Internet of Everything

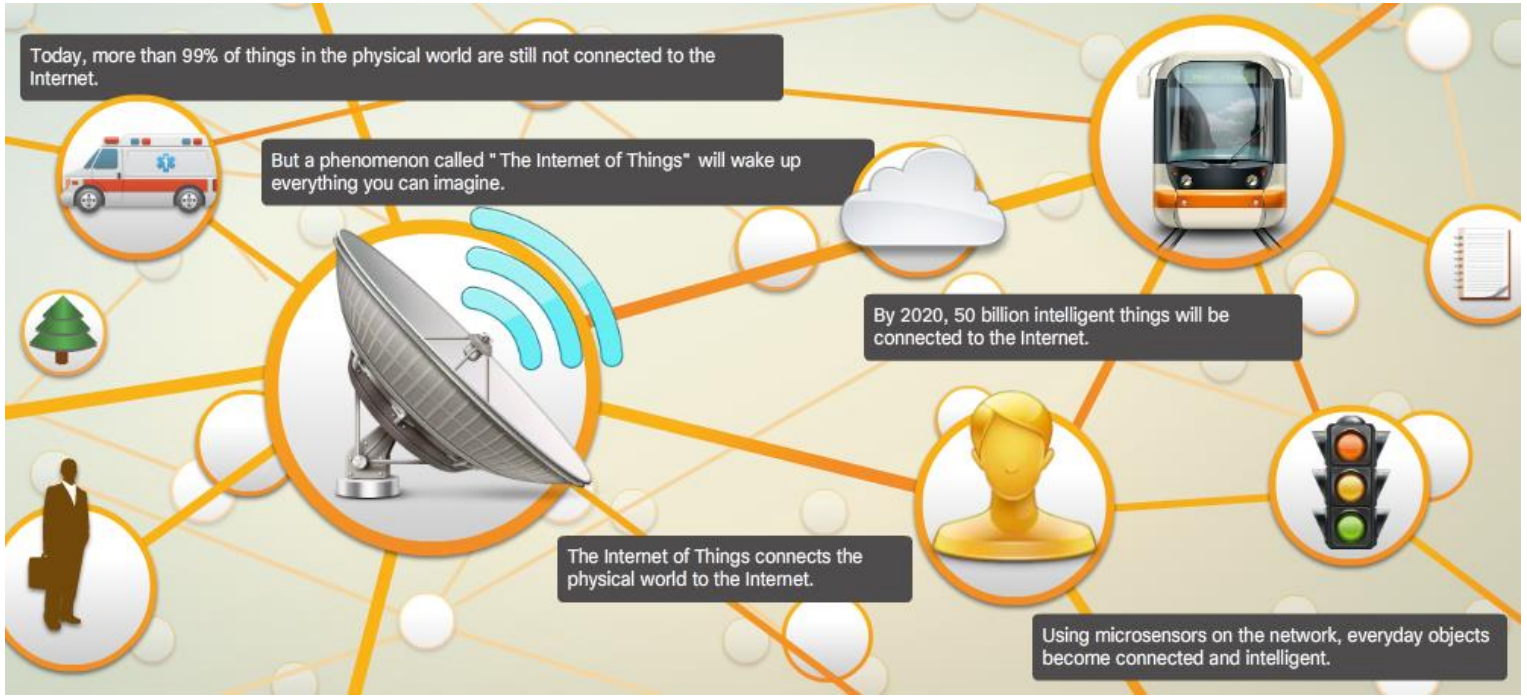
- Erwin.Desmet@heh.Be

Chapter 1: What is the Internet of EveryThings?

Introduction to the Internet of Things

1.1 Internet of Things : The Internet

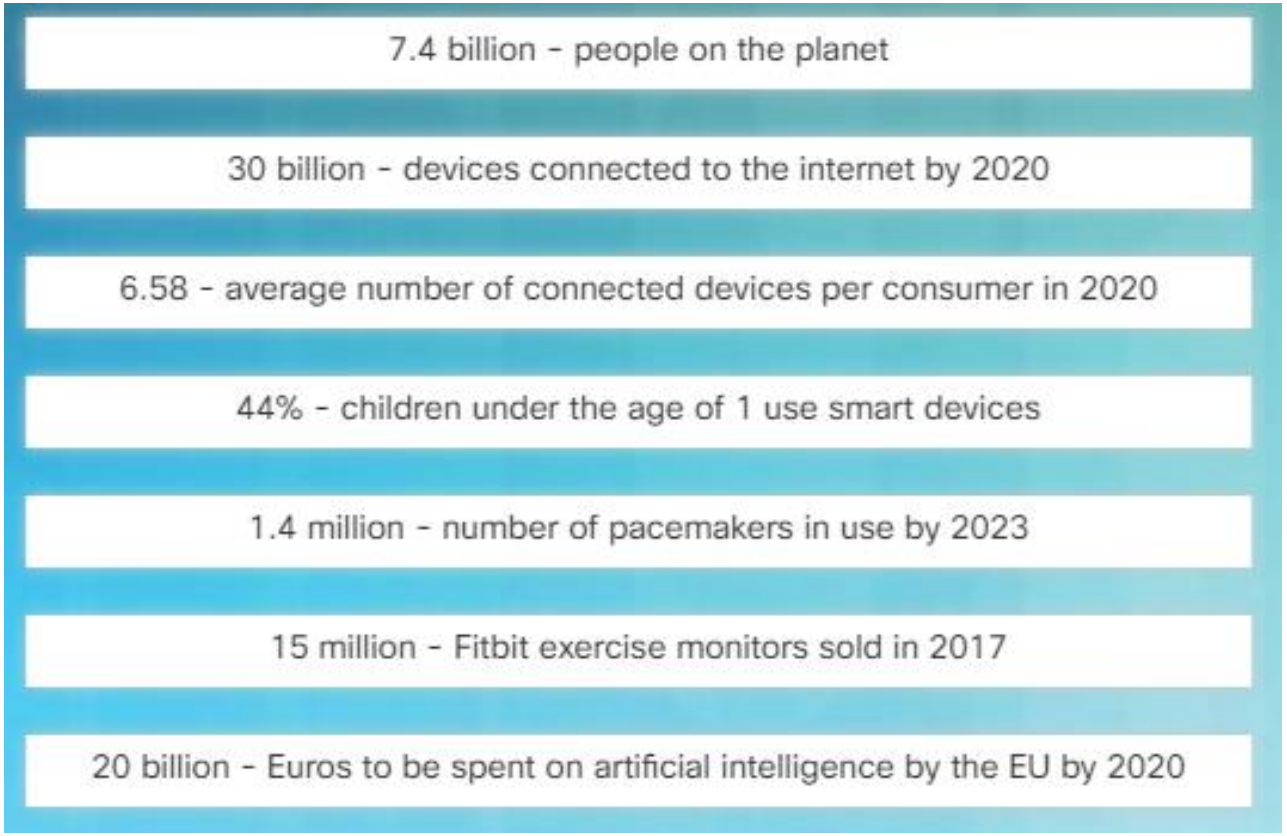
- The Internet (4 periods)
  - A network of networks
  - Using a physical cable or wireless media for connection
- Transitioning to the IoT



Chapter 1: Everything is Connected

- 1.1 Digital Transformation
  - Explain how digital transformation affects business, industry, and our daily lives.
    - Explain how digital transformation enables innovation.
    - Explain how networks provide the platform for Digital Business and society.
- 1.2 Devices that Connect to the IoT
  - Configure an IoT device to connect to the network.
    - Describe the exponential growth of connected IoT devices
    - Configure devices to communicate in the IoT.

Chapter 1: Everything is Connected

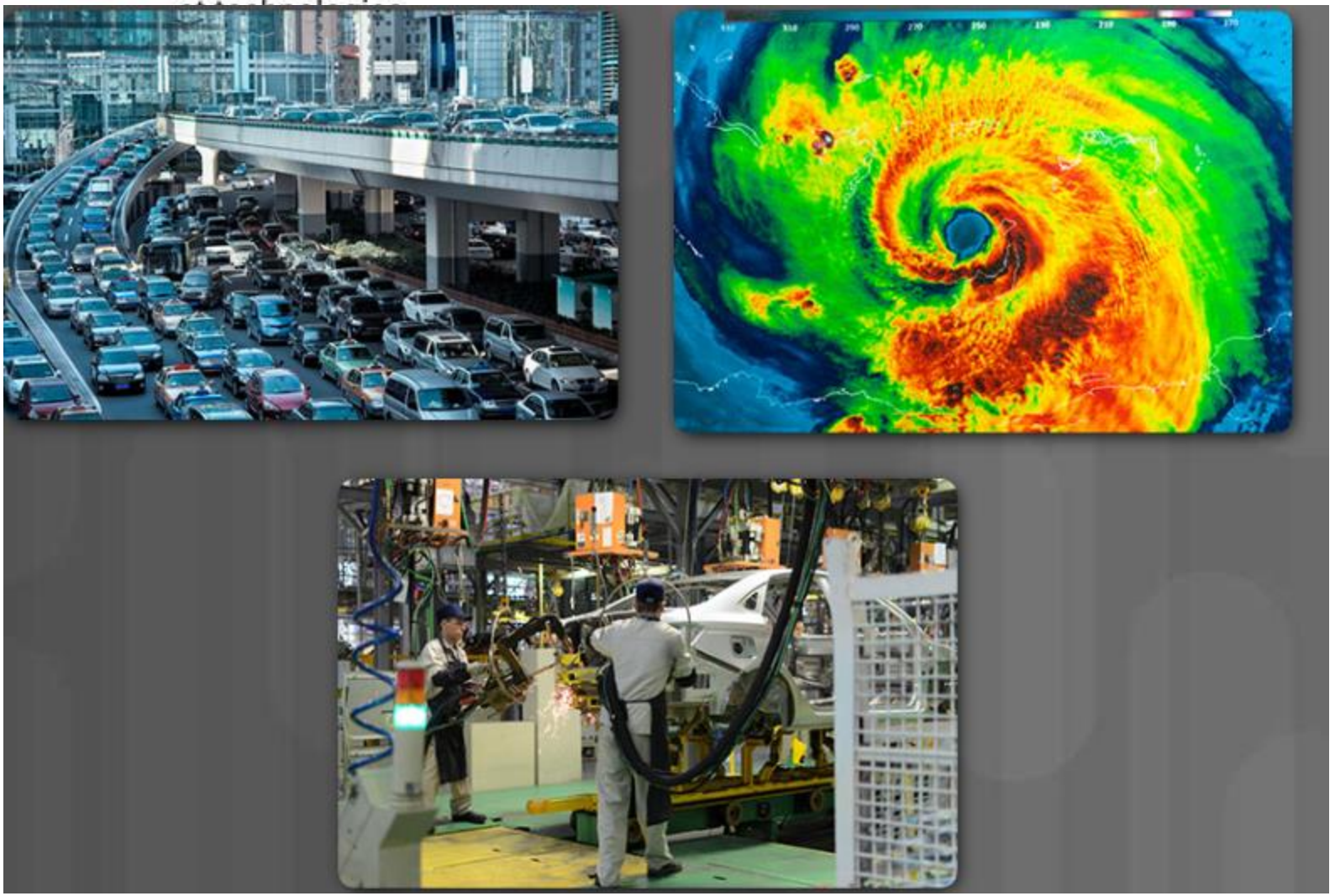


Estimation 2019

The Evolution of Digital Transformation

- Today there are more smart devices than there are people:
  - Many people are connected to the Internet 24 hours a day.
  - By 2020 each consumer will have 6.58 smart devices.
- Modern digital networks make all of this possible
- Digital transformation is the application of digital technology to provide the stage for business and industry to innovate.

The Impact of Digital Transformation on Business



Can Smart Devices Think?

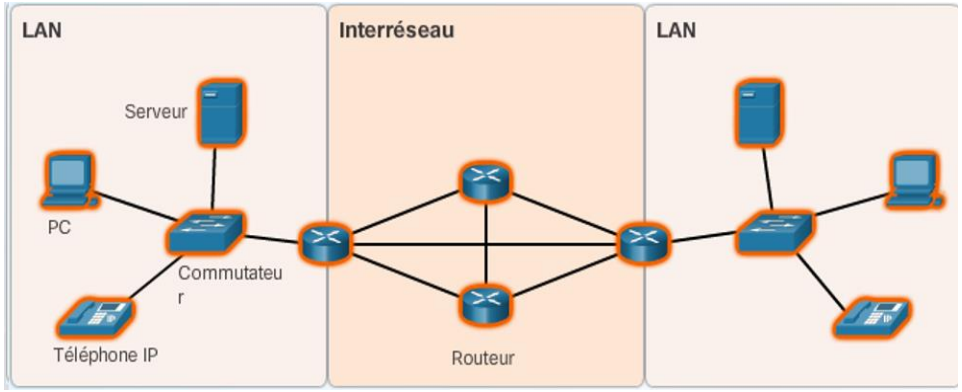
- If programmed appropriately, smart devices are able to evaluate data that is provided to them and modify processes or settings “on the fly”.
- If provided with sufficient data, they can “learn” and modify their own code based on the new parameters.
- Smart Cities use sensors to control many of their infrastructure systems such as traffic flow, parking, water utilization, and hydro.
- Self-driving cars are equipped with many ultrasound sensors, cameras, precision GPSs, and computers.





