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ZigBee Technology

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Abstract: ***In this paper describes the design and implementation of a wireless smart home using ZigBee technology. The Microchip Picdem Z development kit hardware forms the base from which a network coordinator, temperature sensor and light sensor are designed. These devices were implemented directly on the Picdem Z board's prototyping area. We use Microchip's Stack for ZigBee, MPLAB IDE and C18 compiler to transport data between nodes. This interface allows a user to change the state of an appliance or view the current status of sensors from within the home or from a remote computer. Despite the fact that the local interface was not completed, remote control and monitoring. Analysis of the design shows that a star network topology is insufficient to provide coverage throughout a home. In addition, analysis shows that household sources of 2.4 GHz radiation do not prevent the network from functioning.***

1. Introduction

Over the last ten years, the impact of wireless communications on the way we live and do business has been surpassed only by the impact of the Internet.

Cell phones, pagers, and wireless Personal Digital Assistants (PDAs) have become so commonplace in our lives that it is easy to forget those ten years ago, they were a rarity. But wireless communications is still in its infancy, and the next stage of its development will be in supplementing or replacing the network infrastructure that was traditionally "wired" as well as enabling network infrastructures that previously could only be imagined.

From local coffee shops to commercial inventory control systems, within restaurants and throughout public airports, accessing central pools of information and communicating directly between users and among the devices themselves, wireless commerce is beginning to challenge the exchange system that our modern world currently embraces.

No longer are we restricted by the shortfalls of processing and battery power, operating system efficiencies, or heat dissipation within the small footprint of the mobile device. Rather, we are limited only by the practical application of these technologies.
How will we access information?

How will we integrate multiple hardware and software technologies?

Into intelligent and useable form factors, not all business models necessarily imply the use of a single terminal to supply the user with voice, video, and data services. Ergonomic factors may dictate that voice services are maintained privately while data exchange and video information is easily viewable from a specified distance, perhaps on complementary devices [1].

The market for mobile and wireless sensor network (WSN) services, adapted to the enterprise- and civil security customers, has been growing for the last 5-10 years. The stack is layer based, and previous work has covered the areas of MAC protocols and routing schemes [3].

2. Sensor Performance Characteristics

The following are some of the more important sensor characteristics:

- Transfer Function
- Sensitivity
- Span or Dynamic Range
- Accuracy or Uncertainty
- Hysteresis
- Nonlinearity (Often called Linearity)
- Noise
- Resolution
- Bandwidth

3. ZigBee technology

ZigBee is a new technology designed specifically for wireless low data rate control network and sensing applications.

There are a number of applications that can benefit from the ZigBee protocol, building automation networks, home security systems, industrial control networks, remote metering and PC peripherals are some of the many possible applications.

ZigBee has a maximum data rate of 250kbps while consuming only 30mA of current during transmission. The range of ZigBee devices varies from 5-500m but is typically around 50m [2].

A ZigBee network can support a maximum of 255 devices, a significant improvement over Bluetooth. Another benefit of ZigBee technology is the fact that it has a substantially smaller software stack (~32kb) than Wi-Fi or Bluetooth [8].

Table 1: Wireless technology comparison chart

Standard	Bandwidth	Protocol Stack Size	Stronghold	Applications
Wi-Fi	Up to 54Mbps	100+KB	High data rate	Internet browsing, PC networking, file transfers
Bluetooth	1Mbps	~100+KB	Interoperability, cable replacement	Wireless USB, handset, headset
ZigBee	250kbps	~32KB	Long battery life, low cost	Remote control, battery-operated products, sensors

