# Multiprotocol Gateway for Wireless Communication in Embedded Systems

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## ABSTRACT
Multiprotocol gateway is designed to act as the bridge between wireless protocols- RF, Bluetooth and Zigbee on one side and the GSM on another side. It will lead to an implementation of a *HOMOGENEOUS SYSTEM*, i.e. no matter the signal is received from any protocol it will be converted into GSM protocol. It will exploit the recent advances in Wireless Personal Area Network (WPAN). The devices of this network operate on different wireless protocols, in that case what if a person requires a single access point. Then integrating all these devices is nothing but a simple application that consumes the Multiprotocol gateway. We propose combining the capabilities of various wireless protocols (ZigBee, Bluetooth, RF and GSM) which are different by design and are optimized for different applications. The key to success will be in deploying the right wireless technology for the requirements of the application and avoiding the temptation of trying to make one technology meet all needs. Thus each manufacturer of WPAN devices needs only to concentrate on his particular device not about a gateway or any access point. The role of Multiprotocol gateway does not end by serving manufacturers only; it continues to Multiprotocol gateway users too. More importantly now they can monitor their devices through their mobile phones, even if they are at the other half of the globe, i.e. the *RANGE OF COMMUNICATION INCREASES.* Moreover, it helps to attain *MODULARITY*, i.e. any number of transmitters of any type can be added or removed, without affecting the functionality of the whole system.

## General Terms
RF, Zigbee, Bluetooth and GSM

## Keywords
Wireless protocols, WPAN, embedded systems, handshaking signals, homogeneous system, modularity.

## 1. INTRODUCTION
In recent times, various types of devices have used wireless technologies such as RF, GSM, Bluetooth and ZigBee, to give innovative means to embedded systems design. The interoperability among wireless protocols on embedded system devices can avail the user numerous functions that maximize the height of usability. Its realization will exploit the current advances in WPAN, wireless sensors and others areas. Nevertheless, nowadays there exist constraints about the choice of wireless protocol driven by the complexity,

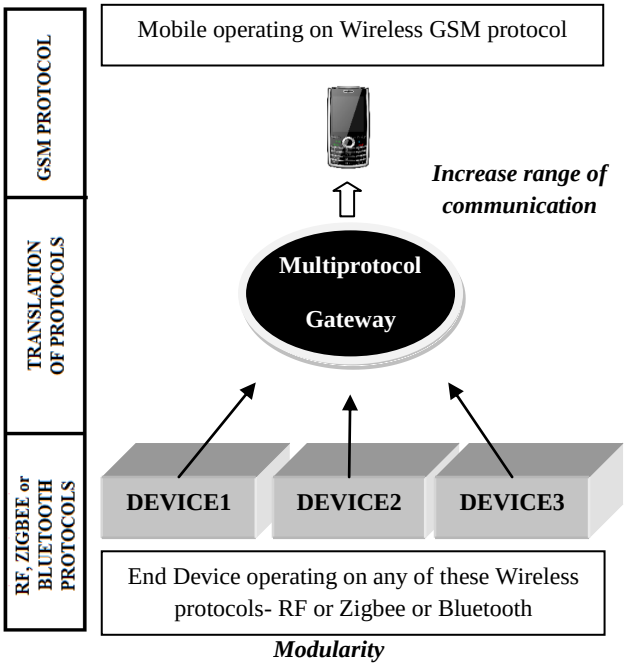


**Fig 1: Multiprotocol Gateway overall system architecture**

interoperability, transmission rate, and other circumstances. Bluetooth is clearly planned for short-range cable replacement for medium bandwidth device to device connections. The ZigBee specification defines cost-effective and energy-efficient mesh network. The GSM is used for the long range and fast communication.

We propose combining the capabilities of these protocols (ZigBee, Bluetooth, RF and GSM) which are different by design and are optimized for different applications. The key to success will be in deploying the right wireless technologies for the requirements of the application and avoiding the temptation of trying to make one technology meet all needs [1]. The main objective of this work is to design and develop a gateway which receives the signals from the various wireless protocols- RF, Zigbee and Bluetooth, and convert it into the GSM signal to achieve following functions (see Fig 1):

To design a HOMOGENEOUS SYSTEM, i.e. no matter the signal is received from any wireless protocol, it will be transformed into one GSM signal.

To INCREASE THE RANGE OF COMMUNICATION by changing signals received from every protocol into the GSM protocol, which has long transmission range.