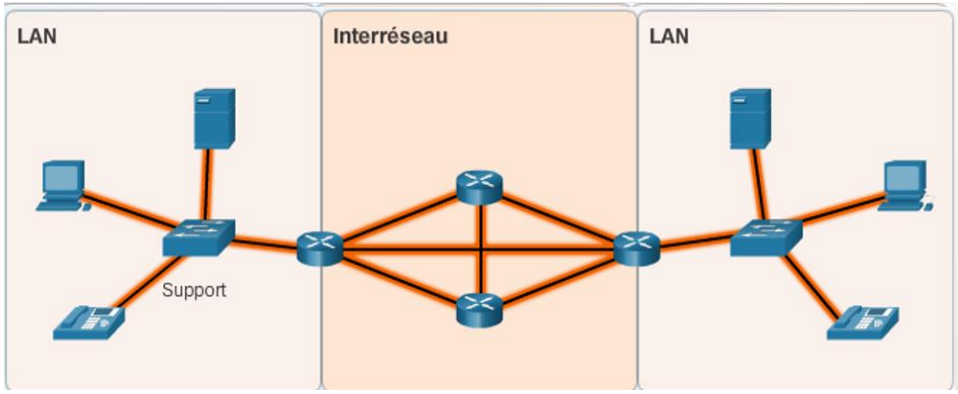
Networking is the Foundation

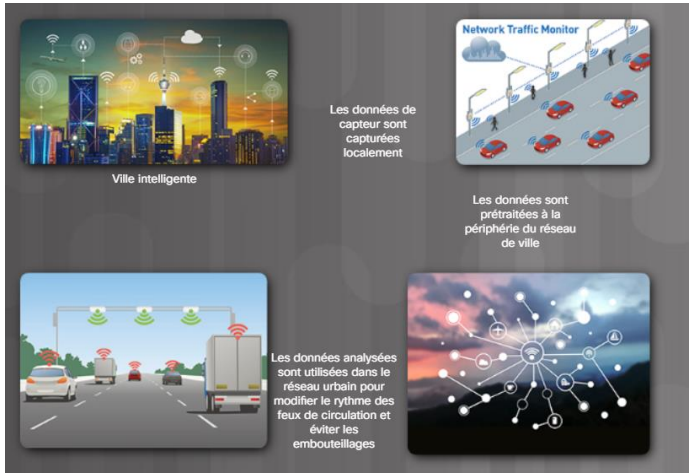
- Fifty billion things provide trillions of gigabytes of data
- Networks provide the foundation for the Internet and the digitized world.
- Networks can range from simple networks consisting of two computers to networks connecting millions of devices.
- Networks can provide products and services to customers through their connection to the Internet.
- The Internet is the largest network in existence and effectively provides the “electronic skin” that surrounds the planet.

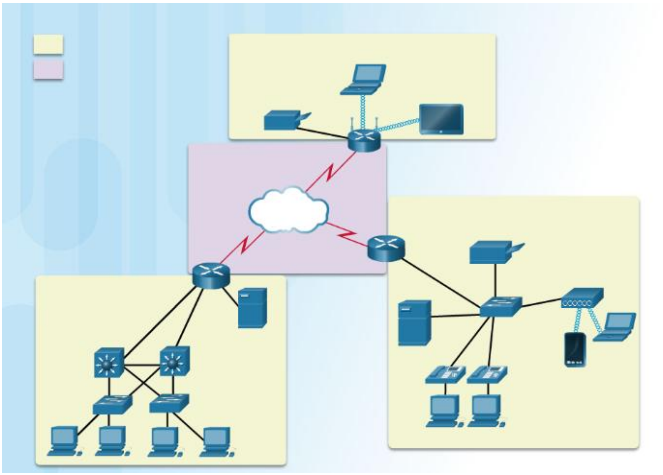


Devices

Media







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.)

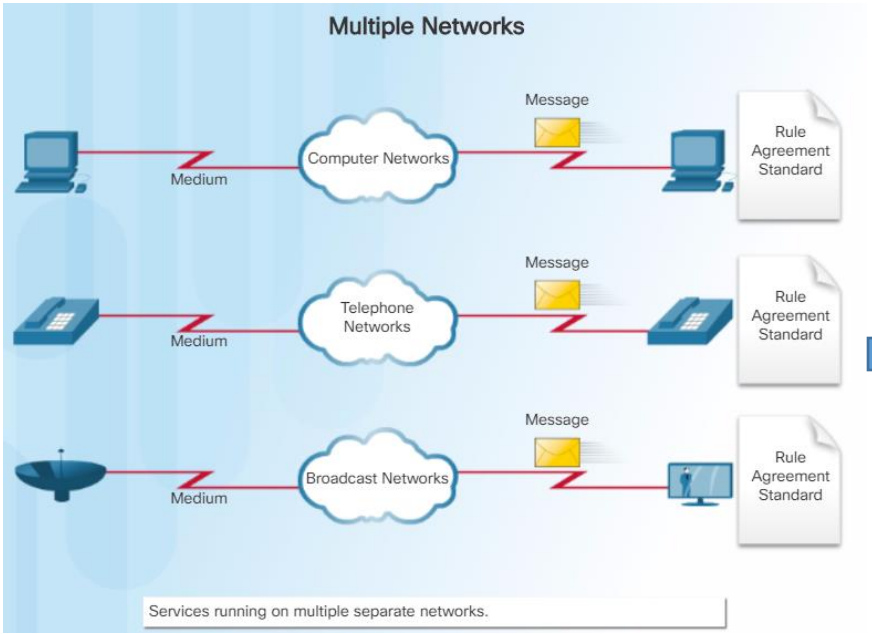
Network Types

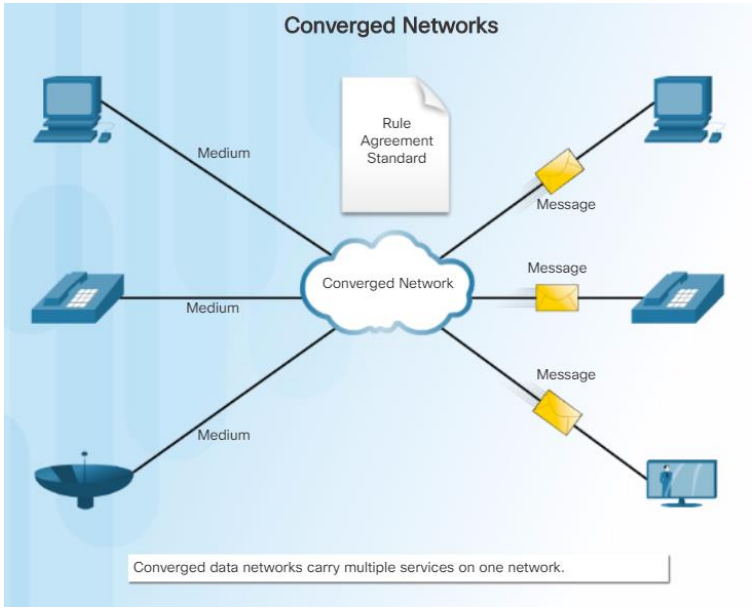
- **Personal Area Network (PAN)** - Connecting your smartphone to your car using Bluetooth is an example of a PAN.

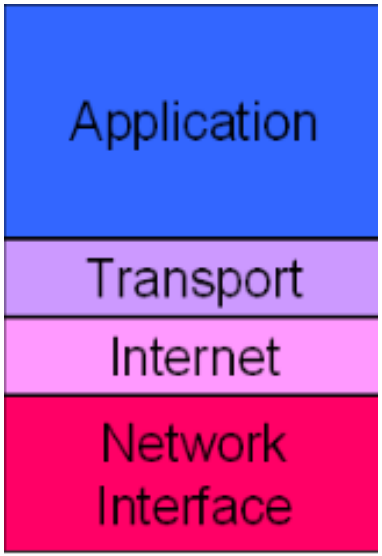
- **Local Area Network (LAN)** - Networks in a small geographic area, such as a home or small business.
- **Wide Area Networks (WANs)** - A collection of LANs that provides inter-LAN and Internet connectivity.
- **Internet** - A multi-layer global network system that connects hundreds of millions of computers.
- **Wireless Networks** - Use electromagnetic waves to carry signals over the network.
- **The Cloud -** Data centers or groups of connected servers used to store and analyze data, provide access to on-line applications, and provide backup services.
- **The Edge** - The physical "edge" of a corporate network.
- **Fog Computing -** The data from IoT devices can be pre-processed for immediate use in the fog located at the edge of the network.

What is the IoT?

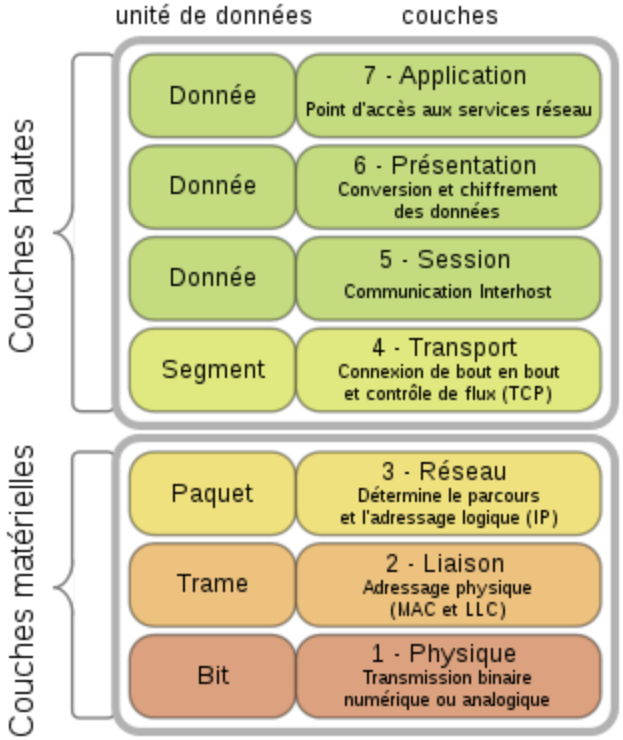
- The Internet of Things (IoT) is the connection of millions of smart devices and sensors connected to the Internet.
- Previously inanimate objects such as doorknobs or light bulbs can now be equipped with an intelligent sensor that can collect and transfer data to a network.
- An estimated 3 million new devices are connected to the Internet each month.
- In the next two years, there are going to be over 30 billion connected devices worldwide.
- Two-thirds will be “things”: sensors, actuators, and newly invented intelligent devices that monitor, control, analyze, and optimize our world.

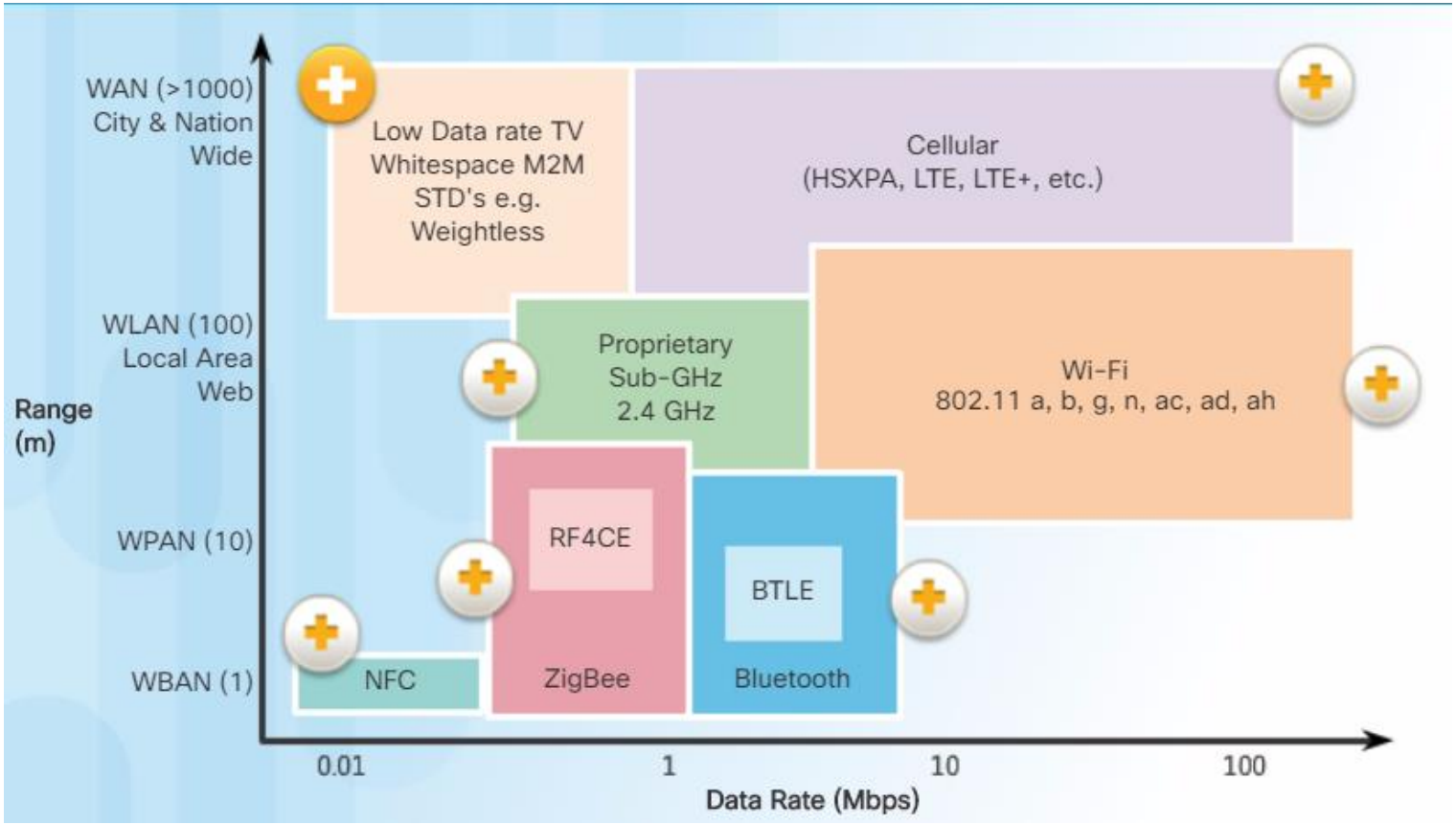

Multiple Networks
Message
Computer Networks
Medium
Rule
Agreement
Standard
Message
Telephone
Networks
Medium
Rule
Agreement
Standard
Message
Broadcast Networks
Medium
Rule
Agreement
Standard
Services running on multiple separate networks.


