

Improving Research Laboratory Operations with IoT



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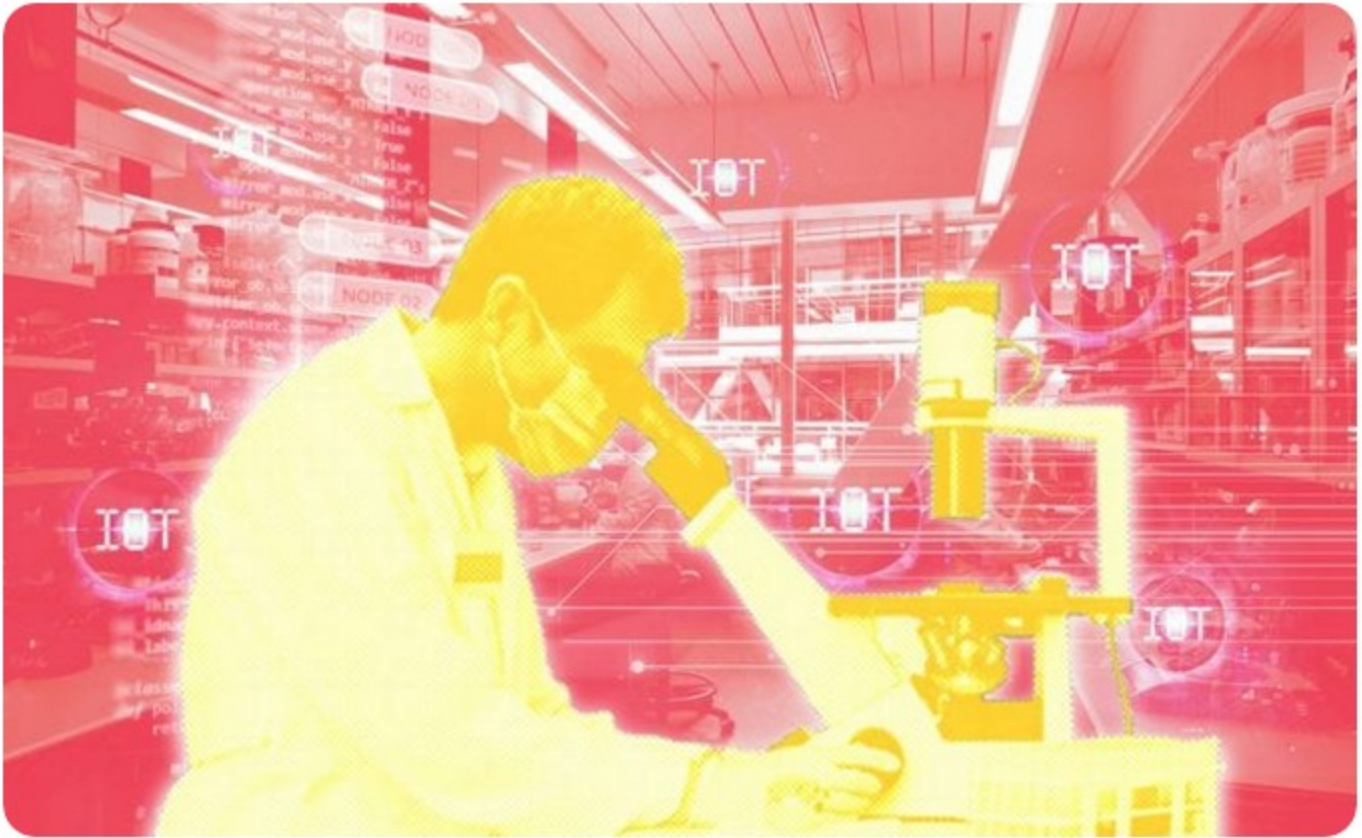


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There has been a lot of progress in introducing IoT to the production environment including defined actions with clear workflow and products with a specific use. However, it's worth asking ourselves if IoT can also benefit less routine operations, like the many tasks that need to be performed in a [research laboratory](#)?

IoT has been stealthily infiltrating research labs and is beginning to show significant results. Compared to manufacturing, laboratories have smaller numbers of a wider variety of equipment, and this equipment is used in several different ways. The employees tend to be more educated, skilled, and thus have a stronger influence on how operational decisions are made. No matter what field or industry the lab serves, it's in everyone's best interest to speed up product discovery and development without increasing costs.

