Introduction to the Internet of Things

The introductory course for those who want to start their IoT learning journey.

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Message to the Student

Welcome

Did you know that farmers can put sensors on their crops that tell them when to water, how much water is needed, and when to harvest? With this information, farmers can get the best quality and quantity from their crops. Coal miners can place sensors in a mine that detect tiny amounts of dangerous gases. This information saves lives.

The Internet of Things (IoT) describes a growing industry of digital technology being harnessed to the Internet in ways that will improve the lives of every person on this planet. We can only guess at the number and types of jobs it will create. Maybe you would like a career in the IoT.

The Introduction to the Internet of Things course (I2IoT) explains what the IoT is, what it does, how it is part of digital transformation, and how you can become part of this. You will learn about the exponential increase of intelligent devices connected to the internet and you will learn to program one of these intelligent devices. The course explains artificial intelligence and the impact of automation to our future. Lastly, you will understand the increased importance of privacy and security.

Welcome to the Introduction to the Internet of Things course!

A Global Community

When you participate in the Cisco Networking Academy, you are joining a global community linked by common goals and technologies. Schools, colleges, universities, and other entities in over 160 countries participate in the program.

Look for the Cisco Networking Academy official site on Facebook© and LinkedIn©. The Facebook site is where you can meet and engage with other Networking Academy students from around the world. The Cisco Networking Academy LinkedIn site connects you with job postings, and you can see how others are effectively communicating their skills.

More than Just Information

The netacad.com learning environment is an important part of the overall course experience for students and instructors in the Networking Academy. These online course materials include course text and related interactive media, paper-based labs, and many different types of quizzes. All of these materials provide important feedback to help you assess your progress throughout the course.

The material in this course encompasses a broad range of technologies that facilitate how people work, live, play, and learn by communicating with voice, video, and other data. Networking and the Internet affect people differently in different parts of the world. Although we have worked with instructors from around the world to create these materials, it is important that you work with your instructor and fellow students to make the material in this course applicable to your local situation.

How We Teach

E-doing is a design philosophy that applies the principle that people learn best by doing. The curriculum includes embedded, highly interactive e-doing activities to help stimulate learning, increase knowledge retention, and make the whole learning experience much richer – and that makes understanding the content much easier.

More than Just Information

Interactive Activities

Interactive activities are embedded within the chapters as checks for understanding. Some of these use "drag and drop" to complete the activity (Figure 1). Others use a "checkbox" method to complete them (Figure 2). You can check your score immediately. You can also reset and do the activity as many times as you like.

Introduction

Labs are activities that are designed to be performed on physical equipment (Figure 3). Some labs are written as class or small group activities that may or may not involve equipment. It is very important to learn and practice physical skills by using the labs in this course in preparation for a career in IT. Working on physical equipment not only develops skills, but also reinforces knowledge and builds confidence. This is very important as you move into the IT field.

Packet Tracer
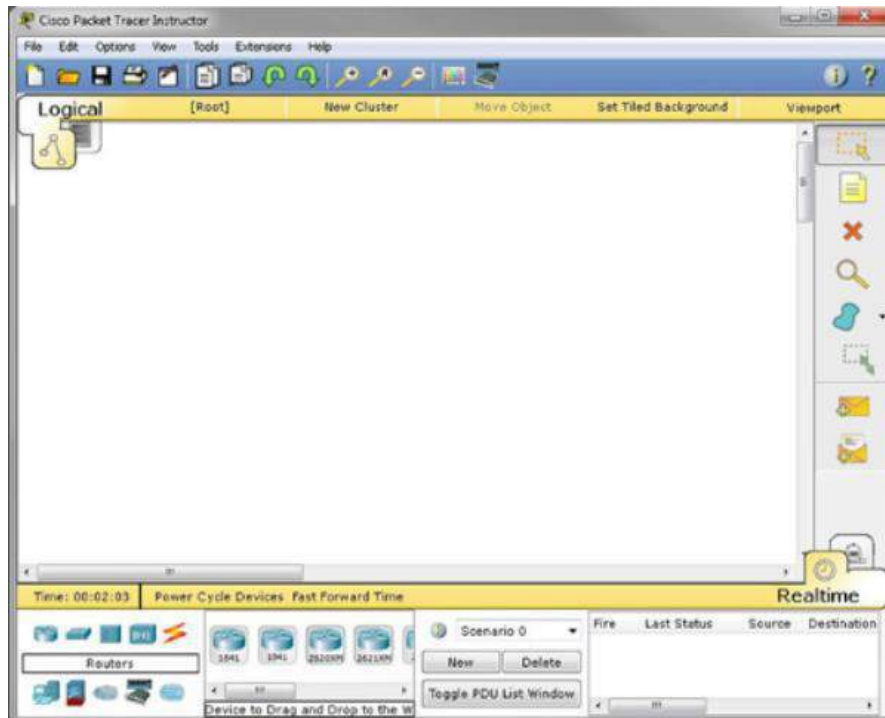
In the Networking chapters, you will configure a simple network using Packet Tracer, the Networking Academy network simulation tool (Figure 4). Packet Tracer is a very robust tool that you will use regularly as you participate in more advanced networking courses. You will complete labs in Chapter 1 to download Packet Tracer, learn how to navigate in the package, and how to create simple networks.

Assessments

Some chapters include topic assessments that are embedded into the curriculum and are meant entirely for self-evaluation. Each chapter in the course has an online chapter quiz (Figure 5). This is scored automatically, showing you the areas where you excel, as well as any areas where you may want to do some additional study or practice. There is an online, end-of-course final exam.

Course Overview

The goal of this course is to explain the Internet of Things and digital technology and to highlight how these two factors are now part of a broader category called digital transformation.

- After completing this course you will be able to do the following:
- Explain the meaning and impact of digital transformation.
- Apply basic programming to support IoT devices.
- Explain how data provides value to digital business and society.
- Explain the benefits of automation in the digitized world.
- Explain the need for enhanced security in the digitized world.
- Discover opportunities provided by digital transformation.

Chapter 1: Everything is Connected

Digital Transformation

The Evolution of Digital Transformation

Tell the truth… how many of you could actually make it through a day without your smartphone?

In our world today, there are more smart devices than there are people. A growing number of people are connected to the Internet, in one way or another, 24 hours a day. An ever-increasing number of people have, and rely on, three, four, or more smart devices. These might include smartphones, exercise and health monitors, e-readers, and tablets. As shown in the Figure, by 2020, it is forecast that each consumer will have an average of 6.58 smart devices.

7.4 billion - people on the planet

30 billion - devices connected to the internet by 2020

6.58 – average number of connected devices per consumer in 2020

44% – children under the age of 1 use smart devices

1.4 million - number of pacemakers in use by 2023

15 million – Fitbit exercise monitors sold in 2017

20 billion - Euros to be spent on artificial intelligence by the EU by 2020
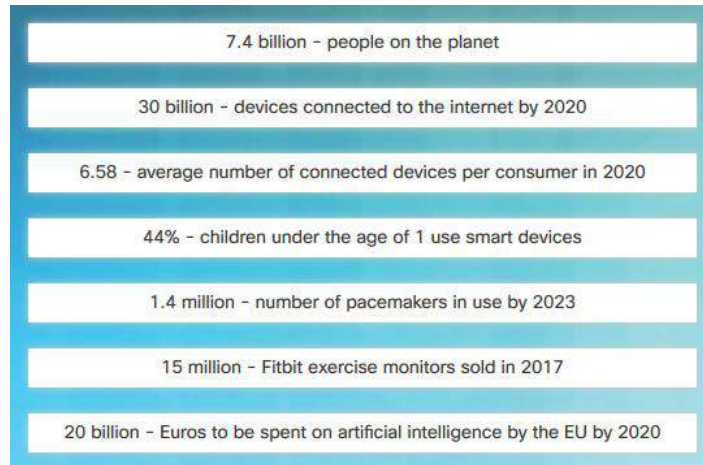
How is it possible for so many devices to be connected?

Modern digital networks make all of this possible. The world is quickly being covered with networks that allow digital devices to interconnect and transmit. Think of the mesh of networks like a digital skin surrounding the planet, as illustrated in Figure 2. With this digital skin, mobile devices, electronic sensors, electronic measuring devices, medical devices, and gauges are all able to connect. They monitor, communicate, evaluate, and in some cases automatically adjust to the data that is being collected and transmitted.

As society embraces these digital devices, as digital networks continue to grow around the world, and as the economic benefits of digitization continue to grow, we are seeing a digital transformation. Digital transformation is the application of digital technology to provide the stage for business and industry to innovate. This digital innovation is now being applied to every aspect of human society.

Figure 1 contains interesting facts. 7.4 Billion people on the planet, 30 billion devices connected to the internet by 2020, 3.64 average number of connected devices per consumer in 2020, 44% children under the age of 1 start using smart devices, 1.4 million pacemakers in use by 2023, 15 million Fitbit exercise monitors sold in 2017, 20 billion euros spent on artificial intelligence by the EU by 2020. Figure 2 is an image of a globe with wired connections representing connectivity across the world.

1.1.1.2 Lab – How Connected are You?

It is important to understand that most people born since the 1990s will have grown up in a primarily digital world. This survey will help you to recognize how much of the day is actually spent "connected". This will help us to see the impact this generation will have on business and the economy.
Follow instructions on lab document.

Determine Your Generation

Determine your connected generation by taking this fun survey that was created by PricewaterhouseCoopers:
http://surveys.strategyand.pwc.com/DigitalGenerationTool/index.php

The Impact of Digital Technology on Business

Digital Technology has enabled business to innovate their approach to interacting with society. People from all generations are comfortable with digital technology and are using smart devices to their advantage throughout their business days.

Many companies provide some or all of their services on-line. From the comfort of your home, car, gym, or office, you can shop for groceries on-line, order restaurant meals to be delivered to your door, book travel on-line, order clothes, camping gear, taxis, stayed connected to friends, or meet new love interest.

Sensors are everywhere generating massive amounts of data.

Smart homes can be equipped with motion sensors, water sensors, light sensors, doorbell sensors and temperature sensors. There can be sensors in traffic lights, transport trucks, parking garages, security cameras, trains and planes. All of these sensors and measuring devices   collect and transmit their data. The data can be stored and analysed at a later date or it can be analysed immediately to be used to modify computers, mobile devices or processes of any sort.

How is the stored and analysed data used?
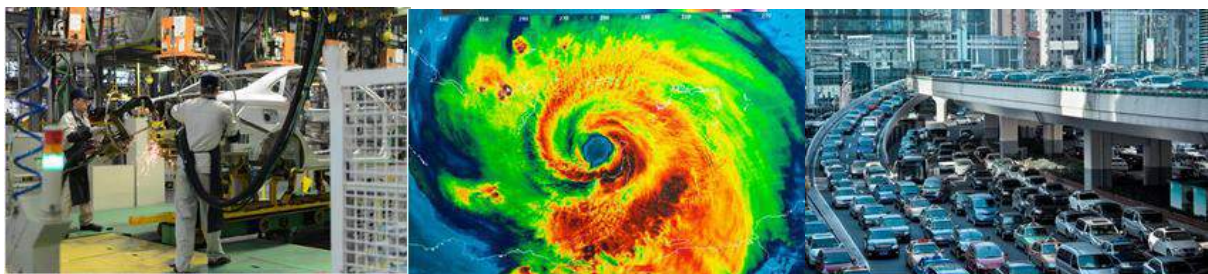
Business: determine buying patterns, forecast new trends and streamline production.

Governments: monitor the environment, forecast population trends, predict crime rates, and plan for social services.

Cities: control traffic, monitor parking, provide police or fire support quicker, and control waste management.

Chapter 1: Everything is Connected

Can Smart Devices Think?

All digital devices work based on computer programs and supplied data. Artificial Intelligence implies that these devices are able to think on their own. If programmed appropriately, smart devices are able to evaluate data that is provided to them and modify processes or settings "on the fly". If they are provided with sufficient data, they can "learn" and modify their own code based on the new parameters.

Smart Cities, such as Barcelona, Spain, use sensors to control many of their infrastructure systems such as traffic flow, parking, water utilization, and hydro.

Example 1: Weight sensors in parking spaces allow drivers to quickly know where there is an available parking spot. This reduces driving and idling time for the driver and lowers carbon emissions for the environment.

Example 2: Sensors on traffic lights can detect traffic congestion. This data is sent to the computer system that collects data and make decisions. The new decisions are sent to actuators that modify red versus green light times to assist the flow of traffic. This also alleviates idling but also reduces driver frustration and accidents.

Imagine a refrigerated transport truck, carrying frozen goods, that is equipped with a global positioning sensor. As the truck drives into a major city, the sensor determines that there is an accident ahead that is causing major traffic congestion. The sensor sends the data to the computer system that collects the data and make decisions. The system then alerts the driver to the new conditions so that the accident can be bypassed.

This automatic interaction has saved the driver time and will get the transported product to market faster with a product that is still frozen.

Self-driving cars are revolutionizing transportation. The cars are equipped with many ultrasound sensors, cameras, precision GPSs, and computers. The combination of the on-board equipment allows the computers to identify, other cars, lanes, pedestrians, and obstructions. This information allows the car to stay in its lane, stop when required, and weave around obstructions.

Some of the manufacturers in the "autonomous car" market are Tesla Motors, General Motors, Volvo, and Mercedes-Benz. Corporations such as Waymo, Google's sibling, and Uber are also designing and testing the technology

The road to complete autonomy using this technology is complicated. There have been many high profile crashes and some serious accidents involving self-driving cars. Some states within the USA have already approved limited use of self-driving cars but researchers believe it will be a few years before the technology becomes mainstream.

Once the technology is proven, what is next? Self-driving trucks? Airplanes? Trains?

Corporate offices can be occupied by thousands of employees. Keeping the environment, such as lighting, heat, humidity, in the building within acceptable parameters helps to keep employees happy and therefore more productive.

Visit https://cisco-netacad.wistia.com/medias/k7s8f8c9cj to view a video about an Ideal Building

Introduction to Packet Tracer

Cisco Packet Tracer is an innovative network simulation and visualization tool. This free software helps you to practice your network configuration and troubleshooting skills. You can use your desktop computer, or an Android or iOS based mobile device. Packet Tracer is available for both the Linux and Windows desktop environments.

Students commonly use Packet Tracer to:

- Prepare for a certification exam.
- Practice what they learn in networking courses.
- Sharpen their skills for a job interview.
- Examine the impact of adding new technologies into existing network designs.
- Build their skills for jobs in the Internet of Things.
- Compete in Global Design Challenges (take a look at the 2017 PT 7 Design Challenge on Facebook).

Packet Tracer is an essential learning tool used in many Cisco Networking Academy courses.
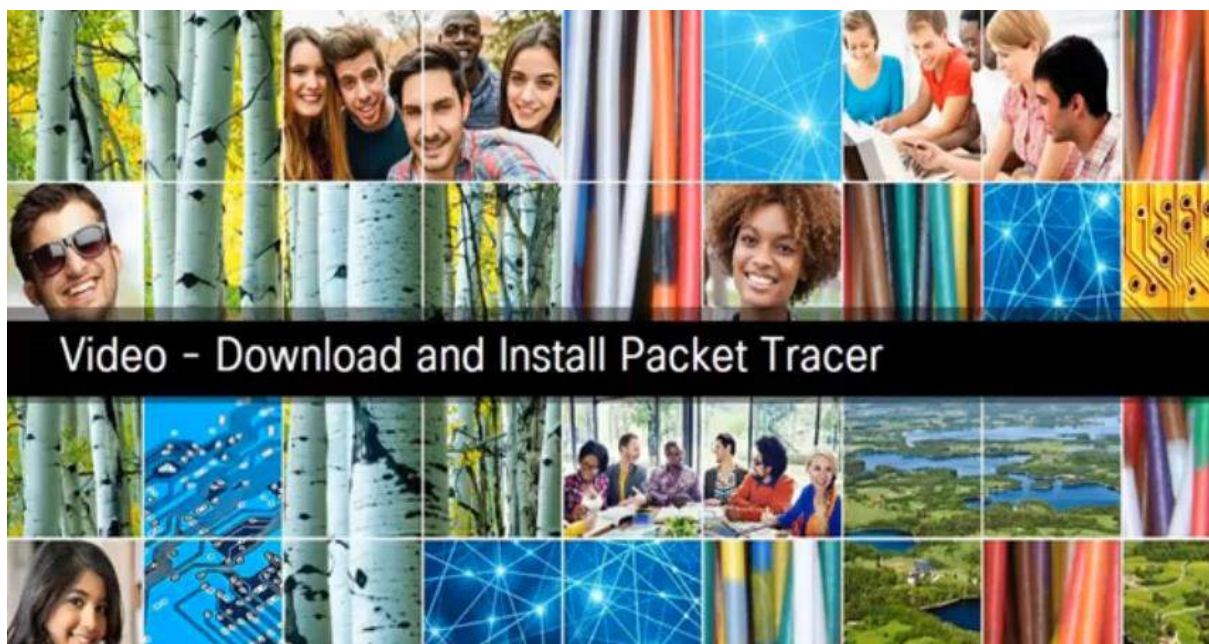
Video – Download and Install Packet Tracer [Transcript]

Hello, everyone, this is our Cisco Packet Tracer install walk through video and this is going to be the I'm Learning page. This is going to show you any classes you're currently enrolled in. If you don't have any classes here just yet, it's okay, you'll be able to experience the awesomeness later on. So here we are. Let's go to the top right corner and we're going to hover over Resources. Then go down and click on Download Packet Tracer. When you click on Download Packet Tracer, we're going to see six options here; two options for Windows, two options for Linux, and two options for mobile devices. Click on the corresponding version that you need for your machine. If you don't know ifyou have a 64 Bit or a 32 Bit machine, you may have to do some online searchingat this time. Once you find out ifyou have a 64 Bit or a 32 Bit operating system, youcan go ahead and click on the corresponding link. I have a 64 Bit version of Windows, so I'm going to click on the 64 BitDownload. When I click on it, I might get a pop-up,your screen might automatically download,it depends on your browser. I'll click on Save File. The download will complete. You can go to your download's folder and locate the file to install, or you can utilize your browser's download section and click on the file to install. When you click onthat file, we get our pop-up, and yes we'll click on Run. This is a very straight forward install with Packet Tracer. When we get this next screen of, hey, it's next,let's just walk on through it: go Next,accept the Cisco agreement,andcontinue on. Verify the install path. Go ahead. The name that's going to show up in your program shortcuts, that's great. Do you want a desktop Quick Launch icon? You get to pick. And finallywe get to review our settings and click on Install. From here Packet Traceris going to install on your machine. It's a rather quick install for this. When Packet Tracer is done installing, we're going to be presented with a pop-up. This pop-up is just a little verification thatPacket Traceris going to integrate with your browser.Please make sure you close your browser or restart your machine. Here's that pop-up, so let's just click Ok. Launch Cisco PacketTracer is checked by default, that's great. We'll click Finish. Now Packet Traceris going to open up automatically because of that check box. As it opens up here, we're going to be able to see an authentication page. Here it is. When Cisco Packet Tracer asks you to authenticate,you'll utilize your NetAcad Account here, or again if you don'tknow it, you can utilize your email address tied to your NetAcad Account. In the password field, please just put in your password for NetAcad and click Log In. Now that we've successfully authenticated, Cisco Packet Tracer has opened up, we are good togo to build our own networks, complete our lab assignments and have some fun.

Chapter 1: Everything is Connected

To obtain and install your copy of Cisco Packet Tracer follow these simple steps:

1. Log into your Cisco Networking Academy "I'm Learning" page.
2. Select Resources from the menu in the upper right portion of your screen.
3. Select Download Packet Tracer.
4. Select the version of Packet Tracer you require.
5. Save the file to your computer.
6. Launch the Packet Tracer install program.
7. After installation, close and restart your web browser.
8. Launch Cisco Packet Tracer by selecting the appropriate icon.
9. When prompted, use your Netacad login information to authenticate.

1.1.1.8 Packet Tracer – Deploying and Cabling Devices

Since Packet Tracer simulates networks and network traffic, the physical aspects of these networks also need to be simulated. This includes actually finding and deploying physical devices, customizing those devices, and cabling those devices. After the physical deployment and cabling is done, then it is time for configuration of the interfaces used to connect the devices.

Finding a device to deploy requires looking in the Device-Type Selection Box. The Device-Type Selection Box works on the concept of categories and sub-categories as shown in the figure.

The top row of icons represents the category list consisting of: [Networking Devices], [End Devices], [Components], [Connections], [Miscellaneous], and [Multiuser]. Each category contains at least one sub-category group.

Download the Packet Tracer file and complete activity

Networking is the Foundation

Thirty billion things provide trillions of gigabytes of data. How can they work together to enhance our decision-making and improve our lives and our businesses? Enabling these connections are the networks that we use daily. These networks provide the foundation for the Internet and the digitized world.

The methods that we use to communicate continue to evolve. Whereas we were once limited by cables and plugs, breakthroughs in wireless and digital technology have significantly extended the reach of our communications.

Networks form the foundation of the digitized world. Networks come in all sizes. They can range from simple networks consisting of two computers to networks connecting millions of devices.

Simple networks in homes enable connectivity to the Internet. They also enable the sharing of resources, such as printers, documents, pictures, and music, between a few local computers.

