LAMPIÃO MICROCONTROLLER IN A TCP/IP NETWORK

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ABSTRACT

Smart sensors are designed to communicate in network environment. This paper presents the extension being introduced to the VHDL description of the microcontroller LAMPIÃO (LDN - Arquitetura de Microcontrolador e Propriedade Intelectual para automaçÃO), so that it can understand the TCP/IP protocol. The objective is to develop a microcontroller which can be used in smart sensor implementations. The LAMPIÃO is simulated inside Xilinx® environment and implemented in a FPGA.

1. INTRODUCTION

Smart sensors, according to the IEEE1451 standard [1], are devices that integrate the transducer, analog conditioning circuitry, data processing and network functions. This concept is taken a step further, when one places all such functions in a single chip. In this context LAMPIÃO (LDN - Arquitetura de Microcontrolador e Propriedade Intelectual para automaçÃO) is being developed at the Laboratory for Devices and Nanostructures to serve as the data processing and communications unit of the integrated smart sensors under development. This project started with H. S. Padilha Jr and E. J. P. Santos [2], who designed a Harvard architecture microcontroller with a small instruction set, capable of controlling the data acquisition process. LAMPIÃO microcontroller is described in the hardware description language VHDL [3],[4].

This paper reports recent developments to introduce new instructions into the VHDL description to add new functionalities, and optimizing existing instructions to make the circuit smaller and faster. The objective is to make LAMPIÃO able to communicate using the TCP/IP protocol. This paper is divided in four parts, the introduction is the first one, then comes the methodology, later the network implementation and finally the conclusions.

2. METHODOLOGY

The LAMPIÃO microcontroller is described in the hardware description language VHDL, this makes it easier to understand, optimizing its implementation, and introducing new functionalities. Moreover, the implementation by field programmable devices adds a greater dynamics to the project, allowing its modification in accordance to the desired functionality. Another positive point is the independence between the microcontroller and the technology, because as technological advances are incorporated, new layouts are generated automatically.

The proposed architecture is Harvard, similar to the used by Microchip® in its microcontroller (PIC). In this architecture, the data and instructions busses are separated, saving the number of accesses to the memory and increasing the speed, although using in more area in its implementation. This architecture is selected because it is simpler to design.

LAMPIÃO has the usual microcontroller functional blocks, such as ALU, registers, program counter, control unit, etc, as shown in the simplified diagram in Figure 1 [2]. As it is being designed for sensor applications, it also has a real time clock and a watchdog timer.

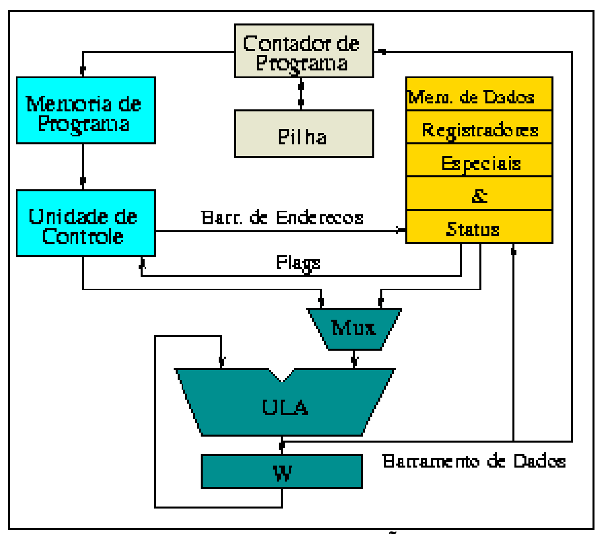

Figure 1. Block-Diagram of LAMPIÃO microcontroller.

The instructions are implemented in order to make the instruction set ortogonal, i. e., making possible for each instruction to use all available addressing modes. The VHDL description is simulated in the Xilinx® environment, and prototyped in a prototyping board, donated by Xilinx®, through its university program. The LAMPIÃO microcontroller as implemented can be used for simple control tasks and for data acquisition.

3. LAMPIÃO MICROCONTROLLER IN NETWORK

There are different network protocols being used in the industry, all such protocols are deterministic in its network access. TCP/IP has statistic access to the network, if two devices try to access the network at the same time, a collision is detected and the devices will wait a random time to try again. This is a shortcoming of TCP/IP in critical processes. However, with the development of fast ethernet, and even gigabit ethernet, this has becoming less of a problem, as such times are measured in microseconds and control times are measured in milliseconds. Moreover, TCP/IP is a freely available, well documented, heavily used protocol all over the world. With this in mind, TCP/IP was selected as the first protocol to be implemented in the LAMPIÃO VHDL description. Other protocols may be added in the future, such as USB, which can be used in mission critical applications.

As practical application, a network of LAMPIÃO microcontrollers measuring the temperature in various points of a structure is considered. The microcontroller as part of smart sensors may inform a supervisor not only the values of the temperature, but also their relative position. For this application only the temperature is informed.

As the first step, the microcontroller should known its IP address and should be able to understand ICMP to reply to a ping command. For this, a new four-bytes register is used to store the IP number, besides counting on instructions whose purpose is to reply to a ping command sent by a supervising computer. Instructions are added to make it faster to decode the ETHERNET and the ICMP header.

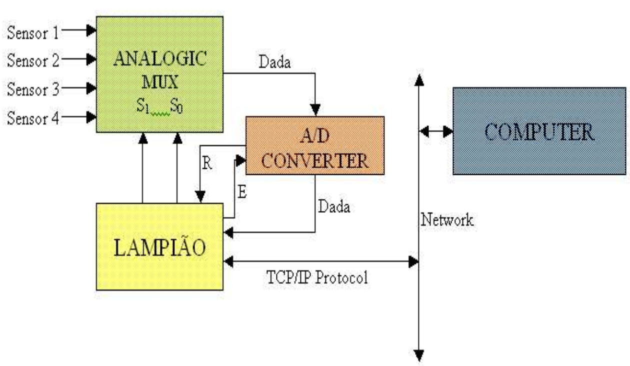

Figure 2. LAMPIÃO in network.

The schematic diagram of the operation of the microcontroller in a TCP/IP network is presented in Figure 2. The ICMP header has 8 bits for type. This byte is all zeroes for echo reply, used in ping. It is three if host or port is unreachable, and eight for echo request, also used in ping. The next eight bits is called code, it is zero for echo reply or request one for host unreachable and three for port unreachable. The next two bytes is the checksum. After that comes data, which depends on the first two bytes (type and code) [5]. The ICMP is encapsulated by the IPv4 header and the ETHERNET header. This last one is the outmost header. The IP header without options has twenty bytes. An ICMP ECHO_REQUEST is 8 bytes long[6][7]. Therefore ICMP plus IP takes at least 28 bytes. ICMP is IP protocol type 01.

The ethernet header starts with a 48 bits MAC address for the destination plus another 48 bits MAC address for the source. Next comes 16 bits of the carrier protocol, IP in our application, then four bits with (0100) for IPv4, then the number of 32 bits words in header. After that eight bits for the type of service for a total of 128 bits or sixteen bytes.

4. CONCLUSIONS

VHDL make easier to implement and modify a microcontroller. Therefore, it is a stimulating task to add new functions for the LAMPIÃO microcontroller, and optimizing the existing ones. In this work, the implementation of ICMP ping has been discussed. As a first application the LAMPIÃO microntroller will be used to inform the measured temperature, later it is expected that it will be able to inform their relative position in the net.

Due to the increasing paper of communications in the most different areas, definitely a microcontroller with high communication capacity is essential to surpass many challenges that we come across in engineering.

5. ACKNOWLEDGEMENT

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