Routing Architecture and Applications of FPGA: A survey

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Abstract. Field Programmable Gate Array (FPGA) is established in the year 1985 and it is well liked in day to day life. FPGA is the semi-conductor device which is around by configurable logic block (CLB) with the interconnect matrix which develops the FPGA very strong and flexible. When related to the Application Specific Integrated Circuit (ASIC), FPGA has simpler design cycle and by using Hardware Description Language (HDL) code or Verilog Hardware Description Language (VHDL) code creates the design faster and more efficient and also takes less manufacturing time. As compare to microcontroller, the FPGA has more flexibility and it also has high processing speed. This paper will discuss about classification of routing architecture in FPGA namely Island style FPGA and hierarchical FPGA. The recent application in the field of security system, video and image processing, medical electronics of FPGA. Keywords: FPGA, ASIC, NRE cost, FPGA architecture.

1. Introduction

FPGA is used for various range of applications purpose. By using the vectors, it will calculate the performance of FPGA. The performance vectors are memory bandwidth computation and input/output bandwidth. FPGA is mainly used for the prototyping structure which is to reduce the error. Due to this reduction of error, it will consume the time in developing process[1].

Normally FPGA have:

1. To implement the logic function, Programming logic block is used.
2. For programming logic blocks the routing interconnect is used.
3. Some interaction will occur in the internal architecture of FPGA and Input output block is used for outside peripherals.

Several programming knowledge are used for the reconfiguration design. Some technologies such as SRAM, DRAM, EPRoM, flash memory. Each mechanism has its advantage and disadvantage .In that, the SRAM fully based on the programming technics where for storing the information in the bits, SRAM are used in the CLB. But FPGA with the SRAM based programming technologies are very successful in the commercial and academic sector due to the CMOS technology [7].

Configuration Logic Block (CLB) is basic components for the flexibility of the FPGA. It has storage capacity and basic logic function. Also it will spread over the FPGA architecture. CLB has the group of Basic Logic Element (BLE). Basic function of BLE is Lookup Table (LUT) and flip-flop. In the modern FPGA contain 10 BLE’s in the cluster. So that FPGA is capacity to introduce the digital circuit by the routing interconnection need to be flexible [1-3].By this process FPGA has more
efficiency. There are main routing architecture in FPGA but in this paper we discuss about island style architecture and hierarchical architecture.

2. FPGA Architecture

2.1 Island style routing architecture

An island style FPGA architecture is also called as old-fashioned architecture or mesh based FPGA architecture which shown in the Fig.1. Through it clearly shown the CLB with the routing interconnection. Based on the 2D grid, the CLB are arranged. FPGA filled up 80-90% of total space for the routing network where 10-20% areas were occupied by the logic area. In the island style FPGA architecture it contains of vertical and horizontal routing which is consistent in switch boxes (SB). The logic block is interconnected with the connection boxes (CB). The connectivity of input and output pins with the adjacent routing channel called as FC (in) and FC (out). If FC (in) =1.0 which means all the channel are linked to the input pins. If FC (out) =0.5 which means 50% of the channel is linked to the input pins and it is in track of adjacent routing channel [11,12].

If single-driver directional wiring is used instead of bidirectional wiring, 32% in area-delay, 9% in delay and 25% improvement area can be attained [2]. The main characteristics of Island style routing are logic block arranged in the 2-D mesh style with routing resource which is evenly distributed. # of wire contained in a channel which is pre-set during the fabrication and one of the key choices made by the architect. The main pros for the island style architecture are efficient connection for a variety of design net length.

