Instructor Materials
Chapter 1: Things and Connections

Connecting Things 2.01

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Chapter 1:
Things and Connections

IoT Fundamentals

Connecting Things 2.01

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Chapter 1 - Sections & Objectives

- 1.1 What are Things?
  - Analyze the things that make up the IoT.
- 1.2 What are Connections?
  - Explain how things connect to other things and to the IoT.
- 1.3 Chapter Summary

1.1 What are Things?

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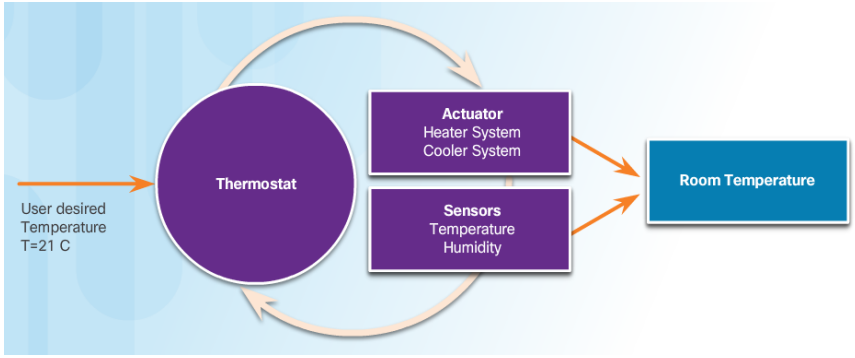
1.1.1 The Internet of Things

- The Presence of IoT in Today's World
  - The IoT is all around us.
  - The IoT helps individuals to improve quality of life.
  - The IoT also helps industries to become more efficient.
- Cisco IoT Solutions
  - The rapid IoT growth has introduced new challenges.
  - Cisco IoT System reduces the complexities of digitization.
  - Six Pillars of the Cisco IoT System are:
    - Network Connectivity
    - Fog Computing
    - Cybersecurity and Physical Security
    - Data Analytics
    - Management and Automation
    - Application Enablement Platform

1.1.2 Building Blocks of an IoT System

- Overview of a Controlled System
  - Feedback loops are used to provide real-time information to its controller based on current behavior.
  - In a closed loop, feedback is continuously being received by the controller from its sensors.
  - The controller continuously analyzes and processes information, and use actuators to modify conditions.
- Sensors
  - A sensor is a device that can be used to measure a physical property by detecting some type of information from the physical world.
  - A sensor may be connected to a controller either directly or remotely.

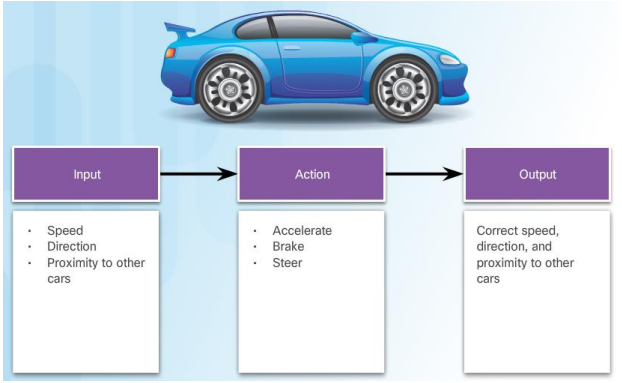


Building Blocks of an IoT System (Cont.)

- Actuators
  - An actuator is a basic motor that can be used to control a system.
  - Can be hydraulic, electric or pneumatic.
  - can be responsible for transforming an electrical signal into physical output.
- Controllers
  - Responsible for collecting data from sensors and providing network connectivity.
  - Controllers may have the ability to make immediate decisions.
  - May also send data to remote and more powerful computer for analysis.

- IoT Process Flow
  - A simple IoT system include sensors connecting, through a wireless or wired connection, to actuators or controllers.
  - Some devices can have more than one function.

