UbiComp IoTs
L6
(IoT - part B)

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IoT

- Imagine a world where just about anything you can think of is online and communicating to other things and people in order to enable new services that enhance our lives.
- From self-driving drones delivering your grocery order to sensors in your clothing monitoring your health, the world you know is set to undergo a major technological shift forward.
- This shift is known collectively as the Internet of Things (IoT).

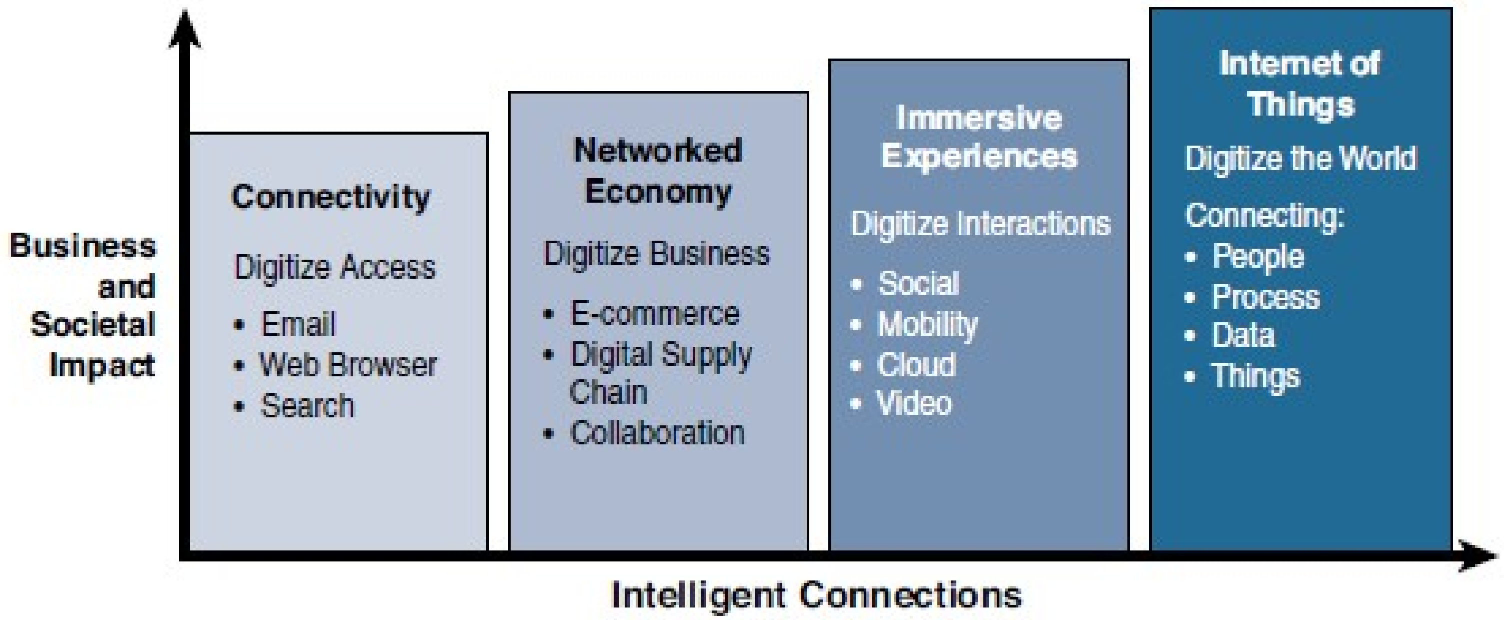


Figure 1-1 *Evolutionary Phases of the Internet*

Table 1-1 *Evolutionary Phases of the Internet*

Internet Phase	Definition
Connectivity (Digitize access)	This phase connected people to email, web services, and search so that information is easily accessed.
Networked Economy (Digitize business)	This phase enabled e-commerce and supply chain enhancements along with collaborative engagement to drive increased efficiency in business processes.
Immersive Experiences (Digitize interactions)	This phase extended the Internet experience to encompass widespread video and social media while always being connected through mobility. More and more applications are moved into the cloud.
Internet of Things (Digitize the world)	This phase is adding connectivity to objects and machines in the world around us to enable new services and experiences. It is connecting the unconnected.

Connecting computing objects

- The basic premise and goal of IoT is to "connect the unconnected." This means that *objects* (useful physical or virtual) that are not currently joined to a *computer network*, namely the *Internet*, will be connected so that they can communicate and interact with people and other objects.
- IoT is a technology transition in which devices will allow us to sense and control the physical world by making objects smarter and connecting them through an intelligent network

IoT example advantages

- ***For example***, in a shopping mall using Wi-Fi location tracking has been deployed, “the_things” are the Wi-Fi devices. Wi-Fi location tracking is simply the capability of knowing where a consumer is in a retail environment through his or her smart phone’s connection to the retailer’s Wi-Fi network. While the value of connecting *the things* to the Internet is obvious and appreciated by shoppers, tracking real-time location of Wi-Fi clients provides a specific business benefit to the mall and shop owners. In this case, it helps *the business* understand where shoppers tend to congregate and how much time they spend in different parts of a mall or store. Analysis of this data can lead to significant changes to the locations of product displays and advertising, where to place certain types of shops, how much rent to charge, and even where to station security guards.

- ***Example 2***: One of the most well-known applications of IoT with respect to animals focuses on what is often referred to as the "connected cow." Sparked, a Dutch company, developed a sensor that is placed in a cow's ear. The sensor monitors various health aspects of the cow as well as its location and transmits the data wirelessly for analysis by the farmer.