Converged Networks
Medium
Rule
Agreement
Standard
Message
Converged Network
Message
Medium
Message
Medium
Converged data networks carry multiple services on one network.


Application
Transport
Internet
Network
Interface

TCP/IP


unité de données
couches
Couches hautes
Couches matérielles
Donnée
7 - Application
Point d'accès aux services réseau
Donnée
6 - Présentation
Conversion et chiffrement des données
Donnée
5 - Session
Communication Interhost
Segment
4 - Transport
Connexion de bout en bout et contrôle de flux (TCP)
Paquet
3 - Réseau
Détermine le parcours et l'adressage logique (IP)
Trame
2 - Liaison
Adressage physique (MAC et LLC)
Bit
1 - Physique
Transmission binaire numérique ou analogique


WAN (>1000)
City & Nation
Wide
WLAN (100)
Local Area
Web
WPAN (10)
WBAN (1)
Range
(m)
Low Data rate TV
Whitespace M2M
STD's e.g.
Weightless
Cellular
(HSXPA, LTE, LTE+, etc.)
Proprietary
Sub-GHz
2.4 GHz
Wi-Fi
802.11 a, b, g, n, ac, ad, ah
RF4CE
BTLE
NFC
ZigBee
Bluetooth
0.01
1
10
100
Data Rate (Mbps)

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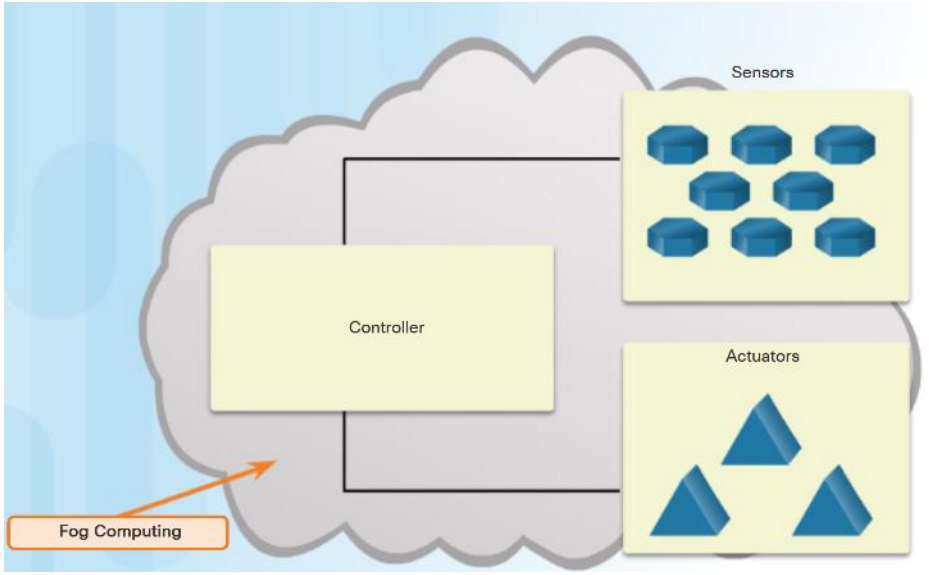
The Growth of IoT Devices

What are the Benefits of Connecting these IoT Devices?

Many different organizations are benefitting from the data collected, saved, and analyzed from sensors

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.
- 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.
- Sensors often work together with a device called an actuator.
- Actuators take electrical input and transform the input into physical action.



The Future of Networks

- Artificial Intelligence (AI) – Devices have the ability to “think” on their own.
- Intent-Based Networking (IBN) – Providing software with rules, guidelines, or intent so that data could modify the network, infrastructure features, or security features within a network.
- Example - A business defines that a contract employee is given access to only a specific set of data and applications. This is the intent. In an IBN system all the network devices will be automatically configured to fulfil this requirement across the network, no matter where the employee is connected.


Coolcam
0:00
CC

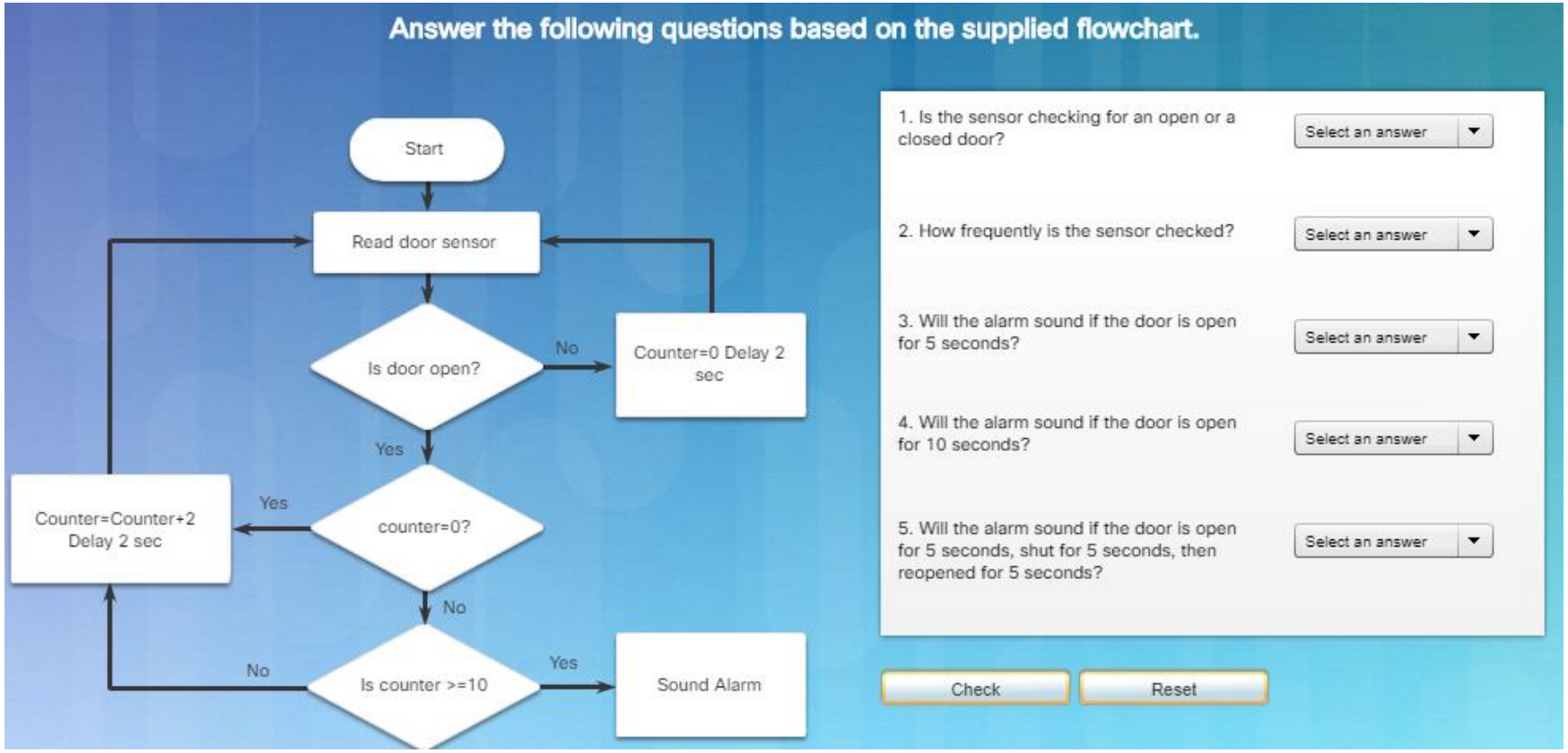

Coolcam
0:00
CC

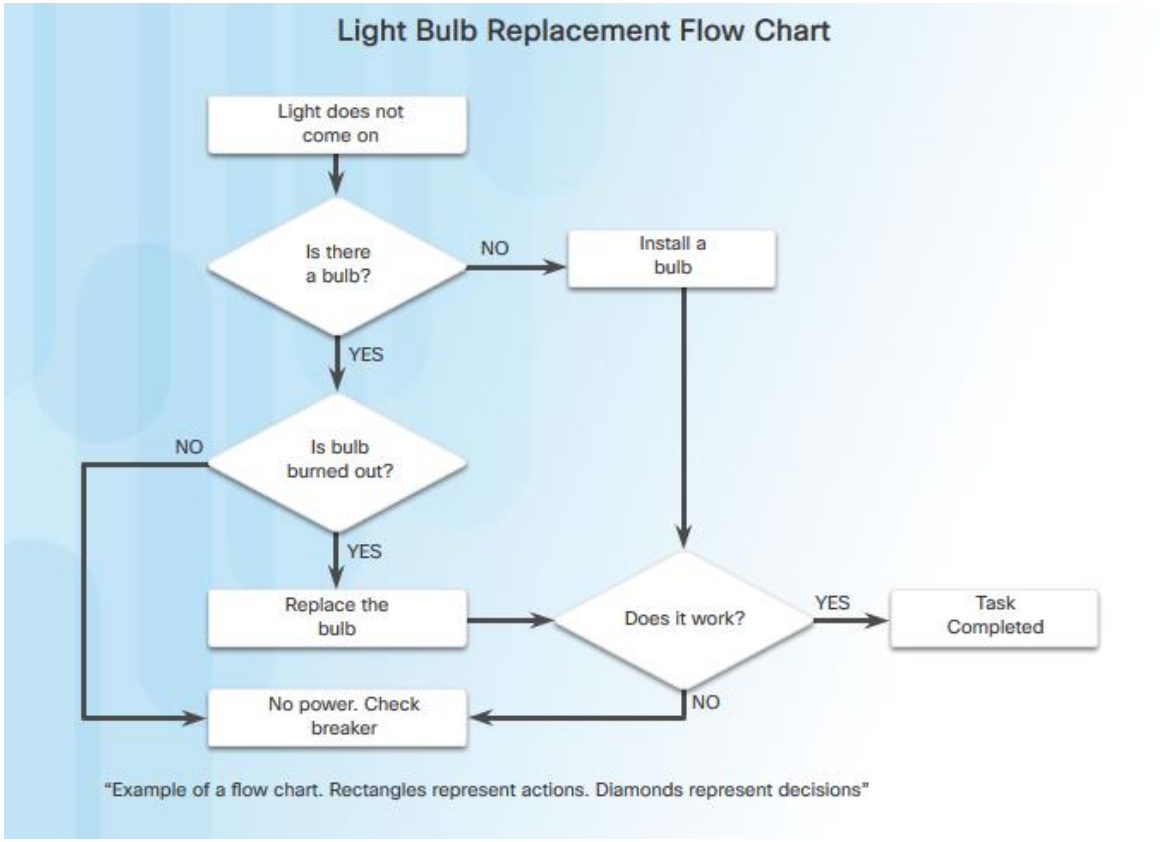
Summary

- As digital networks continue to grow around the world, we are seeing a Digital Transformation - the application of digital technology to provide the stage for business and industry to innovate.
- Sensors are now everywhere in the home, on traffic lights, in farm fields, and on our bodies. The analyzed data from sensors is used by governments, cities, businesses, and individuals to effect changes.
- Networks form the foundation of the digitized world. Types of Networks:
  - PAN: Bluetooth
  - LAN
  - WAN: Internet, the cloud, fog computing
  - Wireless: WiFi, Cellular
- The Internet of Things is the connection of millions of smart devices and sensors connected to the Internet.
- 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 work together with a device called an actuator. Actuators take electrical input and transform the input into physical action.
- The future of networking will revolve around artificial intelligence (AI) and intent-based networking (IBN).

