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Analysis of the Structural Principles of Computer Systems and the Prospect of New Trends

Miaoying Li, Shukun Wu[a,*], Qianna Ye, Xiong Liang, Xiaoli Lin

School of Mathematics & Computer Science, Guangxi Science & Technology Normal University, Laibin, China
[a]wuskctrl@outlook.com
[*]Corresponding author

Abstract: *In the wave of the information age, as the core force in the field of science and technology, the study of the system and structural principle of computer is particularly important. The system and structure of a computer not only determine its performance and function, but also profoundly affect the construction and development of an information society. The purpose of this paper is to deeply explore the principles of computer systems and structures, analyze the advantages and disadvantages of existing technologies, and look forward to future development trends.*

Keywords: *Computer Architecture; operating system; Development research; New Trends*

1. The latest development of computer system and structure at home and abroad

1.1 Recent Trends in Computer Systems and Structures Development at Home and Abroad

1.1.1 Domestic development:

Processor technology: China has made certain achievements in processor technology, such as Feiteng processor, Loongson processor, etc. In the future, domestic processor manufacturers will continue to increase R&D efforts to improve processor performance and ecological construction.

Memory technology: Domestic memory manufacturers such as Yangtze River Storage and Hefei Changying have made important breakthroughs in memory technology, which is expected to gradually improve the competitiveness of the domestic memory industry.

Operating system: China's self-developed operating systems, such as Kirin operating system and Shenwei operating system, are gradually maturing, and will replace foreign operating systems in more fields in the future.

Artificial intelligence chips: With the rapid development of artificial intelligence technology, domestic enterprises have made certain breakthroughs in the field of artificial intelligence chips, such as Cambrian and Yuanxin Technology.

1.1.2 Foreign development:

Processor technology: Foreign processor manufacturers such as Intel and AMD continue to launch new processors to improve processor performance and power consumption.

Memory technology: Foreign memory manufacturers such as Samsung and Micron continue to develop new memory technologies to improve memory performance.

Operating system: foreign operating systems such as Windows and macOS are constantly updated to improve user experience.

Artificial intelligence chips: Foreign companies have also made important progress in the field of artificial intelligence chips, such as Nvidia, Google, etc.

1.2 Future development directions of computer systems and structures

The framework for analyzing the development of computer systems and structures is shown in Figure 1.

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Performance improvement: Computers need to continue to improve the performance of hardware such as processors and memory to meet the growing demand for data processing.

Power consumption reduction: Operating systems improve performance while reducing the power consumption of computer systems to enable green computing.

Artificial intelligence integration: People deeply integrate artificial intelligence technology into computer systems and structures to improve the adaptability of computers in intelligent scenarios.

Quantum computing: Quantum computing technology is expected to subvert traditional computer architectures in the future and bring new breakthroughs to the computing field.

Edge computing and cloud computing: The integration of edge computing and cloud computing will bring more efficient and flexible computing capabilities to computer systems and structures.

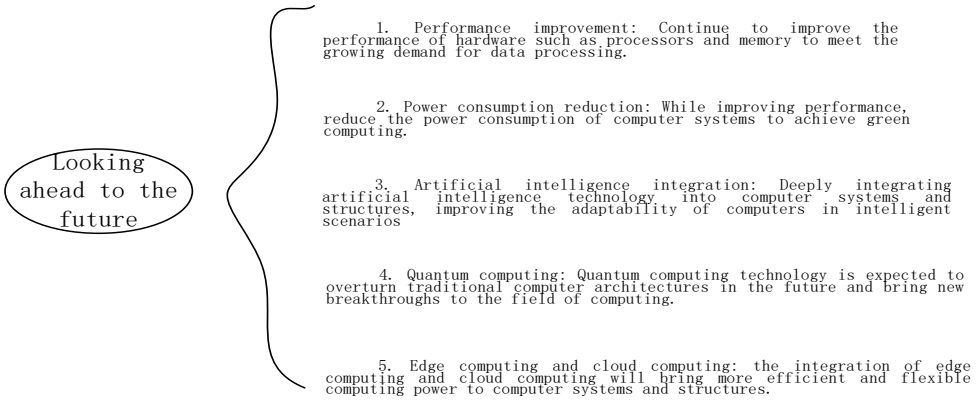

Figure 1: Framework diagram for analyzing the development of computer systems and structures

