White Paper

Agilent OpenLab

Cloud Adoption for Lab Informatics

Trends, Opportunities, Considerations, Next Steps

Introduction

The cloud has become a viable option for virtually every computing workload in the laboratory, from sample management to complex analytics to secure data storage. The reasons for this are well documented: the cloud is elastic and efficient; the cloud requires no capital expenditures (CapEx); the cloud enables teams to focus on lab priorities rather than IT infrastructure.

However, the cloud is not a "one size fits all" proposition; there are critical distinctions and choices to be made. The question for lab leaders is how to move workloads to the cloud with minimal disruption, complexity, and risk. Fortunately, justification is no longer an onerous requirement of cloud adoption. Quite the opposite. Enterprise leaders are now asking analytical lab managers to explain why they haven't yet adopted a cloud-first approach with their current and future software needs.

This paper gives lab managers fresh insights into multiple aspects of cloud adoption, including:

- How the cloud can deliver value for lab informatics workloads and processes
- Cloud adoption benefits for lab IT, lab technicians, and lab managers
- Addressing concerns about moving to the cloud model
- Cloud trends and evaluation criteria
- How to get started on the road to cloud adoption

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Cloud basics

A quick review of cloud deployment and consumption options helps provide context for key concepts and ideas presented in this paper. Since many stakeholders now define these terms to showcase their own products or expertise, the following are based on U.S. National Institute of Standards and Technology (NIST) definitions.

Cloud deployment models

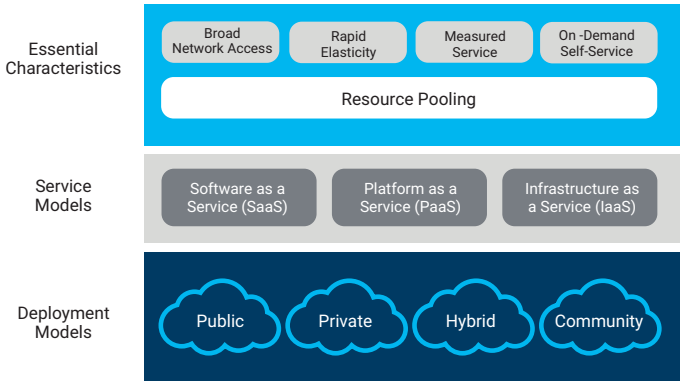
A "cloud" is simply a pool of computing resources (e.g. networks, servers, storage, applications, and services) that service providers can rapidly provision and release. "Cloud computing" is a model for enabling ubiquitous, convenient, on-demand network access to a cloud.

- **Private cloud** is cloud infrastructure operated solely for a single organization, whether managed internally or by a third party, and hosted either internally (on-premises) or externally.
- **Public cloud** renders cloud services over a network that is open for public use. Well-known examples include Amazon Web Services (AWS), Google Cloud, Alibaba, and Microsoft Azure.
- **Community cloud** refers to infrastructure shared between several organizations with common concerns, whether managed internally or by a third party.
- **Hybrid cloud** is two or more clouds (private, community, or public) that remain distinct entities but are bound together, offering the benefits of multiple deployment models.
- **Multi-cloud** is the use of multiple cloud services to reduce reliance on single vendors, increase flexibility through choice, and mitigate risk. Multi-cloud differs from hybrid cloud in that it refers to multiple cloud services rather than multiple deployment modes.

Cloud consumption options

Below are the three main service models relevant to laboratory informatics.

- **Infrastructure as a Service (IaaS)** delivers processing, storage, and other fundamental computing resources to a subscriber over a network. The consumer does not manage or control the underlying infrastructure but has control over operating systems, storage, deployed applications, and networking components such as firewalls. Customers have complete control over the virtualization of their applications and systems. The major public cloud providers (AWS, Azure, Google Cloud) offer resources via this service model.
- **Platform as a Service (PaaS)** supports the complete life cycle of delivering applications via the cloud. PaaS combines a development platform, computing resources, deployment infrastructure, and managed hosting services. It enables customers to cut the cost and complexity of every aspect of developing, deploying, and managing their applications. Google App Engine and Salesforce Heroku are well-known examples.
- **Software as a Service (SaaS)** delivers software solutions over the network. SaaS is far and away the simplest and most convenient type of cloud solution to adopt and deploy into production. Examples include Microsoft Office 365, Google Apps, and Dropbox.



