

## Home Automation Systems

Smart Homes (e.g. IBM Watson): Intelligent homes use connected home IOT data to enhance quality of comfort in a home. An intelligent home can even learn about residents to improve performance.

System design is affected by the requirements ranging from simple control of lights in the house to controlling all appliances. To this security of the house can be added. Safety of the house to check for gas leaks, fire alarms etc. can also be added. Also features to manage the energy budget can be added

A smart home system takes care of

- a) Home Automation
- b) Energy and Cost Management
- c) Health and Wellness of Inmates
- d) Safety and Security

Modern homes usually have a number of appliances such as TVs, refrigerators, music systems, washers/dryers etc. Managing and controlling of these appliances is cumbersome as each appliance has its own control/remote control. For e.g. smart washers/dryers can be controlled remotely and notify when process is complete. Smart thermostats allow controlling temperature of rooms and can also use several learning algorithms to predict user preferences. Smart refrigerators keep track of item is low on stock. Smart TV's allow users to search and stream videos and movies from Internet on a local storage drive. Search TV channel schedule to bring you your favorite programs.

Smart homes also have intruder alert systems that use cameras and PIR Sensor. In case of intruders detected – alert use while also alerting the local police station.

Smoke/gas detection systems can be used for protecting homes from fires or gas leakage. Smoke sensors, gas detectors (CO, LPG) leakage alerts user through SMS as well as alerts the local authorities.

