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Chapter 7
Introduction to IoT

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Objectives

After completing this chapter, you will:

✓ learn how to design, build, and program IoT devices from the ground up.

✓ understand the heavyweight network and Cloud Infrastructures behind IoT systems.

✓ Know how sensors work, how to program them and connect them together, and you'll learn all about applications.

✓ be able to Instantiation and implementation of IoT network

Chap7 Outlines

- Introduction
- Definitions
- Client server relationship
- Configuring Infrastructure Devices

What is IoT?

An IoT (Internet of Thing) network refers to a group of interconnected devices that communicate with each other without the need for human intervention, like: appliances at home, weather devices, autonomous cars, smart appliances…
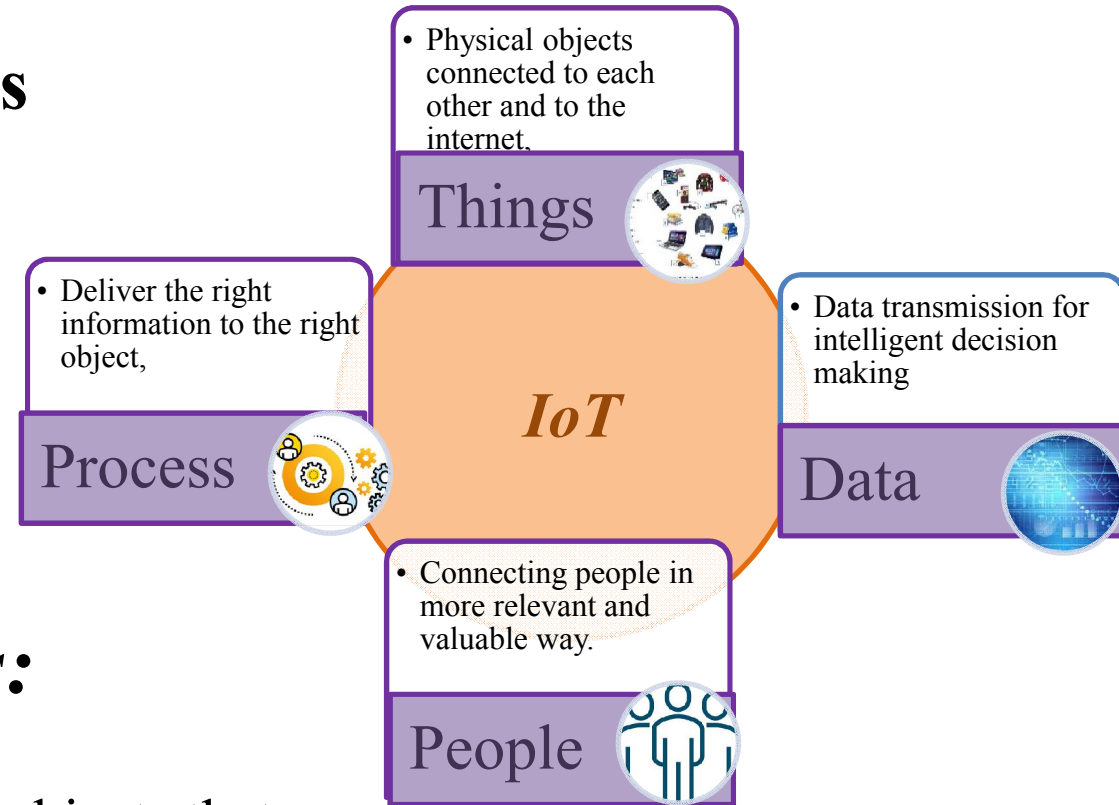
IoT has no practical limit as to the number of devices deployed.

Composed of four Elements: Things, Data, People and Process.

Definitions

- Physical objects connected to each other and to the internet.

Things

- Deliver the right information to the right object,

Process

IoT

- Data transmission for intelligent decision making

Data

- Connecting people in more relevant and valuable way.

People

1. Things:

Things can be objects that:
- ✓ contain embedded technology to interact with internal servers and the external environment,
- ✓ Able to be connected to the network,
- ✓ Can be linked to other objects and can communicate across a secure, reliable and available network platform,
- ✓ Can create vast amounts of data.

- Physical objects connected to each other and to the internet

Things

Things can classified into two categories:

✓ **Connecting to Traditional Computers:**

❖ Common devices having different ways (e,g. Wi-Fi) to connect them wirelessly to laptop and desktop computers

✓ **Connecting to Non-Traditional Computer Things:**

❖ Sensors

❖ Collect data from non-computers

❖ convert physical aspects of our environment into electrical signals that can be processed by computers

❖ Some examples: soil moisture sensors, air temperature sensors, radiation sensors, and motion sensors

❖ RFID – Radio frequency identification

❖ Communicate information between small coded tags (RFID tags) and an RFID reader. Usually, RFID tags are used to identify and track what they are embedded into.

