I. The Healthcare Problem
   a. Explanation of why this solution is needed.
   b. How we can solve the problem.
   c. The components needed to solve the problem.
II. Bluetooth Enabled Medical Device Architecture Explained
   a. The hardware
   b. The firmware
   c. How the system works
   d. Advantages
III. Example of Use Case of Medical Device
   a. Glucose Measurements
IV. Future Evolution of Bluetooth Medical Devices
V. Conclusion

The Healthcare Problem

Christophe del Toso, Ph.D., STMicroelectronics
Andrew Leone, STMicroelectronics

The population of the world is getting older and is living longer which compounds the issues. Add also that chronic diseases are able to be managed better through medication and technology. This adds to the ever growing costs and lack of manpower needed to take care of and treat these people.

How do we minimize the need of patients to visit hospitals and doctors when it may not be necessary? How do we use technology and available infrastructure to minimize these doctor-patient visits?

Telemedicine. Give the patient the ability to test and monitor oneself and submit the data for evaluation by a qualified person without needing to visit a doctor or hospital.

This idea could limit unnecessary visits and help developing countries to provide healthcare remotely as well.

So, how do we accomplish this? Traditionally, it worked by sending information over the telephone lines, but this can be inconvenient because a phone line might not be available. Today, mobile phones are almost in every person's hand in the world. Some developing countries don't even bother putting in wired phones and opt for the wireless infrastructure.

The mobile phone can not only make and receive phone calls; it can send and receive data.

With the advent of Bluetooth wireless technologies, mobile phones can communicate with other Bluetooth devices such as headsets and computers.

What about having medical devices that have a Bluetooth interface and communicate with a mobile phone? This is the ideal solution: the mobile phone has become indispensable and is the "gateway" from the Personal Area Network to the Wide Area Network.

Medical devices such as glucose meter, blood pressure meter, pulse oxymeter, ECG, and EEG, can now be kept at the home or on the patient. The information collected can be channeled to the proper diagnostic or medical data center through the mobile phone.

Commercially available technology such as sensors, Micro-Electro-Mechanical Sensors (MEMS), analog to digital conversion, microcontrollers, and short range wireless communication transceivers combine to create the medical device node. The medical device node can easily transfer various physiological parameters from a remote medical device to a mobile phone, a PC, or most any Bluetooth enabled host.

Description of Bluetooth-enabled medical device architecture

The architecture we'll discuss has been built with ease of implementation and simplicity in mind.

The idea was to develop a modular solution that would allow for a single microcontroller do both tasks of the application and the baseband processor of the Bluetooth.

The Bluetooth RF Transceiver contains the lower level stack up to the Host Control Interface (HCI), and the upper level stack resides on the single microcontroller in the system.

The Bluetooth upper level stack supports the following profiles: Serial-Port-Profile (SPP), Human Interface Device (HID) and an emulation of Dial-Up-Networking (DUN). Again, these profiles are implemented in the microcontroller.

The upper level stack is incorporated into a Real Time Operating System and allows for task management between application code and Bluetooth functions.

The complete Bluetooth circuit needs only a few external components: a discrete band-pass filter with integrated impedance matching, an antenna, clock oscillators, and few capacitors.

Figure 1 shows the block diagram of the architecture.

