

Catherine Runyan

L03/ Dr. Milor

Team: TableTop

ZigBee Wireless Networks

Introduction

Wireless data transfer has become an integral part of many technologies. As the number of applications has increased, so has the need for wireless networks tailored to meet different design constraints. ZigBee is a standard-based wireless technology developed as an open global standard to address the unique needs of low-cost, low-power secure wireless networks supporting low data rates. These devices have been used in everything from home automation networks to factory inventory tracking systems. This paper is a review of technology compliant with ZigBee specifications and the IEEE 802.15.4 standard for wireless medium access control and physical layer specifications for low-rate wireless personal area networks.

Commercial Applications

The ZigBee protocol can be directly embedded in any number of applications, and according to Oyvind Strom, Senior Director of Wireless Microcontrollers at Atmel Corporation, “provides a networking solution for small devices and wireless remote monitoring of sensors and simple input devices best suited for embedded applications in consumer devices [1]”. Core markets for ZigBee technology include consumer electronics, energy management and efficiency, health care, home automation, telecommunication services, building automation, and industrial automation.

One such application is energy modeling for buildings. A typical scheme proposed by the ZigBee Alliance includes a central station connected to different ZigBee devices gathering power consumption data related to different locations in a building [2]. The company SafePlug has taken ZigBee technology a step farther. SafePlug’s standard 120 VDC “SmartEnergy” receptacle includes power consumption monitoring capabilities, but can also identify RFID tags attached to appliances the receptacle is powering to monitor power consumption on an appliance by appliance basis. The “SmartEnergy” receptacle can limit the power per day or per month an appliance can use by turning off power to any receptacle the appliance is plugged into [3]. All monitoring and controls are possible by implementing a wireless ZigBee network.

ZigBee networks can reliably send data wirelessly between nodes. Since ZigBee is an asynchronous protocol, any node may transmit or receive data at any time, even a receptacle. The network automatically calculates how to route data from one node to another with the maximum chance of success. Over 200 companies make up the ZigBee Alliance responsible for establishing ZigBee's specifications, and many of these companies manufacture competing technologies. These manufactures include Atmega, Texas Instruments, Digi International, and Samsung.

Underlying Technology

ZigBee is a technology defined by standards, but implementing the technology requires compliant hardware and software. Per IEEE 802.15.4, ZigBee devices operate in the 2.4 GHz frequency band over 16 channels with a data rate of 250 kbps [4]. A network can support up to 65,000 nodes and multiple network topologies including point-to-point, point-to-multipoint, and mesh networks. These networks, offering 128-bit AES encryption, are considered secure and reliable [5].

A generic ZigBee end device might include an antenna, a microprocessor, a sensor interface, and a power supply. To process data received from these end devices usually requires an application programming interface (API) accessed from a central coordinator device.

Technology Implementation

Generally a ZigBee network consists of three types of devices operating on a wireless network: coordinators, routers, and end devices. One coordinator exists in each network. It starts the network and handles management functions as well as data routing functions. Routers help transfer data in large networks, but are non-essential in smaller ZigBee network implementations. These functions require that the coordinator and the routers have constant AC power, usually a wall plug. However, end devices are typically battery powered. The key to power saving in the ZigBee design is the end devices' ability to go into a sleep mode, consuming very little power while not actively transmitting data. Texas Instrument's CC2530 ZigBee chip, complete with a high performance microcontroller and a 2.4 GHz transceiver, requires a maximum of 29 mA in active mode, but in sleep mode requires as little as 0.4 μ A at 3.6 VDC [6]. Digi's Xbee ZigBee RF Module claims < 0.1 μ A in sleep mode [7]. Ultimately, a sensor functioning as an end device in a ZigBee network may last for years powered by a small battery.

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