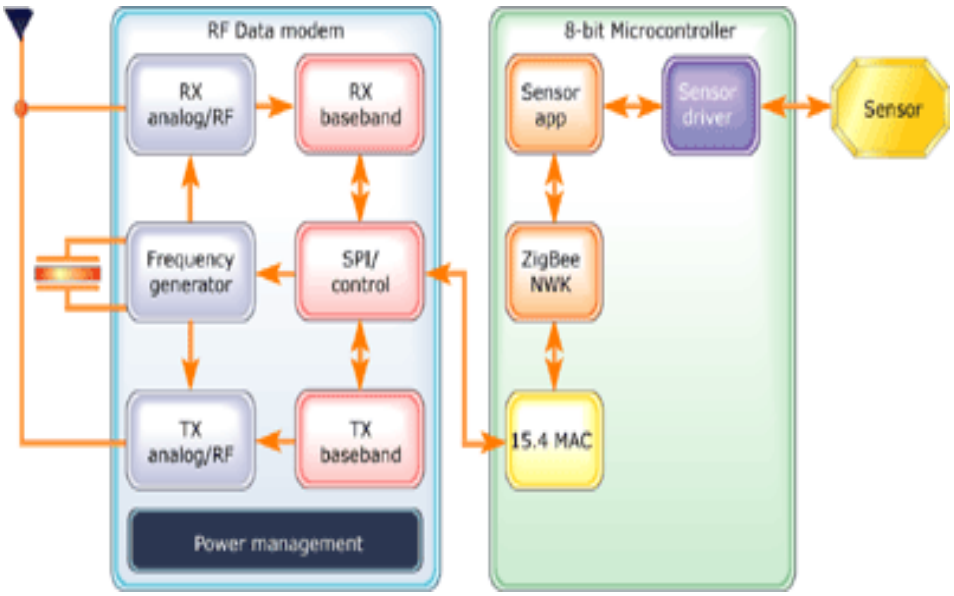

Figure 1: A typical ZigBee-enabled device

As Figure 1shows, a typical ZigBee-enabled device includes a radio frequency integrated circuit with a partially implemented PHY layer connected to a low-power, low-voltage 8-bit microcontroller with peripherals, connected to an application sensor or actuators [9].

Typical Application Areas

The typical application areas in which ZigBee provides a low-cost solution:-

1) Commercial Building and Home Automation: - Electronic control within a building or home can be implemented through wireless networks example applications are (heating, ventilation, air-conditioning, lighting, curtains, doors, locks and home entertainment systems.
2) Security: - Another important application within commercial buildings and the home is security – both intruder and fire detection [7].
3) Healthcare: This field employs sensors and diagnostic devices that can be networked by means of a wireless network[4]. Applications include monitoring during healthcare programs such as fitness training, in addition to medical applications such as patient monitoring.
4) Vehicle Monitoring Vehicles usually contain many sensors and diagnostic devices, and provide ideal applications for wireless networks. A prime example is the use of pressure sensors in types, which cannot be connected by cables.
5) Agriculture: - Wireless networks can help farmers monitor land and environmental conditions in order to optimize their crop yields. Such networks may require wide geographical coverage, but ZigBee addresses this issue by offering network topologies that allow the relaying of messages from node to node across the network [10].

This means that ZigBee devices can be operated by inexpensive and simple microcontrollers, translating into an overall lower cost than the above wireless alternatives [5].

Compared to other wireless protocols, the ZigBee wireless protocol offers low complexity, reduced resource requirements and most importantly, a standard set of specifications. It also offers three frequency bands of operation along with a number of network configurations and optional security capability [6].

The IEEE 802.15.4 defines three frequency bands of operations 2.4 GHz, 915 MHz and 868 MHz each frequency band offers a fixed number of channels.

4. ZigBee Protocol Terminologies

A ZigBee protocol profile is simply a description of logical components (devices) and their interfaces. There is often no code associated with a profile. Each piece of data that can be passed between devices, such as a switch state or a potentiometer reading, is called an attribute. Each attribute is assigned a unique identifier.

These attributes are grouped in clusters. Each cluster is assigned a unique identifier. Interfaces are specified at the

cluster level, not the attribute level, though attributes are transferred individually.

The following tables show a summarize of ZigBee protocol terminology.