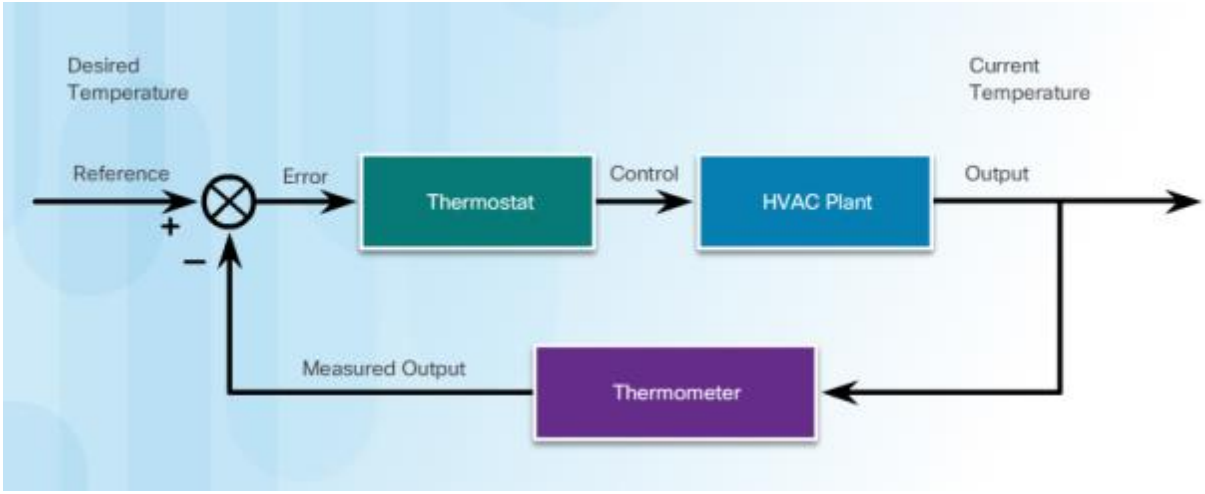
1.1.3 Processes in Controlled Systems



- Processes
  - A process is a series of steps or actions taken to achieve a desired result by the consumer of the process.
- Feedback
  - Feedback is when the output of a process affects the input.
  - Feedback is often referred to as a feedback loop.
  - Feedback loops can be positive or negative.
- Control Systems
  - Includes a controller that uses inputs and outputs to manage and regulate the behavior of the system in an attempt to achieve a desired state.
  - The controlled portion of the system is often called the plant.
  - Choosing the adjustments to apply to a plant to achieve a desired output is called control theory.
  - Control theory is applied to many systems, including driving a car.

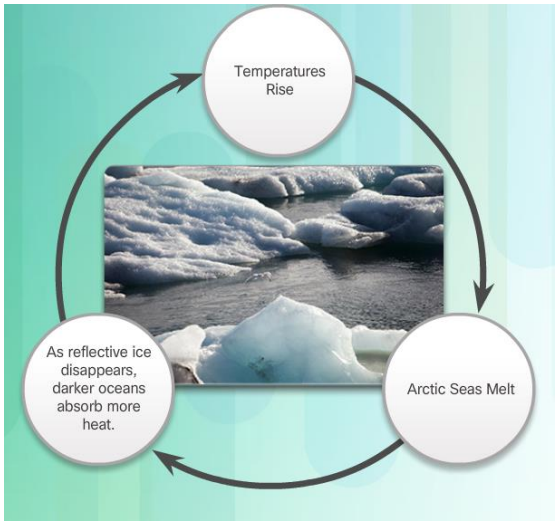
Processes in Controlled Systems (Cont.)

- Open-Loop Control Systems
  - Open-loop control systems do not use feedback.
  - The plant performs a predetermined action without any verification of the desired results.
  - Open-loop control systems are often used for simple processes.
- Closed-Loop Control Systems
  - A closed-loop control system uses feedback to determine whether the collected output is the desired output.
  - The result is then fed back into a controller to adjust the plant for the next iteration of output, and the process repeats.



Processes in Controlled Systems (Cont.)

- Closed-Loop Controllers
  - There are many types of closed-loop controllers:
    - Proportional controllers (P): based on the difference between the measured output and the desired output.
    - Integral controllers (PI): use historical data to measure how long the system has deviated from the desired output.
    - Proportional, Integral and Derivative controllers (PID): include data about how quickly the system is approaching the desired output.
    - PID controller is an efficient way to implement feedback control.
    - The Arduino and Raspberry Pi devices can be used to implement PID controllers.
  - Interdependent Systems
    - Most systems have many interdependent pieces contributing to and affecting the output.



1.2 What are Connections?

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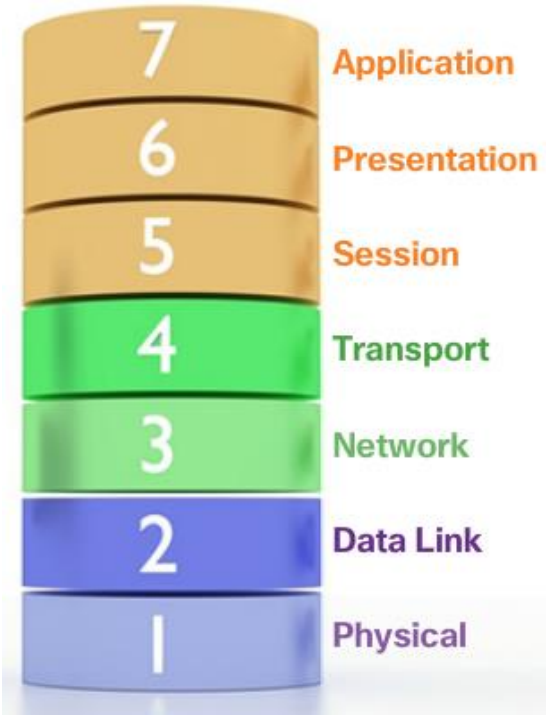
1.2.1 Models of Communication

- Models of Communication
  - Layered networking models are used to illustrate how a network operates. Benefits include:
    - Assists in protocol design.
    - Fosters competition.
    - Promotes technology or capability independence.
    - Provides a common language to describe networking functions and capabilities.