❖ Controller

❖ collects data from sensors and providing an Internet connection

❖ May have the ability to make immediate decisions or send data to a more powerful computer for analysis.

✓ **Connecting to Non-Traditional Computer Things (cont.)**

Processing computers

Data center   Data center

Routers

Controllers

Speaker

RGB LED

Sound Sensor

Water Detector

Air Cooler

Smoke Sensor

Humidity Sensor

LCD

Sensor devices
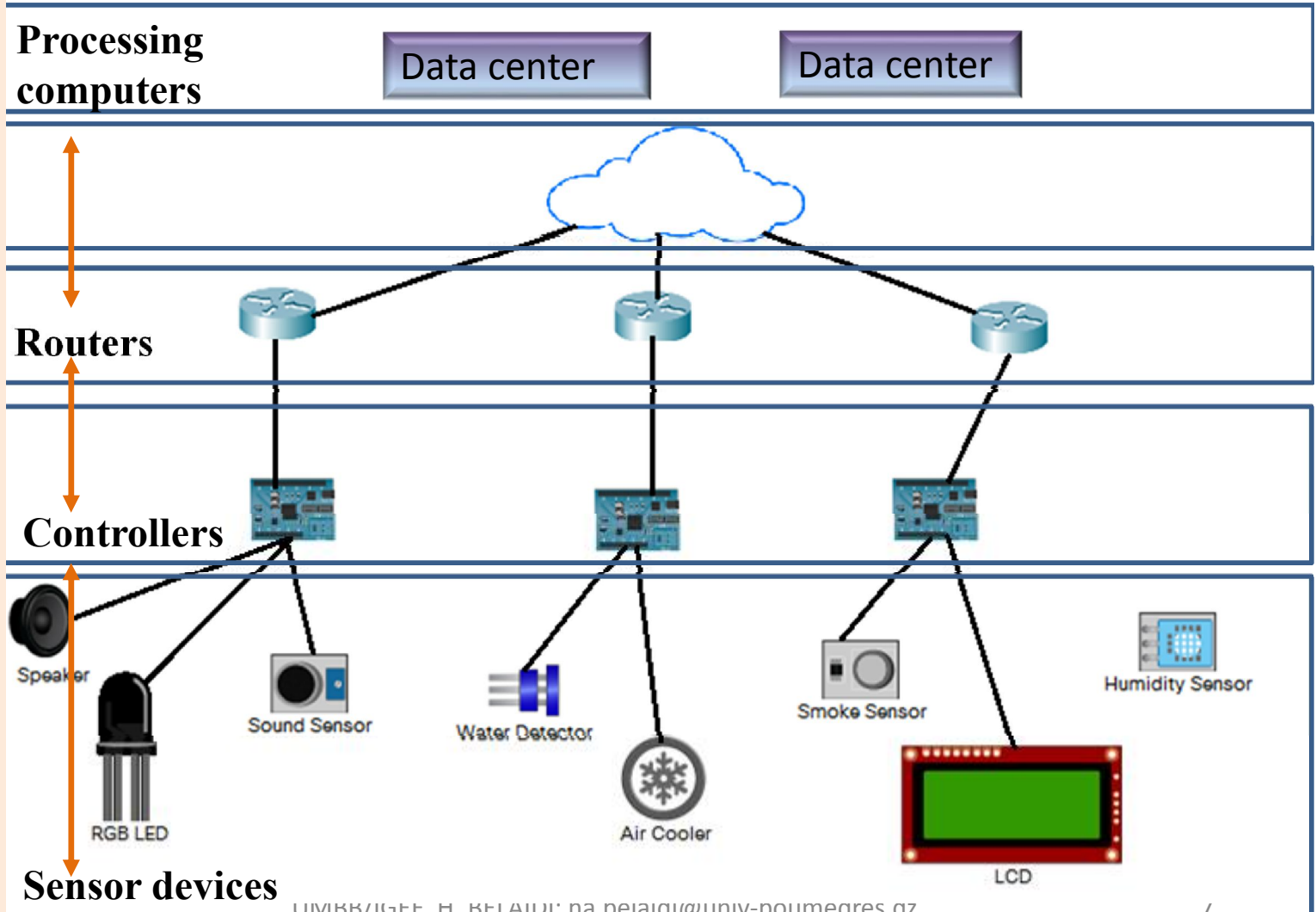
Outlines

2. Data:

✓ Data is a value assigned to anything that is around us.

