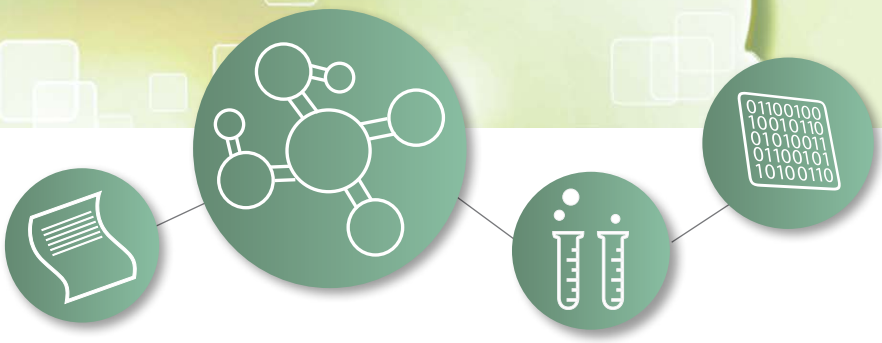

Companies in the cloud: Digitizing lab operations

A range of cloud-based tools—collectively known as the "Internet of Things" (IoT)—can connect everything in a lab, from research protocols and pipettes to data storage and manuscripts. As these tools get easier to use and data become more secure on them, an increasing number of scientists and companies will likely take advantage of complete connectivity. **By Mike May**

The cloud is revolutionizing the ability of organizations, and even individual households, to store, access, and share information—but many life science researchers still refrain from taking the plunge. "Outside the lab we have the easiest experience with our devices and connectivity, but in the lab we go back almost decades," says Silji Abraham, chief information officer at **MilliporeSigma** in Billerica, Massachusetts. Because of the lack of connectivity in life science labs, says Abraham, "We are missing an opportunity to solve problems. Instead scientists continue to worry about capturing and recording what they do."

So far, cloud-based technologies typically get used in very specific technologies, such as next-generation sequencing and some advanced forms of mass spectrometry, says Kevin Barrett, senior vice president of strategic business development at **Gilson,** headquartered in Middleton, Wisconsin. "People are currently focused on using the technology in a sample-centric manner," he says. "Cloud-based data management is inevitable."

Ahead, Barrett and his Gilson colleagues see a much broader use of the cloud in life science labs, and are expecting it to accomplish more than just simplifying scientific workflows. "There's a huge discussion going on about verifiable science," says Barrett, "and cloud-based technology can have a significant impact on that."

Where it works

Three key application areas could benefit the most from cloud-based technology, according to Kamni Vijay, senior marketing director for software and informatics at **Agilent Technologies,** headquartered in Santa Clara, California. The first is collaborative applications that "allow scientists and researchers to work together on a global real-time scale that hasn't been available before," Vijay says. "Information sharing will become more commonplace and immediate."

The second area is applications that require advanced computing. Here, says Vijay, cloud-based approaches "will drop the capital investment needs that laboratories could not otherwise afford." For example, she says, "Instead of purchasing a large server farm, researchers will simply be able to send data for analysis into the cloud and ask for as many on-demand resources as they need."

The third area, Vijay says, is "any application that lends itself to zero-footprint deployment, and can exist on both desktop and mobile versions." This capability could fit an increasing number of small-scale life science laboratories as IoT tools gain traction and include more instruments.

Agilent's iLab Solutions provides an expanding range of uses. "Our iLab Solutions team, led by director of technology Sriram Gollapalli, developed a patent-pending module to enable researchers to control the on/off state for equipment on campus via a SaaS [software as a service]–IoT application," Vijay says. This system can control access to any connected piece of laboratory technology, such as imaging equipment and lasers—essentially anything that provides access to a power outlet that can be switched on or off.

Connecting ELNs

For laboratories to get the most out of their connection to the cloud, their technologies will need to be accommodated, such as electronic lab notebooks (ELNs). As Vijay explains, "Our OpenLAB team also launched an ELN offering earlier this year that is both cloud- and mobile-enabled." With this, she says, "researchers can collect data in a variety of environments."

In Cambridge, Massachusetts, **BioData** supplies several ELN

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options. "We provide our electronic lab notebook through a number of different cloud providers—**Amazon Web Services, Rackspace,** and **SoftLayer**—and, in some cases, onsite or noncloud," says Jonathan Gross, founder and chief technology officer of BioData. "Cloud technologies enable us internally to ensure that all our work is backed up."

