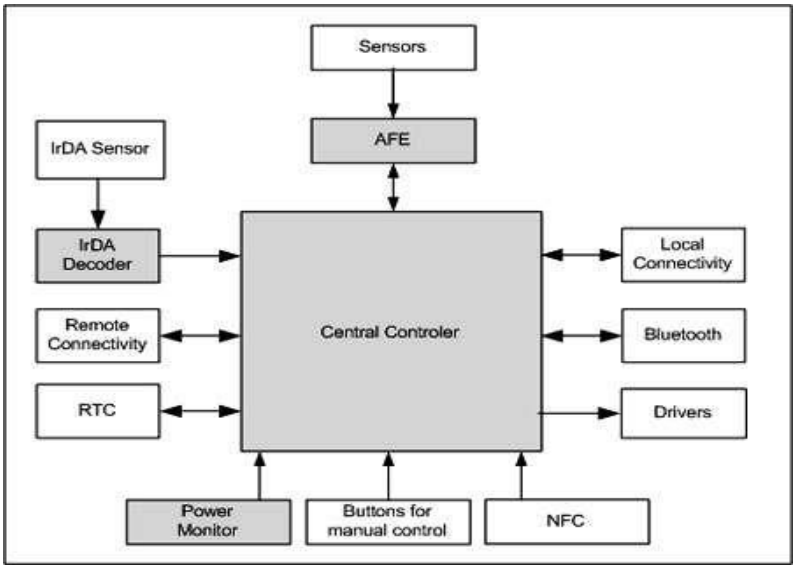
THE ARCHITECTURE OF A HOME AUTOMATION SYSTEM:

While there are several topologies to choose from, for the sake of simplicity we focus in this article on a star topology-based home automation system and its two types of control units,

1. **Central Control Unit**
2. **Room Control Unit**

CENTRAL CONTROL UNIT:



The Central Control Unit is the hub and brain of a home automation system. Common features of a central control unit are:

- Measuring the current environmental conditions using the various sensors and control the lights and fans of rooms accordingly
- Receiving instructions from a remote user over GSM or Ethernet and controlling an appliance in a specific room as per the received instructions
- Controlling appliances based on time, such as automatically switching off a television at a specific time

- Monitoring the current state of power and switch off appliances to protect them when a power fault is detected
- Informing remote users when an intrusion is detected or when some fault is detected in the system

This is the main unit responsible for monitoring the complete home automation system. It interfaces with other system blocks to perform required tasks. The most common interfaces on a CCU. Some of these interfaces are optional and are used as per the system and user requirements.

Different blocks found in a typical central control unit are:

SENSORS:

Sensors are the eyes of a home automation system. They "see" the environment and convert what they find into an electrical quantity that can be measured by a microcontroller or system processor. Basic home automation sensors include temperature sensors, humidity sensors, light sensors, and gas sensors. Data in the form of signals from these sensors can be used to control the various appliances directly without any human intervention. For example, lights can be automatically switched on upon sunset, an air conditioner can be switched off automatically when no movement is detected in the house for a half hour, or an alarm can be raised when the system detects an LPG leakage event.

ANALOG FRONT END (AFE):

Each sensor converts the change in a physical parameter such as temperature or light intensity to a similar change in electrical parameters such as resistance or capacitance. These physical quantities must be converted to a voltage equivalent so that the microcontroller can identify the variation in environment. For this purpose, an analog front end (AFE) is interfaced with analog sensors. The AFE preconditions output signals coming from the sensors by filtering out noise and providing required gain to the signals. AFEs are also required to calibrate the system for sensor readings, thus providing a base value for the system to identify any changes in the environment.

REMOTE CONNECTIVITY:

Depending on need and various design considerations, users may need to be able to control the system and appliances remotely. The two most common ways of doing this are using GSM-based mobile telephony and the Internet. GSM, Ethernet, or both

interfaces can be used to communicate with the system from a remote location. The system can also send or "push" useful information to users such as periodic updates, faults, intrusions, etc. These connectivity options generally require a serial communication protocol like SPI or I2C to communicate with the host processor.

LOCAL CONNECTIVITY:

The Central Control Unit and Room Control Units need to communicate with each other periodically as well as when events occur. There are multiple options available to establish communication between the CCU and RCUs that can be decided upon based on system cost and topology, including Bluetooth, RF transceivers, and XBEEs, among others. Each of these interfaces has its own pros and cons, hence system designers need to consider all of a system's requirements before selecting a particular interface.