✓ In electronic communication, data is represented as 1s and 0s, binary digits.

✓ The advantage of using digital coding is that data can be stored more efficiently and can be transmitted over long distances without the losing quality of our data.

Data to be transferred can be:
  ❖ Structured Data – data entered and maintained in fixed fields within a file or record
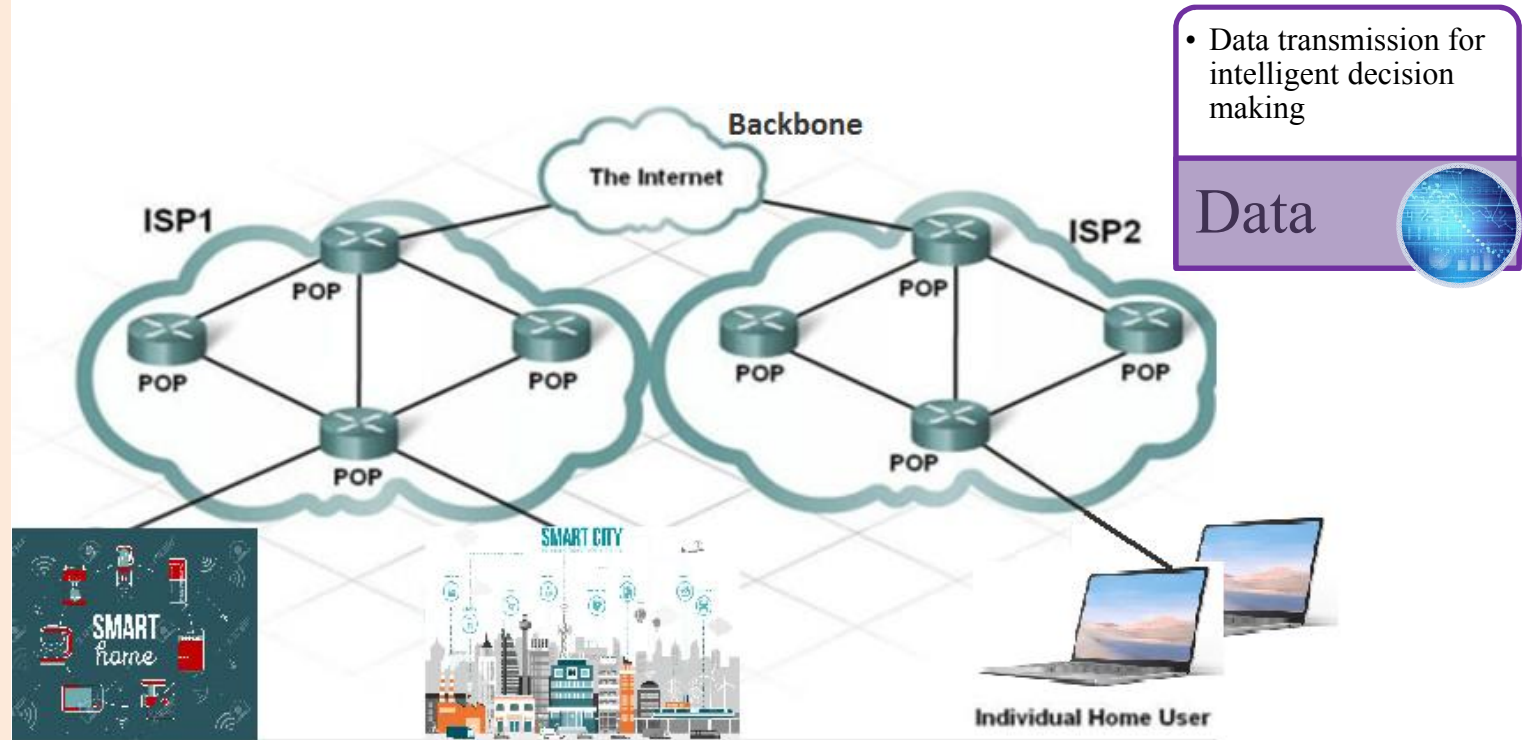 ❖ Unstructured Data – raw data

The Data can be classified according to its storage into:
  ➢ local data,
  ➢ centralized data, and
  ➢ distributed data

Data transportation :

Outlines

- Introduction
- Definitions
- Client server relationship
- Configuring Infrastructure Devices

- Data transmission for intelligent decision making

Data

Data transportation is ensured by ISP Internet Service Providers which:

