Achieving low power wireless connectivity for battery powered healthcare sensors

By Mac Tochigi, product manager, connectivity modules, Murata Europe

With the increasing adoption of smart phones and tablet computers, consumers are looking at doing more with them. One particular area that is gaining popularity is the use of these devices to monitor personal health, especially in the area of fitness and athletic performance improvement. The need to provide small, lightweight and wireless battery powered sensors presents engineers with a challenge to how to make this possible.

Recent advancements in low energy versions of popular communication stacks such as Bluetooth are idea for these application examples. However, engineers are faced with the decision of whether to make a discrete wireless function within their design or, alternatively, design-in one of the compact commercially available wireless modules.

Bluetooth, of course, is not the only wireless connectivity candidate. Wi-Fi and ZigBee are also worthy of consideration. The selection criteria for this decision will certainly include factors such as required data rates, power budget, host connectivity, and any potential costs to licence protocol stacks or silicon. In terms of data transfer requirements, portable healthcare appliances tend to have fairly low needs. In general terms, if the data rate needed is likely to be in excess of 3 Mbps it is likely that Wi-Fi would be the only option. Wi-Fi however does tend to be relatively expensive to implement due to the complexity of host interface connectivity required for security and higher level operating system support. Unfortunately, Wi-Fi is also very heavy on power consumption so it tends not to be suitable for long-life battery-powered devices. If frequency were a key criterion, which it tends not to be, Wi-Fi would be the only candidate if there were a need to operate in the 5 GHz spectrum using the 802.11a standard. ZigBee and Bluetooth are both confined to the 2.4 GHz ISM frequency band.

ZigBee has many advantages in terms of power consumption. Most of the time a ZigBee-based device is likely to spend in sleep mode and can wake up

very quickly to send data. A ZigBee remote controller, for example, can run on a coin cell battery for many years without needing a replacement battery. Data rates in the order of about 250 kbps tend to limit its use for high volumes of data. However, ZigBee has a network advantage that finds it widely used for home automation and smart metering applications. It can use a mesh network topology that allows it to connect up to about 100 nodes. By comparison, Bluetooth/BLE does not have this approach and is used on a peer-to-peer communication basis. Figure 1 shows the average power consumption against data rate for Wi-Fi, Bluetooth, Bluetooth Low Energy and ZigBee. BLE has a good advantage in low data rates.

Figure 1 – Power consumption vs data rate
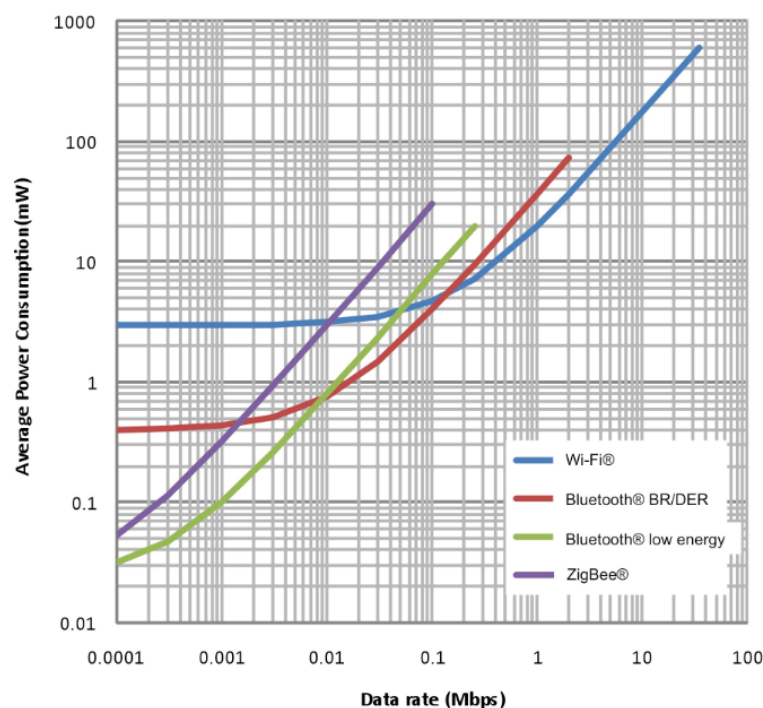
Bluetooth has a small power consumption profile perhaps not quite as good as ZigBee, but has the benefit of having a much higher data rate up to 3 Mbps. Compared to the original (Classic) Bluetooth the power consumption of BLE can be as low as a 1/10 to 1/20th . The BLE protocol is very simple and it facilitates reducing packets. With the recent launch of the Bluetooth low

energy (BLE) profile it is anticipated that BLE will become the dominant standard, taking the preference away from ZigBee and its low power consumption despite the fact that BLE has a slower data rate approaching that of ZigBee.