Chapter 2: Everything Becomes Programmable

Follow the Flowchart



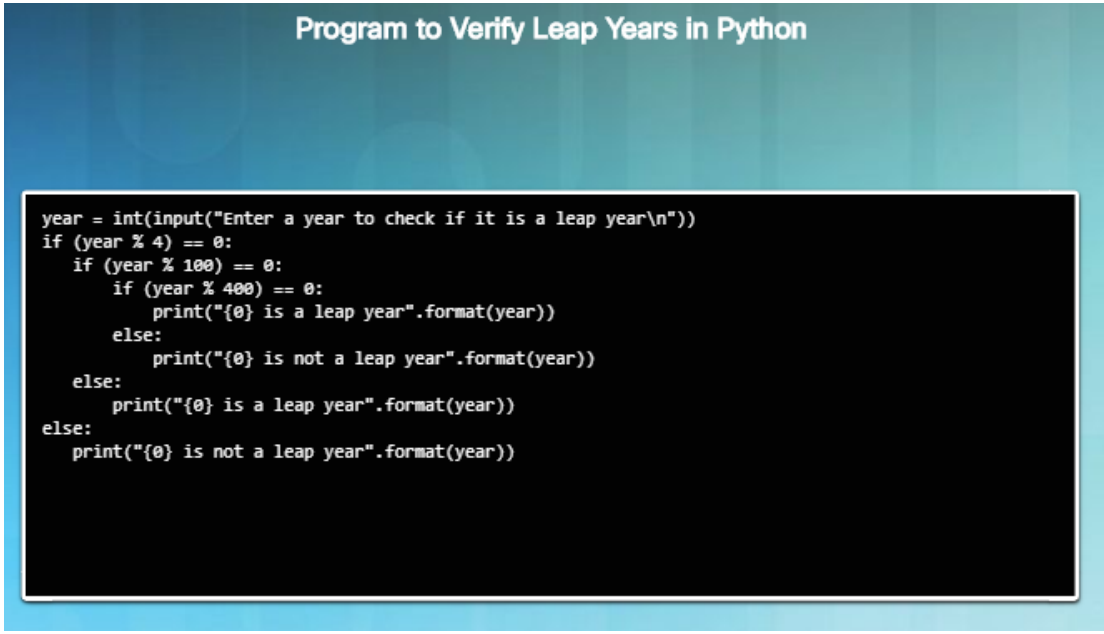


Flowcharts:

- Diagrams that are used to represent processes or workflows.
- Illustrate how a process should work.
- Show input states, any decisions made, and the results of those decisions.

System Software, Application Software, and Computer Languages

- 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.
  - System software works between the computer hardware and the application program.
  - Both system software and application software are created using a programming language.
  - Python is an example of an interpreted programming language.



Programming Variables

- Programming languages use variables to hold phrases, numbers, or other important information that can be used in coding.
  - Variables can hold the result of a calculation, the result of a database query, or some other value.
  - x + y = z
    - “x, y and z” are variables which can represent characters, character strings, numeric values or memory addresses
  - a = 10
    - associates the value 10 to variable “a”
- 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

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

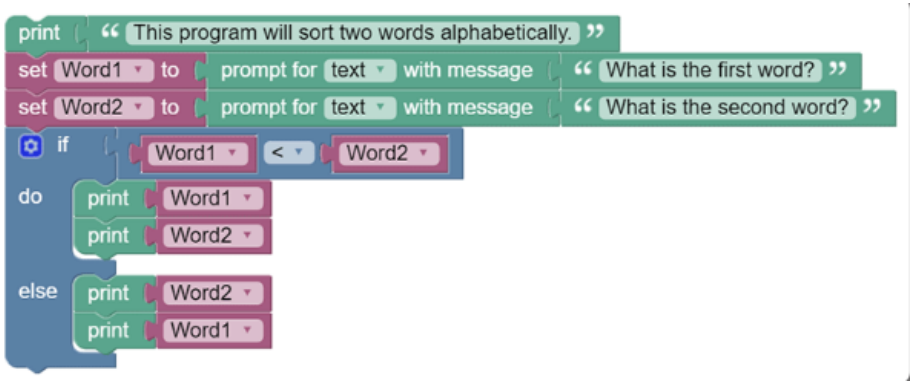
The code above prints " counter = N" (where N is the value of the counter variable "i".)
The message is printed 100 times on the screen.

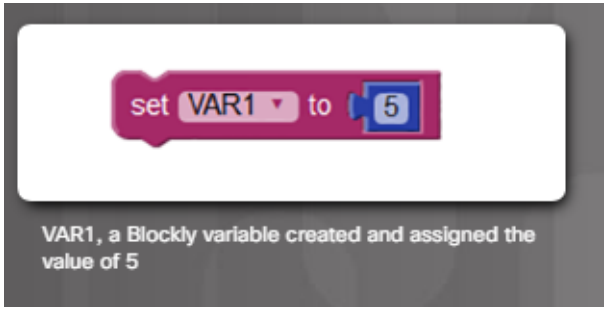
```
WHILE (value < 10) {
   print_on_the_screen "Value is still less than 10"
   value = value + 1
}
```

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.

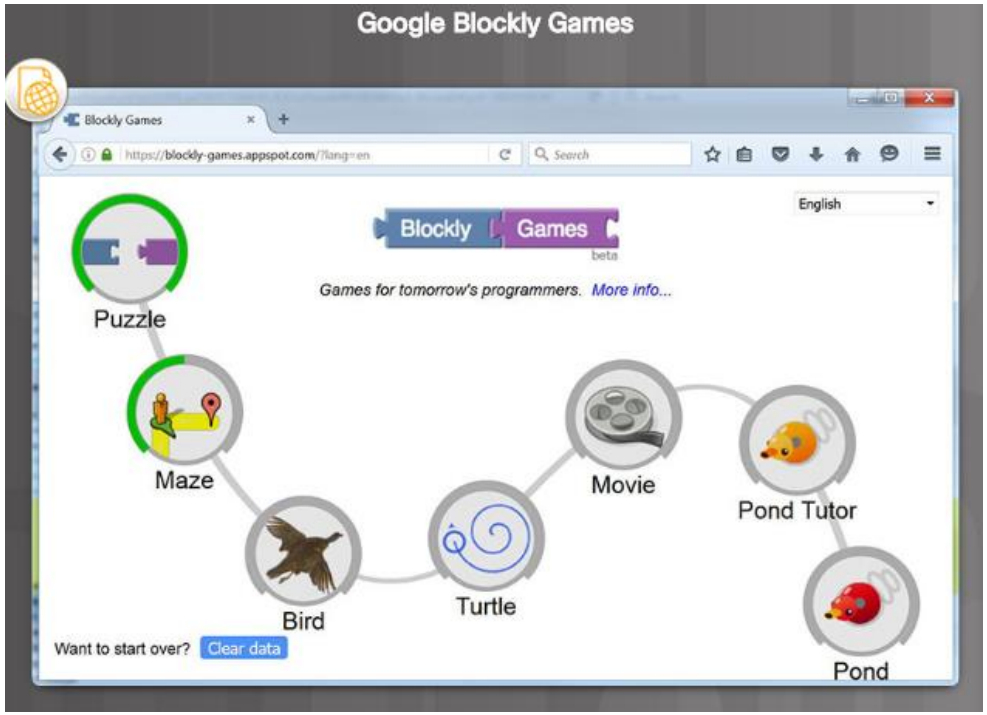
- Most common logic structures are:
  - **IF – THEN** allows the computer to make a decision based on the result of an expression.
    - myVar > 0
      - True if the value stored in the myVar variable is greater than zero.
      - If false, the computer moves on to the next structure,
      - If true, the computer executes the associated action before moving on to the next instruction in the program.
  - **FOR Loops** execute a specific set of instructions a specific number of times, based on an expression.
    - 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.
  - **WHILE Loops** execute a specific set of instructions while an expression is true.

What is Blockly



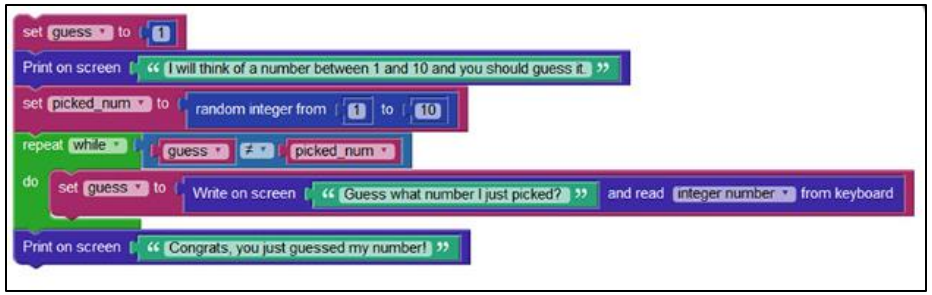


- Visual programming tool created to help beginners understand the concepts of programming. Allows a user to create a program without entering any lines of code.
- Assigns different programming structures to colored blocks which contain slots and spaces to allow programmers to enter values. Programmers can connect structures together by dragging and attaching the appropriate blocks.
- Specific blocks represent functions. Select and drag function blocks to the work space and fill in the required slots.



https://blockly-games.appspot.com/

What is Python?



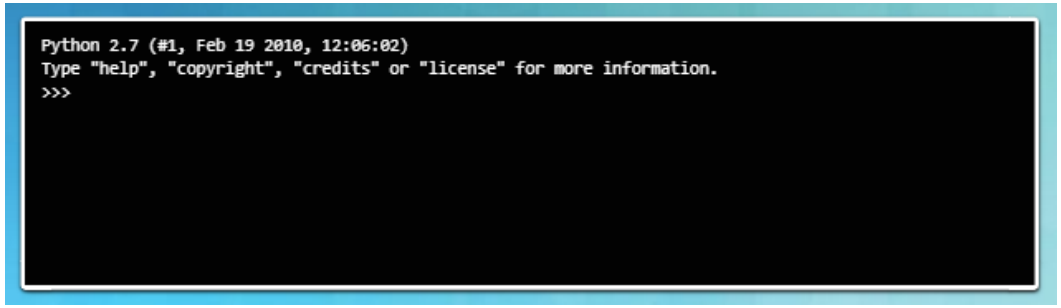

```
import random

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!')
```

- Python is a very popular language that is designed to be easy to read and write.
- Philosophy of the language:
  - Beautiful is better than ugly
  - Explicit is better than implicit
  - Simple is better than complex
  - Complex is better than complicated
  - Readability counts

The Python Interpreter



Interpreter Welcome Message

- 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.
- In Linux machines, the Python interpreter is usually installed in **/usr/bin/python** or **/usr/bin/python3**.
- With the new Windows Python installer, Python is installed by default into the user's home directory. 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.

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
```

- Acts as a simple calculator.

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

- Special variable "_" holds the result of the last expression issued.

```
>>>
>>> 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 will result in an error.

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

- To assign values to variables, use the = sign.

Programming with Python

Variables and Basic Statements in Python (Cont.)

- The interpreter receives and executes statements interactively.

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

- Print statement prints the result of the expression it was given.

```
>>>
>>> '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.
```

- 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.
- Single quotes or double quotes can be used to wrap strings.

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

- Functions allow for a block of code to be given a name and re-used as needed.

Useful Functions and Data Types in Python

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

```
# 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() -** Generates a list of numbers usually used to iterate with FOR loops.
  - **range**(**stop**) - number of integers (whole numbers) to generate, starting from zero
  - **range([start], stop[, step**] – Starting number of the sequence, the ending number in the sequence, and the difference between each number in the sequence.

Useful Functions and Data Types in Python (Cont.)

```
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)
```

Tuples - sequences, separated by parentheses.

Lists - sequence of changeable Python objects, created by putting different comma-separated values between square brackets.

```
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
```

Useful Functions and Data Types in Python (Cont.)

```
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'])
```

- 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.

Useful Functions and Data Types in Python (Cont.)

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
```

- 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.
- Dictionary elements can be accessed, updated, and deleted.

Programming Structures in Python

```
>>>
>>> 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
```

- IF-THEN, ELSE, ELIF
  - Make decisions based upon the result of an expression
  - ELSE specify instructions to be executed if the expression is false.
  - ELIF is used to perform a second test.

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

- FOR Loop
  - Iterates the items of any sequence (a list or a string), in the order that they appear in the sequence

```
>>>
>>> # 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
```

- WHILE Loop
  - Executes a block of code if the expression is true

What is Prototyping?

Defining Prototyping

- Prototyping is the process of creating a working model of a product or system.
- In IoT, it helps to have design skills, electrical skills, physical/mechanical skills, programming skills, and to understand how TCP/IP works.
- 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.

- 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? A team at Google used the “Rapid Prototyping Method” to create the Google Glass.
- Kickstarter, Indiegogo, and Crowdfunder are just three of the many online crowd funding programs.
- What IoT invention will you create?

