Getting the Best Bite from Bluetooth

The move towards application specific embedded processors.

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Bluetooth technology has started down the road to ubiquity. Within a year, Bluetooth wireless interconnectivity will be a standard feature in new PCs, printers, PDAs, pagers, mobile headsets, and more. Within the decade, Bluetooth will be pervasive in new vehicles and aircrafts; in houses, hospitals, nursing homes and factories; in the hands of meter readers and delivery personnel; in game sets and stereos &#151 in fact, any place where there's a need for devices to talk to each other over a short distance without a cumbersome clutter of wires.

Bluetooth market penetration is being driven by the availability of cost-effective Bluetooth embedded modules. These modules have evolved from early thin modules into today's fat modules containing highly functional software stacks. Currently, the trend is towards developing application-specific modules that are custom tailored to particular cost and application needs. This article offers suggestions on how designers and product developers can take advantage of the current development thrust and leverage the creative potential of Bluetooth for a vast range of unexplored applications.

Bluetooth 101

Bluetooth enables devices to talk to each other by means of a low-cost transceiver chip that transmits and receives in the 2.45 GHz band. For example, a Bluetooth port embedded in a host computer would enable printers, laptops, bar code readers, and other peripherals with their own Bluetooth device to link to it wirelessly, without additional redesign. It is important to note that, with today's Bluetooth modules, there is no need to apply native processing resources to wireless communications. Communication processing can be done on the embedded Bluetooth module to keep from degrading the performance of the host device.

Thin to Fat

The first Bluetooth modules were thin and consisted only of an RF chip and antenna packaged with a baseband chip/host controller and interface software. The

subsequent-generation of Bluetooth modules are fat in that a microprocessor and an upper layer Bluetooth software stack residing in ROM or Flash memory is added. The designers of these modules have to be very conscious of power requirements in their choice of a microprocessor. Fortunately, there is no need for a lot of processing power (MIPS) in most Bluetooth scenarios and designers can select relatively low-powered processors such as an inexpensive 16-bit or 32-bit RISC processor.

Basic Design Considerations

There are numerous decisions to be made when designing Bluetooth into a given application. The most basic consideration from an RF standpoint is the location and function of the device(s). Will it reside in a closed or relatively open space? For example, will it function in a truck, car or plane, or will it be in an office, home, store, shop floor, or even out in a field? How far physically will the remote device be from the printer, cash register, router, or other host device? How many registers, routers, and printers will there be in the environment? How will they be oriented?

Do you need a bonded or a promiscuous link? For example, is the printer controlled by one person or a community of users? Is the wireless application merely one of cable substitution, or is this a remote data access or sophisticated ad hoc networking application?

How critical is speed? Some applications don't necessarily need rapid transfers of information, but others do. The amount of data being transmitted and the nature of that data is a critical consideration. Finally there's the issue of power. Do you need Class 1, 2, or 3? Will the host device run off a car battery, a photocell, or an AC outlet?

To keep costs low and effectiveness high, Bluetooth modules have to be matched carefully to the opportunity.

Providing a Unique Personality

When these issues are thoroughly worked through, a designer can begin evaluating Bluetooth profiles to see how they add functionality and reduce costs.

The Bluetooth specification defines different profiles that can be used to add functionality in order to help tailor a module to an application. Originally, 13 profiles were approved. This has now doubled and new profiles are being added all the time. Some of the more popular profiles include TCP/IP dialup networking, AT modem commands, object exchange (OBEX), Server Discovery Profile (SDP), fax, Hard Copy Report Profile (HCRP), image printing (BIP), voice processing, USB, and serial transfers between &quotdumb&quot devices.

It is possible to load a module up with a lot of these profiles, but there is a practical

limit because the code takes up flash memory and ramps up the cost. Hence a module's specific personality is custom tailored to the job through a careful selection of profiles or the use of only a single profile.

Application-Specific Modules

Application-specific modules are embedded Bluetooth modules that take advantage of a unique application software stack, including specific Bluetooth profiles to present tailored personalities. They differ from fat modules in that they provide a more cost-effective and flexible hardware platform for leveraging the versatility inherent in the range of Bluetooth profiles. (See Figure 1)