Cloud value in lab informatics

While no two labs are precisely the same in their missions or the characteristics of their informatics workloads, most share a common goal: they exist to provide meaningful, actionable answers to key questions, empowering stakeholders to make better decisions and continuously improve lab practices. The cloud can have a major impact on achieving that core objective because it helps deliver the most important element needed for effective data analysis: context.

Data alone provides minimal context. For example, an individual data element, such as a weight or a performance metric for a lab technician, is useless in isolation. **Information** is created by aggregating, comparing, and contrasting multiple

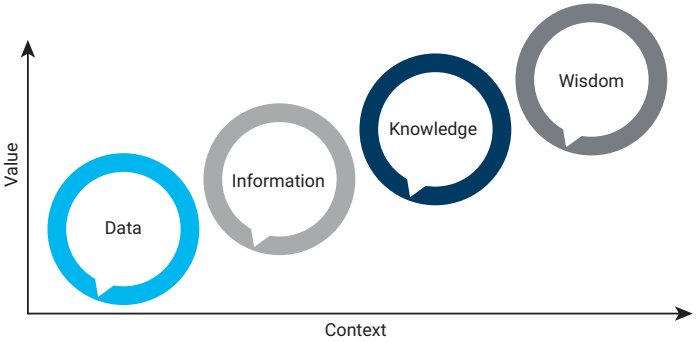
data elements. However, it still cannot answer key questions such as whether a sample meets regulatory compliance requirements, or whether one lab's service routine is better than another's.

Current lab informatics systems that are not cloud-based tend to be highly stratified, limiting their ability to provide the context that turns data into information. These systems sometimes do not allow for data re-use, resulting in "dark data." They are often inefficient and error-prone, relying on manual actions and human decision-making. Many do not scale well and depend on expensive infrastructure.

The core value of the cloud is that it can facilitate the addition of context. It enables informatics labs not only to transform data into information, but also to create **knowledge** and even **wisdom**—the ability to guide better decisions at multiple levels. Deploying lab informatics systems in the cloud can assist lab leaders with mining data to determine:

- How to make processes more efficient
- How training programs could become more effective
- Which instruments need to be serviced or replaced sooner
- How compliance can be achieved with less effort and more consistency
- Many other characteristics that may improve lab performance

The continuum of value: context is critical



The cloud adds value by providing a higher level of connectivity and consistency for lab informatics systems and processes. It enables lab managers to integrate functionality and bring context to every phase of the continuum of value, without increasing cost or risk. The cloud also offers specific capabilities that advance the charters of IT, lab technicians, and lab leaders.

For example:

- **For IT**, cloud adoption makes it possible to do more with less. The cloud model eliminates the need to purchase and maintain infrastructure. It ensures that the organization pays only for the resources it consumes. Fewer staff are required to deliver on the lab's computing and service level needs, saving money and time on recruitment and hiring new IT employees.
- **For lab technicians**, the cloud model can enable faster, easier, more mobile access to data and tools. The cloud can also help with automation or simplification of core processes. To cite just one example, the multicloud storage model enables teams to move data painlessly wherever it makes most sense, on demand. There are no data migration charges, and if teams decide to move data off the public cloud and back to internal private clouds, they can do so easily without any egress charges. Data volumes can be managed through a simple Web portal.
- **For lab leaders**, cloud adoption can reduce costs and increase team morale by enabling streamlined, self-service access to resources. It also provides easier access to capabilities including sophisticated analytics, simplified data migration, and more. Equally important, the cloud model can facilitate collaboration both among team members and between other labs, departments, and business units. It raises productivity while enabling a cross-pollination of knowledge and expertise.
- **From a business perspective**, the cloud can also serve as an accelerant to the lab's digital transformation initiatives. The cloud offers a unique opportunity to leapfrog ahead to modern digital infrastructure and deliver new operational efficiencies. It can dramatically increase the agility of the organization and help it achieve its core mission.