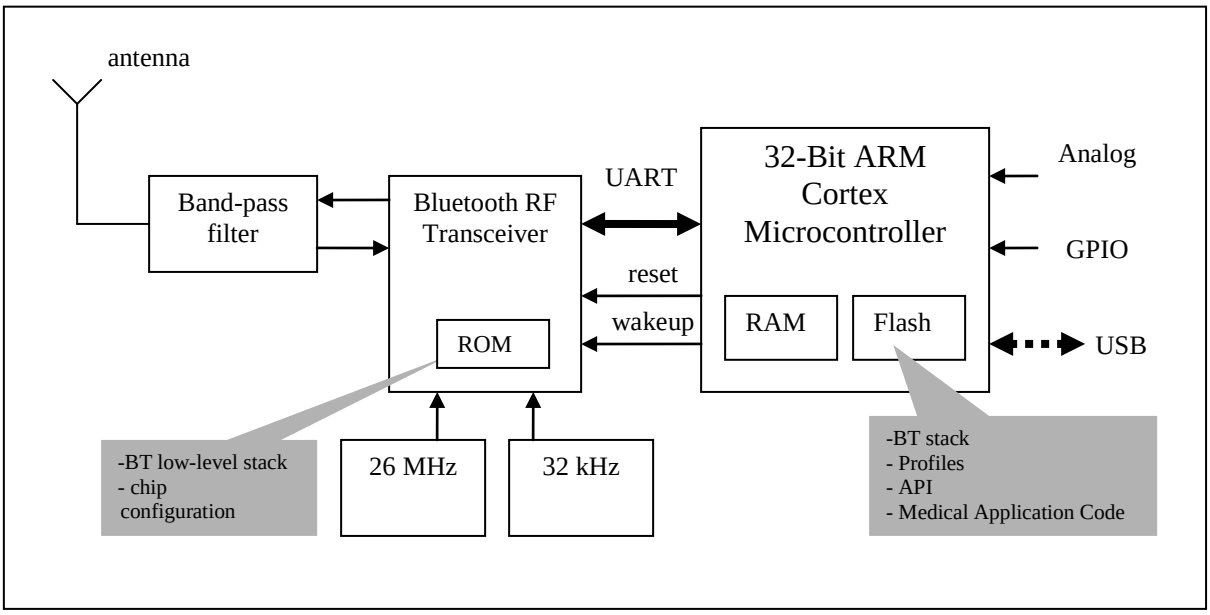

Figure 1: STMicroelectronics platform architecture for Bluetooth-enabled medical devices

Example of use cases for personal medical devices

A typical use case of Bluetooth-enabled medical device is described in Figure 2.

A Bluetooth-enabled medical device such as a glucose meter, blood pressure meter, or oxymeter, is in charge of making measurements of physiological parameters, collecting, and storing them in its internal memory and then transferring the records to a mobile phone Handheld PDA or Laptop PC via Bluetooth.

A mobile phone can then send records to a medical data center through via SMS or through a GPRS/UMTS connection. In return, the medical data center can easily monitor a large community of individuals remotely by sending back the results – if the measurement is good or not, if the patient must re-do a measurement, or if the patient should make an appointment with his doctor.

Thanks to Bluetooth protocol, a medical device can even directly dial-up to the medical data center by a simple Dial-Up Networking connection (DUN) that will use the mobile phone as a GPRS/UMTS gateway. In this case, the Dial-up Networking (DUN) profile of Bluetooth is used, and the patient just has to initiate the dial-up on the medical device by (for example) simply pressing a button.

This will enable new types of web-based services allowing remote patient monitoring.

