HOW TO KEEP COSTS IN CHECK WHEN DESIGNING CONNECTED END POINT/ IOT DEVICES

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As the use of Internet-of-Things (IoT) devices are becoming more common, the need to create cost effective devices is critical. The challenge is how to enable new features and functionality while lowering your costs. Not to mention keeping up with the latest connectivity standards like BLE and Wi-Fi. One of the factors in the costs of a products is the relationship between the hardware and software. In this paper we will talk more about this relationship. Specifically, around the use of Bluetooth and Wi-Fi in the use of End Point / IoT devices.

HARDWARE CONSIDERATIONS

Selecting parts for a wirelessly enabled products requires a lot of comparison between the enormous range of wireless modules and chipsets that are on the market today.

One of most critical factors for developers to consider when selecting wireless hardware for the design of an IoT product is cost.

	Price/unit	Price/25 units	Price/100 units	Price/1K units	Price/25K units	Price/50K units	Price/100K units
BT/BLE Wireless Module							
Texas Instruments CC2564MODACMOG	16.88	14.0684	12.8626	10.69203	9.622827	8.553624	7.484421
SoC (BLE System-on-chip)							
Texas Instruments CC2541F256RHAR	7.01	7.01	5.15	3.7	3.33	2.96	2.59
BT/BLE Wireless Chipset							
Texas Instruments CC2560BRVMR	7.2	5.792	5.2769	3.60381	3.243429	2.883048	2.522667
MCU							
Texas Instruments TMS320F280220PTT	6.95	6.95	5.12	3.69	3.321	2.952	2.583
Total Savings *(of SoC over wireless module)*	$ 9.87	$ 176.46	$ 771.26	$ 6,992.03	$ 157,320.68	$ 279,681.20	$ 489,442.10
Total Savings *(of wireless chipset + MCU over wireless module)*	$ 2.73	$ 33.16	$ 246.57	$ 3,398.22	$ 76,459.95	$ 135,928.80	$ 237,875.40
Wireless Module							
Microchip ATSAMW25H18-MR210PB1952	18.05	16.5052	16.5052	16.5052	14.85468	13.20416	11.55364
SoC (System-on-chip)							
Microchip ATWINC1510B-MU-Y	9.84	8.94	8.09	7.98	7.182	6.384	5.586
Wireless Chipset							
Microchip ATWILC3000 Network IC	1.23	0.9896	0.95	0.95	0.855	0.76	0.665
MCU							
Microchip ATSAM4LC2AA-MUR MCU	6.95	6.32	5.72	5.72	5.148	4.576	4.004
Total Savings *(of wireless chipset + MCU over wireless module)*	$ 9.87	$ 229.89	$ 983.52	$ 9,835.20	$ 221,292.00	$ 393,408.00	$ 688,464.00
Wireless Module							
STMicroelectronics SPBTLE-1S	16.67	14.7	12.94	10.56	9.504	8.448	7.392
SoC (System-on-chip)							
STMicroelectronincs BLUENRG-132	5.11	5.11	3.7599	2.69942	2.429478	2.159536	1.889594
Total Savings *(of SoC over wireless module)*	$ 11.56	$ 239.75	$ 918.01	$ 7,860.58	$ 176,863.05	$ 314,423.20	$ 550,240.60

Figure 1: Comparison of embedded wireless modules vs. SoC vs. MCU + chipset design BOM.[1]

SOFTWARE CONSIDERATIONS

Choosing an OS for an embedded system is challenging, and IoT applications have additional constraints and some very specific requirements. Broadly the need is to provide a real-time, multi-threading program execution environment, that includes the middleware (drivers, protocols etc.) for a variety of peripherals (Wi-Fi, Bluetooth/BLE etc.), whilst demanding a modest amount of target system resources (CPU power and memory).

1. Pricing assumption based upon published pricing on Digikey and/or Mouser up to 1k volume then a discount of 10% for 25k pricing; 20% for 50k pricing and 30% for 100k pricing and is for illustrative purpose only.

An obvious option to consider is Linux. It is very well known among developers and offers an enormous selection of drivers etc. However, Linux could be problematic in this context because it is not intrinsically real time and applies a very high load on system resources; it needs plenty of CPU power, a large amount of memory (multiple MB) and a memory management unit. For an IoT application, this heavy demand for resources is unlikely to be acceptable.

The clear alternative is a real-time operating system (RTOS). Such an OS tends to be very efficient, resulting in less CPU power being needed. Memory footprint is much reduced – commonly a fully-featured OS configuration may only demand 50KB of memory; scalability means that only required OS features are included in the executable image. Wide ranges of drivers and other protocol support tend to be available, meaning that application development can proceed rapidly.