With increased progress in the use of IoT in the production environment, the question remains: can IoT also benefit less routine operations, like the many tasks that need to be performed in a research laboratory?

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The Laboratory Industry

There are a number of different types of laboratories in the United States. They include:

- Testing Laboratories: part of industrial production and supply chains
- Diagnostic and medical laboratories: a wide range of clinical specialties such as pathology, virology, and serology. Veterinary labs are separate if related category
- R&D Laboratories: academic centers, pharmaceutical companies, various technology companies, materials, seed, and a wide range of functions
- Production Laboratories: where the results of R&D labs can be scaled up before attempting commercial production

The first two categories can be sized, as they are mostly independent entities. It's worth noting that there are nearly 11,000 testing laboratories, with \$20 billion in revenue and nearly 38,000 diagnostic and medical labs, with \$55 billion in revenue.

R&D and production laboratories are typically part of larger companies, and their revenues are harder to break out. But the lab industry as a whole is significant, and its outputs are essential for economic growth. Increased effectiveness and efficiency in lab operations will have significant effects because of this.

Labs and Software

As in many other industrial applications, laboratories have been striving to monitor and optimize operations, gather data for analysis, and provide warnings of failure for a long time. Most labs are run through sophisticated software called Laboratory Information Management Systems (LIMS). Another complex set of software assists in modeling and simulation of results. A lab could have more than one LIMS, as well as a Laboratory Execution System (LESs), inventory control software, and other specialized kinds of software.

Many individual pieces of lab equipment, such as refrigerators, have been equipped with remote monitoring and automatic data solutions for some time. But even with machine-to-machine (M2M) solutions of this kind, there is still an extremely large amount of unstructured data, which LIMS does not handle well. Many lab notebooks remain paper-based. The volume of data tracked is still fairly limited.

Unification via IoT

IoT enables a unified solution that monitors everything, no matter what the original vendor, without requiring working with a variety of interfaces and protocols. It eliminates the large number of custom solutions that have been required to get individual pieces of equipment in specific labs to work efficiently.

The resulting dashboard allows for at-a-glance understanding of a lab's day-to-day function, flagging failing equipment, out-of-spec variations in performance, and reagent inventories.

Not incidentally, all this tracking also makes safety monitoring and compliance with regulations such as the FDA's [21 CFR Part 11](#) significantly easier. Reporting will always be a key benefit of IoT.

Monitoring Freezers, Incubators, and Repetitive Procedures

Simply monitoring equipment such as freezers and incubators can show great benefits. The samples being kept at a given temperature are usually the product of many hours of skilled labor, and are being prepared for the next step in the procedure. An unacceptable temperature variation, not to mention complete failure, can set things back by weeks, with attendant costs.

Many lab procedures require large numbers of similar procedures with tight tolerances, as well as continual checking on ongoing processes over many days, 24 hours a day. **Automation** and remote tracking can both reduce load and stress on researchers and improve accuracy. The ability to track processes remotely makes experimentalists' lives easier and more flexible while ensuring that any variation is caught and responded to quickly. Stir plates can be turned off and temperatures modified remotely. High-throughput assays with a lot of pipetting can be done more quickly and with greater accuracy, while, again, clearly tracking results.

Keeping Lab Animals Healthy

Any lab with experimental animals knows that keeping cages clean is a significant task. IoT-enabled sensors can allow for real-time monitoring of cage conditions such ammonia level, humidity, temperature, and animal movement, via sound and light sensors. Cages can be cleaned as needed, minimizing disruption to animals, while also keeping an eye on individual animal health. It can also reveal when ventilation is malfunctioning, a water bottle is empty, or an animal is manifesting the early signs of illness.

Labs Require a Greater Degree of Customization

There is a wide variety of labs devoted to serving distinct subfields, and they can vary significantly even in a given area of biology or chemistry. This wide variation in practice means that every laboratory IoT solution will require a fair amount of customization.

Lab managers hoping to improve operations will have to face a transition period when providing data seems too high a cost and an imposition to sophisticated researchers with well-developed workflows. Improved equipment uptime, remote procedure, lab-animal monitoring, and the availability of clear data will eventually demonstrate the benefits of IoT in the laboratory.