DZone

DZONE'S 2019 GUIDE TO

Internet of Things

CONNECTING DEVICES AND DATA

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Dear Reader,

The Internet of Things is an industry that has not exploded the way many thought it would. Not at first glance, anyway. Developers have been playing with new open-source and customizable hardware for several years, and home automation has evolved well beyond the clapper, but the real meat of the ecosystem is in large-scale projects, in factories, cities, utilities, and hospitals, all of which are slow to change. That's not to say there is no growth, or the potential does not exist. The exciting work is happening in the background, or behind closed doors.

In the medical industry, connected devices are allowing nurses and doctors to remotely monitor patients, and there's potential for hospitals to incorporate inventory management solutions for medicine and to integrate with self-reporting wearable devices like Fitbits. Cities can become "smarter" by using connected devices for waste management, parking, lighting, and traffic. And self-driving cars cannot function as intended without the incredible number of sensors inside the vehicle processing data in real-time.

The Internet of Things is, of course, not without its issues. DZone readers have reported that security and data privacy are, of course, key concerns with the growth of this technology, along with the lack of hardware and software standards to connect physical devices and the challenges of real-life environments and the limitations of the hardware. All of these issues are further complicated by an unfortunate fact: the big players in the space are keeping their cards close to their chest. If you want to break into IoT development and make up for the talent shortage, you're going to have to roll up your sleeves and start trying things out on your own.

In this guide, we'll discuss solutions to process the data your devices generate as quickly as possible, getting started with building your own projects, and ways to take those experiments and make your own products out of them, even ways to monetize the obscene amounts of data you'll find yourself with.

We hope this guide helps inspire you to either create the next big thing, consider the use cases of connected devices in your organization, or just appreciate the change happening around us.

WRITTEN BY MATT WERNER
PUBLICATION COORDINATOR, DEVADA

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Executive Summary

BY KARA PHELPS
CONTENT & COMMUNITY MANAGER, DEVADA

The Internet of Things is a constantly shifting landscape. As pundits debate its successes and failures, IoT use cases keep increasing — in every niche from the automotive industry to the new frontiers of 5G. Smart devices are proliferating in consumer markets, and hobbyists are using these products and applications to sharpen their tech skills.

Of course, data has always been the lifeblood of IoT — and as more data is collected, the need to protect it grows more insistent. More than ever, IoT professionals and hobbyists alike are searching for reliable ways to safeguard their data.

We asked 575 tech professionals to weigh in on the impact of IoT this year. We noticed a few overriding trends that we'll highlight here.

Hobbyists vs. Professionals

DATA

53 percent of survey respondents reported that they hadn't worked on any IoT products in the past but were interested in working on IoT in the future. 39 percent said they had worked on IoT projects before and were still interested in working on more projects. The rest reported they were not interested in working on IoT projects.

Meanwhile, 61 percent of survey respondents said they were interested in IoT for personal development. 47 percent said they were interested in IoT-related projects in their company. 34 percent said they were interested in making consumer IoT products, and 30 percent said they were interested in making industrial IoT products. 28 percent said they were interested in building an IoT-related startup.

IMPLICATIONS

Tech professionals are interested in IoT, but many have not had an opportunity to work on IoT projects at their day-to-day jobs. A significant percentage are taking on IoT projects as hobbies or as personal development, possibly satisfying their interests via an alternate route.

RECOMMENDATIONS

From writing Alexa skills to experimenting with Arduino boards, you don't have to look far for a place to dive into personal IoT projects. Skills you develop as a hobbyist can translate into careers later, if that's what you want. While 62 percent of survey respondents believe IoT is relevant to their organization right now, 87 percent of respondents believe IoT will be relevant to their organization in the future. The demand for a strong IoT skillset already outpaces the current availability in the workforce, and it will only continue to grow this year.

Putting the AI in IoT

DATA

44 percent of survey respondents said they plan to adopt a new IoT-related technology within the next six months. 65 percent of these respondents said they plan to adopt AI and/or machine learning for IoT, 62 percent said they plan to adopt sensors, and 53 percent said they plan to adopt a new development platform.

IMPLICATIONS

Artificial intelligence and machine learning are poised to grow more integral to IoT this year. As organizations expand their sensor networks and strive to make sense of the mountains of data they're already collecting, AI presents a cost-effective solution.

RECOMMENDATIONS

"AI fills the gap between collecting the data and making the most of it," as TechNative writes. If your organization plans to adopt AI or machine learning technologies for IoT in the coming months, make sure your edge computing capabilities measure up. On-site data processing will reduce your reliance on the cloud in situations where real-time analysis and response is critical.

The Security Challenge

DATA

While developing IoT applications, 57 percent of survey respondents reported they've encountered device security challenges. 50 percent said they've been challenged with an unpredictable physical environment. 41 percent said they've encountered the problem of device unreliability.

When presented with a list of common issues in IoT and asked to rate their level of concern, security (78 percent), privacy (60 percent), and a lack of standards (41 percent) were all considered to be major issues by survey respondents.

IMPLICATIONS

Security breaches dominated the news cycle over the last year, and the European Union's General Data Protection Regulation went into effect. Although IoT professionals have been aware of the industry's security challenges for years, many larger organizations are now beginning to understand the importance of data privacy and security to their bottom line.

RECOMMENDATIONS

Both software and hardware can have vulnerabilities, of course. Take steps to protect both. Security issues have slowed the pace of IoT adoption, particularly in sensitive industries like healthcare. Some companies have begun to implement AI and machine learning in their security measures, and physical protections for devices are becoming more important to prevent tampering.

Key Research Findings

BY JORDAN BAKER
CONTENT COORDINATOR, DEVADA

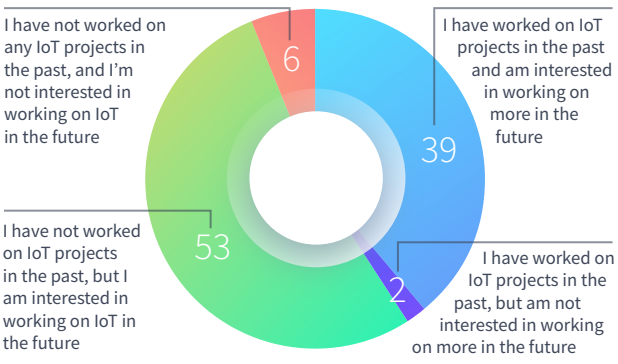
Demographics

For this year's IoT survey, we received 575 responses with a 75% completion rating. Based on this response rate, we calculated the margin of error for this report at 4%. Below is some of the basic demographic information of this group:

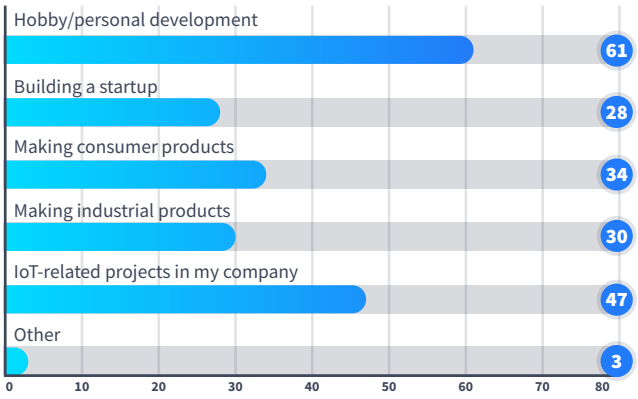
- On average, respondents have 19 years worth of experience as an IT professional.
- Respondents live in four main geographic areas:
  - 34% reside in Europe.
  - 22% live in the USA.
  - 15% are located in South Central Asia.
  - 8% are in South America.
- Respondents work for organizations headquartered in one of four main locations:
  - 35% work for organizations in Europe.
  - 31% work for organizations that are HQed in the USA.
  - 9% work for companies in South Central Asia.
  - 8% are employed by South American companies.
- A majority of respondents work for enterprise-level organizations.
  - 22% work in organizations sized 10,000+.
  - 21% work for organizations sized 100-999.
  - 20% are employed by organizations sized 1,000-9,999.
- Survey-takers reported working for three main industry verticals:
  - 21% work for a software vendor.
  - 14% are in consulting.
  - 10% work in finance/banking.
- Three main roles were reported:
  - 33% are developers/engineers.
  - 21% are developer team leads.
  - 19% are architects.
- Respondents work on four main types of applications:
  - 80% develop web applications/services.
  - 44% develop enterprise business applications.
  - 26% work on native mobile apps.
  - 21% create software for embedded systems.
- Respondents reported using four main languages both inside and outside of work:
  - At work:
    - 72% use Java
    - 59% use JavaScript/Node.js
    - 41% use Python
    - 23% use C/C++
  - Outside of work:
    - 56% use Java
    - 50% use JavaScript/Node.js
    - 48% Python
    - 20% C/C++

SURVEY RESPONSES

How would you describe your relationship with IoT?



In which contexts are you interested in IoT?



IoT Development: Hobbyist vs. Professional

Of the 575 technologists surveyed, 92% reported an interest in working on IoT projects. Interestingly, over half of those interested in IoT (53%) have yet to develop any IoT projects. It thus makes sense that 61% of respondents who reported an interest in IoT told us they want to explore it in the frame of a hobby/personal development project. While hobbyists dominated this survey, another 47% said they're hoping to work on more IoT-related projects for their company. Throughout this report, we'll use these statistics on hobbyists and professional IoT developers as our main points of comparison and as a jumping off point for understanding the way developers get into, approach, and learn about IoT.

Among those surveyed, having the chance to create an IoT project from scratch proved far more popular than picking up and building upon an existing project; in fact, almost twice as many respondents would prefer to work on an IoT project from the ground up. To put it quantitatively, 64% of survey takers told us they'd prefer to take IoT projects on from scratch, versus 36% who said they'd prefer to contribute to an existing project. While this could, in large part, be due to the fact that many respondents are pursuing IoT projects as a means of personal development (indeed, 40% of those who told us they'd like to start from scratch also said they're interested in IoT development as a hobby), we still found that 30% of respondents interested in building a project from the ground up are working on IoT-related projects for their company. When we look at those respondents who said they'd rather make contributions to an existing project, the percentages of those who work on IoT as a hobby versus those who work on IoT in a professional context saw similar response rates. Among hobbyists, 23% said they'd prefer to contribute to existing projects; among professional IoT developers, 17% said the same.