Addressing cloud concerns and misconceptions

Cloud adoption is still a source of anxiety among many laboratory managers due to a wide range of perceived risks and other concerns. While it is always best to proceed with caution where the lab's valuable and sensitive data is involved, many of these concerns have been addressed by the latest generation of cloud services and solutions. A few of the more common considerations include:

- **Does the cloud increase the risk of a data breach or data loss?** Security is easily the most pressing concern for lab managers looking to move workloads to the cloud, and rightly so. Migrating data to and from the public cloud, for example, puts data outside the lab's direct control, and the "shared responsibility" security model of the public cloud means protecting the lab's data and applications is still primarily the lab's responsibility, not the service provider's.

  However, the cloud can also provide innovative new ways to solve security challenges. For example, multicloud services enable labs to test security mechanisms across huge data sets and user populations to identify and prevent sophisticated attacks. In addition, many advanced data integrity and data loss prevention technologies have proven highly effective at thwarting advanced attacks that traditional security technologies do not even detect.

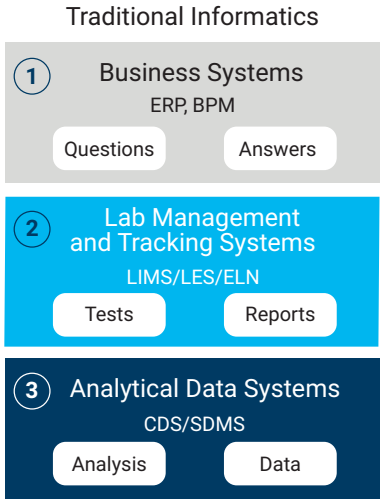
- **Can the cloud provide enterprise-grade capabilities?** Some lab leaders may perceive that cloud offerings do not meet the requirements of enterprise-class reliability, security, and data protection. However, compared to traditional on-premises options, clouds can provide far better data durability, data management capabilities, and security mechanisms.

- **Will data back-up be more difficult and expensive?** Data migration and back-up do not necessarily have to add cost and complexity to lab informatics workloads. For example, administrators can back up data in the cloud through instant snapshots that take seconds rather than hours, allowing data to be backed up more often. In addition, proper tracking and monitoring of cloud service use can help address the concern about "surprise fees" or unexpectedly large invoices from service providers. This helps keep the total cost of cloud adoption within expectations.

- **Will the lab be locked into one vendor's solutions?** It is advisable to carefully evaluate how cloud service providers charge for data migration and data egress. However, many service providers recognize that it is in their interest to increase the client's data agility rather than attempt to lock them in.

Laboratory informatics and the cloud

The figure below highlights the three domains of lab informatics and the common products that meet the demands of each domain.



1. Business systems

Historically, the selection criteria for laboratory informatics solutions such as Enterprise Resource Planning (ERP) and Business Process Management (BPM) solutions would only have included the ability to interface with them. The operational expenditures (OpEx) for business systems were owned by enterprise IT. However, with the adoption of the cloud, OpEx becomes a variable that's dependent on the type of cloud solutions selected.

This extended role for IT means more aspects of business systems must be considered when moving to the cloud. For example, the status of ERP or BPM modernization initiatives will shed insight on the types of informatics solutions that would best fit with the overarching IT strategy. Investigating these considerations allows laboratory management to narrow their product search. It also helps align the lab with IT to ensure buy-in when a cloud solution is ultimately selected.

Business system trends and cloud recommendations

At a technical level, most business systems are already heavily dependent on cloud computing. If organizations have not already deployed these systems in the cloud, there is most likely a plan in place to do so. While SaaS is the ideal service model for most business systems, the deployment approach will be driven by architectural preference.

For example, organizations can opt for ERP vendors with private clouds once security and performance considerations are identified. The deployment approach is a key factor for laboratory leadership since the choice of private, public, or hybrid deployment will impact the viability of solutions in the other layers of informatics.

2. Laboratory management and tracking systems

As the central hub of lab operations, laboratory management and tracking systems in the cloud offer many enticing benefits.

Typically, laboratories utilize a LIMS, LES, or ELN to manage their sample throughput and real-time workflows. Offloading the maintenance of these on-premises systems to the cloud frees IT resources to focus on enhancing lab operation reports or analytics dashboards that pull data from informatics systems.