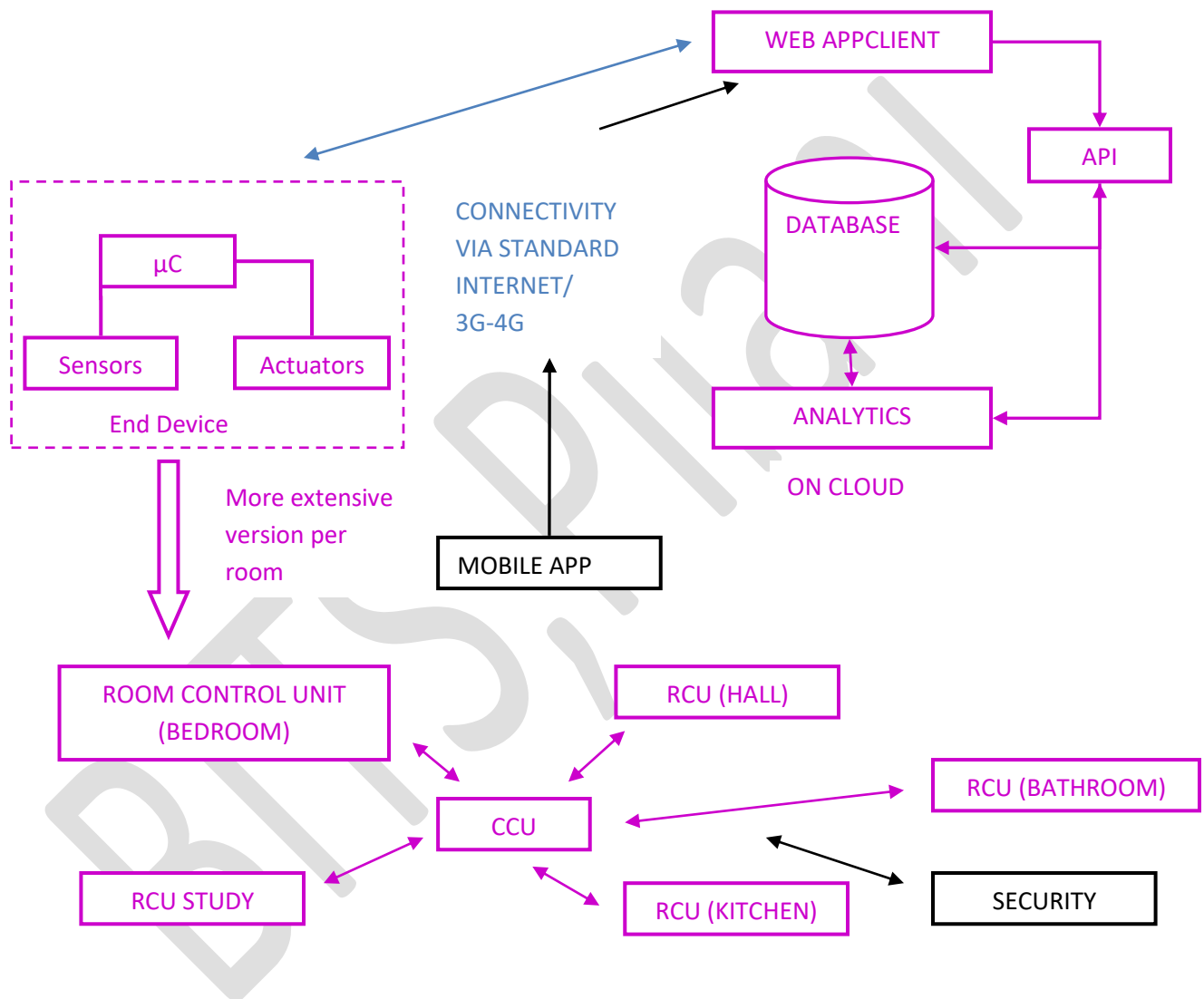
### Home Automation

Home Automation systems allow the remote monitoring and control of the home environment (e.g. humidity, temperature, luminosity etc.) manipulate HVAC systems and control their status with minimum user intervention.

The system architecture for smart homes must satisfy the requirements of measuring home conditions, processing instrumented data, and monitoring home appliances. One possibility is

to use micro-controller enabled actuators for monitoring home appliances and use PaaS and SaaS in cloud computing for processing data.

Apart from algorithm automation, devices can be controlled by the user to suit personal requirements using direct buttons, cell phone, internet or remote control

