Laboratory Information Systems

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KEYWORDS

• Laboratory information systems • Informatics • Laboratory operations • Laboratory management • Computer systems • Pathology informatics • Workflow

ABSTRACT

Laboratory information systems (LISs) supply mission-critical capabilities for the vast array of information-processing needs of modern laboratories. LIS architectures include mainframe, client-server, and thin client configurations. The LIS database software manages a laboratory's data. LIS dictionaries are database tables that a laboratory uses to tailor an LIS to the unique needs of that laboratory. Anatomic pathology LIS (APLIS) functions play key roles throughout the pathology workflow, and laboratories rely on LIS management reports to monitor operations. This article describes the structure and functions of APLISs, with emphasis on their roles in laboratory operations and their relevance to pathologists.

OVERVIEW TO LABORATORY INFORMATION SYSTEMS

Pathologists and pathology laboratories depend on laboratory information systems (LISs) to support their operations and, ultimately, to carry out their patient care mission. Over the past few decades,[1,2] LISs have evolved from relatively narrow, often arcane, and/or home-grown systems into sophisticated systems that are more user-friendly and support a broader range of functions and integration with other technologies that laboratories deploy.

Modern LISs consist of complex, interrelated computer programs and infrastructure that support a vast array of information-processing needs of laboratories. LISs have functions in all phases of patient testing, including specimen and test order intake, specimen processing and tracking, support of analysis and interpretation, and report creation and distribution. In addition, LISs provide management reports and other data that laboratories need to run their operations and to support continuous improvement and quality initiatives.

This article describes the structure and functions of anatomic pathology LISs (APLISs), with emphasis on their roles in laboratory operations and their relevance to pathologists.

ELEMENTS OF LABORATORY INFORMATION SYSTEMS

LABORATORY INFORMATION SYSTEM INFRASTRUCTURE

LISs have a foundation of technical infrastructure. Such infrastructure consists in aggregate of hardware and related dedicated software that enable the LIS to carry out its functions (**Box 1**). Software is computer programming that consists of instructions for the components of the computer system to perform.

Servers are computers that house the main elements of the LIS software, including its main database (see later in this article). Servers provide, or "serve," LIS functions to system users and/or other processes (eg, printers) that request them. Servers can accommodate simultaneous access by multiple users in a networked system environment. An LIS may use one or more servers, and some servers may be dedicated to specific functions like managing communications with other systems (ie, interfaces).

LIS users (sometimes referred to as "end-users") in the laboratory gain access to the LIS through end-user devices, most commonly

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Box 1
Laboratory information system (LIS) infrastructure components

- Servers
- End-user devices: desktop PCs
- Monitors
- Printers: paper and label
- Scanners
- Networks

desktop computers (in this article generically referred to as PCs for personal computer). In a client-server environment (see later in this article), these devices are referred to as *client* devices. Use of LISs on other client devices, such as tablets and smartphones, is emerging as well.[3,4]

LISs require the use of networking technologies for connections among the LIS infrastructure components. Networks consist of physical media and related engineering software that together enable electronic data exchange. Networks in an LIS may include copper (Ethernet), fiber optics, wireless, and/or other media. The network to which an LIS is connected within an organization typically can gain access to the worldwide network of the Internet by way of an organization's gateway to external networks.

LISs also connect to various peripheral devices to execute certain functions. Computer display monitors are an obvious requirement at an end-user PC. The specification requirements for display monitors are getting increasing attention with the advent of whole slide imaging techniques and virtual microscopy, that bring with them need for higher-resolution displays.[5] Printers are necessary for printing reports, and label printers of different form factors print labels for slides, specimen containers, and other assets. Digital scanners enable the capture of hard copy elements, such as paper requisitions or insurance information, into an LIS.

LABORATORY INFORMATION SYSTEM ARCHITECTURE

LIS architecture affects users' LIS experience. The *architecture* of an LIS refers to the model of how the hardware and software components function together to deliver LIS functions. LIS architecture defines the allocation of computing power among system components. LISs are commonly deployed as some variant of *client-server* architecture (**Fig. 1**). In client-server, end-users invoke LIS functions on their "client" devices. The functions go to servers as requests for services, for example editing a report, electronic sign out, data entry, or accessioning a case. Clients and servers work together to perform system functions, and computing resources and power are "distributed" in this manner.

Although older, the *mainframe*, or host-based, architecture exists in some LISs (**Fig. 2**). Mainframe set ups differ from client-server in that computing resources are centralized to a much greater degree on a single powerful computer ("mainframe"). The mainframe, or host, manages all LIS functions. Instead of using computing devices with software, end-users interact with the system using so-called "dumb" terminals that function only for data input and display functions.

Many laboratories now benefit from use of *thin client* LIS architecture (**Fig. 3**). In the thin client model, LIS client software is centralized onto a thin client-server, and end-users interact with the LIS by using client software that performs only

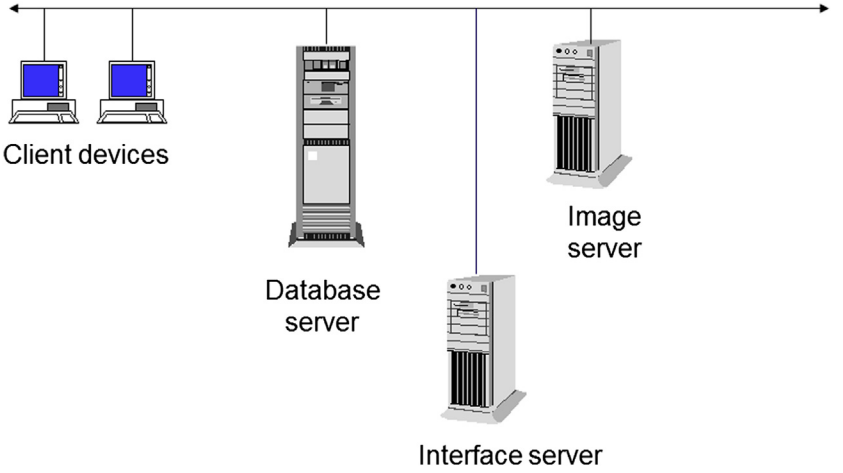

Fig. 1. Client-server LIS architecture.