Advanced Computing Technology and Standardization Research

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Abstract: Advanced computing has become one of the most important technical fields in the 21st century. In the Internet of Things, artificial intelligence, autonomous driving, weather forecasting, aerospace, information research, life sciences, materials engineering and basic scientific research, industry informatization, and data Concentration and other aspects are of great significance and play a fundamental role in the progress of the entire society. This article will start with the introduction of the development process and basic concepts of advanced computing, focusing on the development status and standardization of advanced computing, and will give suggestions for the development of advanced computing in combination with the actual situation in my country.

1 Introduction

1.1 The history of advanced computing

Computing power is productivity. From knot calculation to abacus and slide rule to calculator and computer, the emergence of new computing technology has fundamentally promoted the development of productivity. In the "new infrastructure" era, data has become a new production factor, and computing power will also become a new productivity. Modern computing technology originated from the birth of ENIAC in 1946. It has been more than 70 years of development so far. It has been promoted by semiconductor process devices, CPU chips, and distributed, cluster, and heterogeneous system technologies. After going through the development stages of mainframe/minicomputer, PC/server, cluster/distribution, miniaturization/low power consumption, etc., it has become one of the fastest-

upgrading and innovative fields in the ICT industry.

Since the 1940s, computing technology has experienced large-scale tube computers, transistor computers, integrated circuit computers, and the development of supercomputers to the present. The computing power has also increased from thousands of times per second to hundreds of billions of times. Computing technology It has changed from traditional electronic computing to today's advanced computing, with huge leaps in computing power, algorithms and calculations. Advanced computing is not a single computing technology, but a general term for future-oriented new computing technologies and industries. The connotation has also evolved from a single computing device application to a diversified system and technology, in accordance with computer science changes, computing algorithm changes, and computing positions. Changes and changes in computing methods can be divided into four categories. The specific development process of advanced computing is shown in Figure 1.

Fig 1. The development history of advanced computing

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The mismatch between supply and demand drives the computing technology industry into a new round of development cycle. Innovative applications such as the Internet of Things, artificial intelligence, autonomous driving, and VR/AR have replaced basic software and hardware as a new driving force for innovation, optimizing and accelerating computing needs for different applications Will become the main idea for the recent upgrade of advanced computing technology. At present, the technological innovation model and the restructuring of the industrial ecosystem are imminent. The influence of open source and openness is increasingly prominent, and the diversified ecological development trend also brings more development opportunities for late entrants.

1.2 Basic concepts of advanced computing

No matter what kind of calculation, its essence is the

processing and processing of digital information. On the basis of summarizing the commonalities of a variety of emerging calculations, the industry puts forward the concept of advanced computing. It does not refer to a specific computing technology or Equipment is a general term for emerging computing technologies and industries that are oriented to information needs from quantitative changes to qualitative changes, and have made progress and innovations in computing methods, locations, algorithms, or mechanisms. Its technological development direction has two dimensions: one is the continuous optimization and upgrading of existing architectures, such as cloud computing, edge computing, memory computing, etc.; the other is the disruptive innovation of future new computing architectures, such as quantum computing and brain-like computing , Photon Computing, etc. Figure 2 shows a mind map of advanced computing categorized by technical direction.

Fig 2. Classification mind map of advanced computing technology directions

2 Development status of advanced computing

2.1 International Status of Advanced Computing

In recent years, the development of advanced computing technology and industry has become a strategic commanding height that major countries in the world have seized. It bears the major strategic demands of countries in science and technology, economy, and security, and is also the key for countries to grasp the new round of technological revolution and industrial transformation. Entry point. The United States, Japan, the European Union and other countries and regions attach great importance to the construction and application of advanced computing capabilities and have successively proposed national-level strategies.

2.1.1 The U.S. has invested the most in advanced computing

As a global technology giant, advanced computing technology is in a leading position in the world. The United States has implemented a series of national plans to promote the development of advanced computing since the 20 century 70, including the “Strategic Computer Project” (SCP), “High Performance Computing and Communications Project” (HPCC), and “Accelerated Strategic Computing Project” (ASCI).), "Advanced Computing Facilities Partnership Program" (PACI), etc. From Figure 3, it is found that the development strategy of the US advanced computing industry has obvious advantages in both breadth and depth. This can be seen from the difference in the development direction of advanced computing technology between the United States and other countries. The United States not only has a broad layout in the optimization and upgrading of the existing architecture of advanced computing technology, but also has a deeper involvement in quantum computing and brain-like computing. This is a clear difference between the United States and other countries.