When it comes to the phases of IoT development, an overwhelming majority (89%) said they are likely to write application code, 77% said they'd design APIs, 42% expressed an interest in ETL and data integration, and 33% answered testing. Among the hobbyists, we found that the most popular phase of IoT development, interestingly enough, was testing (65%), followed closely by the writing of application code (63%) and designing APIs (60%). The only phase of IoT development that proved more popular among those working on IoT-related projects for work than as a hobby was ELT and data integration (note: the difference here is only 1%, which is well within the margin of error for this report, but I felt this fact nonetheless warranted further exposition). 52% of respondents working on IoT-related projects for their company reported that they were likely to perform ETL and data integration processes. This is interesting, as the other phases of IoT development delineated above (writing application code, designing APIs, and testing) all proved more popular among hobbyists than professionals. This swing could be partially attributed to the fact that developers working on professional IoT projects are dealing with much larger data sets than hobbyist developers.

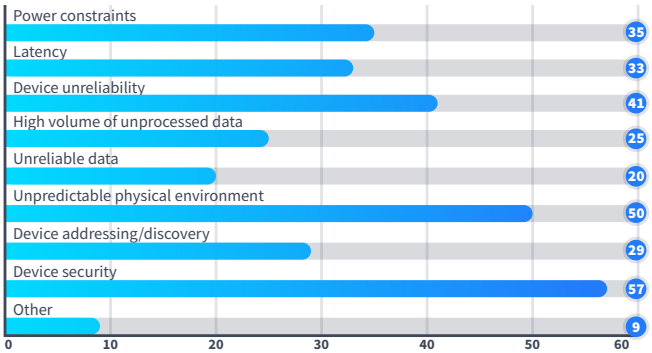
In the following section, we'll continue to explore this dichotomy between hobbyist and professional IoT developers by looking into the types of IoT products respondents own and how this could affect how they view IoT development.

IoT in the Home

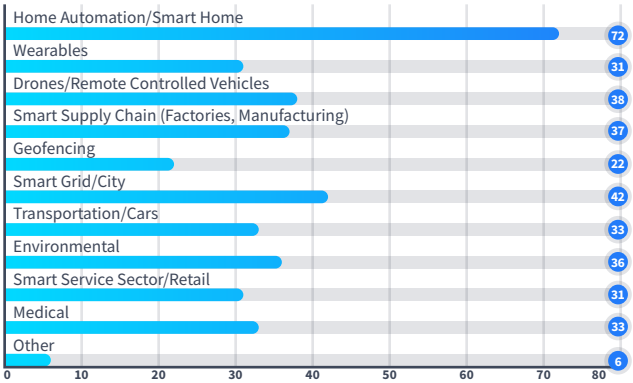
As 61% of respondents told us they are hobbyist IoT developers, it comes as little surprise that the most popular use cases our audience reported to have worked on were home automation/smart home projects. This use case saw far more interest than any others, with 72% of the general survey population saying

SURVEY RESPONSES

Which of the following challenges have you encountered while developing IoT applications?



Which IoT cases would you like to work on?



they'd like to work on smart home apps. When we compare the data of those who have worked on IoT use cases to the data on respondents who have created/own smart home products, we see an interesting correlation. Among the general survey population, 65% of respondents said they have neither created nor purchased a smart home or home automation product. But, among respondents who reported to have worked on IoT projects in the past, we find almost the exact inverse to be true: 69% of respondents who have worked IoT use cases own/have created smart home or home automation products. One possible explanation for this is that by doing things like building Alexa skills or purchasing smart light bulbs, developers take their first foray into IoT and continue to explore from there.

The dominance of smart home/home automation in the IoT space could also point to why most developers create IoT projects as hobbyists rather than in a professional setting. When we asked respondents, "Which IoT use cases would you like to work on?" 69% of those who consider themselves hobbyist IoT developers answered home automation/smart home, versus only 43% of respondents developing IoT-related projects for their company. And when we asked our survey takers which IoT use cases they've actually worked on, 68% of hobbyist IoT devs reported home automation/smart home, versus 49% of respondents developing IoT-related projects in a professional setting.

Security and Other Common Challenges

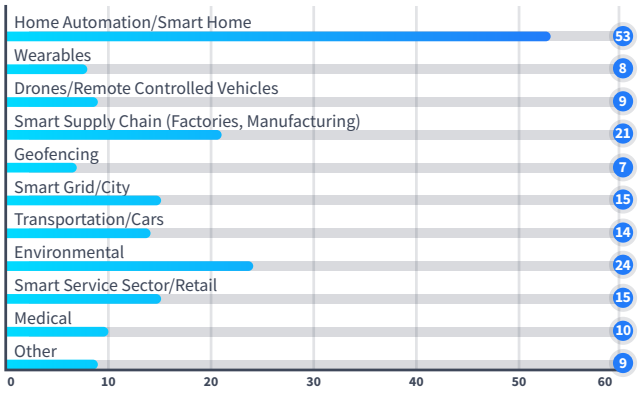
No matter the situation in which IoT applications are being developed, security is one of the main concerns surrounding the growth of IoT devices. Indeed, among the three largest concerns reported by respondents, security and privacy were the top two. 78% told us they're 'very concerned' about security, 60% reported being "very concerned" about privacy, and 41% said they are 'very concerned' about the lack of standards.

Not only is security a concern — it was also one of the biggest challenges reported. 57% of respondents told us they encountered issues with device security while developing IoT applications, making it the most common challenge reported. Other common challenges our survey-takers have come up against are unpredictable physical environments (50%) and device unreliability (41%). Something interesting to note here is that among the categories of IoT developers, hobbyists proved the least concerned about device security. Of those who consider device security a challenge, 31% work on IoT-related projects for their company, 28% are making industrial products, 27% are using IoT to build a startup, 23% are making consumer products, and 21% are hobbyists.

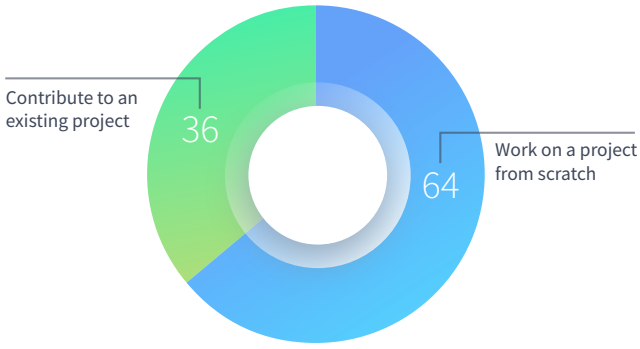
In terms of the nuts and bolts of IoT security, respondents reported a variety of protocols. When asked, "How are you securing your IoT devices and networks?" 36% said they use SSL, 35% use TLS, and 26% report to use end-to-end encryption. Among those respondents who use the protocols surrounding service discovery, UPnP (29%) proved the most popular, followed by Bluetooth SDP (28%), MDNS (22%), and DNS-SD (12%).

SURVEY RESPONSES

Which IoT cases have you actually worked on?



Would you rather work on an IoT project from scratch or make contributions to existing an existing project?



Diving Deeper

Into the Internet of Things

Zones

IoT dzone.com/iot

The Internet of Things (IoT) Zone features all aspects of this multifaceted technology movement. Here you'll find information related to IoT, including Machine-to-Machine (M2M), real-time data, fog computing, haptics, open distributed computing, and other hot topics. The IoT Zone goes beyond home automation to include wearables, business-oriented technology, and more.

AI dzone.com/ai

The Artificial Intelligence (AI) Zone features all aspects of AI pertaining to machine learning, natural language processing, and cognitive computing. The AI Zone goes beyond the buzz and provides practical applications of chatbots, deep learning, knowledge engineering, and neural networks.

Big Data dzone.com/big-data

The Big Data Zone is a prime resource and community for big data professionals of all types. We're on top of all the best tips and news for Hadoop, R, and data visualization technologies. Not only that, but we also give you advice from data science experts on how to understand and present that data.

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 @SMC_on_IoT

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 @helenleigh

 @amiedoubleD

 @LMcUnderwood

 @Cate_Lawrence

 @JoeSpeeds

Books

The Amazon Way on IoT

Get a detailed analysis of Amazon's IoT approach, learn about keys to success from Amazon's playbook, and learn how to develop, execute, and explain your own IoT approach.

Designing Connected Products

See how to develop a stellar UX for consumer IoT, how to approach IoT product strategy and design, and how to work with complex cross-device interactions.

Enterprise IoT

Learn about strategies and best practices for connected products and services based on case study analyses, expert interviews, and the authors' own experiences.

Refcardz

Messaging Infrastructure for IoT at Scale

Download this Refcard to learn more about the foundation of an IoT platform, how to get started with EnMasse, and open-source projects focused on IoT device connectivity.

AMQP Essentials

Practical introduction to AMQP — a binary, multiplexed, symmetric, secure, and lightweight message transport protocol designed for enterprise applications and particularly useful for IoT.

Getting Started With Industrial Internet

Introduces basic concepts and technologies of the Industrial Internet, including sensors and actuators, industrial control systems, human-machine interfaces, real-time streaming data, device security, and more

Podcasts

IoT Podcast

Explore the issues that IoT can help solve and the devices that will lead us to those solutions.

Industrial IoT Spotlight

In this interview-based podcast, get insight into the planning and implementation of IIoT systems.

The Peggy Smedley Show

Learn about the most recent and relevant digital tech trends in IoT.

IoT: Device Data and Stream Processing

QUICK VIEW

01. In highly distributed IoT systems, you are facing networking, connectivity, routing, conversions, analog/digital dissonance, and other challenges that can impact your data. You need to know what data arrived, when, how much, what changed, and where.

02. This data lineage and provenance is key to debugging, auditing, securing, and managing your remote device data.

03. Transmitting data between various devices, networks, routers, gateways and finally data processing servers requires a trustworthy secure networking protocol for messaging. The two options I recommend are Apache NiFi S2S of HTTPS or MQTT.

BY TIM SPANN
BIG DATA SOLUTIONS ENGINEER, HORTONWORKS

Summary

IoT brings a whole new world of data, real-time streaming requirements, operational difficulties, security, and a large stream of massive data that needs to be made available for use at scale. Many of these challenges can be solved by using the best of breed open source tools. A whole new world of data will become available to your stream processing frameworks. In this article, I will show you ways in which you can solve these problems and go from batch to stream.

Introduction

Devices can output large amounts of data very frequently, which can be valuable to enterprises from as early as inception or as late as historical forecasts. This device data usually comes from on-board or connected sensors that measure things like GPS, temperature, humidity, air pressure, luminance, time of flight, gases, electricity, air quality, and motion. Once we have acquired data from a sensor on a device, we need to be able to transmit this data to our remote servers for processing at scale. There are a few caveats when doing so. The first is that we need a secure channel between our many devices and our receiver. We also need to be able to process the millions of device records being sent per second. If we can't process this as it comes in, we lose the value of this live data. We also need to be able to filter, alert, route, combine, query, store, aggregate, and discard the data. Let's break down the problem into manageable steps.