Figure 2 – Bluetooth Low Energy Software Architecture
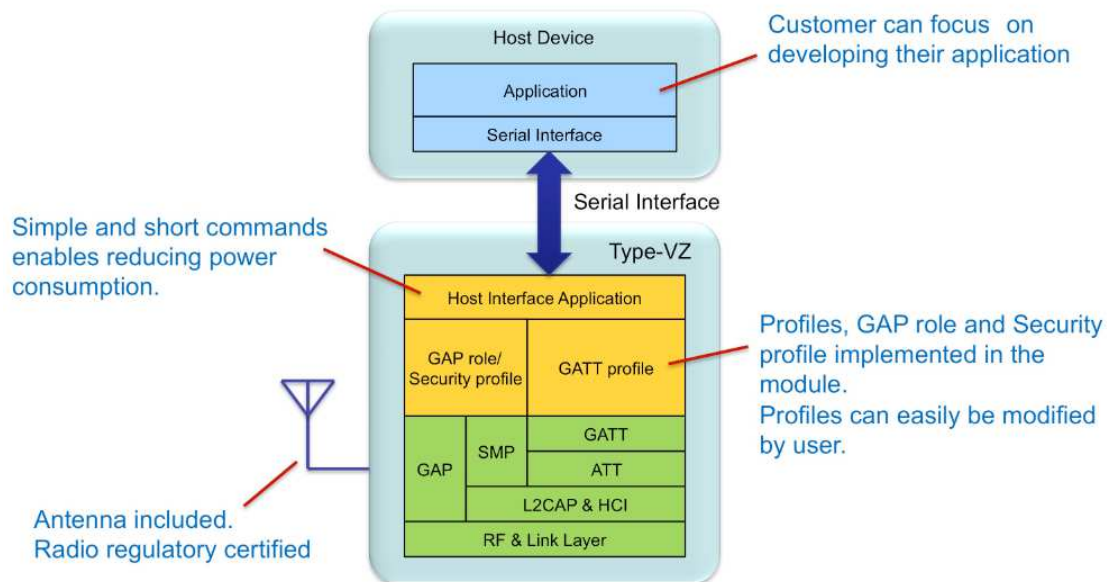
The high numbers of portable consumer devices, such as smart phones and tablets, will continue to increase BLE's adoption during the forthcoming years.

Figure 3 – Current consumption characteristic of BLE

Figure 3 shows the consumption profile of an example data transfer using BLE. The consumption example plot is from a Murata LBCA2ZZVZE BLE wireless module.

Command to start Advertising (57.6kbps)

WAKE
READY
UART_RXD
UART_TXD

Advertising Packet

Sleep(1uA)   Sleep(1uA)

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The decision to design-in a readily available certified wireless module or to design your own discrete solution needs careful consideration. Let's start with reviewing the likely steps you would need to take assuming the selection of the wireless standard has already been made.

Initial research would need to be conducted to identify likely chipset candidates that might suit the application requirement. A detailed specifications / datasheet would need to be sought in order to consider the board space, schematic and layout design requirements. Availability of a quick-to-implement evaluation or development board would greatly assist in this process as would any reference design software that could run on the chipset and interact with your host microcontroller platform. In parallel with the technical evaluation of the chipset and detailed BOM costing would need to be prepared taking into account all necessary additional discrete components to create the wireless function and interfacing to the host. Compliance testing to the required standard (BLE, ZigBee etc) would also have to be conducted, this part of the process potentially introducing additional costs and time into the overall development budget and time-in-market forecast. The need to source or hire suitable test equipment for this stage is often over-looked as is the need to be realistic as to the number of iterations needed for the prototype design. For engineering teams not used to developing their own wireless applications the prospect of working up their own discrete design can be a daunting one. Design iterations required to achieve certification, being diligent

with EMI and having to consider antenna design can deter engineers to consider an alternative.