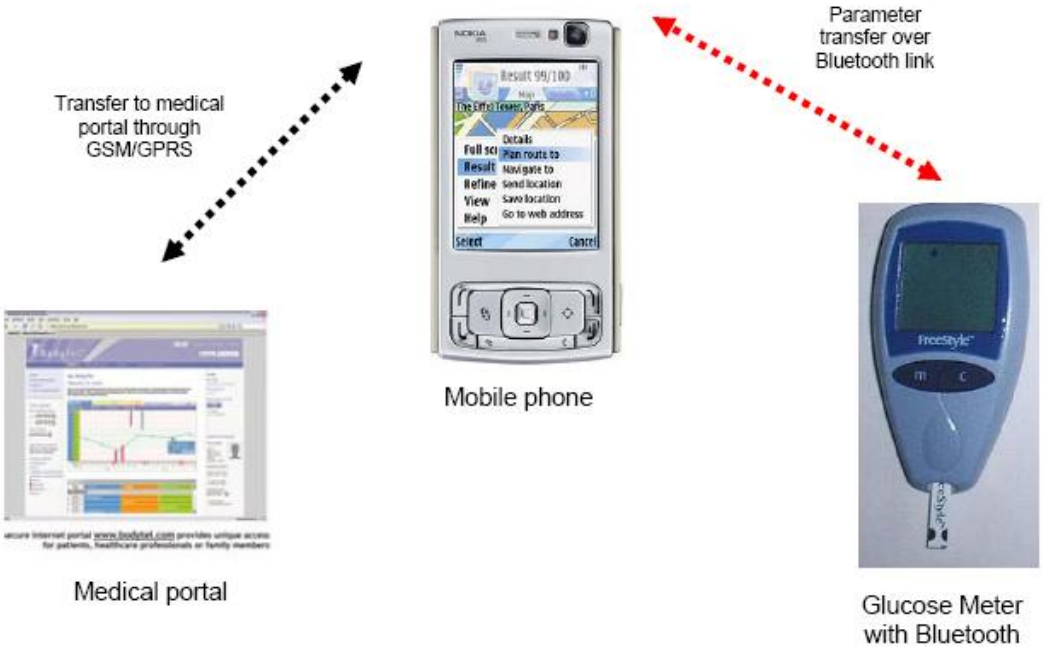

Figure 2: Example of medical use case

In order to tune its architecture platform to this kind of medical application use cases, STMicroelectronics has studied two different use cases for a blood glucose meter.

Typical use cases found for a glucose meter are twofold:
-periodic glucose meter
-continuous glucose meter

A periodic glucose meter corresponds to the use case where the patient needs to send measurements over Bluetooth a few times day (for example, after each measurement).

The Bluetooth link is then activated to send the data and then switched off.

The number of times the Bluetooth link has to be enabled in a day is less than 10 times.
This use case is governed by the fact that the period of Bluetooth activity is very small compared to the period of inactivity.

In that case, one has the possibility to shut a Bluetooth chip in complete power down thus consuming very small amount of current.

The period of Bluetooth activity will usually remain less than few seconds.
In average over a full day, Bluetooth current consumption remains very low, which satisfies the requirements of a battery powered glucose meter.

On the other hand, a continuous glucose meter corresponds to a device that needs to keep the Bluetooth link active all the time because the remote monitoring is done continuously.

In that case, Bluetooth cannot be switched ON/OFF, and it is better from the point of view of current consumption to use the sniff subrating feature that is a key feature introduced in latest Bluetooth standard release BT 2.1 Lisbon.

This feature is automatically enabled when the Bluetooth chip detects no activity after a certain time, which is completely done in an asynchronous way and does not require microcontroller intervention.

Future evolution

One technology trend for these kinds of applications is to evolve towards the Ultra Low Power (ULP) Bluetooth standard. Indeed, this new standard will implement new hardware features and protocol enhancements that will be perfectly optimized for these kinds of applications requiring transfer of low data rates at very low power consumption.

In that context, the roadmap will also be driven here by the mobile phone roadmap which also requires the implementation of the ULP Bluetooth standard.

This will allow all market segments to get access quickly to very inexpensive chipsets, offering better economy of scale than using proprietary RF transceiver technologies or those whose market acceptance is very limited.

In addition, Bluetooth SIG (the industry consortium driving Bluetooth standardization) is currently developing a new Bluetooth profile for medical applications.

All this combined will offer new possibilities to the medical device industry.

Conclusion

The Healthcare device market is growing. Through the leveraging of established technologies developed for consumer and mobile phone industries, engineers can easily and confidently implement Bluetooth connectivity and optimize solutions for the medical device space.

As Bluetooth technology becomes more and more pervasive (Bluetooth is incorporated in more than 60% of mobile phones sold in 2008), healthcare and medical markets can benefit from the development of the technology for portable medical devices to enable new applications and services.