FLEXIBILITY

While pre-programmed modules provide the opportunity for simple development, they prevent the developer from having complete control and understanding of the underlying technology that is in their product. This understanding can be critical in providing support to customers when problems arise as well as shifting developer's reliance on third parties to implement software changes, if indeed such changes can or will be made.

Developers unfamiliar with embedded wireless Bluetooth & Wi-Fi technology will often look search for user-friendly and intuitive API to do the work for them. Embedded development environments are often only able to provide developers with very low-level debugging information such as memory mapping, register status and call stacks, which can be helpful for debugging MCU peripherals, but when it comes to debugging MAC-layer and the radio-layer communication between a microcontroller and RF transceiver, few embedded development environments will provide the contextual information to debug wireless communication between several connected devices.

TABLE 1 - SOFTWARE SOLUTION OFFERINGS.

	Pre-programmed modules	Customized wireless solution based upon Nucleus RTOS & Clarinox software
Performance Tuning	Generally not possible	Real-time memory usage analysis, throughput analysis and tuning is possible via scripting interface to the target system
Debugging	Little real-time debugging capabilities	Bluetooth & Wi-Fi packet sniffing and protocol analysis, customized debug views to visualize relevant information
Hardware Flexibility	Limited hardware options supported by software packages	Freedom of choice - selection of a variety of MCU's and RF IC's.
Cloud Solutions	Locked to a vendor-specific cloud service Cloud vendor ceasing to support can be an issue	Flexibility of cloud service provider
Vendor Support	Modules are sometimes based upon wireless chipsets that no longer have support from the silicon vendor Forced upgrade may be required if any firmware issue is found	Flexibility in software support is available from software vendors throughout development and into production Control over choice of chipset ensures that a newer chipset can be chosen at the start of the project

EXAMPLE SYSTEM

An example of a wireless solution where SoC or chipset + MCU design is suitable is the implementation of wireless barcode scanner devices. Given the small-form factor and ergonomic requirements of such devices requires embedded designs that are not constrained by the size of wireless modules. Furthermore, the reliance on barcode scanners to continuously operate reliably for hours stresses the need of transparent wirelessly debugging and performance tuning – which, more often than not, is not provided by vendors supplying pre-programmed wireless modules.

Together with partner Mentor Graphics, Clarinox has the ideal solution for providing Bluetooth and Wi-Fi functionality for our client's barcode scanner products, where robustness and reliability were key priorities. ClarinoxBlue and ClarinoxWiFi protocol stacks, running on Nucleus RTOS, provide a winning combination. The small memory footprint and light resource intensive RTOS provided by Nucleus, along with Clarinox wireless stacks, provide flexibility to our clients to choose a broader range of chipset & MCU whilst also ensuring low-power operation of their battery powered scanners.

CONCLUSION

To summarize with a few key points:

- The relationship between hardware and software is critical in reducing costs
- Many times, wireless modules and pre-programmed development kits are not cheaper then alternatives such as SoC or chipset-based design.
- Choosing a highly scalable RTOS will enable a smaller memory footprint, require less CPU power, and support wide ranges of drivers and other protocols. All lowering your total hardware costs.
- Flexibility gives the developer complete control of all aspects of the device.

PRICING REFERENCES:

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Corporate Headquarters
Mentor Graphics Corporation
8005 SW Boeckman Road
Wilsonville, OR 97070-7777
Phone: 503.685.7000
Fax: 503.685.1204

Sales and Product Information
Phone: 800.547.3000
sales_info@mentor.com

Silicon Valley
Mentor Graphics Corporation
46871 Bayside Parkway
Fremont, CA 94538 USA
Phone: 510.354.7400
Fax: 510.354.7467

North American Support Center
Phone: 800.547.4303

Europe
Mentor Graphics
Deutschland GmbH
Arnulfstrasse 201
80634 Munich
Germany
Phone: +49.89.57096.0
Fax: +49.89.57096.400

Pacific Rim
Mentor Graphics (Taiwan)
11F, No. 120, Section 2,
Gongdao 5th Road
HsinChu City 300,
Taiwan, ROC
Phone: 886.3.513.1000
Fax: 886.3.573.4734

Japan
Mentor Graphics Japan Co., Ltd.
Gotenyama Trust Tower
7-35, Kita-Shinagawa 4-chome
Shinagawa-Ku, Tokyo 140-0001
Japan
Phone: +81.3.5488.3033
Fax: +81.3.5488.3004

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