Enhancement of the Laboratory Workshop on FPGA: Opportunities and Prospects

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Abstract—**This article is a analysis on the design of systems based on FPGAs from different manufacturers based on OpenSource. Popular boards from leading manufacturers are considered. Options for creating a product using software from both FPGA developers and the developer community are proposed.**

Keywords—FPGA, SymbiFlow, F4FPGA, open source toolchain, Xilinx, Intel.

I. INTRODUCTION

The MTS department conducts remote classes for specialties from several faculties in a discipline consisting of 3 parts:

- Digital signal processing
- Microcontrollers
- FPGAs

To conduct classes remotely for the 2nd and 3rd parts of the "Designing devices on microcontrollers and FPGAs" course, laboratory works are being carried out on boards in the laboratory of the MTS department. Laboratory assistants ruler out connection - disconnection of test boards and measuring equipment. And for microcontroller part to conduct classes, everything is fine: there are enough boards for conducting classes simultaneously in 2 laboratories of the department, the software is supported by different operating systems and has an acceptable volume [1-7]. The most nimble students buy boards for experiments. Some even purchase small-sized oscilloscopes.

But to learn or use an FPGA product is a completely different matter.

II. MAIN PART

The leader in the world of FPGAs is Xilinx, and this is one of the reasons why boards of this particular line are used at the department. Artix-7-T100 is used from the model range and Zynq-7000 is chosen for the perspective of improving the laboratory practice and/or creating special

courses. Though this is not the only FPGA prodictive company. And it is also not all rosy. And, of course, we wish it prosperity, although we cannot properly register on its website to download free software from the territory of Ukraine.
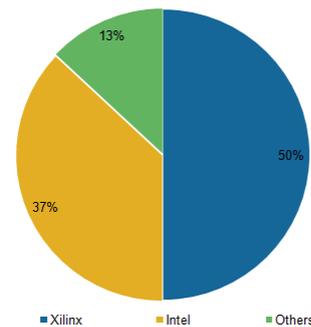

Fig. 1. Programmable Logic Devices' Vendors by Revenue in Calendar 2015.

But if you manage to register, you can use the wonderful Xilinx software. In Vivado or Vitis variants. The operating systems are either Windows or Linux. As for Vivado, in this product you can create and verify an HDL model, simulate a model, trace a project for an FPGA and create a loading sequence, that is, the entire set of tasks. And also it makes possible many other things, for example, the formation of libraries, the creation and adaptation of IP kernels, the study of its really huge documentation. Vivado includes several simulators: Vivado Sim, ModelSim, Questa Advanced Sim, Riviera Pro, Active-HDL. There are plenty to choose from.

For new products, Xilinx recommends Vitis. This product is probably even better and more by its size. In real life, a user usually does not have unnecessary space on the hard disk. And if there is, then it is a little of it. And to install Vivado, it takes about 30 GB, and Vitis is almost 2 times more.

And this is only one firm, and there is something else on the market. No, we're not going to cover everything. But we like to dream.

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For relatively low range Xilinx proposes [8]:

- Spartan-6. FPGAs of the 6th family of Xilinx manufactured using 45 nm technology. Designed for use in cost-effective applications (consumer electronics, wired and wireless communications).

- Spartan-7 I/O Optimization with Highest Performance/Watt. Combining 7 series 28nm programmable logic with high I/O counts, Spartan-7 devices are ideal for any-to-any connectivity, sensor fusion, and embedded vison applications.

- Artix-7 Transceiver Optimized With up to sixteen 6.6Gb/s transceivers and DDR3 support, the Artix-7 family provides the best value for power-sensitive applications such as software-defined radio and low-end wireless backhaul.

- Zynq-7000. Hardware & Software Adaptable SoC For applications typically pairing an application processor with an FPGA, the Zynq®-7000 SoC is the single-chip solution, eliminating die-to-die latency and reducing BOM cost.

Intel in its product line proposes [9]:

- Intel Agilex FPGAs. The Intel Agilex FPGA family, built on 10 nm SuperFin technology (F-Series and I-Series) and Intel 7 technology (M-Series), enables customized acceleration and connectivity for a wide range of compute and bandwidth intensive applications, while providing an improvement in performance and reduction in power. [Intel FPGA product catalog].

- Intel Stratix. The Intel Stratix FPGA and SoC family enables you to deliver high-performance, state-of-the-art products to market faster with lower risk and higher productivity. Flagman.

- Intel Arria. The Intel Arria device family delivers performance and power efficiency in the midrange. The last word is the key.

- Intel Cyclone. The Intel Cyclone FPGA series is built to meet your low-power, cost-sensitive design needs, enabling you to get to market faster. Very interesting and widely used by enthusiasts.

Intel Max. The Intel MAX 10 FPGAs will revolutionize non-volatile integration by delivering advanced processing capabilities in a low-cost, single-chip small form. CPLD.

Intel eASIC Intel eASIC structured ASIC devices complete the gap between FPGA and ASIC by delivering lower power and lower unit price versus FPGAs and lower nonrecurring engineering (NRE) and faster time to market versus standard cell ASICs. Production.

It seems to be no system on a chip (FPGA with a processor).

Software. Quartus Prime and Quartus II are downloadable from the Intel site. There is a free version.

