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PROSPECTS FOR THE DEVELOPMENT OF COMPUTING POWER NETWORK TECHNOLOGY FOR SCIENTIFIC COMPUTING

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Abstract: With the advent of the era of scientific computing, the generation of massive scientific data brings rich basic scientific and technological resources, also brings huge benefits to computing and transmission pressure, requiring a lot of resources to process, there is an urgent need for computing network integration technology to organically combine computing power with the network. The computing power network is connected and decentralized, fragmented calculation human resources, build an integrated ICT infrastructure, providing services such as computing power and network capabilities. The article studies computing power network technology for scientific computing. Build the overall architecture of the computing power network, using technologies such as resource measurement, resource scheduling and computing power routing, deploy computing power network prototype system, providing high-performance scientific Learn numeracy, complete complex simulations and scientific calculations. in high energy physics Conduct test demonstrations for typical applications in the fields of astronomy and astronomy, which can significantly improve the network transmission efficiency and big data processing capabilities of scientific big data, improve scientific research information service capabilities and levels, accelerating the output of major innovation results.
Keywords: Computing power network; Scientific computing; Computing requirements

1. INTRODUCTION

Scientific research experienced experimental science, theoretical science and computational science back, resulting in " Da ta-intensive research " represents the fourth paradigm, Modern scientific research methods have undergone a qualitative leap, many important scientific discoveries Already inseparable from the support of advanced data and computing, cosmic simulation, high-energy substances reason, gene sequencing, new drug development, new material research and development and other scientific research fields. new, which has a positive and long-term role in promoting scientific research and national economic development. far meaning [1-2]. However, scientific data in these scientific research fields have emerged in recent years. Blowout growth, massive data has also caused exponential growth in computing requirements, Leap in computing demands creates new challenges. The first is the challenge of diversification, That is, the complexity of scientific computing scenarios, Multi-dimensionalization of scientific computing architecture; 2 It's a huge challenge, that is, composed of huge models, huge amounts of data, and huge amounts of calculations Challenges to existing data processing models caused by massive applications. face Mass storage, high speed transmission, advanced computing power, new challenges brought by collaborative computing war, on the one hand, a single computing power center is no longer able to meet complex scientific research needs beg, on the other hand, in a distributed computing center environment, the placement of data is correct It has a great impact on scientific computing performance and system energy consumption, the data transmission and access overhead need to be fully considered when scheduling and migrating computing tasks. In view of this, there is an urgent need to carry out distributed computing power collaborative scheduling and multi-system architecture structure, high-performance network transmission and other computing network integration, computing network integration research, move Provide computing power, supporting innovative research under the new paradigm of scientific research.

2. THE NEEDS AND CHALLENGES OF LARGE-SCALE SCIENTIFIC COMPUTING

With the development of computing and network technology, a new approach to large-scale scientific computing Explosive growth in demand, the computational scale faced is huge, although The existing computing power infrastructure has increased from millions to tens of millions of processing cores, but when faced with more complex scientific computing applications, still cannot meet its huge demand for computing power. Major scientific and technological projects in some countries aspect, scientific applications that support scientific discoveries flourish, continued to produce Huge experimental data, in order to be able to process massive experimental data, need Expand the scale of computing power, separate different data centers, computing power cluster, etc. are connected to together to achieve computing power sharing. However, the sharing or integration of computing power is faced with Cross-site data access and data transfer issues, especially large-scale data In case of quantity, data access and transmission efficiency,

depends largely on Network quality. WAN quality varies, if not properly scheduled, will shadow Affects the processing efficiency of distributed computing power. and transfer for experimental data processing in large-scale scientific computing, some scientific data choose to be processed locally, data access and transmission performance can be achieved by optimizing the internal network environment. once Need to provide cross-regional data access and transfer, the current scheduling system has no How to obtain real-time quality of network system, it is difficult to achieve real-time computing tasks Data input and output, usually to process a batch of, a centralized method for transmitting a batch of proceed in formula, and need to avoid busy network periods, lack of real-time network status The disadvantages of collaborative task scheduling gradually become apparent.

3. SCIENTIFIC DATA PROCESSING MODEL

According to relevant statistics from the " National Scientific Data Resources Development Report ", The total amount of scientific data resources in my country has exceeded 100PB, high quality supports the country's critical needs, among which, the processing of scientific data becomes the service department The key to learning calculation [1].Scientific data processing also requires network capabilities. further improve, the computing power resources between computing power nodes are processed through the network. Assignment and scheduling, organize heterogeneous computing resources throughout the network to process ocean Quantitative scientific data [2].Data processing models for scientific computing require network-based network-centric, to achieve effective adaptation of computing resources and network capabilities, maximum Provide efficient network computing power scheduling and orchestration to the maximum extent, serving scientific computing. In the current scientific data processing model, mainly centralized data processing models and distributed data processing models.