Prototyping Resources

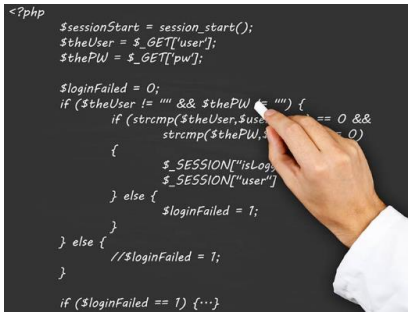
Physical Materials

- A good place to start is, of course, the Internet. People who have never physically met can now collaborate and work together.
- Maker Media is a global platform for connecting makers with each other to exchange projects and ideas.
- Making Society has a good section on modeling plastic and clay.
- LEGO Mindstorms has a large community of contributors and fans.
- 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.
- 3D printing is the process of making a solid object based on a 3D model computer file.

Electronic Toolkits

- 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.
  - 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.
  - 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.

Programming Resources



- Programming is critical to the IoT. Creating custom code is very useful when developing an IoT solution. There are many other free resources that can help you get started with programming:
  - 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.

Summary

- 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.
- 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.
- Python supports many useful functions and datatypes including **Range()**, **Tuples, Lists, Sets, Dictionary**. Python also implements two sub-structures named ELSE and ELIF.

Chapter 3: Everything Generates Data

What is Big Data?

- Data is information that comes from a variety of sources, such as people, pictures, text, sensors, web sites and technology devices.
- Three characteristics that indicate an organization may be dealing with Big Data:
  - A large amount of data that increasingly requires more storage space (volume).
  - An amount of data that is growing exponentially fast (velocity).
  - Data that is generated in different formats (variety).
- Examples of data amounts collected by sensors:
  - One autonomous car can generate 4,000 gigabits (Gb) of data per day.
  - One smart connected home can produce as much as 1 gigabyte (GB) of information a week.

What is Big Data?

Large Datasets

- Companies do not necessarily have to generate their own Big Data.
- There are sources of free data sets available, ready to be used and analyzed.

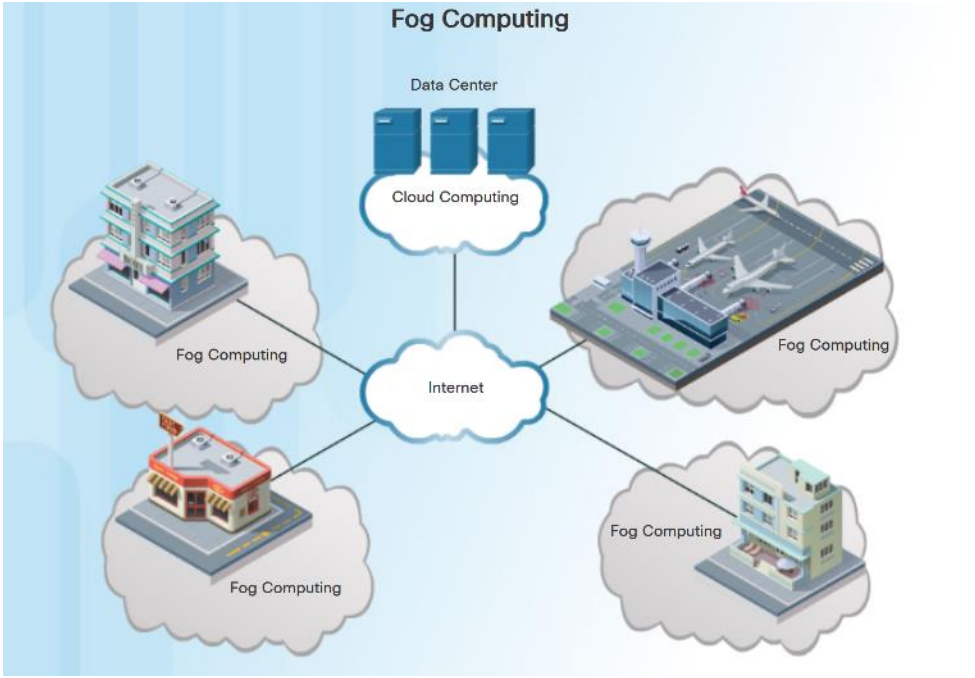
Where is Big Data Stored?

What are the Challenges of Big Data?

- IBM's Big Data estimates conclude that "each day we create 2.5 quintillion bytes of data".
- Five major storage problems with Big Data:
  - Management
  - Security
  - Redundancy
  - Analytics
  - Access

Where Can We Store Big Data?

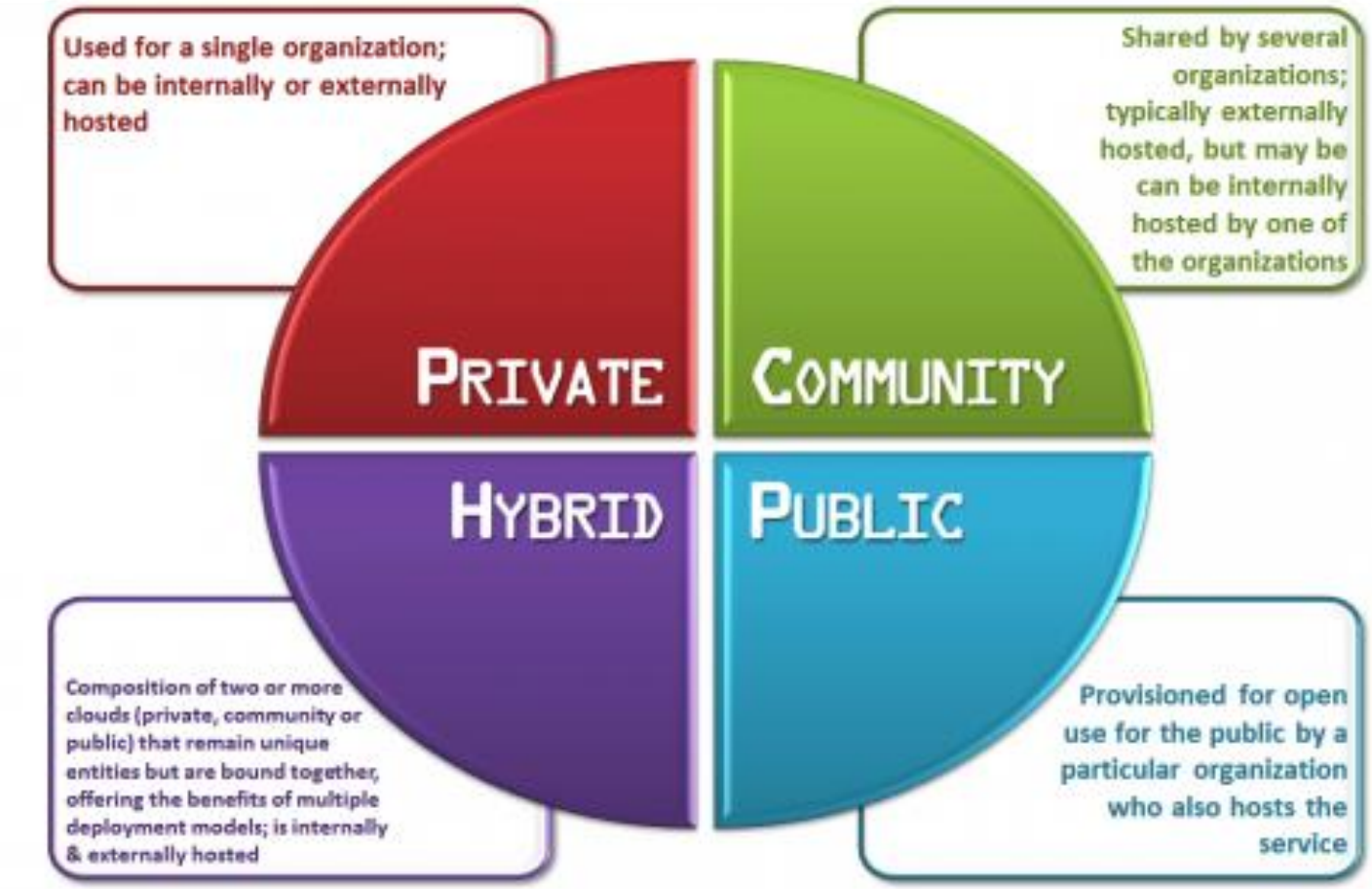
- Big data is typically stored on multiple servers, in data centers.
- Fog computing utilizes end-user clients or “edge” devices to do a substantial amount of the pre-processing and storage.
  - Data from that pre-processed analysis can be fed back into the companies’ systems to modify processes if required.
  - Communications to and from the servers and devices is quicker and requires less bandwidth than constantly going out to the cloud.

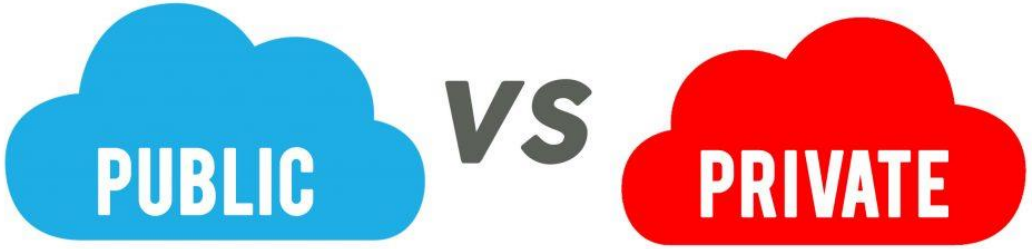


Where is Big Data Stored?

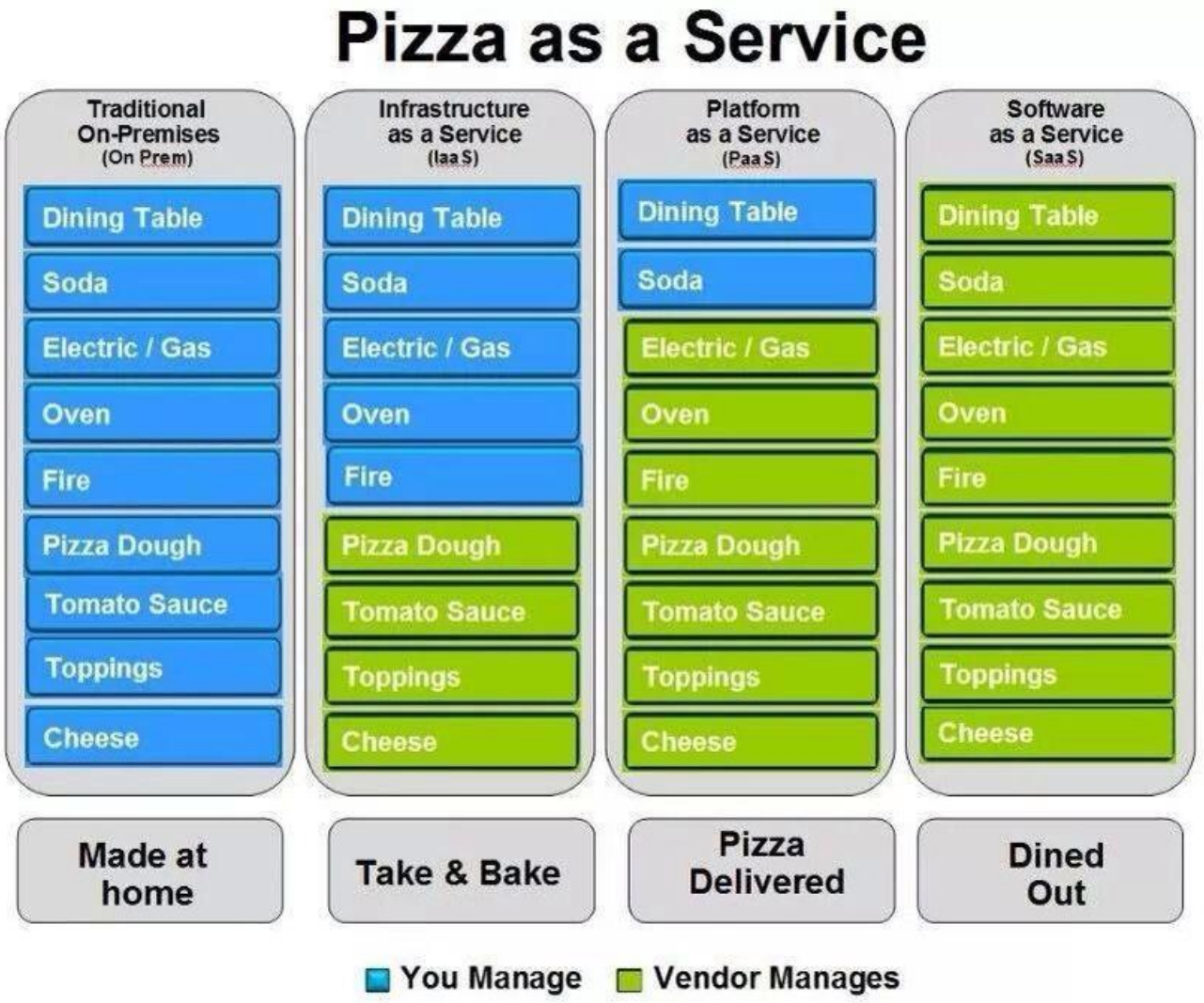
The Cloud and Cloud Computing

- The cloud is a collection of data centers or groups of connected servers.
- Cloud services for individuals include:
  - Storage of data, such as pictures, music, movies, and emails.
  - Access many applications instead of downloading onto local device.
  - Access data and applications anywhere, anytime, and on any device.
- Cloud Services for an Enterprise include:
  - Access to organizational data anywhere and at any time.
  - Streamlines the IT operations of an organization.
  - Eliminates or reduces the need for onsite IT equipment, maintenance, and management.
  - Reduces cost for equipment, energy, physical plant requirements, and personnel training needs.


