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Turning the periphery into the core:

The benefits of integrating your application's hardware with a wireless modem

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Today, it is becoming unusual for a new embedded device design to include no provision for communication to the outside world. The technologies for high-speed machine-to-machine (M2M) wireless communication from almost anywhere on the planet – such as the TCP/IP protocol, cellular telephone networks and Wi-Fi® – are proven and well supported by device manufacturers and network operators. Indeed, if the much-hyped 'Internet of Things' is to become a reality, wireless internet connectivity will need to be implemented in tens of thousands of new and existing embedded end products.

Connecting a device over the air to the internet is simple to describe, but the actual implementation is far from straightforward. The design of cellular sub-systems requires an understanding of RF propagation and reception, the causes and effects of interference, the functioning of the RF and access interfaces, not to mention the complexities of regulatory controls (as imposed by the Federal Communications Commission in the US or the European Commission in Europe, for instance), and of approvals for the many cellular network providers around the world.

Large OEMs can often support dedicated design teams with specific RF and cellular telephone know-how. For the vast majority of small and medium-sized manufacturers, however, the resources are not available to acquire such expertise. For them, the only realistic option has been to bolt on a discrete wireless modem, either by developing a modem design around a cellular module (as supplied by manufacturers such as Cinterion and Sierra Wireless), or more simply by dropping into their existing design a pre-approved cellular modem, such as a SocketModem device from Multi-Tech Systems.

This article, however, proposes a new way of thinking about the problem of wirelessly connecting a previously stand-alone device: rather than bolting a modem on to a core device, designers might instead integrate a core application into a modem.

Incremental approach suffers from drawbacks

Consider, first, today's traditional approach: bolting on a home-grown module-based modem or an off-the-shelf modem to an existing board. In so doing, the designer has added:

- **Cost** – both Bill of Materials (BoM) cost, and (in the case of a module-based design) implementation cost, because of the requirement for certification and carrier approvals
- **Size** – an additional board (in the case of the modem) or circuit area (for a home-grown modem) must now be accommodated in the end product's housing

- **Complexity** – a design which previously had one controller or processor executing the product's core application now has two – one executing the core application, and the other controlling the modem or module.

In some cases, the impact of these drawbacks will be negligible in comparison to the extra value imparted to the end product by the addition of feature-rich wireless connectivity.

Other end products, however, derive only a small proportion of their value from custom hardware design. This applies, for instance, to end products in which the core value is provided by electrical, mechanical or other non-electronic functions, and in which the electronics support little more than a user interface and basic system controls and I/Os. In the same way, in embedded computing devices the OEM's value is generally in the unique application software and user interface which provide functions the end user requires, not in the standard (generally x86- or ARM-based) hardware platform on which the application runs.

In these cases, there is a mismatch between, on the one hand, the relatively small value derived from the system's hardware, and on the other the large amount of developer resource required to design, maintain, upgrade and support the hardware. In this context, bolting on additional (RF communications) hardware to a platform that was already absorbing more than its fair share of engineering effort seems to make no sense.

Reducing complexity and hardware support requirement

Let us assume, then, that the design team has already decided to use an off-the-shelf embedded modem, thus saving the considerable cost, time and design risk associated with the design, testing, qualification, maintenance and support of a custom modem. The obvious thing to do is to bolt this off-the-shelf modem on to the system's main board.

But in fact the logic of the modem decision could be extended to the whole system: if the end product's value is not in the electronics hardware, why not build applications on top of an off-the-shelf hardware applications engine? And having decided to do this, then combining the applications engine and the modem into a single off-the-shelf hardware platform would provide a far more elegant and economical design than a main board together with a discrete modem.

Fig. 1: MultiConnect™ OCG-E is a complete wireless Linux applications engine in a small 3.7" x 1.4" outline

This is the premise of the new MultiConnect™ OCG-E Embedded Open Communications Gateway from Multi-Tech (see Figure 1). In effect, the MultiConnect OCG-E enables the core application(s) to be embedded in the modem, rather than bolting a modem on to discrete hardware running the core application(s). As might be expected of a modem manufacturer, Multi-Tech has provided multiple flavors of 2G and 3G cellular technology to meet the requirements of different regions and a variety of data download and upload rates. It also incorporates optional GPS satellite location technology. This is normal modem fare.

