Comparison of 2.4-GHz proprietary RF and Bluetooth 4.0 for HID applications

By: Anitha TG, Applications Engineer & Sai Prashanth Chinnapalli, Applications Engineer Sr, Cypress Semiconductor Corp.

With the penetration of Wireless technology into the human interface device (HID) market, more and more sophisticated HID products are now coming out in the market with integrated wireless technology (wireless keyboards, wireless mice, etc). Often, developers are limited in their options: follow a popular wireless standard like Bluetooth or develop a proprietary protocol optimized for their application. While wireless standards provide the benefit of interoperability, they also introduce complexity and overhead that an application may not require, resulting in a higher system cost. On the other hand, proprietary protocol gives developers flexibility to customize applications at the expense of requiring developers to take on the development process.

The key RF requirements for selecting a PC HID are cost (the PC HID market is extremely cost sensitive), security, range, power consumption, latency, interference, co-location, and ease of use. In general, standards win in the market because of interoperability of the devices. However, in case of PC HIDs until 2009, only proprietary protocols have dominated the market. This can be attributed to the lack of any wireless standard optimized for the PC HID market in terms of cost, power and efficiency. With the advent of Bluetooth Low Energy Wireless technology aimed at low power applications, we can foresee a new wireless standard occupying the PC HID market. This article compares the Bluetooth 4.0 Wireless technology with the proprietary protocols in the HID market.

Proprietary RF solution

To get a reliable communication link in the 2.4 GHz RF Band, proprietary RF networks make use of their own protocols. A network operates in quiet channel to ensure that the bridge receives packets from nodes. If the channel becomes noisy, the network will hunt for a clean channel and settle there to resume with successful transmissions. If hardware supports Direct Sequence Spread Spectrum (DSSS) transmission, the protocol switches to this mode when interference is detected before starting to hunt for a quieter channel. As these protocols do not follow any IEEE standards, they are computationally light weight and optimized for specific applications with respect to power consumption and packet overhead.

Low Energy Bluetooth

Bluetooth wireless technology is a short range communication system intended to replace the cables connecting portable or fixed electronic devices and is an established IEEE standard. There are two forms of Bluetooth wireless technology systems: Basic Rate (BR) and Low Energy (LE). Both systems include device discovery, connection establishment and connection mechanisms. The LE system includes features designed to enable products that require lower current consumption, lower complexity, and lower cost than BR. The LE system is also designed for use cases and applications with lower data rates and

has lower duty cycles. Devices implementing both systems can communicate with other devices implementing both systems as well as devices implementing either system.

Cost

The Wireless HID market is extremely cost sensitive. Wireless HID product developers are often concerned about selecting a cost-effective microcontroller as the RF Baseband controller for their application. The same microcontroller also needs to have enough Flash to hold the wireless protocol stack. As Bluetooth LE is a standard, the code size is far greater than proprietary protocols and increase cost because of the amount of extra Flash required. The Wireless HID market was dominated by proprietary protocols because of their light-weight protocol stacks. However, these proprietary networks also require an external bridge to be connected to the PC/Host so that they can talk to the other devices in the network. As Bluetooth is an established wireless standard, most of the PCs, mobile phones and other hand-held devices with high processing capabilities will have an integrated Bluetooth bridge with dual mode support (BR and LE support) in the future which eliminates the need for an external bridge. The key to Bluetooth LE, unlike the Bluetooth that we're all used to today, is its "always-off" technology. This allows designs implemented with Bluetooth LE to achieve years of battery life through the use of small coin-cell batteries. As Bluetooth is a standard maintained by the Bluetooth SIG (Special Interest Group), any Bluetooth compliant device should be qualified by this certification board, incurring further development costs.

Power Consumption

Proprietary RF chip manufacturers do not fully disclose power consumption on datasheets. They specify that the power consumption depends on the duty cycles. Developers must therefore obtained their own power consumption data using experimental board set-ups and their respective firmware test environments. As power is the main concern in wireless HID market, the Bluetooth low energy standard specifies that an application should not consume more than 20mA of peak current and 15mA in coin cell applications for a maximum of 3 ms data transfer. Devices using Bluetooth low energy Wireless technology will consume a fraction of the power of other Bluetooth-enabled products. In many cases, products will be able to operate more than a year on a button cell battery without recharging. In this way, it is possible to have, for example, small sensors operating continuously and communicating with other devices like a cell phone or PDA. Small devices like watches and sports sensors based on a stand-alone Bluetooth low energy implementation will enjoy many low-power consumption advantages. Dual-mode implementations, supporting Bluetooth and Bluetooth low energy, will use parts of the existing

Bluetooth hardware, sharing one physical radio and antenna. Dual mode implementations will basically keep the same power consumption as classic Bluetooth technology.

Reliability and Security

The ability to resist interference from other technologies sharing the same frequency band is extremely important as this also impacts end-user performance. Robustness to interference in the 2.4-GHz world means the ability to reliably co-exist with 802.11b/g, Bluetooth, WirelessUSB, and a host of cordless phones and microwave ovens. Only an intelligent coding scheme with a good channel hopping methodology can ensure data reliability. While some radio devices like the CYRF6936 can employ DSSS (Direct-Sequence Spread Spectrum) along with FHSS (Frequency-Hopping Spread Spectrum) transmission schemes, Bluetooth LE uses only adaptive frequency hopping technology common to all versions of Bluetooth technology. DSSS ensures data robustness while FHSS allows the wireless signal to hop to new channels once interference becomes too great. Lack of DSSS in Bluetooth is also a drawback compared to proprietary protocols as proprietary RF can co-exist in noisy environments without having to hop to a quieter channel. Bluetooth LE offers full AES-128 encryption to provide strong encryption and authentication of data packets. At the same time, this also consumes a considerable amount of packet overhead. To ensure a reliable and secure system, it is the developer's discretion to adopt an existing proprietary protocol or a standard like Bluetooth based on the hardware capabilities of the device and the security level requirements of the application. For applications such as wireless mice, for example, little if any security is required.

