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A Survey on Real Time Communication between FPGA Based Embedded System and an Android Phone using different wireless technologies

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***Abstract*— Applications in areas such as telehealth and household security often require wireless communication between low-power embedded systems and personal Smartphone. This paper presents the design and implementation of a project that exploits communication capabilities in smart phones running the Android Operating System and PC to communicate wirelessly in real-time with an FPGA-based embedded system. Advantage of using FPGAs in such systems promises higher processing capabilities and lower power usage than traditional microprocessors, and has the added benefit of being reconfigurable for future development.**

***Index Terms*- Bluetooth; Wi-Fi; FPGA; Android; wireless; communication.**

I. INTRODUCTION

With the continuous development, wireless communications technologies have been applied to life extensively. There are multiple common wireless communication technologies, such as Bluetooth, WSN [1], Wi-Fi, Zigbee, IrDA, GSM et al. But there exist many problems in the data collection process, such as repetitive human work, complex cable connections, real-time requirement of data processing and electromagnetic interference. Taking into account the application range of various techniques, the cost of data transmission, security, reliability and other factors, Bluetooth communications, wireless sensor networks and Wi-Fi communication are the most appropriate method in short range wireless communication and data transmission [2]. Further, the Wi-Fi technology can solve the problems mentioned above. The system shown in this paper uses the Bluetooth communication technology and Wi-Fi communication for wireless data transmission, handling multiple sensors for data collection, and uses the virtual instrument software to monitor and process the data of all nodes [3]. The advantages of this system are that the data acquisition is multi-channel, and the software based on the lower-range wireless data collection runs fast. The system structure can be widely used in many fields, such as wireless data collection, handheld meter measurement and industrial real time information collection.

In recent years, smart phones have become many people's primary personal computing device due to their vast capabilities, low cost, and mobility. This lead to a push towards interfacing these devices with other electronics such as medical monitoring and household security equipment. By exploiting the smart phones wireless capabilities, a user is then able to control various other devices and monitor a wide array of sensors remotely [1].

As an example, the advantages of this ability in telehealth applications are numerous. Remote medical monitoring allows patients to collect and view health related data while on the go, improving the quality of life of those asked to wear sensors for tests. This data is then easily accessed by health care providers, given that smart phones are easily synced with an online database that hosts a content management system (CMS) [1].

This has proven to lower health care costs, improve the quality of the care provided by offering 24 hour monitoring, and provide access to those living in remote areas or have trouble traveling to hospitals and clinics.

II. THE DESIGN

This paper presents a design and method of implementation that establishes a Bluetooth connection between an FPGA and a smart phone running an Android operating system (OS) also communication between FPGA and Android OS using Wi-Fi module. The design is ideal for applications that require real-time monitoring of data such as heart rate and communicating the measured values instantaneously. For this purpose, a hardware circuit is synthesized on an FPGA utilizing a Bluetooth adapter or Wi-Fi module, and an Android application was developed to read and display this data in real-time. The Android OS is the fastest spreading OS on the mobile market. Furthermore, it is open source; thus allowing more ease and freedom when developing applications [2].

A. Architecture for Communication between FPGA and Android Using Bluetooth

Bluetooth can be defined as a wireless form of communication that enables devices to send and receive communication. The FPGA used as the platform for the embedded system is a Xilinx Spartan 3E found on the Nexys2 development board provided by Digilent. The Nexys2 board supported by four Pmod peripheral modules that allow expanding the design to include sensors, actuators or communication devices. [1]

The Bluetooth peripheral module used is Digilent's PmodBT, a complete integrated solution with a UART interface. It allows wireless communication to and from the FPGA without

the need for an OS. The module hosts the National Instrument's IC LMX9838. Any Android smart phone with Bluetooth capability can run the application; provided it is compiled for the OS version the phone is running.

Xilinx's ISE was used to develop the circuit on the FPGA using VHDL. ModelSim was used for simulation. Eclipse, with the Android SDK as a plug-in, was used to develop the application that is responsible for the communication between the phone and the board. Android applications are written in Java, while some of the user interface features are coded in XML.

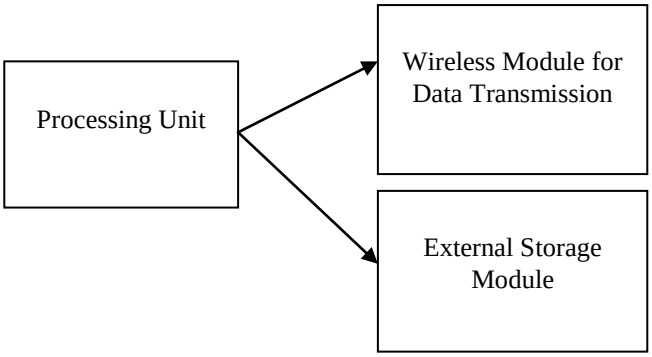

Fig. 1 General Architecture of the System

Figure 1 shows the architecture of the system developed. The Nexys2 board hosts the Spartan 3E which is the base of the system, and can be configured to acquire data from sensors via its many communication interfaces such as UART, RS-232 and VGA. The Pmod BT module interfaces with the board via UART. Both are powered by the same 3.3V provided by the USB.