The ability to focus existing IT resources on high-value, high-priority projects can significantly improve the overall efficiency of the lab. It is also an important consideration in the cost-benefit analysis for moving management and tracking systems to the cloud.

	Lab informatics management systems (LIMS)	Lab Execution Systems (LES)	Electronic Lab Notebook (ELN)
Lab Type	Analytical Testing	Analytical Testing	R&D
Focus	Sample/Process Centric	Sample/Process Centric	Experiment Centric
Purpose	Compliance, Lab Hub	Workflow, SOPs, Compliance	IP, efficiency, recordkeeping

LIMS, LES and ELN trends and cloud recommendations

In deploying LIMS solutions, a key consideration is how to fully integrate the system with current lab operations. The complexity of the implementation itself can seem daunting, but the data being consumed and generated by the LIMS is well structured. Data simplicity makes SaaS an ideal cloud service model for analytical labs. If there is significant outbound interfacing to business systems or other informatics software, a PaaS solution may offer more flexibility.

Most importantly, the LIMS solution should parallel the current or planned deployment models. If there is a clear mandate for using private or public cloud models, lab leaders should have a discussion with vendors on whether they are utilizing public or private cloud infrastructure.

The degree of user interaction with LES and ELN products makes input from lab personnel critical. In addition to workflow fit, lab leaders must consider the strategic fit of cloud offerings with legacy systems or planned system modernization.

Laboratories also need to determine whether their ELN/LES will be static or dynamic in relation to other systems. For example, an ELN being deployed in a research and development setting may be deployed as a standalone application to consolidate data from experiments and maintain compliance needs.

On the other hand, a QC lab would be interested in optimizing workflows by having an LES that dynamically triggers events in downstream software applications. It is important for labs to distinguish this categorization prior to choosing a cloud offering. The degree of complexity with dynamic systems can be greatly reduced or increased by the way it is hosted in the cloud.

Recommended service model for LIMS/LES/ELN: SaaS

The SaaS model is typically the most appropriate for LIMS/LES/ELN deployments because it delivers a combination of agility, cost effectiveness, and native security that makes it a viable cloud option for a wide range of workloads.

3. Analytical data systems

Analytical data systems cover the acquisition, analysis, storage and reporting of instrument data generated within the laboratory. The two categories of informatics solutions offered in this domain include data systems and scientific data management systems.

Data systems overview

Data systems are responsible for data acquisition, analysis, and result-set reporting of samples. The most common data systems found in the lab are chromatography data systems (CDS) and mass spectrometry data systems. Data systems have a wide range of topologies spanning standalone workstation deployment that controls a single instrument to client/server models that manage hundreds of instruments across multiple laboratory sites.

Data system trends and cloud recommendations

Instrument data systems present a unique data integrity challenge for laboratories moving to the cloud. The sources of acquired data from instruments rarely possess local storage and never provide a long-term storage solution. In the event of a network failure, a SaaS data system will leave the lab without any control of instrumentation while also presenting a high risk of data loss at the time of failure.

The lack of failover support adds complexity for SaaS-based data systems. A redundancy measure residing in the lab can provide failover support, but such a configuration needs to be accounted for in the cost-benefit analysis of a SaaS CDS offering.

New instruments are being designed with the ability to store raw data onboard. However, it will be many years before these systems make up 100% of the lab resources. The lack of onboard computing and storage resources to handle network failover highlights a technological shortcoming of instrument data systems. This limitation prevents SaaS from being a realistic option in production environments.

Recommended service model for data systems

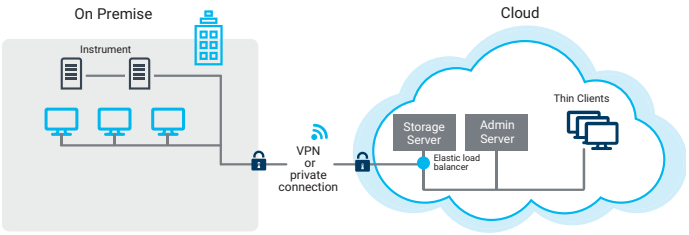
The best cloud service model for data systems is IaaS. This model enables laboratories to minimize the IT footprint in the lab to only the resources needed for instrument control and acquisition. The rest of the data system components can be virtualized in the cloud and thus take advantage of the dynamic scaling and accessibility aspects of the cloud.