Variety, Volume, Velocity, Variability of Data

First, we need to understand the data. There are many IoT devices in both the consumer and business landscape, each generating many types of data at rapid speed. This data can be a fixed schema, change frequently, it can be very sparse, numeric, or binary. For this reality, along with the sheer volume and velocity of the data, I recommend using an edge client and receiving server that can handle any type of data. Fortunately, that exists in the open source space as Apache NiFi. You can easily have thousands of devices with dozens of data points each reporting back every second, which can easily grow to terabytes of data.

Device Data

An example of device data may look like this:

cputemp: 56.7
Memory: 22.6
Y: 471

Device data is often numeric, requires conversions, and appears in massive streams of often unchanging values, sometimes binary or strings. You never know what you may get until you start testing the data locally on the device. For example, I can take a reading from an LTR-559 Light and Proximity Sensor and will receive decimal data or whole numbers ranging from less than 1 to 64,000. You have to find out what your range of data is. Once you know that, you can build an AVRO schema that will let you ensure data range accuracy. This will also let you query that data on the device in MiniFi or in Apache Calcite SQL, using Apache NiFi at the router or gateway level and beyond. Being able to accept many types of data including large

strings, JSON, images, large sets of numbers, and unstructured data is critical when you're working with edge devices. They often get updates or variations on what they can send, and you will sometimes only get periodic network connectivity to update those sensors. You also have to work with hundreds of different devices, different sensors, different versions of sensors and devices, different operating systems, and other factors. See dzone.com/articles/sensors-utilizing-breakout-garden and an example on my GitHub Page.

Edge Processing

As we mentioned, we have a lot of unchanging data that may not need to be sent to a remote source every second. We may want to send periodic data every 15 minutes or hour. We definitely want to send any alert conditions or changes right away. So, we need some ability to analyze data and act on it at the edge. The MiniFi C++ or Java agents are good options for this. We want to collect data at the edge as well as route and monitor it. This is where we can check for edge values and setup alert conditions to trigger an immediate action's location (such as restarting a service) or contact our remote resources. To enable more powerful transformations and enrichment, we will usually have a flow management solution at or near the edge, usually in the same building or network to host an Apache NiFi server or small cluster. This will allow for more powerful transformation, queries, alerting conditions, rule processing, and machine learning classifications and analytics.

Transportation Options

Next, we need to get the data from the devices that read the sensor to another machine. The first step is usually a local router/gateway such as a flow management engine. This can do some aggregation and operate on local networking protocols before we send our streams to another server for processing, analytics, and storage. For transport options, there are three options that I recommend. The first is to use MiniFi's HTTPS transport, which can make it through almost any router, gateway, or proxy that is in the IoT network layer. This allows for secure, fast, robust transport of your data without loss and with full data provenance and lineage.

The second option is to allow MiniFi to send your messages via MQTT, a fast and open messaging protocol, though this option will reduce some of the MiniFi's data provenance and lineage. The last option is for IoT that is within a cloud or internal network that has Kafka available. Using MiniFi to send messages directly to Apache Kafka can allow for a durable queue to store a lot of data and allow for many consumers. All the major stream processing frameworks support reading from Apache Kafka in a streaming manner. The best approach I have seen in the real-world is using MiniFi's S2S HTTPS transport to an Apache NiFi cluster that can do more filtering, conversation, routing, aggregating, and clean up before routing it to another stream processing framework via Apache Kafka.

Data Lineage and Provenance

One of the most difficult things to do when ingesting device data and stream processing is the distributed nature of the systems. You are running on many devices, networks, clouds, systems, computers, containers, VMs, and systems. An event can fail or be duplicated, and this is hard to monitor if you don't have a full lineage of all the steps involved and all the hops. Apache NiFi provides a rich set of data that can be processed easily in many ways since it is in JSON format. This can be done with Apache NiFi itself or any other processing or monitoring tool that we can send these deep logs to.

Stream Processing

Once the data starts flowing into our stream processing engine via Apache Kafka, we can start doing advanced analytics, windowing, joins, complex aggregations, machine learning, deep learning, and more. I recommend using either Kafka Streams, Spark Streaming, or Streaming Analytics Manager for your complex stream processing. But this is after Apache NiFi has performed routing, enrichment, transformation, cleanup, and prefiltered the data and assigned it a schema. Without a schema, our stream processing frameworks are not as efficient and often have to infer what your schema is to various degrees of success. They are amazing with fixed records with schemas that can be in the header, embedded in AVRO data or in a schema registry available via REST API. Kafka Streams lets you do some stream processing in ways you will be familiar with if you have done MapReduce or Spark programming. You can do aggregation, counts, reductions, grouping, or windowed aggregations. I have a simple example that you can see on my GitHub page, using Java to develop a very simple Kafka Streams microservice for processing data sent via Apache Kafka from Apache NiFi. In my example, I am checking for an alert condition upon which I am sending an MQTT message. I could, of course, do many more things inside my Kafka Streams application.

Summation

We have seen that we can collect, route, monitor, transform, enrich, and process device data at scale using open source tools. This process is made more complex because of the nature of edge devices and the constant stream of data that they send. Using the correct open-source tools, we can make this process quick and easy.

TIM SPANN a Big Data Solution Engineer. He helps educate and disseminate performant open source solutions for Big Data initiatives to customers and the community. With over 15 years of experience in various technical leadership, architecture, sales engineering, and development roles, he is well-experienced in all facets of Big Data, cloud, IoT, and microservices. As part of his community efforts, he also runs the Future of Data Meetup in Princeton. LinkedIn Twitter

Is IoT Development Failing?

A common theme in the electronic component industry is the higher number of IoT products, product developments, or projects that fail. Many of these projects are truly brilliant, but why do so many fail?

What IoT brings in a technological advantage, it also adds in complexity. Many applications begin with familiarity. If I've used a series of Microchip MCUs, I'm more likely to want to stick with that in my application. These provide great starting points, but then what? All the hardware design aside (power usage requirements, PCB design, BOM development, etc.), you have to get your device to send data to the cloud or an application, then do something with the data; store it, analyze it, action it, display it, or make use of it in some other way.

But there is one more common theme we see often, small companies that develop a product and have a lot of success with it. What do these companies/developers have in common? Other than being good designers, many have a well-defined starting hardware, have a good understanding of what is needed for connecting hardware to the cloud or at least have it mapped very well, and didn't underestimate certification costs and factored those into the product selection.

What is your starting point? Most MCU and MPU vendors have a platform you can build on, expand on, or add sensors or connectivity through common interfaces (mikroE click boards, Arduino shields, Grove sensors, etc.). What is needed to connect this hardware to the cloud? There are sample software applications that provide an excellent starting point from the cloud vendor, the MCU vendor or other applications builders like Digi-Key's IoT Studio. Certification costs are often a make or break for many projects, either they don't pass, or they're cost prohibitive. FCC, PTCRB, or Carrier certs can easily surpass the design costs. Using certified modules or end-device certified modules for cellular can save 10's to 100's of thousands in costs.

The ability to start with the right platform, map out your IoT project, and minimize your certification costs can lower your time to a great proof of concept you can build on and reduce your development and production costs.

WRITTEN BY JOSH MICKOLIO
PRODUCT MANAGER – IoT AT DIGI-KEY ELECTRONICS

PARTNER SPOTLIGHT

DK IoT Studio

Rapid Development Platform for IoT Designs

Category Online development software

Release Schedule Updated bi-weekly

Open Source? No

Case Study The DK IoT Studio provides a simple development tool for IoT Designs. Pick your platform, add sensors and connectivity, design your app for IOS or Android, and connect your device to the cloud all in the same program. As you build your application, code is generated for your project that you can use as is or edit to fine-tune your project later. You can download a project and share with others to import into DK IoT Studio; a great feature for hardware and software designers alike.

Strengths

- Delivering Radical Simplicity to IoT Developers
- Idea to prototype in minutes
- No need to write code but you still get the code if you want it
- New MCU platforms, sensors and connectivity options every month!
- Support for microservices architecture and container deployment

Website digikey.com/en/resources/design-tools/dk-iot-studio

Blog digikey.com/en/blog

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What Makes a Good Connected Product?

QUICK VIEW

01. Your connected product development is a mixture of strategic and technological decisions that will influence your customer's experience.

02. Ethics isn't an afterthought in a world post-GDPR.

03. Privacy, security, and lifecycle issues are crucial to consider early on in the development of your idea.

BY ALEXANDRA DESCHAMPS-SONSINO
INDUSTRIAL AND INTERACTION DESIGNER

Defining "good" is a matter of culture, but people around me have been asking themselves what makes a good product based on the Internet of Things. We've seen plenty of examples of "bad" behavior — products made defunct after acquisitions, aggressive T&Cs applied to the detriment of consumers, and cybersecurity issues are only a few of what's out there now, 18 years after the term "Internet of Things" was coined by Kevin Ashton.

A time of reflection was kicked off in 2012 at an event that I helped organize in London: the "Open Internet of Things Definition." In 2014, friends of mine started Thingscon with a Berlin conference exploring "responsible IoT." In 2015, the IoT Security Foundation held its first event in Blechley Park. In 2017, I helped organize an event that explored a possible certification mark for connected products, "IoTmark" (now a free tool called Better IoT), and the US passed a law called IoT TIPS Act that same year. The Department for Culture, Media, and Sports published the Code of Practice for Consumer IoT Security in March 2018 followed by the British Standards Institute with an IoT Security Kitemark™ in May 2018. More recently, Thingscon co-founder Peter Bihr launched the Trustable Tech Mark last December. All these and many more around the world show that for a startup considering building a connected product, ethical and technical decisions have to be made to protect their customers and consumers at large.

Here's a breakdown of what any budding Internet of Things entrepreneur should consider today.

Lifecycle

Does your website or packaging communicate clearly to your customers how long they can expect the product to work for? In the event of your company's demise (hey, it happens to the best of us), what will happen to the product? Will it stop working altogether? Ideally, you will think about open-sourcing the hardware or backend service to allow a third party to support it on your behalf, and you'll think about who that might be. It's really important that consumers feel like they're buying a product that will stick to its expected lifespan even if you're not around. Back in 2016, Revolv, a smart home hub, had its service unexpectedly terminated by Google, which had recently acquired the company. That wasn't the most elegant way to go about it, and there was uproar from consumers.

Another aspect of lifecycle to bear in mind is the idea that the product someone buys should maintain the core functionality no matter what. Sonos made it compulsory for consumers to accept their change of Terms and Conditions; otherwise, their connected sound systems would cease to function. These kinds of draconian techniques don't put the consumer in charge of the product they bought. And in the

eyes of many Consumer Protection Acts around the world, they have rights over — and aren't at the mercy of — digital business models.