Used for a single organization; can be internally or externally hosted
Shared by several organizations; typically externally hosted, but may be can be internally hosted by one of the organizations
PRIVATE
COMMUNITY
HYBRID
PUBLIC
Composition of two or more clouds (private, community or public) that remain unique entities but are bound together, offering the benefits of multiple deployment models; is internally & externally hosted
Provisioned for open use for the public by a particular organization who also hosts the service



Publicly Shared Virtualized Resources		Privately Shared Virtualized Resources
Supports Multiple Customers		Cluster of Dedicated Customers
Supports Internet Connectivity		Connectivity Over Internet, Fiber, and Private Network
Suited for Less Confidential Information		Suited for Secured Confidential Information and Core Systems


Pizza as a Service
Traditional On-Premises (On Prem)
Infrastructure as a Service (IaaS)
Platform as a Service (PaaS)
Software as a Service (SaaS)
Dining Table
Soda
Electric / Gas
Oven
Fire
Pizza Dough
Tomato Sauce
Toppings
Cheese
Made at home
Take & Bake
Pizza Delivered
Dined Out
You Manage
Vendor Manages

Cloud and Fog Computing: a Comparison Chart

	CLOUD	FOG
Architecture	Centralized	Distributed
Communication with devices	From a distance	Directly from the edge
Data processing	Far from the source of information	Close to the source of information
Computing capabilities	Higher	Lower
Number of nodes	Few	Very large
Analysis	Long-term	Short-term
Latency	High	Low
Connectivity	Internet	Various protocols and standards
Security	Lower	Higher

Réalisé par Erwin Desmet

INDUSTRIAL IoT DATA PROCESSING LAYER STACK

CLOUD LAYER

Big Data Processing
Business Logic
Data Warehousing

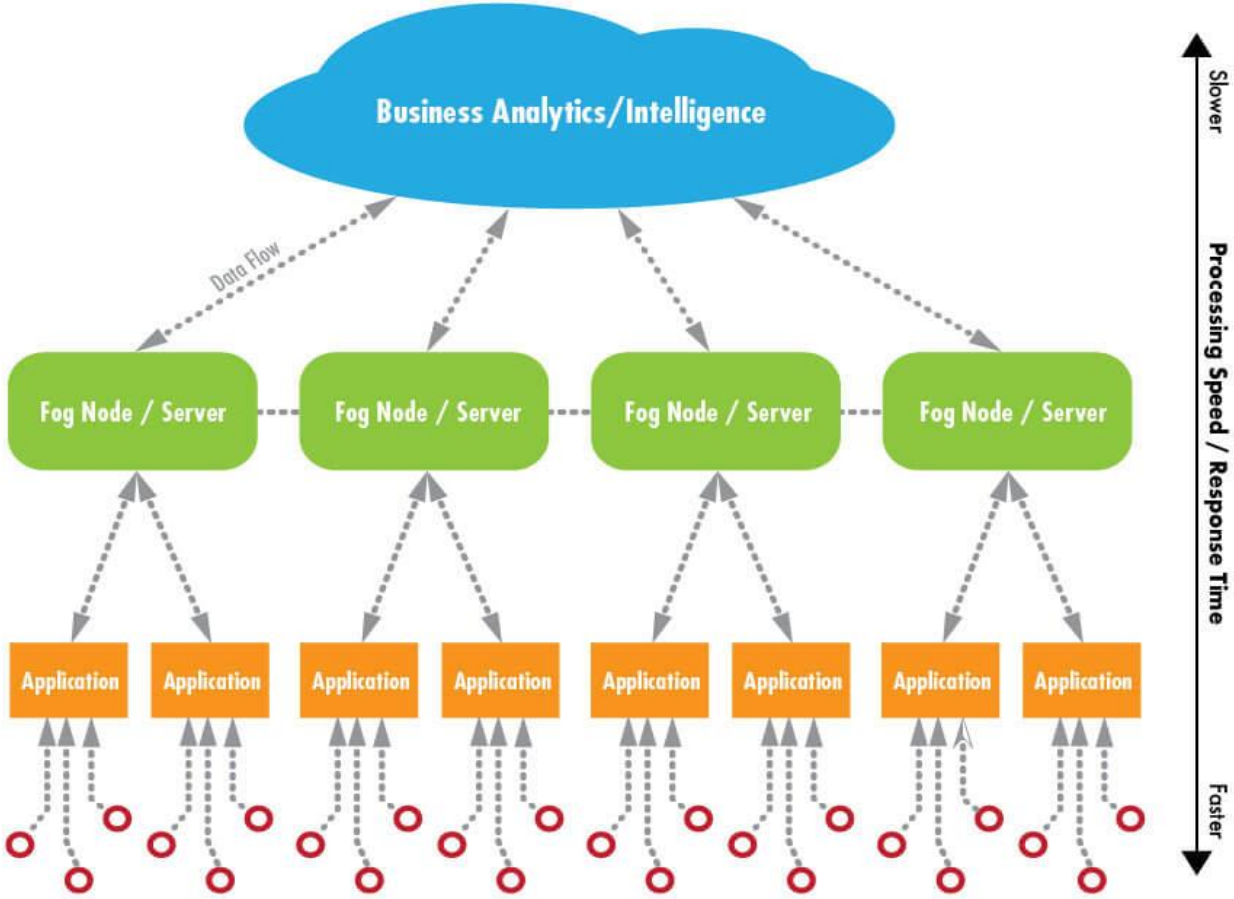
FOG LAYER

Local Network
Data Analysis & Reduction
Control Response
Virtualization/Standardization

EDGE LAYER

Large Volume Real-time Data Processing
At Source/On Premises Data Visualization
Industrial PCs
Embedded Systems
Gateways
Micro Data Storage

Sensors & Controllers (data origination)



Distributed Processing

- Distributed data processing takes the large volume of data and breaks it into smaller pieces.
- These smaller pieces are distributed in many locations to be processed by many computers.
- Each computer in the distributed architecture analyzes its part of the Big Data picture (horizontal scaling).
- Hadoop was created to deal with these Big Data volumes. It has two main features that has made it the industry standard:
  - Scalability - Larger cluster sizes improve performance and provide higher data processing capabilities.
  - Fault tolerance – Hadoop automatically replicates data across clusters.

Définition

Serveurs situés près de la périphérie du réseau de l'entreprise pour le prétraitement des données
Assure le stockage et l'accès aux applications via un navigateur
Outil créé pour distribuer et traiter les grands ensembles de données en plus petits ensembles
Génération d'importants volumes de données
Caractéristique utilisée pour décrire le Big Data
Grand volume de données divisé en parties plus petites et stockées sur différents serveurs

Why Do Businesses Analyze Data?

- 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.
- Value comes from two primary types of processed data, transactional and analytical.
- Transactional information is captured and processed as events happen.
  - 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.

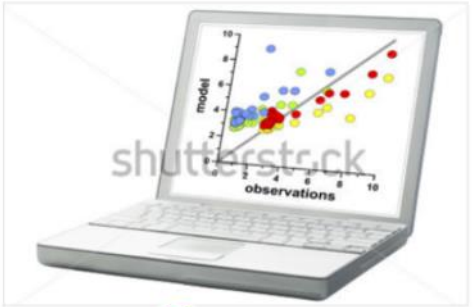
Sources of Information

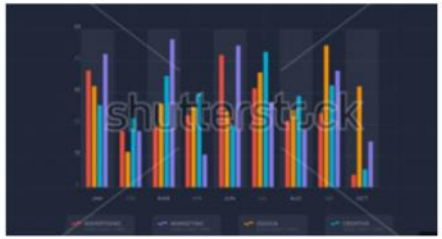
- Data originates from sensors and anything that has been scanned, entered, and released to the Internet.
- Collected data can be categorized as structured or unstructured.
- Structured data is created by applications that use “fixed” format input such as spreadsheets. May need to be manipulated into a common format such as CSV.
- Unstructured data is generated in a “freeform” style such as audio, video, web pages, and tweets.
- Examples of tools to prepare unstructured data for processing are:
  - “Web scraping” tools automatically extract data from HTML pages.
  - RESTful application program interfaces (APIs).

Data Visualization

- Data mining is the process of turning raw data into meaningful information.
- The mined data must be analyzed and presented to managers and decision makers.
- Determining the best visualization tools to use will vary based on the following:
  - Number of variables
  - Number of data points in each variable
  - Is the data representing a timeline
  - Items require comparisons
- Popular charts include line, column, bar, pie, and scatter.

Chart Types





Supporting Business with Big Data

Analyzing Big Data for Effective Use in Business

- Data analysis is the process of inspecting, cleaning, transforming, and modeling data to uncover useful information.
- Having a strategy helps a business determine the type of analysis required and the best tool to do the analysis.
- 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.
- Examples include Knime, OpenRefine, Orange, and RapidMiner.

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Automation

What is Automation?

- Automation is any process that is self-driven, reduces,and eventually eliminates, the need for human intervention.
- The IoT opens up a new world in which tasks previously requiring human intervention can become automated.
- Automation
  - Robots are used in dangerous conditions such as mining, firefighting, and cleaning up industrial accidents
  - used in automated assembly lines.
  - self-serve checkouts at stores
  - automatic building environmental controls
  - autonomous cars and planes.

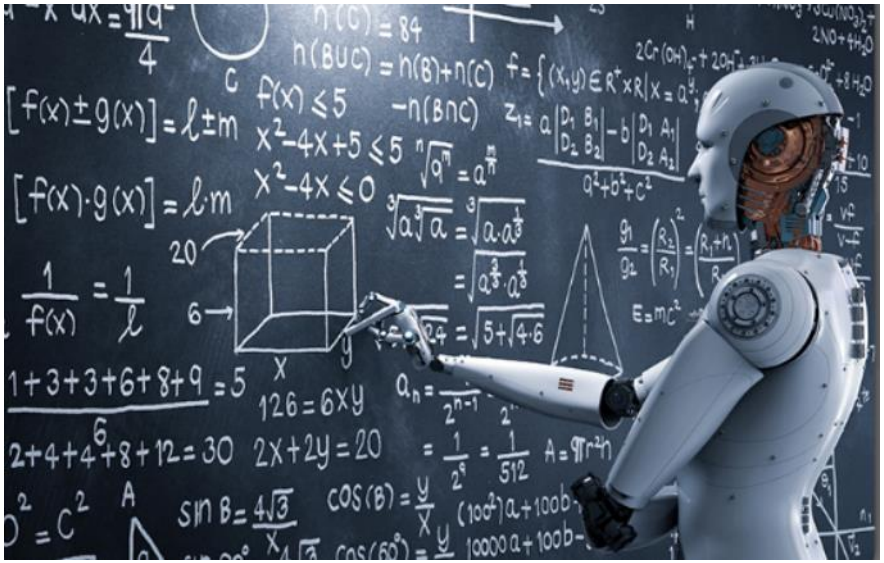
How is Automation being Used?

- Smart Home Automation
- Smart Buildings
- Industrial IoT and Smart Factories
- Smart Cities
- Smart Grid
- Smart Cars
- Stores and Services
- Medical Diagnosis and Surgery
- Aircraft Auto-Pilot

When Things Start to Think

- Many devices now incorporate smart technology to alter their behavior under certain circumstances.
    - 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.

What Is Artificial Intelligence and Machine Learning?



- **Artificial Intelligence (AI)** is the intelligence demonstrated by machines.
  - AI uses intelligent agents that can perceive their environment and make decisions.
  - AI refers to systems that mimic cognitive functions normally associated with human minds such as learning and problem solving.
- **Machine Learning (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.

