OPEN-SOURCE SOFTWARE FOR SAMPLE INVENTORY CONTROL

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INTRODUCTION

The Canadian BioSample Repository (CBSR) has processed and stored biospecimens since 2000. In 2008, CBSR began developing a comprehensive client-server Java application, named Biobank, to be used by nurses, lab technicians, researchers, and lab administrators. Biobank allows multiple users, operating at different computers and different locations, to simultaneously process and log thousands of specimens daily. Nurses can enter specimens into the system, technicians can process and transfer specimens, researchers can request specimens and view inventory information, and administrators can create comprehensive queries and manage users. Biobank is open source and free software, modelled on caTissue from the National Cancer Institute.

Biobank is part of a larger effort by the CBSR to create a network for research collaboration, to facilitate standardization, and to provide help with lab setup, configuration, and training. The system is flexible and can be adapted for almost any storage application, whether it uses handwritten labels, barcodes, test tubes, cryovials, or glass slides to label and store specimens.

Currently, CBSR uses Biobank to manage upwards of 480,000 biospecimens and 14,000 patients across 27 studies in dozens of clinics and processing centers around the world (Canada, the United States, and Europe).

METHODS

A team at the Alberta Innovates Centre for Machine Learning (AICML), in Canada, has programmed Biobank using an iterative design methodology with feedback from lab technicians at CBSR. Biospecimens are assigned standards compliant machine-readable barcodes to minimize human errors and improve efficiency. Lab technicians use a downloadable Microsoft Windows thick-client that works with various flatbed scanners and handheld scanners to identify specimen tube barcodes.

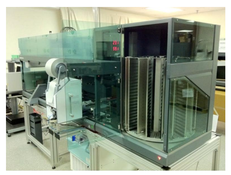

Figure 1: TECAN EVO Freedom robot used for automated sample processing

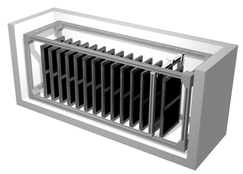

Figure 2: Automated Freezer

Figure 3: NUNC cryovial style freezer hotel

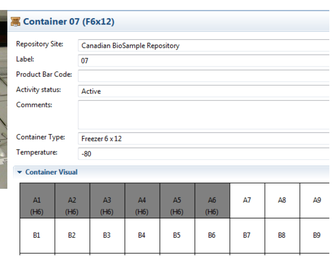

Figure 4: A -80˚C freezer organized with hotels (6 x12 array)

RESULTS

COLLECTION

Clinicians and their staff collect patient biospecimens based on a collection protocol, enter patient consent information into our client, then ship the biospecimens to one of our repository sites. Biobank includes software to print customizable templates with unique 2D and 1D barcode labels, which are scanned for efficient and error-minimized specimen identification. Manifest information is maintained in the software which allows lab technicians at the receiving site to easily track shipments.

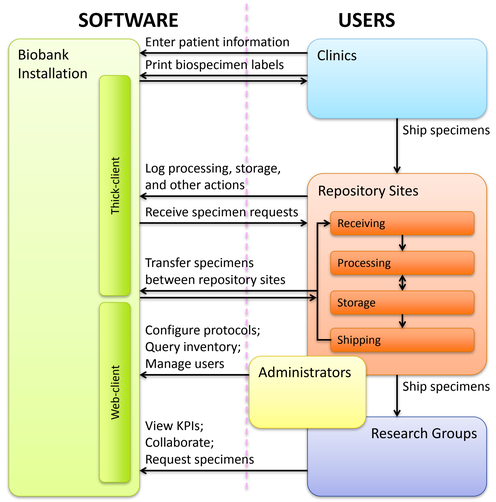

Figure 5: Overview of Biobank's involvement in biospecimen management

PROCESSING & STORAGE

Lab technicians process and aliquot the specimens based on a collection protocol. Most liquid biospecimens are stored in NUNC 2D barcoded cryovials. The technicians can efficiently scan multiple tubes at a time, in a rack, on a low-cost commercially available flatbed scanner. Lab technicians use the inventory tracking software to link a specimen's inventory ID to a patient and a storage container position.

CBSR is currently working on an automated freezer to handle specimen storage and retrieval at low temperatures. Freezer automation allows CBSR to minimize specimen temperature deviations. Work is also underway to integrate Biobank with TECAN EVO Freedom robots to automate specimen processing to increase throughput.