Of course, many consumer rights are limited to refund periods (usually 30 days) and don't impose a period of functionality. How disposable connected products are because of their lack of long-term digital service support contributes to e-waste and pollution, which regulators are bound to examine in the coming years. We can eventually expect a "minimum support clause" to become part of the export and certification process for these products. You should prepare yourself by making it very clear what you'll support, how, and how quickly. This will always help a consumer understand what they're buying and make you stand out on public forums like Trust Pilot.

It's hard being an IoT entrepreneur, as the mixture of software and hardware multiplies the problems that you're likely to encounter — but that doesn't mean that the journey is impossible.

Privacy and Permissions

Chances are, more than one person will use your product — especially if you're a smart thermostat company, for example — and offer multi-user access or work on the premise that the product will eventually be sold on eBay. With this in mind, the consumer you sold your product to might not be the one who uses it years after the purchase was made, and you should be flexible about the number of users engaged at any given time because consumer's lives are complicated. The reason why most companies don't offer this is that they'd like to track individual use so that the data produced becomes more valuable, but this is usually at the expense of enjoyable user experience, which ends up costing you in lost recommendations and purchases from other people.

Privacy is another key concept that, in a world post-GDPR, is still very tangible and makes things difficult for companies. When disposing of a connected toothbrush, a consumer should have the choice to archive that data in a way that is both machine-readable and understandable to them. A connected product should always advertise when it is connected (with a status LED, for example, which voice assistants could do with) and have a button to reset to its factory settings so that all the data that might be collected locally is wiped. This gets complicated with products like Amazon Alexa and all the other voice-activated services, as it's unclear to the consumer how much is being captured at any given time, where it goes, and who ends up storing it. For them not to pose a privacy and security risk, those processes should be made clear with simple-to-understand language and without legalese hidden in the terms and conditions.

Security

From a technical standpoint, security is big business for security firms that are rarely equipped to offer their services to startups. This means that certain technical decisions are taken without malice but backfire when a product gets hacked by a third party. Penetration (PEN) testing is prohibitive to startups, so mitigating as many risks as possible can be achieved with some simple digital security decisions outlined by the OWASP Top 10 Project. Some of these include:

- Minimum cryptographic security on the backend and secure configuration
- A backend that implements additional security options
- Implementing reliable and appropriate backend patching
- Enforcing a strong user identity policy
- Developing clear admin user rights management tools

It's hard being an Internet of Things entrepreneur, as the mixture of software and hardware multiplies the problems that you're likely to encounter but that doesn't mean that the journey is impossible. Many companies have built sustainable and growing businesses, and many of them will end up growing internationally. The first step to success is to mitigate future problems — and doing so ethically makes successful customer interactions more likely. That's not to say that building things ethically is a guarantee of success, but as the fair trade movement proves, it can create its own voice within an industry and give the products a great platform. As more governments get behind some of these efforts, entrepreneurs who design ethically will find it easy to make friends in high places, and that's never a bad thing.

ALEXANDRA DESCHAMPS-SONSINO is an industrial and interaction designer who was the first distributor of the Arduino in the UK. She is the founder of GSM-based product Good Night Lamp and the author of Smarter Homes: How Technology Will Change Your Home Life. She steers Better IoT, a European community project to support SMEs in their IoT development. LinkedIn

How Data Monetization Is Creating a New Data Economy for IoT

QUICK VIEW

01. Data analytics can save companies millions in terms of running costs through predictive maintenance insights, waste reduction, and reduced downtime.

02. Monetized market trading has been rather slow with most companies in pilot mode, building alliances and partnerships for an extended period of time.

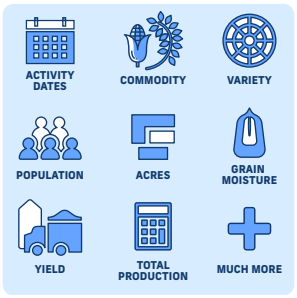
BY CATE LAWRENCE
ZONE LEADER, DZONE

The capabilities of connected technology are expanding rapidly with the trajectory of the Internet of Things moving at a rapid pace, bringing monumental benefits to industries. The ability of connected devices to collect, collate, and analyze data has gone to the next level through the ability of devices to sell and trade everything from storage and computation/analytics to electricity and sensor data. Data analytics can save companies millions in terms of running costs through predictive maintenance insights, waste reduction, and reduced downtime. We've also seen a layer of monetization where connected devices will be layered with various Software-as-a-Service options, from energy cost insights (e.g. knowing a refrigerator is not cold enough or that a home device is using more energy than normal and costing more) to subscription models (e.g. a coffee machine that orders extra coffee beans when running low or a refrigerator connected to a food delivery service).

But we're moving even further — and what's emerging is the evolutionary creation of a "machine economy." This has brought forth a slew of platforms, marketplaces, and trading spaces designed to enable companies to sell or exchange data. Let's look at some noteworthy examples.

Farmobile

Farmobile creates a means to buy and sell farm data. Farmers pay a yearly subscription that includes a passive uplink connection (PUC) — a small, in-cab device that collects machine and agronomic data every second. As farmers work in the fields, Farmobile automatically builds an electronic field record (EFR) of data, including planting dates, commodity, variety, population, harvest dates, total production, average yield, average moisture, and more. Twice yearly, at the end of the planting and harvest seasons, data is certified and placed in a data store for purchase by equipment manufacturers, agronomists, insurers, and other interested parties. Data can be sold multiple times to different buyers each season. Its value compounds year-over-year, providing ongoing monetization opportunities. To date, the PUCs have gleaned data from more than one million acres of farmland.



Last year, the company rolled out its data marketplace, DataStore, the first private digital exchange for machine and agronomic information. DataStore leverages blockchain technology and allows farmers with certified data to receive offers for data and accept or reject them. They also can choose to license their data multiple times, creating a recurring revenue source.

Streamr

Notably, many emerging marketplaces are using blockchain and

related technologies to facilitate a means to buy and sell data. The key benefits posited are the ability to make micro-payments at an extremely low cost via efficient payment methods and immutable records of data transactions. One example is Streamr, which is creating a decentralized means for just about anyone to buy and sell data. Their open-source platform allows data owners to easily connect to the peer-to-peer network to stream their data and also uses blockchain smart contracts and tokens to facilitate transactions and incentivize data exchange respectively. They note:

"Your automobile will soon be producing data about congestion, road quality, and mechanical feedback. If you choose, this can all be sold to highways agencies, fellow drivers, parts manufacturers, and smart city operators who can use it to make automated road repairs, schedule maintenance, and redirect traffic in real-time."

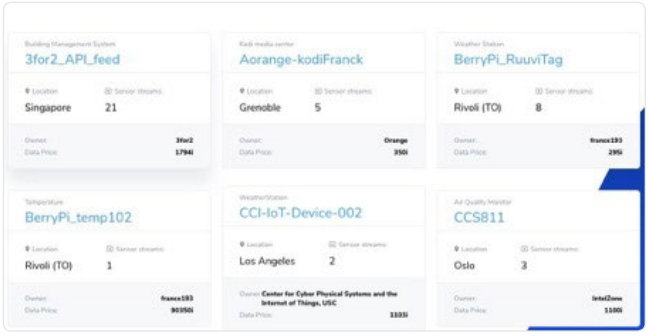
DataBroker

A similar offering is in operation through DataBroker by Data Dao. One of their first use cases involved data from shipping containers from the Port of Antwerp. If insurers were able to buy data around temperature and discover, for instance, when the temperature control failed on a ship, they would know when things went wrong and appropriately manage a claim.

They cite another group of potential buyers: academics, scholars, scientists, and researchers who are always in need of accurate, reliable data to back up their scientific research. While data sharing is cited as a means to accelerate science by facilitating collaboration, transparency, and reproducibility, Data Dao notes that data sharing is still relatively limited. Apart from the privacy issues, proprietary aspects, and ethics, there is a lack of training in data sharing, and sharing data is not associated with credit or reward. Data marketplaces mean that researchers who require weather data or data from pollution, power grids, or vehicle telematics can now buy access to a feed from a weather sensor that is already being used instead of having to invest in sensors themselves.

IOTA

Then, of course, there's the envy of many who wished they got there first: IOTA, with their data marketplace, launched in Nov. 2017. They contend that their public distributed ledger architecture, Tangle, in opposition to blockchain, ensures data authenticity and an audit trail of data as their ledger enables tamper-proof data. Late last year, industrial behemoths Bosch announced that their Cross-Domain Development Kit (XDK) — a "universal programmable sensor device equipped with sensors to measure various ambient data including humidity, noise and light levels, and acceleration" — would now be able to simultaneously collect, upload, and sell data on IOTA's decentralized data marketplace in fully open-source code.



Rest assured, it's not all blockchain — offerings such as Samsung Artik, Dawex, and Terbine do not rely on blockchain technology for real-time data retail. For example, Terbine utilizes IBM cloud, Watson IoT, and AI to facilitate a means to monetize the massive volumes of IoT data available.

The Evolutionary Journey Is Slow and Cautious With More Questions Than Real Answers

In reality, monetized market trading has been rather slow with most companies in pilot mode, building alliances and partnerships for an extended period of time. This makes it easy to generate plenty of questions about data monetization and the role of data marketplaces, specifically:

- How will the data marketplaces compare with each other?
- How will they leverage their competitive advantage?
- What happens to a company's data if an exchange is closed or sold to another competitor?
- Can data be sold after the original purchase to a nefarious third party (presumably something the blockchain-embedded marketplaces are claiming to prevent)?
- What if a data marketplace is hacked?
- How many data marketplaces will proliferate? (Hopefully, it won't be as onerous and the proliferation of competing IoT platforms.)

But what is clear is that we're at the very cusp of IoT providing a new stream of revenue and setting a new data economy — making connected devices more valuable than ever.

CATE LAWRENCE An experienced technology journalist and writer based in Berlin, Cate brings an understanding and focus on IoT, biohacking, and future technology to DZone. She likes to look behind the technology to see the challenges and opportunities its creation poses for developers, users, law makers, and society. LinkedIn Twitter


influxdata
The Modern Engine for Metrics and Events
Why the Industrial IoT World Needs Open Source to Innovate
By gathering all this data centrally and in InfluxDB from all of these different sources and adding custom interpretation on that, our manufacturing customers are able to perform operational improvements with ease.
— Frederik Van Leeckwyck, Factry.io
DOWNLOAD THE E-BOOK

IoT Data is Time Series Data

Time Series Databases are the fastest growing database category, according to independent research, and store measurements tracked over time. Time series are simply measurements that are tracked, monitored, downsampled, and aggregated over time. This could be server metrics, application performance monitoring, sensor data, or trades in a market. The key difference with time series data from regular data is that you're always asking questions about it over time.

If you think about it, sensor data, or IoT data is time series data where the data collected is time-stamped to show change over time in order to improve efficiency for things such as energy use, structural health, or even material quality levels. You can see how useful this data is, but one issue that many companies face is around the massive amounts of data that all of these devices produce. Companies need to figure out a way to store, track, analyze, and make sense of the vast amounts of data that is generated.

