORE WEB-INTERFACE"

There are three basic organizational tools that are used regularly by all Jefferson Lab FEL staff. They are: 1) the electronic log-book system, 2) the Computer Center's networked disk space and 3) some form of "List-making" tool which is usually just a spreadsheet, database or text document. The present Devlore system is a web-site which provides a union of these three common user resources which is tailor-made for the FEL Project with it's specified systems, locations, device types and documentation. It accomplishes this by making heavy use of server-side scripting which automates all of the log-making, network disc accesses and list updating based on how the user interacts with its page content. This effectively provides the FEL team and community with a single site for all aspects of machine documentation and is especially useful for generating "real-time" lists of items which can be queried and sorted in any combination. Named lists include: "Group Tasks" lists, "Maintenance lists", "Prioritized beam operations" list, "Recent Activities" listings and of course the "Bugger" list.

Together these online lists and archiving resources offer the FEL team a documentation web-site that is optimized for daily use as well as long term project archiving. It provides an alternative method of accessing group disk resources by acting as a web-based portal to network folders as opposed to having to manually navigate a tree-based file structure. Devlore also provides off-site access to the FEL logbooks and uses the server's SMTP mail service to send out alerts to the appropriate personnel.

THE DEVLORE DATABASE STRUCTURE

The "Named Items" table in the Devlore Database

   The core of the Devlore database is an ever-growing table which provides a set of fields which define each item. The purpose of the fields can be broken into two major sections:

Section 1: The Item's DETAILS

Table Column	Description	Example
ID	A unique, auto-numbered long integer	775
Item Name	A preferably short (<50 char), user-defined string which describes the item in the terms that are usually referred to in normal conversation.	CCA1F03
Item Type	1 of 8 pre-determined strings that define the nature of the item. 'BL' - A "*Beam-Line*" object (anything with beam transport nomenclature) 'HW' - "*Hardware*" (any physical device which is used in the process of operating the FEL) 'SW' - "*Software*" (Firmware, EPICS screens and anything else that required programming) 'Dwg' - A "*Technical Drawing*" (CAD, etc…) 'Prj' - "*Project or Task*" (anything the represents a action that must occur on numerous items) 'Cbl' - A "*Cable or interconnect*" (self-explanatory) 'Doc' - "*Documents or Procedures*" (not drawings) 'Stk' - "*Stock*" (i.e. Op-Amps, resistors, etc…)	BL
Item Description	A 'memo' field that allows the user to go into any amount of detail to further describe the item.	Zone 3 Cryomodule
Default_Image	A user defined string which is the *filename.ext* of an image which will be used as the default file for the item. (note that it does not need to be an image file type)	cca1f03.jpg
System_Code	1 of 'N' pre-defined strings that defines the system that the item belongs to.	6.0
Region_Code_1	A primary 1 of 'M' pre-defined location prefixes and a text suffix which is completely user definable. (Prefixes include, but are not limited to: '0F' - The FELs Injector beam region prefix '1F' - The FELs LINAC beam region prefix '4F' - The FELs Wiggler beam region prefix 'FL06'- The FEL's Drive Laser Clean room 'FL07'- The FEL's operations Control room 'REF' – A General Reference section	1F03
Region_Code_2	A secondary 1 of 'M' region code for the item created specifically to allow items of type "Cbl" to have two end locations but also used when convenient.	FL03
Item_Owner	1 of 'X' authenticated usernames which is to be considered the owner of the item and is the primary person to be contacted as necessary.	richard

   Together, these fields provide a complete set of parameters which define "what the item is" that is being represented by the database record.

The next section defines the current "Status" of the item and any "Flags" that may apply to it.