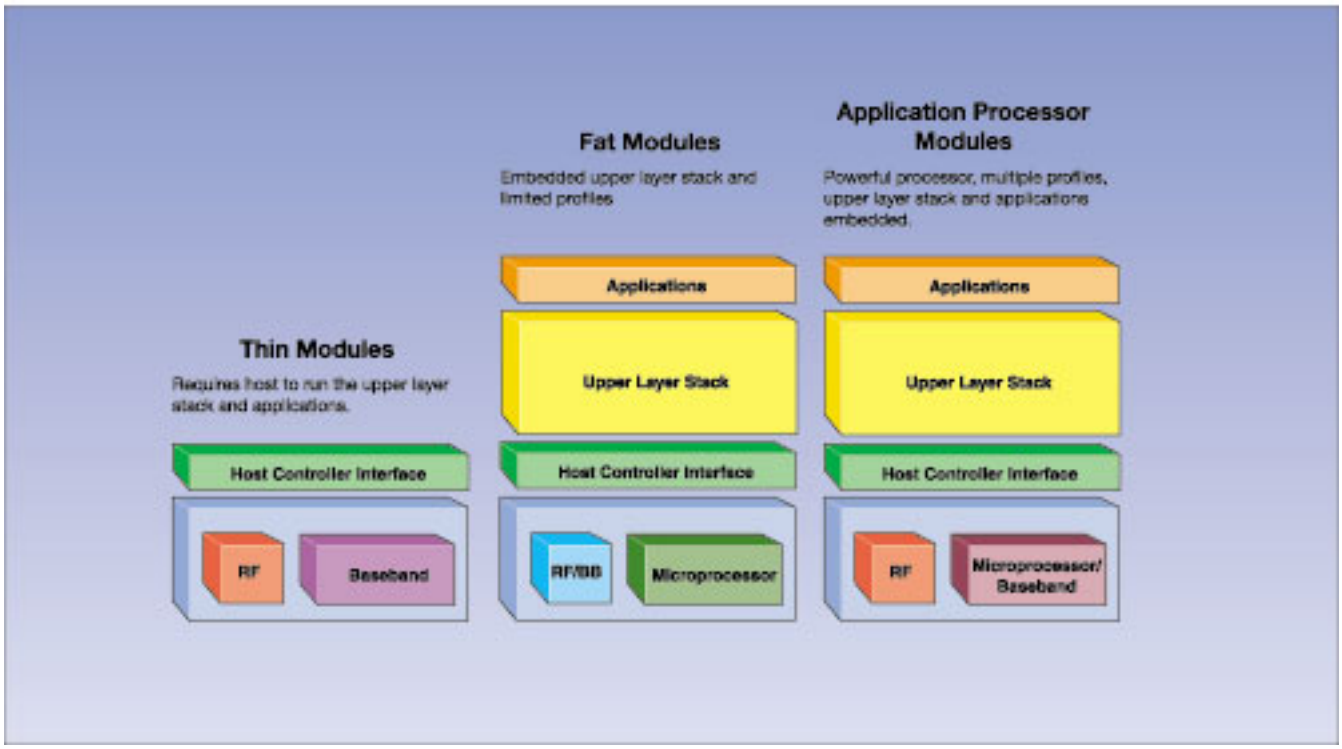

Figure 1. This illustration shows the migration from Bluetooth's original and simplistic design to today's more sophisticated application specific modules.

Physically, an application-specific module is a fat module with just two chips. One chip contains the microprocessor along with the baseband and host controller functions. The second chip is the RF chip. This saves on indirect costs (e.g.: real estate) and also direct costs.

As discussed, there is already a myriad of Bluetooth opportunities and many more in the wings that are as yet unexplored. To keep costs low and overall effectiveness high, Bluetooth modules have to be matched carefully to the opportunity. There really is no one-size-fits-all solution. Conventional fat modules can support Bluetooth profiles, but do so in a larger and less flexible form factor. Application-specific modules can replace applications currently addressed by fat modules, can go places where fat modules can't, and will keep costs down.

Finding the Ideal Fit &#151 Now and for the Future

Over time, the cost effectiveness and versatility of application-specific Bluetooth modules will enable them to proliferate through many types of wireless devices. Imagine a handheld remote control that automatically takes on the characteristics of whatever device you want it to control. What would be needed is an application-specific Bluetooth module in each machine: your CD/DVD player, TV, security systems, lights and so on. A single remote control would display an icon for each machine and tapping on the appropriate icon would enable the remote to communicate with the desired device. (See Figure 2) What happens next is the interesting part.

Figure 2. This is a conceptual example of how a PDA could be used as a remote control to communicate with various Bluetooth-enabled devices.

When you tap on the DVD icon, for example, a tiny application that is embedded in the DVD player's Bluetooth module is sent wirelessly to the remote. The remote accepts the application, which then tells the remote the DVD player-specific command icons to display. Essentially, the application informs the remote that "this is the world you need to conform to at this moment and here are its characteristics." The modules in each machine are application-specific, but the remote is generic and can take on the characteristics of any type of device.

A similar scenario can play out in vehicles where the increase in electronic devices has resulted in a cabling nightmare. As automobiles become &quotBluetoothed,&quot a single wireless appliance can command a variety of Bluetooth-enabled systems, from the climate control system to the CD changer to the Internet radio receiver. Different audio signals from the latter systems can also be sent to wireless headsets, so each passenger can enjoy their own entertainment programs.

The application-specific embedded modules that drive these and other scenarios

play host to the Bluetooth profiles that make the applications possible. Fundamental profiles such as file transfer and network gateway form the base, to which can be added profiles for broadband Ethernet, audio and so on as the particular application dictates.

Application-Specific RF

From an RF standpoint, the RF sector of each application-specific module should be considered as application specific as the rest of the module. Because antennae have their own characteristics and radiation patterns, RF designers possess considerable power to precisely match antenna performance to a Bluetooth application.

We've already mentioned how space, distance, and orientation are factors in optimizing a Bluetooth implementation. Whether the device is mobile or static is also an issue. How far from the truck might the gas meter reader have to go? How far from the monitor might a nursing home patient be? If the application functions on a factory floor, in a store, or out on the street, an extended antenna is likely required. Consumer devices such as stereos can probably use an embedded antenna. A PDA or pager, on the other hand, requires an omni-directional antenna.

After these basic factors are considered, creativity starts to heat up. Do you make the antenna a component or a trace? How do you best get it out to the edge of the device? Can it be layered on the RF shield or some other component? It's already clear that the growing popularity of Bluetooth will drive ever more creative solutions.

Conclusion

Bluetooth has attracted attention because it is an efficient and low cost wireless technology. Its ultimate success in the marketplace hinges on providing flexible new functionality &#151 both for existing and for yet unknown applications &#151 at a progressively lower cost. The question is, what functionality does your application require?

Do you want a device that synchronizes its data with your PC as you talk on its integrated phone? An application-specific Bluetooth module can be custom tailored to do the job effectively and cost-effectively. Do you want to route heat sensor, meter, or bar code readings to a host? A module can be tailored for that as well.

What needs to be remembered is that there is no one perfect Bluetooth fit. Rather, the advent of application-specific Bluetooth modules enables designers to carefully and creatively configure the most viable Bluetooth module for a given wireless job. Thus there is a multitude of perfect fits-as many as there are applications.

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