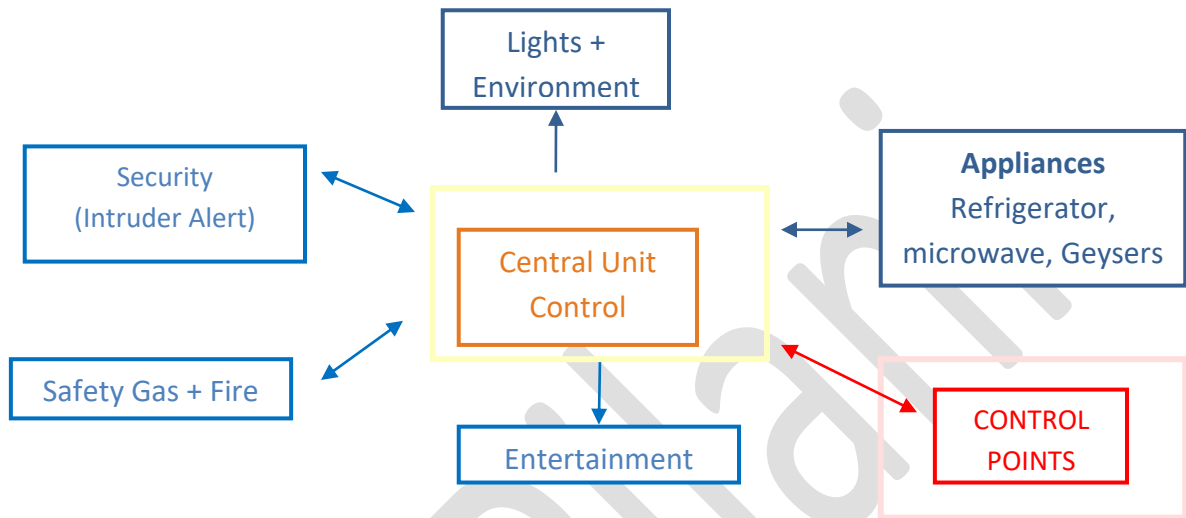


### Central Control Unit

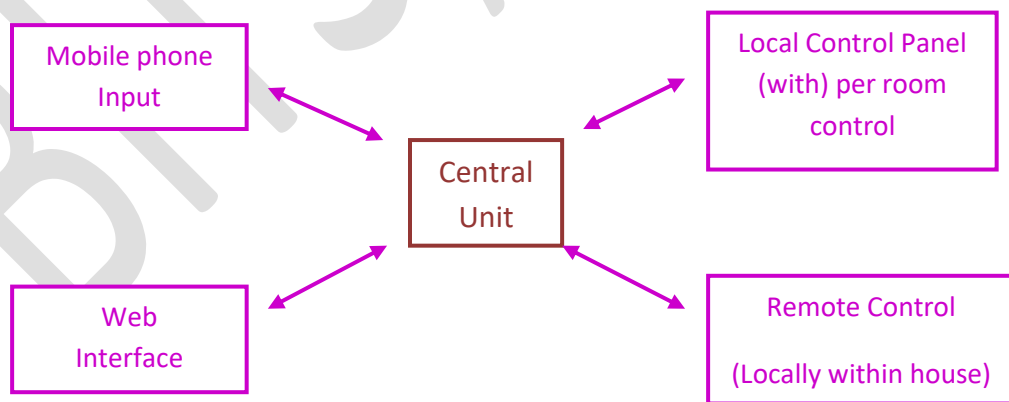
The CCU is the hub and brain of a home automation.

- Receives parameters sensed by room control unit and issues commands based on.
- Receives instruction from a remote observer via GSM/Ethernet to sense parameters from a certain room or control appliances in a certain room.

- Monitor power consumption and control devices based on power consumption costs (obtained via internet) thereby working on an energy budget. It can also be used to turn off appliances in order to protect them.
- Inform users when there is an intruder or an unexpected fault in the system.



A Basic Home Automation System



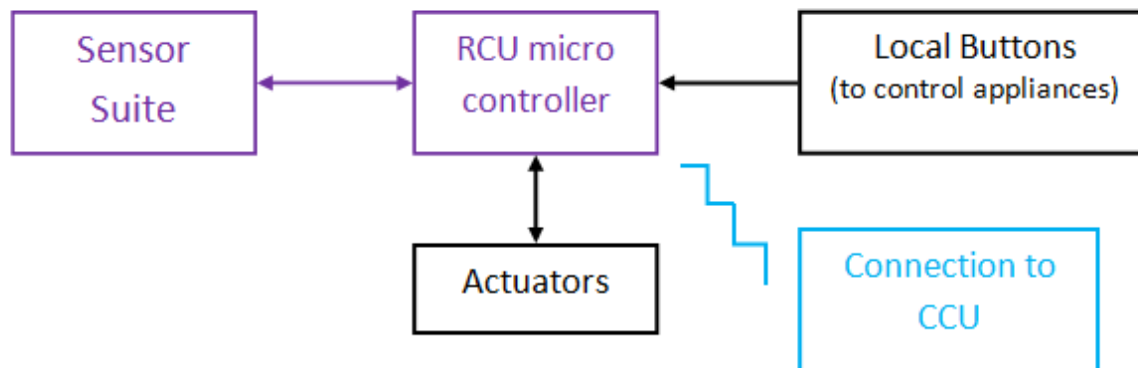
Control Points for home automation system

## Room Control Unit

A Room control unit controls the appliances inside a particular room. It has a set of sensors to sense the surrounding environment. Based on the current conditions, it can decide upon a course of action. Common features of a room control unit are:

- Monitor current conditions of the home environment and send to CCU.
- Receive instructions from CCU and control appliance.
- In case of security systems/ safety systems send alert to the CCU in order to take required action.
- Manage local buttons available – and a turn on/off appliances.

A typical RCU will have an architecture as shown in figure.



