RTOS Platform Preserves Proven IP and Enables New Features

The Project: Preserve prior IP investments in long-lifecycle applications while also enabling new features to be introduced without compatibility issues.

The Solution: Use a hybrid Windows plus real-time operating system (RTOS) platform to ease compliance concerns and maintain development schedules.

By Paul Fischer and Richard N. Carver

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The Abbott Prism system

The need to preserve prior investments in real-time software code is a defining factor influencing decisions made in embedded system design. This is particularly important for long-lifecycle applications where stringent agency certification or approval is required. The risks involved in recoding proven real-time software can be huge. Besides the significant cost of agency recertification, subtle incompatibilities can erode customer confidence and destroy chances of meeting market windows. Many embedded system developers need to maintain compatibility at all costs, even while adding competitive new features to their products.One example is the design of the latest high-volume blood-screening analyzer from Abbott Diagnostics, a division of Abbott Laboratories. The Abbott Prism system is targeted at blood donation centers, such as those maintained by the Red Cross, where large volumes of blood samples are tested on a daily basis. The American Association of Blood Banks states that approximately eight million volunteers donate about 15 million units of whole blood every year; confidence in test results is of utmost importance.

Before a blood donation enters the blood supply, it must be tested for evidence of exposure to viruses that might cause disease, such as hepatitis, HIV, and other retroviruses. The typical screening process involves making several assays on each blood sample. The Abbott Prism consolidates and automates this testing into a single instrument, reducing the errors associated with manual handling of samples and improving efficiency and throughput of the process. According to Abbott, their Prism systems screen donated blood in over 30 countries, processing more than 40% of the global blood supply.

Evolving While Maintaining Compatibility

The Abbott Prism system, so named because it uses an optical assaying technique, is the latest in a series of products that represent 20 years of development by Abbott Labs. While Abbott's newer instruments provide functionality similar to that of their predecessors, the underlying technologies used to build these systems continues to evolve over time. With each new design, Abbott has made a concerted effort to minimize changes to critical function areas, decreasing the time required to certify a new generation of the instrument and maintaining a high degree of confidence in the performance of the Prism product family.In a Prism instrument, every blood sample can go through up to six screening tests at the same time. According to standard protocol, when a sample reacts positively to a test (indicating that it may be carrying a harmful virus), it must be re-tested two more times. If two of three results for a sample are reactive, the test is considered to be positive. The complete testing process for each sample takes approximately one hour, from start to finish. In order to meet throughput goals, a large number of samples are processed and tracked simultaneously.

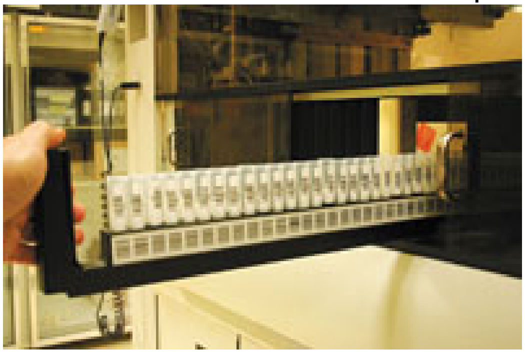
Centrifuged blood samples are placed into racks of 28-tubes each. As a rack is loaded into the analyzer, barcodes are read from the tubes so that the system can track each sample. Up to ten racks of samples can be loaded into the analyzer at one time.

Samples are drawn from each tube and dispensed into reaction trays using disposable pipettes manipulated via an XYZ positioning system. Pressure sensors measure sample aspiration and aid in the identification of clots and bubbles in the blood. Pressure monitoring is also used to detect problem events, such as a pipette hitting the bottom of a test tube.

After completing dispensing from a rack of tubes, the rack may be removed from the analyzer and a new rack of tubes can be loaded to provide continuous processing for up to 24 hours. Samples that are initially reactive may be reloaded at any time, and since the system will recognize that the sample was initially reactive, it can automatically schedule the sample to be tested two more times to determine if the sample is confirmed reactive or non-reactive for any given test. Retesting only dispenses samples to those tests requiring retesting, and not for tests that were initially non-reactive.