Fig 3. Types and quantities of advanced computing strategic plans in various countries (Note: The picture is from the "Journal of the Chinese Academy of Sciences" Volume 34, Issue 2)

2.1.2 Japan has always been a big country in advanced computing

Similar to the United States, the Japanese government attaches great importance to advanced computing technology and continuously strengthens its R&D investment in the field of advanced computing. As early as 1990, the SX-3/44R system developed by NEC Corporation of Japan became the world's fastest advanced computer at that time. Later in 1993, the "Numerical Wind Tunnel" system developed by Fujitsu, and the "Earth Simulator" of NEC in 2004 ranked first in the world again. Among the global TOP 500 advanced computers calculated in June 2015, Japan occupies 40 seats. Among them, the "K computer" developed by Fujitsu is ranked fourth in the world, and the "K computer" will be located in the Japan Institute of Physics and Chemistry (RIKEN) to serve Scientific research in physics, chemistry, biology, medicine, materials, energy and other fields. In addition, Japan is carrying out the Exascale Supercomputer Project (E-level advanced computing) project. The goal is to build an E-level advanced computing and software system to replace the existing "K computer", which will serve the future Japanese scientific and technological research such as medicine Design, earthquake impact research, etc.

2.1.3 The European Union has long been an active area for advanced computing

In 2002, 11 advanced computing centers in 7 EU countries jointly initiated the DEISA project, aiming to establish a pan-European advanced computing infrastructure. In the global Top500 advanced computer statistics in June 2015, the European Union occupies 28% of the seats. Facing exaFlops (ExaFlops) computing needs, the European Union proposed the EESI and MareIncognito supercomputing plans, which mainly break through the key technologies of exaFlops in terms of parallel programming models and application algorithms, including programming models, load balancing

technologies, and micro Processor/junction technology, performance analysis tools, interconnection technology and advanced applications, etc.

2.2 Domestic status of advanced computing

my country's advanced computing industry is in the early stages of development and is facing the big market opportunities brought about by the development of the digital economy. It keeps up with the international pace in standard setting and focuses on international cooperation, but it exists in core technologies such as high-end computing chips, operating systems, and new materials. Shortcomings, the industry model is developing in the direction of integration and subversion.

2.2.1 my country has made some progress in the development of key advanced computing technologies, but the development of hardware and software is not balanced

my country has made some breakthroughs in some key technologies of advanced computing. In terms of trusted computing, my country independently developed the country's first trusted computing platform module and trusted computing platform in 2003. In 2006, it began to formulate trusted computing specifications and related standards. Lenovo, Tongfang, Founder and other companies also began to launch Related Products. In terms of biological computing, Peking University has achieved breakthrough work in biological computing. In 2007, it proposed a parallel DNA computing model, which can solve all 48 3-colors of a 3-color graph with 61 vertices. , Even today's fastest supercomputer, it will take 13217 years to complete. It can be seen that my country has achieved certain results in the development of advanced computing, and it is at the world's leading level in certain fields.

However, my country's software and hardware development is not balanced, and the development structure still needs to be adjusted. In high-performance

computers, hardware is more important than software. At present, a large number of application software of high-performance computers is completely dependent on imports, which greatly limits the independent development of my country's advanced computing technology. In terms of heterogeneous computing, hardware has become a development shortcoming. Compared with the design innovation and architecture innovation of foreign heterogeneous computing, domestic enterprises are more application innovation and integration innovation. For example, in terms of enterprise scale, my country has nearly 1,700 IC design companies, but 99% of the company's core IP (CPU, DSP, GPU, etc.) are licensed from abroad. Therefore, my country still needs to improve the key technologies in the supply chain and industrial chain as soon as possible, strive to achieve independent research and development, and enhance innovation capabilities.

2.2.2 Chinese advanced computing standards and policies keep up with international steps and focus on international cooperation

my country actively formulates strategies and development policies in various fields of advanced computing, striving to be at the forefront of the world. In terms of edge computing, my country's Edge Computing Industry Alliance was established in 2016 to promote the cooperation of various industrial resources in the "government, industry, university, research and application" and published the "Edge Computing Reference Architecture" 1.0 and 2.0, which provide the development of my country's edge computing industry. Important guidance. In terms of fog computing, Shanghai established the International Fog Computing Industry-University-Research Alliance Greater China in 2017 to promote the integration and technical exchange of fog computing at home and abroad. In terms of high-performance computing, in 2006 the State Council issued the "Outline of the National Medium- and Long-Term Science and Technology Development Plan (2006-2020)", which included "new concept-based, floating-point computing capabilities and As a key development area, "efficient and reliable supercomputer system" breaks through the core technology of high-performance computing. In the subsequent "Eleventh Five-Year Plan", it was proposed that the key technology of high-performance computing should be close to the international advanced level. In the future development process, relevant strategies and policies will continue to play an important role in technical guidance and industry promotion.