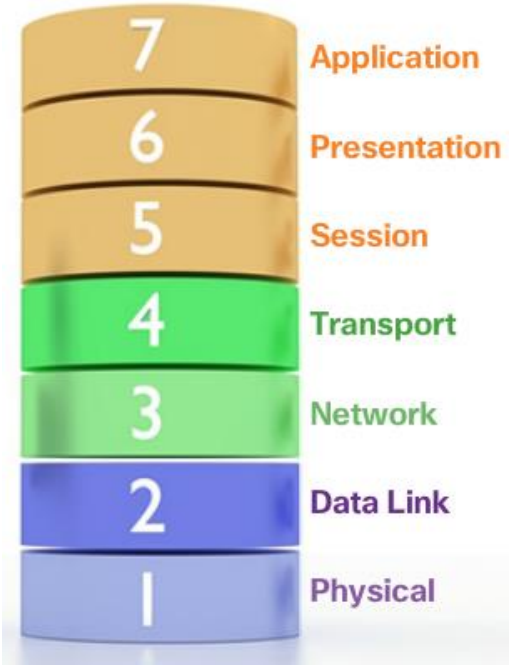


1.2.1 Models of Communication (cont'd)

- Standardization
  - The challenge for the IoT is to ensure these emerging IoT devices can connect securely and reliably to the Internet and to each other.
  - Consistent, secure, and commonly recognized technologies and standards is needed.
  - Organizations such as the Industrial Internet Consortium, OpenFog Consortium, and the Open Connectivity Foundation, are helping to develop standard architectures and frameworks.

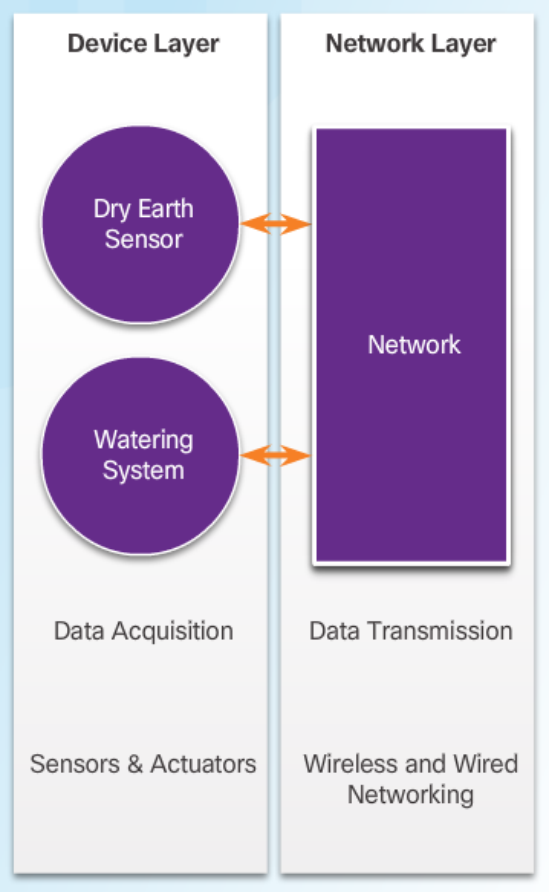
Models of Communication (Cont.)

- TCP and OSI Models
  - Both OSI and TCP/IP models are used to describe network connections and often used interchangeably.
  - The TCP/IP model is commonly referred to as the Internet model.
  - The OSI model provides an extensive list of functions and services that can occur at each layer.
- IoT World Forum Reference Model
  - Developed as a common framework to guide and to help accelerate IoT deployments.
  - It's intent is to provide common terminology and help clarify how information flows and is processed for a unified IoT industry.