In businesses and large organizations, networks can provide products and services to customers through their connection to the Internet. Networks can also be used on an even broader scale to provide consolidation, storage, and access to information on network servers. Networks allow for email, instant messaging, and collaboration among employees. In addition, the network enables connectivity to new places, giving machines more value in industrial environments.

The Internet is the largest network in existence and effectively provides the "electronic skin" that surrounds the planet. In fact, the term Internet means a "network of networks". The Internet is literally a collection of interconnected private and public networks. Businesses, small office networks, and home networks connect to the Internet.

Network Types

Modern networks can be a bit confusing. There are many types that are characterized by their geographic size, by the number of devices or networks that they connect, and by whether they support mobile devices or not. Networks can also be characterized by their function and purpose.

Personal Area Network (PAN)

Personal area networks are small networks where connected wireless devices are within personal reach. Connecting your smartphone to your car using Bluetooth is an example of a PAN.

Local Area Network (LAN)

LANs are typically networks in a small or local geographic area, such as a home, small business or department within a large corporation. LANs can connect two or more devices, including computers, printers, and wireless devices. LANs provide access to larger wide area networks (WANs) and the Internet.
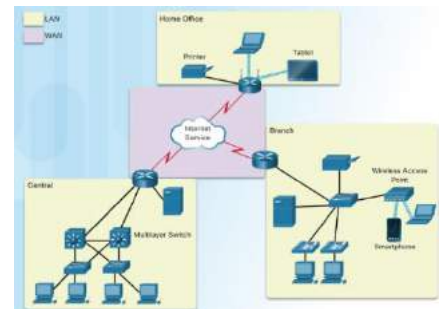
Wide Area Networks (WANs)

The term WAN typically refers to a collection of LANs that provides inter-LAN and Internet connectivity for businesses and governments.

Internet The Internet is a multi-layer global network system that connects hundreds of millions of computers. The Internet is not owned by any one person or organization. This large system is comprised of multiple local and global networks serving private, public, business, academic, and government purposes. It allows for the exchange of data between more than a hundred Internet-linked countries worldwide. This makes the Internet an enormous carrier of various information resources and services. Some of these include text and multi-media data, email, online chat, VoIP, file transfer and file sharing, ecommerce, and online gaming.

Wireless Networks

Wireless networks are those computer networks that use electromagnetic waves instead of wires in order to carry signals over the various parts of the network. Wireless networks can be described as PANs, LANs or WANs, depending on their scope.

Wireless Networks		
Type	Range	Standards
Personal area network (PAN)	Within reach of a person	Bluetooth, ZigBee, NFC
Local area network (LAN)	Within a building or campus	IEEE 802.11 (WiFi)
Metropolitan area network (MAN)	Within a city	IEEE 802.15 (WiMAX)
Wide area network (WAN)	Worldwide	Cellular (UMTS, LTE, etc.)

Because browsing the Internet is considered a normal daily activity, wireless access points have become common place in the communication infrastructure today. Public Internet-connected places include libraries, airports, coffee shops, hotels, and specialized Internet cafes. Thanks to Wi-Fi technology, the Internet can now be accessed by every person with a laptop, tablet, or smartphone. Figure 4 shows the different categories of wireless networks that are available.

The Cloud

The term "cloud" is used in many different ways. The cloud is not as much a type of network as it is a collection of data centers or groups of connected servers that are used to store and analyze data, provide access to on-line applications, and provide backup services for personal and corporate use (Figure 5). Cloud services are provided by different organizations.

The Edge

The edge refers to the physical "edge" of a corporate network.

Fog Computing

With the rising number of sensors used by the Internet of Things, there is often a need to store the sensor data securely and closer to where the data can be analyzed. This analyzed data can then be used quickly and effectively to update or modify processes within the organization. Figure 6 shows an example of a smart city and how sensor data is processed. The fog is located at the edge of a business or corporate network. Servers and computer programs allow the data to be pre-processed for immediate use. Then the pre-processed data can be sent to the cloud for more in-depth computing if required.

1.1.2.4 Lab – Mapping the Internet

In this lab, you will use an Internet connection and three route tracing utilities to examine the Internet pathway to destination networks.
Follow instructions on lab document.

1.1.2.5 Packet Tracer - Create a Simple Network Using Packet Tracer

In this lab, you will use Packet Tracer to create a simple network.

Download the Packet Tracer file and complete activity

Devices that Connect to the IoT

What is the IoT?

The Internet of Things (IoT) is the connection of millions of smart devices and sensors connected to the Internet. These connected devices and sensors collect and share data for use and evaluation by many organizations. These organizations include businesses, cities, governments, hospitals and individuals. The IoT has been possible, in part, due to the advent of cheap processors and wireless networks. Previously inanimate objects such as doorknobs or light bulbs can now be equipped with an intelligent sensor that can collect and transfer data to a network.

Researchers estimate that over 3 million new devices are connected to the Internet each month. Researchers also estimate that in the next four years, there are going to be over 30 billion connected devices worldwide.

Perhaps a third of connected devices will be computers, smartphones, tablets, and smart TVs. The remaining two-thirds will be other kinds of "things": sensors, actuators, and newly invented intelligent devices that monitor, control, analyze, and optimize our world.

Some examples of intelligent connected sensors are: smart doorbells, garage doors, thermostats, sports wearables, pacemakers, traffic lights, parking spots, and many others. The limit of different objects that could become intelligent sensors is limited only by our imagination.

1.2.1.2 Lab – Imagine a New Intelligent Sensor

Many devices have sensors in them that affect the operation of processes or generate data to assist governments and businesses. Use your imagination to think of devices that could be made more useful if they contained intelligent sensors.

Follow instructions on lab document.

What are the Benefits of Connecting these IoT Devices?

Businesses have more information about products that they sell and who is purchasing them. Armed with this type of data, they can streamline production and target their marketing and advertising to specific areas or audiences, promotes creation of new business opportunities and marketing ideas.

Manufacturing saves money, improves efficiency, and improves productivity of manufacturing processes and operations. Manufacturers reduce downtime by predicting maintenance requirements and improving scheduling of field service employees.

Retailers are able to do more target marketing, reduce losses based on unsold products, and can provide loyalty bonuses for preferred or frequent customers, as well as manage types of in-store products.

Governments monitor environmental issues, target funding for social issues, and have informed control of power output.

Cities have the ability to control traffic patterns based on time of day or major events, monitor and control garbage and recycling, monitor health and housing needs, and evaluate future transportation requirements.

Individuals can reap improved fitness and health benefits, better home and family security, and reduced costs for energy and heating systems. They can enjoy more varied entertainment, limit the speed a teenage driver can reach, or even monitor the health of an older family member at the wheel of their car.

1.2.1.4 Lab - Advantages and Disadvantages of IoT Devices

In this activity, you brainstorm to determine if the advantages of collecting sensor data outweigh any disadvantages.

Follow instructions on lab document.

How are IoT Devices Connected to the Network?

A sensor needs to be connected to a network so that the gathered data can be stored and shared. This requires either a wired Ethernet connection or a wireless connection to a controller. Controllers are responsible for collecting data from sensors and providing network or Internet connectivity. Controllers may have the ability to make immediate decisions, or they may send data to a more powerful computer for analysis. This more powerful computer might be in the same LAN as the controller or might only be accessible through an Internet connection.
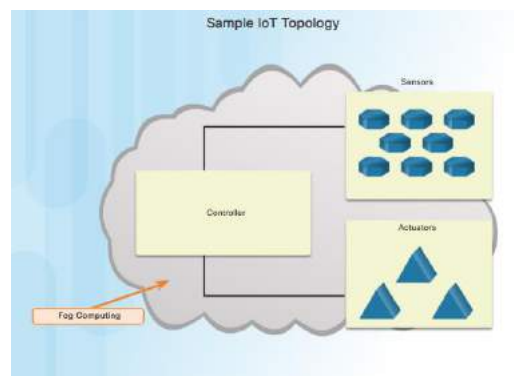
Sensors often work together with a device called an actuator. Actuators take electrical input and transform the input into physical action. As an example, if a sensor detects excess heat in a room, the sensor sends the temperature reading to the microcontroller. The microcontroller can send the data to an actuator which would then turn on the air conditioner.

The majority of new devices such as fitness wearables, implanted pacemakers, air meters in a mine shaft, and water meters in a farm field all require wireless connectivity. Because many sensors are "out in the field" and are powered by batteries or solar panels, consideration must be given to power consumption. Low-powered connection options must be used to optimize and extend the availability of the sensor.

The image contains actuator and sensor representations with a line representing connection to the controller. All are contained in a gray cloud labelled fog computing.

Explore a Smart Home

Packet Tracer has a wide variety of sensors and smart devices that will allow you to design smart homes, smart cities, smart factories, and smart power grids.

To locate the available sensors and smart devices, select End Devices from the Device Selection box at the lower left-hand side of the screen. Next, select the subcategory Home. In this subcategory, you will see many IoT devices including an air conditioner, ceiling fan, coffee maker, and CO detector. These devices can be connected to your network wirelessly or with a physical cable.

To connect the devices to your network, you need a home gateway or registration server. To find a home gateway, select Network Devices from the Device Selection box and then select Wireless Devices from the subcategories.

To control the devices, you have two options:

1. You can interact directly with a device. Hold down the Alt key and at the same time click on the device to turn it on or off.
2. You can connect remotely over the network. Using a remote PC, tablet or smart phone, use a web browser to connect to the home gateway or registration server. From here, you can turn the devices on or off using the features of the home gateway or registration server.

To configure devices, click on the device to open it. After it is opened, multiple tabs are displayed:

- Specifications – describes the features, usage, local and remote control of the device
- Physical – available modules and power connections
- Config – shows display name, serial number, network configuration, and IoT server
- Attributes – displays the device attributes such as MTBF, power consumption, and cost

To configure the home gateway, click on the device. Within the device multiple tabs are displayed:

- Physical – available modules, and power
- Config – shows display name, interfaces (Internet, LAN, and wireless) to be configured
- GUI – shows services to be turned on/off
- Attributes – shows features and values related to device such as mean time between failure (MTBF), cost, power sources, and wattage

Chapter 1: Everything is Connected

Video – Explore a Smart Home [Transcript]

Hello everyone this is our Cisco Packet Tracer internet of things walk through video. In this video we're going tointeract with many different IOT devices here in this Smart Home within Cisco Packet Tracer. So this is just a house and all these devices I put on top of it make it into a Smart home. So where did all these devices even come from? Well here in the bottomleft corner we see by default where network devices. Here we can see we have categories for routers, switches, hubs, wireless devices and even security. We're going into End Devices. So I'll click on End Devices and here we'll see our common end devices,our PC's and laptops, printers, and phones and TV's, but besides that there's even other subcategories. For example, Home. Inside of home we'll see the air conditioning units, smart appliances like coffee makers, we'll see speakers and ceiling fans, smokedetectors, and even lamps and lawn sprinklers. All of these items that we can try to interact with and control here in Cisco Packet Tracer. It is very easy to deploy all we'd have to do is click on one and click on our screen, and then it's on our house. We'll be setting one of those up later. Our next subcategory we can even see a smart city. It includes streetlamps, more on solar panels, and even wind detectors. We can go further and take a look at industrial and even go further than that in power grid items. All these being deployable here in Cisco Packet Tracer. So let's take a look at our current power as it is right now. With our smart house we have our ceiling fan, we have our thermostat, smoke detector, smart lamp, our appliance which is a coffee maker, and even our door with opening and closing and locking, and a garage door. At the top we have a battery back up system, as well as a solar panel that is receiving energy from the sun. Now all the way at the bottom by the pool there is a lawn sprinkler, we'll be utilizing that later on. In the middle of our house we have something called an MCU. And this a micro controller, and this allows us to actually program events for when the front door or the ceiling fan should be turned on or turned off automatically based on variables. Besides that, at the top we have what's called a Home Gateway, and this is how we're going tobe interconnecting all of our IOT devices here in this smart house. So we click on the Home Gateway, we can see here that we go to thePhysical tab. In the Physical tab we can see our physical view of what the Home Gateway looks like. It has four network ports on the front and an internet port, as well as multiple wireless antennas for connectivity.In our Config tab we can see what typeof interfaces are here and what we can configure. For the GUI tab we can see that there's an index.php file. This is used for a registration server that's on the Home Gateway this is going to allow us to remotely or locally manage all of our IOT devices that are network capable, from sitting on a webpage. We'll take a look at that a little bit later. In the Attributes tab we can see our MTBF for meantime, between, or before failure, the cost, power source, and some basic other information. So how do we interact with these devices? Well we can either have them registered with our Home Gateway and control them via webpage, but there's another way too. We're able to click on these while we hold down our Alt key.

For example, this Smart Coffee Maker's off right now. If I hold down my Alt key, I can left click on the coffee maker and it turns on, a light goes on. I can click on it again and it turns off. Same with the Smart Lamp, its off right now, but if I hold down my Alt key and left click on it, it turns on,click on it again it goes brighter, and then it turns off. Now we can deploy new devices very quickly and easy inside of Cisco Packet Tracer, as well as we can hook them up to networks and registration servers to be controlled very quickly as well. So right now I have a lawn sprinkler, what I can do is I can click on it and we can take a look at a couple of the features and settings on it. When I click on the Lawn Sprinkler, it tells us this is a sprinkler for the lawn. We're able to have it registered tothe registration server so we can control it and this things going toraise the water level that's the purpose of the lawn sprinkler it will put out water. Down below we can see we can ALT-Click on it to directly interact with it and also we can remotely control it via a registration server. So how does this registration server work? Because that's what we're about to utilize. First I need to go on a machine that can access that webpage on the Home Gateway. So I'll click on the Tablet, on the Tablet I'll go to my Desktop tab and my Web Browser. I'm going toput in the IP address of the

Home Gateway, which is 192.168.25.1 that's the default IP. When I hit enter it'll ask me for a Username and Password. The default is admin for both of those. So check it out, all these devices here are registered to the Home Gateway. So I can go ahead and click on any of these items like the Smart Coffee Maker and I can actually turn it on or turn it off from here. And as you make changes in this system you'll be able to seeit live occurring on the devices so turn on the coffee maker and now it's on, and I can even turn it off. Same with other items like the lamp. I can put the lamp on dim, goes on low, I can put it on, which is high, or again turn it off. So how do we add our own device to this? Well we have this lawn sprinkler and it's kind of boring to have to go outside and turn the water on and off. What if it could be remotely controlled? Well we can make it happen.

So what we're going todo is we're going todo id we'll click on the Lawn Sprinkler and now the Lawn Sprinkler, I'm going togo to my Config tab. In the Config tab is a wireless adapter for my Lawn Sprinkler, I'm going tomake sure I set it up though so it actually utilizes a wireless password and I have to type that in. And that's going tobe mySecretKey. By doing this I want tomake sure it gets an address and hooked to wireless, I see the wireless connection came through and hit the Home Gateway. Now I'm on the wireless network, but lastly we need to tellit to actually hook up. And we'll go more into detail in this in the later video. Use a Home Gateway for the registration IOT server. At this time, this Lawn Sprinkler should be connected to that home Gateway and if I go back to my Tablet, Check it out. At the bottom here what we did not see before now we see Lawn Sprinkler, Grass. I can click on it and look at that right now the Lawn Sprinklers off from sitting with my tablet on the couch in my Smart House I can tell that status to go green by clicking onit and now I'm watering the lawn remotely. This could be done locally on my Smart Home network or even externally from something on the internet. If I set up the Home Gateway to be accessible. So take your time, play with Cisco Packet Tracer, and build your own convenient and awesome smart home networks.

1.2.2.1 Packet Tracer - Adding IoT Devices to a Smart Home

In this activity you will open a Packet Tracer file with an existing home network, explore the devices on the network and then add additional wired and wireless IoT devices.

Download the Packet Tracer file and complete activity

Accessing and Monitoring an IoT Network

The Home Gateway device acts as a local connection to your IoT smart devices. This device was designed to provide Internet access, wireless connectivity, and local logic for smart devices. The Home Gateway device provides an IoT registration service that is always turned on and an auto discovery service for Things in the local Ethernet and wireless network. After devices are connected to the home gateway, the user can control and monitor the smart devices from their smartphone, tablet, or PC.

After a home gateway device has been added to the logical workspace, click on the device. You will see the following:

- Physical tab – the device has an Internet port, four LAN ports, and multiple antennae.
- Config tab – this shows the interfaces and network settings that are configurable.
- GUI tab – this shows the registration server inside the device that allows for interaction with IoT devices. It is on by default but can be turned off.
- Attributes tab – This is blank by default but can show features and values such as MTBF, cost, power source, and wattage.

After connecting the home gateway to an existing network, select the Config tab. The internet and the wireless interfaces should obtain IP addressing information from the network.

To connect an IoT device, such as a fan, wirelessly, click on the fan and select the Config tab. Select the Advanced button in the lower right corner to view more options.

To configure and register the fan with the home gateway:

Step 1. Select I/O Config and then select wireless adapter from the network adaptors dropdown list.
Step 2. Select Config to verify that the fan has established a wireless connection to the correct SSID. This can also be done visually by viewing the fan in the workspace.
Step 3. Select Config/Settings and select the home gateway as the IoT server registration device.

To control the fan remotely

Step 1. Add a tablet, PC, or smart phone to the workspace and connect it to the home gateway. Click on the remote device and select Desktop/IPConfig to verify connectivity.
Step 2. Return to the desktop and select the web browser. Use the default gateway address from the remote device as the URL. This is the address of the home gateway. After you are into the home gateway, you should see the registered fan and be able to modify its settings.
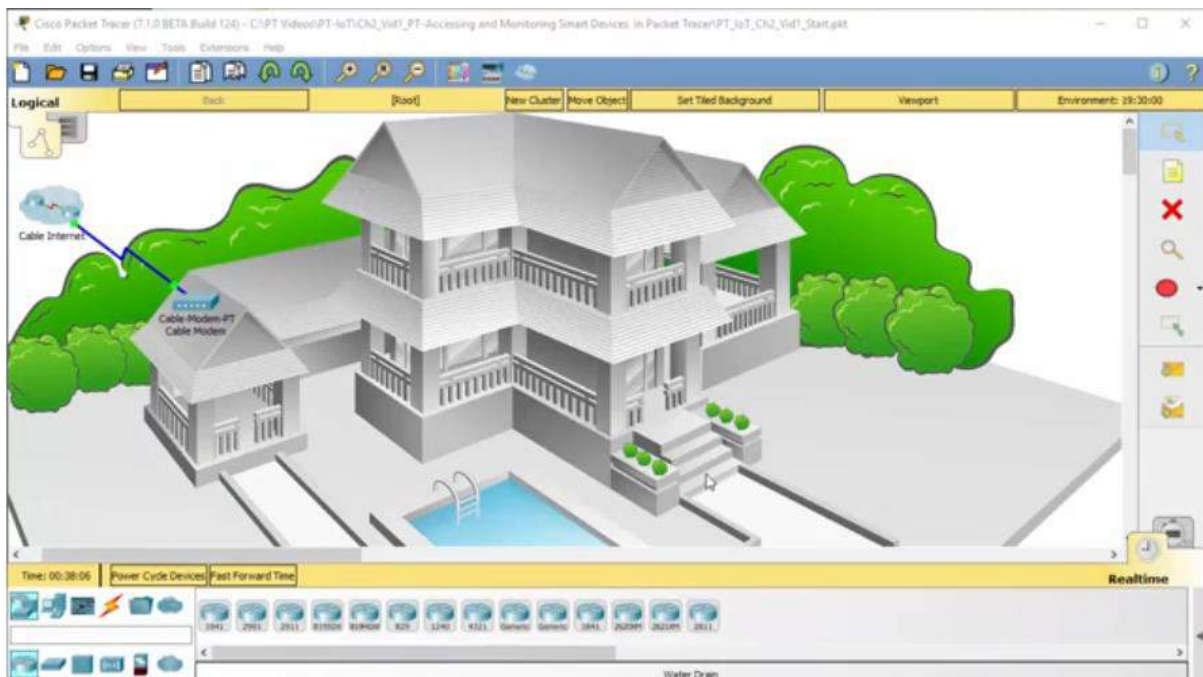
Chapter 1: Everything is Connected

Video – Accessing and Monitoring Smart Devices [Transcript]

Hello everyone, this is our Cisco Packet Tracer, Accessing and Monitoring Smart Devices walk-through video. This video is going to be great. Packet Tracer and IoT coming together and actually utilizing something called a smart home gateway are all happening right here, so let's get into it. Right now, we have a cable Internet connection hooked to a cable modem. What we are going to do is deploy a wireless home gateway. To do that we need to be in network devices and then the subcategory of wireless devices. So we'll click on it. Inside of here we'll see we have multiple devices. What we want right now is going to be the home gateway, which is right here. I'll click on the home gateway, and I'll click in my house and now we have it deployed. When we click on the home gateway we see the physical tab, and I see four wired connections from my house and one wired connection for the internet. Besides that we also have wireless connections in order to hook to wireless devices. So let's do some cabling. I'll minimize the home gateway. And now we're going to go and click on our cabling connection. I'm going to click on my automatic cable. I'll click on the cable modem, and I'll click on the home gateway. And now this is going to carry Internet from the cable modem to the home gateway. So at this time we can go ahead and click back on the home gateway and we'll take a look at some of the tabs inside of here. Inside of here we have the config tab, and under the config tab we have basic settings for the home gateway, which includes the name then we have multiple settings for the three different types of connections, the internet connection, the LAN and wireless. Besides that we have the GUI tab and with the GUI tab we see that it's running a web server. This is a web registration server that operates on the home gateway. This allows us to connect our IoT devices to this registration server, in order to control and monitor them. Also we have the attributes tab, which includes specifications regarding mean time between failure, cost, power, and even rack units and wattage. So let's take a look at actually getting some IoT devices in our smart home typology. So I'll minimize the home gateway a second time, and now it's time to pick out some IoT devices. I'm going to go ahead and click on end devices, then I'll click on home. Inside of home I want to deploy some IoT devices. For example, I'll take the ceiling fan. I'll click on that. I can deploy that on the left side of the house. Besides the IoT ceiling fan, we may also want an IoT lamp. I'll click on the lamp, and I'll deploy that upstairs. A door would be nice. For the front door, I'm going to go ahead and click on this smart IoT door here, and I'll deploy that at the front. And lastly something to monitor, I'm going to scroll all the way over to the side and near the end of our home smart devices, we'll see a wind detector. I'll click on the wind detector, and we'll deploy that at the top of the house. Now we have all these IoT devices deployed across my house. What we want to be able to do now is be able to configure these IoT devices to actually work with the home gateway. With the home gateway we're going to use the wireless connections, and inside of config and inside of wireless, I'll be able to see the wireless name is Home Gateway. Besides that I need to make sure that my IoT devices understand how to connect to this home gateway device. So let me minimize the home gateway, and now I'm going to click on that fan. When I click on the fan, it opens up. With this fan we can see the basic specifications of how it works regarding off, low speed, high speed, and we can also see that it can be connected to a registration server. We can also interact directly with this fan by holding the alt key and clicking on it, but we want to control this from the home gateway. So we can take a look at this fan in the config tab, and in the config tab, we see how this fan connects to a network. It connects to a fast Ethernet port. That's a cable, so we need to get this thing on wireless. To get it on a wireless we're going to click on the advanced button and when you click on advanced, now we have more tabs at the top. The one we want is IO config. We click on IO config, we can then see the network adapters that are possible. I want to change this fast Ethernet adapter to a 1W. When I click 1W, now I have a wireless adapter on the fan. There's no apply button here. We're just going to go back to the config tab, and now in the config tab, I see I have a wireless interface. I can click on wireless, and we see here it's automatically set to Home Gateway. This is the name we had to make sure it matched. Also, we're receiving an IP address from the home gateway, as we see here inside of DHCP.