## Sensors

Basic home automation systems have the following sensors

- Temperature
- Humidity
- Light
- Proximity (Sensing presence of people)

for sensing environment inside the house. There are numerous manufactures for these systems. The sensors come with varying resolutions and interface – serial and parallel/ analog or digital.

The main issue with home automation is the whole spectrum of devices/ sensors/ actuators that are available.

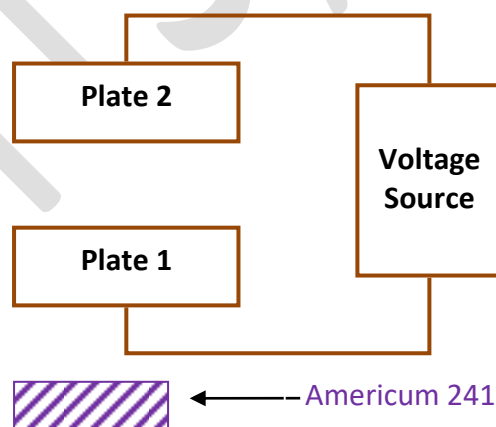
## Sensing system/ Sensors for Safety

Sensors for detecting Carbon Monoxide (In garages), LPG (especially inside kitchens), Smoke sensors (For fire safety in every room). The output of these sensors are usually compare against threshold values will have to be selected carefully as false alarms will have serious consequences.

Gas sensors can be conductimetric/ potentiometric sensors – where the output resistance varies based on the concentration of gases. Smoke and fire detectors can be used for fire safety in home automation. Smoke detector is a device that detects smoke, typically an indicator of fire. Most smoke detectors work either by optical detection (photo electric) or by physical process (ionization) there are some detectors that use both principles in order to increase sensitivity to smoke.

Photo electric smoke sensors work on the principal of a light sensor and a photo sensitive sensor arranged so that the rays from the light source do not fall onto the photosensitive sensor. When smoke particles enter into the light path, some of the light is scattered by reflection and refraction into the sensor. The light signal is processed and used to convey an alarm when it meets preset criteria.

Ionization smoke sensors: An ionization smoke detector uses a radio isotope such as americium-241 to produce ionization in air; a difference due to smoke is detected and alarm is generated. Inside the ionization detector there is small amount of americium-241. The radioactive element americium-241 has a half-life of 432 years and is a good source of alpha particles. An ionization chamber is shown in figure – two plates connected to voltage source



The radioactive material ionizes the air between the plates. Smoke particles entering the chamber reduce the conductivity in the chamber. It is alpha particles that cause ionization. The ionize the oxygen and Nitrogen atoms in the air of chamber. When smoke enters the chamber, it disrupts the current. The smoke particles attach to ion and neutralize them.

### **Intruder Alert Systems –Sensors**

The capability of these systems varies from DIY kits to high security systems that make use of cameras and alert systems.

A complete security system will include sensors placed at the doors/windows (that have auto lock), motion sensors and cameras.

When leaving the premises and arming the security system, all lights, air-conditioning/heating and appliances can be switched off. When the front door is opened – lights can be turned on when movement is detected on the stairs/ near windows etc. lights have to be turned on. Outside motion detectors in the garden or driveway can turn on outside spot lights and play a prerecorded warning messages. Alert to house owner/ security agency can be sent. The complexity of the system varies based on type and level of security.

Many home security systems also require voice/image recognition. They may have round the clock cameras based monitoring systems and remote locking facilities. Assuming even a very simple system for home security has sensors for motion detection and remote locking facilities. In case movement is detected – alerts to the house owner / security agency can be sent.

**Motion Sensors:** This is the 1-inch pin of the security system – as it is the main device that detects when someone is attempting to break-in. A motion sensor can use one or more multiple technologies to detect movement in an area.

#### ***Types of motion sensors***

**PIR (Passive IR)** – It detects body heat in surrounding area. Multiple sensors can be used for creating a protective grid. If an object creates too many grid zones and the infrared energy levels change rapidly, the sensors are tripped.

