What is IoT 101?

The term IoT was coined by Kevin Ashton in 1999. At that time, most of the data fed to computers was generated by humans; he proposed that the best way would be for computers to take data directly, without any intervention from humans. And so he proposed things such as RFID and sensors, which gather data, should be connected to the network, and feed directly to the computer.

> *You can read the complete article where Ashton talks about what he means by IoT here: http://www.itrco.jp/libraries/RFIDjournal-That%20Internet%20of%20Things%20Thing.pdf.*

Today IoT (also called the **internet of everything** and sometimes, the fog network) refers to a wide range of things such as sensors, actuators, and smartphones connected to the internet. These things can be anything: a person with a wearable device (or even mobile phone), an RFID-tagged animal, or even our day-to-day devices such as a refrigerator, washing machine, or even a coffee machine. These things can be physical things—that is, things that exist in the physical world and can be sensed, actuated, and connected—or of the information world (a virtual thing)—that is, things that aren't tangibly present but exist as information (data) and can be stored, processed, and accessed. These things necessarily have the ability to communicate directly with the internet; optionally, they might have the potentiality of sensing, actuation, data capture, data storage, and data processing.

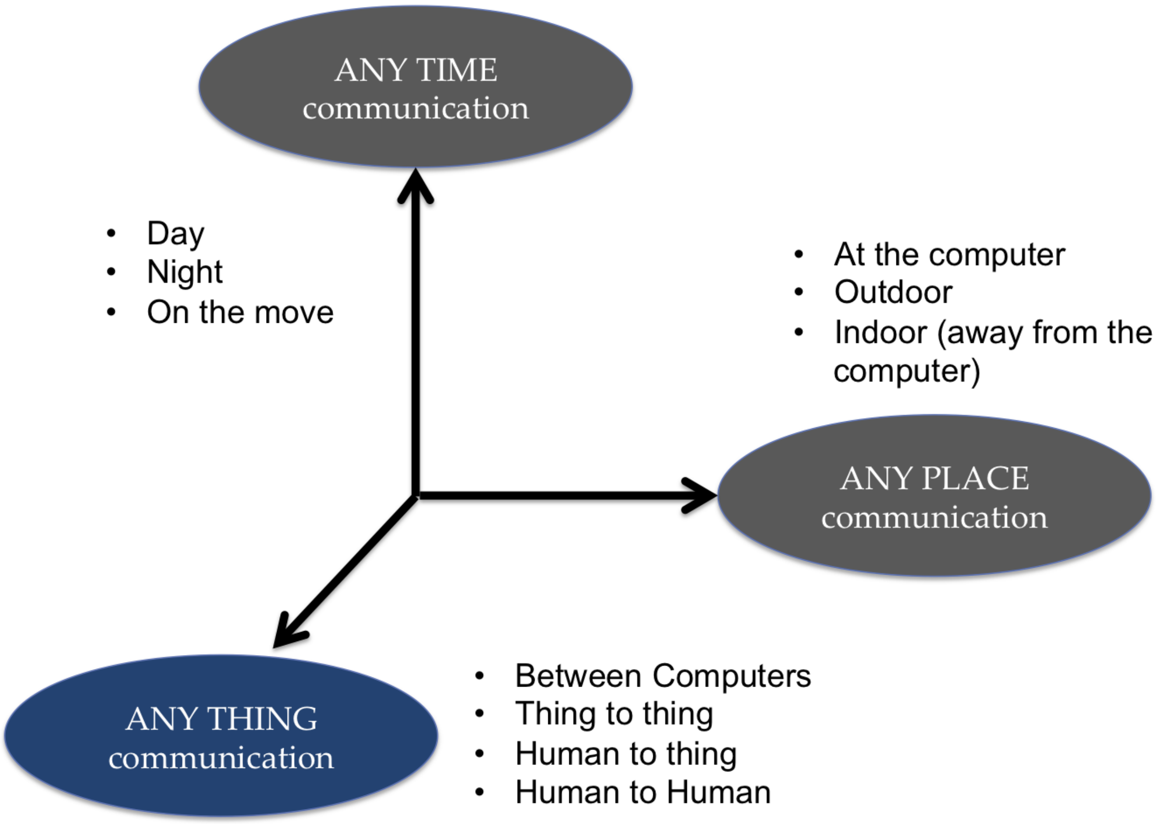
The **International Telecommunication Unit** (**ITU**), a United Nations agency, defines IoT as:

"a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies."

You can learn more at https://www.itu.int/en/ITU-T/gsi/iot/Pages/default.aspx.

The wide expanse of ICT already provided us with communication at any time or any place; the IoT added the new dimension of ANY THING communication:

Kapoor, A. (2019). Hands-on artificial intelligence for iot : Expert machine learning and deep learning techniques for developing smarter iot systems. Packt Publishing, Limited.