Because of this, Time Series Platforms are becoming a critical architectural component in IoT implementations.

The Time Series Workload

Time series data is very different from any other workload: millions of writes per second, the ability to do real-time queries on huge datasets, time-based functions that help measure change over time, optimal disk compression with these large data sets, and the need to keep high-value data accessible for real-time access, while storing older data with potentially different time precision available for historical analysis.

InfluxData is the leading Time Series Platform and comes out of the box ready to use. Learn more.

WRITTEN BY CHRIS CHURILO
DIRECTOR OF PRODUCT MARKETING, INFLUXDATA

PARTNER SPOTLIGHT

InfluxData

The modern engine for metrics and events

Category Time Series Data Platform

Release Schedule Quarterly release cycles

Open Source? Yes

Case Study tado° connects cooling and heating systems with the Internet to enable consumers to intelligently control them. Their app adjusts to the residents' behavior in real time and also takes current weather forecasts and building characteristics into account. tado° uses InfluxData to gather analytics data collected from its hundreds of thousands of units across the globe. tado° uses this data to power its smartphone apps which helps its customers understand their energy usage and determine their ideal setting. This IoT monitoring use case shows how using the right tool to power tado°'s IoT platform gives the company the proper insights to generate energy savings for its customers.

Strengths

- Developer Happiness
- Faster Time to Awesome
- Ease of Scaleout and Deployment

Notable Customers

- Tesla
- Siemens
- BBOXX
- Spiio

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Getting Started With IoT Hobbyist Projects

QUICK VIEW

01. There are dozens of IoT projects we can build to experiment with IoT utilizing sensors, cloud platforms, external peripherals, or any combination of the three.

02. Low-cost sensors and components enable us to experiment with IoT by building several IoT projects by ourselves so that we can realize what is IoT and how to use it.

03. On the market, there are dozens of prototyping boards with different features and specifications that we can use to build an IoT project.

04. An important role is played by M2M protocols that enable data exchange between smart devices and IoT cloud platforms.

BY FRANCESCO AZZOLA
IT ARCHITECT

The Internet of Things is revolutionizing not only several aspects of our lives, but it is also having a big impact on several areas, for example:

- Manufacturing
- Transportation
- Utilities
- Smart cities
- Smart homes

An interesting aspect of IoT is that we can use it to build hobbyist projects and we can experiment with them by ourselves, thanks to the availability of low-cost components.

When we approach the IoT for the first time, we may feel confused and disoriented, because it involves several disparate technologies, some of which are widely used, such as HTTP, and others which are specific to IoT development.

Moreover, an important role is played by hardware components such as sensors and microcontrollers. This article aims to be a practical guide to help you approach the development of an IoT project from a hobbyist's point of view.

When you start building your first IoT project, there are several pieces you need to consider. Generally speaking, an IoT project is built on several small bricks, including:

- Sensors
- Prototyping boards
- IoT cloud platforms
- External peripherals
- Motors
- Applications developed using different programming languages

Before analyzing the roles these bricks play, it is important to briefly describe what kind of IoT projects you can build by yourself.

Use Cases

There are countless projects we can build to experiment with IoT tech. From the hobbyist's point of view, we can group these projects into these categories:

- Sensor-based projects
- Cloud-based projects
- Projects with external peripherals (such as LEDs, displays, servos, motors, etc.)

SENSOR-BASED PROJECTS

This is the easiest IoT project you can build. These kinds of projects use sensors such as:

- Temperature sensors
- Pressure sensors
- Humidity sensors
- Light sensors
- Gyroscopes
- Gas sensors

For these projects, we want read the sensor data values and use them locally without the need for an internet connection. A typical example could be a weather station or a system that monitors gas leakages.

CLOUD-BASED PROJECTS

This is a more complex project in which we use an IoT cloud platform to store and analyze data. An IoT cloud platform is a cloud platform that provides several services to simplify IoT project development. These services can include:

- Data ingestion
- Data analysis
- Data visualization
- Connection and device management
- Provide security and authentication

This type of project is an extension of the sensor-based project, except the data that is acquired is are sent to the IoT cloud platform through the Internet. It is also possible to use IoT cloud platforms to remotely control these devices.

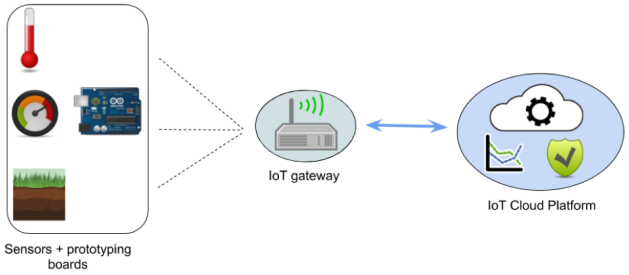
PROJECTS WITH EXTERNAL PERIPHERALS

These IoT projects use external peripherals connected to prototyping boards. For example, a simple IoT project might use an LED strip connected to a prototyping board (such as Arduino or ESP8266). We can also connect DC motors or servos to build a simple robot. Another interesting use case is based on a relay that we can use to turn an appliance on or off.

Another interesting use case is based on the integration between smartphones and an IoT ecosystem. Almost all of the categories described above can be integrated with a smartphone so that we can control a prototyping board remotely or visualize information gathered by sensors.

IoT Project Architecture Overview

Before starting an IoT project, it is useful to have an overview of the architecture of an IoT project so that you can understand the role played by individual components.



This simplified IoT project overview is based on using prototyping boards.

Generally speaking, at the edge of an IoT system, there are sensors connected to some prototyping boards. In this context, the prototyping board controls the sensors and acquires data from them. At this level, there are also actuators, which are devices that we can use to intervene in the physical world. For example, they can switch lights on or off, open or close a door, and so on.

These prototyping boards do not do heavy work. Usually, these kinds of prototyping boards exchange data with a gateway that collects all the information coming from several boards/sensors, applies some data transformation to it, and sends it to a cloud platform.

The simplest way to include an IoT cloud platform is by using data ingestion and data visualization. A common project is to visualize the data coming from sensors, which requires a cloud platform to both analyze the data and, consequently, to take some action to implement a specific business process. For example, using a specific algorithm and the data gathered from soil sensors, an IoT cloud platform could send a command to an actuator to turn on the watering system in a garden. The rise of machine learning algorithms integrated with the IoT are creating new scenarios where machine learning can be used to control devices and appliances.

Another typical use case of an IoT platform is to integrate cloud services so that when an event occurs, it will trigger a chain of events that involves those services. For example, it is possible to send a notification to our smartphone when a value measured by a sensor is over a threshold.

There are several IoT platforms that provide a free account with some limitations, which we can use to build a hobbyist IoT project.

When you build an IoT project, you can simplify the architecture

shown above, connecting the prototyping boards directly to the IoT platform as long as the prototyping board supports the platform protocols and security standards.

> The rise of machine learning algorithms integrated with the IoT are creating new scenarios where machine learning can be used to control devices and appliances

IOT PROTOCOLS

In the project overview defined above, it is important to specify and describe the IoT protocols that we should use when building a project.

As mentioned before, in this context there are some protocols we already know from other applications, such as HTTP/HTTPS, but there are other protocols specific for IoT and more oriented to an M2M data exchange. One of the most widespread protocols is MQTT. It is a widely adopted, message-based, lightweight protocol based on the publish/subscribe (pub/sub) paradigm. To make things simple, the key component is an MQTT-broker that dispatches messages to one or more MQTT clients. The broker uses *topics* to filter the MQTT clients that will receive the message. There are several MQTT implementations for different prototyping boards (Arduino, Raspberry and so on).

Almost all IoT platforms use MQTT to exchange data. There are other protocols that we'll just mention without covering them in depth, including: AMQP, CoAP, Stomp.

IoT Prototyping Boards

By now, we have described which kind of IoT projects we can build by ourselves as well as prototyping boards. Nowadays, there are several boards, which have different features and computing power. The classic development boards commonly used when developing DIY IoT projects are:

- Arduino family boards
- Raspberry family boards
- ESP boards
- Particle boards

This is just a small list of the dozens of development boards available on the market that can fulfill our needs. It is important to select the right board according to the role it will play in our IoT project. A rule of thumb is:

- If we only need to control sensors or actuators we can use an Arduino Uno or compatible boards.
- If we require an internet connection, we can select an ESP family board (i.e ESP8266) that has built-in WiFi support.
- If we need more computational power because we need to implement application logic, we can use a Raspberry Pi 2 or 3. We could run some machine learning algorithms or frameworks on these boards (see Tensorflow).
- If you want to develop an IoT project within a complete ecosystem where you do not have to worry about selecting a specific IoT platform, you might consider Particle boards.

Conclusion

At the end of this brief introduction to IoT, we've reviewed the dozens of IoT projects you can build to experiment with IoT. These low-cost components and boards allow us to take the first steps into the IoT world without spending too much or committing to massive industrial IoT projects.

FRANCESCO AZZOLA is an electronic engineer with over 15 years of experience in computer programming. He is the author of the book "Android Things Projects," and loves creating IoT projects using Arduino, Raspberry Pi, Android, and other platforms. He is especially interested in the convergence between IoT and mobile applications. He is SCEA, SCWCD, and SCJP certified. He runs a blog called survivingwithandroid.com about Android and IoT. LinkedIn Twitter

Why the Industrial IoT World Needs Open Source to Innovate

QUICK VIEW

01. Commercial data historian solutions present various challenges — primarily cost, vendor lock-in, and scalability.

02. Open source solutions, as an alternative to proprietary software, allow the industrial sector to optimize operations and allow developer teams to quickly bring ideas to fruition faster.

03. InfluxDB is central to many IIoT solutions as it provides high throughput ingest, compression and real-time querying of time series data.

BY CHRIS CHURILO
DIRECTOR OF PRODUCT MARKETING, INFLUXDATA

The industrial world has a long history of modernizing their process controls in order to keep production running efficiently and safely while minimizing downtime. Yet many are locked in established data historian solutions that are costly and lack the methods needed to provide innovation and interoperability. In contrast, open source software — which is built on the foundation of community — inherently provides diverse design perspectives not available from a single software vendor. It provides freedom from vendor lock-in, which means it will always provide you with the ability to integrate with other solutions. And finally, open source software provides customization, allowing you to adapt the code to fit your ever-changing system requirements (which is not easy with proprietary systems). In this article, we will examine what the existing solutions lack and review a few open source projects that should be considered for future success for operators.

