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A Review of FPGA implementation of Internet of Things

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ABSTRACT: A hot topic in today's context, FPGA implementation of Internet of Things (IoT) is recently introduced technique. The Internet of things is connecting people and smart devices on a scale that was once unimaginable. One more challenge for IoT is to handle vast amount of sensing the data generated from smart devices that are resource limited and subject to missing data due to link failures. By implementing IoT on FPGA platform, we present a concept in this paper, i.e. the use of low cost FPGA implementation of entire IoT subset including TCP/IP protocol, Control-System, Data Acquisition etc. The IoT applications on FPGA platform have received significant attention from the research community in the past few years. This technique offers a complete, low cost, powerful and user-friendly way of 24 hours real-time monitoring and remote sensing system. The main aim of this research is to highlight how the users can access the FPGA based design resources from anywhere. Thus we present a concept that shortens the application of momentarily unused resources for executing various tasks automatically.

KEYWORDS:FPGA, IoT (Internet of Things), VHDL, IP (Internet Protocol).

I. INTRODUCTION

FPGA-based hardware Web services have already been realized and defined [1], [2]. Their embedded nature permits the developers to simply adjust those services to energeticallyinterrelate with their surroundings, e.g. to attain real-world measurement data or control various actuators [3]. Such entities can be called environment-aware Web services in difference to classical Web services that work on remote physical or virtual machines.
In the modern era IP address is added to the targeted VHDL Code design in order to make Internet of things (IOTs) enable VLSI Design as show in figure 1.

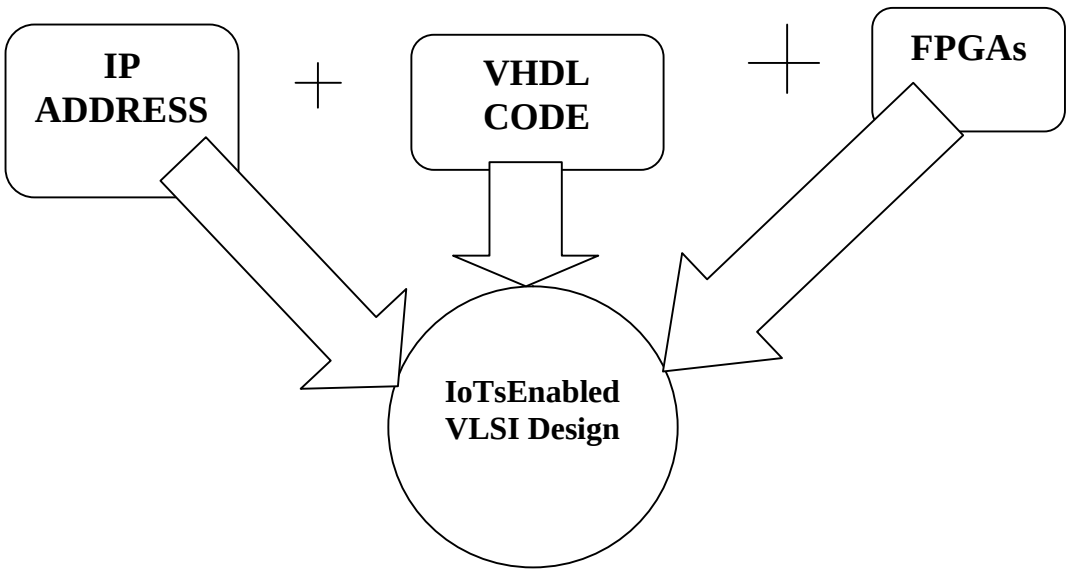

Fig. 1: IoTs Enable VLSI Design

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IOT is implemented on various FPGA devices to project diverse devices for various applications. As the number of IOT devices are increasing fast, results the need to build a smart world of devices with less human stimuli [4]. General idea of IOT is to assign an IP address to a relative device to be pinged out from inaccessible distance, broadly used for real time data collection [11].

1.1 Internet of Things

The internet has enabled an unpredictable growth of information sharing with the introduction of embedded and sensing technology, the number of smart devices including sensors , mobile phones, RFIDs and smart grids has grown quickly in recent years. Ericsson and Cisco predicted that fifty billion small embedded sensors and actuators will be associated with the internet by 2020 [12].