2. The role and position of the computer system and structure in the operating system

The system and structure of a computer are composed of two parts: hardware and software, and the hardware part is generally composed of a central processing unit (CPU), memory, input and output equipment, and output and output control systems. The software part is composed of programs and data, and the computer system provides the basic architecture for the control system. An operating system is a kind of system software in a computer system, which is responsible for managing and controlling the reasonable allocation of hardware resources and software resources of a computer. [3]

2.1 The role of computer systems and structures in operating systems

The system and structure of the computer in the operating system adopt the basic principles of von Neumann in the hardware part, and the hierarchical structure in the software part to help the operating system better allocate the resources of the computer system.

1) The hardware part of the computer system adopts the basic principles of von Neumann

The von Neumann Fundamentals refers to the principle of stored program control, i.e., controllers, combinators, memories, input devices, and output devices. Based on von Neumann's basic principle, the operating system, as system software, can use the concept of stored programs to store its own program instructions and data in the memory of a computer in the same way as other applications. The operating system's code and data are stored in memory in binary form so that they can be executed sequentially by the central processing unit (CPU). The operating system realizes the management and allocation of hardware resources by controlling the combinators and controllers of the computer, and is responsible for the allocation and control of various resources such as scheduling processes, managing memory, and managing input and output devices. Feng. The basic principle of Neumann is shown in Figure 2.

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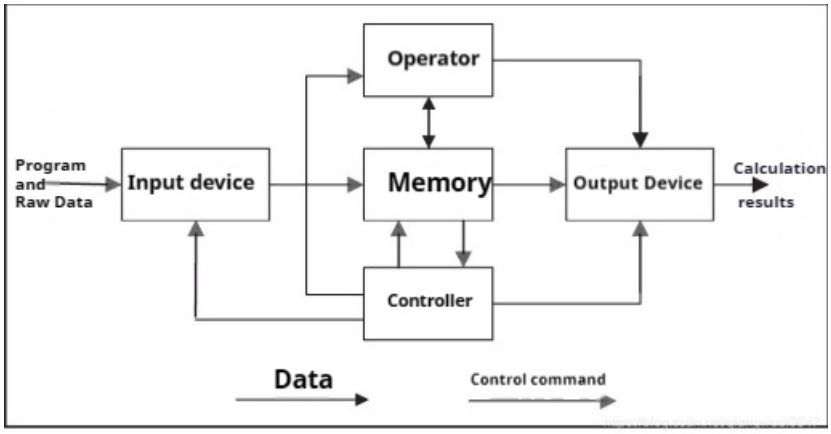

Figure 2: Von Neumann's basic principle

2) The software part of a computer system adopts a hierarchical structure

The hierarchical structure simplifies the computer system, and by dividing the system functions into different levels, the operating system realizes the management, coordination, and control of different levels. This hierarchical structure makes the operating system easier to maintain and debug, increases the reliability and availability of the system, ensures the flexibility of the program, and by dividing various functions into different levels, the operating system can be more flexible to support different applications, making the operating system more versatile and scalable, and strengthens the division of labor and cooperation, so that each level of the operating system can focus on its own responsibilities, such as hardware drivers, file management, Process management, etc., makes the functional division of the operating system clearer, and at the same time, all levels can cooperate with each other, improving the efficiency and performance of the operating system. Figure 3 shows the hierarchical structure of a computer system. [2]

