

I. INTERNET OF THINGS

The idea of adding sensors and intelligence to basic objects was discussed throughout the 1980s and 1990s (and there are arguably some much earlier ancestors), but apart from some early projects -- including an internet-connected vending machine -- progress was slow simply because the technology wasn't ready. Chips were too big and bulky and there was no way for objects to communicate effectively.²

Processors that were cheap and power-frugal enough to be all but disposable were needed before it finally became cost-effective to connect up billions of devices. The adoption of RFID tags -- low-power chips that can communicate wirelessly -- solved some of this issue, along with the increasing availability of broadband internet and cellular and wireless networking. The adoption of IPv6 -- which, among other things, should provide enough IP addresses for every device the world (or indeed this galaxy) is ever likely to need -- was also a necessary step for the IoT to scale.

Kevin Ashton, co-founder of the Auto-ID Center at the Massachusetts Institute of Technology (MIT), coined the phrase 'Internet of Things' in 1999, although it took at least another decade for the technology to catch up with the vision.

"The IoT integrates the interconnectedness of human culture -- our 'things' -- with the interconnectedness of our digital information system -- 'the internet.' That's the IoT," Ashton

IoT has evolved from the convergence of wireless technologies, microelectromechanical systems (MEMSes), microservices and the internet. The convergence has helped tear down the silos between operational technology (OT) and information technology (IT), enabling unstructured machine-generated data to be analyzed for insights to drive improvements.

The first internet appliance, for example, was a Coke machine at Carnegie Mellon University in the early 1980s. Using the web, programmers could check the status of the machine and determine whether there would be a cold drink awaiting them, should they decide to make the trip to the machine.

IoT evolved from M2M communication, i.e., machines connecting to each other via a network without human interaction. M2M refers to connecting a device to the cloud, managing it and collecting data.

Taking M2M to the next level, IoT is a sensor network of billions of smart devices that connect people, systems and other applications to collect and share data. As its foundation, M2M offers the connectivity that enables IoT.

The internet of things is also a natural extension of supervisory control and data acquisition (SCADA), a category of software application programs for process control, the gathering of data in real time from remote locations to control equipment and conditions. SCADA systems include hardware and software components. The hardware gathers and feeds data into a computer that has SCADA software installed, where it is then processed

and presented in a timely manner. The evolution of SCADA is such that late-generation SCADA systems developed into first-generation IoT systems.

The concept of the IoT ecosystem, however, didn't really come into its own until the middle of 2010 when, in part, the government of China said it would make IoT a strategic priority in its five-year plan.

1.1. What is the Internet of Things?

A thing in the internet of things can be a person with a heart monitor implant, a farm animal with a biochip transponder, an automobile that has built-in sensors to alert the driver when tire pressure is low or any other natural or man-made object that can be assigned an Internet Protocol (IP) address and is able to transfer data over a network.

Increasingly, organizations in a variety of industries are using IoT to operate more efficiently, better understand customers to deliver enhanced customer service, improve decision-making and increase the value of the business.¹

The Internet of Things, or IoT, refers to the billions of physical devices around the world that are now connected to the internet, all collecting and sharing data. Thanks to the arrival of super-cheap computer chips and the ubiquity of wireless networks, it's possible to turn anything, from something as small as a pill to something as big as an aeroplane, into a part of the IoT. Connecting up all these different objects and adding sensors to them adds a level of digital intelligence to devices that would be otherwise dumb, enabling them to communicate real-time data without involving a human being. The Internet of Things is making the fabric of the world around us smarter and more responsive, merging the digital and physical universes.²

Pretty much any physical object can be transformed into an IoT device if it can be connected to the internet to be controlled or communicate information.

A lightbulb that can be switched on using a smartphone app is an IoT device, as is a motion sensor or a smart thermostat in your office or a connected streetlight. An IoT device could be as fluffy as a child's toy or as serious as a driverless truck. Some larger objects may themselves be filled with many smaller IoT components, such as a jet engine that's now filled with thousands of sensors collecting and transmitting data back to make sure it is operating efficiently. At an even bigger scale, smart cities projects are filling entire regions with sensors to help us understand and control the environment.

