Application of WINDLX Simulator in Teaching Practice to Solve the Data-Related in the Pipeline

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Abstract. Data-related in the pipeline of Computer Architecture courses is hard to be understood by students in actual teaching. In this paper, with WINDLX simulation platform tools, through the Windows operating system graphical, interactive WINDLX simulator, to achieve the above theoretical content of the dynamic reproduction, so that students can personally feel the real-time operation of the computer in the instruction flow links. This simulator not only can demonstrate the working principle of DLX instruction in the pipeline machine, but also can provide the statistic of program status. The powerful function of WINDLX simulator has played a positive role in promoting.

Keywords: WINDLX · Computer architecture · Data-related · Instruction set

1 Introduction

Computer architecture as an important computer science pyramid course basic course, which is based on the external features of computer systems to study the basic structure of computer systems. The goal we hope to achieve in teaching is that after studying this specialized subject, students not only improve their research on the overall structure and systematic analysis level, but also to grasp the basic knowledge of all aspects of the computer architecture, such as computer architecture design methods. However, there are many problems in the actual teaching, for example: this course is theoretically strong, involving a large number of knowledge points, it is very abstract for students to learn, they can not profoundly understand the theoretical knowledge of classroom learning, the interest in this course greatly reduced often feel boring, empty, elusive, the interest in this course greatly reduced. In this paper, we use DLX simulator to the actual teaching, solve the data-related in the pipeline to make it easy for students to understand.

2 DLX Instruction Set Structure

2.1 DLX Register

The DLX includes 32 general purpose registers (GPRs) named R0, R1, R2, … R31, the value of R0 is always 0. Based on this feature, this register can be used to synthesize a

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set of useful operations from a simple instruction set. The DLX also contains a set of floating point registers (FPRs) that can be used as either 32 32-bit single-precision floating-point registers, can also be used to store double-precision floating-point numbers, that is, F0 and F1 form a 64-bit double-precision floating-point register, and F2 and F3 form a 64-bit double-precision floating-point register, and so on. These 64-bit floating-point registers are named F0, F2, … , F28, F30. In this way, DLX provides 32 32-bit single-precision floating-point registers or 16 64-bit double-precision floating-point registers. This design of DLX is more efficient. You can extended single precision to double precision to deal with.

2.2 DLX Addressing Method

Using the characteristics of the R0 register is always zero, DLX with very little hardware cost, provides five addressing modes. They are: register addressing; immediate addressing (immediate range is 16 bits), displacement addressing (a register plus the offset to form the address of the operand), register indirect addressing the amount of displacement in the address mode is equal to 0), direct addressing mode (R0 in the register in displacement addressing mode).

The DLX memory is addressed by the byte-first format of the 32-bit address. Because it is a Load-Store instruction set structure, all memory accesses must be done through memory or GPR or load or store operations between memory and FPR. The address for accessing a single word must be in the form of xx00B, the address for accessing the half word must be in the form of xxx0B, the address of the access byte is arbitrary.

3 WINDLX Simulator Introduction

WINDLX platform includes six navigation functions, located at the top of the WINDLX platform interface are: File, Window, Execute, Memory, Configuration, Breakpoints as can be seen from Fig. 1. Click the File option in the navigation bar to see the drop-down menu has four function keys, which are reset WINDLX environment, load the program into the platform and exit the platform. The other five navigation bar corresponding WINDLX platform provides other features that can be set according to user needs.

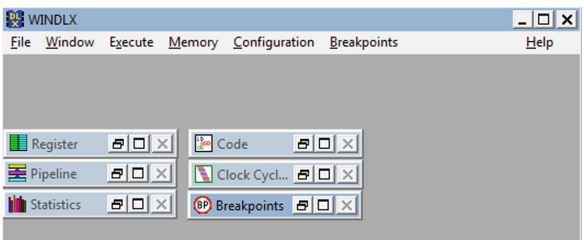

Fig. 1. WINDLX simulator

The Pipeline shows the five functional stages through which an instruction executes. The execution section of the DLX pipeline is divided into four units: intEX unit (integer operation), faddEX unit (floating point addition and subtraction), fmulEX (floating point multiplication), fdivEX (floating point division). We can modify its settings. Clock Cycle Diagram shows the instructions in the pipeline overlap, the different colors of this window pipeline and the Pipeline window color correspond, as shown in Fig. 2.