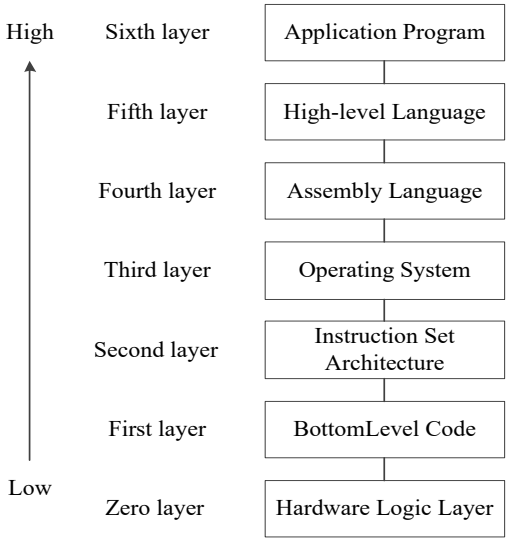

Figure 3: Hierarchical structure of a computer system

2.2 The position of the computer's system and structure in the operating system

The basic principle of von Neumann is mainly reflected in the management and control of resources in the manipulation system, while the hierarchical structure is mainly reflected in the internal organization and functional division of the software system. These two principles work together to form the architecture of the operating system.

1) FengNeumann Fundamentals: vonNeumann's basic principle refers to the fact that a computer stores program instructions and data in the same memory, and that programs can be executed sequentially, and this structure of stored programs greatly improves the flexibility and versatility of computers. In the operating system, vonNeumann's basic principles are mainly reflected in the

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management and control of hardware resources by the operating system, including the management and scheduling of memory, I/O devices, central processing units, etc. [1]

2) Hierarchical structure: At the software level, the operating system adopts a hierarchical structure, which organizes the code of different functions into multiple levels, each with different responsibilities and functions. This structure is conducive to improving the maintainability, scalability, and portability of the system. In the operating system, the hierarchical structure is mainly embodied between the operating system kernel and the user-space program, the kernel is responsible for providing low-level access and control to the hardware, and the user-space program accesses the functions of the kernel through the interface provided by the operating system.

3. The specific workflow of the computer system and structure

The specific workflow (or working method) of the computer system and structure can be divided into the following steps:

Input: The user sends instructions and data to the computer through input devices (such as keyboards, mice, etc.).

Processing: The central processing unit (CPU) of the computer receives the input data and performs corresponding calculations and processing according to the instructions. This process includes arithmetic operations, logical operations, and the execution of control instructions.

Storage: During processing, the computer stores data and instructions in memory. There are two types of memory: random access memory (RAM) and read-only memory (ROM). RAM is used to store the programs and data that are being executed, while ROM is used to store the programs that are needed when the computer boots up.

Output: The computer displays the processed results to the user through the output device (such as monitor, printer, etc.). This includes text, images, sounds, and more.

Control: The controller inside the computer is responsible for coordinating the work of each component to ensure the correct execution of instructions. The controller schedules the operation of the computer according to the command period, clock signal and other control signals.

Power supply: The power supply of the computer provides stable voltage and current for each component to ensure their normal operation.

Heat dissipation: The computer will generate heat during operation, and the heat dissipation system is responsible for discharging the heat in time to ensure the normal operation of the computer and prolong the service life of the components.

Fault detection and maintenance: The computer has the function of fault detection and self-maintenance, so that it can alarm and repair in time when problems occur.

Figure 4 shows the specific workflow of the computer system and structure.

