Sensors, Actuators, Smart Objects and Control Units

This section defines sensors, actuators, and smart objects and describes how they are the fundamental building blocks of IoT networks.

Sensor Networks: This section covers the design, drivers for adoption, and deployment challenges of sensor networks.

Sensors:

A sensor does exactly as its name indicates: It senses. More specifically, a sensor measures some physical quantity and converts that measurement reading into a digital representation. That digital representation is typically passed to another device for transformation into useful data that can be consumed by intelligent devices or humans.

Active or passive: Sensors can be categorized based on whether they produce an energy output and typically require an external power supply (active) or whether they simply receive energy and typically require no external power supply (passive). Invasive or non-invasive: Sensors can be categorized based on whether a sensor is part of the environment it is measuring (invasive) or external to it (non-invasive). Contact or no-contact: Sensors can be categorized based on whether they require physical contact with what they are measuring (contact) or not (no-contact).

Absolute or relative: Sensors can be categorized based on whether they measure on an absolute scale (absolute) or based on a difference with a fixed or variable reference value (relative).

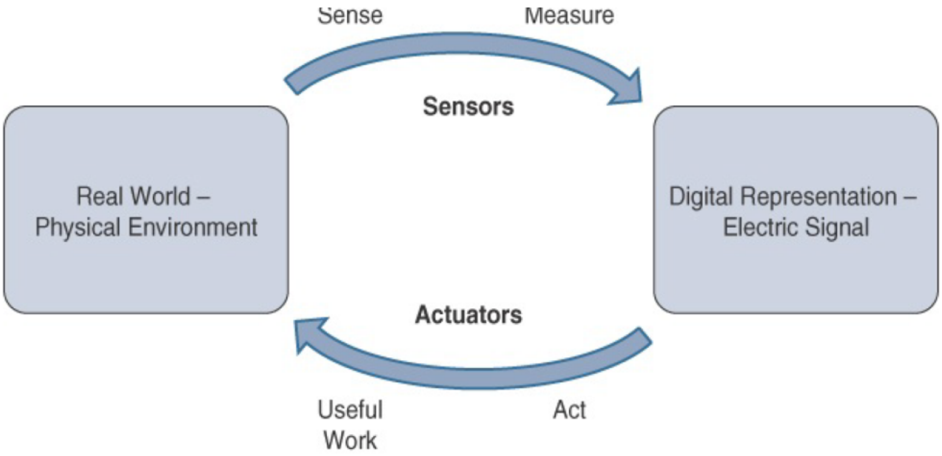
Area of application: Sensors can be categorized based on the specific industry or vertical where they are being used.

How sensors measure: Sensors can be categorized based on the physical mechanism used to measure sensory input (for example, thermoelectric, electrochemical, piezoresistive, optic, electric, fluid mechanic, photoelastic).

What sensors measure: Sensors can be categorized based on their applications or what physical variables they measure.

Actuators:

Actuators are natural complements to sensors. Figure 3-4 demonstrates the symmetry and complementary nature of these two types of devices. As discussed in the previous section, sensors are designed to sense and measure practically any measurable variable in the physical world. They convert their measurements (typically analog) into electric signals or digital representations that can be consumed by an intelligent agent (a device or a human). Actuators, on the others hand, receive some type of control signal (commonly an electric signal or digital command) that triggers a physical effect, usually some type of motion, force, and so on.



Some common ways that they can be classified include the following:

Type of motion: Actuators can be classified based on the type of motion they produce (for example, linear, rotary, one/two/three-axes).

Power: Actuators can be classified based on their power output (for example, high power, low power, micro power)

Binary or continuous: Actuators can be classified based on the number of stable-state outputs.

Area of application: Actuators can be classified based on the specific industry or vertical where they are used.

Type of energy: Actuators can be classified based on their energy type.

Smart Objects

Smart objects are, quite simply, the building blocks of IoT. They are what transform everyday objects into a network of intelligent objects that are able to learn from and interact with their environment in a meaningful way. It can't be stressed enough that the real power of smart objects in IoT comes from being networked together rather than being isolated as standalone objects. This ability to communicate over a network has a multiplicative effect and allows for very sophisticated correlation and interaction between disparate smart objects. For instance, recall the smart farming sensors described previously. If a sensor is a standalone device that simply measures the humidity of the soil, it is interesting and useful, but it isn't revolutionary. If that same sensor is connected as part of an intelligent network that is able to coordinate intelligently with actuators to trigger irrigation systems as needed based on those sensor readings, we have something far more powerful.

A smart object, is a device that has, at a minimum, the following four defining characteristics Processing unit: A smart object has some type of processing unit for acquiring data, processing and analyzing sensing information received by the sensor(s), coordinating control signals to any actuators, and controlling a variety of functions on the smart object, including the communication and power systems. The specific type of processing unit that is used can vary greatly, depending on the specific processing needs of different applications. The most common is a microcontroller because of its small form factor, flexibility, programming simplicity, ubiquity, low power consumption, and low cost.

Sensor(s) and/or actuator(s): A smart object is capable of interacting with the physical world through sensors and actuators. As described in the previous sections, a sensor learns and measures its environment, whereas an actuator is able to produce some change in the physical world. A smart object does not need to contain both sensors and actuators. In fact, a smart object can contain one or multiple sensors and/or actuators, depending upon the application.
Communication device: The communication unit is responsible for connecting a smart object with other smart objects and the outside world (via the network). Communication devices for smart objects can be either wired or wireless. Overwhelmingly, in IoT networks smart objects are wirelessly interconnected for a number of reasons, including cost, limited infrastructure availability, and ease of deployment. There are myriad different communication protocols for smart objects.
Power source: Smart objects have components that need to be powered. Interestingly, the most significant power consumption usually comes from the communication unit of a smart object. As with the other three smart object building blocks, the power requirements also vary greatly from application to application. Typically, smart objects are limited in power, are deployed for a very long time, and are not easily accessible. This combination, especially when the smart object relies on battery power, implies that power efficiency, judicious power management, sleep modes, ultra-low power consumption hardware, and so on are critical design elements.

Trends in Smart Objects

Size is decreasing: As discussed earlier, in reference to MEMS, there is a clear trend of ever-decreasing size. Some smart objects are so small they are not even visible to the naked eye. This reduced size makes smart objects easier to embed in everyday objects.

Power consumption is decreasing: The different hardware components of a smart object continually consume less power. This is especially true for sensors, many of which are completely passive. Some battery-powered sensors last 10 or more years without battery replacement.

Processing power is increasing: Processors are continually getting more powerful and smaller. This is a key advancement for smart objects, as they become increasingly complex and connected.

Communication capabilities are improving: It’s no big surprise that wireless speeds are continually increasing, but they are also increasing in range. IoT is driving the development of more and more specialized communication protocols covering a greater diversity of use cases and environments.

Communication is being increasingly standardized: There is a strong push in the industry to develop open standards for IoT communication protocols. In addition, there are more and more opensource efforts to advance IoT

The following are some of the most significant limitations of the smart objects in WSNs:

Limited processing power

Limited memory

Lossy communication

Limited transmission speeds

Limited power

Control Units:

It is a unit of small computer on a single integrated circuit containing microprocessor or processing core, memory and programmable input/output devices/peripherals. It is responsible for major processing work of IoT devices and all logical operations are carried out here.