Range

Wireless HID applications usually communicate within a short range and hence the need for a range of more than 10 meters is very rare. If the desired range of communication is more, the power consumption level of the device will also increase. While proprietary RF protocols claim to support longer range with the help of external power amplifiers, Bluetooth LE spec suggests a possible range of over 100 meters.

Speed/Throughput

Bluetooth LE supports an over-the-air data rate of 1Mbps which is sufficient for wireless HID applications. However, application throughput is only 256 kbps due to overhead. Proprietary protocols have the advantage of limiting packet overhead as per application requirements and hence may be able to support higher throughput. For applications like gaming mice, audio applications, and touch applications which require an effective throughput of greater than 250 kbs, implementing Bluetooth LE will fall short of proprietary standards.

Topology

Most Wireless HID applications require either a point-to-point network (i.e., wireless keyboard or mouse) or a star network (i.e., sensor networks). Proprietary protocols optimize the protocol for a particular topology. Depending upon the targeted microcontroller and the methodology of addressing a slave device in the system, the number of slave devices that can be connected in a network is limited. Bluetooth LE technology is optimized for one-to-one connections while allowing one-to-many connections using a star topology. With the use of quick connections and disconnections, data can move in a mesh-like topology without the complexities of maintaining a mesh network. For example, a user using an integrated Bluetooth BR/LE Phone can record the pulse rate from a wrist watch, burnt calories value from his shoes, and outside temperature from his cap when all these appliances are integrated with Bluetooth LE.

Certification

The Bluetooth Special Interest Group (SIG) is the body that oversees the development of the Bluetooth standards and licenses Bluetooth technology and trademarks to manufacturers. To become a licensee, a company must become a member of the Bluetooth SIG. The SIG also manages the Bluetooth SIG Qualification program, a certification process required for any product using Bluetooth wireless technology and a pre-condition of the intellectual property license for Bluetooth technology. The main tasks for the SIG are to publish the Bluetooth specifications, protect the Bluetooth trademarks, and evangelize Bluetooth wireless technology. An overview of the qualification process, including steps of the Qualification Process and Qualification Types and Fees, is available on the Bluetooth SIG public portal. In case of proprietary protocols, many manufacturers provide the qualification specification nearly free of cost so that product developers can qualify the protocol at their end to minimize development expense and time.

Applications

Any application can easily make use of a proprietary RF given the ease of modifying the protocol. IN this way, applications can be modified to adapt to their environment by changing power output levels, activating a more robust means of communication, or by moving to a quieter environment to communicate.
In a market full of narrow, local, proprietary connectivity solutions, Bluetooth low energy technology differentiates itself through its:

* Ease of implementation and multi-vendor interoperability
* Ultra-low peak, average and idle mode power consumption
* Low cost of integration
* Power handling
* Resistance to interference

Bluetooth Low Energy technology extends the personal area network (PAN) to include Bluetooth enabled devices that are powered by small, coin-cell batteries. With low energy technology, sports and health care equipment, human interface (HIDs) and entertainment devices are enhanced. The technology can be built into products such as watches, wireless keyboards, gaming and sports sensors, which can then connect and communicate with to host devices such as mobile phones and personal computers.

The other hallmark features of Bluetooth LE include low cost and greater range. Since new Bluetooth LE chips are so small and inexpensive, this expands the feasibility of implementing them into everyday consumer products. For example, devices can be inside the sole of a shoe to track a person's speed, distance, pace and other statistical information. By utilizing a low power wireless standard like Bluetooth LE chip embedded in the sole, the battery life of these new chips exceeds the average life span of a pair of running shoes.

Though Bluetooth LE looks like a promising technology for many applications, there are certain concerns that the industry needs to address before adopting this technology for HID applications. Certainly there is the advantage of eliminating the need of external bridge. However, there is the question of when the electronics industry will be ready with integrated dual mode Bluetooth radios. Integrating a dual mode/single mode Bluetooth radio into hosts also raises the question of co-existence with WiFi, WiMax, Classic Bluetooth, and other 2.4 GHz technologies. This could be a major challenge for the developers to provide the complete solution. Until then, a short-term solution could be having an external bridge shipped with the PC. As Bluetooth LE is still in the development phase, the profiles for all applications are not finalized. This will impact the penetration of Bluetooth LE into the wireless HID domain for a considerable length of time.

Although Bluetooth is a standard protocol, it is not free from drawbacks in its binding methodologies. For example, imagine a classroom environment where many students are using Bluetooth mice and all of them try to get their mice bound at the same time to their respective PCs. Cross binding may occur with one mouse talking to another PC instead of the one to which it is intended to bind. Proprietary protocols like the ones offered by Cypress Semiconductors avoid these issues by using KISS (Keep It Simple Solution) bind, Manufacturing bind, and Auto binding techniques. Developers need to implement similar binding methodologies if they are targeting Bluetooth LE for these sorts of HID applications.

Like any product, adaptation is a vital component to success. With its low cost and low energy usage, Bluetooth LE seems to be a good competitor in the wireless HID market. However, while Bluetooth LE is enticing many companies to enter the wireless HID market, Bluetooth LE cannot succeed until it competes and implements better features than what proprietary protocols have been successfully implementing over the past decade.

Cypress Semiconductor
198 Champion Court
San Jose, CA 95134-1709
Phone: 408-943-2600
Fax: 408-943-4730
http://www.cypress.com