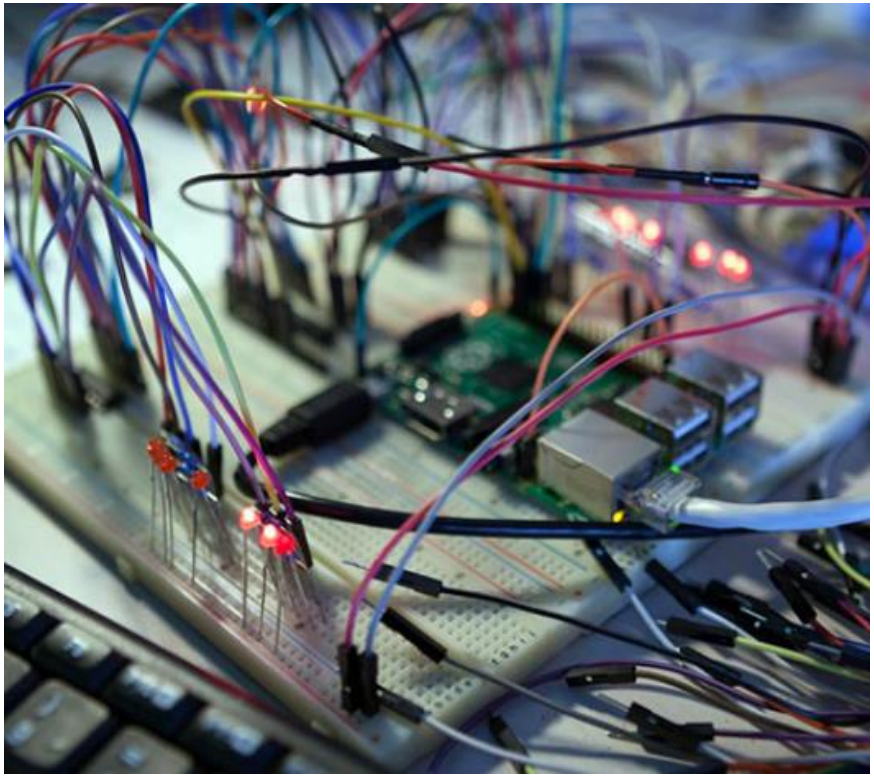
Models of Communication (Cont.)

- Simplified IoT Architecture
  - Several architectures exist to help facilitate the design and creation of IoT systems.
  - The OSI model, TCP/IP model, and the IoT World Forum Reference model have been presented as examples.
  - A simpler approach is based on connection levels. The levels are:
    - Device-to-Device
    - Device-to-Cloud
    - Device-to-Gateway-to-Cloud
    - Device-to-Gateway-to-Cloud-to-Application



1.2.2 Layers of Connections

- Connections Within Networks
  - Connections can have different contexts.
  - Power connections, circuit connections or network connections.
- Physical Connections
  - Relate to the media and cable type.
  - Common media types include copper, fiber optics and wireless.



Layers of Connections (cont'd)

- Data Link and Network Connections
  - Network communication requires protocols to establish the rules of communications. Data Link protocols:
    - Allow the upper layers to access the media
    - Prepare network data for the physical network
    - Control how data is placed and received on the media
    - Exchange frames between nodes over a physical network media, such as copper or fiber-optic
    - Receive and directing packets to an upper layer protocol
    - Perform error detection
  - The most popular data link layer connection used in wired networks is Ethernet.
  - Other data link protocols include wireless standards such as IEEE 802.11 (Wi-Fi), IEEE 802.15 (Bluetooth), and cellular 3G or 4G networks.
  - LoRaWAN and NB-IoT are examples of emerging IoT supporting technologies.

Layers of Connections (Cont.)

- Application Connections
  - The IoT supports many types of connections.
  - Devices must use the same application layer protocols to connect.
  - The application will vary depending on the devices and type of connection involved.
  - MQTT and REST are newer application protocols, created to support IoT devices that connect in the myriad of different types of remote configurations.
  - MQTT is a lightweight messaging protocol with minimal overhead that provides high data integrity and security for remote environments.
  - REST or RESTful web services is a type of API designed to make it easier for programs to interact over the Internet.

1.2.3 Impact of Connections on Privacy and Security

- What is Metadata?
  - Metadata refers to the data about data.
  - Metadata can be embedded within a digital object or it can be stored separately.
  - Metadata is not usually seen by a user.
- The Impact of IoT on Privacy
  - Suggestions and design considerations concerning privacy include:
    - Transparency
    - Data Collection and Use
    - Data Access
- Challenges for Securing IoT Devices
  - Some IoT network security impacting factors include:
    - Increasing Number of Devices
    - Non-Traditional Location of Devices
    - Changing Type and Quantity of Gathered Data
    - Lack of Upgradeability

1.3 Chapter Summary

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Summary

- The Internet of Things (IoT) is all around us. An IoT system is usually made up of sensors to monitor events, actuators to influence the environment, hardware to create the platform and its connections, and software to provide a framework to execute processes.
- A process is a series of steps or actions taken to achieve a desired result.
- Layered networking models are used to illustrate and model how devices communicate. Physical, data link, and network layers are concepts that are used to illustrate how network communication operates.
- Security and privacy issues must be considered in all phases of creation of an IoT system. Each level of connectivity brings with it different requirements and concerns..