Forward the data across the Internet

Supply the connections to allow Internet access to individuals and businesses
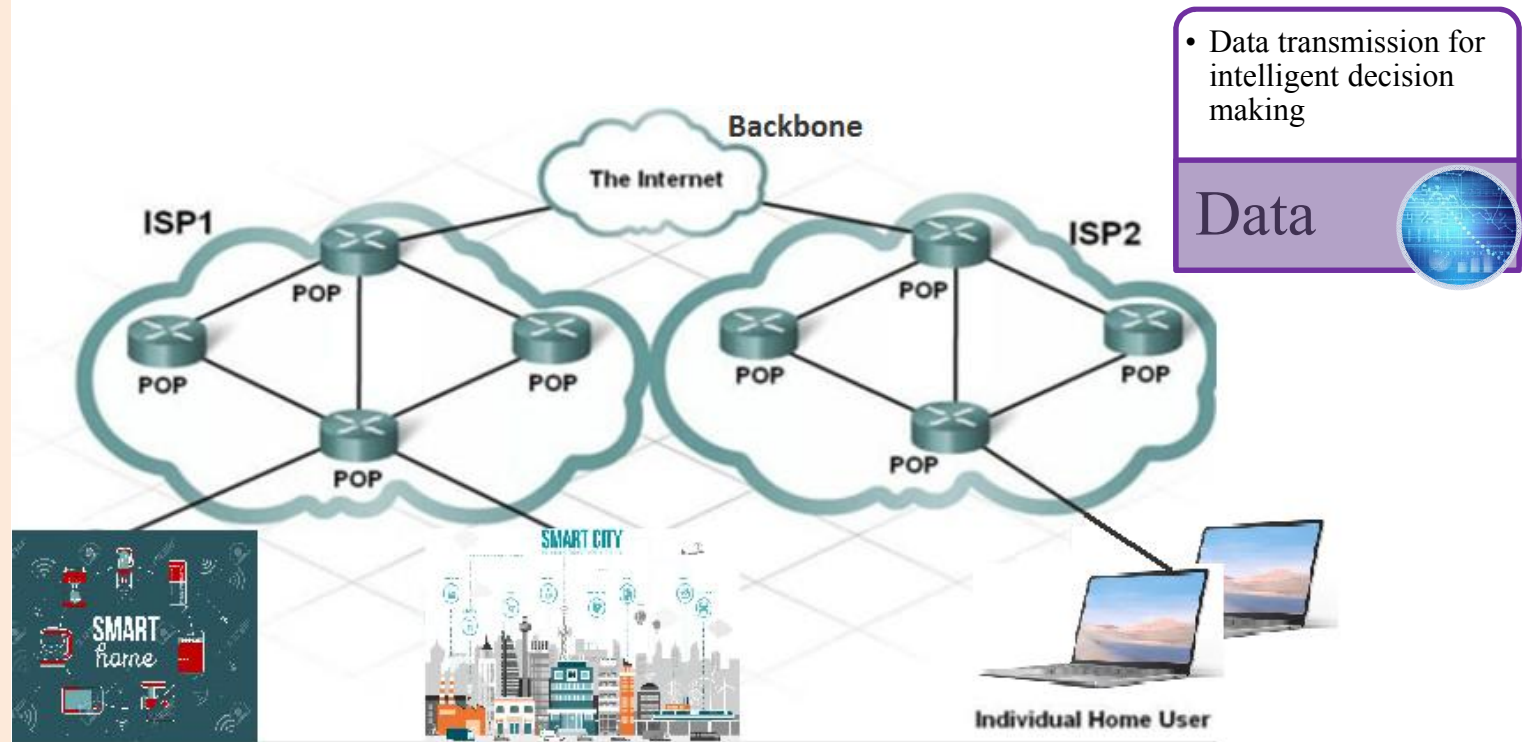
Interconnect with other ISPs

Connect networks at Point of Presence (POP)

Form the Internet Backbone when multiple ISPs are interconnected

- Data transmission for intelligent decision making

Data

A PoP is a set of telecommunications technologies and equipment that allows users to access the Internet. The equipment in a PoP can vary from routers to aggregators to Asynchronous Transfer Mode (ATM) switches.

3. People:

People Must be Connected

– Data transform into usable information leads to:

- better-informed decisions

- appropriate actions

Information Transforms Behavior

– Allows people to make informed decisions that bridge the differences between actual outputs and desired output

– Feedback loop

- real-time information based on current behavior

- deliver actionable information to modify that behavior

4. Process:

The Role of Process

❖ M2M (Machine to Machine) Connections

✓ Data is transferred from one machine or "thing" to another over a network.

✓ M2M is the most critical part of the Internet of Things.

✓ Critical components include sensors, actuators, and controllers with network connections for communications and instructions

✓ The most well-known type of M2M communication is telemetry.