1.2 FPGA

The Field Programmable Gate Array (FPGA) is a family of reconfigurable hardware, where Field Programmable means the operation changing capability in the field, and Gate Array means the construction of basic internal architecture of the device. Digital computing tasks can be developed in software and compiled into a bit stream file. This bit stream file contains information about how the components should be wired together. FPGAs combine the best parts of ASICs and processor based systems, in fact FPGAs are parallel in nature. Advantage of using a software programmed processor is that software is very flexible to change while a disadvantage is that performance can suffer if the clock is not fast. The advantage of an ASIC is that it can provide very high performance because of its dedicated type of operation and its disadvantages are:

1) High cost to volume ratio;
2) Extended delay between designs to end product;
3) Incapability to include new changes after the system is fabricated and
4) Difficulties in debugging errors.

FPGAs fill the gap between hardware and software and offer numerous advantages such as:

1) Flexibility, 2) Reliability, 3) Low cost, 4) Fast time-to-market and 5) Long term maintenance.

After observing this, we conclude that an FPGA is the best reconfigurable hardware platform for the implementation of IoT applications.

II. LITERATURE REVIEW

Various types of research works have been done and still going on day by day to implement IoT applications on FPGA platform. We have read lot of papers which are related to design and implementation of IoT applications on FPGA platform and the work done in those papers is listed below:

2.1 FPGA Implementation of Automatic Industrial Monitoring System.

In this paper, authors proposed the automatic monitoring of industrial system that deals with the core controller of FPGA, the analog sensor such as gas sensor, digital sensor and dust sensor such as PIR motion sensor [5]. To monitor industrial equipment, various sensors have been used and their voltage range is 4.4 V. This confirms a safer monitoring system. The parameters of Area, Power and timing report are analysed. The consumption of area is 937 LUT's, power obtained is 48.11mW and delay is 9.065ns from QUARTUS II 10.0. The maximum voltage to operate the ALTERA CYCLONE BOARD is 3.3V. This has the input frequency of 50 MHz which is generated from the crystal oscillator. The GSM module and ADC is coded in VHDL language. Finally the output can be measured through mobile network and LCD displays its current status. This work can be improved further by connecting proximity sensor, and various other sensors depending on the industry requirement. The automatic monitoring system using IoT(Internet of Things) can be considered for the future work. This paper helped us to understand the concept about IoT.

2.2 WLAN Specific IoT Enable Power Efficient RAM Design on 40nm FPGA

In this paper authors proposed the design and Implementation of power optimized RAM on 40nm FPGA. This RAM is design as IoT enable by adding an additional input of 128-bits and through this the RAM can be accessed via internet [4]. Xilinx ISE 14.6 used to simulate this design. Four different types of LVCMOS and five different WLAN frequencies are taken into account.At WLAN frequency 2.4GHz, there is maximum drop of 85% and at 0.9GHz there is minimum reduction of 64.91% in IO power with using LVCMOS12 instead of LVCMOS25.This design of RAM is

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implemented using 40nm FPGA, further it can be executed using 28 nm and 16 nm ultra scale FPGA. LVCMOS IO standard is used for power efficient design in this work. In future there is a vast scope to reframe this work using other IO standards like Stub Series Terminated Logic (SSTL), High Speed Transceiver Logic (HSTL).

2.3 FPGA Implementation of QoS Multicast Routing Algorithm of Mine Internet of Things Perception Layer based on Ant Colony Algorithm

In this paper, the authors improved the ant colony algorithm, and analyzed simulation results of the improved algorithm, and proved the convergence of this improved algorithm. Perceiving network topology of QoS multicast routing network by using improved ant colony optimization algorithm, then construct a dynamic network topology to form a multicast tree. In view of space and time complexity of ant colony algorithm, adopts FPGA to realize QoS multicast routing algorithm of mine internet of things perception layer based on ant colony algorithm [6]. Experimental analysis proved that FPGA realization of QoS multicast routing algorithm of mine internet of things perception layer based on ant colony algorithm is feasible.

2.4FPGA based Preliminary CAD for Kidney on IoT Enabled Portable Ultrasound Imaging System.

In this paper, the authors proposed a fully-automated kidney abnormality detection system based on wavelet based noise removal, robotic feature selection and administered classification. Experimental results show that the designed classifier authenticates the abnormality without any error. Providing such information helps sonographers to recommend immediate precaution and also monitor disease progression. Thus the proposed technique aids preliminary CAD for kidney on IoT enabled portable ultrasound systems [7].