Let's repeat and do this with the remaining three devices. I'll minimize and now we see the fan is hooked up. Let's go to the door. We'll click on the door. The door opens up. Inside of the door we're going to go to our advanced button. Input, output, IO config. Make sure we change the network adapter to wireless. To the config tab, make sure we're hooked to the wireless network, which we are. We're getting an IP address. And now the door is done, as well. Two more devices. We'll do the light and the wind detector, as well. Click on the light, and the light opens up. Head over to the advanced button. Config, set our wireless, and we'll make sure it connects to the wireless network. Awesome, the light is good. It also receives an address. Lastly, is going to be a wind detector. This is our sensor. We'll open the wind detector. When the wind detector opens up, same thing as you did before. Make sure we can get this thing with a wireless adapter on it, so we can hook this up to that registration server. Awesome. So everything is hooked up right now, but in order for us to interact with these devices and that home registration server, we need something that can open a webpage and view that registration server. So I'm going to go back to my end devices and inside of my subcategory of end devices, I want a tablet, so I'm going to go find and say yeah, wireless tablet. I'll click on the tablet PC and I'll put it right next to the pool. Now I can click on that tablet PC and on the tablet PC itself, I'm going to click on the config tab and there we go, wireless. The wireless network name is default, and that's not the right one for this. We need to set this to Home Gateway like we saw previously with all of my IoT devices hooking to the home gateway wireless. Besides just Home Gateway for the SSID, which is the wireless name, I can click again on DHCP. I'm getting an address from the home gateway. Now let's continue onwards and be able to configure and manage and monitor my IoT devices. So I'll click on desktop, and I'll click on web browser. The actual IP address of that home gateway is 192.168.25.1, when I click on go, this'll connect to that home gateway. The username and password here is admin, admin then I can click submit. Now that password can be modified at a later time. Right now I have no IoT devices deployed here, so what I need to do is actually hop on the IoT devices and tell them to register to the registration server, known as Home Gateway. To do it, I just need to hop on each one of those devices and there's a special place inside of config called settings. When I'm in the config tab and settings, I can scroll down to the bottom and you can see here, IoT server is none. Need to select the radial button of Home Gateway. When I click that button, I can then go back to my tablet and click go, and check it out, the ceiling fan now shows. We'll do the same thing on the other three IoT devices. The door, settings, use an IoT server of Home Gateway. Same with the lamp. And lastly, with my wind detector. And now that all the devices know to use a home gateway, we can check out that home gateway webpage one more time, and take a look at this. We have the ceiling fan, we have the door, we have the light, and there's the wind detector. I can click on any one of these devices. I can either control them like we see herewith the ceiling fan or when I click on the wind detector, we can actually monitor that there's wind. We can even take a look at the door and the light and see the status of them and, of course, be able to make changes on some of these IoT devices. So play with Cisco Packet Tracer. Build your own IoT smart home network, and become a Cisco IoT all-star.

1.2.2.3 Packet Tracer - Connect and Monitor IoT Devices

In this activity, you will add a Home Gateway and several IoT devices to an existing home network and monitor those devices through the Home Gateway.

Download the Packet Tracer file and complete activity

The Future of Networks

Networks are now connecting billions of sensors. Through software, the data from these sensors can cause changes to physical environments without human intervention.

As was mentioned previously, all digital devices work based on computer programs and supplied data. Artificial Intelligence implies that these devices are able to think on their own. If programmed appropriately, smart devices are able to evaluate data that is provided to them and modify processes or settings immediately. If they are provided with sufficient data, they can "learn" and modify their own code based on the new parameters.

So what comes next?

We know that software can be written to let data modify parameters within code for changing the temperature setting in your home or the speed with which your teenager can drive the family car. Why could we not provide software with rules, guidelines, or intent so that data could modify the network, infrastructure features, or security features within a network? This is actually already possible. It is called Intent-Based Networking (IBN).

Here is a simple example to better understand the concept of IBN: The business may define that a contract employee is given access to only a specific set of data and applications. This is the **intent**. In an intent-based networking system (IBN), all the network devices will be automatically configured to fulfil this requirement across the network, no matter where the employee is connected. VLAN, subnet, ACL and all other details will be automatically defined and configured following best practices. The intent has to be defined once in a central management console, and then, the network will continuously assure it, even if there are changes in the network.
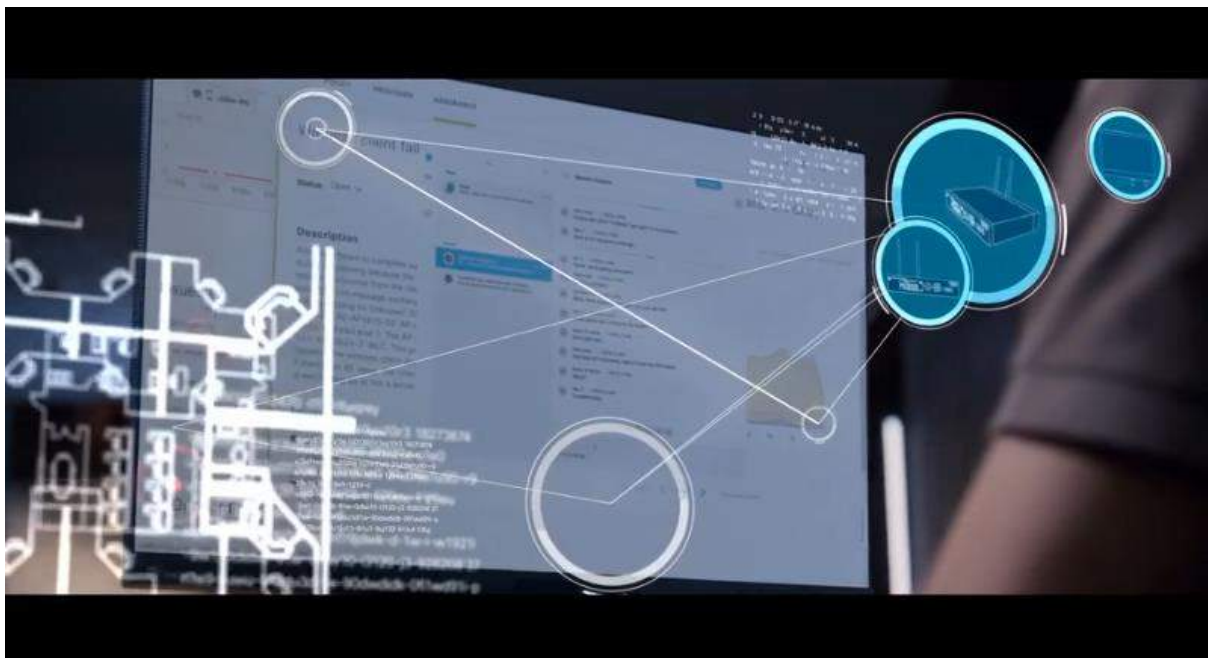
Video – Cisco Intent-Based Networking [Transcript]

- [Narrator] From the moment my day begins, I'm bombarded by issues from the CEO on down.
- [Man] Today, Opticia opens their new campus downtown.
- [Man] 75,000 square foot downtown headquarters.
- [Woman] We're having wireless issues.

Chapter 1: Everything is Connected

- [Man] The connections are dropping.
- [Narrator] Blindly trying to find the root cause. Never sure if an issue is truly fixed, because my team can't recreate it.
- [Man] We're trying to find the problem.
- [Man] I'm looking at the DNA data now.
- [Woman] It might be insufficient
- [Man] We're definitely having connectivity problems.
- [Narrator] Without enough time or the right people, we're constantly chasing a growing mountain of problems that outpace us every day.
- [Man] Of all the days for the network to have an issue
- [Woman] There's a lot of press coverage.
- [Man] Do you think IT can pull this off?
- [Narrator] What if my network could be intuitive like mysenses, recognizing patterns, instantly processing information, making split second decisions, and gaining context by clearly seeing the big picture.
- [Man] We think we have the problem isolated.
- [Woman] DNA center is recommending a patch.
- [Narrator] Well, you can, with intent-based networking by Cisco. It provides my team intelligence from the millions of sensors and devices connected to it.
- [Man] Access point stopped accepting five
- [Woman] I'm gonna pull up your historical data
- [Man] I'm gonna run a wireless spectrum sweep from the network centers.
- [Narrator] Letting us travel back in time, seeing all the factors.
- [Man] We need to enable cleaner.
- [Narrator] And guiding us to the right solution fast. It's like nothing before. Giving usthe context to know what is truly important. Now the network helps my team take the right action immediately, freeing us up to create, innovate, and help achieve what's next.
- [Woman] Nice wok, everyone.
- [Narrator] Intent-based networking by Cisco

Video – Network Architecture -Cisco DNA [Transcript]

It'sa very different world today, a world of endless devices and demands. And you're never going to get above it all, and impact it all, by solving tomorrow's problems with yesterday's network. Introducing the help and advantage you need, digital network architecture from CISCO. CISCO DNA with DNA Center at its core creates a holistic end to end platform for your enterprise, so you can better manage your business. Not merely a graphical interface, DNA Center builds on 30 years of CISCO networking knowhow madesimple and intuitive. All of your essential workflows are built in, creating a single point of management with endless reach. You can add devices, assign roles, and then analyze the impact across desks or continents. You'll define a change once, and watch it provision end to end. And effortlessly set policies to manage entire work groups, distributed far and wide. And while you're managing today's challenge, CISCO DNA Center is proactively assessing and analyzing tomorrow's for you. You get the assurance to address challenges before they become problems, so instead of outdated processes burning up budgets and time, CISCO DNA Center drives both down, freeing you to drive your businesses digital transformation. Imagine a network that lowers costs, reduces complexity, eliminates threats, and liberates you. That's a network built on CISCO DNA, just part of the new era in networking. The network, intuitive. Start architecting the control you need.

Summary: Everything is Connected

The world is quickly being covered with networks, which allow digital devices to interconnect and transmit. As digital networks continue to grow around the world, and as the economic benefits of digitization continue to grow, we are seeing a digital transformation. Digital transformation is the application of digital technology to provide the stage for business and industry to innovate.

Sensors are now everywhere, collecting and transmitting massive amounts of data. The generated data can be stored and analyzed at a later date, or it can be analyzed and used immediately. Sensors can be in the home, on traffic lights, in farm fields, and on our bodies. The analyzed data is used by governments, cities, businesses, and individuals to effect changes such as monitoring the environment, forecasting population growth, controlling waste management, or securing a home.

Networks form the foundation of the digitized world. There are many types of networks that are characterized by their geographic size, by the number of devices or networks that they connect, and by whether they support mobile devices or not. Networks can also be characterized by their function and purpose.

- PAN: Bluetooth
- LAN
- WAN: Internet, the cloud, fog computing
- Wireless: Wi-Fi, Cellular

A sensor typically connects to a controller using a wireless connection. Controllers collect data from sensors and send the data for storage or analysis. Controllers may have the ability to make immediate decisions, or they may work together with a device called an actuator. Actuators take electrical input and transform the input into physical action.

Networks are now connecting billions of sensors and have the ability to make changes to physical environments without human intervention. The future of networking will revolve around artificial intelligence (AI) and intent-based networking (IBN). If programmed appropriately, smart devices are able to evaluate data that is provided to them and modify processes or settings. If they are provided with sufficient data, they can "learn" and modify their own code based on the new parameters.

Chapter 2: Everything Becomes Programmable

Apply Basic Programming to Support IoT Devices

Flowcharts

Flowcharts are used in many industries including engineering, physical sciences, and computer programming where a complete understanding of processes or workflows is required. Flowcharts are diagrams that are used to represent these processes or workflows.

Flowcharts illustrate how a process should work. Flowcharts should not require complex, industry-specific terminology or symbols. A flowchart should be easy to understand without having to be an expert in the chosen field.
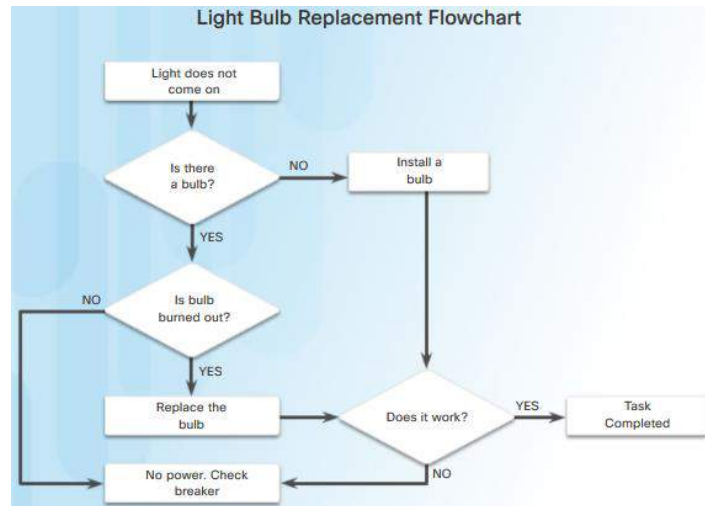
Flowcharts should show input states, any decisions made, and the results of those decisions. It is important to show the steps that should be taken when the result of a decision is either yes or no.

It is common for programmers to create a first draft of a program in no specific programming language. These language-independent programs are focused on the logic rather than in the syntax and are often called algorithms. A flowchart is a common way to represent an algorithm. An example of a flowchart is shown in the figure.

System Software, Application Software, and Computer Languages

There are two common types of computer software: system software and application software.

Application software programs are created to accomplish a certain task or collection of tasks. For example, Cisco Packet Tracer is a network simulation program that allows users to model complex networks and ask "what if" questions about network behavior.


```
year = int(input("Enter a year to check if it is a leap year\n"))
if (year % 4) == 0:
    if (year % 100) == 0:
        if (year % 400) == 0:
            print("{0} is a leap year".format(year))
        else:
            print("{0} is not a leap year".format(year))
    else:
        print("{0} is a leap year".format(year))
else:
    print("{0} is not a leap year".format(year))
```

System software works between the computer hardware and the application program. It is the system software that controls the computer hardware and allows the application programs to function. Common examples of system software include Linux, Apple OSX, and Microsoft Windows.

Both system software and application software are created using a programming language. A programming language is a formal language designed to create programs that communicate instructions to computer hardware. These programs implement algorithms which are self-contained, step-by-step sets of operations to be performed.

Some computer languages compile their programs into a set of machine-language instructions. C++ is an example of a compiled computer language. Others interpret these instructions directly without first compiling them into machine language. Python is an example of an interpreted programming language. An example of Python code is shown in the figure.

When the programming language is determined and the process is diagrammed in a flowchart, program creation can begin. Most computer languages use similar program structures.

Programming Variables

Programming languages utilize variables as dynamic buckets to hold phrases, numbers, or other important information that can be used in coding. Instead of repeating specific values in numerous places throughout the code, a variable can be used. Variables can hold the result of a calculation, the result of a database query, or some other value. This means that the same code will function using different pieces of data without having to be rewritten.

For instance "x + y = z" is an example of a programming expression. In this expression, x, y and z are variables which can represent characters, character strings, numeric values or memory addresses.

A variable can refer to a value. For instance the expression "a = 10" associates the value 10 to variable a.

A variable can also represent a memory location. The expression "a = 10" represents that the value 10 is stored in some location of the computer memory, which is referred to as 'a'.

Variables can be classified into two categories:

- **Local Variables** - These are variables that are within the scope of a program / function / procedure.
- **Global Variables** - These are variables that are in the scope for the time of the program's execution. They can be retrieved by any part of the program.

Variables allow programmers to quickly create a wide range of simple or complex programs which tell the computer to behave in a pre-defined fashion.

Basic Program Structures

People impart logic to computers through programs. Using specific logic structures, a programmer can prepare a computer to make decisions. The most common logic structures are:

- **IF – THEN** - This logic structure allows the computer to make a decision based on the result of an expression. An example of an expression is myVar > 0. This expression is true if the value stored in the myVar variable is greater than zero. When an IF-THEN structure is encountered, it evaluates the provided expression. If the expression is false, the computer moves on to the next structure, ignoring the contents of the IF-THEN block. If the expression is true, the computer executes the associated action before moving on to the next instruction in the program.

```
IF (value1 > value2) THEN print_on_the_screen "Value1 is greater than Value2"
```

The code above prints "Value1 is greater than Value2" on the screen, if the expression value1 > value2 is true.

- **FOR Loops** – These are used to execute a specific set of instructions a specific number of times, based on an expression. The term loop comes from the fact that the set of instructions is executed repeatedly. While the syntax of FOR loops varies from language to language, the concept remains the same. A variable acts as a counter inside a range of values identified by a minimum and a maximum. Every time the loop is executed, the counter variable is incremented. When the counter is equal to the defined maximum value, the loop is abandoned and the execution moves on to the next instruction.

```
FOR (i=0; i < 100; i++) {
    print_on_the_screen "counter =" + i
}
```

The code above prints " counter = N" (where N is the value of the counter variable "i".)
The message is printed 100 times on the screen.

- **WHILE Loops** – These are used to execute a specific set of instructions while an expression is true. Notice that often the instructions inside the loop will eventually make the expression evaluate as false.

```
WHILE (value < 10) {
    print_on_the_screen "Value is still less than 10"
    value = value + 1
}
```

The code above prints "Value is still less than 10" on the screen while value < 10. Notice that the program also increments value every time the WHILE loop is executed.

2.1.1.8 Lab - Create a Process Flowchart

Flowcharts are normally used to diagrammatically illustrate the process flow before a computer program is created. In this lab you will create a simple flowchart showing the process used to find a predetermined integer value.

Follow instructions on lab document.

What is Blockly?

Blockly is a visual programming tool created to help beginners understand the concepts of programming. By using a number of block types, Blockly allows a user to create a program without entering any lines of code.

Blockly implements visual programming by assigning different programming structures to colored blocks. The blocks also contain slots and spaces to allow programmers to enter values required by the structure. Programmers can connect programming structures together by dragging and attaching the appropriate blocks. Programming structures such as conditionals, loops, and variables are all available for use.