❖ M2P (Machine to People) Connections

✓ Information is transferred between a machine and a person

✓ Facilitate the movement, manipulation, and reporting of data from machines to help people make informed judgments.
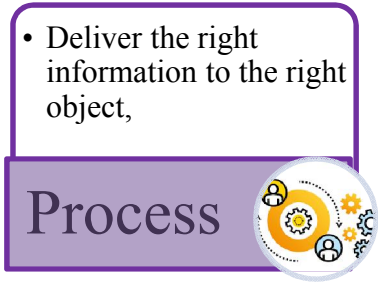
Outlines

❖ P2P (People to People) Connections

   ✓ Information is transferred from one person to another, often called Collaboration.

❖ Timely and Relevant Information

   ✓ Leverages the connections between data, things, and people to deliver the right information, to the right thing or person, at the right time

- Deliver the right
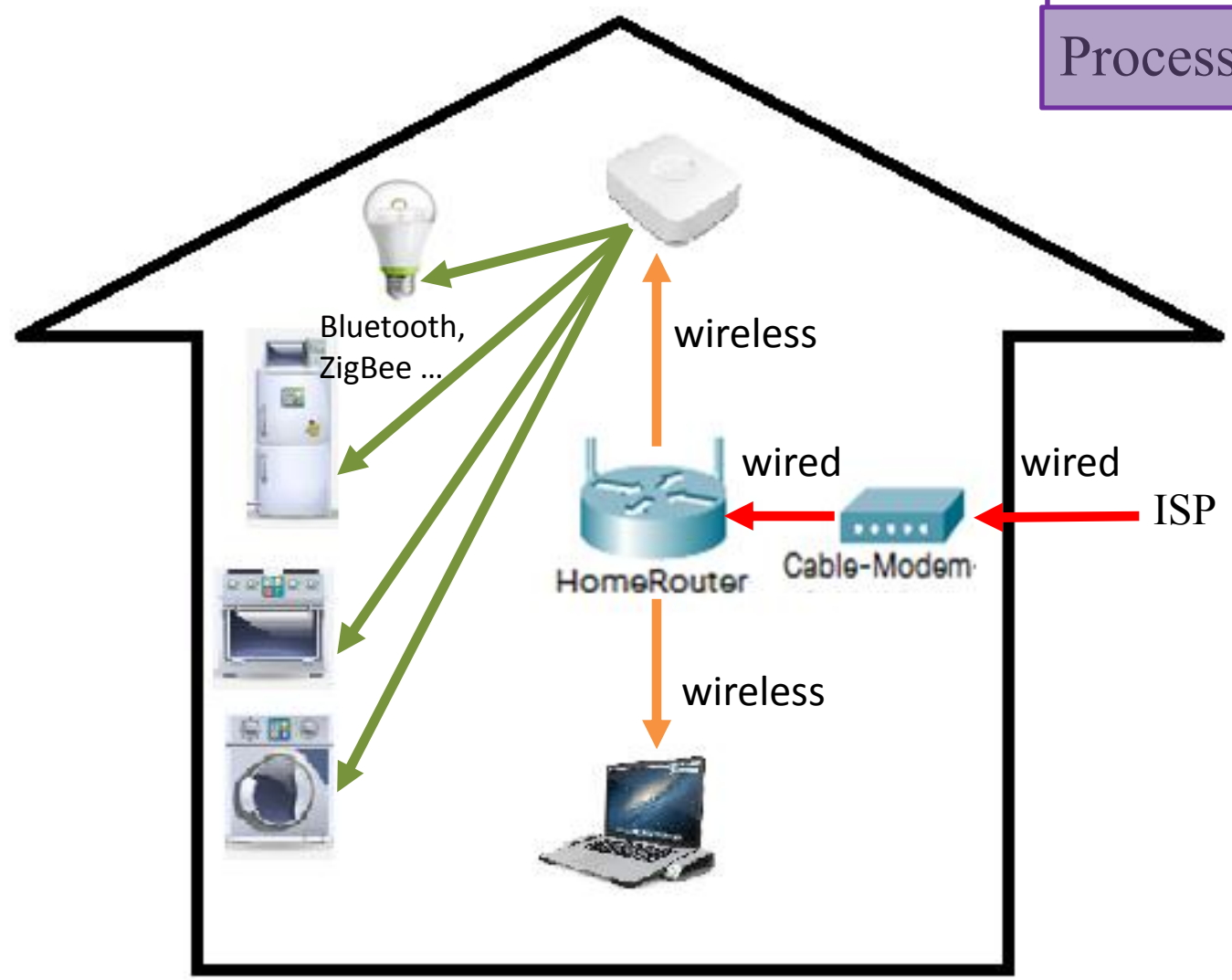 information to the right
  object,

Process

Bluetooth,
ZigBee …

wireless

wired   wired

HomeRouter   Cable-Modem   ISP

wireless

Outlines

- Connecting Things for Consumers
  - The home network probably has a router with both wired and wireless capabilities.
  - The home network connects to the Internet through a local Internet Service Provider (ISP).
  - Sensors can be part of the home network.
  - These sensors are part of the M2M networks that are unique to the IoT. The sensors can communicate with each other and send data through the gateway router (home router), through the ISP network, to a server environment in the Cloud. Here data can be accumulated and analyzed.