Rather than adopt a discrete approach the alternative is to use a readily available wireless module. The consideration for this approach is not just a financial one. Typically, such modules come fully certified, occupy less board space, have passive components embedded, and are usually guaranteed to work. All these factors represent a significant saving in project time and risk, and even more when you consider that the product's future will be decided by the consumer's user experience.

Figure 4 – Example blood pressure monitor application

Figure 4 shows an example application of a blood pressure monitor communicating readings to a tablet computer using a wireless module. An MCU instigates reading blood pressure data and displaying it on the built-in LCD display and then passes it to the BLE module via the UART.
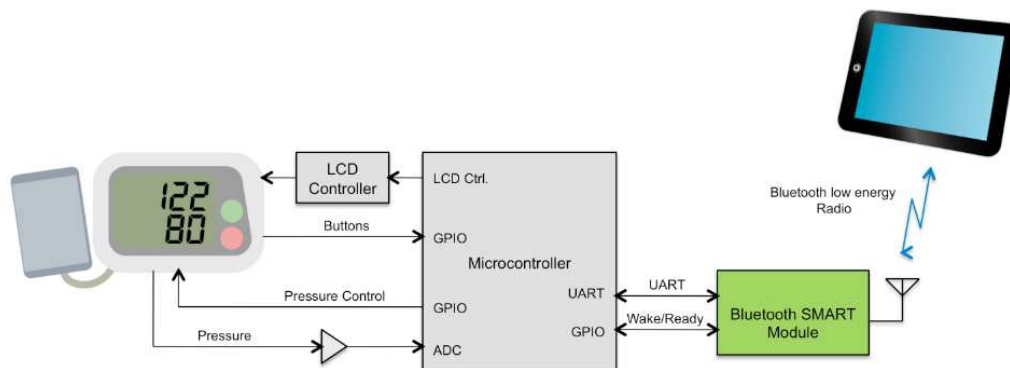
An example of a BLE wireless module is Murata's LBCA2ZZVZE. Incorporating the CC2541 chipset from Texas Instruments, the module measures just 20 x 13 x 2.4 mm. It incorporates all the BLE protocol stacks, wireless approval certification, UART interface and chip antenna. Output power is –2 dBm typical. The average power consumption is less than 100uA for 500msec of connection interval.

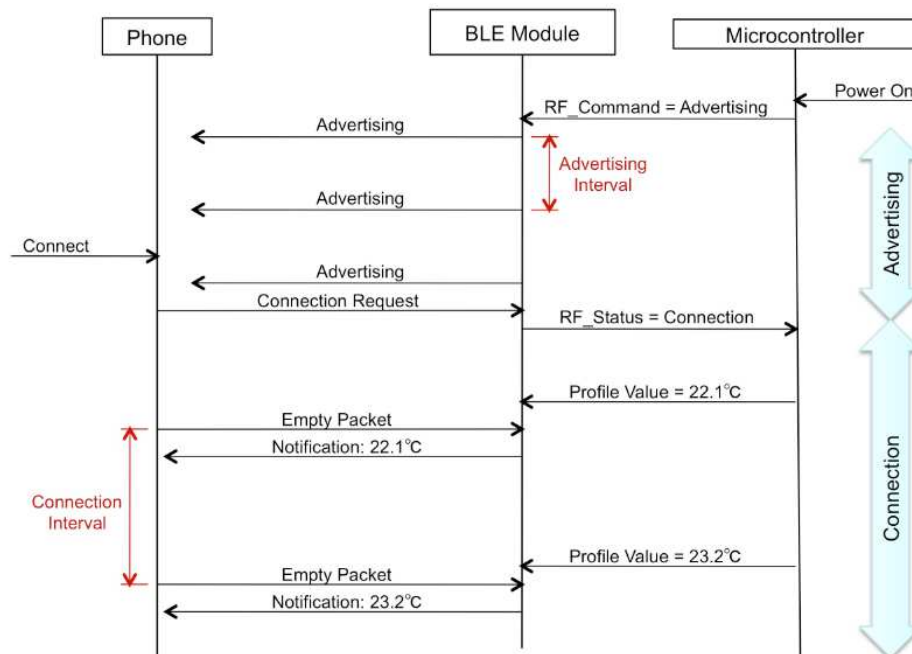**Figure 5 – Message sequence example of data transfer**

Figure 5 shows the communication process involved in sending temperature read from a sensor to a mobile phone handset. Advertising, a defined state of the Bluetooth Low Energy communication specification is controlled by the generic access profile (GAP) and the link layer (LL).

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