Creating a new variable in Blockly is a simple matter of dragging the variable block onto the work space and filling in the value slot. It is also possible to change the contents of a variable as the program is being executed.
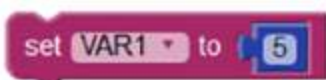
Blockly also supports functions. Similar to the variables, Blockly has specific blocks to represent functions. Also similar to variables, programmers simply select and drag function blocks to the work space and fill in the required slots.
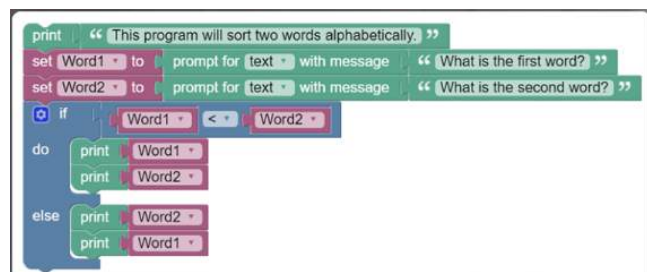
Notice in Figures 1 and 2 that the variable block and the print on screen block both have a bevel tab on the bottom and a slot on the top. This means that the two blocks can be snapped together to create a program sequence. Blockly will execute the block on the top first, then move on to the block below it.

Other blocks are available such as an IF THEN block, a WHILE block and a FOR block. There are also blocks specifically for sensors and actuators.

Blockly can be used to translate the block-based code into Python or JavaScript. This is very useful to beginner programmers.

Blockly Games

Google provides a series of free and open source educational games that can help you learn programming. The series is called Blockly Games.

To learn more about Blockly Games, or to try it yourself, visit https://blockly-games.appspot.com/ .

There are a number of levels to complete to help you get started. Blockly may look like a toy, but it is a great tool to improve your logical thinking skills, which is one of the building blocks of computer programming.
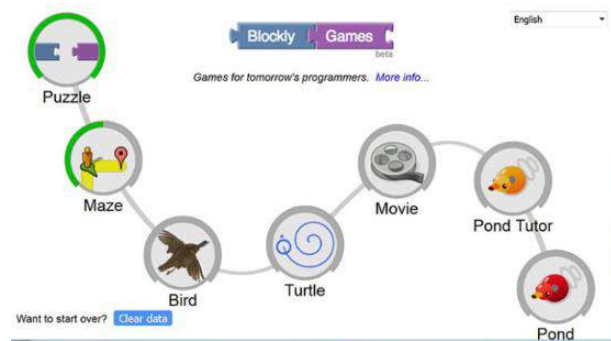
2.1.2.3 Packet Tracer - Blinking an LED Using Blockly

Cisco Packet Tracer has incorporated Blockly as one of the programming languages available in its IoT functionality. In this lab you will control the blink rate of an LED using Blockly code.

Download the Packet Tracer file and complete activity

What is Python?

Python is a very popular language that is designed to be easy to read and write. Python's developer community adds value to the language by creating all types of modules and making them available to other programmers.

The core philosophy of the language is summarized by the document The Zen of Python:

- Beautiful is better than ugly
- Explicit is better than implicit
- Simple is better than complex
- Complex is better than complicated
- Readability counts

Despite the fact Python is designed to be easy, there is still a learning curve. To make it easier to learn Python, a beginner can use Blockly to enhance his or her Python understanding.

While different programming languages have different semantics and syntax, they all share the same programming logic. Beginners can use Blockly to easily create a language-independent program, export it as Python code and use this newly created code to learn about Python syntax, structure and semantics.

The figures show the Guessing Game program in both Blockly and Python formats.
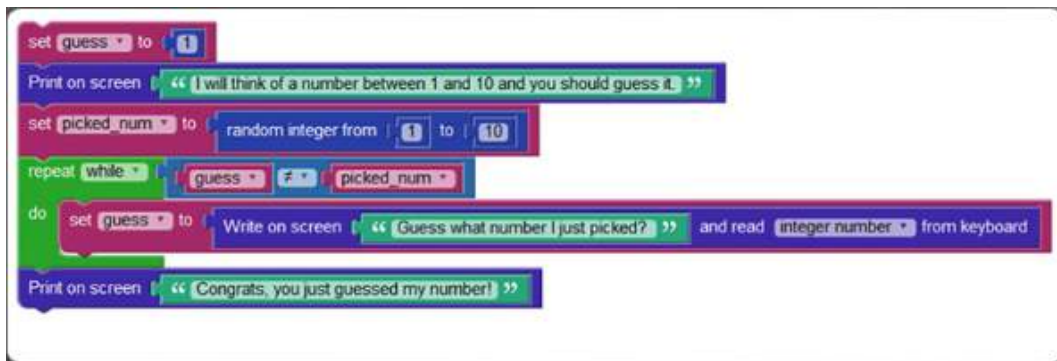
```
import random

guess = None
picked_num = None


guess = 1
print('I will think of a number between 1 and 10 and you should guess it.')
picked_num = random.randint(1, 10)
while guess != picked_num:
    guess = int(input ('Guess what number I just picked? '))
print('Congrats, you just guessed my number!')
```

The Python Interpreter

Python is an interpreted language; therefore, an interpreter is required to parse and execute Python code. The Python interpreter understands and executes Python code. Python code can be created in any text editor and Python interpreters are available for many operating systems. Python developers can create and deploy Python programs in practically any operating system. Third party tools such as **Py2exe** and **Pyinstaller** can also be used to package the Python source code into an executable file, eliminating the need for the Python interpreter when running Python code.

In Linux machines, the Python interpreter is usually installed in **/usr/bin/python** or **/usr/bin/python3** (depending on the available Python versions on the system). With the new Windows Python installer, Python is installed by default into the user's home directory. In older Windows machines, Python is often placed in **C:\PythonXX** (where XX is the version of Python). After the Python interpreter has been installed, it operates somewhat like the Linux shell. This means that when called with no arguments, it reads and executes commands interactively. When called with a file name argument or with a file as standard input, it reads and executes a script from that file.

To start the interpreter, simply type **python** or **python3** at the shell prompt.

Some legacy systems are still running on an older version of Python 2, but many new systems are moving to use the new Python version 3. Python's version is printed on the first line when the interpreter is launched. This course is built on Python 3 code.

```
Python 3.6.5  (default, Apr 16 2018, 15:31:49)
[ GCC 4.8.5 20150623 (RED Hat 4.8.5-16) ] on linux
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

When the Python interpreter is called with no arguments, and commands are entered via the keyboard, the interpreter is said to be in interactive mode. In this mode, the interpreter waits for commands. The primary prompt is represented by three greater-than signs (>>>). Continuation lines are represented by three dots (...). Continuation is the default secondary prompt.

The **>>>** prompt indicates the interpreter is ready and waiting commands.

```
>>> the_world_is_flat = True >>> if the_world_is_flat: ... print "Be careful not to fall
off!" ... Be careful not to fall off!
```

Continuation lines are needed when entering multi-line code. The figure shows an IF-THEN block written in Python.

Another way of using the interpreter is **python -c command [arg]** ... which executes the statement(s) in the command. Because Python statements often contain spaces or other characters that are particular to the shell, it is suggested to enclose the entire command between single quotes.

Variables and Basic Statements in Python

The interpreter receives and executes statements interactively.

```
>>>
>>> 25+ 25
50
>>> 70 + 7*6
112
>>> (50 - 5.0*6) / 4
5.0
```

The interpreter acts as a simple calculator. You can type an expression on it and it will write the value. Expression syntax is straightforward. The operators +, -, * and / work just as they do in most other languages (for example, Pascal or C). Parentheses (()) can be used for grouping, as shown in the figure.

```
>>>
>>> tax = 12.5 / 100
>>> price = 100.50
>>> price * tax
12.5625
>>> price + _
113.0625
>>> round(_, 2)
113.06
```

Python's interactive mode implements the special variable "_" to hold the result of the last expression issued, as shown in the figure.

```
>>>
>>> birth_year = 1941
>>> curr_year = 2016
>>> curr_year - birth_year
75
```

Variables are labeled memory areas that are used to store runtime program data. To assign values to variables in Python, use the equal to (=) sign. No result is displayed before the next interactive prompt, as shown in the figure.

```
>>>
>>> my_new_variable
Traceback (most recent call last):
  File "<stdin>", line 1, in<module>
NameError: name 'my_new_variable' is not defined
>>>
```

Attempts to use a not defined variable (no assigned value), will result in an error, as shown in the figure.

Strings, defined as a sequence of characters, can also be handled by interactive mode. Use the backslash character (\) to escape characters. As an example, a string uses double quotes but also needs to use a double quote within the string. If the string is entered as follows: **"I really "need" this."**. Python will get confused and think that the first double quote within the string actually ends the string. If you place a backslash (\) before the double quotes inside the string as follows: **"I really \"need\" this"**, the backslash (\) causes Python to escape or ignore the character that follows.

Single quotes or double quotes can be used to wrap strings, as shown in the figure.

```
>>>
>>> 'spam eggs'  # single quotes
'spam eggs'
>>> 'doesn\'t'  # use \' to escape the single quote...
"doesn't"
>>> "doesn't"  # ...or use double quotes instead
"doesn't"
>>> '"Yes," he said.
'"Yes," he said.
>>> "\"Yes,\" he said."
'"Yes," he said.
```

```
>>>
>>> i = 256*256
>>> print ('The value of i is', i)
The value of i is 65536
```

The print statement prints the result of the expression it was given. It differs from just writing the expression you want to write (as we did earlier in the calculator examples) in the way it handles multiple expressions and strings. Strings are printed without quotes, and a space is inserted between items, so you can format things nicely, as shown in the figure.

Functions are an important part of many programming languages. Functions allow for a block of code to be given a name and re-used as needed. The figure defines a function to add two numbers and print the result.

```
# Function to add two numbers:
def add_nums():
    a = 5
    b = 11
return a+b
>>> print (add_nums())
16
>>>
```

Useful Functions and Data Types in Python

Python supports many useful functions and datatypes. Some of the more important ones are as follows:

Range()

The range() function generates a list of numbers usually used to iterate with FOR loops. Figure 1 shows examples of the range() function.

```
# One parameter
for i in range(3):
    print (i)
0
1
2
# Two parameters
for i in range(3, 6):
    print (i)
3
4
5
# Three parameters
for i in range(4, 10, 2):
    print (i)
4
6
8
```

- **range(stop)** - This is the number of integers (whole numbers) to generate, starting from zero.
- **range([start], stop[, step]** – This is the starting number of the sequence, the ending number in the sequence, and the difference between each number in the sequence.

Tuples

A tuple is a sequence of unchangeable Python objects. Tuples are sequences, separated by parentheses. Figure 2 shows examples of tuples.

```
tup1 = ('dancing', 'singing', 400, 1842);
tup2 = (1, 2, 3, 4, 5, 6, 7 );
print ('tup1[0]: ', tup1[0])
print ('tup2[1:5]: ', tup2[1:5])

When the above code is executed, it produces the following result -
tup1[0]: dancing
tup2[1:5]: (2, 3, 4, 5)
```

Lists

Lists are a sequence of changeable Python objects. Lists can be created by putting different comma-separated values between square brackets. Figure 3 shows examples of lists and how they can be updated.

```
list1 = ['car', 'train', 47, 2016];
list2 = [1, 2, 3, 4, 5, 6, 7 ];
print ('list1[0]: ', list1[0])
print ('list2[1:5]: ', list2[1:5])

When the above code is executed, it produces the following result -
 list1[0]: car
 list2[1:5]: [2, 3, 4, 5]
```

Updating Lists

```
list = ['car', 'train', 47, 2016];
print ('available at index 2 : ')
print (list[2])
list[2] = 2017;
print ('New value available at index 2 : ')
print (list[2])

When the above code is executed, it produces the following result -
Value available at index 2 :
 47
 New value available at index 2 :
 2017
```

Sets

Sets are unordered collections of unique elements. Common uses include membership testing, removing duplicates from a sequence, and computing standard math operations on sets such as intersection, union, difference, and symmetric difference. Figure 4 shows examples of sets.

```
x = [1,2,3,1,2,3,1,2,3]
set(x)
{1, 2, 3}
y = [1, 1, 6, 6, 6, 6, 6, 8, 8]
set(y)
{1, 6, 8}
z = [("Bird", "Cat", "Dog", "Dog", "Bird", "Bird")]
set(z)
{('Bird', 'Cat', 'Dog', 'Dog', 'Bird', 'Bird')}
```

```
animals = set(["Cow", "Fish", "Pig", "Horse"])
animals.add ("Cat")
print (animals)
set(['Fish', 'Cat', 'Horse', 'Cow', 'Pig'])

for group in [animals]:
    group.discard ("Fish")
    print (group)
set(['Cat', 'Horse', 'Cow', 'Pig'])
```

Dictionary

A dictionary is a list of elements that are separated by commas. Each element is a combination of a value and a unique key. Each key is separated from its value by a colon. The entire dictionary is written within braces. Dictionary elements can be accessed, updated, and deleted. There are also many built-in dictionary functions such as a function that compares elements within different dictionaries and another that provides a count of the total number of elements within a dictionary. Figure 5 shows examples of dictionaries.

Dictionary with 4 elements:

```
dict = {'Age' : 34, 'City' : 'Rome', 'Year' : 2016, 'Month' : 'March' }
print ("dict['City']: ", dict['City'])
print ("dict['Year']: ", dict['Year'])

dict['City']: Rome
dict['Year']: 2016
```

Update a value

```
dict['Year'] = 2015

print ("dict['Year']: ", dict['Year'])

dict['Year']: 2015
```

Add a new element and determine the number of elements in the dictionary

```
dict['Sport'] = "Swimming"

len(dict)

5
```

Programming Structures in Python

Similar to other languages, Python implements an IF-THEN structure. IF-THEN blocks can be used to allow the code to make decisions based upon the result of an expression.

```
>>>
>>> x = int(input("Please enter an integer: "))
Please enter an integer: 42
>>> if x < 0:
...     x = 0
...     print ('Negative changed to zero')
... elif x == 0:
...     print ('Zero')
... elif x == 1:
...     print ('Single')
... else:
...     print ('More')
...
More
```

The code performs a few tests and prints a message in accordance with the results of the test. Notice that Python also implements two sub-structures named ELSE and ELIF. ELSE allows the programmer to specify instructions to be executed if the expression is false. Short for ELSE IF, ELIF is used to perform a second test in case the first expression is false and another test is required. There can be zero or more ELIFs, and the ELSE part is optional.

```
>>>
>>> # Measure some strings:
... words = ['cat', 'window', 'defenestrate']
>>> for w in words:
...     print (w, len(w))
...
cat 3
window 6
defenestrate 12
```

The FOR loop in Python iterates the items of any sequence (a list or a string), in the order that they appear in the sequence.

The WHILE loop executes a block of code if the expression is true. The program shown uses a WHILE loop to calculate and print an initial sub-sequence of a Fibonacci series in which each number in the series is the sum of the previous two.

The third line contains a multiple assignment operator. The variables **a** and **b** get the new values of 0 and 1 in a single statement.

The WHILE loop calculates the next term in the Fibonacci series while the condition b < 10 is true. As in C, Python assumes any non-zero integer value as true and zero as false. The test used in the figure is a simple comparison.