But this embedded gateway is not a modem: it is a fully-fledged Linux operating environment running on a 400MHz Atmel ARM9 processor, with 256MB of Flash memory and 64MB of SDRAM (see Figure 2). It runs CoreCDP, a Linux distribution developed by Multi-Tech, and offers a wide variety of interfaces (SPI, 1²C, serial, ADC) for sensors and other peripheral devices. It also supports the standard OpenEmbedded framework for development of Linux-based application software.

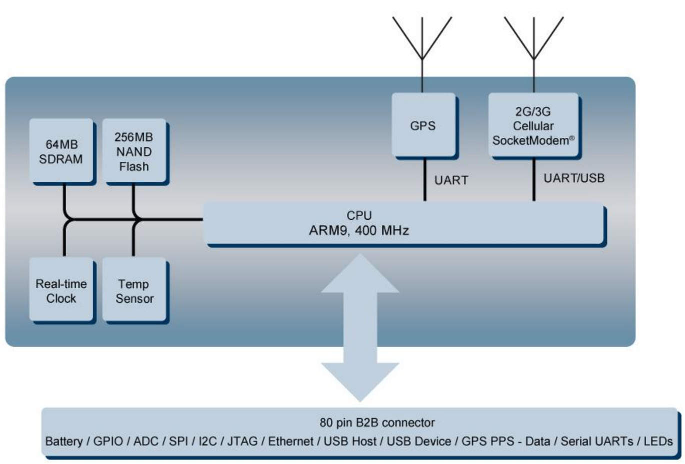

Fig. 2: MultiConnect OCG-E supports multiple peripheral devices via an 80-pin connector

In its standard guise, the MultiConnect OCG-E (where the 'E' stands for 'Embedded') provides a powerful processing environment which will support the majority of embedded application requirements. But it can readily be customized by Multi-Tech to customers' specifications, for instance by eliminating unnecessary interfaces to reduce bill-of-materials cost. Multi-Tech can also provide engineering services to add extra features such as Wi-Fi networking capability.

A counterpart product, MultiConnect™ OCG-D (where 'D' stands for 'Device') is a full stand-alone gateway product, complete with a chassis and casing (see Figure 3). This is ideal for OEMs which wish to go from concept to field trials as quickly as possible, as the MultiConnect OCG-D can operate as a complete end product hardware platform.

Fig. 3: MultiConnect OCG-D offers a ready-to-ship hardware implementation for end products

MultiConnect OCG-E, by contrast, is suitable for OEMs with hardware design capability, and which wish to retain control over form factor and feature sets in order to be able to accommodate the gateway in an existing end product, or to modify the hardware design to meet particular application requirements.

Both versions offer full carrier and regulatory approvals for CDMA and GSM networks most anywhere in the world.

Application example: defibrillator

The MultiConnect OCG-D, which has been in volume production since early 2011, provides an illustration of the way in which a single device can be used to support both the communications interface and the applications using the interface. For instance, in late 2010 a US defibrillator manufacturer wanted to enhance its stand-alone product by enabling it to communicate wirelessly. The device is typically used in ambulances to revive patients in transit to a hospital's emergency room. Cellular communications capability enables the device to report usage, location and the patient's vital signs in real time to the hospital's medical staff so that they can prepare equipment and staff in time for the patient's arrival.

In this case, the defibrillator had already passed the US Food and Drug Administration's time-consuming and expensive approvals process for medical devices. Adding communications capability required not only a modem but also an applications layer, to support medical communications protocols, to encrypt personal data, to perform system and power control, and to provide a user interface.

If the manufacturer embedded a modem inside the defibrillator, it would need to be retested for FDA approval. By integrating all the electronics functions – communications and applications execution – into one discrete device, the MultiConnect OCG-D, the defibrillator manufacturer could quickly develop applications software, and get to market with the least delay; in fact, it developed a working prototype of its wireless internet-enabled device within two months of starting the design project. At the same time, it avoided the need for FDA recertification.

Since the MultiConnect OCG products support a standard (Linux) environment, software development engineers who can write to the platform are readily available. Help is also on hand from Multi-Tech engineers and from the user community via www.multitech.net.

Conclusion

As the application example described above shows, implementing wireless internet capability brings with it a considerable requirement for application software; a processor board is therefore a natural companion to an embedded cellular or Wi-Fi modem. Bolting a modem on to a discrete, home-grown processor board will be an appropriate choice for many OEMs, but leaves the tasks of designing, manufacturing, maintaining and supporting the processor board with the OEM, as well as increasing the complexity of the end product's architecture.

Using an integrated modem/processor board provides an elegant hardware architecture but also relieves OEMs of the burden of hardware design, support and production, and allows them to focus on the core activities that bring value to their customers.

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