To attain MODULARITY, i.e. any number of transmitters of any type can be added or removed, without affecting the functionality of the whole system. [2]

## 2. SYSTEM FUNCTIONALITY

See Fig 2. The main microcontroller acts as the heart of the gateway. It receives three type of wireless signals (RF, Zigbee and Bluetooth) using their corresponding receivers and save the data in its registers. It keeps on displaying the current status of all the transmitting devices on the LCD. The gateway can be placed in the building having numerous separate divisions. Where each division has some kind of sensors or devices, whose data has to be monitored at a central location [3], [4], [5]. All these devices are made to send their status by using wireless protocols. The Gateway will receive these signals and display the data on LCD. However, if the monitor is at far location, then he has an option to send a message to gateway. It will decode that SMS and if it matches with the pre stored code, then it will transmit the status of all the attached devices in the form of SMS to the monitor.

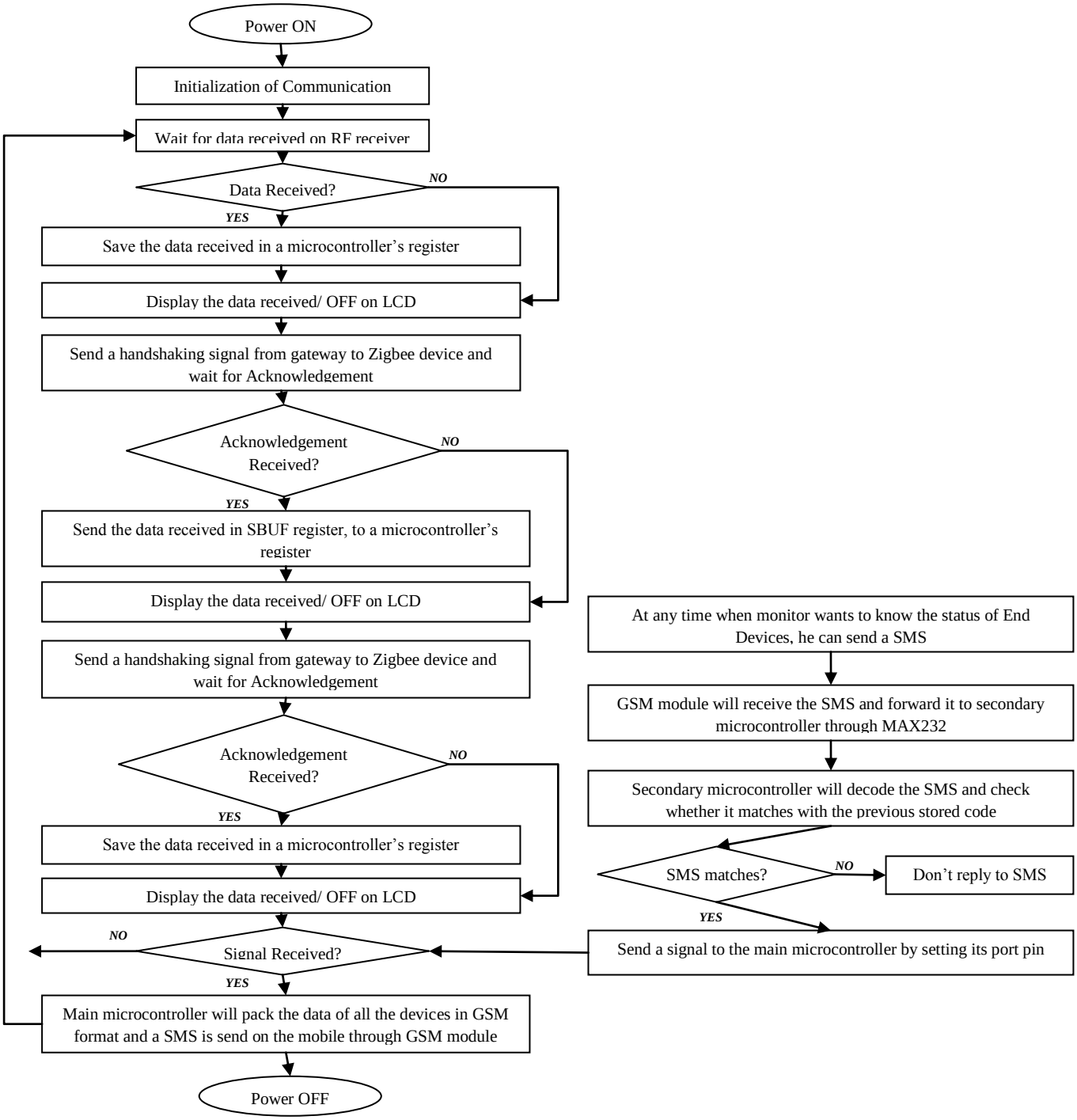


**Fig 2: Flow Diagram of System Functionality**

# 3. DEVELOPMENT ARCHITECTURE

## 3.1 Multiprotocol Gateway

Core functionality of multiprotocol gateway is to bridge the end devices working on different wireless protocols and GSM Mobile. Its architectural components can be seen in Fig 3. RF, Bluetooth and Zigbee receiving modules are attached at the receiving side. So that any signal of these types can be decoded. RF data [6] is converted from serial to parallel form using 8 bit decoder and applied to one of the ports of main microcontroller [AT89S52]. Zigbee [7], [8], [9] and Bluetooth [10], [11] modules are attached to RX pin of main microcontroller using a relay, in such a way that relay toggles between both the modules and receive the signal on either module on which it is present at that time. Main microcontroller processes the data and display the received signal on LCD; side by side it also transmits the data on GSM module [12] through MAX232. One secondary light weight microcontroller [AT89C2051] is used to reduce the work load on main microcontroller. This microcontroller receives the incoming GSM signal (SMS), decodes it, and if it matches with the code, then it sends the signal on one of the port pins of main microcontroller. Further the main microcontroller sends the data or current status of transmitter side devices to GSM module for transmission. The power supply unit is designed to provide 5V, 3.3V dc voltages to the system using a 230V ac input.

