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Designing SoMs and SoCs for embedded systems

State of the SoM

The SoM (System on a module) is the backbone of embedded systems. With the advancement of small form factor, low cost and low power ASICs, it's becoming increasingly easier to design an SoM for a particular application in mind. Due to IoT becoming increasingly important and staple in the current field of technological solutions, being able to use an SoM that can run as the back or frontend of a system level solution appears to be critical for many companies in the era of low power hardware design. This means that Raspberry Pi class SoMs are becoming increasingly popular, but certain specialized SoMs such as ones designed by NXP or Atmel for DSP applications are becoming those companies' increasing focus. At the same time, the advancement of SoC design means that its also becoming more popular to design SoCs for similar applications as well, and companies like SiFive are trying to push the industry in that direction.

X86 or ARM processors

The core component of an SoM is the CPU. It goes without much defense that x86 is the most well-known architecture of CPUs [1]. But their purposes are very different, despite both being commonly used for an SoM. X86 class processors are typically used for more complex processing applications, such as running a non-Realtime OS. The instruction set is complex, but more actions are done in one instruction as a result. In summary, x86 is ideal for applications where power is freely available, and timing is non-critical. ARM class processors are RISC machines, meaning they run with a simpler instruction set [2]. While this makes the class non ideal for running anything more complex than an RTOS, they are much lower power consumption and must faster in executing simpler threads. This makes them ideal for the IoT space, where low power and speed is critical.

Raspberry Pi

The Pi class of SoMs have proven to be overwhelmingly popular and successful when it comes to an easy to use, low power and easily accessible SoM The Pi is a class of SoM called SBC (single board computer). The datasheet for their smallest model (Pi Zero) shows that this SoM is no different component wise than a typical computer: it has a single core 1GHz ARM CPU, 512MB of Ram sitting on the CPU, a micro SD slot, an HDMI port and processor, two micro USB ports, one of which is used to power the device [3]. The Pi Zero W also has WIFI and Bluetooth chips on the board. This Pi is

incredibly small, 65mm by 30mm by 5mm. The Pi 3 by comparison contains all of the features of the Pi Zero, with a faster quad core ARM processor, 40 pin GPIO with SPI and I2C, a display port, camera port, audio out, and ethernet [4]. This is while still only being powered off a micro USB port. Because they are not just low power but easy to power, raspberry Pi's are incredibly popular for a huge variety of systems, and some companies like Amazon have tutorials on how to create an Alexa with Raspian and a raspberry Pi.

Putting an SoM on an SoC

For low bandwidth IoT applications, the raspberry pi suits those purposes just fine. Higher bandwidth applications can require more dedicated hardware solutions on the board to use, such as a dedicated ADC that can run at 80 MS/s. SoCs can also form the backbone of an SoM, and because higher data rates are becoming increasingly important, having a capable SoC is the go-to solution in many cases. In the following example, the i.MX RT1020 is used, which is an SoC that NXP sells for 7 dollars per chip on Digikey. It features an ARM Cortex M7 quad core processor, 256 KB of on-chip storage, a USB 2.0 controller, an Ethernet controller, an on-chip buck regulator and LDO for power management, 4 I2C and 4 SPI buses, 2 16-channel ADCs to say the least about what it has [5]. SoCs like this offering are becoming more common in the industry, as the lowest power and highest speed devices in the embedded systems space are going to be devices with as much shoved on the chip as possible. Companies like Samsung and Digi International have tried to put these SoCs on a custom SoM for easier and quicker firmware development, similar in concept to a Raspberry Pi. The Digi International SOM Wi-i.MX6UL contains 256MB of RAM, an NXP i.MX6UL-2 WiFi SoC with same buses as the RT1020. This SoM contains external Bluetooth connectivity and external NAND flash with a crypto processor on the package [6]. These SoMs are becoming more popular for quicker turnaround time on development for embedded devices.

Future considerations in SoC and SoM design space

NXP is not alone in the direction they are pushing the embedded systems industry. Companies like Microchip technologies, Qualcomm, Broadcom and similar are also trying to push the industry hard in the direction of using more SoCs for design applications. With the advance of RISC-V, which is an open source CPU architecture (code is available on Github), designing your own SoC for use in embedded applications is becoming more popular [7]. The time required to develop one from scratch however is sometimes prohibitive for medium businesses, which is why SiFive seeks to push the industry with open source ASIC design tools using RISC-V. Designing your own a-la-carte CPU with only what the application requires is what appears to be SiFive's goal. Their software seeks to equate building a custom SoC, with certain design constraints in mind, like building Legos, for less than a million dollars. For

embedded systems where the CPU is the core of the system, creating a custom ASIC that only has exactly what the application requires means that power management and development time both get optimized, which makes designing a low power system more accessible and simpler [8].

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