

Review Article

Internet of Things: Architectures, Protocols, and Applications

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The Internet of Things (IoT) is defined as a paradigm in which objects equipped with sensors, actuators, and processors communicate with each other to serve a meaningful purpose. In this paper, we survey state-of-the-art methods, protocols, and applications in this new emerging area. This survey paper proposes a novel taxonomy for IoT technologies, highlights some of the most important technologies, and proposes some applications that have the potential to make a striking difference in human life, especially for the differently abled and the elderly. As compared to similar survey papers in the area, this paper is far more comprehensive in its coverage and exhaustively covers most major technologies spanning from sensors to applications.

1. Introduction

Today the Internet has become ubiquitous, has touched almost every corner of the globe, and is affecting human life in unimaginable ways. However, the journey is far from over. We are now entering an era of even more pervasive connectivity where a very wide variety of appliances will be connected to the web. We are entering an era of the Internet of Things (abbreviated as IoT). This term has been defined by different authors in many different ways. Let us look at two of the most popular definitions. Vermesan et al. [1] define the Internet of Things as simply an interaction between the physical and digital worlds. The digital world interacts with the physical world using a plethora of sensors and actuators. Another definition by Peña-López et al. [2] defines the Internet of Things as a paradigm in which computing and networking capabilities are embedded in any kind of conceivable object. We use these capabilities to query the state of the object and to change its state if possible. In common parlance, the Internet of Things refers to a new kind of world where almost all the devices and appliances that we use are connected to a network. We can use them collaboratively to achieve complex tasks that require a high degree of intelligence.

For this intelligence and interconnection, IoT devices are equipped with embedded sensors, actuators, processors, and transceivers. IoT is not a single technology; rather it is an

agglomeration of various technologies that work together in tandem.

Sensors and actuators are devices, which help in interacting with the physical environment. The data collected by the sensors has to be stored and processed intelligently in order to derive useful inferences from it. Note that we broadly define the term *sensor*; a mobile phone or even a microwave oven can count as a sensor as long as it provides inputs about its current state (internal state + environment). An *actuator* is a device that is used to effect a change in the environment such as the temperature controller of an air conditioner.

The storage and processing of data can be done on the edge of the network itself or in a remote server. If any preprocessing of data is possible, then it is typically done at either the sensor or some other proximate device. The processed data is then typically sent to a remote server. The storage and processing capabilities of an IoT object are also restricted by the resources available, which are often very constrained due to limitations of size, energy, power, and computational capability. As a result the main research challenge is to ensure that we get the right kind of data at the desired level of accuracy. Along with the challenges of data collection, and handling, there are challenges in communication as well. The communication between IoT devices is mainly wireless because they are generally installed at geographically dispersed locations. The wireless channels often have high