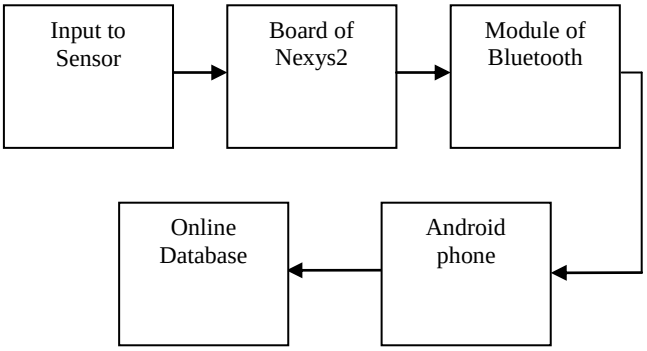

Fig. 2 Architecture of the System Using Bluetooth Module

The smart phone hosts the Android application which receives data from the board and displays it. The application can then be built upon to add uploading functionality so that the data received can be stored online.

B. Architecture for Communication between FPGA and Android Using Wi-Fi Module

Wi-Fi is short for 'wireless fidelity' and is a limited-range wireless networking code which is used in many airports, hotels or other services, who offer public access to Wi-Fi networks, to allow people to log on to the Internet and receive emails whilst on the move. As Wi-Fi is a reasonably fast method of transmitting information in wave form, it is often used in computers and also notebooks. In future, it will become possible to access the Internet from just about anywhere, without the use of any wires.

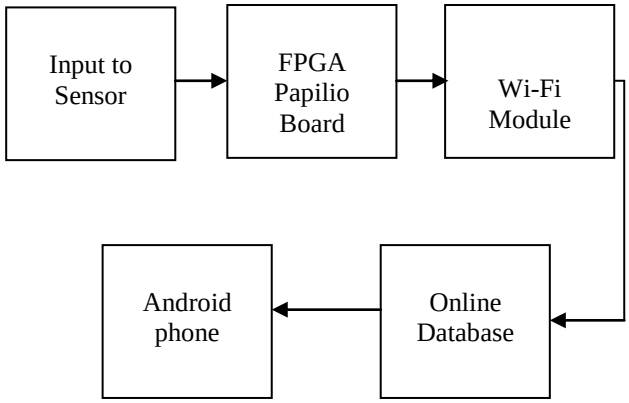

Fig. 3 Architecture of the System Using WIFI Module

The Papilio is an Open Source FPGA development board based on the Xilinx Spartan 3E FPGA. A survey on Wi-Fi module is going on. The Wi-Fi module which is compatible with FPGA kit has to be search. Also we require a smart phone with Android OS. By enabling the Wi-Fi feature of Android phone we can directly communicate with the FPGA based embedded system.

III. ADVANTAGES OF USING WI_FI OVER BLUTOOTH

Bluetooth and **Wi-Fi** are different standards for wireless communication. Bluetooth technology is useful when transferring information between two or more devices that are near each other when speed is not an issue, such as telephones, printers, modems and headsets. It is best suited to low-bandwidth applications like transferring sound data with telephones (i.e. with a Bluetooth headset) or byte data with hand-held computers (transferring files) or keyboard and mice. Wi-Fi is better suited for operating full-scale networks because it enables a faster connection, better range from the base station, and better security (if configured properly) than Bluetooth.

IV. COMPARISON CHART

Parameter	*Bluetooth*	*Wi-Fi*
Frequency	2.4 GHz	2.4, 3.6, 5 GHz
Cost	Low	High
Specifications authority	Bluetooth SIG	IEEE, WECA
Security	It is less secure	Security issues are already being debated.
Year of development	1994	1991
Security	Low (800 Kbps)	High (11 Mbps)
Primary Devices	Mobile phones, mouse, keyboards, office and industrial automation devices. Activity trackers, such as Fit bit and Jawbone.	Notebook computers, desktop computers, servers, TV, Latest mobiles.
Hardware requirement	Bluetooth adaptor on all the devices connecting with each other	Wireless adaptors on all the devices of the network, a wireless router and/or wireless access points
Range	5-30 meters	With 802.11b/g the typical range is 32 meters indoors and 95 meters (300 ft) outdoors. 802.11n has greater range. 2.5GHz Wi-Fi communication has greater range than 5GHz. Antennas can also increase range.
Ease of Use	Fairly simple to use. Can be used to connect upto seven devices at a time. It is easy to switch between devices or find and connect to any device.	It is more complex and requires configuration of hardware and software.
Power Consumption	Low	High
Latency	200ms	150ms
Bit-rate	2.1Mbps	600 ps

V. CONCLUSION

The communication established between FPGA and smart phone can serve as the infrastructure in many other applications where the high processing capability and low power consumption of FPGAs would like to be exploited. This work can also serve as instruction for those seeking to establish reliable wireless communication between an FPGA and a smart phone running the Android OS.

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