IoT impact

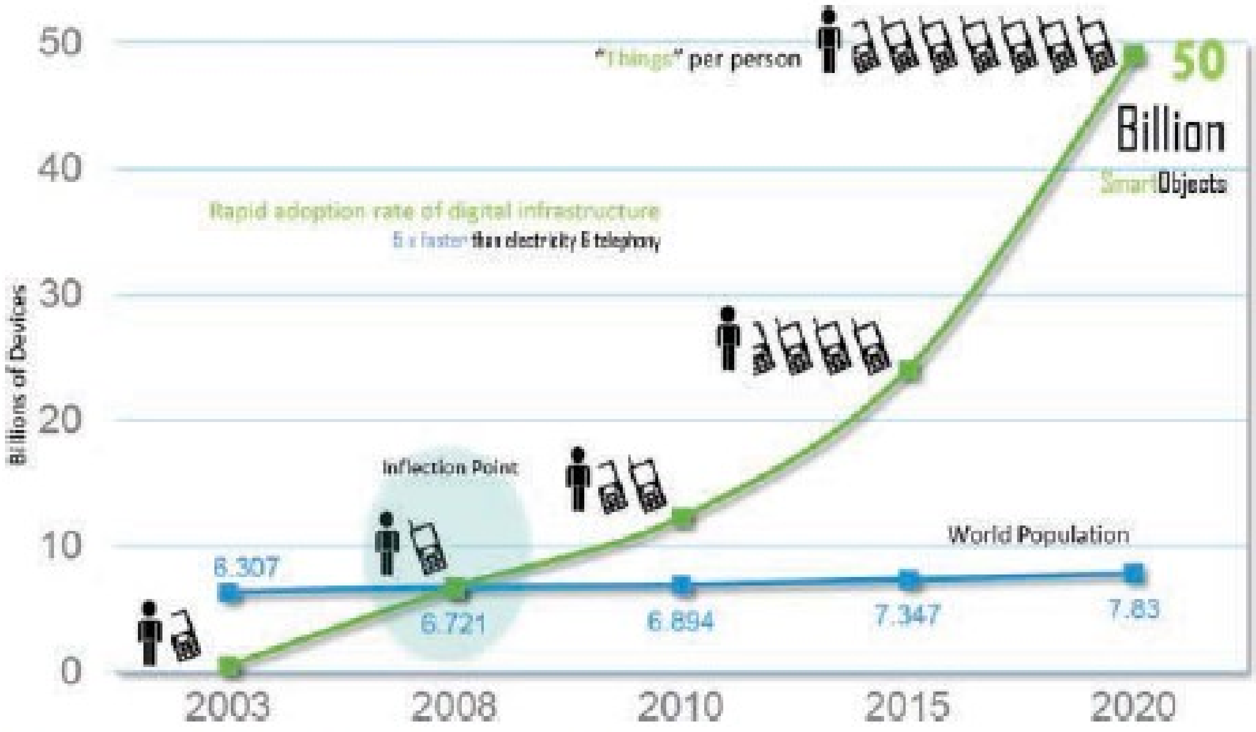


Figure 1-2 *The Rapid Growth in the Number of Devices Connected to the Internet*

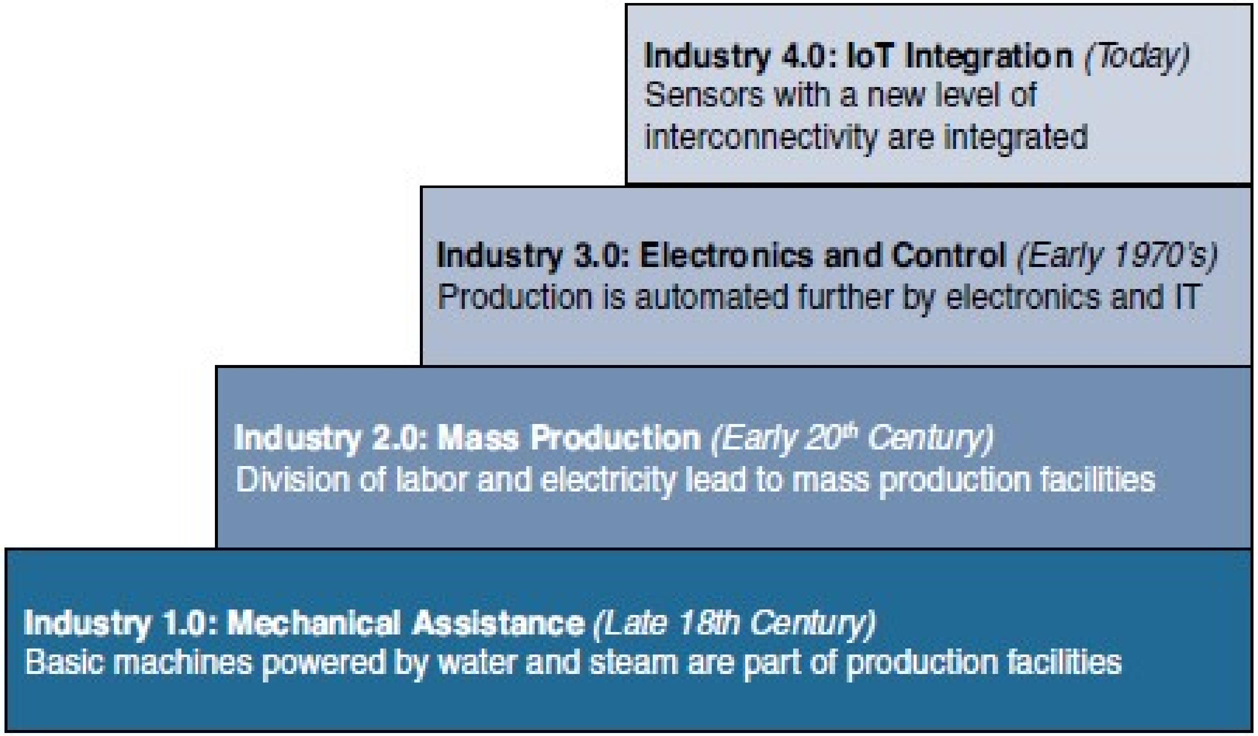


Figure 1-6 *The Four Industrial Revolutions*

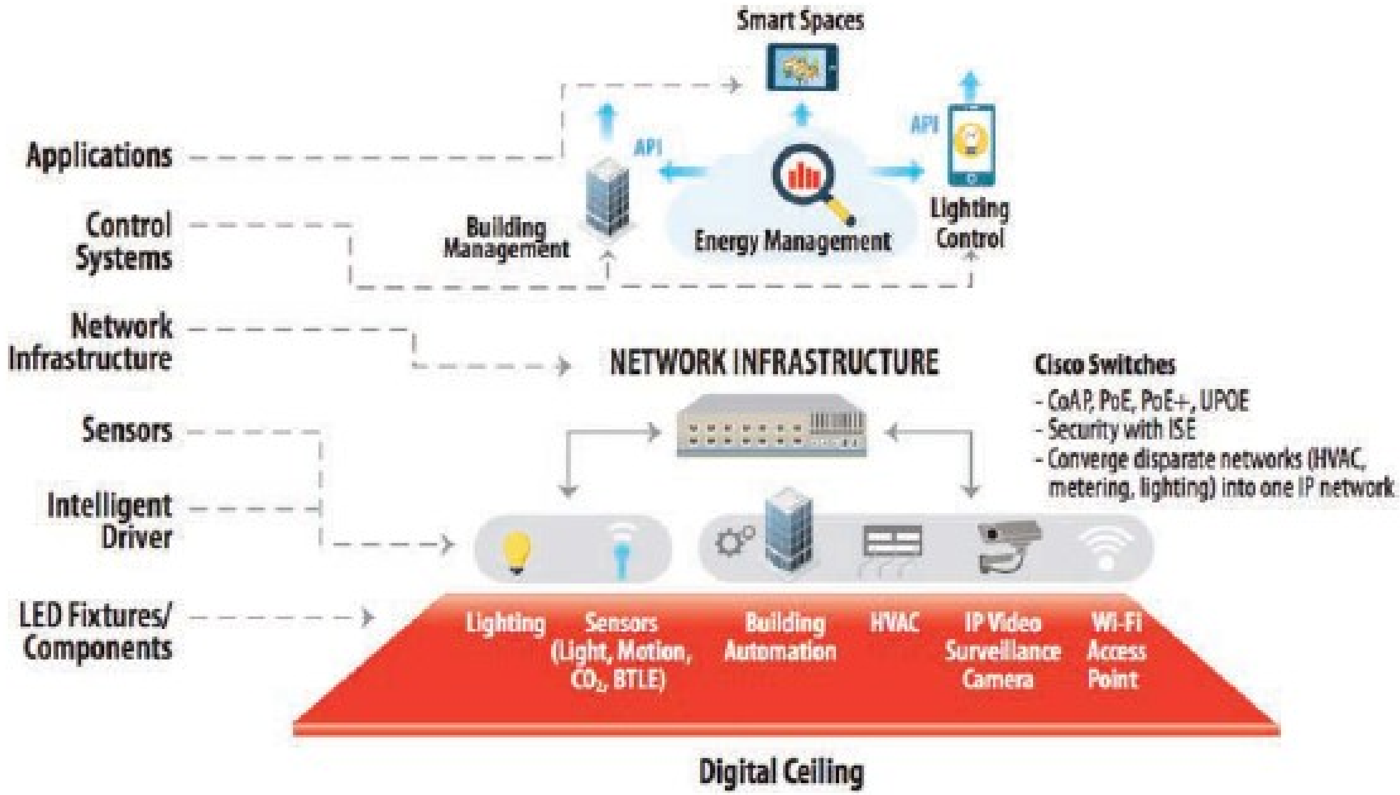
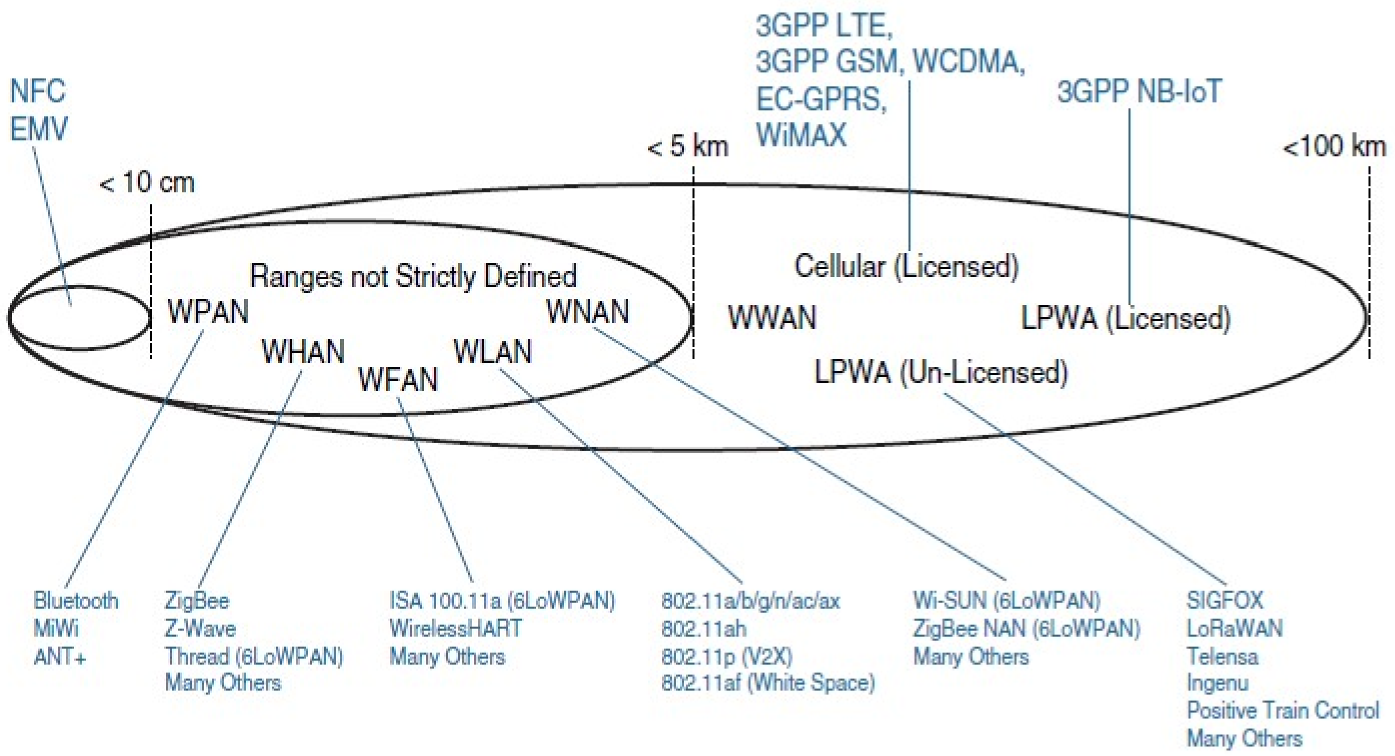