- Connecting Things for Industries
  - Requires reliability and autonomy
  - May require operations and calculations that happen too quickly to depend on human intervention.
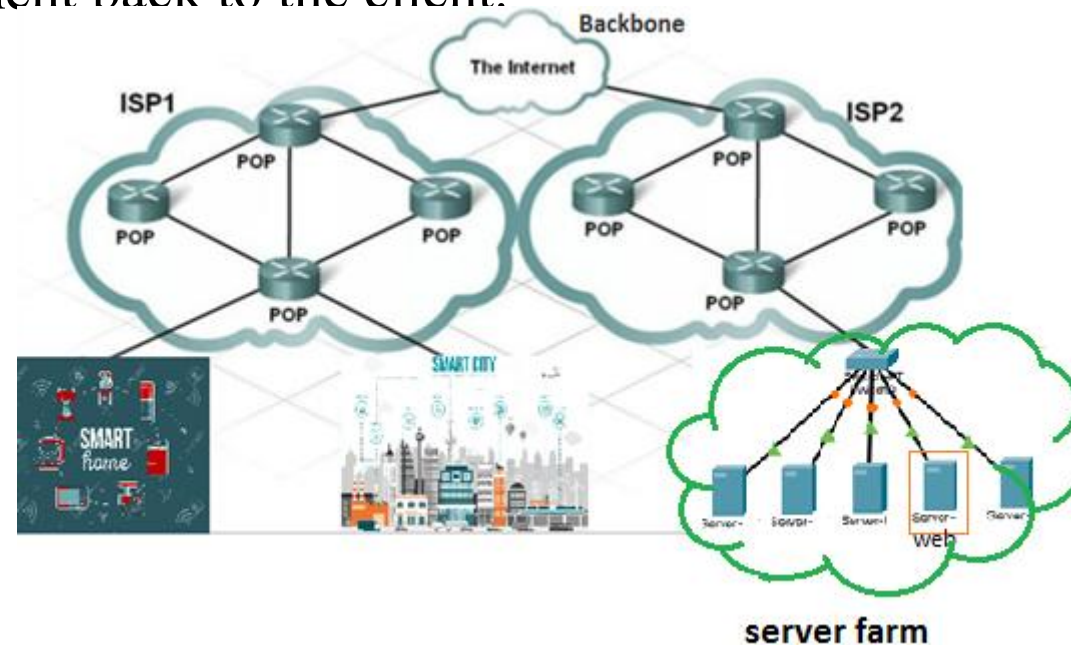
Client server relationship

There exist several servers interconnected via the Internet offering services such as web sites, email, financial transactions, and music downloads to clients…

The relationship in client/server systems is that the client sends a request to a server, and the server responds by executing a function, such as directing the requested document back to the client.

▪ A uniform resource locator (URL) is used to locate the server and a specific resource. The URL identifies:

- Protocol being used, usually HTTP (Hypertext Transfer Protocol) for web pages
- Domain name of the server being accessed
- Location of the resource on the server
- Resource

http://example.com/example1/index.htm

Some of the protocols used for Internet services are:

- **Domain Name System (DNS)** - Resolves Internet names to IP addresses.

- **Secure Shell (SSH)** - Used to provide remote access to servers and networking devices.

- **Simple Mail Transfer Protocol (SMTP)** - Sends email messages and attachments from clients to servers and from servers to other email servers.

- **Post Office Protocol (POP)** - Used by email clients to retrieve email and attachments from a remote server.

- **Internet Message Access Protocol (IMAP)** - Used by email clients to retrieve email and attachments from a remote server.

- **Dynamic Host Configuration Protocol (DHCP)** - Used to automatically configure devices with IP addressing and other necessary information to enable them to communicate over the Internet.

- **Web Server** - Transfers the files that make up the web pages of the World Wide Web using Hypertext Transfer Protocol (HTTP).

- **File Transfer Protocol (FTP)** - Used for interactive file transfer between systems.

Types of Ports

Small business and home routers typically have two primary ports:

- **Ethernet Ports:** These ports connect to the internal switch portion of the router. All devices connected to the switch ports are on the same local network.