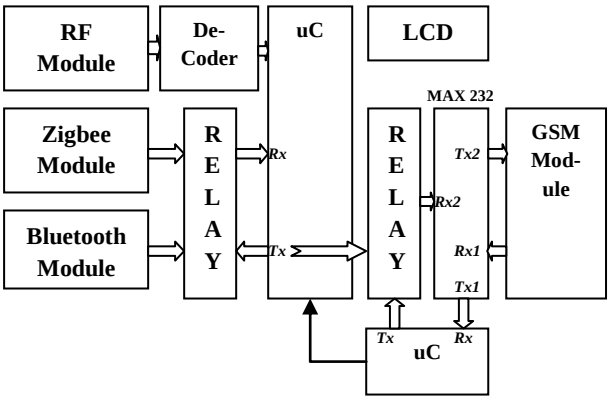


**Fig 3: Block Diagram of Multiprotocol Gateway**

## 3.2 End Devices

Three types of end devices are designed to attain the practical feasibility of the gateway. First device consists of temperature sensor. It acquires the data of temperature, converts it into digital format using 8 bit ADC and then processes the data using microcontroller. Further encodes it and transmits it using RF transmitter at 315MHz (see figure 4). Second and third device transmits the data of humidity sensor and smoke sensor respectively, using the serial transition (see figure 5 and 6). Both of these devices have the option to transmit either by Zigbee or Bluetooth using module select switches. This is done to attain modularity, i.e. any number of transmitters of any type can be added or removed, without affecting the functionality of the whole system. We can test the gateway for the combination of - Zigbee and Bluetooth or Zigbee and Zigbee or Bluetooth and Bluetooth.

# 4. CORE TECHNOLOGIES

GSM, ZigBee, Bluetooth and RF. Xlings was used for the embedded software development.

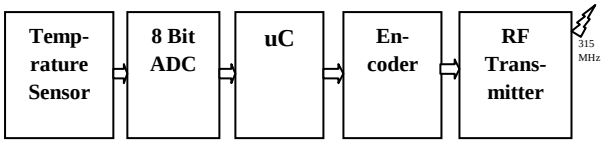


**Fig 4: Block Diagram of Device 1: Sends the data of Temperature sensor using RF Transmitter**

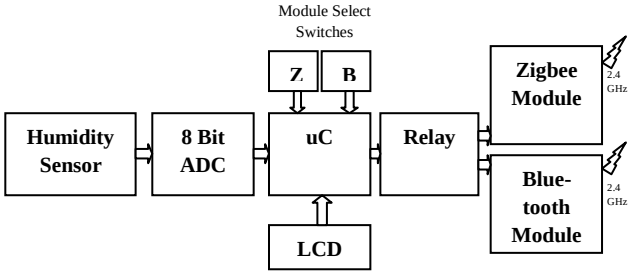


**Fig 5: Block Diagram of Device 2: Sends the data of Humidity sensor using Zigbee or Bluetooth Module**

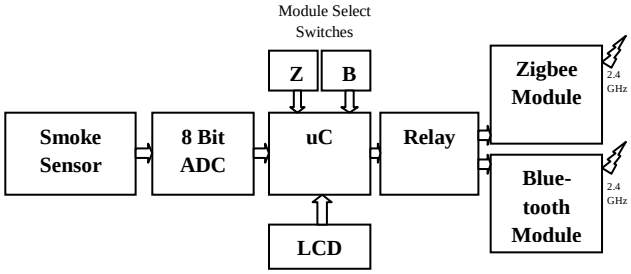


**Fig 6: Block Diagram of Device 3: Sends the data of Smoke sensor using Zigbee or Bluetooth Module**

# 5. MULTIPROTOCOL GATEWAY UNIQUENESS AND ROLE IN SUSTAINABLE AUTOMATION

In the modern era smart homes/offices/factories are getting popular. Every day more sophisticated systems are launched in the market, preferably with the remote accessibility. Like in remote controlled house different types of sensors may be used to record different values and all their data my be accessible using different types of wireless protocols. What if a person wants to use a single interface for all the devices?