2.2.3 The advanced computing industry model is shifting from iterative innovation to integrated and disruptive innovation

Iterative innovation is a process of continuous development of a single technology, while advanced computing is a multi-discipline fusion technology. Changes have taken place in calculation methods,

calculation locations, calculation algorithms, and computer science. Fusion technology innovation has become advanced computing Mainstream of development. In the system design of advanced computing, it not only includes traditional processors, storage devices and software, but also adds new elements. For example, the development of green computing includes the development and design of materials, and the development of heterogeneous computing depends on the evolution of semiconductor technology. These new development directions enable advanced computing to have more room for development in various fields, and realize integrated and subversive innovative development.

3 Standardization of advanced computing

3.1 International standardization situation

The International Organization for Standardization continues to pay attention to the research work in the field of standardization technology related to advanced computing. JTC 1/JAG/JETI will focus on the development of quantum computing and cognitive computing in the next 15 priority standardization technology fields. At the same time, my country is also playing a role in international standardization work. Played a pivotal role.

In November 2016, the edge computing research group led by my country was established in JTC 1/SC 41, and in May 2017, the edge computing architecture international standard technical report was established in JTC 1/SC 41. In September of the same year, my country led the proposal The fog computing reference model was established in IEEE SA.

In March 2018, the JTC 1/JAG conference made an advanced computing report, which mainly introduced the technical progress, application status and standardization requirements of quantum computing, edge/fog computing, and cognitive computing. It is recommended to set up a research group in JAG or JETI to carry out standardization research work, and set up a special working group to carry out standard setting work in due course. The report was recognized by the participating experts, and JETI included advanced calculations into the research scope

In December 2018, my country has successively promoted the establishment of quantum computing research groups and advisory groups in ISO/IEC JTC 1, and at the same time compiled the "Quantum Computing Research Report" with experts from multiple countries, which has won unanimous praise from the international community. Subsequently, at the 37th JTC 1 plenary meeting in June 2020, my country promoted the establishment of the Quantum Computing Working Group (JTC 1/WG 14). The working group will be convened by Chinese experts. One of the key tasks of the working group is to promote The first international standard for quantum computing ISO/IEC 4879 "Information Technology Quantum Computing Terms and Vocabulary" that has been proposed and passed the project

3.2 Domestic standardization situation

my country attaches great importance to the research work in the field of standardization technology related to advanced computing. As early as 2006, it issued the "Trusted Computing Platform Cryptographic Technology Program", which guided the formulation of the "Trusted Computing Cryptographic Support Platform Function and Interface Specification" published in the same year. , And in this standard describes the functional principles and requirements of the trusted computing cryptographic support platform, and defines the interface specifications for the trusted computing cryptographic support platform to provide services for the application layer.

In September 2017, the project approval of the "Information Technology Edge Computing Part 1: General Requirements" standard was carried out. At the same time, the task plan for the standard was issued in 2019, and the standard is expected to be released in 2021.

In 2020, the Internet of Things Subcommittee of the National Beacon Commission established an advanced computing research group. The research group will focus on advanced computing top-level design and standardization demand analysis, research and sort out the advanced computing industry framework and technology system, and promote advanced computing countries, Development of industry and group standards.

4 Development Trends of Advanced Computing

4.1 Optimization and acceleration for the needs of differentiated applications will be the main direction of the recent development of the advanced computing technology industry

Different application scenarios have huge differences in computing power requirements. For example, IoT applications have moderate computing performance requirements but strong requirements for low power consumption. Autonomous driving applications require low latency and high concurrency to ensure real-time performance. VR/AR requires high performance and Consider low power consumption. The stagnant development of Moore's Law and the increasingly prominent bottleneck of von Neumann have made computing resources increasingly scarce in the future. The upgrading of the computing technology industry will be more targeted around specific application requirements. On the one hand, the overall computing will be improved through software and hardware technology optimization. The performance of the system, on the other hand, abandons the idea of general development in the past, and adopts a dedicated acceleration mode for different application computing needs to ensure that computing supports application innovation.

4.2 In the short term, the advanced computing technology industry will continue to develop based on the existing silicon-based von Neumann system

Although since entering the 21st century, governments, research universities and giant companies around the world have spared no effort to promote the research and development of quantum computing, brain-like computing, new materials and physical devices, but according to the current development progress, the distance is large. Industrial application still takes a long time. In this context, innovation in the computing technology industry will still be based on the existing silicon-based von Neumann system for at least the next 5-10 years.