As reaction trays move from station to station within the analyzer, reagents are added and the samples are heated to assist the reactions. When sample reactions have completed, a chemical "trigger" reagent is injected, causing each sample to

luminesce. The “flash” of light given off by this “chemiluminescence” reaction is measured and quantified by the Prism blood analyzer, forming the basis of the test result.
“There is a lot going on in the system at any given moment, and the need to maintain the integrity of each sample test is critical,” says Richard N. Carver, a principle software engineer for the Abbott Diagnostics Division. “Our real-time software needs to manage hundreds of tasks reliably. There are tasks responsible for controlling each station of each channel, the barcode scanner, the sample manager XY-table, the sample manager pipetting assembly, sample scheduling, report generation, report printing, updating the results database, host processor communication, information display, resource/reagent monitoring, heater control, event logging, cycle coordination, and quite a few more,” notes Carver. “When we developed the newest Prism, we needed to make sure that we didn’t change the fundamental elements of the process.”



Loading sample racks into the Abbott Prism system

Abbott’s RTOS Evolves

The core control mechanism in the Prism instrument is an Intel Architecture PC running TenAsys Corporation’s iRMX for Windows [which incorporates an iRMX API placed atop the INtime RTOS (real time operating system) for Windows.] The control PC connects to multiple microcontroller-based controllers within the unit via a BITBUS interface (BITBUS is a serial master/slave communications interface that transfers data at 375 kbps.) The instrument supports up to six testing channels with each channel handling the processing for a given test. The control PC sets up each channel as a separate job, or real-time application, to be managed by the TenAsys RTOS. An RTOS is needed to ensure that all instrument channels remain synchronized throughout the process, and in order to maintain reliable operation. Reliability and accurate timing are essential for maintaining system throughput.The Prism system was originally based on the iRMX286 operating system running on Intel Multibus hardware. In the 1980s, Abbott selected the Intel RTOS to control the system because of its proven reliability on Intel processor-based platforms. Their choice to migrate the latest Prism blood analyzer to a TenAsys RTOS platform was driven, in part, to move the application from an RTOS-only platform to a hybrid Windows plus RTOS platform. The choice to use iRMX for Windows simplified that transition, allowing Abbott to port their proven software with minimal changes. The TenAsys RTOS platform provided Abbott with a means to reuse proven intellectual property, in the form of existing real-time software, ensuring compatibility between product generations. This approach was critical to maintaining development schedules and for simplifying compliance with the US FDA's strict product certification rules.

Adding Windows Enables New Features

The TenAsys INtime RTOS provides real-time OS functions that run alongside Microsoft Windows. In Abbott's older machines, iRMX hosted the operator interface as well as all control tasks; now machine control functions are handled by real-time tasks running on the INtime RTOS, freeing Abbott to incorporate new and updated operator interface features on the Windows XP operating system.Moving to the new platform also gives Abbott access to more cost-effective hardware platforms and up-to-date interfaces for communication and I/O, such as USB. Additional advantages include the ability to incorporate new communication protocols for interaction with external systems and to adapt more sophisticated data reporting methods.
"By migrating the system processor to the latest PC hardware and software technology, we saved costs and obtained access to the latest industry-standard hardware resources," said Carver. "Embedding a PC in the analyzer has given us the additional benefit of being able to run our development software environment directly on the target hardware, saving development time and effort compared to using separate development workstations."
The Abbott Prism enhances its usability through the use of the Windows user interface while continuing to use TenAsys real-time software for their critical control and sequencing functions, thereby maximizing the leverage of their proven real-time intellectual property.

Conclusion

The ability to preserve previous investments in IP, while also ensuring that compliance does not become too great an issue, are two significant factors in Abbott's decision to adopt the new RTOS system for its Prism system. Further, with the additional benefit of being able to introduce new features to the system without fear of compatibility issues made Abbott's selection a much easier one. They invested in a system that would allow the technology to continue to grow and develop without significant fear of adverse effects.
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