Let's consider an example; a person buys a RF accessible Temperature sensor, Zigbee accessible Humidity sensor and Bluetooth accessible Smoke sensor. Now, that person needs to integrate these three devices so that he can use single interface for these systems. Now the problem occurs, how one can integrate these devices into one automated system when all these follow their own standards. This is where Multiprotocol Gateway comes into action. It provides a common standard for all manufactures.

Multiprotocol gateway introduces specification which allows any manufacturer to make his devices Multiprotocol gateway enabled: simply allowing the devices to communicate with Multiprotocol gateway. Thus each manufacturer needs only to concentrate on his particular device, not about a gateway or any access point. A single Multiprotocol gateway at a certain home/office will serve a number of devices which are manufactured by various manufacturers. Then integrating all these devices is nothing but a simple application that consumes the Multiprotocol gateway, which provides trusted services to access devices. That is how Multiprotocol gateway solves the issue of integration of multiple vendor specific devices into a single smart solution. The role of Multiprotocol gateway does not end by serving manufactures; it continues to Multiprotocol gateway home/office users too. More importantly now they can monitor these devices through their mobile phones, even if they are at the other half of the globe. Multiprotocol gateway mobile interface adds more worth by implementing the mobility to this smart monitor solution. It should be clear that Multiprotocol gateway is a bridge between the manufacturer and smart home/office user in the market of consumer electronics.

## 6. RESULTS

Table 1 shows the results obtained and the Fig 7 shows the pictorial view of the system. Three end devices are recording the values of room temperature, humidity and smoke. Device 1 records the value of room temperature i.e. 30 $^{o}$C, but the actual data of the room is 32 $^{o}$C. Device 2 records the value of room humidity i.e. 25%, whereas the correct value is 27%. Device 3 records the value of smoke present in the room i.e. 80% but the correct value is 79%. For analyzing the functionality of the Multiprotocol Gateway, the data of these three end devices are sent by using different wireless protocols. Device 1 is sending the data of room temperature using the RF transmitter. Device 2 and device 3 are sending the data of humidity and smoke respectively, by using either Zigbee or Bluetooth module. Different modes of transmission are selected to verify Homogeneity of the system (i.e. no matter the signal is received from any protocol it will be converted into GSM protocol) and Modularity of the system (i.e. any number of transmitters of any type can be added or removed, without affecting the functionality of the whole system). Multiprotocol Gateway translates all the wireless protocols on the receiver side to the GSM protocol at the output side. When the Monitor sends the SMS code to the gateway, it will reply the status of all the end devices attached to it in the form of SMS.

**Table 1: Results obtained**

| | Actual Data of Room | Data recorded by Sensors | Mode of Data Transmission | | | Homogenous System | Multiprotocol Gateway | Increased range of communication | Data received by SMS |
|---|---|---|---|---|---|---|---|---|---|
| Temp-erature | 32 °C | 30 °C | RF | RF | RF | | | | 30 °C |
| Humidity | 27% | 25% | Zigbee | Zigbee | Bluetooth | | | | 25% |
| Smoke | 80% | 79% | Zigbee | Bluetooth | Bluetooth | | | | 79% |
| | | | Modularity is attained | | | | | | |


**Fig 7: Pictorial View of the System**

## 7. FUTURE

The system will be presented for the acceptance of end device manufacturer's community, which would be a bigger challenge. Gateway can be designed to support large number of end devices in plug and play mode. On the monitoring side of the gateway, it can be connected to a central server and an internet application can be designed to access the end devices using the internet services.

## 8. CONCLUSION

Technically Multiprotocol gateway acts as bridge between various wireless communication protocols, as it translates the RF, Zigbee and Bluetooth data into GSM. But moreover this gateway is a vertical solution given to sustainable automation in home/office environments by bridging the side of manufactures and end users. This gateway will provide three features, firstly, to design a HOMOGENEOUS SYSTEM, i.e. no matter the signal is received from any wireless protocol, it will be transformed into one GSM signal. Secondly, to INCREASE THE RANGE OF COMMUNICATION by changing signals received from every protocol into the GSM protocol, which has long transmission range. Thirdly, to attain MODULARITY, i.e. any number of transmitters of any type can be added or removed, without affecting the functionality of the whole system.

## 9. ACKNOWLEDGEMENT

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