RESEARCH & COLLABORATION

A web client, currently under development, will provide researchers, collaborators, and lab administrators with analytic tools to examine Biobank's inventory information. Key Performance Indicators (KPIs) will display metrics, such as, study progress and processing throughput.

Grid data services will allow inventory data to be shared between installations and for interfacing with existing infrastructures, such as, caGrid.

ADMINISTRATION

Site and study administrators can control a user's permission to view or submit individual forms and can restrict those permissions to specific sites and/or studies. Roles and groups provide larger grained control. A role defines a set of permissions characteristic to a particular job, such as, an Administrator, a Study Manager, or a Lab Technician Level Senior or Junior. A group defines a set of permissions or roles for a specific site and/or study.

Storage container configuration is very flexible in Biobank. Any container hierarchy can be represented and containers can be configured to hold only a specific set of specimen types.

Advanced reports provide an intuitive graphic user interface for building complex, filtered queries and aggregations on the database, including only the information the executing user is authorized to see.

Extensive chain of custody information is maintained. Biospecimen collections, transfers, processing, property modifications, and other event data are recorded and searchable. User actions are also audited, logged, and easily queried for regulatory purposes.

SECURITY

All communications between the client and server utilize encryption via SSL. All user access is authenticated using caBIG's Common Security Module.

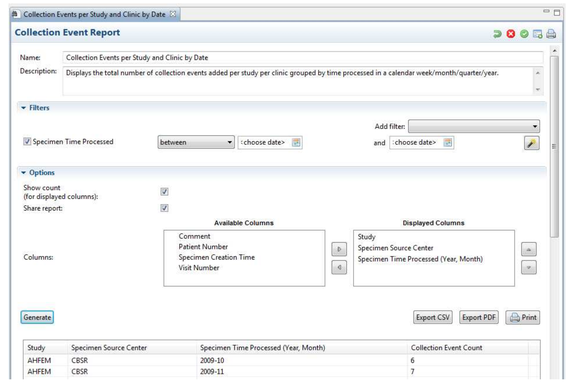

Figure 10: typical Advanced Report that may help determine study activity

Figure 6: A pallet of 2D barcoded cryovials

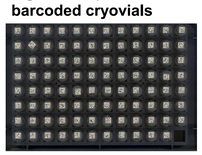

Figure 7: A scanned image of 2D barcoded cryovials in an SBS array

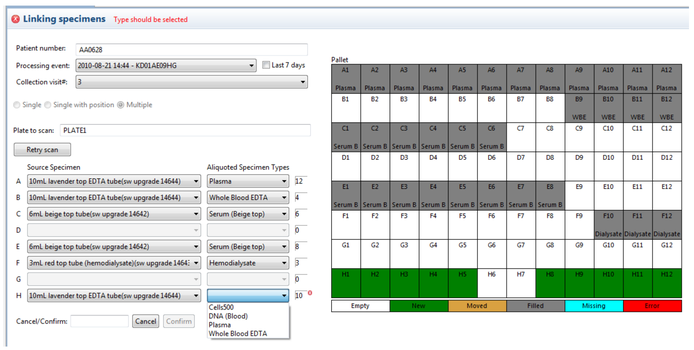

Figure 8: Entering 2D barcoded cryovials into Biobank using a flatbed scanner

Figure 9: Site container configuration

SOFTWARE ARCHITECTURE

Biobank is a client-server application with an N-tier server architecture. Multi-platform based thick clients are available for Microsoft Windows, Apple OS X, and Linux. However, only the Microsoft Windows client interfaces with flatbed scanners. The client and server are based on and use open source Java technologies.

USAGE

The Ontario Health Study, based in Toronto, Canada, is using Biobank to store their biospecimens. This group has also assembled a programming team to aid in developing features for Biobank.

The Livestock Gentec team at the University of Alberta Faculty of Agriculture is currently configuring Biobank to track bovine and swine specimens.

CBSR uses Biobank to manage 27 studies in dozens of clinics and processing centers around the world.

CONCLUSION

Biobank is a free, open-source software system designed to offer an affordable solution to research inventory management. Its goal is to advance and support translational research, providing users who have much in common with an integrated way to share their resources.

Because open-source software is extensible, Biobank provides a great launching point. Biobank aims to be standards-compliant and encourages its users to adopt practices that ultimately result in increased compatibility, efficiency, and reliability. As part of our open-source vision, we welcome collaborative development.

Over the last three years Biobank has been used and validated by technicians at CBSR, thirteen collection sites and three processing centres in North America and Europe.