When asked how cloud-based approaches benefit scientists, Gross points out several areas. For collaboration, he says, "We see lots of work done remotely. Being able to see the results in real time and share your expertise is crucial to the success of a project."

When most of us think about the cloud, storage is a key feature. "I remember days where scientists would have tons of CDs holding microscopy images as backups," Gross says. "Today, scientists upload them to the cloud, perform remote analysis on these files, and store the data there if needed."

The key to cloud-based technologies comes from taking the broader perspective. As Gross says, "Science is generating vast amounts of data, and the cloud infrastructure and lower cost of storage supports it." He adds, "We already see equipment pushing data directly to the cloud. I expect that more technology providers will follow."

Some leading developers of research tools agree. "We are on a journey to create connectivity of our devices with the IoT platforms," says Abraham. "We want to make life simpler in the lab—automate the process of recording experiments and capturing data through the cloud and IoT technology—so scientists can focus on experiments and results."

Protocols and pipettes

At **Thermo Fisher Scientific,** headquartered in Waltham, Massachusetts, Tommy Bui is part of a team focused on leveraging the Thermo Fisher Cloud to enhance research productivity, performance, and collaboration. "We're still in the early stages of getting our products connected and developing a roadmap that will deliver comprehensive and relevant solutions for scientists worldwide," Bui says.

Thermo Fisher Cloud engineers started with an underlying computing framework that supported web-based connectivity with complex instrumentation. Bui adds, "It's important to our customers that we're continuing to expand on our innovative, intuitive, and scalable approach to connectivity—one that's increasingly flexible and able to accommodate a range of instruments and equipment vital to diverse and pressing research workflows. We're not focused on pockets of innovation with silos of connection."

As part of the roadmap, Bui and the team have been focused on connecting handheld pipettes to the Thermo Fisher Cloud. "We're arming our customers with pipettes that will enable them to download preset protocols from the cloud or create and share protocols via the cloud to one or more pipettes simultaneously," Bui says, "Connectivity with the cloud and multiple pipettes in a lab will save time, reduce human error, improve consistency and reproducibility, and ultimately enhance research results."

When it comes to pipettes, the name that comes to many minds is the PIPETMAN from Gilson. "The pipette is [the] 'ground zero' of data collection," says Nicolas Paris, Gilson's CEO, who claims that next year there will be a Bluetooth-enabled, cloud-connected PIPETMAN. "We'll turn the PIPETMAN into an IoT product, so that people can track what happens at the bench."

PHOTO: © SERGEY NIVENS/SHUTTERSTOCK.COM

"We're trying to create an ecosystem of instruments, scientists, and research." – Alok Tayi, TetraScience CEO and cofounder.

This IoT PIPETMAN function will tell researchers if the device has been calibrated properly and is geared to reduce errors associated with improper pipetting techniques. It will also provide information about what needs to be done (and has been done) to verify manual steps in an experiment.

Scientists won't need a new PIPETMAN to get connected. "The real risk of cloud-based management is that it creates two tiers in research: the haves and the have-nots," Paris explains. "By connecting existing instruments, we hope to avoid this by making our technology available to a large number of researchers."

Designing an ecosystem

As IoT digs deeper into labs, the entire R&D "ecosystem" will change and grow more interconnected—like NASA combining a wide range of devices and locations to launch a rocket. Alok Tayi, CEO and cofounder of **TetraScience** in Allston, Massachusetts, describes his company's technology this way, calling it "mission control for R&D." He elaborates, "We use IoT to connect individual experiments and instruments into a single online dashboard." Customers leverage the dashboard for three core functions: managing instruments and assets, automating experiments, and collecting and managing data.

Two factors that challenge companies like TetraScience are the numerous types of lab equipment available and the diversity of equipment manufacturers. "So we create partnerships with manufacturers," Tayi explains. "That way, they can offer new capabilities to customers, such as remotely diagnosing problems and adding automated analytics and imaging."

By combining these capabilities and different versions of equipment, Tayi plans to change labs in fundamental ways. "We're trying to create an ecosystem of instruments, scientists, and research," he says.