```
>>>
>>> # Fibonacci series:
... # the sum of two elements defines the next
... a, b = 0, 1
>>> while b < 10:
...     print (b)
...     a, b = b, a+b
...
1
1
2
3
5
8
```

Notice that the body of the loop is indented. Indentation is Python's way of grouping statements. At the interactive prompt, you have to type a tab or space(s) for each indented line. More complicated input for Python should be done with a text editor. When a compound statement is entered interactively, it must be followed by a blank line to indicate completion (because the parser cannot guess which line will be the last line). Note that each line within a basic block must be indented by the same amount.

2.1.3.6 Lab - Setting Up a Virtualized Server Environment

Virtualization software allows a single physical server to host multiple virtual machines. These machines are isolated from each other and can be saved, copied, and shared. This provides an excellent development and testing environment.

In this lab you will set up a virtual development environment and install a virtual machine in preparation for experimentation with Python.

Visit https://course-dl-prod.s3.amazonaws.com/I2IoT20/I2IoT_v20.ova to download the Virtual Machine.

Follow instructions on the lab document.

2.1.3.7 Lab – Basic Python Programming

In this lab you will use a virtual environment and the IDLE IDE to explore basic Python programming.

Follow instructions on the lab document.

2.1.3.8 Lab - Create a Simple Game with Python IDLE

In this lab you will create a simple number guessing game using Python. This game is based on the flowchart created earlier.

Follow instructions on the lab document.

Prototyping Your Idea

Defining Prototyping

Prototyping is the process of creating a rudimentary working model of a product or system. For prototyping in the IoT, it helps to have design skills, electrical skills, physical/mechanical skills (work with your hands to put things together), programming skills, and to understand how TCP/IP works. But you do not need to be an expert in any of these areas. In fact, prototyping helps you to refine these skills.

Because the IoT is still developing, there are still unknown tasks to discover. This is a great time to invent something that is part of the IoT. Because the IoT combines people, process, data, and things, there is no end to the inventions that the IoT can help create and then incorporate.

For news and ideas that are already being talked about in the IoT, visit
https://newsroom.cisco.com/internetofthings.

The figure shows a bulleted list defining prototyping. Prototyping is fully functional, but not fault-proof. Prototyping is an actual, working version of the product. Prototyping is used for performance evaluation and further improvement of product. Prototyping has a complete interior and exterior. Prototyping may be relatively expensive to produce. Prototyping in the IoT is often used as a technology demonstrator.

Prototyping

- Is fully functional, but not fault-proof.
- Is an actual, working version of the product.
- Is used for performance evaluation and further improvement of product.
- Has a complete interior and exterior.
- May be relatively expensive to produce.
- In the IoT, is often used as a technology demonstrator.

How to Prototype'

How do you prototype? There are a few ways to get started. A team at Google used the "Rapid Prototyping Method" to create the Google Glass. Visit http://ed.ted.com/lessons/rapid-prototyping-google-glass-tom-chi to view a TedTalk about this process.

Of course, Google has a large number of resources to pay for the people and materials that go into prototyping. Most of us need some financial help to get our ideas out of our heads and into a prototype. For us, there is crowd funding. Kickstarter, Indiegogo, and Crowdfunder are just three of the many online crowd funding programs. Visit http://vimeo.com/40128933 to view the Pebble Watch Kickstarter Video. This online video was used to generate donations to help this group of inventors create the Pebble Watch.

What IoT invention will you create?

Physical Materials

A good place to start is, of course, the Internet. People have exchanged ideas for ages, but the Internet allows for idea exchanges on a whole new level. People who have never physically met can now collaborate and work together. There are several web sites you can visit to connect with other makers.

Maker Media is a global platform for connecting makers with each other to exchange projects and ideas. The platform also provides a place where makers can find and buy products for their projects. For more information, go to Makezine at http://makezine.com.

It is helpful to have practical skills when working with certain materials; for example, wood and metal are common prototyping materials, but they may be too difficult for a beginner to use. You might be surprised with what you can do with plastic, clay, paper, and wires. Search Google for more information or ideas on how to work with the different prototyping materials.

LEGO Mindstorms has a large community of contributors and fans. With LEGO Mindstorms, you can create LEGO robots and control them using an application. The kits come with everything you need to make it work. Go to LEGO Mindstorms at http://mindstorms.lego.com.

Meccano, or Erector Set, is a model construction system that consists of reusable metal strips, plates, angle girders, wheels, axles, and gears, with nuts and bolts to connect the pieces. It lets you build working prototypes and mechanical devices. Go to Erector Set at www.erector.us.

3D printing is the process of making a solid object based on a 3D model computer file. A machine, called a 3D printer, is connected to the computer. A number of companies now build and sell 3D printers. Go to Makerbot at https://www.makerbot.com.

Electronic Toolkits

Computer programs cannot run without a computer. While you can create programs for almost any computer, some platforms are designed for the beginner. Below you will find some of the most popular platforms.

Arduino is an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. You can develop interactive objects that take input from a variety of switches or sensors to control lights, motors, and other physical objects. Go to Arduino at http://arduino.cc.

While the Arduino is not suitable for use as a computer, its low power requirement makes it capable of controlling other devices efficiently.

The Raspberry Pi is a low cost, credit-card-sized computer that plugs into a computer monitor or TV. You operate it using a standard keyboard and mouse. It is capable of doing everything a computer can do, from browsing the Internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. Go to Raspberry Pi at http://www.raspberrypi.org.

The Beaglebone is very similar to the Raspberry Pi in size, power requirements, and application. The Beaglebone has more processing power than the Raspberry Pi; therefore, it is a better choice for applications with higher processing requirements. Go to Beaglebone at http://beagleboard.org.

Programming Resources

Programming is critical to the IoT. Creating custom code is very useful when developing an IoT solution. You have already learned about Blockly and Python. There are many other free resources that can help you develop your programming skills.

The MIT OpenCourseWare (OCW) is a web-based publication of almost all MIT course content. Open and available to the world, OCW is a great place to get familiar with computer programming for free. OCW programming related courses can be found at http://ocw.mit.edu/courses/intro-programming.

Khan Academy is a non-profit educational website created in 2006 to provide "a free, world-class education for anyone, anywhere". The lectures related to computer programming can be found at https://www.khanacademy.org/computing/cs.

Code Academy is another excellent resource. It relies on interactivity to help people learn how to write computer programs. You can find them at http://www.codeacademy.com.

Community Inventor and Entrepreneurship Workshops

So, perhaps you have just created something really great. What now? There are a number of places where you can get help exposing your idea or prototype to others.

Investigate what is available in your community. Check with your local government, schools, and chamber of commerce for information about workshops, classes, and expert advice.

The Internet has many resources to help your idea get exposure. A good example is Quirky. Quirky allows users to share their ideas. When an idea is submitted, other Quirky users can vote and choose whether or not they want to support your idea. If an idea is good, it may become a real product. You can learn more about Quirky at https://www.quirky.com/how-it-works.

2.2.2.5 Optional Lab - Setting up PL-App with the Raspberry Pi

Cisco Prototyping Lab is a set of hardware and software components that enable the rapid prototyping and modelling of various IoT digitization and data analytics solutions.

The hardware components are part of the Prototyping Lab Kit (PL-Kit). The PL-Kit is based on Open HW prototyping boards such as Raspberry Pi and Arduino. The PL-Kit includes additional sensors, actuators, and electronic components. The PL-Kit can be used to build sophisticated prototypes of end-to-end IoT systems that can sense and actuate the real physical world, analyze and process the data, and connect to network and cloud systems. The primary software component of the Prototyping Lab is the Prototyping Lab App (PL-App).

The PL-App together with the PL-Kit enable IoT digitization and data analytics learning and rapid prototyping. PL-App provides a web-based environment to access the software and hardware resources of the Raspberry Pi, using Jupyter notebooks. With PL-App you can access existing IoT labs or write your own new applications directly on the board, execute them, and monitor the output with various visualizations.

In this lab you will download a Raspberry Pi OS and install it on a microSD card. After installing the microSD card, the Raspberry Pi and the Arduino connected to the Raspberry Pi can be controlled from the PL-App interface. This lab provides basic guidelines for the initial configuration of the Raspberry Pi board with a PL-App environment.

Download the Cisco PL-App here:

- Windows: http://static-course-assets.s3.amazonaws.com/Downloads/VM/PL-App_Launcher.exe
- Mac: http://static-course-assets.s3.amazonaws.com/Downloads/VM/PL-App_Launcher.dmg
- PL-App Image for Introduction to IoT 2.0: http://static-course-assets.s3.amazonaws.com/Downloads/I2IoT20/en_I2oT2.0_PL-App_Image.zip

Visit https://cisco-netacad.wistia.com/medias/wsgq6aoelv, to view a video walk through of this lab.

Follow instructions on the lab document.

2.2.2.6 Optional Lab - Using a PL-App Notebook

PL-App notebooks are based on the Jupyter open source project. Jupyter notebooks allow markup content such as text and graphics to be mixed with interactive code in different cells. Code cells can be adapted to specific needs. They can be modified and executed independently. This enables rapid prototyping concepts, where the development of the final application can be divided into smaller sections, each dealing only with the specific problem.

In this lab you will explore the structure of Jupyter notebooks and how they can be used in the prototyping process.

Note: In order to view the Blockly code in the Jupyter notebooks please use the Google Chrome web browser.

Visit https://cisco-netacad.wistia.com/medias/k4qva56lih, to view a video walk through of this lab.

Follow instructions on the lab document.

2.2.2.7 Optional Lab - Blinking an LED using Raspberry Pi and PL-App

In this lab, you will use a sample PL-App notebook to interact with an LED as part of a simple circuit. You will build a simple circuit on a breadboard with a resistor and an LED. You will then use the LED Blink program to control the blinking rate of the LED.

Note: In order to view the Blockly code in the Jupyter notebooks please use the Google Chrome web browser.

Note: This Jupyter notebook can be found by starting Pl-App and navigating to the Introduction to IoT folder under Course Materials.

Visit https://cisco-netacad.wistia.com/medias/7g9uhyxotx. to view a video walk through of this lab.

Follow instructions on the lab document.

2.2.2.8 Optional Lab - Introduction to Arduino

In this lab, you will learn to use the Arduino and Arduino IDE to control the blinking rate of an LED.

Visit https://cisco-netacad.wistia.com/medias/svxcp1fmkd, to view a video walk through of this lab.

Follow instructions on the lab document.

Summary: Everything Becomes Programmable

This chapter began by discussing how to apply basic programming to support IoT devices. Flowcharts are diagrams that are used to represent processes. There are two common types of computer software: system software and application software. Application software programs are created to accomplish a certain task. System software works between the computer hardware and the application program. Programming variables can be classified into two categories:

- **Local Variables** - These are variables that are within the scope of a program / function / procedure.
- **Global Variables** - These are variables that are in the scope for the time of the program's execution. They can be retrieved by any part of the program.

The most common logic structures are IF – THEN, FOR Loops, and WHILE Loops.

Blockly is a visual programming tool created to help beginners understand the concepts of programming. Blockly implements visual programming by assigning different programming structures to colored blocks.

Python is a very popular language that is designed to be easy to read and write. Python is an interpreted language; therefore, an interpreter is required to parse and execute Python code. Variables are labeled memory areas that are used to store runtime program data. Python supports many useful functions and datatypes including Range(), Tuples, Lists, Sets, Dictionary. Python also implements two sub-structures named ELSE and ELIF.

Next, the chapter detailed prototyping. Prototyping is the process of creating a rudimentary working model of a product or system. A team at Google used the "Rapid Prototyping Method" to create the Google Glass. The Internet allows for idea exchanges on a whole new level. There are several web sites you can visit to connect with other makers:

- http://makezine.com
- http://mindstorms.lego.com
- www.erector.us
- https://www.makerbot.com
- http://arduino.cc
- http://www.raspberrypi.org
- http://beagleboard.org
- https://blockly-games.appspot.com/
- http://ocw.mit.edu/courses/intro-programming
- https://www.khanacademy.org/computing/cs
- http://www.codeacademy.com
- https://www.quirky.com/how-it-works

Chapter 3: Everything Generates Data

Big Data

What is Big Data?

Data is information that comes from a variety of sources, such as people, pictures, text, sensors, and web sites. Data also comes from technology devices like cell phones, computers, kiosks, tablets, and cash registers. Most recently, there has been a spike in the volume of data generated by sensors. Sensors are now installed in an ever growing number of locations and objects. These include security cameras, traffic lights, intelligent cars, thermometers, and even grape vines!

Big Data is a lot of data, but what is a lot? No one has an exact number that says when data from an organization is considered "Big Data." Here are three characteristics that indicate an organization may be dealing with Big Data:

- • They have a large amount of data that increasingly requires more storage space (volume).
- • They have an amount of data that is growing exponentially fast (velocity).
- • They have data that is generated in different formats (variety).

How much data do sensors collect? Here are some estimated examples:

- • Sensors in one autonomous car can generate 4,000 gigabits (Gb) of data per day.
- • An Airbus A380 Engine generates 1 petabyte (PB) of data on a flight from London to Singapore.
- • Safety sensors in mining operations can generate up to 2,4 terabits (TB) of data every minute.
- • Sensors in one smart connected home can produce as much as 1 gigabyte (GB) of information a week.

While Big Data does create challenges for organizations in terms of storage and analytics, it can also provide invaluable information to fine-tune operations and improve customer satisfaction.

Visit http://cs.co/9004DiluE, to see a video about how San Diego's Metropolitan Transit System uses Big Data.

Large Datasets

Companies do not necessarily have to generate their own Big Data. Smaller organizations might not have the sensors, the volume of customers, or the ability to generate the variety of information that could benefit their company. There are sources of free data sets available, ready to be used and analyzed by anyone willing to look for them.

Many companies of various sizes believe they have to collect their own data to see benefits from big data analytics, but it is simply not true.

Visit https://www.forbes.com/sites/bernardmarr/2016/02/12/big-data-35-brilliant-and-free-data-sources-for-2016/, to view a website that identifies available databases.

3.1.1.5 Lab – Explore a Large Dataset

In this lab you will explore a sample dataset to view the power of Big Data.

Follow instructions on the lab document.

What Are the Challenges of Big Data?

IBM's Big Data estimates conclude that "each day we create 2.5 quintillion bytes of data". To put this into context, every minute of every day:

- We upload over 300 hours of YouTube video.
- We send over 3.5 million text messages.
- We stream over 86 thousand hours of Netflix video.
- We like over 4 million Facebook posts.
- We request over 14 million forecasts from The Weather Channel.

To see more live Internet statistics, visit http://www.internetlivestats.com/.

The rapid growth of data can be an advantage or an obstacle when it comes to achieving business goals. To be successful, enterprises must be able to easily access and manage their data assets.

With this enormous amount of data being constantly created, traditional technologies and data warehouses cannot keep up with storage needs. Even with the cloud storage facilities that are available from companies like Amazon, Google, Microsoft, and many others, the security of stored data becomes a big problem. Big Data solutions must be secure, have a high fault tolerance, and use replication to ensure data does not get lost. Big Data storage is not only about storing data, it is also about managing and securing it.

There are five major data storage problems with Big Data:

- **Management**: Data can be generated and collected from multiple different sources, so a management system must be used to organize and collate all of the sources. There are few data-sharing standards and thousands of data management tools available.
- **Security**: For data to be of value to enterprises, it must be kept secure and only accessible by authorized users.
- **Redundancy**: Safeguards should be put in place to maintain the integrity of the stored data. Processes for backups, redundancy and disaster recovery are required.
- **Analytics**: Big data contains both structured and unstructured data. Unstructured data such as emails or photos, are difficult to analyse and consume a lot of storage space. Structure data, such as a spreadsheet, is easier to analyse and store. Data storage systems must be able to manage both types.
- **Access**: Big Data must be accessible from anywhere at anytime. Storage solutions need to support the quantity of input and output requests. Companies should also be aware of the strain placed on WAN links.

Where Can We Store Big Data?

Big data is typically stored on multiple servers, usually housed within data centers. For security, accessibility, and redundancy, the data is usually distributed and/or replicated on many different servers in many different data centers.

Fog Computing

Fog computing is an architecture that utilizes end-user clients or "edge" devices to do a substantial amount of the pre-processing and storage required by an organization. Fog computing was designed to keep the data closer to the source for pre-processing.

Sensor data, in particular, can be pre-processed closer to where it was collected. The information gained from that pre-processed analysis can be fed back into the companies' systems to modify processes if required. Because the sensor data is pre-processed by end devices within the

company system, communications to and from the servers and devices would be quicker. This requires less bandwidth than constantly going out to the cloud.

After the data has been pre-processed, it is often shipped off for longer term storage, backup, or deeper analysis within the cloud.

The Cloud and Cloud Computing

As mentioned before, the cloud is a collection of data centers or groups of connected servers. Access to software, storage, and services available on the servers is obtained through the Internet via a browser interface. Cloud services are provided by many large companies such as Google, Microsoft, and Apple. Cloud storage services are provided by different vendors such as: Google Drive, Apple iCloud, Microsoft OneDrive, and Dropbox.

From an individual's perspective, using the cloud services allows you:

- To store all of your data, such as pictures, music, movies, and emails, freeing up local hard drive space
- To access many applications instead of downloading them onto your local device
- To access your data and applications anywhere, anytime, and on any device

One of the disadvantages of using the cloud is that your data could fall into the wrong hands. Your data is at the mercy of the security robustness of your chosen cloud provider.

From the perspective of an enterprise, cloud services and computing, support a variety of data management issues:

- It enables access to organizational data anywhere and at any time.
- It streamlines the IT operations of an organization by subscribing only to needed services.
- It eliminates or reduces the need for onsite IT equipment, maintenance, and management.
- It reduces the cost of equipment, energy, physical plant requirements, and personnel training needs.

It enables rapid responses to increasing data volume requirements.

Distributed Processing

From a data management perspective, analytics were simple when only humans created data. The amount of data was manageable and relatively easy to sift through. However, with the explosion of business automation systems and the exponential growth of web applications and machine-generated data, analytics is becoming increasingly more difficult to manage. In fact, 90% of data that exists today has been generated in just the last two years. This increased volume within a short period of time is a property of exponential growth. This high volume of data is difficult to process and analyze within a reasonable amount of time.
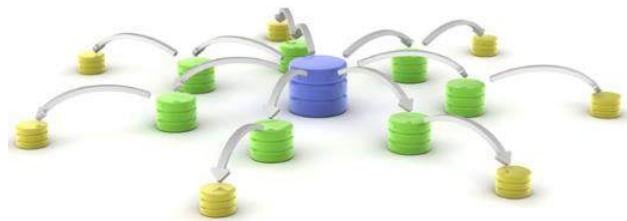
Rather than large databases being processed by big and powerful mainframe computers and stored in giant disk arrays (vertical scaling), **distributed data processing** takes the large volume of data and breaks it into smaller pieces. These smaller data volumes are distributed in many locations to be processed by many computers with smaller processors. Each computer in the distributed architecture analyzes its part of the Big Data picture (horizontal scaling).

Most distributed file systems are designed to be invisible to client programs. The distributed file system locates files and moves data, but the users have no way of knowing that the files are distributed among many different servers or nodes. The users access these files as if they were local to their own computers. All users see the same view of the file system and are able to access data concurrently with other users.

Hadoop was created to deal with these Big Data volumes. The Hadoop project started with two facets: The Hadoop Distributed File System (HDFS) is a distributed, fault tolerant file system, and MapReduce, which is a distributed way to process data. Hadoop has now evolved into a very comprehensive ecosystem of software for Big Data management.

Hadoop is open-source software enabling the distributed processing of large data sets that can be terabytes in size and that are stored in clusters of computers. Hadoop is designed to scale up from single servers to thousands of machines, each offering local computation and storage. To make it more efficient, Hadoop can be installed and run on many VMs. These VMs can all work together in parallel to process and store the data.

Hadoop has two main features that have made it the industry standard for handling Big Data:

- Scalability - Larger cluster sizes improve performance and provide higher data processing capabilities. With Hadoop, cluster size can easily scale from a five node cluster to a one thousand node cluster without excessively increasing the administrative burden.
- Fault tolerance – Hadoop automatically replicates data across clusters to ensure data will not be lost. If a disk, node, or a whole rack fails, the data is safe.

Why Do Businesses Analyze Data?

Every organization must become more efficient and innovative to stay competitive and relevant in the digitized world. The IoT is an integral part of achieving that efficiency and innovation.

The goal of many businesses is to collect and analyze the massive amounts of new product-usage data to gain valuable insights. Data analytics allows businesses to better understand the impact of their products and services, adjust their methods and goals, and provide their customers with better products faster. The ability to gain new insights from their data brings value to the business.

To businesses, data is the new oil. Like crude oil, it is valuable, but if it is unrefined it cannot be easily used. Crude oil has to be changed to gasoline, plastic, chemicals, and other substances to create a valuable product. It is the same with data. Data must be broken down and analyzed for it to have value.

Value comes from two primary types of processed data, transactional and analytical. Transactional information is captured and processed as events happen. Transactional information is used to analyze daily sales reports and production schedules to determine how much inventory to carry. Analytical information supports managerial analysis tasks like determining whether the organization should build a new manufacturing plant or hire additional sales personnel.

Sources of Information

The source of data in the large datasets is varied. Apart from sensor data, other data originates from anything that has been scanned, entered, and released to the Internet from sources such as:

- Social media sites - Facebook, YouTube, eHarmony, and Twitter
- HTTP, Web pages, and search engines on the Internet
- Historical data from public and private archives
- Metadata that is attached to emails, transmitted documents, and pictures
- Medical forms, insurance forms, and tax forms
- Genomics research using DNA

Collected data can be categorized as structured or unstructured.

Structured data is created by applications that use "fixed" format input such as spreadsheets or medical forms. Even if data is considered structured, different applications create files in different formats that are not necessarily compatible with one another. Structured data may need to be manipulated into a common format such as CSV.

Comma-separated values (CSV) files are a type of plaintext file that use commas to separate columns in a table of data, and the carriage return character to separate rows. Each row is a record. Although they are commonly used for importing and exporting in traditional databases and spreadsheets, there is no specific standard. JSON and XML are also plaintext file types that use a standard way of representing data records. These file formats are compatible with a wide range of applications. Converting data into a common format is a valuable way to combine data from different sources.

Unstructured data is generated in a "freeform" style such as audio, video, web pages, and tweets. Unstructured data requires different tools to prepare data for processing or analysis. The following are two examples:

- Web pages are created to provide data to humans, not machines. "Web scraping" tools automatically extract data from HTML pages. This is similar to a Web Crawler or spider of a search engine. It explores the web to extract data and create the database to respond to the search queries. Web scraping software may use Hypertext Transfer Protocol or a web browser to access the World Wide Web. Typically, web scraping is an automated process which uses a bot or web crawler to do data mining. Specific data is gathered and copied from the web to a database or spreadsheet. The data can then be easily analyzed.
- Many large web service providers such as Facebook provide standardized interfaces to collect the data automatically using application programming interfaces (APIs). The most common approach is to use RESTful APIs. RESTful APIs use HTTP as the communication protocol and JSON structure to encode the data. Internet websites like Google and Twitter gather large amounts of static and time series data. Knowledge of the APIs for these sites allow data analysts and engineers to access the large amounts of data that are constantly being generated on the Internet.

There is an image of a man holding a cell phone while texting and a woman watching videos on a desktop computer. These images are labelled unstructured data. There is an image of a man looking at a spreadsheet on his computer and a person using a tablet to review health insurance information. The image is labelled structured data.

Data Visualization

Data mining is the process of turning raw data into meaningful information by discovering patterns and relationships in large data sets.

To be of value, the mined data must be analyzed and presented to managers and decision makers. There are many different visualizations that can be used to present the value in the data. Determining the best chart to use will vary based on the following:

- Number of variables to show
- Number of data points in each variable
- Is the data representing a timeline
- Items that require comparisons

Some of the most popular chart types are line, column, bar, pie, and scatter.

Chart Types

- **Line Charts**: One of the most commonly used types of comparison charts. Use line charts when you have a continuous set of data, the number of data points is high, and you would like to show a trend in the data over time. Some examples include:
  - Quarterly sales for the pas five years.
  - Number of customers per week in the first year of a new retail shop.
  - Change in a stock's price from opening to closing bell.

- **Column Charts**: Positioned Vertically. They are probbaly the most common chart type usedwhen you want to display the value of a specific data point and compare that value across similar categories. Some examples include:
  - Populations of the BRICS nations (Brazil, Russia, India, China and South Africa).
  - Last year's sales for the top four car companies.
  - Average student test scores for six math classes.

- **Bar Charts**: Similar to column charts except they are positioned horizontally or vertically. Longer bars indicate larger numbers They are best used when the name of each data point is long. Some exaples include:
  - Gross Domestic Profit (GDP) of the top 25 nations.
  - Number of cars sold by each sales representative.
  - Exam scores for each student in a math class.

- **Pie Charts**: Used to show the composition of a static number. Segments represent a percentage of that number. The number of categories should be kept to a minimum. After ten or more segments, the slices begin to lose meaning and impact. The total sum of the segments must equal 100%. Some examples include:
  - Annual expanses for a corporation (e.g. rent, administrative, utilities).
  - A country's energy sources (e.g. oil, coal, gas, solar, wind).
  - Survey results for favorite type of movie (e.g. action, romance, comedy, drama, science fiction).

- **Scatter Plots**: Very popular for correlation visualizations, or when you want to show the distribution of a large number of data points. Some examples include:
    - Comparing each country's life expectancy to its GDP.
    - Comparing the daily sales of ice cream to the average outside temperature.
    - Comparing the weight to the height of each person.
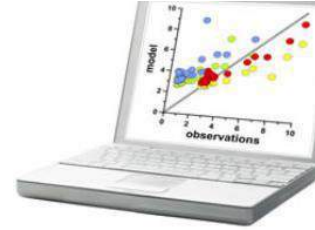
3.1.3.5 Activity - Explore Analyzed data

Visit http://www.babynamewizard.com/voyager, and have fun exploring the data visualization showing the popularity of baby names by decade and by letters.

Analyzing Big Data for Effective Use in Business

Big data is just that – BIG! It is most useful if you can analyze it to get value out of it. Data analysis is the process of inspecting, cleaning, transforming, and modeling data to uncover useful information. Analyzing big data typically requires tools and applications created for this purpose. These analysis tools have been designed to provide businesses with detailed information, patterns, and valuable insights.

Before beginning any analysis, it is critical to know what problem the business is trying to solve or what information the business is looking for. Are they interested in customer behavior in specific states, energy consumption patterns in different city quadrants, or the number of Facebook "likes" based on age?

Having a strategy helps a business determine the type of analysis required and the best tool to do the analysis. A strategy also helps to determine the most effective way to present the results for management.

Tools and applications range from using an Excel spreadsheet or Google Analytics for small to medium data samples, to the applications dedicated to manipulating and analyzing really big datasets.

There are many Big Data Analytics tools that a business could select such as: Knime, OpenRefine, Orange, and RapidMiner.

- **KNIME**: The KNIME Analytics Platform is the leading open solution for data-driven innovation, designed for discovering the potential hidden in data, mining for fresh insights, or predicting futures. Organizations can take their collaboration, productivity and performance to the next level with a robust range of commercial extensions to our open source platform.

- **OpenRefine**: (formerly Google Refine) is a powerful tool for working with messy data. OpenRefine takes data and cleans it; transforming it from one format into another, and extending it with web services and external data. Please note that since October 2nd, 2012, Google is not actively supporting this project, which has now been rebranded to OpenRefine. Project development, documentation and promotion is now fully supported by volunteers.

- **RapidMiner**: Much like KNIME, RapidMiner operates through visual programmingand is capable of manipulating, analysing and modelling data. RapidMiner's unified data science platform accelerates the building of complete analytical workflows, from data prep to machine learning to model validation to deployment. This all happens in a single environment, dramatically improving efficiency and shortening the time to value for data science projects.

- **Orange**: An open source data visulization and data analysis for novice and expert, and provides a large toolbox to createinteractive workflows to analyze and visualize data. Orance is packed with different visualizations, from scatter plots, bar charts, trees, o dendograms, networks and heat maps.

3.1.3.7 Lab – Using Excel to Forecast

The following lab is an example of using an Excel spreadsheet to execute some forecasting on a small sampling of data. The Forecast menu option is available in the 2016 version of Excel. If you do not have this version, the formula is provided.

If you do not have access to Excel, the forecasting formula has been provided so that you can use Open Office or Libre Office.

Follow instructions on the lab document.

Summary: Everything Generates Data

Big Data usually has three characteristics. It is a large amount of data that increasingly requires more storage space (volume), that is growing exponentially fast (velocity), and that is generated in different formats (variety).

Fog computing is an architecture that utilizes end-user clients or "edge" devices to do a substantial amount of the pre-processing and storage required by an organization. Fog computing was designed to keep the data closer to the source for pre-processing.

The cloud is a collection of data centers or groups of connected servers giving anywhere, anytime access to software, storage, and services using a browser interface. Cloud services provide increased data storage as required and reduce the need for onsite IT equipment, maintenance, and management. They also reduce the cost of equipment, energy, physical plant requirements, and personnel training needs.

Distributed data processing takes large volumes of data from a source and breaks it into smaller pieces. These smaller data volumes are distributed in many locations to be processed by many computers with smaller processors. Each computer in the distributed architecture analyzes its part of the Big Data picture.

Businesses gain value by collecting and analyzing massive amounts of new product-usage data to understand the impact of their products and services, adjust their methods and goals, and provide their customers with better products faster.

Collected data can be categorized as structured or unstructured. Structured data is created by applications that use "fixed" format input such as spreadsheets or medical forms. Unstructured data is generated in a "freeform" style such as audio, video, web pages, and tweets. Both forms of data need to be manipulated into a common format to be analyzed. CSV, JSON, and XML are plaintext file types that use a standard way of representing data records. Converting data into a common format is a valuable way to combine data from different sources.

Data mining is the process of turning raw data into meaningful information by discovering patterns and relationships in large data sets. Data visualization is the process of taking the analyzed data and using charts such as line, column, bar, pie, or scatter to present meaningful information. A strategy helps a business determine the type of analysis required and the best tool to do the analysis. A strategy also helps to determine the most effective way to present the results for management.

Chapter 4: Everything Can be Automated

What Can be Automated?

What is Automation?

Automation is any process that is self-driven and reduces, then eventually eliminates, the need for human intervention.

Automation was once confined to the manufacturing industry. Highly repetitive tasks such as automobile assembly were turned over to machines and the modern assembly line was born. Machines are excellent at repeating the same task without fatigue and without the errors that humans are prone to make in such jobs. This results in greater output, because machines can work 24 hours a day without breaks. Machines also provide a more uniform product.

The IoT opens up a new world in which tasks previously requiring human intervention can become automated. As we have seen, the IoT allows the collection of vast amounts of data that can be quickly analyzed to provide information that can help guide an event or process.

As we continue to embrace the benefits of the IoT, automation becomes increasingly important. Access to huge amounts of quickly processed sensor data started people thinking about how to apply the concepts of machine learning and automation to everyday tasks. Many routine tasks are being automated to improve their accuracy and efficiency.

Automation is often tied to the field of robotics. Robots are used in dangerous conditions such as mining, firefighting, and cleaning up industrial accidents, reducing the risk to humans. They are also used in such tasks as automated assembly lines.

We now see automation everywhere, from self-serve checkouts at stores and automatic building environmental controls, to autonomous cars and planes. How many automated systems do you encounter in a single day?

Video – What is Automation [Transcript]

The internet. Once here. Now, it's suddenly everywhere, unleashing a world of opportunities. The internet of things. It's already here. In cars that drive themselves. Here, where gate sensors put fans in their seats faster. Here, bringing doctors and patients together virtually. Smart buildings are already reducing energy costs here. Drones use infrared imaging to detect crop failure here while sensor-driven pumps conserve water here. Network sensors and cameras let students in and keep trouble out here while smart vending machines personalize the shopping experience here. The internet of things is cutting unscheduled downtime here. It's turning data into profits, streetlights into guardians, and mines into safer, more profitable production centers. Here, millions of containers can now be tracked in real-time from a single location while connected emergency vehicles turn the lights green here. And playgrounds are now safe places to play here. Welcome to a world of things. Already making a worldof difference in so many ways, in so many places. Where will you take it next?

How is Automation Being Used?

- **Smart Home Automation**: For many, the home environment has become a more automated environment. Devices such as Apple Homekit, Amazon Alexa and Echo, and Google Assistant allows us to give voice commands to control such things as lights, locks, doors, thermostats, plugs, switches, alarm systems, window covering, sprinkler system sensors, and more. Even kitchen appliances and pet care functions are being automated. Companies are producing new products every day to work with these home automation systems.

- **Smart Buildings**: Enterprises of all types are using smart technology to automate building processes. Smart building deploy many of the same technologies as smart homes. These processes provide efficient lighting, energy, heating, air conditioning, and security. For example, a smart building can reduce energy costs using sensors that detects how many occupants are in a room and adjust the heating or cooling appropriately. Smart buildings can also connect to and communicate with the smart grid. This enable more efficient management of energy systems. Visit https://www.cisco.com/c/en/us/solutions/workforce-experience/digital-building/index.html, for more information on smart buildings.

- **Industrial IoT and Smart Factories**: The Industrial IoT (IIoT) brings together machines, advanced analytics, and people. It is a network of manufacturing devices and sensors connected by secure, high-speed communications technologies. This results in systems that can monitor processes; collect, exchange and analyse data; and use that information to continually adjust the manufacturing process. We are currently in the Fourth Industrial Revolution, or what is called Industry 4.0. this describes an environment where machinery and equipment are able to improve processes through automation and self-optimization. Indutry 4.0 extends beyond the manufacturing process and into functions like planning, supply chain logistics and product development. For more information on Industry 4.0, visit https://newsroom.cisco.com/press-release-content?articleId=1840946.

- **Smart Cities**: What do Hamburg, Barcelona, Kansas City, Jaipur, Copenhagen, and Manchester have in common? They are all "smart cities" that use digital technology to make their city a better place to live. Some of these cities use technology to reduce carbon emissions or monitor CO2 levels. Other use technology to provide free city-wide Wi-Fi access, improve public safety, or improve transportation options.
  To learn more about smart cities, visit https://www.cisco.com/c/en/us/solutions/industries/smart-connected-communities/what-is-a-smart-city.html

- **Smart Grids**: Visit https://www.bing.com/videos/search?q=cisco+video+smart+grid++video&&view=detail&mid=B7FB5331E222D3085D5EB7FB5331E222D3085D5E&&FORM=VRDGAR, to learn about Smart Grid technology.

- **Smart Car Technology**: Most of today's new motor vehicles have integrated technology that assists drivers to be safer on the road. Technology exists that prevent drivers from drifting into adjacent lanes or making unsafe lane changes. Systems automatically apply the brakes if a vehicle ahead of them stops or slows suddenly. These safety technologies use a combination of hardware and software to identify safety risks and to take action to avoid a crash. The continuing evolution of these technologies have given rise to Automated Driving Systems (ADS) that can handle the whole task of driving when we do not want to, or cannot do it ourselves. Self-driving vehicles can now operate fully autonomously, without the intervention of a driver.

- **Stores and Services**: Tasks that were once done by people are now increasingly being done by machines. Fast food restaurants are setting up self-serve kiosks for order entry, banks are increasing turning to automated teller machines or apps that are designed to run on smart phone, and supermarkets and department stores have installed self-serve checkouts. Systems have been designed to monitor inventory levels and automatically place orders to accurately match supply to demand and eliminate excess inventory.

- **Medical Diagnosis and Surgery**: The medical profession relies on doctors and nurses to run tests and make a diagnosis based on results. Systems have now been developed that use technology to accurately and automatically conduct these medical tests. These systems then search through comprehensive databases making a large number of calculations and comparisons. The result is in a more accurate diagnosis and treatment regime than might be possible from a single individual. Also, machines are now being used to more precisely control the treatment, which minimizes peripheral damage to the patient.

- **Aircraft Auto-Pilot**: Planes today are built to fly themselves. A complex collection of systems automates a plane's operations. After a flight path is entered, the auto-pilot system collects information about the route, location, air speed, altitude and engine thrust. It makes adjustments to keep the plane safely on the intended path. Redundancy in system design ensures that a failure in any one system would not jeopardize passenger safety.

4.1.1.3 Lab – Automating Everyday Events

In this lab you will examine your daily life. What processes are already automated and what processes would you like to see automated in the future?

Follow instructions on the lab document.

When Things Start to Think

Can things think? Can a device learn from its environment? In this context, there are many definitions of the word "think". One possible definition is the ability to connect a series of related pieces of information together, and then use them to alter a course of action.

For example, when we are young we have no concept that a fire is hot and that placing our hand in the fire will cause pain. A fire may appear visually pleasing and actually encourage one to try and touch the flames. We quickly learn that the fire can cause injury. We then start to associate the image of the fire with the pain it can cause. From this point on we start to think about the results of touching the fire and base our actions on this acquired information.

Many devices now incorporate smart technology to alter their behavior under certain circumstances. This can be as simple as a smart appliance lowering its power consumption during periods of peak demand or as complicated as a self-driving car.

Whenever a decision or course of action is taken by a device based on an outside piece of information, then that device is referred to as a smart device. Many devices that we interact with now have the word smart in their names. This indicates that the device has the ability to alter its behavior depending on its environment.

What smart technology and devices have you interacted with today?

## 4.1.1.6 Packet Tracer – Explore the Smart Home

In this activity, you will explore the smart home example. Depending on the application, some data is best processed close to its source. The smart home example takes advantage of fog computing to monitor and act upon the levels of smoke detected in the home.

Download the Packet Tracer file and complete activity

What Is Artificial Intelligence and Machine Learning?

Artificial Intelligence (AI) is the intelligence demonstrated by machines. This is in contrast to natural intelligence which is the intelligence displayed by living organisms. AI uses intelligent agents that can perceive their environment and make decisions that maximize the probability of obtaining a specific goal or objective. AI refers to systems that mimic cognitive functions normally associated with human minds such as learning and problem solving.

Some of the tasks that currently are deemed to require a degree of AI are autonomous cars, intelligent routing in content delivery networks, strategic game playing, and military simulations.
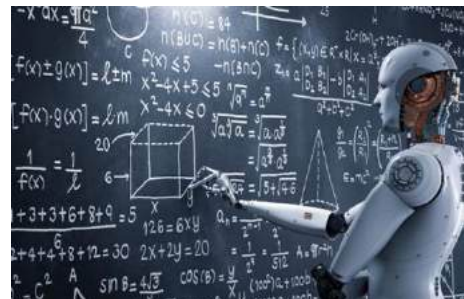
As technology develops, many of the tasks that at one time required AI have become routine. Many of these tasks have migrated from AI to Machine Learning (ML).

ML is a subset of AI that uses statistical techniques to give computers the ability to "learn" from their environment. This enables computers to improve on a particular task without being specifically programmed for that task.

This is especially useful when designing and programming specific algorithms is difficult or infeasible. Examples of such tasks in computer science include malicious code detection, network intruder detection, optical character recognition, computer speech recognition, and computer vision.

One objective of learning is to be able to generalize based on experience. For machines, this involves the ability to perform accurately on new, previously unseen tasks after gaining experience with a learning data set. The training data set must come from data that is representative of the larger data pool. This data pool enables the machine to build a general model about this data, which would help it make accurate predictions.

ML in the IoT

One of the features of the IoT is that it enables the collection of extremely large pools of data that can "teach" programs how to respond in certain conditions. Some of the more common uses of ML technology include:

- **Speech Recognition** - Many different companies now offer digital assistants which allow you to use speech to communicate with a computer system. Apple, Microsoft, Google and Amazon all offer this service. These companies not only allow commands to be given verbally, but offer speech-to-text capabilities.
- **Product Recommendation** - Systems build up a customer profile and recommend products or services based on previous patterns. Users of Amazon and eBay receive recommendations on products. Organizations such as LinkedIn, Facebook, and GooglePlus recommend users you may wish to connect with.
- **Shape Recognition** - Programs exist that allow crude hand-drawn diagrams and notes to be converted to more formal diagrams and text. This allows the shapes and lines of hand writing to be converted to more formal text which can then be searched and analyzed.
- **Credit Card Fraud Detection** - A profile is constructed about the purchasing patterns of a client. Any deviation from these patterns triggers an alert and the system automatically takes action. This action ranges from denying the transaction to notifying the authorities. Some of the events that are detected and could indicate a fraudulent transaction include purchasing products not normally purchased, purchases in a different geographic area, rapidly purchasing many different products, and purchasing large-ticket items.
- **Facial Recognition** - Security cameras are everywhere, from stores and streets to airports and transportation hubs. These cameras continually scan the crowds, normally watching for dangerous or illegal activities, but they can also be used to identify and track individuals. The system builds a pattern of specific facial features and then watches for a match to these facial patterns triggering some action.

Think about your interactions with online and offline systems over the past week. How many ML applications have you interacted with?

4.1.2.3 Lab – Design a Prototype of an AI Application

With IoT devices and IoT networks getting popular, technologies for IoT devices are also improving rapidly. IoT devices are no longer limited to sensors and actuators; they may have the capability to think and act accordingly according to environment changes, thanks to the development of artificial intelligence (AI) and machine learning (ML).

In this lab you will work with a group to design the prototype for an AI application.

Follow instruction on the lab document.

What Is Intent-Based Networking (IBN)

For a business to survive, it must be agile and respond quickly to the needs and demands of its customers. Businesses are increasingly dependent on their digital resources to meet customer demands, so the underlying IT network must also be responsive enough to quickly adapt to these requirements. This normally involves adjustments to many systems and processes. These adjustments may include changes to security policies and procedures, business services and applications, and operational policies.