ML and the IoT

- Common uses of ML technology include:
  - **Speech Recognition** – used in digital assistants.
  - **Product Recommendation** - Systems build up a customer profile and recommend products or services based on previous patterns.
  - **Shape Recognition** - Programs exist that allow crude hand-drawn diagrams and notes to be converted to more formal diagrams and text.
  - **Credit Card Fraud Detection** - A profile is constructed about the purchasing patterns of a client.
  - **Facial Recognition**

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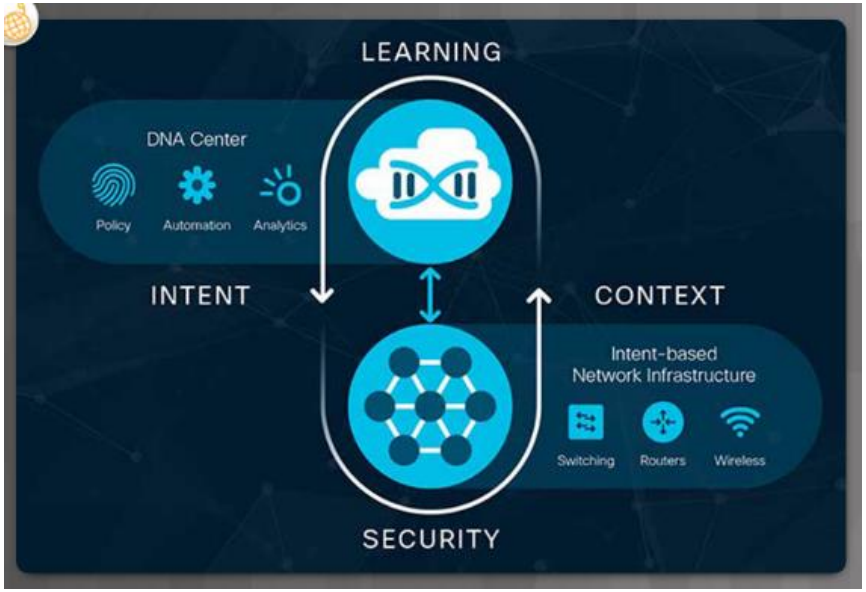
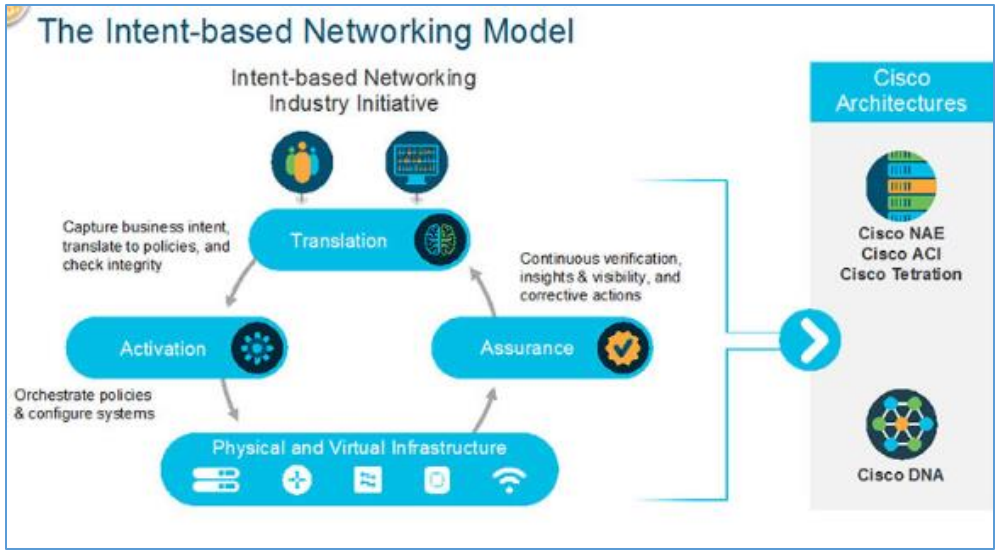
What is Intent-Based Networking (IBN)



- IT industry creating a systematic approach to tie infrastructure management to business intent (IBN).
  - Business network must seamlessly and securely integrate IoT devices, cloud-based services, and remote offices.
  - Network must secure these new digital initiatives from the ever-changing threat landscape.
  - Network must be responsive enough to quickly adapt to changes to security policies and procedures, business services and applications, and operational policies.

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.
  - Network is able to translate the intent into policies and then use automation to deploy the appropriate configurations required.
- Intent-based networking model consists of three key elements:
  - **Assurance** - end-to-end verification of network-wide behavior.
  - **Translation** - ability to apply business intent to network configuration.
  - **Activation** - occurs after the intent has been specified and the policies created.

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Types of Data

PII	Informational
Social security number	Rain gauge value
Email address	Number of cars through an intersection
Bank account numbers	Hospital emergency use per state
Student tuition bill	Average plane capacity
Credit rating	House thermometer reading
Debit card number	Census data
Fingerprints	Immigration values
Birth date	Average potato crops per province
Username/password	Next train time per station
Vehicle identification number (VIN)	Average gas consumption per flight
Mortgage information	
Home address	
Facebook photographs	

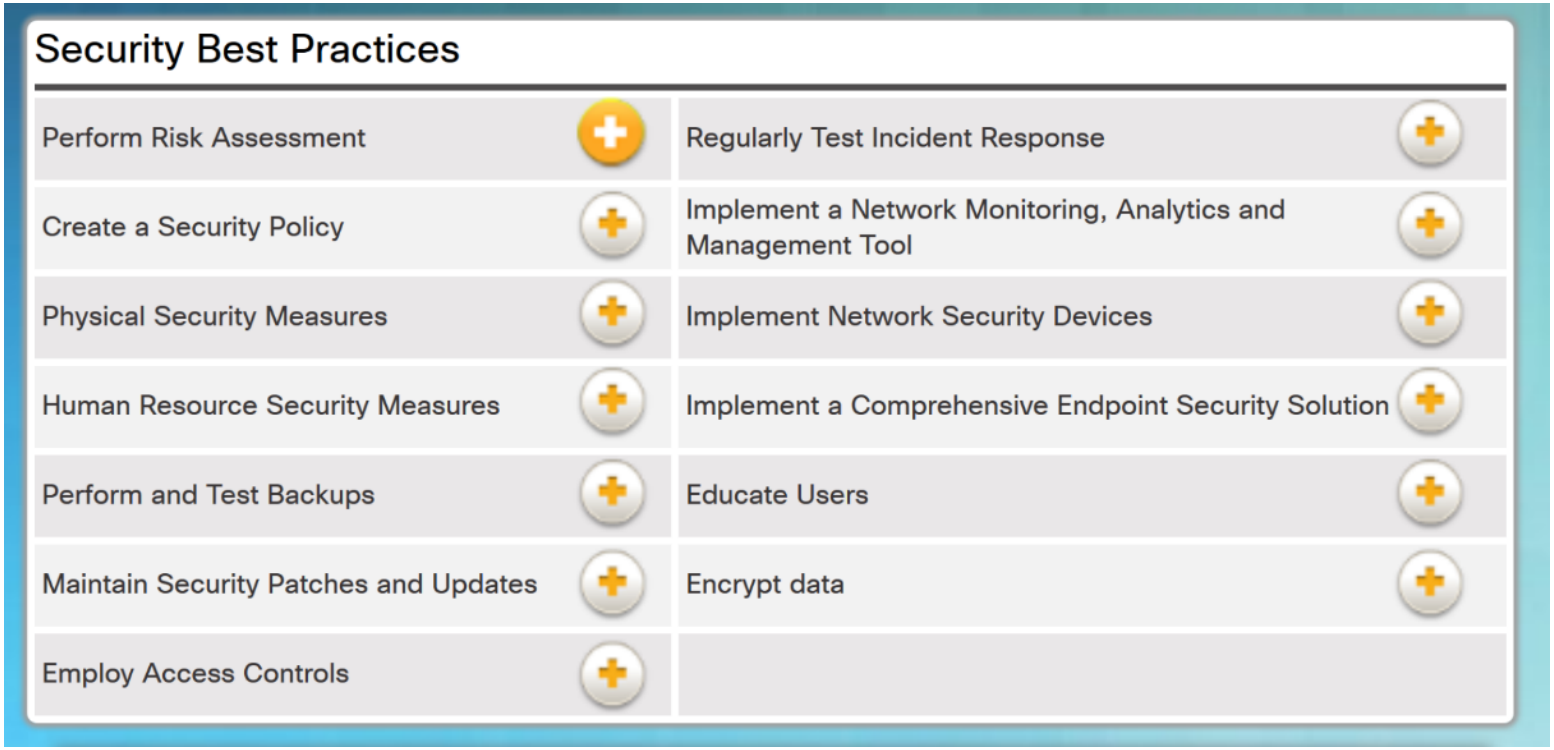
- The quantity, volume, variety, and immediacy of generated data has changed.
- Personally identifiable information (PII) or sensitive personal information (SPI) is data relating to a living individual that can be used on its own or with other information to identify, contact, or locate a specific individual.
- Informational data can also contain sensitive information concerning corporate secrets, new product patents, or national security.

Why is Security so Important?

Who Wants our Data?

- **The Good Guys**
  - Legitimate companies that have an agreement in place to use the collected data about you.
    - We agree to this in “Terms and Conditions” or “Terms of Service and Agreements”
  - White hat hackers who test security to help protect data.
- **The Bad Guys**
  - Black hat hackers, want access to collected data for many nefarious reasons:
    - To access user IDs and passwords to steal identities
    - To access data to commit a crime.
    - 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 create political unrest or to make a political statement.

Security Best Practices



Why is Security so Important?

Data in the Wrong Hands

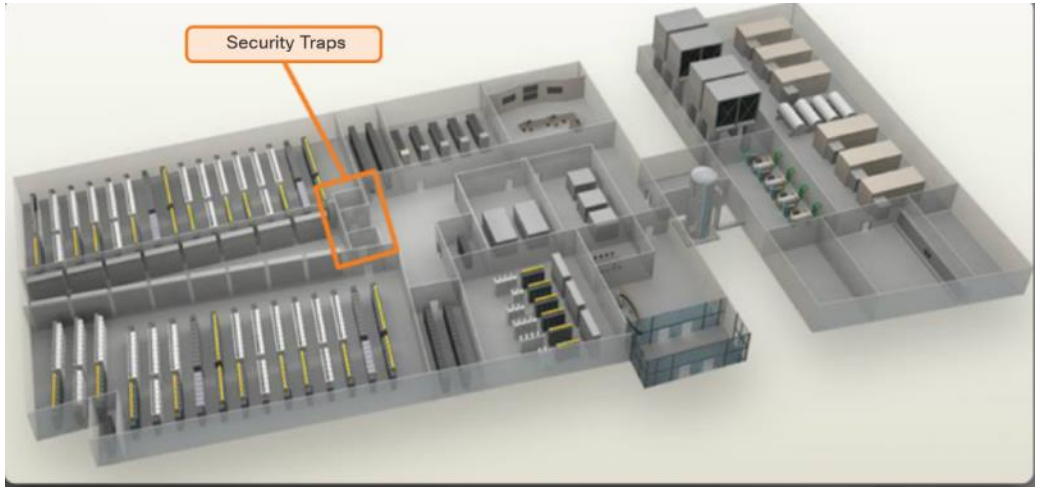
- Login credentials and other personal data for more than one Million Yahoo and Gmail accounts are reportedly being offered for sale on the dark web.
- Cybercriminals penetrated Equifax (EFX), one of the largest credit bureaus, in July 2017 and stole the personal data of 145 million people
- A breach of MyFitnessPal affected 150 million users.
- Ransomware attackers stole 57 million drivers and rider accounts from Uber.

Challenges of Securing IoT Devices

- **Increasing Number of Devices** - The number of interconnected sensors and smart devices is growing exponentially, increasing the opportunity for attacks.
- **Non-Traditional Location of Devices** - Some connected IoT devices are able to interact with the physical world.
- **Lack of Upgradeability** - IoT sensor-enabled devices may be located in remote and/or inaccessible locations where human intervention or configuration is almost impossible.

Physical Security

- **Outside perimeter security** - on-premise security officers, fences, gates, continuous video surveillance, and security breach alarms.
- **Inside perimeter security** - continuous video surveillance, electronic motion detectors, security traps, and biometric access and exit sensors.



Safe Wi-Fi Usage

Steps to Help Protect Your Company Wireless Network

Change the default administrator password	Configure the wireless router to use WPA2-AES encryption
Change the network service set identifier (SSID)	Keep the wireless router's firmware updated
Do not advertise the SSID name	Use Media Access Control (MAC) Address Filtering
Create a Guest Wireless Network	Disable your wireless router's remote management feature
Enable the built-in firewall	Physically secure the wireless router

Protecting Devices

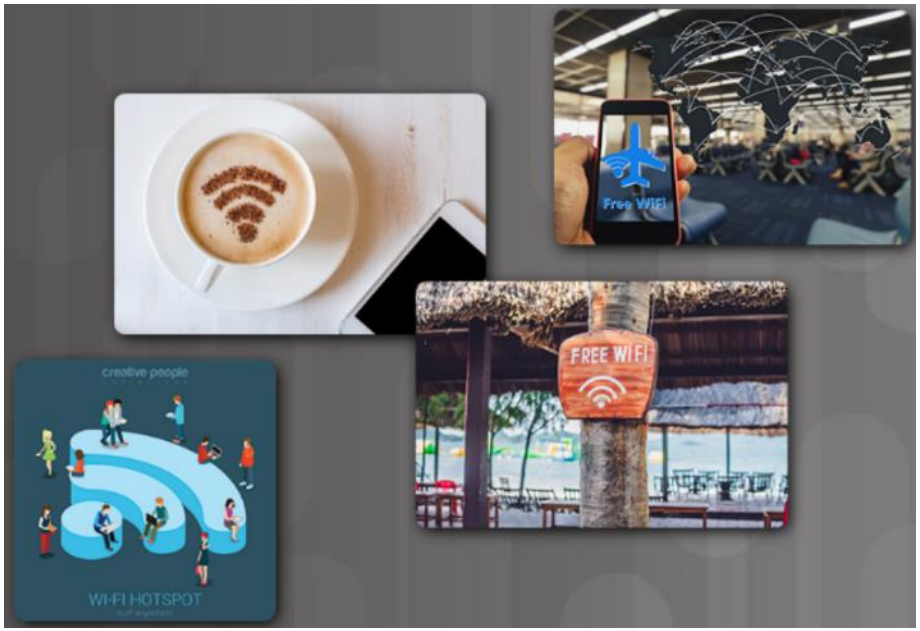
- **Keep the Firewall On**
- **Manage Your Operating System and Browser**
- **Protect All Your Devices**
- **Use Antivirus and Antispyware**

Smart Homes

- Smart sensors in our homes increase the potential for security issues.
- The sensors could provide a way for hackers to get into our home network and gain access to any PCs and data that are connected to it.
- 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

- Safety rules to follow when using a public or unsecure Wi-Fi hotspot:
    - Do not access or send any sensitive personal information
    - Verify that 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.
- Bluetooth can be exploited by hackers to eavesdrop on some devices, establish remote access controls, distribute malware, and drain batteries.
    - Turn off when not in use.