New dimension introduced in IoT (adapted from b-ITU-T Y.2060 report)

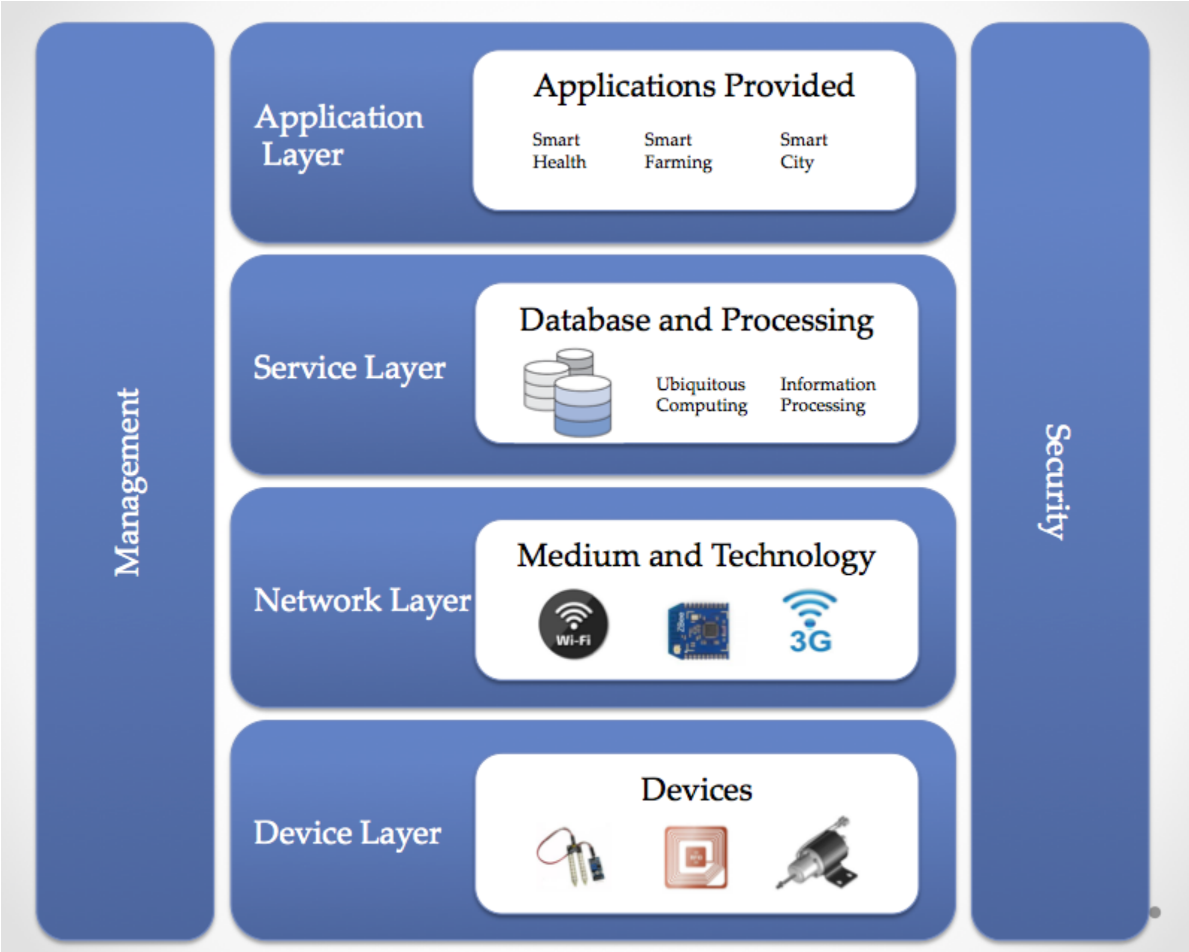
It's predicted that IoT as a technology will have a far-reaching impact on people and the society we live in. To give you a glimpse of its far-reaching effects, consider the following scenarios:

- You, like me, live in a high rise building and are very fond of plants. With lots of effort and care, you've made a small indoor garden of your own using potted plants. Your boss asks you to go for a week-long trip, and you're worried your plants won't survive for a week without water. The IoT solution is to add soil moisture sensors to your plants, connect them to the internet, and add actuators to remotely switch on or off the water supply and artificial sunlight. Now, you can be anywhere in the world, but your plants won't die, and you can check the individual plant's soil moisture condition and water it as needed.
- You had a very tiring day at the office; you just want to go home and have someone make you coffee, prepare your bed, and heat up water for a bath, but sadly you're home alone. Not anymore; IoT can help. Your IoT-enabled home assistant can prepare the right flavor coffee from the coffee machine, order your smart water heater to switch on and maintain the water temperature exactly the way you want, and ask your smart air conditioner to switch on and cool the room.