Current situation

Industrial organizations around the world, whether large or small, have been working with a number of solutions to digitally transform their manufacturing processes. Most organizations use a system of software and hardware components called Supervisory Control and Data Acquisition (SCADA) to help control machinery and systems in a factory in real time. In particular, these systems control processes locally or remotely by gathering event data from sensors, valves, pumps, motors, and recordings. In addition, the relevant data is presented to the operator to make decisions about the machinery to keep it running optimally. Many industries rely on SCADA systems — including energy producers, manufacturing, and food and beverage — to collect event data such as:

- Instrument readings (flow rate, valve position, temperature)
- Performance monitoring (units/hour, machine utilization vs. capacity, scheduled vs. unscheduled outages)
- Environmental readings (weather, atmospheric conditions, groundwater contamination)
- Production status (machine up/down, downtime reason tracking)

All process and event data include a value and a timestamp and are stored in a data historian to show trends per machine

or across a collection of machines. A data historian is a time series database, and as such, needs to allow for fast ingest and query of data in near real-time and provide compression of the data to minimize storage.

There are many commercial data historian solutions in the market, and several have been in market for some time, yet all these solutions come with a number of challenges — primarily cost, vendor lock-in, and scalability.

Cost — These solutions are not cheap, charge an annual license and support fee, and are costly to setup and maintain. Moreover, custom development on top of these off-the-shelf products is common, which may require outside consulting resources. And since these solutions are proprietary systems, the work is time-consuming and expensive.

Vendor Lock-in — These solutions are often Windows-based and do not offer a simple, open API for other software to interface with. This means you are limited to integrate and buy all components from only one vendor, locking you into a proprietary solution.

Scalability — Collecting event data from your equipment is just the beginning. True digital transformation requires more data sources and more analysis of the combined data to gain a better understanding of your systems. Doing so with the existing solutions will require the vendors to create (and charge for) new interfaces for data import. The good news is that this data is easy to export to spreadsheets. The bad news is that spreadsheets only give you a static view. What is required instead are modern dashboarding engines which have obsoleted the idea of exporting large time series data sets. Ultimately, with all this data coming in, you can no longer rely on manual techniques for analysis.

An open-source alternative

To contend with these challenges, the industrial sector should consider new ways for optimizing operations, including trying open source solutions. Previously, open source held the stigma of being the cheap alternative to proprietary software. Today, open source is at the heart of innovation in organizations, as it allows developer teams to quickly bring ideas to fruition faster.

InfluxDB

Built for developers, InfluxDB provides high throughput ingest, compression, and real-time querying of that same data. Efficiency and effectiveness have to start in the data structure, ensuring that time-stamped values are collected with the necessary precision and metadata to provide flexibility and speed in graphing, querying and alerting. The InfluxDB data model takes the following form:

```
<measurement name>,<tag set> <field set> <timestamp>
```

The measurement name is a string, the tag set is a collection of key/value pairs where all values are strings, and the field set is a collection of key/value pairs where the values can be int64, float64, bool, or string. Support for data encoding beyond float64 values means that metadata can be collected along with the time series, and not limited to only numeric values. In addition, there are no hard limits on the number of tags and fields.

Efficiency and effectiveness have to start in the data structure, ensuring that time-stamped values are collected with the necessary precision and metadata to provide flexibility and speed in graphing, querying and alerting.

Having multiple fields and tags under the same measurement optimizes the transmission of the data, which is important for remote devices sending metrics. The measurement name and tag sets are kept in an inverted index which makes lookups for specific series very fast. See below how battery metrics mapped in InfluxDB line-protocol:

```
telemetry,product_id=1,battery_type=lead-acid
voltage=10.1,current=-0.5,temperature=23.4
1464623548s
```

Factry

Factry Historian is a data collection platform for production systems. They use InfluxDB to store time series data, and open sourced two projects to collect and expose time series data

using the OPC-UA standard. The OPCUA-to-InfluxDB open source app polls a number of PLC values and writes the data into the database. If the database is unavailable, it buffers the data in a local database. You can see they types of values they are able to collect and store.

```
[[measurements]]
name               = "temperature"
tags               = { equipment = "TANK42" }
nodeId             = "ns=3;s=PLC_TANKS.db103.16,r"
collectionType     = "polled"
pollRate           = 12     # samples / minute.
deadbandAbsolute   = 0      # Absolute max
difference for a value not to be collected
deadbandRelative   = 0.0    # Relative max
difference for a value not to be collected
```

They also open-sourced an OPC-UA server that exposes the data stored so a SCADA system can connect to this server and read the data at the interval it needs.

The Factry solution can serve as a model for a creating a Data Historian replacement, using open source projects for data collection and storage.

Grafana Labs

Grafana is an open source tool for visualizing time series data. It connects directly to your data source to help you create visualizations that can show data in near-real time, instead of the stale data that you present with spreadsheets. Grafana has a number of visualization options to help you understand your data, and is backed by a vibrant community who help to contribute a number of dashboards and plugins for a variety of use cases.

The interesting thing about dashboards is that they help to fuel collaboration and inquisitiveness, which can result in even more efficiencies. With a simple point-and-click interface, you will find all users starting to dig into the data to find areas to improve upon.

Figure1: Grafana dashboard

Loud ML

Loud ML is an open-source deep learning API that makes it simple to prepare, train, and deploy machine learning models and crunch the data stored in a number of datastores. The user selects the times series that they want to model and sets the model date ranges, then Loud ML will build the models and save them for inference in production. You can add predictive capabilities and machine learning to your application in minutes and use it for:

- Forecasting capacity, usage, and load imbalance for energy producers and suppliers
- Forecasting demand for inventory and supply chain optimization
- Predict equipment failure for maintenance operations planning

The user interface makes it easy to start building powerful predictions of your operational data.

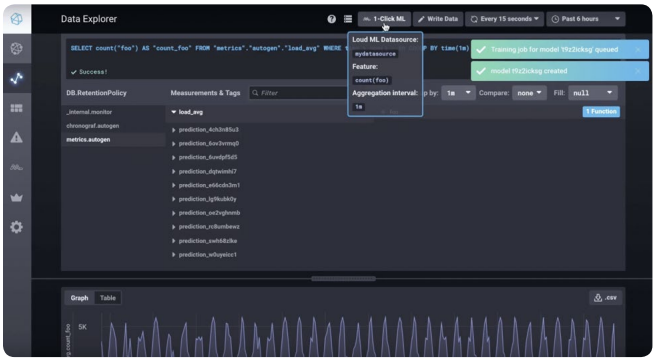


Figure 2: 1-click machine learning with LoudML and Chronograf

Conclusion

Open source tools are powerful and easy to use and have shown to make a difference in various industries, leveling the playing field for startups to compete with established players. These solutions are quick to setup and get started, but more importantly, they will work in your environment and produce the improvements that will start to appear in your bottom line quickly.

CHRIS CHURILO is responsible for Product Marketing at InfluxData. Prior to joining InfluxData, she defined and designed a SaaS monitoring solution at Centroid, and prior to that she was the VP of product management at iPass and was the LOB for several cloud services that required her to track the business and operational metrics and analytics to help identify and resolve issues. LinkedIn - Twitter

2019 Executive Insights on IoT

QUICK VIEW

01. Security, scalability, and integration are three keys to a successful IoT strategy.

02. Secure IoT devices by using best practices including access and authentication, as well as encryption.

03. Organizations can get more out of IoT by having specific use cases in mind, realizing how valuable their data is, and the potential for getting value from the data.

BY TOM SMITH
RESEARCH ANALYST, DEVADA

To understand the current and future state of IoT, we spoke to more than a dozen IT executives active in the space. Here's who we spoke to:

- **Mike Donovan**, V.P. of Product, Aquicore
- **Adam Fingerman**, CEO, ArcTouch
- **Dave Schuman**, Mobility Leader, Cloudera
- **OJ Ngo**, CTO and Co-founder, DH2i
- **Suzy Visvanathan**, Director of Product Management, MapR
- **Uri Sarid**, CTO, MuleSoft
- **David McCall**, President, and **Clarke Stevens**, Chair, Data Model Tools Task Group and Vice Chair, Data Modeling Work Group, Open Connectivity Foundation
- **Zach Supalla**, Founder and CEO, Particle
- **Steven Blum**, CTO, PubNub
- **David Bericat**, Global Technical Lead, Industrial IoT and Edge Computing, Red Hat
- **Vaughn Shinall**, Head of Product Outreach, Temboo
- **Ray Wu**, CEO, Wynd

Key Findings

1. Security, scalability, and integration are the keys to a successful IoT strategy. IoT devices must be secure since security vulnerabilities can have real-life impact on users and the people around them. You need to ensure you are protecting the deployment and the data flowing through it. There are many security strategies. The most important are end-to-end encryption, access management, secure firmware provisioning, and open-port management.

Determine the platform size needed and its ability to scale for a number of years based on ever-growing data ingestion and processing requirements. You must be reliable at scale, not just in the lab. Your infrastructure should be able to scale globally so as users are added further from your points of presence, performance doesn't falter.

Deploy IoT assets as modular pieces that are introduced incrementally, visibly, and intentionally. Get all of the parties together to avoid functional isolation. Focus on interoperability throughout the IoT pipeline.

Fundamentally, it's really hard to build a well-functioning IoT product. There are about 1,000 things you need to get right —

security, connectivity, hardware, app layer, manufacturing, testing — and the smallest mistakes can make a huge difference. Companies need to invest enough resources and set reasonable deadlines so their IoT teams have the time and resources they need to build a fully-baked solution correctly from the start.

2. Secure IoT devices by using best practices including access and authentication, as well as encryption. Start thinking about security from the very beginning. Use industry standard best practices and protocols. Take a holistic approach to thinking about security. Provide a well thought out, open implementation, with specifications to develop secure solutions. Ensure devices are produced by the people who claim to produce them. Insure privacy, integrity, and provenance of the device.

IoT security is a multifaceted issue which includes 1) device security, 2) transport security, 3) data security, 4) credential security, and, 5) system intrusion security. Have end-to-end encryption — industry-standard TLS, as well as enterprise-grade AES. Messages in-transit should stay encrypted the entire journey, never being unpacked in the middle of transit.

3. Organizations can get more out of IoT by having specific use cases in mind, realizing how valuable their data is, and the potential for getting value from it. Think big, start small, and prove the use case with a minimum viable product. Learning will be significant and you will learn as you evolve — observe, orient, decide, act, and iterate. Figure out the problem you are trying to solve. Address a real business and generate real value so you have something to sell, make money, and scale. Do this by connecting the data you have to the problems people are trying to solve. Realize the value of your data and how data potentially impacts the people in your organization and your industry, as well as your customers. Generate recurring value to generate recurring revenue.

4. The biggest change in IoT in the past year has been the explosion of voice interface platforms like Alexa, Google Home, and Apple Home Kit. These platforms provide a way for multiple devices to connect and talk. It takes a while to get standards in place to enable devices to work together and voice interface platforms are helping people to see the importance of standards and interoperability guidelines. You need standards if you are developing proprietary software, devices, and applications so they are interoperable.