Preparing for the Transition to the IoE (Cont.)

- Technical Requirements and Potential Constraints

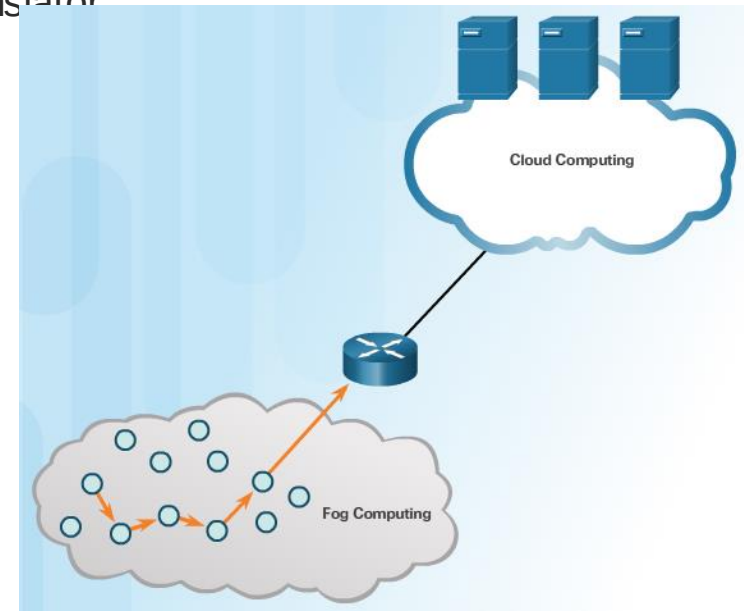
Implementing an IoE Solution
Planning an IoE Solution

- The IoE Architectural Approach

Application Layer	This Layer provides automated, dynamic, application-centric responses to changing traffic and usage demands. The application layer includes the intelligence needed to improve use experiences. It allows for the integration of traditional IT apps, and the use of collaboration applications and industry specific appliation.
Platform layer	This refers to Cisco solutions that provide orchestration, management, and policy adjustments based on changing demands, to accelerate service delivery. It allows applications and users to receive the resources they need, when they need them, without manual or coplicated IT tasks and configuration changes. The platform layer creates business agility by implementing new services and new analytical applications that can handle Big Data needs.
Infrastructure layer	This layer integrates power, security, core networls, access architectres, and storage with physical and virtual resources. It includes the right mix of hardware and software Across enterprse, cloud, and service provider networks. It converges all connections, Both OT and IT, into IP and accounts for cloud computing and mobile connectivity.

Challenges to Implementing IoE Solutions

- Proprietary Ecosystems = Proprietary Protocols
  - convert proprietary networks to IP-based networks
  - proprietary protocols can communicate through a translator
- Accelerated Technological Growth
- Growth Relevancy to IoE
  - Moore's and Metcalfe's Laws allows the prediction of:
  - Computing powers
  - Availability of new technology
  - Advances of competitors
- Big Data Challenges
  - Bandwidth capacity
  - User data privacy
  - Data Management
  - Selection and analysis of appropriate data
- More connected things = Bandwidth Requirements
- Cloud vs Fog Computing
  - Where should the data be processed? – away (cloud computing) or close to the source (fog computing)
- The Learning Society – Training is necessary to take advantage of the opportunities in IoE



Security and the IoE
IoE Security

- Need for Additional Security
  - Increased amount of connected devices and data = increased demand for security of data
  - Hacking attacks are a daily occurrence
  - No organization is immune
- Security Strategy
  - Adaptable & Real-Time Security
  - Secure & Dynamic Connections
  - Protecting Customer & Brand Trust

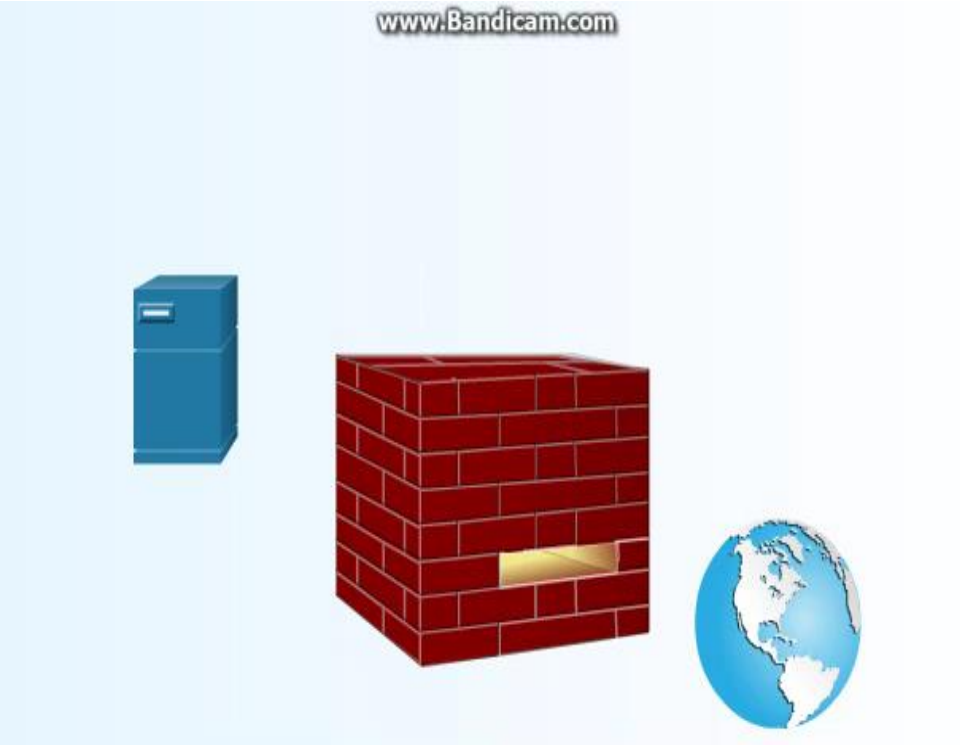
Security and the IoE
IoE Security (Cont.)

- Pervasive security solution avoids disjointed security implementations.
  - Consistent, automated, and extend to secured boundaries across organizations
  - Dynamic, to better recognize security threats through real-time predictive analytics
  - Intelligent, providing visibility across all connections, and elements of the infrastructure
  - Scalable, to meet the needs of a growing organization
  - Agile, able to react in real-time
  - Comprehensive, end-to-end solution

Security and the IoE
Security Measures

- Security Architecture
  - Access Control
  - Context-Aware Policies
  - Context-Aware Inspection and Enforce
  - Network and Global Intelligence
- Security Devices
  - Firewalls
  - Intrusion Prevention System (IPS)
- Application-Centric Security
  - protect environments by fully integrating customized security technologies for the needs of a specific application
- Wireless Security – What security would you implement at the access point?
- Redundancy and High Availability
  - Redundant equipment and network connections
  - Load sharing
  - Secured backups of data in an encrypted format

Dispositifs de sécurité : pare-feu

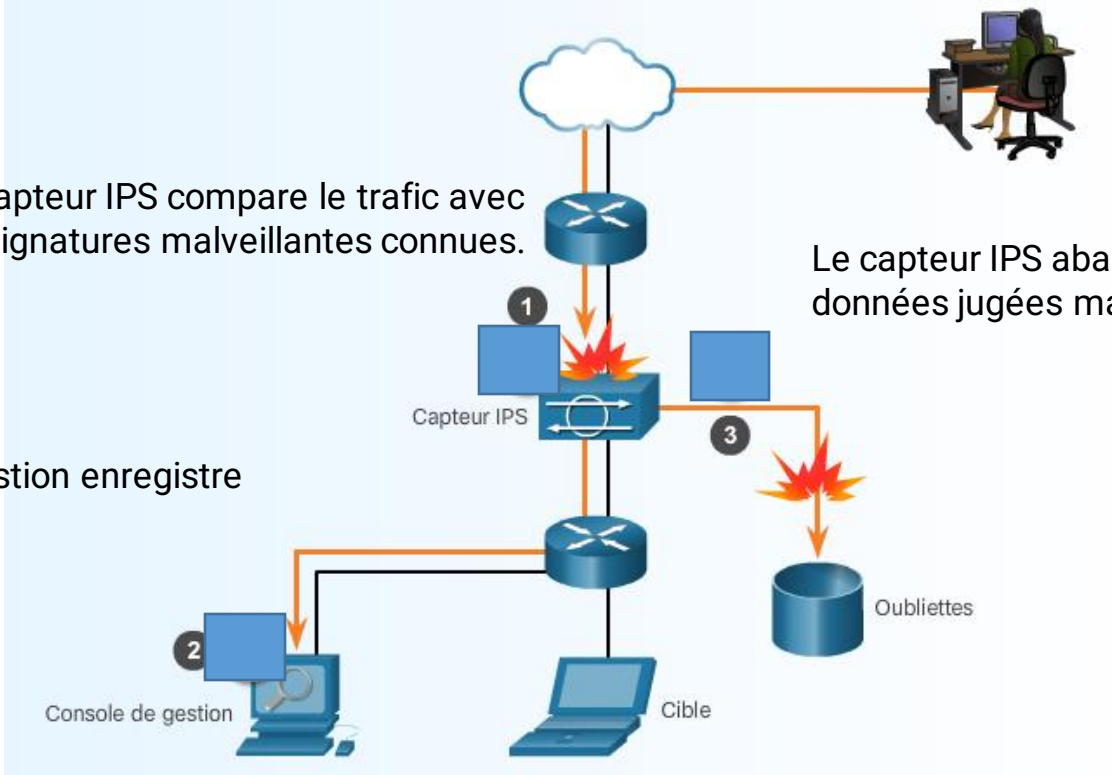


Dispositifs de sécurité : Fonctionnement du système de prévention d'intrusions

Le capteur IPS compare le trafic avec les signatures malveillantes connues.

Le capteur IPS abandonne les données jugées malveillantes.

La console de gestion enregistre les événements



Security and the IoE
People and the IoE

- People are the Weakest Link
  - Malicious intent
  - Mistakes or follow unsecure practices
- Security Policy – rules, regulations, and procedure
  - Remote Access Policy
  - Information Privacy Policy
  - Computer Security Policy
  - Physical Security Policy
  - Password Policy
- Personal Data and the IoE
  - Volunteered
  - Observed
  - Inferred

Summary

- The quantity, volume, variety, and immediacy of generated data has changed.
- Personally identifiable information (PII) or sensitive personal information (SPI) is 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.
- Informational data can also contain sensitive information concerning corporate secrets, new product patents, or national security.
- White hat hackers test security to help protect data.
- Black hat hackers, want access to collected data for many nefarious reasons.
- **Outside perimeter security** - on-premise security officers, fences, gates, continuous video surveillance, and security breach alarms.
- **Inside perimeter security** - continuous video surveillance, electronic motion detectors, security traps, and biometric access and exit sensors.

Summary (Cont.)

- Challenges of securing devices on the IoT:
  - **Increasing Number of Devices** - The number of interconnected sensors and smart devices is growing exponentially, increasing the opportunity for attacks.
  - **Non-Traditional Location of Devices** - Some connected IoT devices are able to interact with the physical world.
  - **Lack of Upgradeability** - IoT sensor-enabled devices may be located in remote and/or inaccessible locations where human intervention or configuration is almost impossible.
- Know the steps to protect your company's wireless network.
- Steps for protecting your own devices:
  - Keep the Firewall On
  - Manage Your Operating System and Browser
  - Protect All Your Devices
  - Use Antivirus and Antispyware

Summary (Cont.)

- Smart sensors in our homes increase the potential for security issues.
- Safety rules to follow when using a public or unsecure Wi-Fi hotspot:
  - Do not access or send any sensitive personal information
  - Verify that 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.
  - Set up a VPN on your smart phone.

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