2.2 Hierarchical routing architecture

In hierarchical routing architecture is otherwise called as tree-based architecture. The main goal in hierarchical routing is to increasing the circuit speed and decreasing circuit area. The FPGA logic block divides into groups and clusters. In hierarchical architecture, the signal bandwidth move away
from the bottom level and the top level has the widest path of hierarchy. In the lowest levels of routing hierarchy connection between logic block and cluster through wire. The grouping of LBs forms to clusters. The wires are directly linked to the logic block which placed in logic leave of the interconnected tree and all further wire in sections are separated from the logic part. A logic block has 2 pair which is 2-input LUT and D-type flip flop. The output pins are connected fully and the input pins are based on the k-strategy. It has two levels such that compressing and non-compressing [12].

The advantage of hierarchical routing architecture, if interconnection delay is not significant, the delay is almost equal for all connection. It has superior performance for some logic design [2]. Due to the fully popular switch pattern, hierarchical offer lower density than other FPGA. It has more secure and too lower delay.

Fig. 2 Hierarchical routing architecture

3. Applications of FPGA

The various application of FPGA includes digital signal processing, cryptography, bio-informatics, device controllers, software-defined radio, filtering, medical imaging processing and many more.

3.1 Security System

HeigrujamManasSingh et.al [6] experimentally proved that FPGA based Real-Time Underground Mine Environment Monitoring and Warning System. In this paper, to detect poisonous gases like methane (CH4) and carbon monoxide (CO) and give the warning to the employee in the underground mine environment. To develop the experiment in FPGA the VHDL code is used. The gas sensor is interconnect with the FPGA design and it will observe the data. The threshold value for the gas is fixed in the structure, if the gas is above the threshold value it will generate the warning information to the employee. The observation design system on FPGA board is very reliable and effective so that it will give the safety measure to the workers. To implement the system Nexys 4 Artix7 and for the design purpose Vivado 2015.2 software and also other electronics material are used to detect the gas. The methane gas will getting out and it generate poisonous gases. Thus gases can cause severe headaches and damage the workers body. By using the FPGA structure, it gives fast results in forms of light and sound.

KavitaB. Hunasikatti et.al [9] Implementation of FPGA Based Closed Loop V/f Speed Control of Induction Motor Employed for Industrial Applications. To advance the tracking ability and to control the speed by using the Xilinx block sets which is developed under the PI controller. Induction motor is link with the FPGA controller for hardware experiment. This experiment is implementing by using
Xilinx Simulink which is in closed loop v/f speed control of induction motor. It is mainly used for industrial purpose to control the speed of induction motor.

3.2 Video and Image Processing
Naveen B et.al [10] proved that FPGA Implementation of Image Splitting and Enlarging. The physical time image is splitting the size P*Q into four enflamed image blocks without zooming. It is implemented in FPGA and it is simulated in the model sim 6.3f for image splitting and enlarging. By using FPGA ARTIX 7 device this experiment is tested successfully. At last it executes matrix forms and verified with the output image. It is not mainly used for the medical field but this type is mainly used for sports and railways for displaying the image [4].

3.3 Medical Electronics
Mohammed Alareqi et.al [8] Design and FPGA Implementation of Real-Time Hardware Co-Simulation for Image Enhancement in Biomedical Applications. In this method it has various of enhancement technique such as contrast stretching, brightness control, inverting image operation and segmentation. By using are implemented in the FPGA Virtex5 (XUPV5-LX110T). By using the DSP tool and MATLAB Simulink the image get enhanced. As a result, the vein can be detected by this technique.

3.4 Storage Application
Jakob Stangl et.al [7] A Fast and Resource Efficient FPGA Implementation of Secret Sharing for Storage Applications. For sharing the data in secretly, the IOT process is used which named as cloud approaches. Performance metrics are added to the bit width of secret words are given, which has the higher level protocols. In this process magnitude is high than the software implementation and it is significantly faster than hardware architecture.
4. Conclusion
In 1985, FPGA has been implemented to the world and now it plays a major role in the electronics company. It is mainly suitable for the prototyping model and it easily reduces the NRE cost for the material. In other cases FPGA is better than the ASIC. In this survey paper, we explain briefly about the global routing architecture along with the current application. It is expected that it will increases with quicker ratio in future.

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