The figure on the top right is an example of such a deployment, where OpenLab CDS is deployed as an IaaS offering. The architecture is similar to on-premises systems where VMware/Citrix virtualization is used for application hosting. A few differences between deployment types include:

- **Client scalability** – IaaS has dynamic scalability that is superior to its on-premises alternative. IaaS enables seamless resource expansion or contraction of resources based on demand.
- **Remote access** – The ability to access data systems from offsite locations is greatly improved with IaaS models. If a public cloud provider is utilized, laboratory IT environments can be replicated to a desired geographical location with ease.
- **Disaster Recovery (DR)** – On-premises DR strategies require resource redundancy in the event of system failure, which results in high capital expenditures for largely unused assets. The cloud removes the capital expenditure of retaining back-up infrastructure.

Recommended deployment models for data systems

IaaS is versatile enough to be deployed in private, hybrid and public cloud models. In addition, the analytical data systems layer is typically independent from other layers, so these systems can be prioritized in strategic planning without compromising data system support. For labs taking a holistic view of their informatics portfolio, this provides a more structured way to develop a cloud strategy.

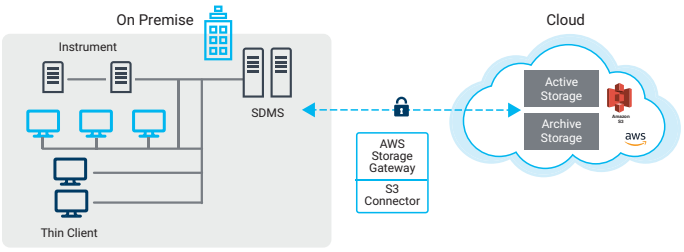


An example of a data system deployed as an IaaS offering.

SDMS overview

SDMS (Scientific Data Management Systems) handle data storage from all instrumentation within the laboratory and manage post-processing tasks conducted with informatics data.

Data-centric by design, SDMS solutions are an ideal starting point for laboratories that are in early stages of incorporating the cloud for their informatics needs. A key distinction to make prior to determining an SDMS cloud strategy is whether it is data-system or laboratory-centric from a utility stand-point. If a laboratory uses its SDMS primarily as a backend storage solution for their data system, the two systems should be handled together. On the other hand, if an SDMS is utilized as a lab-wide storage solution for any/all informatics needs, then the option to handle it as a separate system is available.



An example of a SDMS deployed as an IaaS offering.

SDMS trends and cloud considerations

In the laboratory-centric SDMS scenario, labs can opt for many cloud services to fit their needs. New SDMS offerings can be found as IaaS/SaaS solutions and in any of the deployment models. For a currently deployed SDMS that's on-premises, extending the data storage capacity by connecting to a cloud storage location is a logical first step. This hybrid approach can use cloud storage in both a passive/active capacity while also taking advantage of turnkey archival solutions that the cloud offers.

How to get started

The advancement of cloud technology has significantly expanded the range of choices for deploying and managing lab informatics workloads. With so many options, it is easy to take unnecessary steps in the investigation stage, and potentially hit a wall of fatigue or inertia. Our overarching goal at Agilent is to offer guidance and simplify the process of finding the best solutions for each customer's distinct needs.

A good starting point on the road to cloud adoption is asking a few basic questions:

- Specifically, what do you hope to achieve by moving to the cloud model?
- What are the current cloud proficiencies and skill levels of lab IT staff and lab technicians?
- Do you have a champion who can enlist executive support?
- Do you have a partner you can trust to design and implement the plan?

Finally, it is important to note that you have a broad choice of cloud providers. Make sure your prospective cloud service provider can support all of the cloud models you're considering, all of the cloud deployment options that could benefit your organization, and all of your specific goals.

To learn more about what Agilent is doing in the cloud, visit: **www.agilent.com/chem/openlab**

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