Figure 1-8 *A Framework for the Digital Ceiling*



WPAN: Wireless Personal Area Network
WHAN: Wireless Home Area Network
WFAN: Wireless Field (or Factory) Area Network
WLAN: Wireless Local Area Network
WNAN: Wireless Neighborhood Area Network
WWAN: Wireless Wide Area Network
LPWA: Low Power Wide Area

Figure 2-9 *Access Technologies and Distances*

Informational Technology (IT) or Operational Technology (OT)

- IT supports connections to the Internet along with related data and technology systems and is focused on the secure flow of data across an organization.
- OT monitors and controls devices and processes on physical operational systems. These systems include assembly lines, utility distribution networks, production facilities, roadway systems, and many more. Typically, IT did not get involved with the production and logistics of OT environments

- Management of OT is tied to the lifeblood of a company, if OT fails then higher impact on business than IT fails.

Table 1-3 *Comparing Operational Technology (OT) and Information Technology (IT)*

Criterion	Industrial OT Network	Enterprise IT Network
Operational focus	Keep the business operating 24x7	Manage the computers, data, and employee communication system in a secure way
Priorities	1. Availability 2. Integrity 3. Security	1. Security 2. Integrity 3. Availability
Types of data	Monitoring, control, and supervisory data	Voice, video, transactional, and bulk data
Security	Controlled physical access to devices	Devices and users authenticated to the network
Implication of failure	OT network disruption directly impacts business	Can be business impacting, depending on industry, but workarounds may be possible
Network upgrades (software or hardware)	Only during operational maintenance windows	Often requires an outage window when workers are not onsite; impact can be mitigated
Security vulnerability	Low: OT networks are isolated and often use proprietary protocols	High: continual patching of hosts is required, and the network is connected to Internet and requires vigilant protection

Source: Maciej Kranz, *IT Is from Venus, OT Is from Mars*, blogs.cisco.com/digital/it-is-from-venus-ot-is-from-mars, July 14, 2015.

IoT challenges

- With the rise of IoT and standards-based protocols, such as IPv6, the IT and OT worlds are converging or, more accurately, OT is beginning to adopt the network protocols, technology, transport, and methods of the IT organization, and the IT organization is beginning to support the operational requirements used by OT.
- There are fundamental cultural and priority differences between these two organizations as shown in table (1-3).

QoS and IT/OT convergence

- Take the case of deploying quality of service (QoS) in a network. When the IT team deploys QoS, voice and video traffic are almost universally treated with the highest level of service. However, when the OT system shares the same network, a very strong argument can be made that the real-time OT traffic should be given a higher priority than even voice because any disruption in the OT network could impact the business.
- When IT/OT convergence is managed correctly, IoT becomes fully supported by both groups. This provides a “best of both worlds” scenario, where solid industrial control systems reside on an open, integrated, and secure technology foundation