MANUAL CONTROL:

In a typical home automation system, there are situations when the user needs to manually control one or more appliances. Keypads and/or infrared remotes are most commonly used to provide system control to users. Manual user control should be authorized by the system to prevent control of the system by an intruder and the shutting down of intrusion alerts.

REAL TIME CLOCK (RTC):

Home automation systems must be able to control appliances based on time. An accurate time source is required to control appliances using time-based settings. An external RTC can be used to maintain time for the system and the central controller can access it to receive current time related information.

NFC INTERFACE:

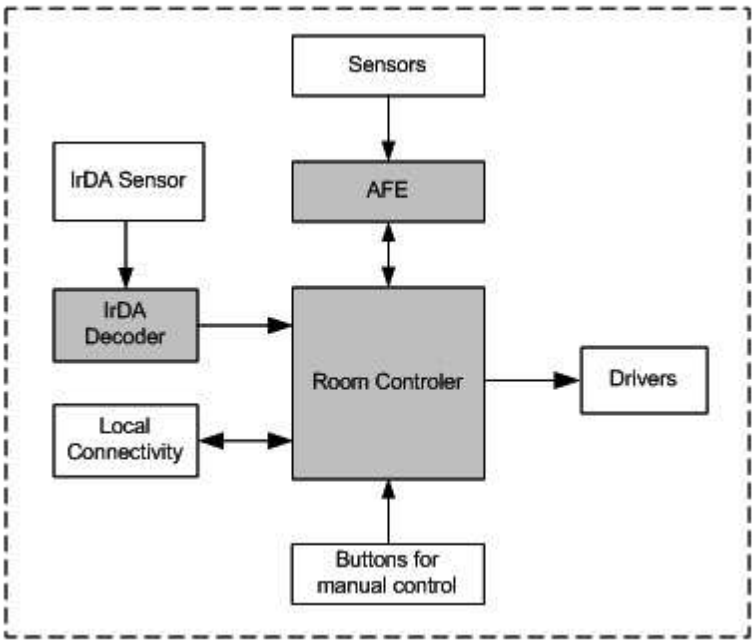
Near Field Communication (NFC) is used for close proximity communication. This technology is quickly gaining traction in embedded applications for communications and information sharing. It can be used to at the main door to lock or unlock the door using the homeowner's NFC-enabled smartphone.

POWER MONITOR:

In any house there are many electrical appliances that are sensitive to voltage fluctuations and need a reliable supply voltage within a specific range to work as expected. A power monitor block can be added to the Central Control Unit to check

the instantaneous power supply voltage. This block brings down the voltage level of power supply to a level where the system can monitor it using an ADC. Using input from this block, the controller can detect low voltage, high voltage, and voltage fluctuation situations. In extreme cases, this block can instruct RCUs to switch off sensitive appliances to prevent damage.

ROOM CONTROL UNIT:



A Room Control Unit controls the appliances in 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 the current environmental conditions using the various sensors and communicate this data to the CCU
- Receive instructions from the CCU and control appliances in the room as per the received instructions
- Control appliances based on inputs from a hand-held remote
- Control appliances based on inputs from user buttons

The room control unit is responsible for controlling the appliances installed in a particular room. This unit receives control commands from the central control unit and also from user buttons that can directly control appliances. The room control unit can also have various types of sensors built in to locally monitor the appliances in the respective room. If the RCU has an IrDA interface, the user can control appliances using an infrared remote. Optionally, if Bluetooth is used for local communication, then the user can control the system using a smart phone.

An RCU is an auxiliary unit responsible for monitoring local environmental conditions and controlling local appliances connected to the unit. RCUs are essential for a large house with multiple rooms. These units communicate the local environmental conditions to the central control unit, and also control the local appliances based on commands from the CCU. This unit interfaces with other blocks in the system to perform the required tasks. A block level diagram and description of an RCU.

BUTTONS:

These buttons are provided to directly control the appliances, enabling the user to directly switch on or off any appliance using a switch board. These buttons also serve as an emergency control panel in case the CCU system fails.

INFRARED SENSOR & DECODER:

These blocks provide an interface for commonly used, handheld infrared remotes.

RELAY DRIVERS:

The relays need ~100mA of current to activate, so relay drivers must have the required drive strength to power the relays. These also protect the controller from the inductive kick generated in the relays.