# Low Cost Wireless for Embedded Applications

## Introduction

With the increasing pervasiveness of network aware embedded devices and a rising focus on intra-device communications, efforts have focused on introducing low-cost short-range wireless networking capability into the embedded space. To address this, a common solution employed is a Wireless Personal Area Network (WPAN), which provides low-footprint communications tailored to the requirements of embedded devices and additionally emphasizing ease of use. This technical review provides an overview of some commercially available WPAN hardware, briefly overviews the underlying technology, and explores details of implementation.

## Commercial Applications of Low-Cost Wireless

Devices in the embedded space are commonly subject to specific limitations, which must be accounted for in order to create an ideal WPAN implementation. Effectively integrating WPAN capability into an embedded device requires taking into account a restricted physical footprint, low energy consumption, and limited processing power. A very commonly employed brand is the XBee 802.15.4 line of point-to-point radio hardware by Digi International, which offers data rates up to 250 Kbps, low power draw at 215 mA during peak load, and is priced in the affordable range of $19-32 [1]. This and other XBee product families are generally accepted as ideal hardware for embedded wireless due to the wide range of available product configurations, which are capable of operating a variety of frequency bands, physical form factors, and WPAN architectures [2].

A competing WPAN implementation is the Bluetooth protocol, specifically the Bluetooth Low Energy (LE) technology targeted towards embedded devices. Similar to the XBee, Bluetooth LE aims to fulfill the goal of enabling low cost, low power wireless with a minimal physical footprint. Bluetooth LE also specifically aims to ensure interoperability with the large number of existing Bluetooth devices such as mobile phones, tablets, and computers. The Bluetooth LE standard specifies data rates up to 0.27 Mbit/s and peak current draw of 15 mA [3]. Bluetooth LE is still a fledgling standard and, unlike the XBee whose offerings include prototype-oriented through-hole mounting, the vast majority of commercial options are in the form of SMT chips to be directly installed in a target system [4]. Well-known chipmakers such as Texas Instruments price these devices in the vicinity of $6 [5].

**Underlying Technology behind WPAN**

While the available WPAN implementations may vary somewhat between each other, the underlying core principles are generally similar. Both the IEEE 802.15.1 (Bluetooth) and the IEEE 802.15.4 (Xbee/Zigbee) standards place an emphasis on ubiquitous ad-hoc communication between embedded devices, with low data rate networking servicing an area typically in the vicinity of 10 meters depending on the specific protocols in use [6]. In meeting these standards, WPAN implementations use point-to-point networking to allow devices to communicate with each other directly. An added benefit of this approach is that it does not require a centralized node, allowing devices to drop in or out of the network at any time without impacting other devices. In order to mediate multiple wireless device access to the same medium, each WPAN protocol utilizes separate signaling and physical layer implementations. In this regard, modern XBees communicate using Direct Sequence Spread Spectrum (DSSS) modulation on either the 868-868.8 MHz, 902-928 MHz, or 2400-2483.5 MHz bands. Bluetooth LE also operates on the 2.4 GHz band, and operates with Phase Shift Keying (PSK), Frequency Shift Keying (FSK), or Spread Spectrum (SS) depending on the implementation specifics.

**Building Blocks for Implementation**

Given the large number of available WPAN implementations available on the commercial market, it is practically guaranteed that an embedded system which requires wireless capabilities will be able to find a suitable match. As an added benefit to the embedded system designer, most WPAN implementations attempt to present data in a protocol-agnostic manner. As a result, the burden of effort shifts towards integration of the WPAN hardware into an existing system, and away from the specifics of the WPAN implementation in and of itself. Some hardware implementations, such as the XBee, utilize common protocols (e.g. UART) to facilitate communication to “external” devices such as a microcontroller unit (MCU). Hence, integrating wireless communications into an existing embedded system is as simple as ensuring interoperability with the specific protocol in use by the WPAN hardware.

# References


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