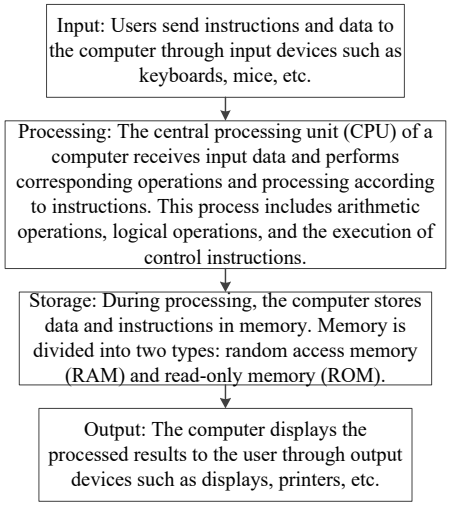

Figure 4: Computer system workflow diagram

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4. The deficiencies of the computer system and structure

The system and structure of computers have promoted the development of science and technology to a large extent, but there are also some shortcomings. Here are some of the main drawbacks:

Memory limitations: Computers have limited memory capacity, and as application requirements continue to grow, memory capacity becomes a bottleneck. While the continuous development of memory technology has alleviated this problem, there are still certain limitations.

Processor performance limitations: While processor performance has been improving, it still has limitations when it comes to handling complex tasks and large-scale data. In addition, the processor's clock boost is slowing down, indicating that it is challenging to further improve processor performance. [7]

Memory latency: Computer memory access is relatively slow, resulting in latency issues when processing large-scale data. While the emergence of new storage technologies (e.g., NVM, Optane, etc.) has improved, there is still room for improvement.

Connectivity bottlenecks: In computer systems, the interconnection speed between processors, memory, and external devices is limited. As networks grow in size and data volumes, interconnectivity becomes a key factor in improving system performance.

Software complexity: The software in computer systems is becoming more and more complex, making maintenance and upgrades difficult. In addition, software vulnerabilities and security issues are becoming more prominent.

Energy consumption: Computer systems, especially data centers, have high energy consumption, which not only increases operating costs, but also has a negative impact on the environment. As a result, green computing is in the spotlight.

Compatibility issues: There are compatibility issues between hardware and software from different vendors, which can lead to system instability and performance degradation. [6]

AI and human collaboration: Despite significant advances in AI technology, there are still challenges to human assistance, such as communication barriers, moral and ethical issues, and more. In short, while promoting the development of science and technology, the computer system and structure have also exposed some shortcomings. In order to solve these problems, we need to constantly explore new computing models, hardware technologies, and software methods. The shortcomings of the computer system and structure are shown in Figure 5

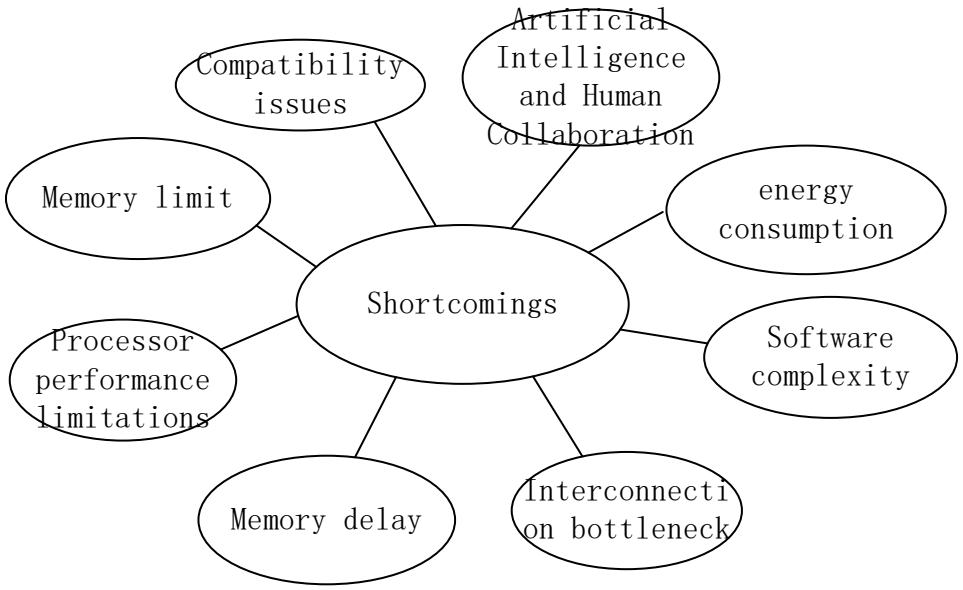

Figure 5: Diagram of Shortcomings in Computer Systems and Structures

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5. Conclusion

Computer systems and structures are constantly evolving, and there are many potential areas for improvement to meet the growing demand. Here are some possible areas for improvement:

1) Memory performance improvement: Improve the speed, capacity, and stability of your computer's memory, and reduce access latency. For example, the use of next-generation storage technologies such as 3D XPoint, NVMe, etc.

2) More efficient processor architecture: Increase the speed and performance of instruction execution by improving the design of computer processors. For example, using more advanced process technologies, increasing the number of processor cores, optimizing the instruction set, etc.

3) Hardware acceleration: For specific computing tasks, develop special hardware accelerators for computers, such as AI inference accelerators and graphics processing units (GPUs), to improve computing efficiency.[4]

4) Hardware and software co-optimization: Through the co-design of hardware and software, the system performance can be improved. For example, computer instruction-level parallelism, thread-level parallelism, multi-core processor optimization, etc.

5) Software-level optimization: Improve computer operating systems, compilers, schedulers and other software components to improve resource utilization, reduce power consumption, and improve system stability.

6) Sustainability and green computing: The energy consumption and environmental impact of computer systems require the use of energy-saving technologies and green energy to reduce carbon emissions and improve system sustainability. [5]

7) Artificial intelligence and machine learning: People can use artificial intelligence technology to optimize the design and operation of computer systems, and realize automatic and adaptive system management. These improvements can be applied individually or in combination to the design of computer systems and structures to improve computing performance, efficiency, and sustainability. However, each improvement method has its advantages and disadvantages, and the actual application needs to be weighed according to specific needs and scenarios.

In short, computer systems and structures will continue to develop in the direction of high performance, low power consumption, intelligence, and environmental protection in the future, bringing more efficient and convenient computing services to human society. Suggestions for the development of computer systems and structures are shown in Figure 6.

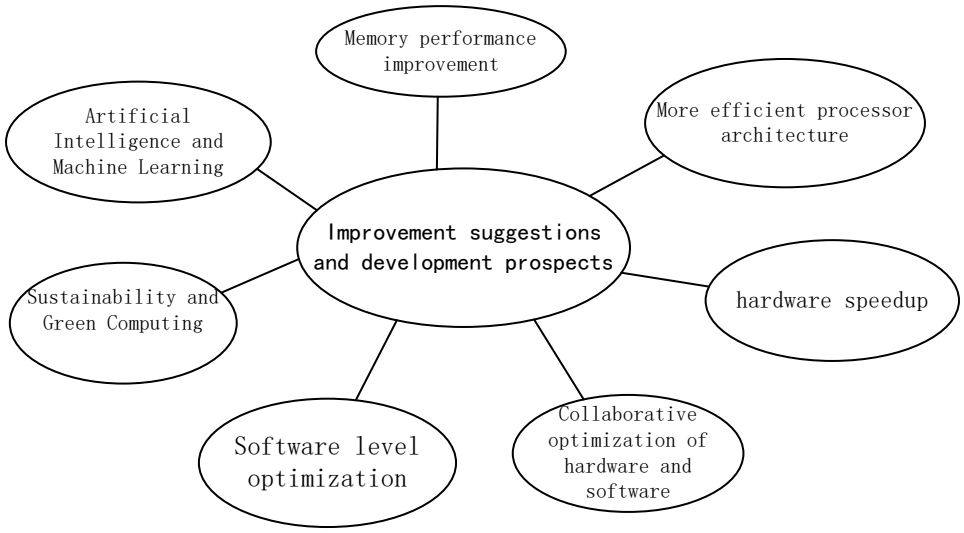

Figure 6: Schematic diagram of suggestions for the development of computer systems and structures

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