The choices are limited only by your imagination. The two preceding scenarios correspond to consumer IoT—the IoT with a focus on consumer-oriented applications. There also exists a large scope of **Industry IoT** (**IIoT**) where manufacturers and industries optimize processes and implement remote monitoring capabilities to increase productivity and efficiency. In this book, you'll find the hands-on experience with both IoT applications.

IoT reference model

Just like the OSI reference model for the internet, IoT architecture is defined through six layers: four horizontal layers and two vertical layers. The two vertical layers are **Management** and **Security** and they're spread over all four horizontal layers, as seen in the following diagram:



IoT layers

The **Device Layer**: At the bottom of the stack, we have the device layer, also called the **perception layer**. This layer contains the physical things needed to sense or control the physical world and acquire data (that is, by perceiving the physical world). Existing hardware, such as sensors, RFID, and actuators, constitutes the perception layer.

The **Network Layer**: This layer provides the networking support and transfer of data over either wired or wireless network. The layer securely transmits the information from the devices in the device layer to the information processing system. Both transmission **Medium and Technology** are part of the networking layer. Examples include 3G, UMTS, ZigBee, Bluetooth, Wi-Fi, and so on.

The **Service Layer**: This layer is responsible for service management. It receives information from the network layer, stores it into the database, processes that information, and can make an automatic decision based on the results.

The **Application Layer**: This layer manages the applications dependent upon the information processed in the service layer. There's a wide range of applications that can be implemented by IoT: smart cities, smart farming, and smart homes, to name a few.

IoT platforms

Information from the network layer is often managed with the help of IoT platforms. Many companies today provide IoT platform services, where they help not only with data but also enable seamless integration with different hardware. Since they function as a mediator between the hardware and application layer, IoT platforms are also referred to as IoT middleware and are part of the service layer in the IoT reference stack. IoT platforms provide the ability to connect and communicate with things from anywhere in the world. In this book, we'll briefly cover some popular IoT platforms such as the Google Cloud Platform, Azure IoT, Amazon AWS IoT, Predix, and H2O.

You can select which IoT platform is best for you based on the following criteria:

- **Scalability**: Addition and deletion of new devices to the existing IoT network should be possible
- **Ease of use**: The system should be perfectly working and delivering all its specifications with minimum intervention
- **Third party integration**: Heterogeneous devices and protocols should be able to inter-network with each other
- **Deployment options**: It should be workable on a broad variety of hardware devices and software platforms
- **Data security**: The security of data and devices is ensured

IoT verticals

A vertical market is a market in which vendors offer goods and services specific to an industry, trade, profession, or other groups of customers with specialized needs. IoT enables the possibility of many such verticals, and some of the top IoT verticals are as follows:

- **Smart building**: Buildings with IoT technologies can help in not only reducing the consumption of resources but also improving the satisfaction of the humans living or working in them. The buildings have smart sensors that not only monitor resource consumption but can also proactively detect residents' needs. Data is collected via these smart devices and sensors to remotely monitor a building, energy, security, landscaping, HVAC, lighting, and so on. The data is then used to predict actions, which can be automated according to events and hence efficiency can be optimized, saving time, resources, and cost.
- **Smart agriculture**: IoT can enable local and commercial farming to be more environmentally friendly, cost-effective, and production efficient. Sensors placed through the farm can help in automating the process of irrigation. It's predicted that smart agricultural practices will enable a manifold increase in productivity, and hence food resources.
- **Smart city**: A smart city can be a city with smart parking, a smart mass transit system, and so on. A smart city has the capability to address traffic, public safety, energy management, and more for both its government and citizens. By using advanced IoT technologies, it can optimize the usage of the city infrastructure and quality of life for its citizens.
- **Connected healthcare**: IoT enables critical business and patient monitoring decisions to be made remotely and in real time. Individuals carry medical sensors to monitor body parameters such as heartbeat, body temperature, glucose level, and so on. The wearable sensors, such as accelerometers and gyroscopes, can be used to monitor a person's daily activity.

We'll be covering some of them as a case study in this book. The content of this book is focused on information processing and the applications being implemented on IoT and so we'll not be going into details of the devices, architecture, and protocols involved in IoT reference stacks any further.

> *The interested reader can refer to the following references to know more about the IoT architecture and different protocols:*
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> - *Da Xu, Li, Wu He, and Shancang Li. Internet of things in industries: A survey. IEEE Transactions on industrial informatics 10.4 (2014): 2233-2243.*
> - *Khan, Rafiullah, et al. Future internet: The internet of things architecture, Possible Applications and Key Challenges.* ***Frontiers of Information Technology*** *(**FIT**), 2012 10th International Conference on. IEEE, 2012.*
> - *This website provides an overview of the protocols involved in IoT: https://www.postscapes.com/internet-of-things-protocols/.*