With traditional networks, many different components must be manually adjusted to meet ever-changing business requirements. This requires different technicians and engineers to ensure that the systems are changed in a manner that allows them to work together to accomplish their goal. This sometimes results in errors and delays, and often in sub-optimal network performance.

The new business network must seamlessly and securely integrate IoT devices, cloud-based services, and remote offices in an agile, responsive, and business-relevant manner. Additionally, the network must secure these new digital initiatives from the ever-changing threat landscape.

To address this need, the IT industry has initiated an effort to create a systematic approach to tie infrastructure management to business intent. This approach is known as intent-based networking. The figure illustrates the general idea behind intent-based networking. With this new paradigm, business needs are automatically and continually translated into IT infrastructure execution.

Visit https://www.cisco.com/c/en/us/solutions/intent-based-networking.html, for information about Cisco Intent-based networking.

How are ML, AI, and IBN Linked?

Intent-based networking harnesses the power of automation, AI, and ML to control the function of a network to accomplish a specific purpose, or intent.

Intent-based networking allows the IT team to specify, in plain language, exactly what they want the network to accomplish and the network makes it happen. The network is able to translate the intent into policies and then use automation to deploy the appropriate configurations required across the network.

The intent-based network uses AI and ML to ensure that any services that are deployed meet the required service level. If they do not meet the service level, the intent-based network can make alerts and provide suggestions for improvement. In some cases, the intent-based network can automatically reconfigure the network to comply with the service levels.

The intent-based networking model shown in the figure consists of three key elements:
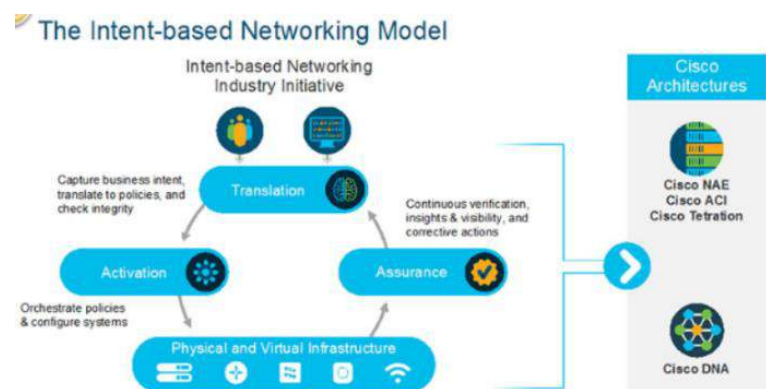
- **Assurance** - The assurance element is end-to-end verification of network-wide behavior. It predicts the results of any changes, tracks compliance with the original intent, and makes recommendations or adjustments when there is a misalignment between the intent and the outcome. This stage relies

heavily on AI and ML. Systems are part of a closed-loop that continually monitors performance and security of the network, and reconfigures the network to ensure compliance.

- **Translation** - The translation element is the ability to apply business intent to network configuration. The intent is what you wish to accomplish, not how it is accomplished. This intent is specified in plain language and used by the system to create policies across the system. For example, an intent might be to segment guest traffic from corporate traffic, or to enable access for remote users.
- **Activation** - The activation element occurs after the intent has been specified and the policies created. This is when individual devices are provisioned to match the intent-based policies. This can be an automated or semi-automated mode that allows the network team to verify configuration before the devices are deployed.

An intent-based network creates an agile, responsive network that scales easily and adapts to meet business requirements. It makes efficient use of highly-skilled resources and allows man and machine to work together to optimize the customer experience. Additionally, intent-based networking provides a more secure digital experience by automating time consuming or complicated processes. This makes deploying security policies much easier.
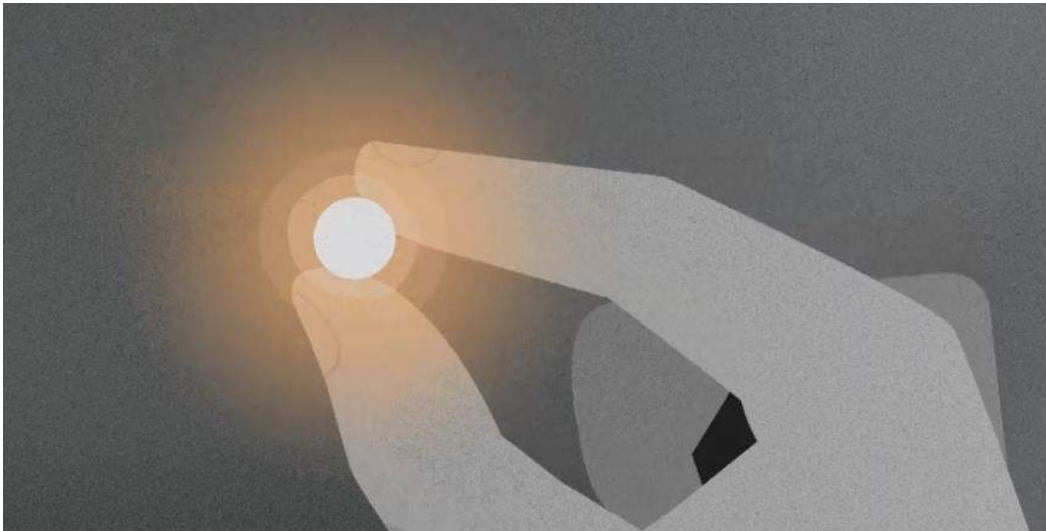
Use Cases for Intent-Based Networking

Intent-based networking allows the company to focus on business goals. It provides an automated system that understands what the organization needs and then makes it happen.

The Cisco Digital Network Architecture (Cisco DNA) is an example of an intent-based network. It is an open, extensible, software-driven architecture. It accelerates and simplifies enterprise network operations, while lowering costs and reducing risks.

Cisco DNA automation and assurance are built on a software-defined networking (SDN) controller, rich contextual analytics, network virtualization, and the limitless scalability of the cloud.

For more information on how Cisco Digital Network Architecture is being used across different industry verticals visit https://www.cisco.com/c/en/us/solutions/enterprise-networks/index.html.

Video –Intent-Based Networking [Transcript]

Your business has needs. Your network has limitations. And you're caught in the middle. Convention won't cut it. You need an open network built on something much bigger. Possibility, and just like that, challenges become inspirations. Incongruity becomes harmony. Obstacles become opportunities, and time lost becomes time to innovate. So you can push your intent into every corner of the network, reaching higher, and farther faster than ever before. Silos become conduits, so you can channel the intelligence of the network into what you already have in place, and introduce services and solutions that weren't possible before. Platforms extend beyond the network and out to any business operation, where good ideas lead to better ideas, lead to great ideas. And the most powerful thing about this network, where almost anything is possible, it's fully controlled by you. Finally network your way with the world's most advanced intent based network. Now open for anything.

4.1.3.4 Lab – Researching Intent-Based Networking (IBN)

Today the network connects everything. What if the network could constantly adapt, protect, and notify based on the intent of the business owner? An intent-based network, on an open platform, can align the end-to-end network with that intent. It can bridge the gap between what the business needs and what the network delivers.

In this lab you will explore some of the possibilities created by intent-based networking (IBN).

Follow instruction on the lab document.

Summary: Everything Can be Automated

This chapter began by discussing automation. Automation is any process that is self-driven and reduces, then eventually eliminates, the need for human intervention. The IoT opens up a new world in which tasks previously requiring human intervention can become automated. Many devices now incorporate smart technology to alter their behavior under certain circumstances. Some examples of smart technology can be found in smart homes and buildings, cities, a smart power grid, and smart cars.

Next, the chapter detailed Artificial Intelligence (AI). AI is the intelligence demonstrated by machines. As technology develops, many of the tasks that at one time required AI have become routine. Many of these tasks have migrated from AI to Machine Learning (ML). ML is a subset of AI that uses statistical techniques to give computers the ability to "learn" from their environment. Some examples of ML in the IoT include speech and facial recognition, product recommendation, and credit card fraud detection.

The next topic of this chapter covered Intent-Based Networking (IBN). The new business network must integrate IoT devices, cloud-based services, and remote offices in a way that is relevant and responsive to business. The network must secure these new digital initiatives from the ever-changing threat landscape. IBN is a systematic approach to tie infrastructure management to business intent.

Finally, this chapter discussed how intent-based network uses AI and ML to ensure that any services that are deployed meet the required service level. A model of IBN contains three elements including assurance, translation and activation. The Cisco Digital Network Architecture (Cisco DNA) is an example of an intent-based network. It is an open, extensible, software-driven architecture.

Chapter 5: Everything Needs to be Secured

Security in the Digitized World

Types of Data

Has data really changed? Well technically no, data generated by computers and digital devices is still groups of 1s and 0s. That has not changed. What has changed is the quantity, volume, variety, and immediacy of the generated data.

Historically companies would have access to our information gathered from forms, spreadsheets, applications, credit card purchases and other types of files. Much of the information was stored and analyzed at a later date. Sensitive data was still collected, stored and analyzed but, historically, hackers were more interested in hacking into systems to obtain corporate or government secrets.

Today, gathered data is taking on new characteristics. The digitized world has opened the floodgates for data gathering. IoT sensor-enabled devices are collecting more and more data of a personal nature. Wearable fitness trackers, home monitoring systems, security cameras, and debit card transactions are all collecting personal data as well as business and environmental data. Data is often combined from different sources and users may be unaware of this. Combining fitness monitoring data with house monitoring data could produce data points to help map the movements or location of a homeowner. This changing type of data collection and aggregation can be used for good purposes to help the environment. It also increases the possibility of invasion of our privacy, identity theft, and corporate espionage.

Informational

- Rain gauge value
- Number of cars through an intersection
- Hospital emergency use per state
- Average plane capacity
- House thermometer reading
- Census data
- Immigration values
- Average potato crops per province
- Next train time per station
- Average gas consumption per flight

PII

- Social security number
- Email address
- Bank account numbers
- Student tuition bill
- Credit rating
- Debit card number
- Fingerprints
- Birth date
- Username/password
- Vehicle identification number (VIN)
- Mortgage information
- Home address
- Facebook photographs

Personally identifiable information (PII) or sensitive personal information (SPI) is any data relating to a living individual that can be used on its own or with other information to identify, contact, or locate a specific individual. The data gathered by companies and government institutions can also contain sensitive information concerning corporate secrets, new product patents, or national security.

Because we are gathering and storing exponential quantities of both sensitive and informational data, it has increased the need for extra security to protect this information from natural disasters, hackers, and misuse.

5.1.1.2 Lab – Types of Data

In this lab, we will review different types of collected data and determine if it is sensitive in nature and who might benefit from stealing it.

Follow instructions on the lab document.

Who Wants our Data?

The Good Guys

Legitimate companies have an agreement in place that gives them permission to use the collected data about you for purposes of improving their business. Remember those "Terms and Conditions" or "Terms of Service and Agreements" documents that we say yes to but do not usually read? The next time that you are presented with one, take the time to read through it. The contents might surprise you.

Other legitimate users of our data would be companies that use sensors on their own devices or vehicles. Governments that have environmental sensors, and cities who have installed sensors on trains, busses or traffic lights also have a right to the data they generate.

Some hackers, called white hat hackers, are paid by legitimate companies and governments to test the security of a device or system. Their goal is not to steal or modify data but to help to protect it.

The Bad Guys

Other hackers, called black hat hackers, want access to collected data for many nefarious reasons:

- To sell the information to a third party.
- To modify the data or disable functionality on a device.
- To disrupt or to damage the image of a legitimate company.
- To access devices, web pages, and data to create political unrest or to make a political statement.
- To access user IDs and passwords to steal identities.
- To access data to commit a crime.
- To hack into systems to prove that they can do it.

Data in the Wrong Hands

Hackers have accessed the data of many companies over the years. The impact is significant and has resulted in the data of millions of users being released on the web.

According to recent news, login credentials and other personal data linked to more than one Million Yahoo and Gmail accounts are reportedly being offered for sale on the dark web marketplace. The online accounts listed for sale on the Dark Web allegedly contain usernames, emails, and plaintext passwords. The accounts are not from a single data breach; instead, several major cyber-attacks are believed to have been behind it.

Cybercriminals penetrated Equifax (EFX), one of the largest credit bureaus, in July 2017 and stole the personal data of 145 million people. It was considered among the worst breaches of all time because of the amount of sensitive information exposed, including Social Security numbers.

The company only revealed the hack two months later. It could have an impact for years because the stolen data could be used for identity theft.

The breach in 2018 affected an estimated 150 million users of its food and nutrition application, MyFitnessPal.

The investigation indicates that affected information may include usernames, email addresses, and hashed passwords.

From the New York Times:

SAN FRANCISCO (late 2016)— Uber disclosed Tuesday that hackers had stolen 57 million driver and rider accounts and that the company had kept the data breach secret for more than a year after paying a $100,000 ransom. The breach cost Uber in both reputation and money.

Visit https://cisco-netacad.wistia.com/medias/jjnqkypamu, to view a video of "Anatomy of an IoT Attack."

5.1.1.5 Lab - Internet Fingerprint

The purpose of this lab is to introduce the aspect of "fingerprinting" an individual using the worldwide web. The objective is to introduce various methods to extract as much information as possible using only the Internet browser and various sites effectively.

Follow instructions on the lab document.

Security Best Practices

Securing the network involves all of the protocols, technologies, devices, tools, and techniques that secure data and mitigate threats. Network security is largely driven by the effort to stay one step ahead of ill-intentioned hackers. Just as medical doctors attempt to prevent new illnesses while treating existing problems, network security professionals attempt to prevent potential attacks while minimizing the effects of real-time attacks. Networks are routinely under attack. It is common to read in the news about yet another network that has been compromised.

Security policies, procedures, and standards must be followed in the design of all aspects of the entire network. This should include the cables, data in transit, stored data, networking devices, and end devices.

Some security best practices are listed below:

- **Performance Risk Assessment**: Knowing the value of what you are protecting will help in justifying security expenditures.
- **Create a Security Policy**: Create a policy that clearly outlines company rules, job duties, and expectations.
- **Physical Security Measures**: Restrict access to network assets in networking closets and server locations. Install appropriate fire suppression systems.
- **Human Resource Security Measures**: Employees should be properly researched with background checks.
- **Perform and Test Backups**: Perform regular backups and test data recovery from backups.
- **Maintain Security Patches and Updates**: Regularly update server, client, and network device operating systems and programs.
- **Employ Access Controls**: Configure user roles and privilege levels as well as strong user authentication.

- **Regularly Test Incident Response**: Employ an incident response team and test emergency response scenarios.
- **Implement a Network Monitoring, Analytics and Management Tool**: Choose a security monitoring tool that integrates with other technologies.
- **Implement Network Security Devices**: Use next generation routers, firewalls, and other security appliances.
- **Implement a Comprehensive Endpoint Security Solution**: Use enterprise level antimalware and antivirus software.
- **Educate Users**: Educate users and employees in secure procedures.
- **Encrypt Data**: Encrypt all sensitive company data including email.

Physical Security

Today's data centers store vast quantities of sensitive, business-critical information; therefore, physical security is an operational priority. Physical security not only protects access to the premises, but also protects people and equipment. For example, fire alarms, sprinklers, seismically-braced server racks, and redundant heating, ventilation, and air conditioning (HVAC) and UPS systems are in place to protect people and equipment.

This figure one shows a representation of a data center.

Physical security within the data center can be divided into two areas, outside and inside.

- **Outside perimeter security** - This can include on-premise security officers, fences, gates, continuous video surveillance, and security breach alarms.
- **Inside perimeter security** - This can include continuous video surveillance, electronic motion detectors, security traps, and biometric access and exit sensors.
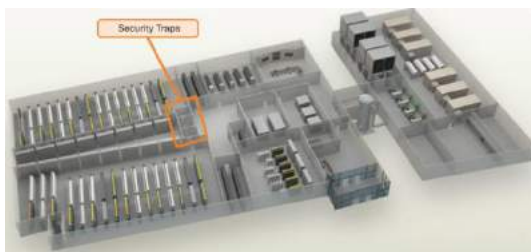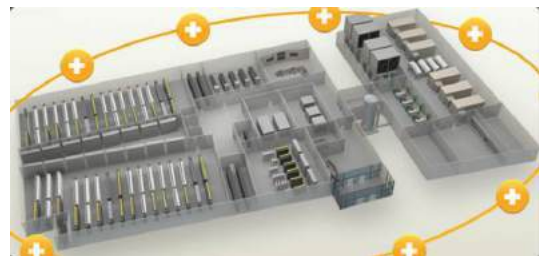
Security traps provide access to the data halls where data center data is stored. Security traps are similar to an air lock. A person must first enter the security trap using their badge ID proximity card. After the person is inside the security trap, facial recognition, fingerprints, or other biometric verifications are used to open the second door. The user must repeat the process to exit the data hall.

This figure displays the biometric requirements at the Cisco Allen Data Center, in Allen, Texas.

Challenges of Securing IoT devices

IoT devices are developed with the necessary network connectivity capabilities but often do not implement strong network security. Network security is a critical factor when deploying IoT devices. Methods must be taken to ensure the authenticity, integrity, and security of the data, the path from the sensor to the collector, and the connectivity to the device.

Increasing Number of Devices - The number of interconnected sensors and smart devices is growing exponentially, increasing the opportunity for attacks. Sensors and smart devices tend to be small devices, with varying operating systems, CPU types, and memory. Many of these entities are expected to be inexpensive, single-function devices with rudimentary network connectivity.

Non-Traditional Location of Devices - Some connected IoT devices are able to interact with the physical world. They are now located in appliances, in automobiles, on or in our bodies, and in our homes. Sensors may gather data from the refrigerator or the heating system. They could also be located in city lampposts or attached to tree trunks. These non-traditional locations make physical security difficult or impossible to achieve. The devices should be manufactured to be resistant to tampering, and they should be placed so that they are not obvious and are very difficult to access.

Lack of Upgradeability - IoT sensor-enabled devices may be located in remote and/or inaccessible locations where human intervention or configuration is almost impossible. The devices are often designed to be in service many years longer than is typical for conventional high-tech equipment. Some IoT devices are intentionally designed without the ability to be upgraded, or they might be deployed in situations that make it difficult or impossible to reconfigure or upgrade. New vulnerabilities are uncovered all of the time. If a device is non-upgradeable, then the vulnerability will exist for the rest of its lifetime. If a device is upgradeable, the typical consumer may not have a technology background, therefore, the upgrade process should perform automatically or be easy enough to be performed by a layperson.

Safe Wi-Fi Usage
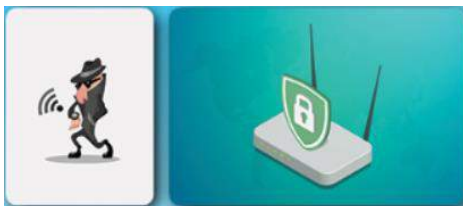
Wireless networks are popular in all types and sizes of businesses because they are easy to set up and convenient to use. For employees and guests, the company needs to deliver a wireless experience that enables mobility and security. If a wireless network is not properly secured, hackers within range can access it and infiltrate the network.

Below are steps to take to help to protect a wireless network.

- **Change the default administrator password**: Strong passwords should contain more than 8 digits and consist of letters, numbers, and special characters.
- **Change the network service set identifier (SSID)**: A wireless network's name is called a service set identifier (SSID). Wireless routers are usually shipped with a default SSID making the network vulnerable to attack.
- **Do not advertise the SSID name, if possible**: Most wireless routers advertise the SSID name. Employees would have knowledge of the SSID name through the company.
- **Create a Guest wireless network**: For companies that require guest access, it is important to segregate the guest network from the employee network.
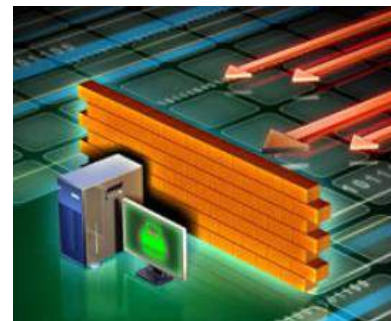
- **Enable the built-in firewall**: Most wireless router have built-in firewalls, but sometimes they ship with the firewall turned off. Make sure that the router's firewall is turned on.
- **Configure the wireless router to use WPA2-AES encryption**: Every wireless router offers encryption that scrambles your data and makes in unreadable to everyone except by the intended recipient. Wi-Fi Protected Access 2 (WPA2) is best because it employs the hardest-to-crack encryption algorithm.
- **Keep the wireless router's firmware updated**: When you keep your wireless router's firmware updated, known bugs and vulnerabilities are fixed, making your router more secure.
- **Use Media Access Control (MAC) Address filtering**: If only employees use a particular wireless network, configure your wireless router to check the MAC addresses of devices trying to connect to it, allowing connections only from the devices it recognizes.
- **Disable you wireless router's remote management feature**: Many wireless routers have a feature that lets you manage them from a remote location. Unfortunately, it often leaves routers susceptible to attacks. Disable remote management if you do not need to use this feature.
- **Physically secure the wireless router**: Ensure that the router is in a secure location and is only accessible by authorized personnel.

Protecting Devices

Keep the Firewall On

Whether it is a software firewall or a hardware firewall on a router, the firewall should be turned on and updated to prevent hackers from accessing your personal or company data. Visit the following links to learn how to turn on the firewall for the version of your operating system:

- **Windows 7 and 8.1**: http://windows.microsoft.com/en-us/windows/turn-windows-firewall-on-off
- **Windows 10**: http://windows.microsoft.com/en-us/windows-10/turn-windows-firewall-on-or-off
- **Mac OS X devices**: http://support.apple.com/en-us/HT201642

Use Antivirus and Antispyware

Malicious software, such as viruses, Trojan horses, worms, ransomware and spyware, are installed on your computing devices without your permission, in order to gain access to your computer and your data. Viruses can destroy your data, slow down your computer, or take over your computer. Only download software from trusted websites to avoid getting viruses and spyware in the first place. Antivirus software is designed to scan your computer and incoming email for viruses and delete them. Sometimes antivirus software also includes antispyware. Keep your software up to date to protect your computer from the newest malicious software.

Manage Your Operating System and Browser

Hackers are always trying to take advantage of vulnerabilities in your operating systems and your web browsers. To protect your computer and your data, set the security settings on your computer and browser at medium or higher. Update your computer's operating system including your web browsers and regularly download and install the latest software patches and security updates from the vendors.

Protect All Your Devices

Your computing devices, whether they are routers, PCs, laptops, tablets, or smartphones, should be password protected to prevent unauthorized access. The stored information should be encrypted, especially for sensitive or confidential data. For mobile devices, only store necessary information, in case these devices are stolen or lost when you are away from your home. If any one of your devices is compromised, the criminals may have access to all your data through your cloud-storage service provider, such as iCloud or Google drive.
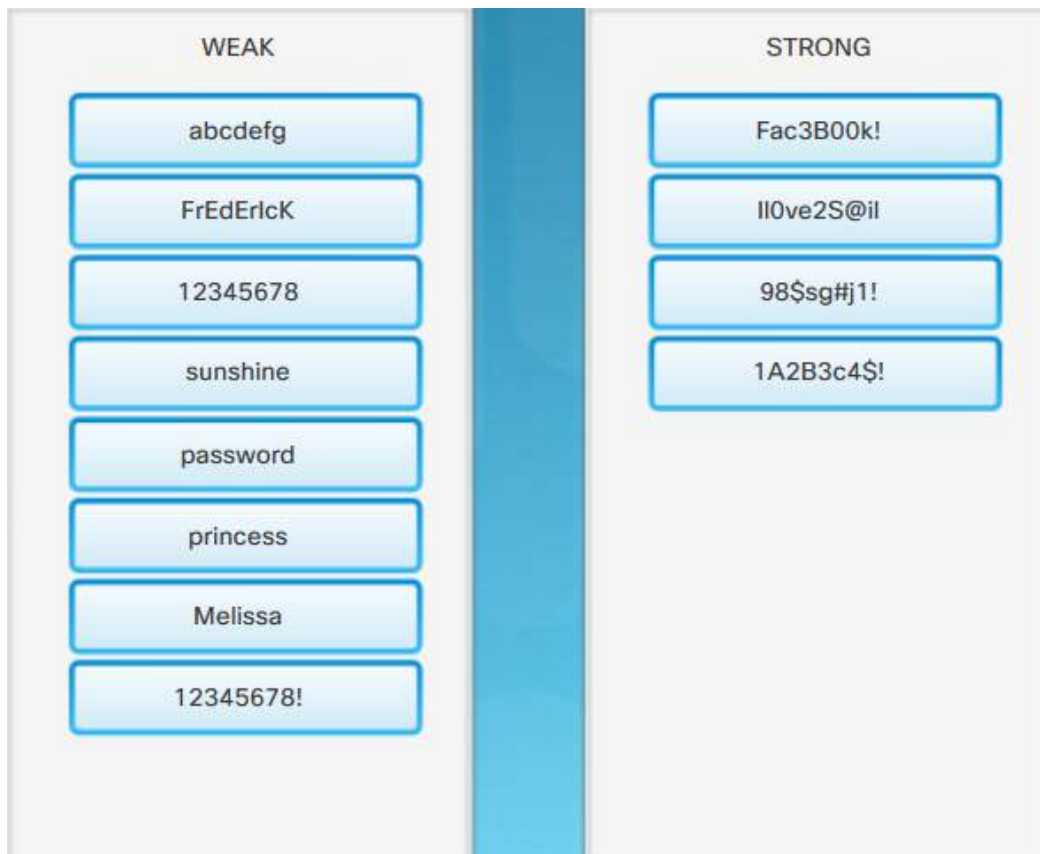
5.1.2.6 Packet Tracer - Configure Wireless Security

In this Packet Tracer activity, you will secure a wireless router on a home network.

Download the Packet Tracer file and complete activity

How to Protect Your Personal Data

| DO	DO NOT
✓ Backup important data to more than one location, for example: the cloud AND a USB drive	✓ Leave your laptop/smartphone unlocked and unattended
✓ Modify the default password and SSID on your home wireless router	✓ Broadcast your wireless network SSID
✓ Use WPA2 and encryption for security on your wireless router	✓ Leave your wireless network unsecured
✓ Know when your data is going to the cloud	✓ Leave your wireless router with default settings
✓ Read instructions and set your privacy settings accordingly on social media sites	✓ Post personal pictures of yourself and your young children to Facebook
✓ Understand that combining unrelated data can create PII	✓ Use the same password for every site
✓ Use strong passwords	✓ Share your passwords with friends
✓ Back up your data frequently	✓ Post information that lets people know that you are not at home
	✓ Write passwords down and leave in an obvious place

Strong Passwords

WEAK	STRONG
abcdefg	Fac3B00k!
FrEdErIcK	Il0ve2S@il
12345678	98$sg#j1!
sunshine	1A2B3c4$!
password	
princess	
Melissa	
12345678!	

Smart Homes