To get this done, Tayi knows that he can't get people to build completely new labs filled with state-of-the-art equipment. Instead, he explains, "We help labs enter the digital age cont.>

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by retrofitting existing instrumentation and putting it on the cloud. We help support that ecosystem, as labs and research evolve over time."

One of the partnerships combines TetraScience with **Consolidated Sterilizer Systems** (CSS), also located in Allston, which manufactures autoclaves. "We wanted to get our autoclaves to communicate through the cloud, like your thermostat or TV at home does," says Arthur Trapotsis, president and CEO of CSS.

Instead of having CSS build its own cloud, Trapotsis decided to team up with TetraScience. "If end users have to log into 37 different clouds, it will be annoying and very cumbersome," he explains. "So we went with the TetraScience ecosystem because manufacturers of different equipment types can, theoretically, plug into it. As a result, lab personnel can have one cloud platform to monitor their entire lab." Trapotsis and his team have already released their cloud-enabled autoclaves. "In 2017," says Trapotsis, "we'll have a cloud-conversion kit that you can retrofit onto an older autoclave to make it cloud-compatible."

Taking labs to new heights

As labs work their way into the IoT and the cloud, more than one company will develop ecosystems. At **LabCloud** in Cambridge, Massachusetts, Charles Beyrouthy, CEO and cofounder, says, "We want to put the entire research operation—from data management to procurement—all in one system in the cloud." Perhaps most surprising of all, Beyrouthy wants to help researchers obtain that for free.

To accomplish this feat, Beyrouthy and his colleagues teamed up with lab equipment vendors to get them in front of firms that might use their products. Today, more than 50 vendors work with LabCloud, and that collaboration funds LabCoud's ability to provide the resources for companies and scientists. But LabCloud is first and foremost about the users. As Beyrouthy says, "We don't produce a feature unless we can see somebody using it at an operational level."

LabCloud also intends this ecosystem to be easy to use. "As a single scientist, getting started is pretty simple—just sign up and you can use the lab notebook, data analysis, and inventory features that are preconfigured for you out of the box," says Igor Romashko, chief technology officer at LabCloud.

Things get more complicated with more users, however. "The complexities usually kick in when you need to set up your team in terms of creating accounts and user roles, and setting appropriate permissions as required," Romashko says. "We have wizards or guides to help users on that front."

In fact, LabCloud provides a range of tools to help users, including "three online user trainings per week that focus on specific aspects of the software in more detail and go over the advanced features, as well as addressing client-specific questions and best practices," Romashko says. "We also offer complimentary consulting on the use of our software for client-use cases."

"Dashboard for preclinical research"

While running a group doing in vivo research, Eric Ibsen—cofounder and vice president at **Studylog Systems** in South San Francisco, California—tried a variety of software tools to keep track of the work, but "it was incredibly inefficient, because they were not integrated," he says. "I started looking around, and I couldn't find anything purpose-built by researchers for researchers to emulate the workflow process."

So, he and his colleagues created Studylog Animal Study Workflow Software, which Ibsen describes as "a complete dashboard for preclinical research." In general, this tool provides study management on top of a database. "It automates and streamlines the entire process of animal studies, including planning, designing, and scheduling a study; collecting data; running statistics; making graphs; and creating reports—all by just pushing a few buttons," Ibsen explains. "The people who use it tell us that Studylog lets them double or quadruple the number of studies they can do."

In addition, all the information goes in a database. "It is stored securely on a central server, instead of in thousands of Excel files," Ibsen says. "It can then be made accessible to appropriate personnel and systems via the web." He adds, "This system is affordable for most organizations, from individual academic labs to multinational pharmas."

Amazing feats in the forecast

Despite all the exciting IoT activity underway, many more advances lie ahead. "There is much work to be done in the field of laboratory informatics before it can truly be considered 'mature,'" says Romashko. "One aspect that we see emerging in the next three to five years is the use of machine learning and artificial intelligence to enhance the user experience for the scientist, enabling predictive experimentation."

To explain, Romashko says, "Imagine a situation where laboratory informatics software can predict the result of any given protocol, taking into account previous experiments and public domain knowledge, or warn the scientist regarding a potential error or problem."

Thus, beyond simply making science work better in its current form, digital lab management could create new ways of doing science that eclipse what can be done today.

Mike May is a publishing consultant for science and technology.

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