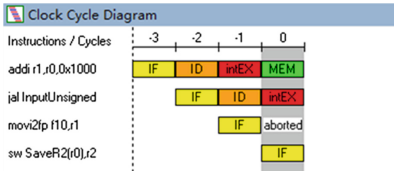

Fig. 2. Clock Cycle Diagram sub-window

The Statistics displays statistics that include the total number of clock cycles required for program execution. Breakpoints show the details of the breakpoint set. Using these subwindows, you can analyze and complete representative data-related, structurerelated and control-related processing experiments and clearly visualize the results of the experimental process.

4 Data Related and Processing Methods

During the execution of an instruction, if the instructions, operands and index offsets used are just the result of executing the previous instructions, you must wait for the completion of the previous instruction execution, and write the result to the main memory or general register, the current instruction to start execution. that is, different instructions on the main memory operand or register there is a “first read and write” association, this correlation is called data-related. Since the data-related impact is only a handful of instructions in the vicinity of this instruction, it is considered to be partially relevant.

In the absence of WINDLX simulator applied to the practice of teaching, for the time being only teachers in theory can first define the data-related text description, then lists two or more instructions in the process of overlapping is how to generate data-related processes, to run a bubbling sort, for example, first double-click WINDLX executable program, open the platform, we will load the data-related programs to the platform. Then in the experimental platform in the navigation bar above the window to find the Configuration option, click the Configuration option, in the drop-down menu to find Enable Forwarding function keys, click on it to make sure that the check mark in front of it disappears, showing that no redirect technology was used, as shown in Fig. 3.

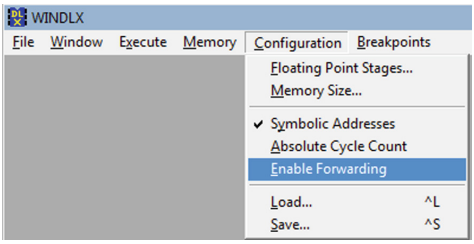

Fig. 3. Cancel redirect technology

After completing this step, we start running the program pre-loaded into the platform, also in the navigation bar above to find the Execute option, click and select the Run function key and click on it. After the program execution is completed, we open the Statistics window under the platform (Fig. 4).

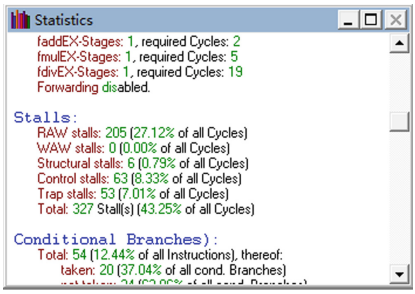

Fig. 4. Related statistical results window

As described earlier, the Statistics window provides information on all aspects, including the reasons for suspension and one of them. Then we can clearly see through the statistics sub-window after the completion of the program execution data related to the number of 205, here to program somewhere in the data-related. For example, as shown in Fig. 5. R-Stall data-related, seqi r5, r3, 0xa in the decoding phase need r3 data, but lbu r3, 0x0(r2) still in the implementation stage, The data in r3 has not been written back yet, so we need to wait for the data to happen.

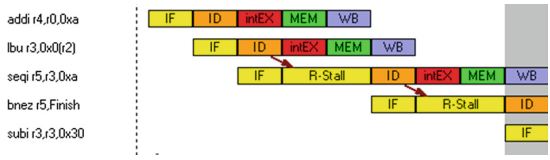

Fig. 5. Generates data-related part of the space-time map

Reduce data-related method is to redirect technology, reset the platform, reload the previous program into the platform. After the loading is successful, select the Configuration option in the navigation bar above the platform and click the Enable Forwarding softkey in the drop-down menu to make sure that the check mark in front of it is displayed. This shows that the redirection technique is successfully used, as shown in Fig. 6.