5. There is tremendous diversity in the use cases for IoT, including home automation and indoor environment, agriculture, environmental, logistics, manufacturing, oil and gas, heavy equipment, energy, utility, smart city, and autonomous vehicles.

6. Reasons for failure are all over the board, with mentions of not focusing on security, choosing the wrong protocols, not focusing on battery and bandwidth consumption, getting locked into a single-vendor environment, insufficient user testing, lacking fundamentals, fear of failure, lack of collaboration between technology and business, use of default passwords, lack of a defined use case, and trying to "boil the ocean."

7. The biggest opportunities in the evolution of IT are cognitive services that will play an increasingly important roles people build intelligence, via ML, into their IoT apps. ML models will evolve to use data more productively. There will be access to different kinds of data that people have not had access to in the past. There are a lot of low-hanging opportunities to reduce waste and improve efficiency, as well as quality of life.

8. Security continues to be the biggest concern regarding IoT today. Security needs to be a consideration for the end product, as well as the technology used to power it. Every part of the application needs to have security built in, with the backend infrastructure and device itself being of equal importance. It's easy to go fast and not think about security, but you're going to see attacks, and those hurt trust. Upkeep of security is important as well. You need to ensure devices and applications remain secure as hackers become more sophisticated. Ultimately, it is up to the product creator and owner of the data to take the right steps (including using proper tools) to protect users.

9. Developers don't need embedded device experience anymore as new frameworks have allowed web and mobile developers to use familiar, native languages to build IoT apps. However, there is still plenty to learn about Kubernetes, GPUs, the Nvidia code library, UX design, Node, and Docker. Developers also need to stay abreast of new tools and be able to secure data on the wire and at-rest. Ultimately understanding the business problem you are trying to solve and being able to collaborate and communicate with others is critical.

TOM SMITH is a Research Analyst at Devada who excels at gathering insights from analytics—both quantitative and qualitative—to drive business results. His passion is sharing information of value to help people succeed. In his spare time, you can find him either eating at Chipotle or working out at the gym. LinkedIn - Twitter

IoT Solutions Directory

This directory of monitoring, hosting, and optimization services provides comprehensive, factual comparisons of data gathered from third-party sources and the tool creators' organizations. Solutions in the directory are selected based on several impartial criteria, including solution maturity, technical innovativeness, relevance, and data availability.

Company	Product	Product Type	Vertical	Website
ADLINK Technology	Vortex Edge PMQ	IIoT hardware, data connectivity, predictive analytics	Healthcare, transportation, smart cities, energy	ist.adlinktech.com/vortex-edge/vortex-edge-pmq
Aeris	Aeris Mobility IoT Platform	IoT platform, connectivity middleware	Healthcare, logistics, transportation, utilities	aeris.com/aeris-mobility-platform
Afero	Afero	IoT platform, security, cloud infrastructure, connectivity middleware	Industrial IoT, wearables, medical, transportation, home automation	afero.io/platform
Alchitry	Mojo V3	Development board	Prototyping, hobbyists, DIY	alchitry.com/products/mojo-v3.html
Altizon	Datonis	Connectivity middleware, device mgmt, big data analytics	Smart city, industrial IoT, utilities	altizon.com/datonis-iiot-platform
Amazon	Amazon Echo	Consumer product	Home automation	amazon.com/Amazon-Echo-And-Alexa-Devices
Amazon	AWS IoT Platform	IoT platform, connectivity middleware, device mgmt	Smart city, transportation, healthcare	aws.amazon.com/iot
Apache Foundation	MyNewt	IoT OS	Device mgmt, connectivity	mynewt.apache.org
Apple	Apple HomeKit	Developer program, SDK	Home automation	developer.apple.com/homekit
Applied Informatics	macchina.io	IoT platform, messaging middleware	App development, device mgmt	macchina.io
Arduino	Arduino Uno	Development board	Prototyping, hobbyists, DIY	arduino.cc

Company	Product	Product Type	Vertical	Website
ARM	Mbed IoT Device Platform	IoT platform, operating system, device mgmt	Prototyping, app development	mbed.com/en/platform
Arrow	Dragonboard 410c	Development board	Prototyping, hobbyists, DIY	arrow.com/en/campaigns/the-dragonboard-is-here
Atmel	Atmel Microcontrollers	Microcontrollers	Hardware	futurlec.com/ICAtmel.shtml
Ayla Networks	Ayla IoT Platform	IoT platform, messaging middleware	Home automation, wearables, logistics	aylanetworks.com/platform
Ayyeka	Ayyeka Wavelets	Sensors	Utilities, smart city, IIoT	ayyeka.com
Beagleboard.org	BeagleBone Black	Development board	Prototyping, hobbyists, DIY, mobile	beagleboard.org/black
BestMile	BestMile	Smart car connectivity platform	Transportation	bestmile.com
Blue Pillar	Aurora	IoT platform	Industrial IoT, energy	bluepillar.com/aurora-energy-network-of-things-platform
Bluetooth	Bluetooth	Device connection	Hands-free point-to-point connections	bluetooth.com/bluetooth-technology
Blynk	Blynk	IoT mobile app	Prototyping, hobbyists, DIY, mobile	blynk.cc
Bosch Software Innovations	Bosch IoT Suite	IoT platform, device mgmt	IIoT, agriculture, home automation, transportation, logistics	bosch-si.com/iot-platform/bosch-iot-suite/homepage-bosch-iot-suite.html
Buddy	Ohm	Smart building sensors	Smart buildings, smart cities	buddy.com/building-monitoring
Bug Labs	Dweet.io	IoT messaging platform	Device mgmt, monitoring	dweet.io
Bug Labs	Freeboard	IoT device visualization	Monitoring, analytics	freeboard.io
Buoy	Buoy	Water system sensors	Home automation, utilities	buoy.ai
C3 IoT	C3 AI Suite	IoT rapid app development platform	Logistics, smart cities, manufacturing	c3.ai/products/c3-ai-suite
Canonical	Ubuntu Core	IoT OS	Industrial IoT, robotics	ubuntu.com/core

Company	Product	Product Type	Vertical	Website
Carmine	Carmine Telematics	Fleet mgmt & monitoring	Logistics, transportation	carmine.io/telematics
Carvi	Carvi	Smart car sensors	Transportation, logistics, insurance	getcarvi.com
Casa Jasmina	Casa Jasmina	Development community	Home automation	casajasmina.cc
Cisco	Cisco Internet of Things Dev Center	Networking, messaging middleware	IIoT, smart city, data analytics	developer.cisco.com/iot
Cisco	Jasper Control Center	IoT platform, networking	Device mgmt, analytics	jasper.com/control-center-for-iot
ClearBlade	IoT Edge Platform	IoT platform	Security, device mgmt, data filtering	clearblade.com
Cloudera	Cloudera	IoT platform	Analytics, ML, data mgmt	cloudera.com/solutions/improve-products-and-services.html
Compology	WasteOS	Sensor network	Logistics, smart city	compology.com/technology
Concirrus	Concirrus Platform	IoT platform, device mgmt	Insurance, data analytics	concirrus.com
Connected Technologies	Connect One	Networking	Device mgmt, healthcare, industrial IoT, smart city, home automation	simplifywithconnectone.com
ConnectM	Yantra Platform	IoT platform, load balancing, data analysis	Home automation, logistics, IIoT	connectm.com/yantra-platform
Control4	Control4	Developer program, SDK	Home automation	control4.com
CoreRFID	CoreRFID	Sensors	Logistics, manufacturing, monitoring	corerfid.com
Couchbase	Couchbase Server	Engagement DB	Key-value, document, data caching	couchbase.com/products/server
Cumulocity	Cumulocity	IoT platform, messaging middleware	Device mgmt, analytics	cumulocity.com
Current	Daintree	Sensors, device mgmt	Utilities, home automation, logistics	products.currentbyge.com/control-systems/daintree-enterprise-wireless-controls
DataArt	DeviceHive	IoT platform, data analytics	Connectivity, analytics	devicehive.com

Company	Product	Product Type	Vertical	Website
DGLogik	DGluk5	IoT platform	Agriculture, analytics, healthcare, industrial IoT, smart city, logistics	dglogik.com/products/dglux5-ioe-application-platform
Digi	Digi XBee3	Networking, sensors	Smart city, IIoT	digi.com
Digi-Key Electronics	Digi-Key	IoT electronics, development board	Wearables, hardware, DIY	digikey.com
DotMatrix Technologies	DotMatrix Connected Device Language	IoT platform	App development & deployment	dotmatix.net
Eclipse Foundation	Kura	Connectivity middleware	Device mgmt	eclipse.org/kura
Eclipse Foundation	Vorto	IoT platform	Device mgmt	eclipse.org/vorto
ElasticM2M	Elastic IoT Platform	IoT platform, IoT modules, data analytics	Transportation, marine, energy, smart buildings, climate	elasticm2m.com/platform
Electric Imp	Electric Imp Platform	IoT platform, connectivity middleware, security	Utilities, IIoT	electricimp.com/platform/how-it-works
enModus	enModus	Smart lighting modules	Utilities, smart city, home automation	enmodus.com
Eurotech	Everyware IoT Platform	IoT platform	Device mgmt	eurotech.com/en/products/iot
Evothings	Evothings Studio	Mobile app development platform, device mgmt	Healthcare, home automation, IIoT	evothings.com
Exosite	Murano	IoT platform	IIIoT, home automation, healthcare	exosite.com/iot-platform
F5 Networks	Big-IP	Networking, load balancing	IIoT, smart city	f5.com/products/big-ip-services
Filament	Filament	Networking	IIoT	filament.com
FitBit	Fitbit	Developer program, API	Wearables	dev.fitbit.com
Flexera	Flexera	Software & tech mgmt	IT asset mgmt	flexera.com
Gadget Factory	Papilio Wiki	Development board	Prototyping, hobbyists, DIY, mobile	papilio.cc