IoT architectures

- M2M IoT architecture
- World forum IoT architecture

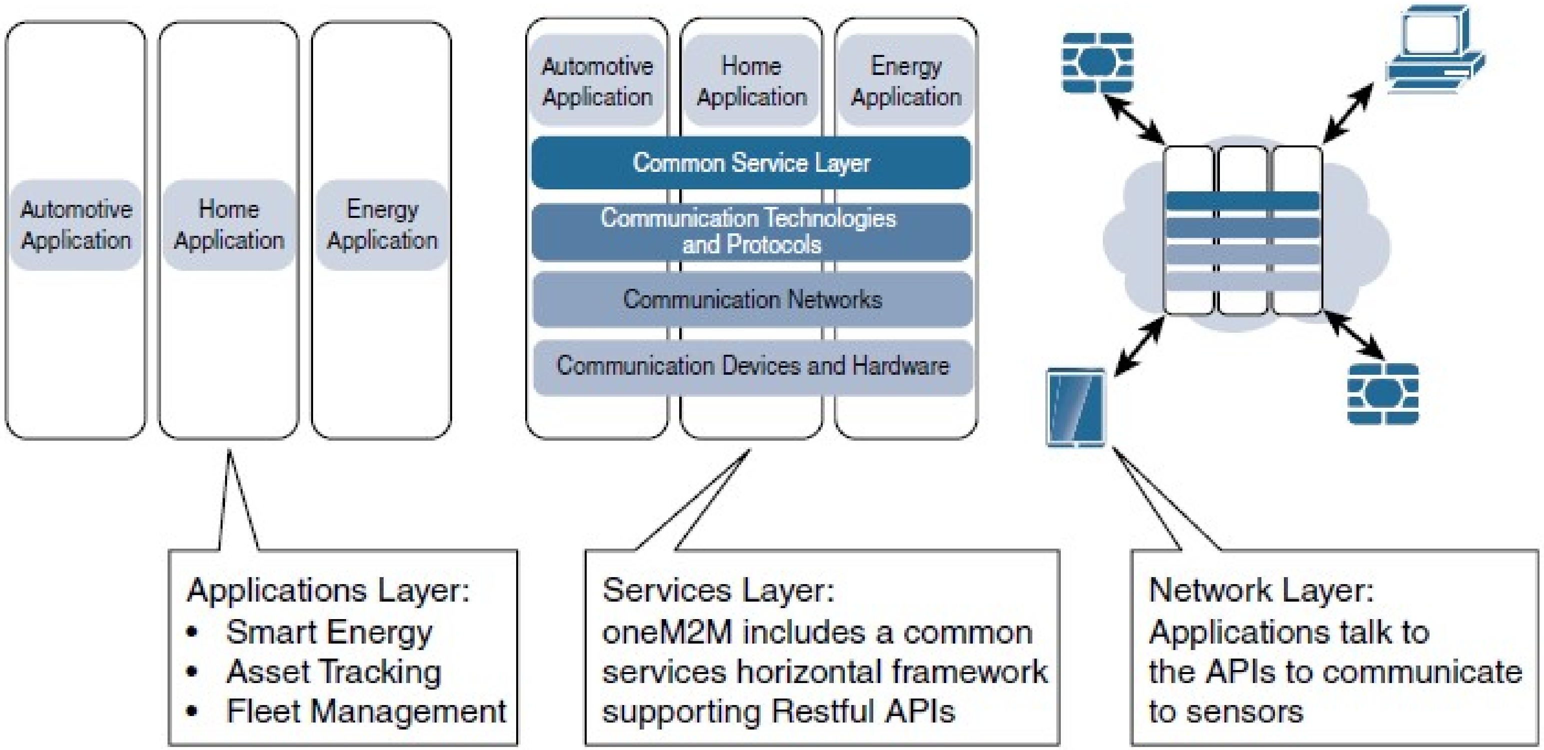


Figure 2-1 *The Main Elements of the oneM2M IoT Architecture*

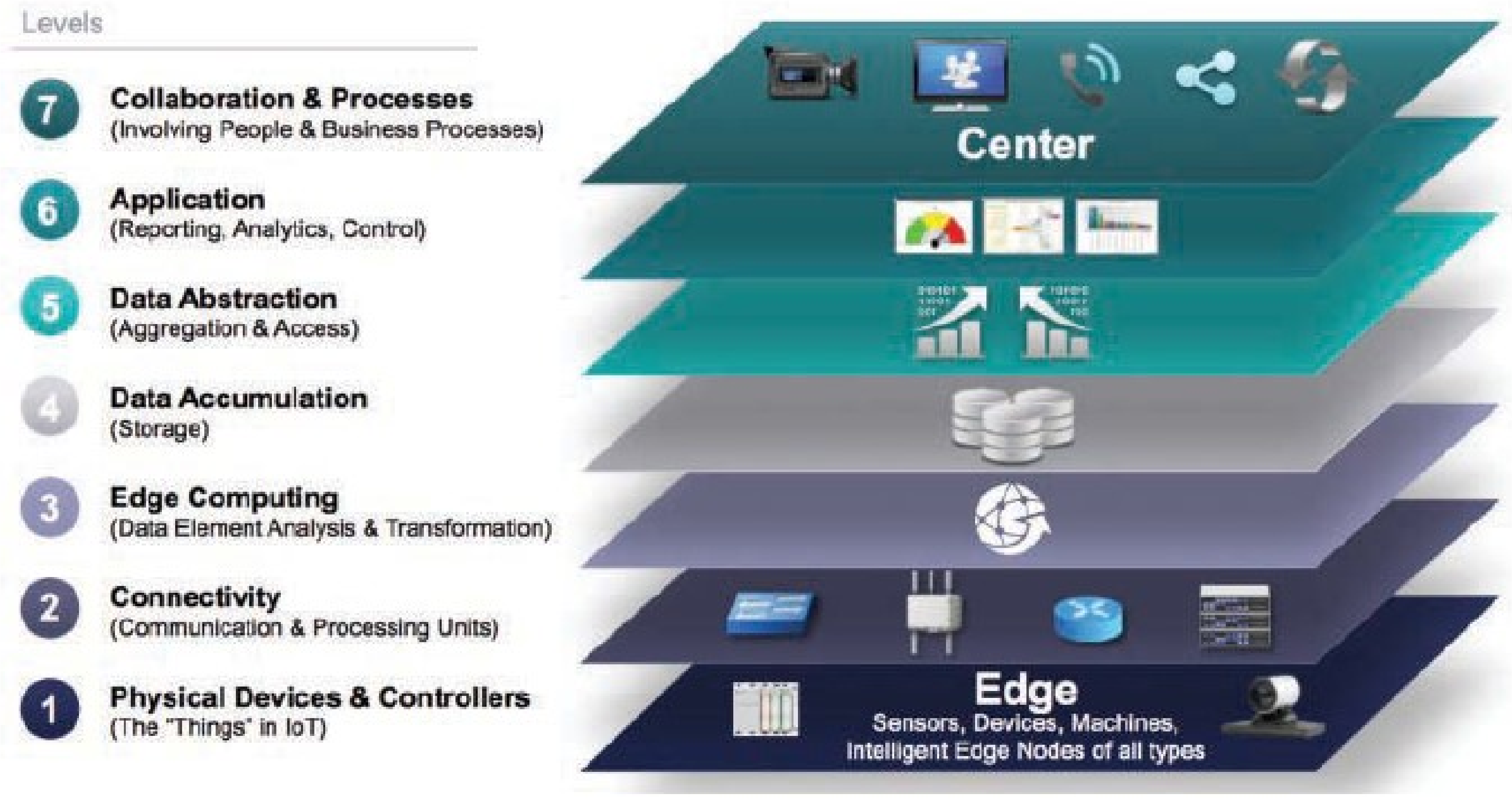


Figure 2-2 *IoT Reference Model Published by the IoT World Forum*