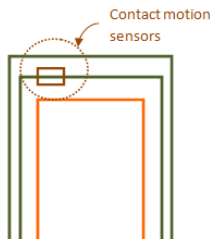
**Microwave sensors:** sends out microwave pulses and measures the reflection off a moving object. The advantage of these sensors is that they cover a large area. The disadvantage is their cost and that they are vulnerable to electric interference.

**Area Reflective Type:** Can use IR/ ultrasonic waves and measures the reflection off a moving object.

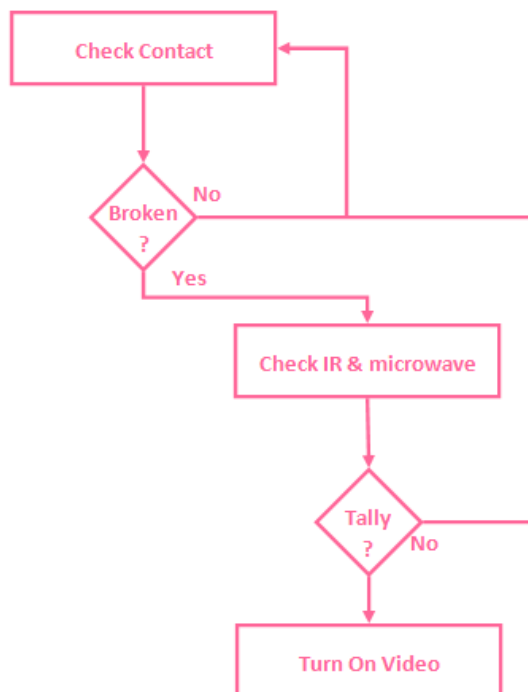
**Vibration Sensors:** Detects vibration, it uses a small mass on a lever when vibrations are detected – alerts are sent.

Image/ Video Sensors: Capture Videos/ Images of intruders. Main issue is storage and cost of these systems.

Contact Motion Sensors: These sensors are PIR. They are placed at the edges of closed doors or windows – when the door / window is opened these sensors detect motion and raise an alarm.



Sometimes a combination of these sensors can be used for intruder detection. For instance a combination of contact motion, PIR, Microwave and video sensors can be used. If the contact sensors detects opening of door/ window can enable PIR/ Microwave sensors to scan for intruder. If both sensors agree (this reduces error) the video/image sensor (camera) can be turned to record the intruder (this reduces storage requirements). Though this system will be highly accurate – the costs will be very high.



## Actuators in Home Automation System

Smart Home System – based on environment and user input various elements in a smart home can be controlled. Automatic turning on/off of appliances such as TVs, Refrigerators etc. Samsung has for instance developed SHP (Smart Home Protocol) to connect its home appliances product range and control it remotely.

Similar actuator/ relays can be used for open/closing doors sounding alarm etc. remotely in a home security system.

## Existing Home Automation System

Home Automation systems involves control and automation of

- Light, Heating (HVAC)
- Security
- Safety
- Control Home Appliances

There are a number of smart home solutions ranges from DIY systems to high end systems such as IBM Watson's smart home.

## IBM Watson Smart Home Solutions

This covers

- Home automation and convenience: This integrates all room environments and devices to enhance the user experience.
- Energy and cost Management: It allows the user the ability to analyze energy consumption and optimize it.
- Health and wellness: connected home sensors, IoT data and alerts can improve the health and wellness of residents and equip care givers, health providers and concerned family members with the tools and insights they need to monitor and care for residents.
- Safety and security: Combines capabilities such as video and audio, biometric sensors, presence detectors, leak detectors, and smoke, fire and air quality sensors to reduce the risk of accidents or security problem. The data collected can be use to alert resident, first responders etc. such that in case of disasters alerts are sent out.