2.5Research Directions for the Internet of Things

In this paper, the author proposed one vision of the future is that IoT becomes a utility with increased superiority in sensing, actuation, communications, control, and in creating knowledge from huge amounts of data. This will result in qualitatively different lifestyles from today. What the lifestyles would be is anyone's guess. It would be fair to say that we cannot predict how lives will change. We did not predict the Internet, the Web, social networking, Facebook, Twitter, millions of apps for smartphones, etc., and these have all qualitatively changed societies' lifestyle. New research problems arise due to the large scale of devices, the connection of the physical and cyber worlds, the openness of the systems of systems, and continuing problems of privacy and security [8]. It is hoped that there is more cooperation between the research communities in order to solve the myriad of problems sooner as well as to avoid re-inventing the wheel when a particular community solves a problem.

2.6Reconfigurable FPGA-based embedded Web services as distributed computational nodes.

In this article, the authors presented a concept for a better utilization of spare FPGA resources by employing them to perform independent computational tasks. They apply this approach toFPGA based embedded and environment-aware Web services compliant with the SOA paradigm. Additional functional modules have to be provided for each service and particulararchitectural guidelines have to be followed, which they present in this paper as a reference. They attempt to keep additional hardware costs as low as possible. Initially, They applied the concept presented to the previously developed FPGA hardware software platform designed to run various Web services. Future development goals include:

a. Automatic service advertising(which is related to the issue of service repository [9])
b. Developing or adapting available algorithms which would allow us to automatically move computations between FPGA based Web services and the service management subsystem to ensure uninterrupted Web service operation.

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III. PROBLEM STATEMENT

Field Programmable Gate Array (FPGA) circuits play a important role in major recent embedded process control designs. However, exploiting these platforms requires deep hardware conception skills and remains an important time consuming stage in a design flow. High Level Synthesis technique avoids this bottleneck and increases design productivity as observed by industry specialists.
Unlike general-purpose computing systems, which separate the design of hardware and software, embedded systems involve the simultaneous design of hardware and software. The challenge of creating a system which clusters FPGAs in a distributed computing environment requires designers to be knowledgeable in hardware, software, and networking concepts.
Looking to above literature review, the problem arise is that how to implement the applications of IOT on the FPGA platform.

IV. PROPOSED METHODOLOGY

1. Design & Development of a FPGA based IOT implementation for multi-tier sensor nodes & control systems.
2. Use of low cost FPGA for implementation of entire IOT subset including TCP/IP protocol, Control System, Data Acquisition etc.
3. Demonstration of a single FPGA containing & controlling multiple IOT implementations simultaneously.
4. Design & Development in high level VHDL coding so as to facilitate multi-platform portability for our IOT implementation.
5. Support for Ethernet based wired or Wi-Fi/Bluetooth based connectivity to Internet using dedicated hardware modules.
6. GSM Modem Based Connectivity to Internet Server Using 2G/3G GSM Networks.
7. Demonstration by implementation of a multi sensor control system connected to Internet Server & a Server Application running on a dedicated IP with control & data logging facility.

V. CONCLUSION

The growing number of complex IoT applications have raised new challenges in the design of IoT based embedded systems. The FPGAs are one of the areas that are in vogue and its development is related to the evolution of hardware components and their diversity of use. In this paper, we have introduced the study of technology paradigm for IoTs on FPGA platform. The technology is suitable for a real time monitoring in controlling and sensing in industrial automation with large number of controlled devices. Several factors that play a significant role in FPGA-based IOT design include:-proper selection of FPGA architecture, design methodology & optimization techniques etc. In this paper a review of FPGA-based IOT design methodologies have been presented. For the FPGA implementation of IOT applications, some techniques are tailored for certain partitioning schemes & some are for different input description languages like C, Simulink, VHDL etc. FPGA based IOT implementations either incorporate physical model for the FPGA or support the Wi-Fi based connectivity to Internet using dedicated hardware modules. We have grasped many important concepts that will help us in future.

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BIOGRAPHY

Ajay Rupani was born in Jodhpur, India in 1991. He received his B. Tech. degree in Electronics and Communication Engineering from JIET, Jodhpur, India in July 2012. He is currently pursuing the M. Tech. degree in VLSI Design at Rajasthan Institute of Engineering and Technology, Jaipur, with a thesis work on FPGA implementation of Internet of Things. He has published two International journals papers. His areas of interests are ASICs, IoT, FPGA, VHDL, and VLSI Design.

Gajendra Sujediya, received the M. Tech. degree from Shree Balaji College of Engineering and Technology, Jaipur, India in 2008 in Digital communication. He has teaching experience of 9 years. He is currently an Assistant Professor with RIET JAIPUR since July 2014.He has presented numerous journal and conference papers. His research interests include VLSI design, VHDL Programming, Wireless communication and Digital communication.