Section2: The Item's STATUS

Table Column	Description	Example
Status_Code	1 of 7 pre-determined strings that define the status of the item. 'OK' - Items with no operational issues 'P1' - CRITICAL ISSUES - No BEAM until fixed! 'P2' - Issues that MUST be resolved soon 'P3' - Issues that SHOULD be resolved soon 'P4' - Low Priority Issues - as time permits 'X' - item status is not relevant at this time '?' - Item status is not specified	P1
Status_Notes	A 'memo' field that allows the user to go into any amount of detail to further describe the item's status.	The IR detectors are being removed by L. King to install them on the new cryomodule that is undergoing testing by SRF. The IR detectors will be re-installed with the new cryomodule
Date_Updated	An timestamp that is automatically updated as the information in the record set changes.	8/30/2005 5:50:05 PM
Point_of_Contact	1 of 'X authenticated usernames which is to be considered the point-of-contact for the item in regards to any current work to be done.	richard
Flag_Buggered	TRUE - Indicates that the items has been buggered FALSE – Indicates that the item is in it's normal configuration (even though it's status is independent of this field)	TRUE
Flag_Safed	TRUE - Indicates that the item has been "safed-out" form a system operations point of view. This is usually a situation where a question would be raised whether or not another action would impact the system adversely. FALSE – Indicated that the item is not in a mode that would allow its function to be ignored.	FALSE

WEB BASED INTERFACE

The entire Devlore system is built around a common desktop PC running Microsoft Windows Server 2003. We are using the standard Internet Information Services (IIS) server to host a web-site that can be accessed via the world-wide web at: "http://laser.jlab.org". By providing the Devlore server with a specific Jlab user-account that has the same network site permissions as anyone in the FEL users group, the system is then able to access the UNIX-based disk space over the network. These folders have been mapped to the server as "virtual directories" and are used for archiving all the files added to Devlore. The server makes heavy use of server-side scripting in the ASP programming language. ASP is an "Active Server Page" language created especially for this type of purpose. Empowered by the ASP programming tools, the Devlore system is considered a "web-application" that can have the same capabilities of a client-installed software package, but has the added benefit of running off of a server and uses the clients web-browser as the user-interface. This provides users the ability to access the system from any platform with no advantage of being at one machine or another.

Figure 1 (below) is a section of a screen shot taken from the Devlore database overview page. From this page, a user is presented with an summary of the status of items in the database. A user can refine the numbers of items found in the summary by clicking on the System (WBS) code of interest or by clicking on the Location Code of interest as seen on the map of the 10kW FEL machine layout image.
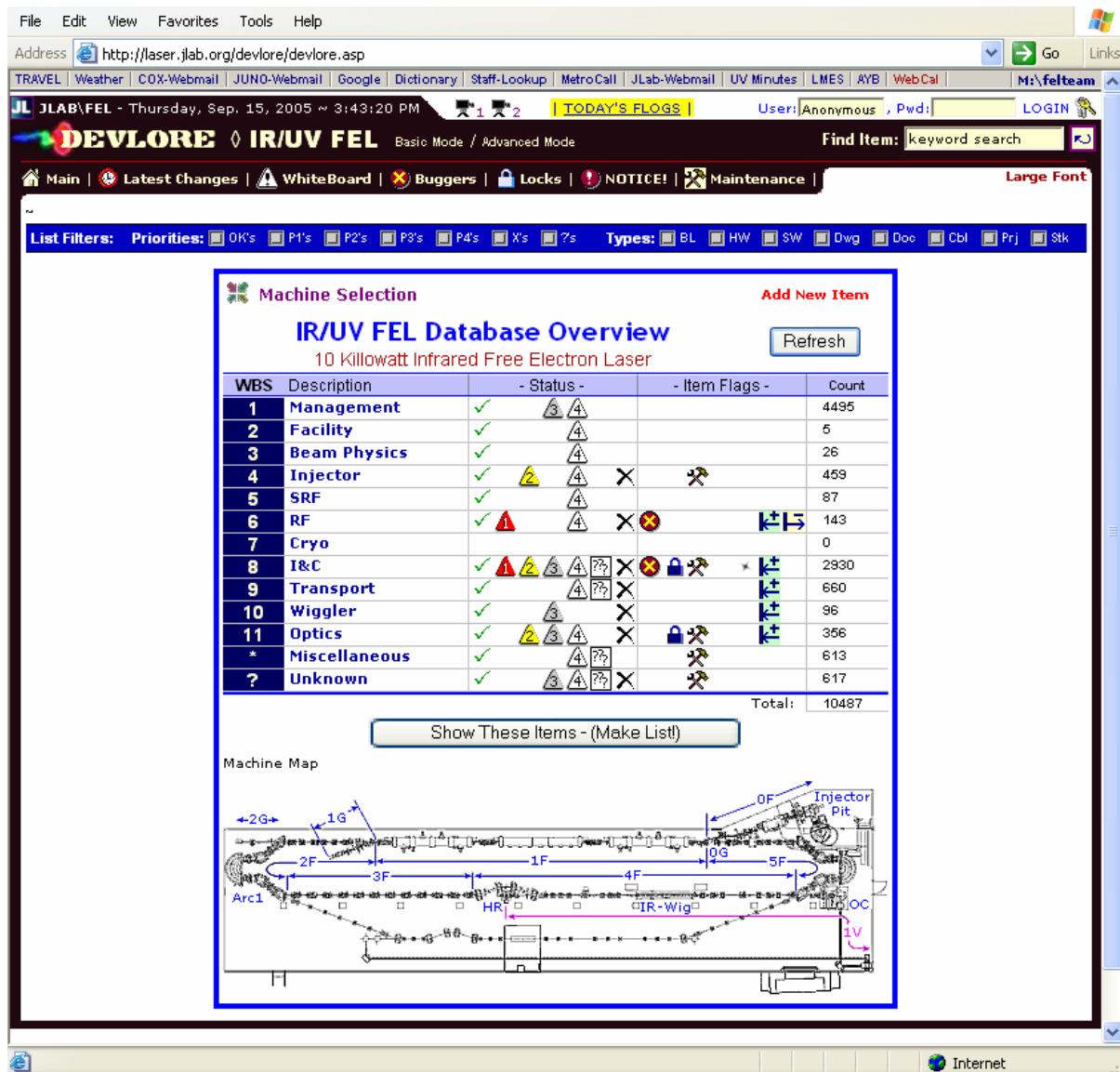