Table 2: Attribute

• Represents a physical quantity or state
  ○ A switch value (State: on/off)
  ○ A temperature in degree
  ○ A percentage
• 16 bit attribute id
  ○ 0x000 for OnOff attribute
• Single data entity
• The units and data type are predefined
	Attribute
	Attribute Name: **OnOff**
	On: 0xFF
	Off: 0x00
	Toggle: 0xF0

Table 3: Cluster

• Container for a number of Attribute • Identified by a cluster ID • Mandatory Vs Optional • All attributes within the cluster must be supported	**Cluster** - OnOffCluster **Attribute** Attribute Name: **OnOff** On: 0xFF Off: 0x00 Toggle: 0xF0

Table 4: Device Description

• Description of a device that is part of a larger target application • Collection of clusters • Specifies if the clusters are inputs or outputs • 16 bits ID SRC:0xfffe	Switch Remote Control Device Description **O/P Cluster** - OnOffCluster **Attribute** Attribute Name: **OnOff** On: 0xFF Off: 0x00 Toggle: 0xF0

The profile defines the values of the Attribute Ids and the Cluster Ids, as well as the format of each attribute. The profile also describes which clusters are mandatory and which are optional for each device. In addition, the profile may define some optional ZigBee protocol services as mandatory.

The user can take these definitions and write his code to use them. He can write the code any way he wants, grouping the functions any way he wants as long as he supports the mandatory clusters and services, and uses the attributes as they are defined in the profile. This way, one manufacturer's switch will work with another manufacturer's load controller. Figure 4.3 shows graphically how the various terms relate to each other.

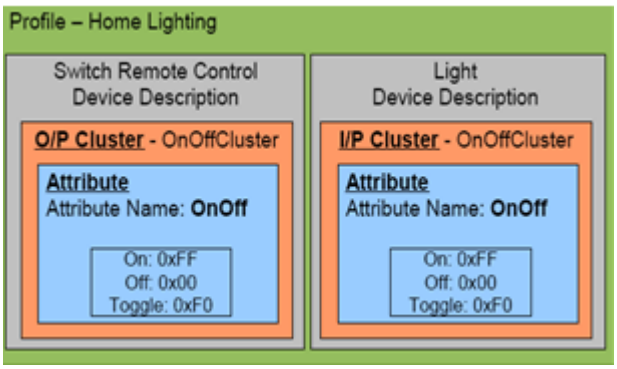

Figure 2: Device Profile

The Figure 2 shows two devices from Home Control, Lighting profile. Each has only one endpoint. The Light Controller has one input cluster on that endpoint. The Switch Remote Control has one output cluster and one input cluster on its endpoint. The switch could also be implemented such that the two clusters are on separate endpoints as shown in figure 3. Data flow is at the cluster level [12].

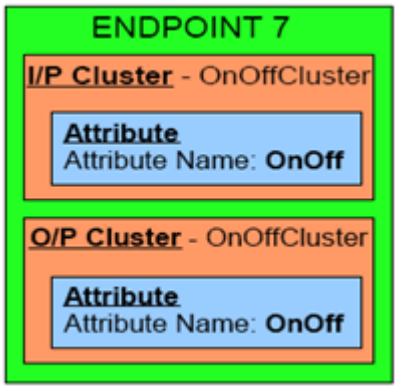

Figure 3: Endpoint

5. Data Transfer Mechanism

In a non-beacon enabled network, when a device wants to send a data frame, it simply waits for the channel to become Idle. Upon detecting an idle channel condition, the device may transmit the frame.

If the destination device is an FFD, then its transceiver is always on, and other devices may transmit to it at any time. This capability allows for mesh networking. However, if the destination device is an RFD, it may power down its transceiver when it is idle to conserve power.

The RFD will not be able to receive messages while it is in this state. This condition is handled by requiring that all messages to and from the RFD go through the child RFD's parent. When the RFD powers up its transceiver, it requests messages from its parent. If the parent has buffered a message for the RFD, it then forwards that message to the child.

This allows the child RFD to conserve power, but requires that the parent FFD have enough RAM to buffer messages for all of its children. If the child does not request messages within a certain time period (MAC Transaction Persistence Time), the message wills time out, and the parent will discard it. Called a binding link.

We have do some experiments like Interfacingthe different sensors to the wireless Network using ZigBee protocol.

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