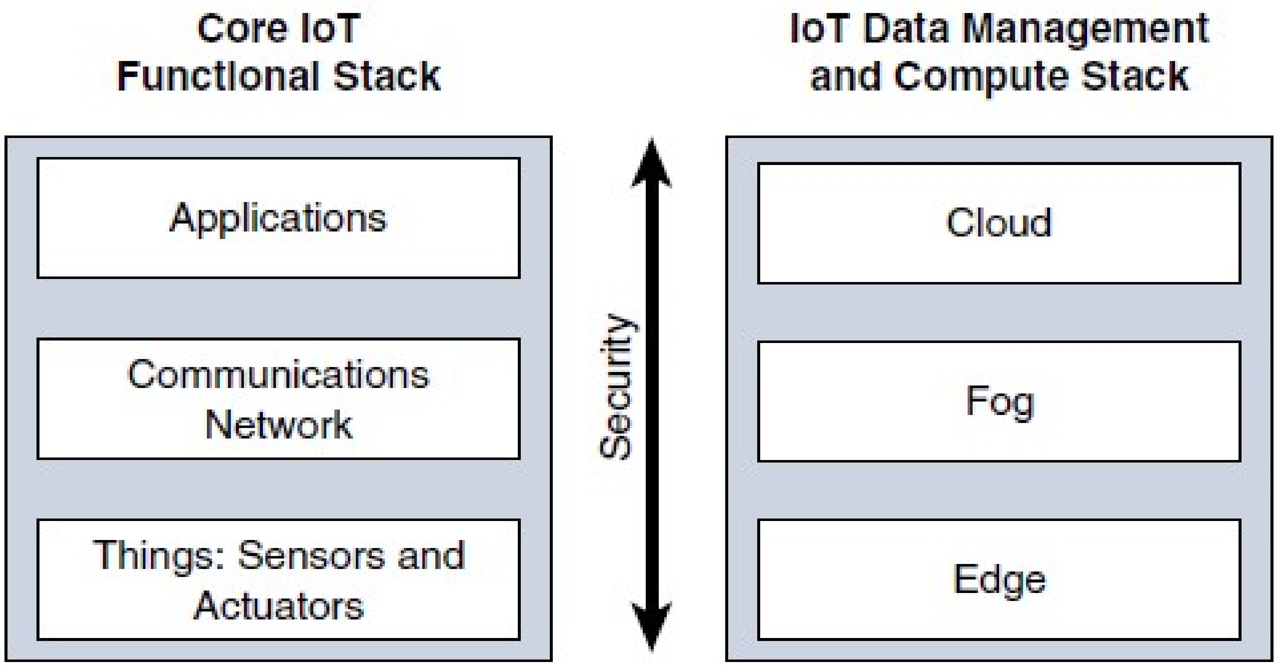


Figure 2-6 *Simplified IoT Architecture*

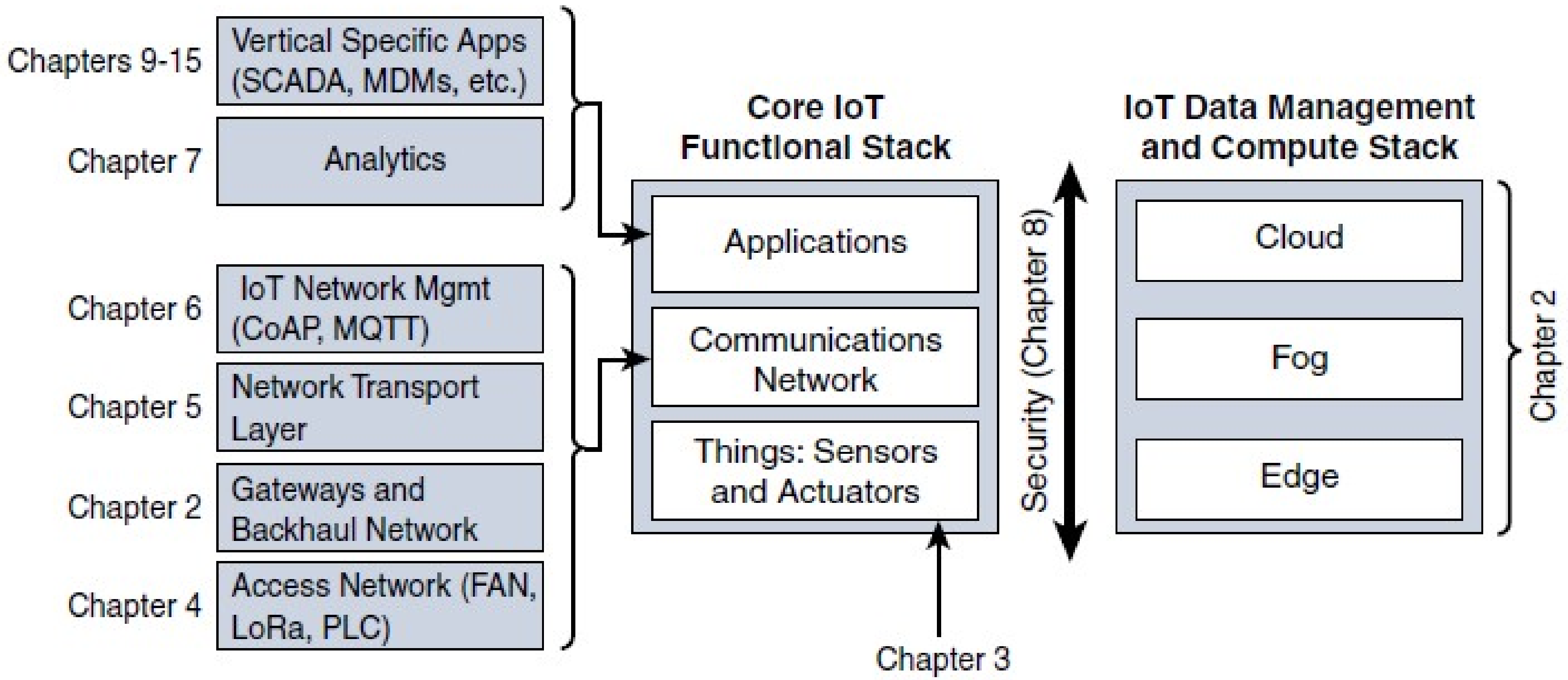


Figure 2-7 *Expanded View of the Simplified IoT Architecture*

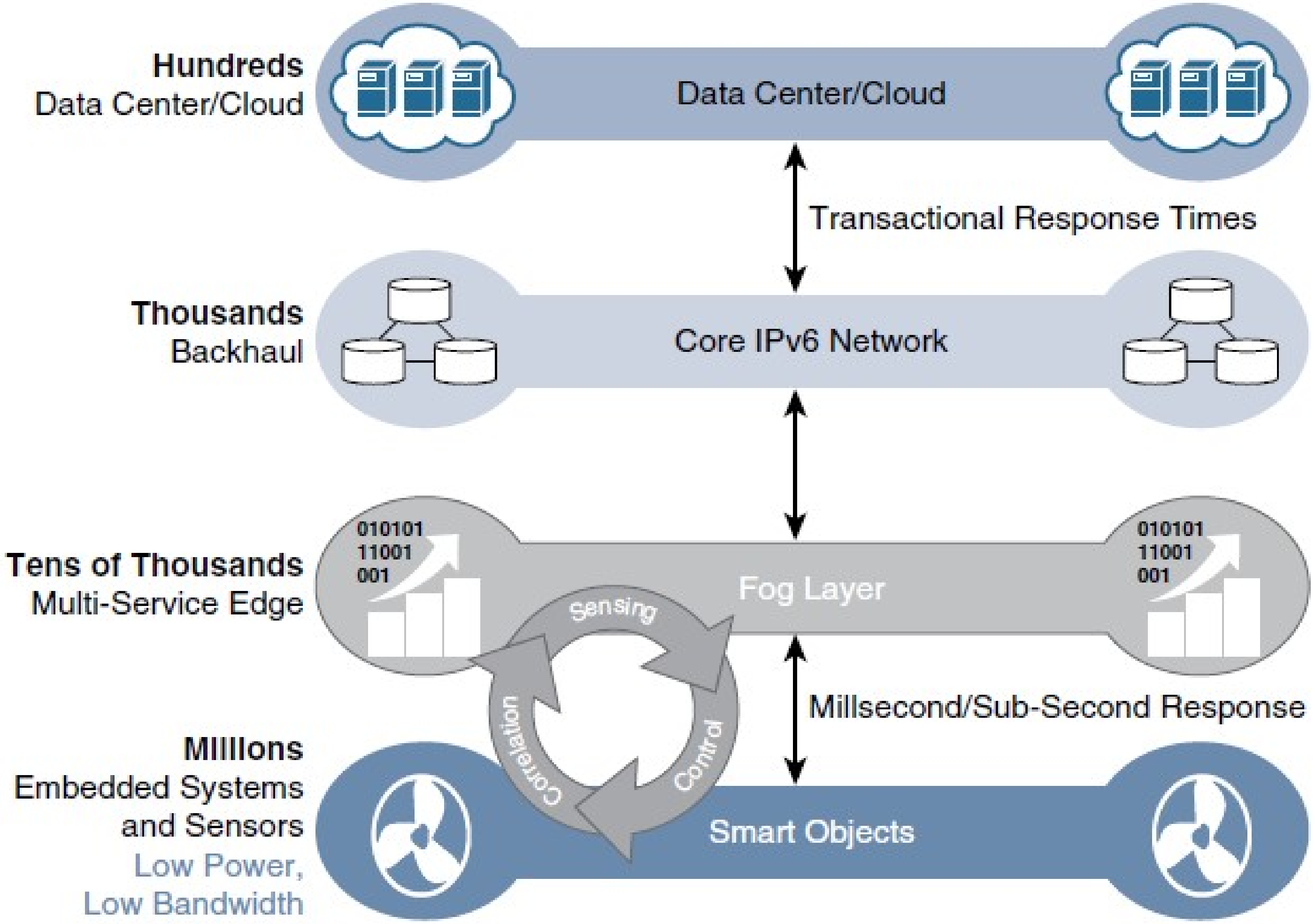


Figure 2-15 *The IoT Data Management and Compute Stack with Fog Computing*