4.3 Advanced computing equipment will develop towards energy saving and lightweight

With the development of information technology and the advent of the 5G era, more and more data centers are responsible for Internet data storage and processing functions, and reducing computing power has become a key issue that needs to be resolved. At present, high-performance computers and supercomputers consume tens to hundreds of megawatts. Energy-saving computing will become one of the development trends of advanced computing. As the computer architecture is shifting from centralized to distributed, future computing equipment will develop towards lighter weight and decentralized, realizing distributed data processing and storage, improving system reliability, and reducing central server load.

5 Suggestions for the development of advanced computing

As the driving engine of the current digital economy and intelligent society, advanced computing plays an important role in new fields such as industrial Internet, car networking, e-commerce, and artificial intelligence. In recent years, the development of advanced computing and industry has become a strategic commanding height that all countries have seized one after another, bearing the major strategic demands of all countries in science, technology, economy, and security. my country's advanced computing industry is in the early stage of development, facing multiple challenges such as core technology being restricted by people and imperfect industrial chain development. my country needs to plan early to promote the development of advanced computing industry and build a complete industrial ecosystem as soon as possible.

5.1 Strengthen top-level planning and design, and specify the direction of industrial development

It is recommended that relevant national government

departments and research institutions take the lead to establish a working group to promote the development of advanced computing industry, specifically responsible for major issues such as advanced computing development strategy, industrial planning, technological innovation, and related policy research and formulation. Strengthen the overall coordination of resources, introduce a strategic plan for the development of the advanced computing industry chain at the national level as soon as possible, formulate guidelines for the development of the advanced computing industry, and point out the direction for the development of the advanced computing industry.

5.2 Establish a cooperation platform mechanism to promote the development of industrial applications

Advanced computing technology scientific research requires a large amount of high-investment, long-term research and development cycle test platforms and supporting environments. It is recommended to establish a cooperation platform mechanism at the national level, carry out planning guidance and resource integration, set up special funds, and support advanced computing technology through high-quality development projects. Industrial technology basic public service platform projects in the field, avoid inefficient repeated investment and repeated construction of common basic platforms. In terms of application deployment, it is recommended to organize the formulation of related standards such as basic commonality of advanced computing, key technologies and industry applications, and establish an advanced computing standard system as soon as possible. Encourage enterprises to substantively participate in advanced computing research groups through policies and financial subsidies, and carry out applied research on advanced computing standard testing and certification, intellectual property services, etc.

5.3 Make up for shortcomings in the industrial foundation, break bottlenecks and build advantages

It is recommended to comprehensively sort out the industrial basic shortcomings involved in advanced computing technology research, and carry out targeted layout and research on high-end computing chips, operating systems, sensors, system integration and other general technical shortcomings, and accelerate the industrialization of core technological achievements. In this process, we will simultaneously strengthen the training of talents in related fields such as technology, core components, software and testing, and provide effective support for advanced computing technology research.

5.4 Guide the orderly development of localities and enterprises, and promote the coordinated development of the industrial chain

It is recommended that the state adopt policies to guide local governments to give play to their comparative

advantages, form a differentiated development pattern of advanced computing industry segments, focus on supporting central cities with better basic conditions to improve R&D capabilities and industrial levels, and accelerate the cultivation of a group of companies with certain technical strength and business scale. Advanced computing companies with outstanding innovation capabilities continue to strengthen the systematic development of my country's advanced computing field. Relying on industry organizations, establish industry development alliances, hold advanced computing industry technology and industry experience exchange meetings, and give full play to the leading role of advanced computing backbone enterprises. It is recommended to use the market demand brought by my country's digital economy to guide the investment of advantageous resources such as financial institutions and Internet companies to promote the coordinated development of the advanced computing industry chain.

6 Conclusion

In recent years, due to the impact of technological change in, and advanced computing technology innovation into highly active period, the supply and demand do not match the development of advanced computing technology industry into a new round of cycle, industrial networking, e-commerce, Internet, car city of typical industry such as artificial intelligence and wisdom of innovation application replace basic software and hardware as new kinetic energy, for different application computing needs of optimization and acceleration will become the main recent advanced calculation technology upgrading. At present, technological innovation mode and industrial ecological system reconstruction are imminent, and the influence of open source and openness is increasingly prominent. The diversified ecological development trend also brings more development opportunities for the latter entrants.

References

1. *Journal of the Chinese Academy of Sciences* Volume 34, Issue 2
2. *Edge Computing Reference Architecture* Version 1.0, 2.0
3. *Outline of the National Medium- and Long-Term Science and Technology Development Plan (2006-2020)*
4. *Study Report of Quantum Computing* by ISO/IEC JTC1 AG4
5. ISO/IEC 4879 *Information technology - Quantum computing-Terminology and vocabulary*;
6. GB/T 29829-2013 *Information security technology Trusted computing password support platform function and interface specification*