The National Lung Screening Trial (NLST) objective is to determine whether screening with low-dose helical computed tomography (CT) scan versus chest X-ray (CXR) can reduce lung-cancer specific mortality in participants who are at high risk for developing lung cancer. From 2002-2004, the NLST enrolled 53,143 participants, aged 55-74, in two components: the American College of Radiology Imaging Network (ACRIN) component and the Lung Image Database Evaluation (LIDEX) component. Participating centers were randomized to either CT or CXR arms and received up to 3 imaging screens at annual intervals. As of fall 2010, screening is complete; final collection of participant follow-up data through 2009 is underway, an anticipated 2011 endpoint is anticipated in 2011.

The LSS enrolled 34,614 participants through 10 screening centers and 2 satellite centers (Figure 1). Available CT exams (48,947) were de-identified of protected health information and delivered to a CT image library (CTIL) at Washington University by stringent quality assurance measures (automated checks of DICOM headers and visual inspection of images) were applied before images were archived. Associated baseline medical histories, medical updates at screening, radiologist interpretations of images, and CT exam and CT-scanner data are maintained at the LSS Coordinating Center, Westat, an independent research firm contracted to manage that will be the backbone for the CT Image Library migration from the NLST project and will eventually host public access to the CT Image Library. These three Xen Virtual Machines have been instrumental in giving us the flexibility to test and re-test NBI software.

To install the NBI software, two components are needed: the NBI software (current version 4.4) and the User Provisioning Tool, UPT (4.2). In addition, a standard Java environment and MySQL database server (MySQL 5.1.59-1.41.1, -1.71, -1.56.1, mysql-5.0.56, and myisql-client-5.0.67). The installation of NBI was done on three Xen Virtual Machine guests (xen, rabbit, ct-ilb) distributed over several physical systems. Each virtual system is running CentOS 5.4 and is configured with conservative memory, moderately-sized hard drive, and single CPU.

All three systems mount a large redundant-mirrored disk array to store uploaded images. The MySQL database is also mounted on the disk array for the first two systems, but the Xen system (xen-ilb) uses locally mirrored storage for a possible speed improvement in processing images.

With respect to the network, the first two virtual machines are located on our D2M network to allow connections from the public Internet. The base operating system of the physical servers is CentOS 5.3.5 and in its network connection we use a cancer Bioinformatics Grid Laboratory (cBioGrid) private network for additional security. This configuration is accomplished using standard VLAN networking, but modifying the Xen network scripts.

The last column shows that the first two virtual machines run as Xen guests on a Dell 2950, the third virtual machine guest runs on a Dell R510.

The first two servers are used to test the installation and operation of NBI and UPT software, as well as to test the update process to the NBI software. The third server is used to host the cBioGrid servers, and will eventually host public access to the CT Image Library. These three Xen Virtual Machines have been instrumental in giving us the flexibility to test and re-test NBI software.

Figure 5 shows cumulative migration progress from the first 2.3 million images posted to the system. The average posting was 2.71 images/second, including deliberate sleep stops to check database integrity (seven time-points near the horizontal axis). The oscillatory deviations to the left (transfer beginning) are attributed to a mis-configured firewall issue and an off-and-on intensive 200-node supercomputer job dominating bandwidth to the medical-center's shared BlueArc storage resource. The dips to the right of the center also reflect BlueArc behavior. At the average transfer rate, the 2.2 million-image CT Image Library will require about 60 days to convert to NBI.