Smart home technology has become very popular and its popularity is increasing every year as the technology evolves. Who doesn't find it appealing to turn your home thermostat up or down while you are at work, or to have your refrigerator order groceries to be delivered when you get home? How cool is it to check on the dog or to verify that your teenagers are doing their homework after school by activating your home security cameras?

As we install more and more smart sensors into our homes, we do increase the potential for security issues. Often the sensors are connected to the same network as our home or small business devices so that a breach of one device can radiate outwards to affect all connected devices. The sensors could also provide a way for hackers to get into our home network and gain access to any PCs and data that are connected to it.
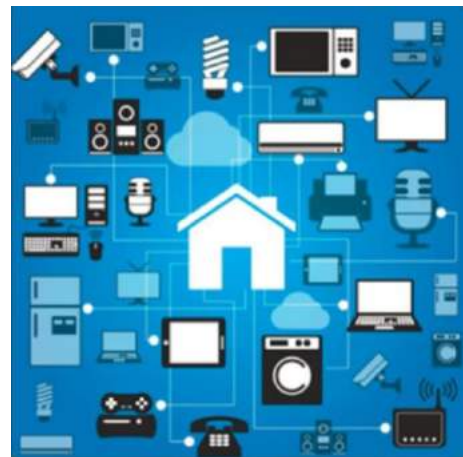
Even virtual assistants such as Apple SIRI, Amazon Echo, or Google Home can be security risks. People use these devices to turn on music, adjust room temperatures, order products on-line, and get directions for where they are going. Can this cause any harm? It is possible that personal information such as passwords or credit card information could be leaked.

Fortunately many of the security flaws of the early smart technology sensors have already been discovered. Developers are working to correct the flaws and improve security measures to protect their systems from attack. Before purchasing home security systems, it is very important to research the developer and the security and encryption protocols that are in place for its products.

Public Hotspots

When you are away from home, a public Wi-Fi hot spot allows you to access your online information and surf the Internet. Common activities on public Wi-Fi include logging into a personal email account, entering personally identifiable information, logging into social media, and accessing bank or financial information. All of this information could be stolen if the Wi-Fi connection is unsecure.

Safety rules to follow if you are using a public or unsecure Wi-Fi hotspot:

- Do not access or send any sensitive personal information over a public wireless network.
- Verify whether your computer is configured with file and media sharing, and that it requires user authentication with encryption.
- Use encrypted virtual private network (VPN) tunnels and services. The VPN service provides you secure access to the Internet, with an encrypted connection between your computer and the VPN service provider's VPN server. With an encrypted VPN tunnel, even if a data transmission is intercepted, it is not decipherable.
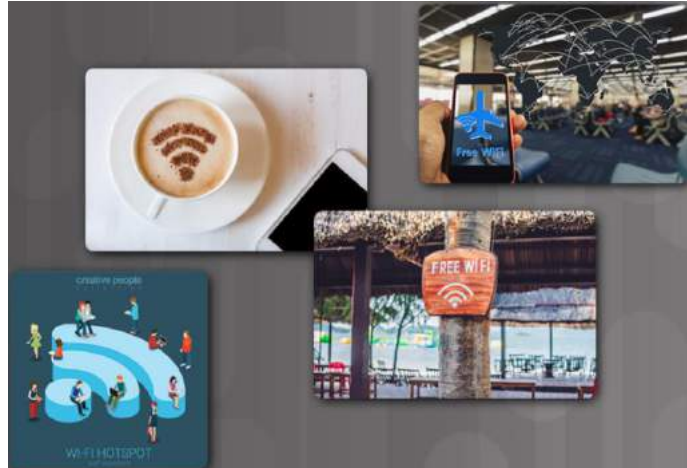
Many mobile devices, such as smartphones and tablets, come with the Bluetooth wireless protocol. This capability allows Bluetooth-enabled devices to connect to each other and share information. Unfortunately, Bluetooth can be exploited by hackers to eavesdrop on some devices, establish remote access controls, distribute malware, and drain batteries. To avoid these issues, keep Bluetooth turned off when you are not using it.

Setting Up a VPN on Smartphones

A VPN is a secure network using an encrypted Internet connection that acts as a secure "tunnel" for data. It can be created over the public Internet connection to enable users to hide their identity when they are using the Internet. You should use a VPN service when you connect to a Wi-Fi network that is not your own (e.g. at the library or coffee shop). It prevents others on that public network from eavesdropping on your web use when you are using non-secure websites or communications.

Many businesses require VPN access into their internal networks if employees are working remotely or are mobile. The employee will be provided with the VPN client, as well as user ID and password information. For those who do not have access to a business VPN, there are many smartphone VPN service applications that you can download for free or for a monthly fee. Examples of these VPN apps include: ExpressVPN, NordVPN, and TunnelBear.

If you have a business VPN or if you download a VPN service application, they will provide the information and support required to set up your VPN.

How to manually set up a VPN from the Android settings

Step 1 · Unlock your phone.

Step 2 · Open the **Settings** app.

Step 3 · Under the **Wireless & networks** section, select **More**.

Step 4 · Select VPN.

Step 5 · At the top-right corner you will find a plus sign (+), tap it.

Step 6 · Your network administrator will provide you with all your VPN information.Simply select your desired protocol and 'enter all the information.

Step 7 · Tap **Save**.

Step 8 · You can connect by going back to the VPN settings and selecting your VPN of choice. You will be asked to enter a username and password.

Step 9 ·You can also hit the 3-dot menu button to set your VPN to always be on.

How to manually set up a VPN on your iPhone or iPad

Step 1 · Launch **Settings** from your Home screen.

Step 2 · Tap **General**.

Step 3 · Tap **VPN**.

Step 4 · Tap **Add VPN Configuration**. If you have one already configured, select the **VPN client** you want to use and toggle the **Status** switch on.

Step 5 · Tap **Type**.

Step 6 · Select your **VPN type** from IKEv2, IPsec, or L2TP

Step 7 · Tap **Add Configuration** in the upper left corner to go back to the previous screen.

Step 8 · Enter the **VPN settings information** including description, server, and remote ID

Step 9 · Enter your **authentication login** including your username (or certificate), and password.

Step 10 · If you use a proxy, enable it by tapping **Manual** or **Auto**, depending on your preferences.

Step 11 · Tap **Done**.

Step 12 · Under VPN Configurations, toggle the **Status** switch on.

5.1.3.6 Lab - Discover Your Own Risky Online Behavior

In this lab, you will explore actions performed online that may compromise your safety or privacy.

Follow instructions on the lab document.

Summary: Everything Needs to be Secured

This chapter began by discussing the types of data. Personally identifiable information (PII) or sensitive personal information (SPI) is any data relating to a living individual that can be used on its own or with other information to identify, contact, or locate a specific individual. Legitimate companies have an agreements (Terms and Conditions or Terms of Service) that gives them permission to use the collected data about you for purposes of improving their business. Other legitimate users of our data would be companies that use sensors on their own devices or vehicles. Governments that have environmental sensors, and cities who have installed sensors on trains, busses or traffic lights also have a right to the data they generate.

Some hackers, called white hat hackers, are paid by legitimate companies and governments to test the security of a device or system. Their goal is not to steal or modify data but to help to protect it. Black hat hackers want access to collected data for many reasons, including selling it, damaging the reputation of a person or company, and causing political unrest.

Next, the chapter detailed security best practices. Security includes physically securing the outside and inside perimeters of places, such as data centers, where data is stored. Securing IoT devices is challenging due to the sheer number of them, the fact that they are found in non-traditional locations, and that many of them cannot be upgraded.

Black hat hackers frequently access available Wi-Fi. There are many steps you can take to protect your company's wireless network. To protect devices, keeps the firewall turned on, manage your operating system and browser, and use antivirus and antispyware.

Safety rules to follow if you are using a public or unsecure Wi-Fi hotspot:

Do not access or send any sensitive personal information over a public wireless network.

Verify whether your computer is configured with file and media sharing, and that it requires user authentication with encryption.

Use encrypted virtual private network (VPN) tunnels and services. The VPN service provides you secure access to the Internet, with an encrypted connection between your computer and the VPN service provider's VPN server. With an encrypted VPN tunnel, even if a data transmission is intercepted, it is not decipherable.

As we install more and more smart sensors into our homes, we do increase the potential for security issues. Often the sensors are connected to the same network as our home or small business devices so that a breach of one device can radiate outwards to affect all connected devices.

Chapter 6: Educational and Business Opportunities

Where Can I Go From Here?

Become an Informed Consumer

The last few years have given us improvements in the speed and availability of Internet services, as well as advances in cloud computing and sensor technology. These technical gains, together with recent developments in automation and artificial intelligence, have created a highly digitized world. Digitization currently impacts every aspect of our daily lives. Digitization continues to provide new opportunities for professionals who are trained to develop and support the technology that is used to deliver the IoT.

The IoT provides an immeasurable amount of information that is readily available for consumption. This information can be quickly analyzed and used to automate many processes that were previously considered impossible to turn over to machines. For example, just a few years ago self-driving cars existed only in our imaginations and now they are a reality. Think about what else has changed in your life because of the IoT.

The IoT is also freeing humans from the drudgery of routine and repetitive tasks such as restocking shelves and order fulfillment. We may now have more time for higher intellectual pursuits and the chance to explore all the IoT has to offer.

We are at a point in time in which opportunities are limited only by our imagination. We now have the ability to embrace all of the benefits that the IoT has to offer and to help shape the future. How will you use the IoT to help improve the future?

Challenges in the Digitized World

The IoT provides many benefits but at the same time it presents many challenges. Since the IoT is a transformational technology, we are now faced with an ever expanding collection of new technology that we must master. The IoT is changing every aspect of our lives.

This is not the first time we have experienced a technological development that has such an impact. Mechanization on the farm allowed increased productivity of available farmland and started the migration of the population from rural to urban areas.

The development of the automobile allowed for greater mobility of the workforce and increased recreational activities. The personal computer allowed the automation of many routine tasks with improved accuracy and efficiency. The Internet started to break down geographic barriers and improve equality between people on a global scale. These are only a few of the transformational technologies that we have experienced in recent history.

Every one of these technologies presented major changes to an established society and was met with initial fear and apprehension. After the initial fear of the unknown was overcome and the technology was embraced, the inherent benefits became obvious. Each perceived challenge opens up many new opportunities.

Can you imagine how your life would be without a car, personal computer, or access to the Internet?

The Evolving Job Market

The IoT is changing the job market. Traditional jobs are being replaced with jobs that are designed to embrace this new world and all it offers.

In IT, opportunities may be specific to fog computing, developing new processes, or a specialization in a discipline that has not yet been realized. These jobs reflect skills spanning multiple disciplines that include computer science, computer engineering (a blend of computer science and electrical engineering), and software engineering in the following areas:

- Artificial Intelligence
- Application Development
- IoT Program Developer
- IoT Security Specialist
- Collaboration
- Enterprise Networks
- Data Center and Virtualization

Not all jobs created by the IoT are IT-related. The IoT should be considered an enabling technology which has applications across all industries and aspects of our daily lives. For example, a city planner uses the data collected by IoT-enabled devices to plan out new city services. Sales people use IoT technology to enhance the sales experience with the customer, and stores use IoT technology to maintain proper inventory levels to match customer demand.

The IoT has created an abundance of jobs within its sphere. These jobs exist across various spectrums of the design, development and enabling of the IoT. There are broad categories that summarize the job opportunities that exist in the evolving digitized world:

- **Enablers** – These jobs develop and implement the underlying technology.
- **Engagers** –These jobs design, create, integrate, and deliver IoT services to customers.
- **Enhancers** – These jobs devise their own value-added services, on top of the services provided by Engagers, which are unique to the Internet of Things.

Entrepreneurs needed!

The IoT is also creating a demand for a new kind of IT specialist. These are individuals with the knowledge and skillsets to develop new IoT-enabled products and process the data they collect.

An entrepreneurial workforce is needed that specializes in both information science and software or computer engineering.

Additionally, operational technologies and information technologies are converging in the IoT. With this convergence, people must collaborate and learn from each other to understand the things, the networks, and methodologies that harness the limitless potential of the IoT.

Lifelong Learning

With the ever changing landscape of the digitized world, we must stay current in order to realize the full potential of what the IoT has to offer.

The job market will continue to offer more opportunities as new technologies evolve. The skill sets required for these jobs will evolve at the same time, thus creating the need for lifelong learning.
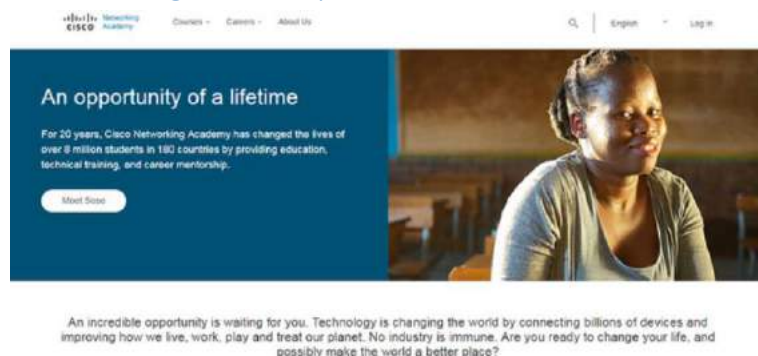
Cisco Networking Academy

The rapid growth of networks has created a global shortage of people who are qualified to implement and maintain networking solutions, especially in places where networks are being built to promote economic development. At the same time, people need access to better training and career opportunities to successfully compete in the global economy.

With over 10,400 academies in 180 countries, the Cisco Networking Academy helps individuals prepare for industry-recognized certifications and entry-level information and communication technology (ICT) careers in virtually every type of industry. The Cisco Networking Academy helps address the growing demand for ICT professionals, while improving career prospects in communities around the world.

The Cisco Networking Academy Program has trained more than five million students to date. Many graduates have gone on to successful IT careers in a variety of industries, while others have harnessed the entrepreneurial spirit and knowledge they acquired to start their own businesses and create new jobs.

Networking Academy Curriculum

The Networking Academy delivers a comprehensive, 21st century learning experience. Students develop the foundational IT skills needed to design, build, and manage networks, along with career skills such as problem solving, collaboration, and critical thinking. Students complete hands-on learning activities and network simulations to develop practical skills that will help them find their place among networking professionals around the world. These are some of the offerings of the Networking Academy:

- **IoT Fundamentals** – This series of courses teaches you about the IoT and how it can be used to enhance society. This series continues to evolve. It currently includes courses and activities to develop your skills for securely collecting data and connecting sensors to the cloud, analyzing big data, and creating your own IoT solution.
- **IT Essentials** - IT Essentials covers the fundamentals of computer hardware and software. It also introduces more advanced concepts, such as security, networking, and the responsibilities of an IT professional.
- **Entrepreneurship** - The Entrepreneurship course teaches critical business skills, financial skills, attitudes, and behaviors to help students develop an entrepreneurial mindset which can empower them to improve their overall quality of life.
- **Introduction to Cybersecurity** - The Introduction to Cybersecurity course covers trends in cybersecurity and demonstrates the need for cybersecurity skills in various industries.
- **CCNA Routing and Switching** – Cisco Certified Networking Associate (CCNA) Routing and Switching provides a comprehensive overview of networking concepts and skills. It covers skills and knowledge required for administrators of devices in small to medium-sized networks. This curriculum has an emphasis on practical application, work-force readiness, and soft-skills development.
- **CCNA Security** - CCNA Security introduces the core security concepts and skills needed to install, troubleshoot, and monitor a network to maintain the integrity, confidentiality, and availability of data and devices.
- **CCNP –** The Cisco Certified Networking Professional (CCNP) curri culum is the next step for people who have completed the CCNA Routing and Switching courses.

For more information on our latest offerings, go to the Networking Academy website at www.netacad.com.

Communities of Interest

A community of interest is a group of people who share a common interest or passion about a specific topic. These people get together to share information and ideas about this topic.

This shared interest allows the group to develop into a true community. Members of these communities are extremely knowledgeable and passionate about the topic being discussed and are willing to share their knowledge with other community members. This makes the community an excellent resource for the development of the area of interest.

The Internet allows these communities to exist virtually and span several geographic areas and time zones. Members can share files and technology in real time.

Several IoT communities exist. The IEEE runs an IoT community that can be found here: https://www.ieee.org/membership-catalog/productdetail/showProductDetailPage.html?product=CMYIOT736. LinkedIn also has an IoT community here: https://www.linkedin.com/company/iot-community/.

Some communities are supported by industry and provide a place to help development of their products and technology, as well as those of their business partners. Two such communities provided by Cisco are the Cisco Learning Network and Cisco DevNet.

The Cisco Learning Network is a collection of resources, information, and discussion forums. It is designed for people who wish to develop their skills in various Cisco technologies and pursue Cisco certification. To see what the Cisco Learning Network has to offer and to become a member, visit their website at learningnetwork.cisco.com.

DevNet is a Developer Program from Cisco that consists of a website, an interactive developer community, coordinated developer tools, integrated discussion forums, and sandboxes. To learn more about what DevNet offers visit their website at developer.cisco.com. Search the Internet to see some of the ways people are using the resources provided by DevNet in the development of IoT technology.

Industry Certifications

Industry certifications are highly respected by employers around the world and help validate the skills needed to launch successful careers in networking and IT. Certifications are achieved by passing an exam proctored by a certifying authority. Students must complete training materials specific to the certification exam. Field experience is often very helpful, but not always required, to pass a certification exam. Cisco Networking Academy provides courses that prepare students for the industry certifications below:

- **CompTIA A+**: The CompTIA A+ certification for computer support technicians demonstrates competence in areas such as installation preventive maintenance, networking, security, and troubleshooting. IT Technician, IT Administrator, and Field Service Technician are examples of jobs that students can pursue using the CompTIA A+ certification.
- **CCENT**: The Cisco CCENT certification for entry-level network technicians validates the ability to install, operate, and troubleshoot a small branch network and perform basic network security tasks. Support Desk Technician and Network Support Technician are examples of jobs that students can pursue using the Cisco CCENT certification.
- **CCNA Routing and Switching**: The Cisco CCNA Routing and Switching certification validates the ability to install, configure, operate, and troubleshoot medium-sized routed and switched networks, and implement and verify connections to remote sites in a wide-area network (WAN). Examples of jobs that

the CCNA Routing and Switching certification can help students to find are Network Administrator, Network Installer, and Network Engineer.

- **CCNA Security**: The Cisco CCNA Security certification for the network security professionals validates the knowledge needed to install, troubleshoot and monitor Cisco network security devices; develop a security infrastructure; recognize network vulnerabilities; and mitigate security threats. Students who gain CCNA Security certification would be well qualified for a position as a Network Security Specialist.

There are two basic types of certification available: vendor-specific and vendor-neutral. Vendor-specific certifications are tailored to technologies offered by a company to prove that an individual is qualified to deploy and manage that technology. Vendor-neutral certifications are offered by many different organizations. They show that an individual has a well-rounded skillset centered on common systems and programs, rather than specific brands of technology.

Most often, certifications must be renewed over time. Requirements for re-certification may be earning continuing education units (CEUs), passing a re-certification exam, or both. CEUs can be earned by attending classes, professional membership, on-the-job experience, or research and publishing of materials that support the certification technology.

The Cisco Certification Tracks are shown in the figure. To explore all of the different Cisco career certifications, visit the following website: https://learningnetwork.cisco.com.

Certification Tracks	Entry	Associate	Professional	Expert	Architect
Collaboration				CCIE Collaboration	
Data Center		CCNA Data Center	CCNP Data Center	CCIE Data Center	
Design	CCENT	CCDA	CCDP	CCDE	CCAr
Routing & Switching	CCENT	CCNA Routing and Switching	CCNP	CCIE Routing & Switching	
Security	CCENT	CCNA Security	CCNP Security	CCIE Security	
Service Provider		CCNA Service Provider	CCNP Service Provider	CCIE Service Provider	
Service Provider Operations	CCENT	CCNA Service Provider Operations	CCNP Service Provider Operations	CCIE Service Provider Operations	
Video		CCNA Video			
Voice	CCENT	CCNA Voice	CCNP Voice		
Wireless	CCENT	CCNA Wireless	CCNP Wireless	CCIE Wireless	

Additional Learning Resources

Certifications can show an employer that an individual has the appropriate skills for a job. Community college or university degrees can show that a person has gained a broad understanding in a field of study. This broad understanding creates a solid foundation for emerging career opportunities in the IoT. A combination of industry certifications and university degrees provides a student with the best background, experience, and education to pursue a career with greater opportunities and higher salary.

When looking for a degree to pursue at a community college or university that will pertain to the skillsets needed for a career in the IoT, watch for some of the following degrees:

- Business Intelligence
- Computer Information Systems
- Computer Programming
- Computer Science
- Database Administration
- Electromechanical Automation
- Electronics Engineering
- Linux Networking
- Machining
- Network Administration
- System Analysis
- Web Server Administrator

This is not an exhaustive list. Even traditional degree programs such as supply chain management, business, and project management are helpful for careers in IoT. Computer-Aided Design (CAD), drafting, math, and physics are applicable and show a diverse education, which is perfect for an IoT career.

6.1.2.6 Lab – IoT Related Job and Learning Opportunities

As an individual or group, you will search for and document IoT educational and job opportunities that are available to you. You will then share these results with your colleagues.

Follow the Instructions on the lab document.

Summary: Educational and Business Opportunities

This chapter began by discussing the challenges and opportunities in the digital world. Digitization continues to provide new opportunities for professionals who are trained to develop and support the technology that is used to deliver the IoT.

In IT, opportunities may be specific to fog computing, developing new processes, or a specialization in a discipline that has not yet been realized. These jobs reflect skills spanning multiple disciplines that include computer science, computer engineering (a blend of computer science and electrical engineering), and software engineering. There are broad categories that summarize the job opportunities that exist in the evolving digitized world:

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An entrepreneurial workforce is needed that specializes in both information science and software or computer engineering. The Cisco Networking Academy Program has trained more than five million students to date. Many graduates have gone on to successful IT careers in a variety of industries, while others have harnessed the entrepreneurial spirit and knowledge they acquired to start their own businesses and create new jobs. Go to www.netacad.com to see the variety of courses offered.

There are two basic types of certification available: vendor-specific and vendor-neutral. Vendor-specific certifications are tailored to technologies offered by a company to prove that an individual is qualified to deploy and manage that technology. Vendor-neutral certifications are offered by many different organizations. Certifications can show an employer that an individual has the appropriate skills for a job. Community college or university degrees can show that a person has gained a broad understanding in a field of study. This broad understanding creates a solid foundation for emerging career opportunities in the IoT.