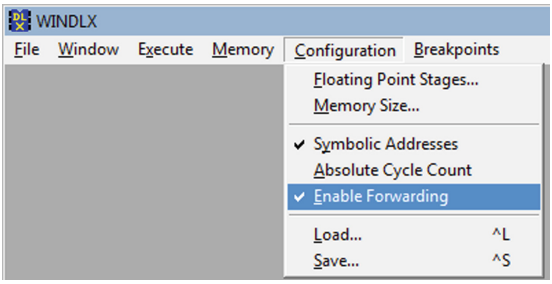

Fig. 6. Using redirection technology

After these steps are successfully completed, the data can be passed on to the next piece of data using the virtual wires provided by the WINDLX platform. Re-enter the data. After the execution of the program is completed, we also open the Statistics window below the platform. As shown in Fig. 7.

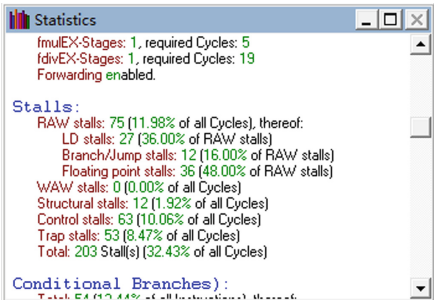

Fig. 7. Using the redirect technology related statistics

Using redirect technology, we found that the number of data-related reduction from the original 205 to 75, the total number of program clock cycles also reduced.

Compared to the theory of teaching, such a teaching method to introduce the simulator is a good way to generate relevant data from all aspects of reduced to a vivid display in the form of graphic students. Similarly, the structure-related and control-related will also be described through the platform.

5 Conclusion

With such information being abundant, we have contributed to the constant melody under the theme of "innovation". Compared to the traditional theory of teaching, WINDLX simulator's powerful features give us an intuitive visual experience, can be clearly in-depth details of the work inside the processor, truly the theoretical teaching and experimental teaching organic combination. Application windlx simulator for students to learn the data-related in the pipeline has an important supporting role.

References

1. Chen, L.J., Gao, X.F., Cui, J., et al.: Analysis of pipeline performance of scalar processor. J. Comput. Technol. Dev. **26**(11), 82–85 (2016)
2. Zhang, C., Wang, Z., Zhang, C., et al.: Computer Architecture, vol. 3. Higher Education Press, Beijing (2003)
3. Lopez-Guede, J.M., Soto, I., de Leceta, A.M.F., Larrañaga, J.M.: Educational innovation in the computer architecture area. J. Procedia – Soc. Behav. Sci. **186**, 388–394 (2015)
4. Lan, X., Huang, L.: Computer architecture software simulation technology. J. Electron. Eng. Softw. Eng. **19**(24), 57 (2016)
5. Mihyar, H.: Computer simulator: an educational tool for computer architecture. J. Am. J. Appl. Sci. **3**(11), 2114–2121 (2006)
6. Application of micro-class in the teaching of basic computer in university. J. Comput. Knowl. Technol.: Acad. Exch. **12**(1), 157–159 (2016)
7. Cai, S.: Research on simulation technology of computer architecture software. J. Low Carbon World **3**, 181–182 (2016)
8. Liu, S., Guo, R., Liu, T., et al.: Teaching research driven by specialty directions for postgraduate course "applied mathematics" in computer science. In: International Conference on Information Technology in Medicine and Education, pp. 781–785 (2016)
9. Pan, Z., Liu, S., Fu, W.: A review of visual moving target tracking. J. Multimedia Tools Appl. **76**(16), 16989–17018 (2017)
10. Liu, S., Pan, Z., Song, H.: Digital image watermarking method based on DCT and fractal encoding. J. IET Image Process. **11**(10), 815–821 (2017)
11. Lu, M., Liu, S., Kumarsangaiah, A., et al.: Nucleosome positioning with fractal entropy increment of diversity in telemedicine. J. IEEE Access (2017)
12. Liu, S., Pan, Z., Cheng, X.: A novel fast fractal image compression method based on distance clustering in high dimensional sphere surface. J. Fractals-Complex Geom. Patterns Scaling Nat. Soc. **25**(23), 1740004 (2017)