

BACKGROUND INFORMATION

Lexmark International has offices throughout North and South America, Asia, Africa and Europe. The company has more than 13,000 employees worldwide in over 150 countries (2007). The corporate headquarters for research and development are located in Lexington, KY where the company began as a spin off IBM in 1991. Lexmark is a Fortune 500 company which develops, manufactures and supplies laser and inkjet printers, multifunction products, and associated supplies and services for business and individual consumers.

Lexmark's Printing Solutions and Services Division (PS&SD) works closely with businesses and institutional customers, both small and large, to help them address their paper, document and workflow-related challenges. Department C29L is responsible for PDL and DLE firmware and is a sub-department of C44M which comprises all of Lexmark's embedded systems development.

The PDL and DLE firmware department is primarily responsible for designing emulators within the firmware which emulate different hardware architectures and allow for various printer settings. Some of these include PJJ and PCL, which are page description languages the printer uses for device settings. Some of these device settings include media types, print options, and input bins. There are a variety of others included in Lexmark's competitive business and consumer printers.

Co-op students within Lexmark's C29L department work as software engineering students among the department's full time software engineers and software contractors.

MAJOR RESPONSIBILITIES AND DUTIES

The second co-op experience at Lexmark built on many of the skills and knowledge acquired from the first co-op. Familiarity with Lexmark's work environment and software tools helped the co-op assist other software engineers with problem tracking and development of debugging tools for some of the major subsystems of the embedded firmware architecture. The co-op assisted by writing unit tests in various Linux scripting languages, writing a test harness for embedded firmware used in diagnosing field issues, enhancing previous internal tools, and designing and implementing new internal tools.

The first major responsibility of the co-op was developing a debug harness for capturing data passed to the printer's emulation manager. The emulation manager is responsible for emulator management, environment and resource management, scheduling emulator jobs, and data port management. The harness provided data given to the emulation manager before it was filtered by other subsystems in the firmware architecture. The development required writing system messages to allow the capture of data, adding a system interrupt for dumping the captured data, and writing CGI to display a web interface which automated the tool's use. The interface was added to the service engineers' utility library.

The next task required testing and diagnosis of customer problems affected by the emulation manager and one of the system emulators. The particular problem dealt with smart switching to a Korean emulation while a PCL or PostScript emulation was selected. These sorts of problems are commonly handled using data sniffing routines called by the emulation manager. The data sniffing routine labels a job and the emulation manager starts the appropriate emulator. Methods of diagnosing these system events were learned

using GDB and other C/C++ debuggers. Learning how to analyze code logic, diagnose system threads, and in some cases use simulations when the hardware was not available were part of the training. Much of the time spent this co-op involved tracking problems in the emulation manager and learning more about its design from another developer.

Another task required writing additional options to internal commands used for sending print jobs over the network. The options added the ability to specify the size of the buffer and time period before sending the packet of data to the printer. The co-op was introduced to socket programming used by the TCP protocol and taught how to use port structures for listening and accepting data.

The last major responsibility was development of two internal PHP/MySQL tools. The first tool allows workers to plan the review of a specification or coding solution, schedule and record meetings, and resolve issues. Minor enhancements were made to allow the user to query metric reports and enter email preferences. In the second project, the co-op enhanced an open source PHP/MySQL web tool and met requirements made by multiple departments within the embedded systems development team. The process involved designing, implementing, documenting, and presenting a new tool to be used by upper management for project organization. Development required enhancing the tool's PHP modules and creating new database tables for additional storage. A presentation on tool usability was given to management and documented on the internal wiki.

Aside from the projects, the student was also involved with daily tasks that included compiling and testing release code, and troubleshooting or maintaining printer hardware. A wealth of information on the firmware development process and tools was provided in daily mailing lists and on internal wikis. This was technical reading material

discussing implementation guidelines, proper firmware building techniques, programming interfaces, and the status of build servers and workstations. There was also guidance provided in weekly department meetings with the discussion of future products and designs. A very knowledgeable and resourceful workplace was established which stressed teamwork, communication, and understanding by all team members. Lexmark is a highly innovative and progressive community.

EMPLOYER BENEFITS

The functions of the student position achieve many goals for the business. Firstly, the student allows for greater productivity and efficiency of full time software engineers. When an engineer can put forth maximum effort on the design and implementation of software, goals are reached at a faster pace. The minor tasks of hardware maintenance, software maintenance, testing, and some documentation can be performed by the student saving the company resources, time, and effort.

At the same time, the company hopes to promote knowledge and experience, networking skills, teamwork, and leadership in a certain area. This will also save the company resources, time, and effort by not having to train a new hire if the student chooses to become a full time engineer after a co-op or internship. The student gives the business an opportunity to evaluate candidates for future positions which prove they can handle deadlines, be responsible in attending meetings, and work well with a team. These are all important goals of any department offering internships within the corporation.

To approximate total income for a full time entry level intern, one would find around \$2000/month in pay to be reasonable and around \$500/month in accommodation gratuity for traveling students. The company also provides paid lunch and social events at certain times to celebrate important events. The corporation would expect a student's full cooperation in working 40 hours/week and subtracting time spent on breaks and lunches. These are all small expenses to be paid for by the company and individual. The possibility of finding a salaried employee who would take on major leadership roles within the company is more important.

STUDENT BENEFITS

From an educational perspective, this co-op experience provided all the necessary tools and the environment to become a successful software engineer. The job enhanced programming skills learned in early CECS curriculum, and inspired learning of new tools and languages currently used in software development. This includes working in a Linux environment and using languages which provide an object oriented approach to solving problems. The job also enhanced problem solving skills learned in mathematics and other sciences when technical challenges were brought forth. A specific example would be adding the amount of bytes in a Unicode string or converting microseconds to milliseconds.

The co-op has not affected my current course curriculum as of one semester; however it will certainly affect my course selections in the coming years. To become a successful software engineer in a corporation such as Lexmark, one must have a strong foundation and working knowledge in computer operating systems, programming logic and design, computer algorithms, and informational structures. A specific suggestion of the employer was to develop design skills and specifically embedded software design with memory and size constraints.

In terms of career development, the experience promoted interactive learning, helpful sources of information and reading material, and an understanding of the software industry. There are many aspects of software design which may not seem particularly obvious, such as daily updating source code before you begin to make changes. Engineers must strive to communicate their ideas and goals with one another, as well as with their teams.