The term IoT is mainly used for devices that wouldn't usually be generally expected to have an internet connection, and that can communicate with the network independently of human action. For this reason, a PC isn't generally considered an IoT device and neither is a smartphone -- even though the latter is crammed with sensors. A smartwatch or a fitness band or other wearable device might be counted as an IoT device, however.

The Industrial Internet of Things (IIoT) or the fourth industrial revolution or Industry 4.0 are all names given to the use of IoT technology in a business setting. The concept

¹ <https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT>

² <https://www.zdnet.com/article/what-is-the-internet-of-things-everything-you-need-to-know-about-the-iot-right-now/>

is the same as for the consumer IoT devices in the home, but in this case the aim is to use a combination of sensors, wireless networks, big data, AI and analytics to measure and optimise industrial processes.

If introduced across an entire supply chain, rather than just individual companies, the impact could be even greater with just-in-time delivery of materials and the management of production from start to finish. Increasing workforce productivity or cost savings are two potential aims, but the IIoT can also create new revenue streams for businesses; rather than just selling a standalone product – for example, like an engine – manufacturers can also sell predictive maintenance of the engine.

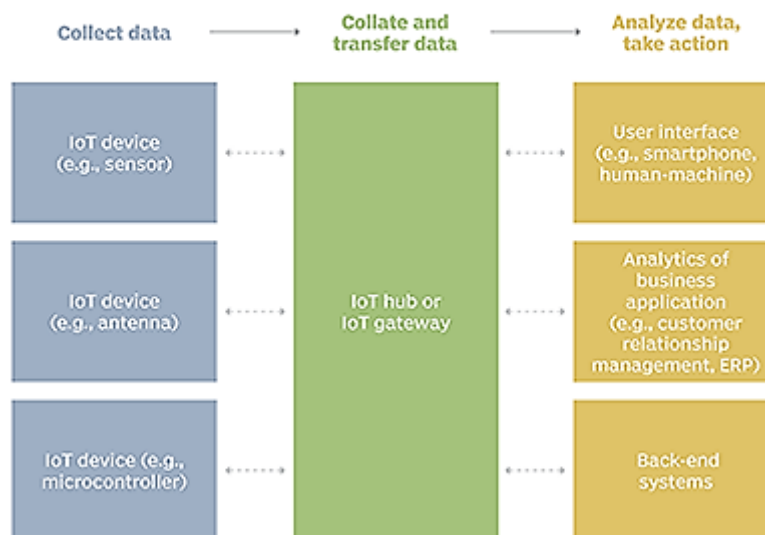
1.2. How IoT works

An IoT ecosystem consists of web-enabled smart devices that use embedded systems, such as processors, sensors and communication hardware, to collect, send and act on data they acquire from their environments. IoT devices share the sensor data they collect by connecting to an IoT gateway or other edge device where data is either sent to the cloud to be analysed or analysed locally. Sometimes, these devices communicate with other related devices and act on the information they get from one another. The devices do most of the work without human intervention, although people can interact with the devices -- for instance, to set them up, give them instructions or access the data.

The connectivity, networking and communication protocols used with these web-enabled devices largely depend on the specific IoT applications deployed.

IoT can also make use of artificial intelligence (AI) and machine learning to aid in making data collecting processes easier and more dynamic.

Example of an IoT system



An example of how an IoT system works from collecting data to taking action.
Source: <https://internetofthingsagenda.techtarget.com/definition/Internet-of-Things-IoT>

The internet of things helps people live and work smarter, as well as gain complete control over their lives. In addition to offering smart devices to automate homes, IoT is essential to business. IoT provides businesses with a real-time look into how their systems really work, delivering insights into everything from the performance of machines to supply chain and logistics operations.

IoT enables companies to automate processes and reduce labor costs. It also cuts down on waste and improves service delivery, making it less expensive to manufacture and deliver goods, as well as offering transparency into customer transactions.

As such, IoT is one of the most important technologies of everyday life, and it will continue to pick up steam as more businesses realize the potential of connected devices to keep them competitive.