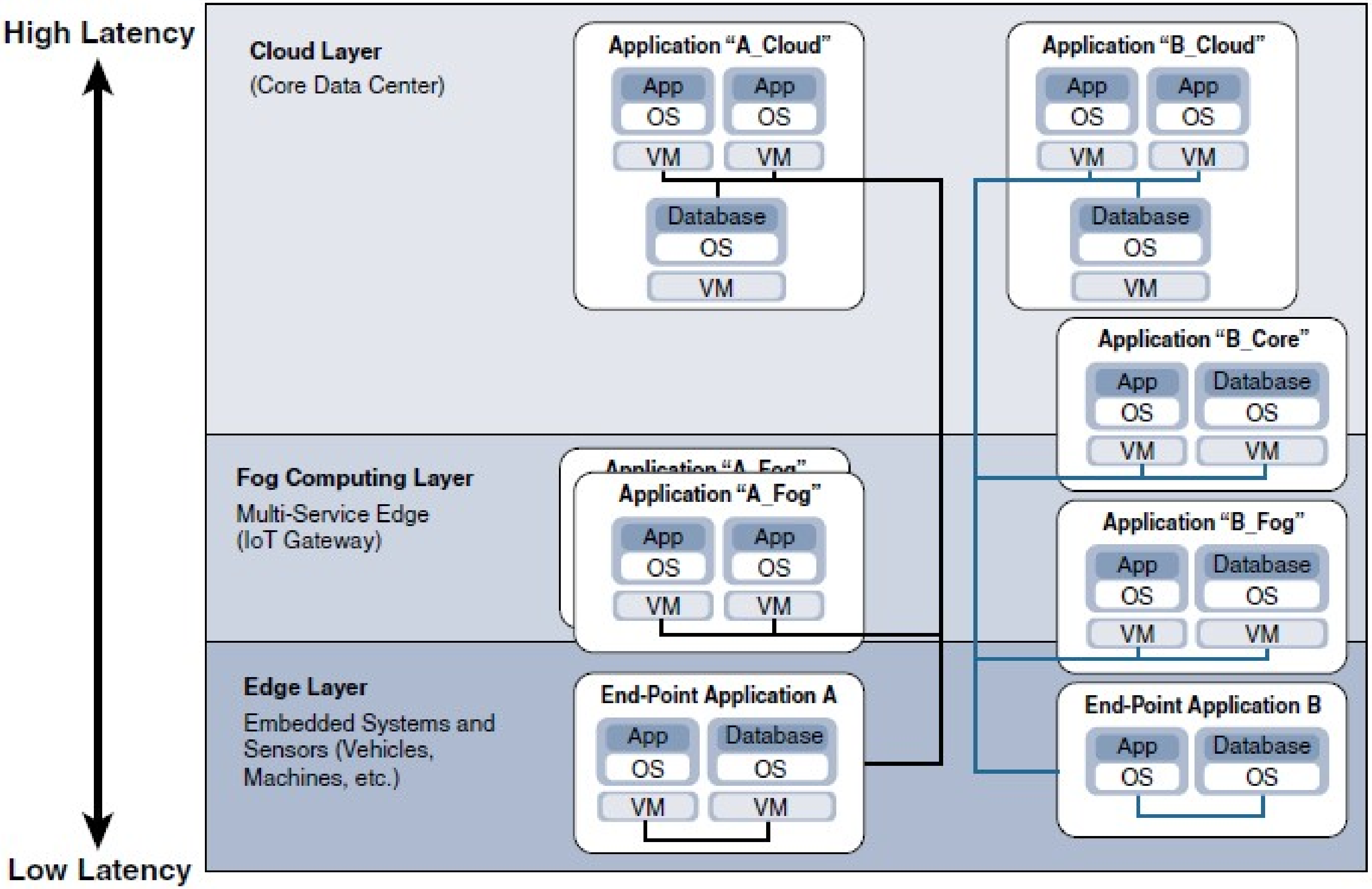


Figure 2-16 *Distributed Compute and Data Management Across an IoT System*

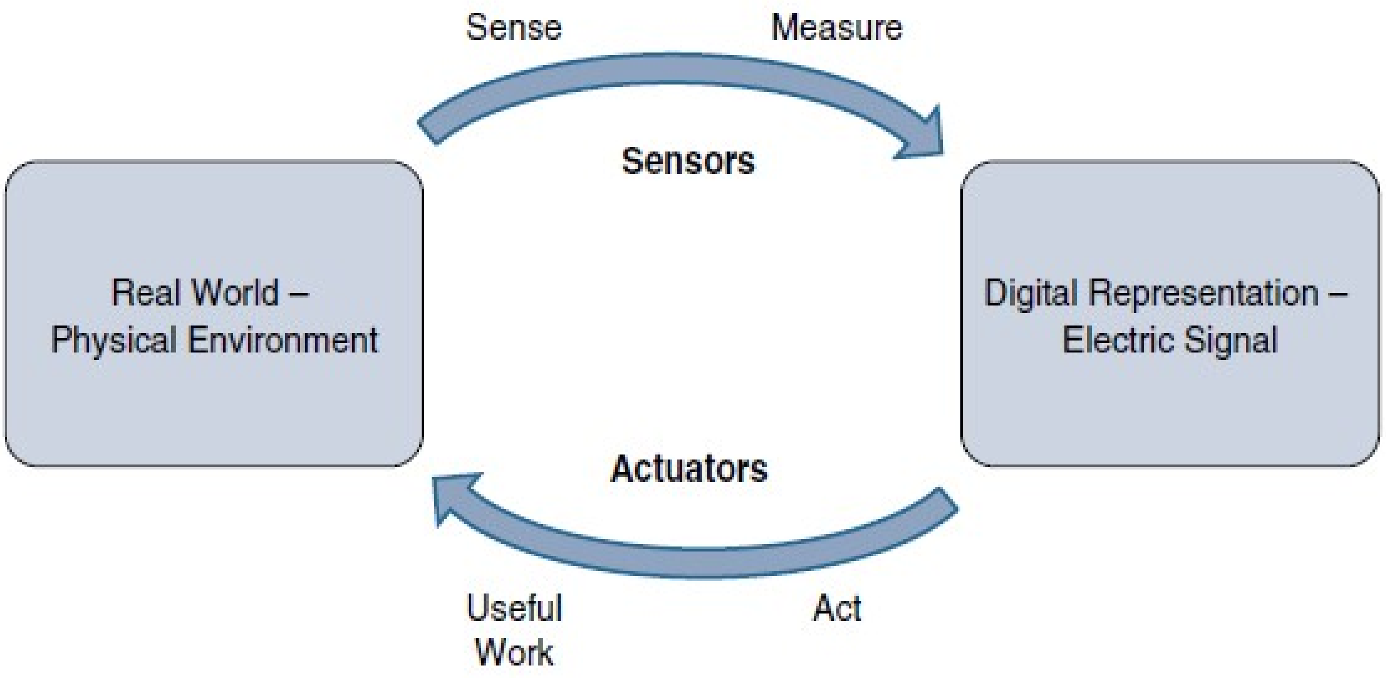


Figure 3-4 *How Sensors and Actuators Interact with the Physical World*

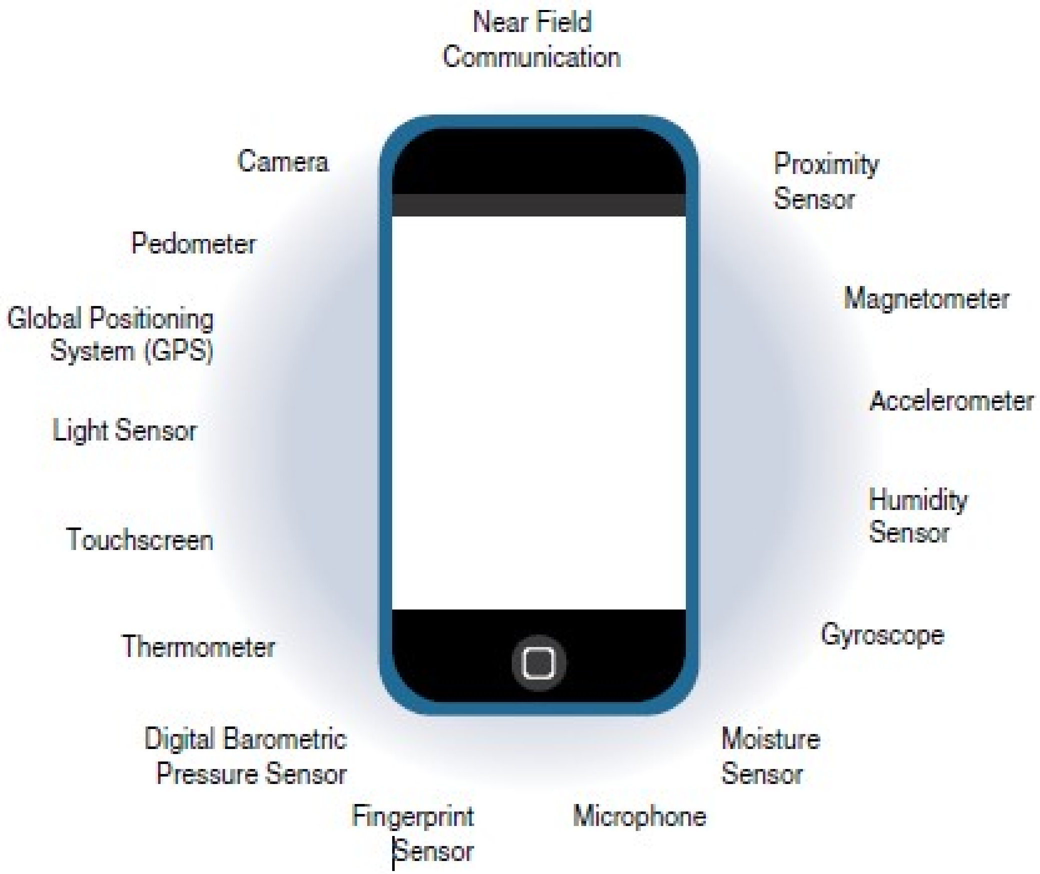


Figure 3-2 *Sensors in a Smart Phone*