- **Internet Port:** This port is used to connect the device to another network, such as the Internet.

Ethernet Ports   Internet Port

Settings

– Wireless Network Name (SSID) - Name of the WLAN network

– Wireless Password - Password clients use to connect to the wireless network

– Router Password - Password used to manage the router

– Wireless router provides DHCP services to connected local network clients when connected to the wireless router
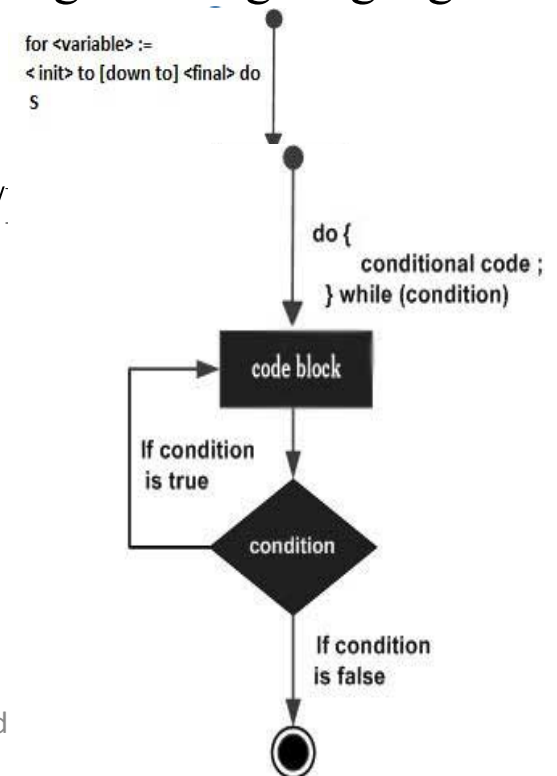
Gateway

- To reach a device on a different IP network, the devices must first forward the packet to the default gateway.
- In a small business environment the default gateway is the router used to connect the LAN to the Internet.

Programming

– Sensors must be told what to capture and where to send that data.

– A controller must be programmed with a set of instructions to receive that data and decide if it should process and relay that data to another device.

– A computer program is a set of instructions given to a computer, to be executed in a specific order.

– Most common logical structures found in programming languages:

• IF condition THEN instructions (If/Then)

• FOR expression DO instructions (For/Do)

• WHILE condition DO instructions (While/

```
for <variable> :=
< init> to [down to] <final> do
S
```

```
do {
    conditional code ;
} while (condition)
```

code block

If condition
is true

condition

If condition
is false

- Types of Programs

– Firmware contains the instructions that the device performs as it boots up.

– Operating Systems allow humans to interact with a computer.

– Applications are designed and written to perform a specific task or service.