Figure 1: A screen shot of the Devlore Database Overview Page

The following features are typical of every page generated by the server and can be seen in Figure 1: The user login with username and password, the "keyword search" text box for general searches and the checkboxes which tell the system what type and status values the user wishes to se listed. In addition to the 'custom' searches that can be performed, the system is designed to make certain 'common lists' available with single-click menu options. These are seen across the top of the page content window and are: "Main" (see figure 1), "Latest Changes", "Whiteboard", "Buggers", etc…

Figure 2 (see next page) shows a Devlore screen shot that is typical of the lists returned by any query made to the database whether from a general "keyword search", an "expert query" or one of the 1-Click List buttons. Each item returned in the list has the following information presented for it (but only shown if the user chooses): The Item's details, namely: "ID", "name", "description", "location", "system", "owner", etc.. Also shown as requested is the item's current status information, namely: "Status Code", "Status Notes", "Point of Contact", the "date of the last log entry" (which includes a link to view all of the logs which pertain to that item only). An online version of the network folder which is dedicated for each item is always available as indicated by the small network folder icon.

Figure 2: A Devlore screenshot from an "expert search page" searching for the keyword "firmware"

CONCLUSIONS AND FUTURE CONSIDERATIONS

There are additional aspects of this system that have not been discussed in this paper such as: Inventory control, requirement documents and System/Location Logbooks and control system performance data logging. Interested readers are invited to visit the Devlore web-site which is actively running for the Jefferson Lab Free Electron Laser Facility by using the following web address: http://laser.jlab.org/devlore. Like any software project, Devlore has some features which need improvement and others which work well. Currently, the limitations are based on two areas, 1) browser compatibility issues and 2) the sometimes confusion array of options available to the user. Browser compatibility issues will be worked over time. With regards to the learning curve, not too much can be done without sacrificing search power. The devlore system was designed with a database in mind and the web-interface is geared towards users who are database savvy. Nonetheless, a site upgrade is in progress and is intended to be more intuitive for the non-database users.

REFERENCES

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