IBM terms it as a cognitive environment – where the house knows the users schedule better than him. A home that unlocks itself when the user approaches and welcomes him with an ideal temperature, lighting and can even make a dinner suggestion. A demo project is underway at IBM's Hursley Campus in UK.



## Samsung Smart Home

Using Samsung smart home users can control various Samsung appliances – including ACs, refrigerator, washing machine, microwave oven, TV with an app installed on Samsung smart phone/ Smart TV/Gear.

IP based cameras can be used for monitoring activities inside the house. Also, location based services alert the system when you are close to your home and system queries the user on the desired temperature/ lightening condition. Remotely operated digital locks can also be used to unlock the house as you approach it.

The home is intelligent as it automatically adjusts the environment based on the mode you are in. If for instance you are in movie mode – it will automatically dim the lights, turn on surround sound. While you are watching the movie, it will alert you if the laundry is done, or inform you if anyone is at the door.

The system can also be controlled via voice controls.

Also, the Samsung system can perform Energy Management. For example, to reduce food wastage the fridge can automatically inform the user if it is already can automatically inform the user if it is already stacked with a type of food.

System also analyzes electricity consumption by various appliances in order to optimize energy consumption.

There are also companies such as honey well that only provide security solutions that provide the safety and security features of a smart home.

## Issues with Home Automation Systems

Other than solutions such as Samsung or IBM Watson's smart homes there are brand such as Nest, Hue, Honeywell, Yale, IRIS, Belkin, Sonos, korus etc. that individually control appliances such as A/C, lights, Locks, Cameras, garage, home audio, window shades in short anything connected to a common power source.

The issue is when they need to aggregate together and work at the same time. For instance, if a user gets a NEST thermostat, Philips hue lighting. Lutron switches, Sonos audio and Honeywell security – how will they work together – for instance if Philips lights have to be turned on – if Honeywell security detects an intruder. Two separate applications need to be integrated today.

Also each of these devices may work on a different wireless platform such as – Zigbee, Zwave, liron; Radio RAZ, wifi. The only option is such as scenario is to build one APP that integrates all these applications together.

Though home automation systems do not have any issues in terms of power consumption or other restrictions as a wearable system. Though security (network, software and hardware) is a major characteristic of the system there are many authentication, encryption, decryption, algorithms available that can be used in case of home automation systems, as there will be no issues in terms of size or processing power.

In terms of OS that can be used for home automation – as there is no issues in terms of form factors for these systems – the end devices can run full- stack Linux protocol stack and native remote systems can have IOS/ Android. The issue would be that different appliances may end up with different OS and middle were solutions may be required.

The main issue with home automation systems is the multiple off-shelf- solutions that may or may not be compatible with each other. This requires a common platform/ standard.

There are several open source platforms available such as:

*Cala OS* – full stack home automation platform, including a server application, a touch screen interface, web application, native mobile application on IOS/ Android with a preconfigured Linux OS to run underneath.

*Domoticz* – is a home automation system with a pretty wide library of supported devices, ranging from weather stations to smoke detectors to remote controls. It is designed with a html5 front end making it accessible from both desktop browsers as well as modern smart phones, and it is light weight.

*Home Assistant* – open source home automation platform, and is designed to be easily deployed on any machine that run Python 3. It integrates with a number of devices – allowing integration with weather information or Amazon echo to control locks or lights.

*Open HAB (Home automation Bus)* is one of the best-known home automation tools that supports a large number of devices. It is written in Java and is portable across most OS. Open HAB is devices or plugins to the systems. Open HAB also ships iOS and Android applications for device control and custom UI.

*Open Motics*: Open Motics is a home automation system with both hardware and software with open licenses – hence this suitable for designing a comprehensive solutions for controlling devices rather stitching solutions from different providers together.

These are not the only options available. Many home automation enthusiasts go with a different solution, or even device to roll their own. Some other potential options include: **Linux MCE, Pi Dome, Mister House or Smart homatic.**

## Home Automation System

The Home Automation System as can be seen from figure below is a Level – 5 IoT System.