- Programming Languages

  – Python, java …

Example

This example deals with room temperature monitoring,

Especially in summer, the AC is programmed to start cooling if the temperature exceeds 25°c, and to remain ON, until the temperature falls under 20°c, AC then goes back OFF and remains OFF until the temperature exceeds 25°c again. In winter, the furnace is programmed to start heating the room if the temperature falls under 10°c and to remain ON until the temperature exceeds 20°c, the furnace then goes back OFF and remains OFF until the temperature falls under 10°c again.
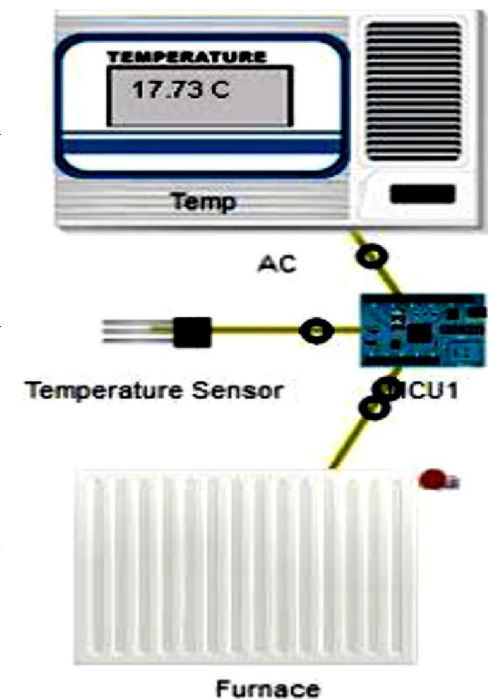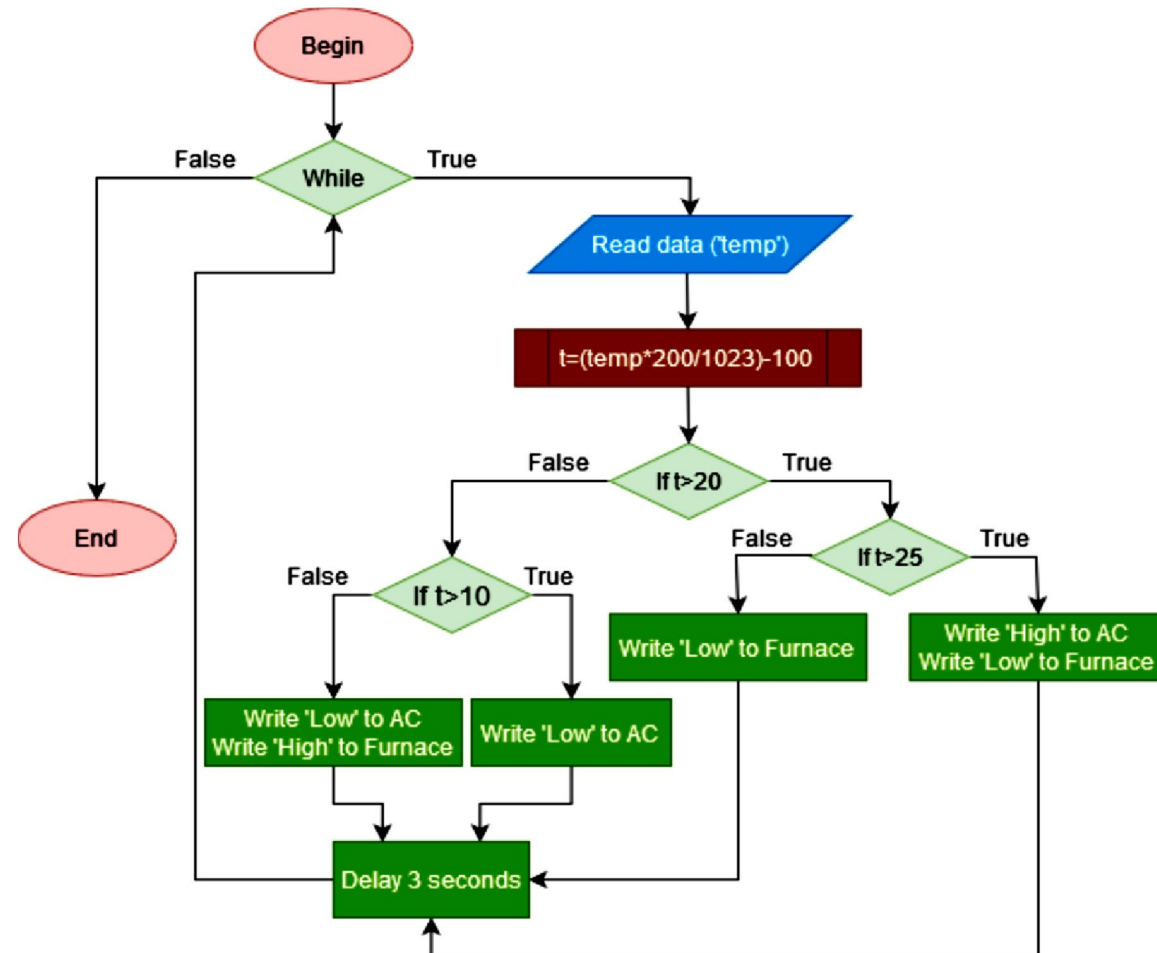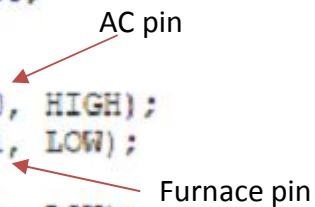
Room temperature monitoring flowchart.

Python is also used to program MCU1 microcontroller to perform these tasks; the flowchart is given in figure 4. The temperature sensor gives values from 0 to 1023 (mapping from -100C to 100 C).

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```
1   from gpio import *
2   from time import *
3
4   def main():
5       pinMode(0, OUT)    #AC pin
6       pinMode(1, OUT)    #Furnace pin
7       pinMode(7, IN)     #Temperature sensor pin
8       print("Getting data...")
9       while True:
10          temp=analogRead(7);
11          t=((temp*200)/1023)-100;
12          if (t>20):
13              if (t>25):
14                  digitalWrite(0, HIGH);
15                  digitalWrite(1, LOW);
16              else:
17                  digitalWrite(1, LOW);
18          else:
19              if (t>10):
20                  digitalWrite(0, LOW);
21              else:
22                  digitalWrite(0, LOW);
23                  digitalWrite(1, HIGH);
24          delay(3000);
```

AC pin

Furnace pin

Room temperature monitoring python program.