Smart object or ubicomp object

Four minimum Characters:

- Process unit
- Communicate
- Actuate and/or Sense
- power

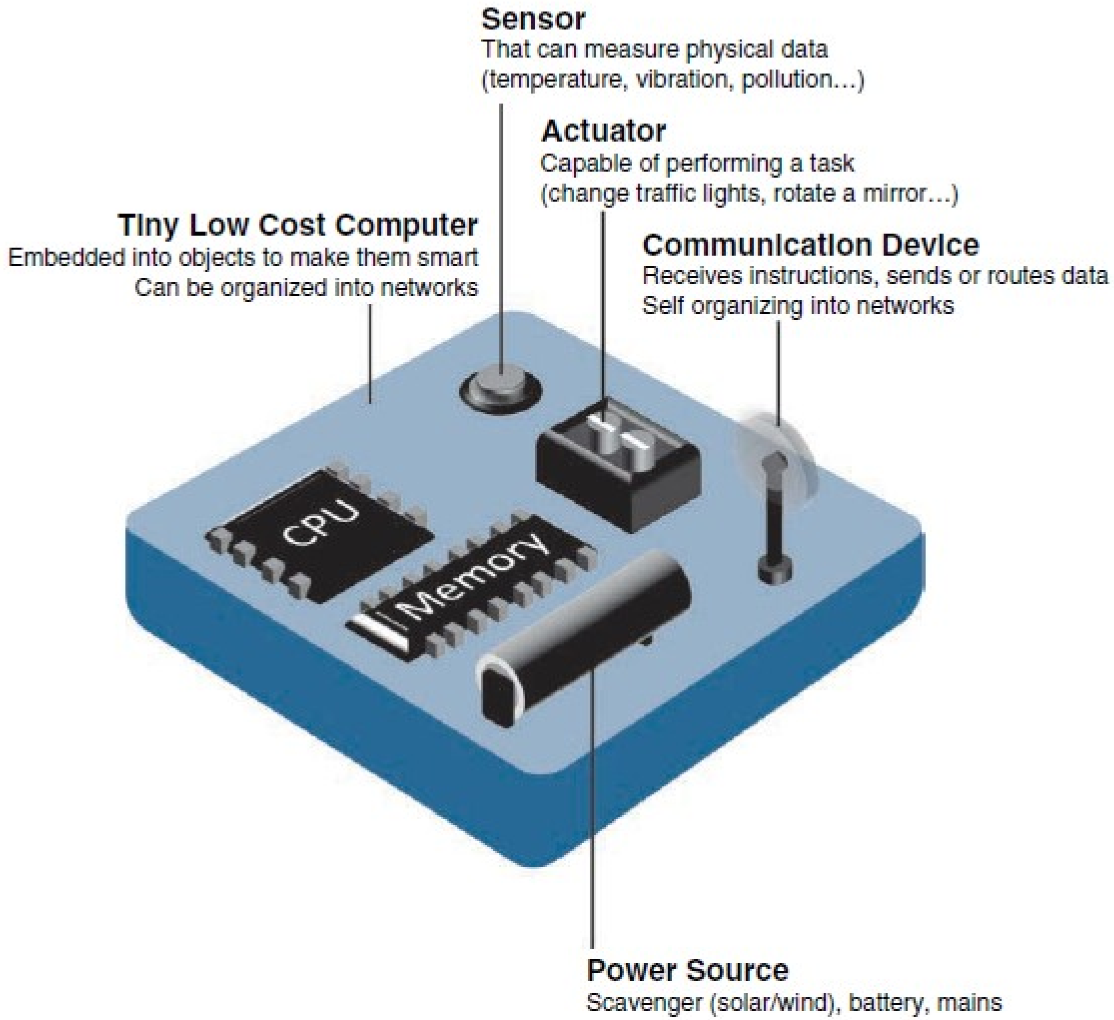


Figure 3-7 *Characteristics of a Smart Object*

Chapter 4: Connecting Smart Objects

The following subsections cover technologies for connecting smart objects:

- **IEEE 802.15.4:** This section highlights IEEE 802.15.4, an older but foundational wireless protocol for connecting smart objects.
- **IEEE 802.15.4g and IEEE 802.15.4e:** This section discusses improvements to 802.15.4 that are targeted to utilities and smart cities deployments.
- **IEEE 1901.2a:** This section discusses IEEE 1901.2a, which is a technology for connecting smart objects over power lines.
- **IEEE 802.11ah:** This section discusses IEEE 802.11ah, a technology built on the well-known 802.11 Wi-Fi standards that is specifically for smart objects.
- **LoRaWAN:** This section discusses LoRaWAN, a scalable technology designed for longer distances with low power requirements in the unlicensed spectrum.
- **NB-IoT and Other LTE Variations:** This section discusses NB-IoT and other LTE variations, which are often the choice of mobile service providers looking to connect smart objects over longer distances in the licensed spectrum.

optimization

- Constrained nodes and networks
- Non-IP devices
- Header compression

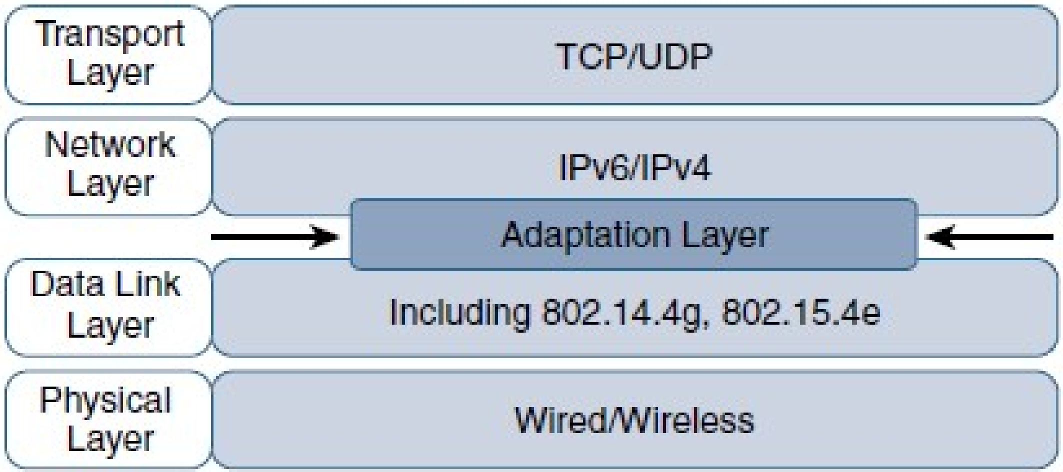


Figure 5-1 *Optimizing IP for IoT Using an Adaptation Layer*

IoT application protocol

- CoAP
- MQTT

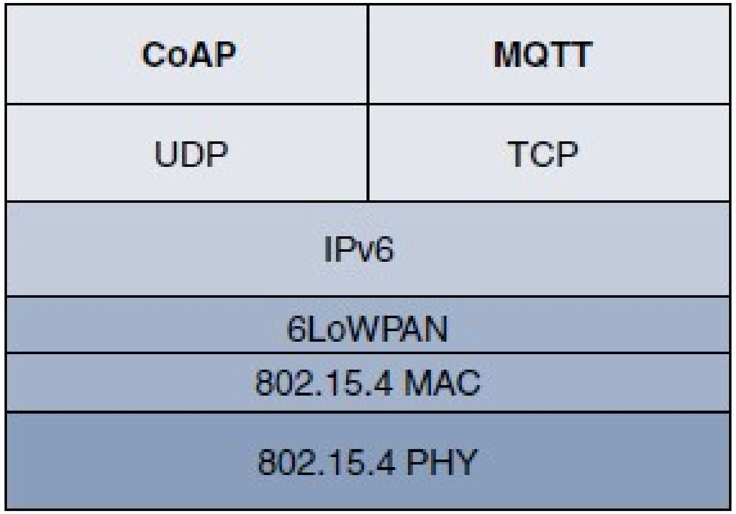


Figure 6-6 *Example of a High-Level IoT Protocol Stack for CoAP and MQTT*

Constrained Application Protocol (CoAP)

- The CoAP framework defines simple and flexible ways to manipulate sensors and actuators for data or device management.

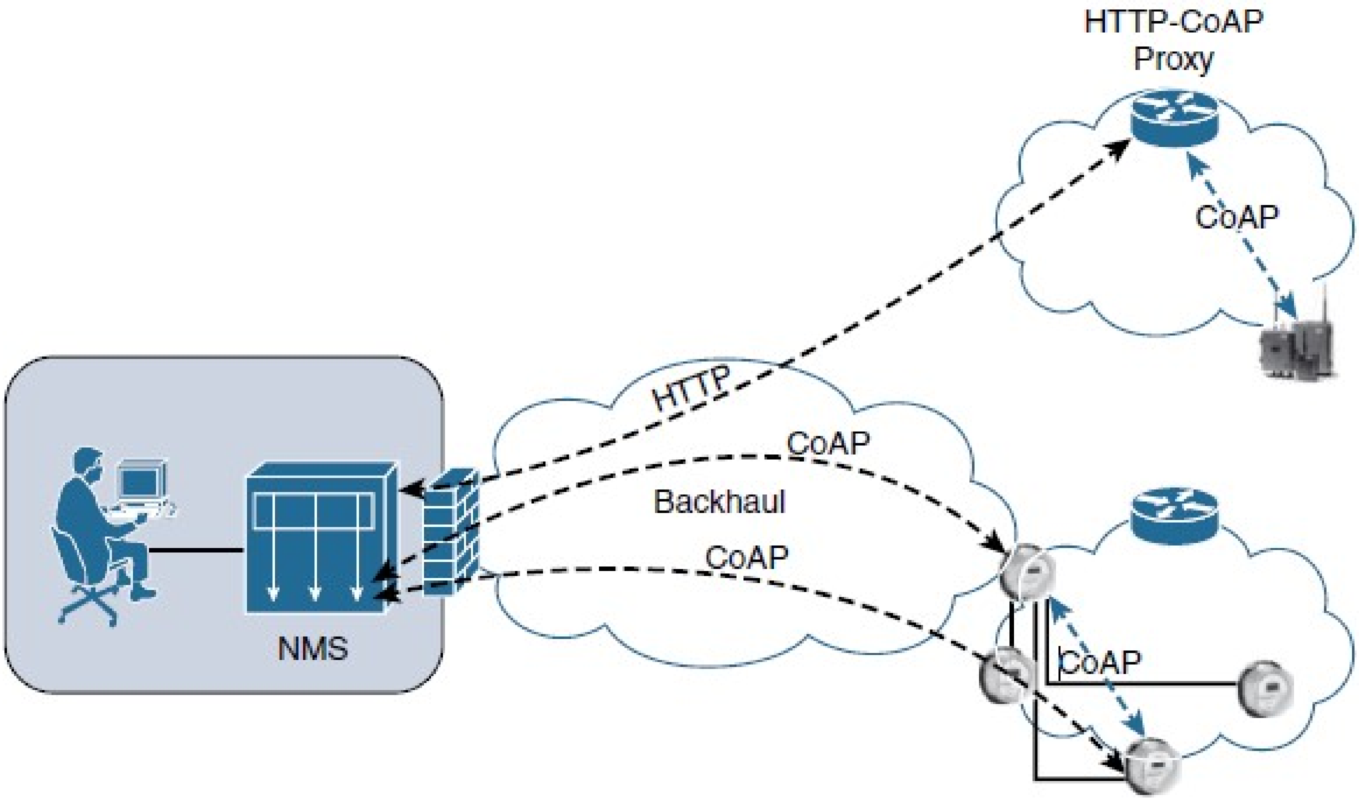


Figure 6-8 *CoAP Communications in IoT Infrastructures*