Other manufacturers are doing a good job of occupying a stable niche in this market and are worthy of every respect. To name a few it should be mentioned Lattice. Low power FPGA. (ICE40 Ultra, ECP5, LatticeECP3) and QuickLogic

III. PRACTICAL ASPECTS

And what would we like. According to the impression from communication with colleagues, ISE webpack is perceived by students better than Vivado. Because this product is smaller, more transparent, clearer, better for understanding. But it does not support Artix 7, so it is not suitable for us. More, to make a load sequence, one need to use a stand-alone utility, since there is no such function in ISE. In general, there are fewer functions. And so, returning to the command line is not our way. Although for understanding and taking into account pressing factors, everything can be possible. The general scheme of designing devices on HDL (Fig. 2).
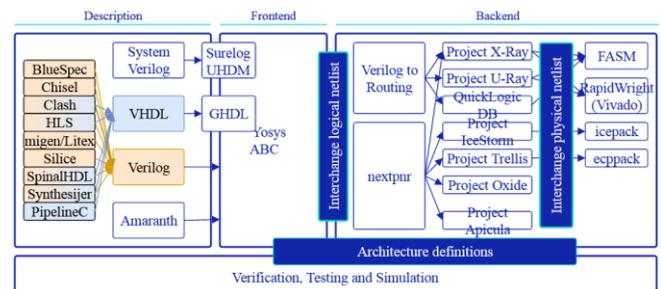

Fig. 2. The general scheme of designing devices on HDL.

But there are enthusiasts [10]. They create to make our life easier and at the same time unite efforts .The purpose of their pleasant pastime is the development of a full cycle project on an FPGA based on open source software. Platform is Linux. Includes FPGA synthesis and tools supporting design tracing for popular boards. Of course, only the lower price segments of the manufacturers' lines are considered, the review of which is higher.

SymbiFlow (now F4FPGA) is a fully open source toolchain for the development of FPGAs of multiple vendors. Currently, it targets the Xilinx 7-Series, Lattice iCE40, Lattice ECP5 FPGAs, QuickLogic EOS S3 and is gradually being expanded to provide a comprehensive end-to-end FPGA synthesis flow (Fig. 3).
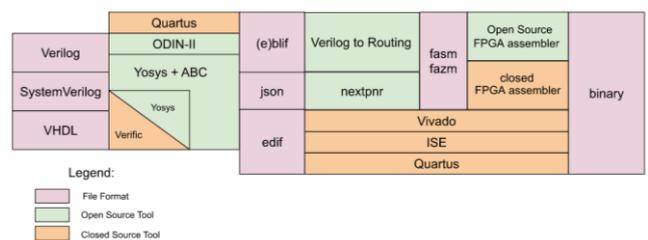

Fig. 3. F4FPGA Toolchain design flow.

The central resources are the so-called FPGA "architecture definitions" (i.e. documentation of how specific FPGAs work internally) and the "interchange schema" (for logical and physical netlists). Those definitions serve as input to frontend and backend tools, such as Yosys , nextpnr and Verilog to Routing. They are created within separate collaborating projects targeting different FPGAs:

- Project X-Ray for Xilinx 7-Series.

- Project IceStorm for Lattice iCE40.

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- Project Trellis for Lattice ECP5 FPGAs.

To prepare a working bitstream for a particular FPGA chip, the toolchain goes through the following stages:

- A description of the FPGA chip is created with the information from the relevant bitstream documentation project. This part is done within the F4PGA Architecture Definitions. The project prepares information about the timings and resources available in the chip needed at the implementation stage, as well as techmaps for the synthesis tools.

- Then, logic synthesis is carried out in the Yosys framework, which expresses the user-provided hardware description by means of the block and connection types available in the chosen chip.

- The next step is implementation. Placement and routing tools put individual blocks from the synthesis description in specific chip locations and create paths between them. To do that, F4PGA uses either nextpnr or Verilog to Routing.

- Finally, the design properties are translated into a set of features available in the given FPGA chip. These features are saved in the FASM format, which is developed as part of F4PGA. The FASM file is then translated to a bitstream, using the information from the bitstream documentation projects.

Only Verilog is used as the description language. If it's VHDL, it needs to be translated to Verilog.

Supported Architectures:

- Xilinx 7-Series: the most popular Xilinx FPGA family.

- Lattice ice40: world's smallest FPGAs for mobile devices.

- Lattice ecp5: low cost FPGAs with high performance features.

- QuickLogic EOS S3: FPGA + CPU sensor processing platform.

- QuickLogic QLF K4N8: a 24x24 eFPGA with 6144 flip-flops, 4608 LUT4s, adder and shift-register support.

Somewhere the use of the Zynq 7000 is considered, but on average the lower price segment is exploited. Are big systems the lot of big companies and big money?

CONCLUSION

Currently, the MTS department uses Vivado software fo FPGA labs. But the team is closely following the trends in the market.

Taking into account the specifics of the moment, we want to use a convenient product with a suitable set of functions. And maybe it doesn't have to be all the features of all the products in the line. Using the F4PGA does not seem to be too simple from a methodological point of view, but it may be one of the options if it is not possible to install a large product, for example, due to lack of memory. Another option

would be to use Python and the HDL library. Just a big shed with a set of tools for all occasions (Vivado or Vitis) you can't take with you on the road. The proposal of possible further solutions is presented in fig. 4.

Fig. 4. The proposal of possible further solutions.

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