Company	Product	Product Type	Vertical	Website
GE	Predix Platform	IoT platform, operating system	Industrial IoT	ge.com/digital/iiot-platform
GizmoSphere	Gizmo 2	Development board	Prototyping, hobbyists, DIY, mobile	element14.com/community/community/designcenter/single-board-computers/gizmo2
Google	Android Studio	IoT development platform	Wearables, mobile	developer.android.com/studio
Google	Jacquard	Connected clothing	Device mgmt	atap.google.com/jacquard
Google	Nest Developers	Developer program, smart thermostat, API	Home automation	developers.nest.com
Google	Wear OS	Developer program, consumer product, API	Wearables, mobile	wearos.google.com
Google CLoud IoT	Xively	IoT platform, connectivity middleware	Industrial IoT	xively.com
Greenwave Systems	AXON Platform	Messaging middleware, IoT gateway, analytics	Networking, sensors, mobile	greenwavesystems.com/product/axon-iot
Habit Analytics	Muzzley	IoT platform	Device mgmt, home automation	smarthome.muzzley.com
Habit Analytics	Q by Muzzley	IoT platform	Consumer IoT monetization	q.muzzley.com
Helium	Helium Smart Sensors	Sensors	Home automation, environmental, analytics	helium.com
Huawei	Huawei	Networking	IIoT, smart city, agriculture, environmental	huawei.com/minisite/iot/en
IBM	Bluemix	IoT platform	App development, big data analytics	ibm.com/cloud-computing/bluemix/node/4471
Imprint	RIOT	Operating system	IoT hardware, app development	riot-os.org
InfluxData	InfluxData	Time series platform	Data ingestion, real-time querying	influxdata.com/products
infswift	infswift IoT Platform	IoT platform, stream processing, data analytics	Energy, agriculture, climate, smart cities, home automation, transportation	infiswift.tech
Insteon	Insteon Hub	Sensors, developer program, API	Home automation	insteon.com/which-hub-are-you
Intel	Up Squared Grove IoT Development Kit	Development board	Prototyping, hobbyists, DIY	software.intel.com/en-us/iot/hardware/up-squared-grove-dev-kit

Company	Product	Product Type	Vertical	Website
InterSystems	InterSystems IRIS Data Platform	Data platform	Transaction processing, data analytics	intersystems.com/products/intersystems-iris
Itron	Silver Spring	Networking	Industrial IoT, smart city	silverspringnet.com/solutions
Kentix	Kentix360	Sensors	Home automation, home security	kentix.com/en/solutions-and-more/kentix360
Kontakt.io	Kontakt Beacons	Beacons, sensors	Networking, smart city, IIoT, home automation, agriculture	store.kontakt.io
Kontakt.io	Location Engine	Messaging middleware	Networking, smart city, IIoT, home automation, agriculture	kontakt.io/location-engine
leakSMART	LeakSmart	Sensors	Home automation, IIoT	leaksmart.com
Lightbend	Lightbend Platform	Fast data apps	Microservices, ML, intelligent security mgmt	lightbend.com/lightbend-platform
LinkLabs	Symphony Link	Development board modules, routers, API	Prototyping, industrial IoT	link-labs.com/symphony
Litmus Automation	LoopEdge	Edge computing platform for IIoT	Industrial IoT	litmusautomation.com/loopedge
Mender	Mender	IoT platform	DevOps, automated deployment	mender.io/product/features
Meshdynamics	Meshdynamics	Surveillance, hardware, networking	Security, monitoring, IIoT, smart grid	meshdynamics.com
Meshify	Meshify Enterprise	IoT platform, messaging middleware	Device mgmt, IIoT	meshify.com/applications
Microduino	mCookie	Development board modules	Prototyping, hobbyists, DIY	microduinoinc.com/mcookie
Microsoft	Azure IoT Suite	IoT platform, data analytics	Device mgmt, analytics, industrial IoT	azure.microsoft.com/en-us/features/iot-accelerators
Microsoft	Windows 10 IoT Core for NXP	IoT operating system	Robotics, industrial IoT, home automation	developer.microsoft.com/en-us/windows/iot
mnubo	mnubo	Predictive analytics for devices	Manufacturing, industrial IoT, agriculture, home automation	mnubo.com

Company	Product	Product Type	Vertical	Website
Mojio	Mojio	IoT platform	Transportation, smart cars	moj.io/connected-car-platform
MuleSoft	MuleSoft Anypoint Platform	Connectivity middleware	Device mgmt, connectivity	mulesoft.com/platform/enterprise-integration
myDevices	Cayenne	IoT app development platform, messaging middleware	Data analytics	mydevices.com/cayenne/features
Myriad Sensors	PocketLab	Sensors	Environmental	thepocketlab.com
NATS	NATS	Messaging middleware	Connectivity	nats.io
Netvibes	Dashboard of Things	Analytics platform	Home automation	netvibes.com/en/explore/dashboard-of-things
Neura	Neura	IoT platform	Healthcare	theneura.com
Node-RED	Node-RED	IoT platform	Connectivity, device mgmt	nodered.org
NPM	HomeStar	Messaging middleware	Home automation	github.com/dpjanes/node-iotdb/blob/master/docs/homestar.md
NXP	Kinetis MCUs	ARM processors & microcontrollers	Hardware	nxp.com/products/processors-and-microcontrollers/arm-based-processors-and-mcus/kinetis-cortex-m-mcus:KINETIS
Onion	Omega2	Development board modules	Prototyping, hobbyists, DIY	onion.io/omega2
Open Hybrid	Open Hybrid	IoT platform	App development, prototyping	openhybrid.org
Oracle	Oracle Internet of Things Cloud Service	IoT platform	Device mgmt, analytics	oracle.com/solutions/internet-of-things
OutSystems	OutSystems	Enterprise app development platform	Build, deploy, & manage enterprise apps	outsystems.com/platform
Particle	Device Cloud	Networking, messaging middleware	Device mgmt	particle.io/device-cloud

Company	Product	Product Type	Vertical	Website
Particle	Particle Photon	WiFi development board	Prototyping, hobbyists, DIY	particle.io/wifi
Philips	Philips Hue	Development program, SDK	Home automation	developers.meethue.com
PlatformIO	PlatformIO IDE	Development environment	Embedded development, debugging	platformio.org/platformio-ide
PlatformIO	PlatformIO Core	IDE, IoT platform	App development	docs.platformio.org/en/latest/core.html
Prodea	Arrayent IoT Services Platform	IoT platform, data analytics, device mgmt	App development	prodea.com/iot-services-platform
PTC	Thingworx	IoT platform	App development, device mgmt, big data analytics	ptc.com/en/products/iot/thingworx-platform
PubNub	PubNub Data Stream Network	Networking, messaging middleware	Connectivity, device mgmt	pubnub.com/products/global-data-stream-network
Raspberry Pi	Raspberry Pi 3 Model B+	Development board	Prototyping, hobbyists, DIY	raspberrypi.org
Red Hat	Red Hat JBoss AMQ	Connectivity middleware	Messaging device mgmt	redhat.com/en/technologies/jboss-middleware/amq
Reekoh	Reekoh	IoT platform, connectivity middleware	Device mgmt	reekoh.com
Relayr.io	Relayr	Device mgmt, ML analytics, connectivity middleware	Business scaling	relayr.io
Remforce	Remforce Boiler and Leak Monitoring	Sensors	Home automation	remforce.com/base-boiler-kit
Rigado	Rigado	IoT data solutions	Commercial IoT	rigado.com
RTI	Connext DDS	Connectivity middleware	IIoT	rti.com/products/connext-dds-professional
Runtime.io	Runtime	Device mgmt, Apache MyNewt mgmt	Device mgmt, connectivity	runtime.io
Salesforce	Salesforce IoT	IoT platform, device mgmt, data analytics	Connected devices, app development	salesforce.com/products/salesforce-iot/overview

Company	Product	Product Type	Vertical	Website
Samsara	Samsara	Sensors	Logistics, utilities, industrial IoT, environmental, transportation	samsara.com
Scanalytics	Scanalytics SoleSensors	Sensors	Analytics, industrial IoT, home automation, retail	scanalyticsinc.com
Seeed Studio	Wio	Development boards & modules	Prototyping, hobbyists, DIY	seeedstudio.com/series/Wio-11.html
Sense	Sense	Sensors	Home automation, utilities	sense.com/product.html
Sierra Wireless	Sierra Wireless Embedded Solutions	Embedded modules, routers, IoT gateways	Hardware	sierrawireless.com/products-and-solutions/embedded-solutions
Sigfox	Sigfox	Networking, IoT connectivity	Industrial IoT	sigfox.com
Structural Health Systems	Concrete Sensors	Sensors	Industrial IoT, construction	concretesensors.com
Telit	Telit IoT Portal	IoT connectivity, IoT platform	Smart transportation, agriculture, retail, healthcare, automotive, smart cities	telit.com/m2m-iot-products/iot-platforms/telit-iot-portal
Telit	Telit IoT Modules	Development board modules, routers, API	Smart cars, cellular communication, networking	telit.com/m2m-iot-products/iot-module-selector
Temboo	Temboo	IoT development platform	Smart energy, smart cities, logistics, manufacturing	temboo.com/iot-applications
Tessel.io	Tessel 2	Development board	Prototyping, hobbyists, DIY	tessel.io
Texas Instruments	TI LaunchPads	Development boards & modules	Prototyping, hobbyists, DIY	ti.com/tools-software/launchpads/launchpads.html
thethings.iO	thethings.iO	IoT platform	Agriculture, logistics, industry, smart home, smart cities	thethings.io/iot-dashboards-features
TrendMicro	TrendMicro	IoT security	Hybrid cloud, networks, user protection	trendmicro.com
Tridium	Niagra 4	IoT app dev platform, analytics	Industrial IoT, smart cities	tridium.com/en/products-services/niagara4

Company	Product	Product Type	Vertical	Website
Ubidots	Ubidots	IoT platform, data analytics	Hobbyists, DIY, logistics, home automation, industrial IoT	ubidots.com/platform
U-Blox	U-Blox	Development board WiFi modules	Prototyping, connectivity, networking	u-blox.com/en/product-search
Verdigris	Verdigris	Sensor network & platform	Smart buildings, smart cities	verdigris.co
Verizon	Hum	Sensors, mobile app	Smart cars	hum.com
VersaSense	VersaSense	Sensors	Home automation, industrial IoT, hobbyists, DIY	versasense.com
VSCP	VSCP	IoT platform	Device mgmt, control protocol	vscp.org
Waylay	Waylay	IoT data platform	Cloud-to-cloud data orchestration	waylay.io
WebNMS	WebNMS IoT Platform	Connectivity middleware, analytics	Energy, smart cities, logistics	webnms.com/iot/unified-webnms-iot-platform.html
Wilderness Labs	Netduino 3	Development board modules	Prototyping, hobbyists, DIY	wildernesslabs.co/Netduino
Wiring	Wiring	Microcontroller IoT platform	Prototyping, hobbyists, DIY	wiring.org.co
WSO2	WSO2 IoT	Connectivity middleware	Device mgmt, connectivity	wso2.com/iot
Wyliodrin	Wyliodrin STUDIO	IDE, IoT platform	Prototyping, hobbyists, DIY	wyliodrin.com
Yeti	Yeti	IoT platform	Home automation	getyeti.co
Zebra Technologies	Zebra Savanna	IoT platform	Data intelligence, configuration mgmt	zebra.com/us/en/solutions/savanna.html
Zolertia	RE-mote	Development board	Prototyping, hobbyists, DIY	zolertia.io/product/re-mote-professional-pack

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