Evaluation Form – Technical Background Review

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_______ / 30 Technical Content

- Current state-of-the-art and commercial products
- Underlying technology
- Implementation of the technology
- Overall quality of the technical summary

_______ / 30 Use of Technical Reference Sources

- Appropriate number of sources (at least six)
- Sufficient number of source types (at least four)
- Quality of the sources
- Appropriate citations in body of text
- Reference list in proper format

_______ / 40 Effectiveness of Writing, Organization, and Development of Content

- Introductory paragraph
- Clear flow of information
- Organization
- Grammar, spelling, punctuation
- Style, readability, audience appropriateness, conformance to standards

_______ / 100 Total - Technical Review Paper

Compact High Performance Computing Platform

Introduction

Unlike a conventional desktop or laptop computer, a single-board computer (SBC) is built on a single circuit board without expansion slots for peripheral functions or expansion. This configuration reduces the number of circuit boards required, and therefore reduces a system's overall cost. Also, higher reliability and power efficiency can be obtained by eliminating connectors and bus driver circuits [1].

Modern SBC systems are often based on microcontrollers, but ordinary microprocessors are still common in more complex systems. In either case, the specific type of processors should be carefully chosen to fulfill certain application requirements. ARM Cortex-A series processors are the best candidates for High-Performance Applications [2]. The Cortex-A family shares a commonly supported RISC (Reduced Instruction Set Computing) architecture and instruction sets, which ensures high power efficiency and proven compatibility across a range of the highest performing devices.

This technical review briefly summarizes some commercially available single board computers using ARM Cortex-A series processors, explains the advantages of the products and provides ideas for implementation.

Commercial Applications of High Performance Single-board Computers

Many commercial applications has limited power supply, system size, as well as very complex environment. A very specific type of computer is needed to meet this demand. Single-board computers (SBC) are the best choice due to its small size and high reliability. One most commonly used SBC is Raspberry Pi, a series of credit card sized platforms offered by the Raspberry Pi Foundation in the UK [3]. The Model B of the second generation product is equipped with 900Mhz quad-core ARM Cortex-A7 CPU and 1GB memory. This gives the tiny board outstanding performance among its category. There are 4 USB ports [4], one on board Ethernet, and 17 GPIOs (General Purpose Input/Output) on board, as well as I2C (Inter-Integrated Circuit), and SPI (Serial Peripheral Interface) bus [5] to connect a variety of sensors. The power consumption is 5V 800mA, which is relatively small considering its performance. Additionally, the most unique market competitiveness is its software eco-system. Multiple mainstream Linux systems are supported [6] and there are many detailed tutorials and documentations. This SBC is marketed at US$35.

Another strong competitor is BeagleBoard Black, an open-source single-board computer produced by Texas Instruments in association with Digi-Key and Newark element14. Powered by 1GHz single core ARM Cortex-A8 processor and 512MB DDR3 memory, it is capable to run most Linux distributions such as Debian and Ubuntu. Although its performance is not the highest, there are several unique advantages make it very popular in robotics. First of all, booting Linux image only takes within 10 seconds thanks to its on-board flash storage. Second, the 92 pin headers give it comprehensive expansion ability and almost all the low-level peripheral interfaces are provided. Last but not least, the power consumption is just 2 Watts [7]. This product is quoted at US$45.

Technology of SBCs using ARM Cortex-A processor

Most ARM Cortex-A processors shares a SOC (System On Chip) design. By putting all components of a computer and other electronic systems on a single chip, the SOC design minimizes the number of peripheral components on the circuit board. This technique makes it possible to build a powerful quad-core computer on a credit card sized circuit board [8]. For example, a poker sized SBC can achieve 20377 in Octane2.0 benchmark thanks to this compact design.

Almost all SBCs based on Cortex-A family processors has multiple configurable pin headers as well as specific interfaces such as USB and Ethernet. Pin headers generally can be configured as GPIOs and low-level peripheral buses. GPIOs can handle analog and digital signals, thus read and output a certain voltage. Low-level peripheral buses includes I2C, SPI and CAN (controller area network) [5] [7], which is most commonly used in communicating with sensors and controlling the system.

Conventional computers need heavy discrete multi-voltage power supply causes huge limitations on system deployment [10]. The Single-board computer usually only use 5V power supply, with current less than 2 Amps [11]. In addition, some products have on-board voltage regulators which further expand their application environments.

Building blocks for implementing ARM Cortex-A based SBCs

Due to its small size and low requirement on power supply, the SBC can be implemented on portable systems much easier than conventional computers. Solar, wave, wind or other kind of renewable energy is capable to provide applicable voltage and current after regulating. Energy consumption can be further reduced if intelligent power management techniques is applied [12].

Multiple sensors can be attached on the low-level peripheral buses and the control signal will be sent to the actuators using GPIOs. Also, GPS modules [13] and wireless communication modules [14] are connected to the serial ports of the single-board computer.

Mainstream Linux distributions as well as Andriod and Windows IoT can be deployed on most SBCs based on Cortex-A family processors [15]. Almost all programming languages such as C, C++, Java, Python, Ruby are supported [16]. This makes the software developing process more flexible and easier.

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