3.1 Centralized Scientific Data Processing Model and Challenges

The centralized data processing model combines multiple scientific data generation places Data is transferred to one place for centralized processing, scientific numbers in the field of astronomy Data processing uses a centralized data processing model. dispersed in different places square astronomical observatory, combining the massive number of observations generated by multiple observation sites Transmit data to remote data centers in real time, strictly synchronized according to time scale Related processing, it can be obtained that the radio signal of the observed target reaches the ground with different Station antenna time difference, that is, the observation delay, and then carry out various scientific research and engineering applications [3]. Very long baseline interferometry (V ery Long Baseline Interferometry, VLBI) is a method with extremely high angular resolution and measurement Precision radio astronomy observation technology, in Astrophysics, celestial bodies and geodesy It has been widely used in fields such as measurement and deep space exploration.. VLBI observations usually involve multiple geographically distant radio telescope observation stations jointly participating in simultaneous processes. OK, that is, VLBI itself is " distributed " Big scientific device. The massive observation data obtained by all measuring stations are processed strictly and simultaneously according to the time scale, the time for the radio signal of the observed target to reach the antennas of different measuring stations on the ground can be obtained Difference, that is, the observation delay, and then carry out various scientific research and engineering applications [3].

With the successful launch of our country's lunar and planetary exploration missions, future More and more detectors will require VLBI systems for tracking and measurement. CVN will build a new observation station, and plans to carry out dynamic dual subnets for different Detectors in the sky perform simultaneous observations. In order to meet the global tracking and measurement capabilities force, when conditions are met, it is necessary to expand to overseas VLBI stations to achieve global Seamless relay observation. The centralized data processing model faces great challenges war, using a single calculation point, on the one hand, single point calculation effect Low rate, on the other hand, transmitting a large amount of raw data without processing to a remote Cheng data center, wasting a lot of bandwidth resources, and the transmission link cannot provided that it is protected, data transmission is extremely susceptible to link status The impact of the situation, once a certain set of experimental data cannot be accurate due to network congestion arrive exactly, will affect the feasibility of the entire system to carry out scientific data computing and processing. reliability and availability. Therefore, the VLBI orbit measurement system faces the data transmission network The pressure on network bandwidth and the capability requirements for dynamic distributed collaborative observation and data processing, there is an urgent need for new technologies to further improve the real-time VLBI orbit measurement system. Flexibility and reliability availability.

3.2 Distributed Scientific Data Processing Models and Challenges

The distributed data processing model refers to the scientific Data is distributed to multiple places for processing, high-energy physics practice in the field of physics Experimental data processing adopts this mode. High energy physics experimental data 10 extremely huge, for example, the Beijing Electron Positron Collider(BESIII)produces approximately 1PB raw data, has accumulated more than 10PB+ data; large The Gulf of Asia

Neutrino Experiment generates 200TB of raw data every year, has accumulated More than 2 petabytes of raw data; High Altitude Cosmic Ray Observatory(LHAASO)The amount of data generated every year exceeds 6PB. Process massive experimental data, need to depend on Relying on large-scale computing power. At present, each experimental cooperation group is trying to integrate the cooperative units into data center,computing power clusters, etc. (hereinafter referred to as sites) are connected together, Realize computing power sharing [4]. For example, the JUNO experiment established a grid system based on Dirac software, will Russia, Italy, France, China and other countries' computing power integrated into the computing grid; the BESIII experiment is a pioneer in high-energy physics in China test, there are many domestic cooperative units, and also established small and medium-sized computing stations point, and try to bring the computing sites together. as mentioned before, faced with the computing requirements of huge amounts of data for scientific research, Whether it is a centralized or distributed scientific data processing model, are in urgent need of Achieve unified utilization of computing and transmission resources, and the emerging computing power network Technology can exactly meet this need [10]. Computing network can realize science Efficient transmission of big data, via caculation, storage and network resources coordination same, Scheduling and Management, which brings great benefits to scientific research from the following three aspects: promotion effect.

1) Significantly improve the efficiency of scientific big data transmission and processing: Via HashNet Network technology enables distributed computing, collaborative utilization of transmission resources, carry Improve computing and transmission efficiency.

2) Significantly reduce scientific big data transmission and processing costs: Via HashNet network technology,which can make full use of idle computing resources, while significantly Reduce network bandwidth requirements, reduce data transmission and processing costs.

3) Improve scientific research information service capabilities and levels, accelerating major innovation Output: Through the demonstration application of advanced network technologies such as computing power network use, improve scientific research information service capabilities and levels, accelerate related disciplines The output of major innovation achievements in the field.

4. COMPUTING NETWORK TECHNOLOGY FOR SCIENTIFIC COMPUTING

4.1 Overall Architecture of Computing Power Network for Scientific Computing

Computing power sharing or integration faces cross-site data access and Data transfer issues,especially in the case of large-scale data, data access Question and transmission efficiency, depends largely on network quality. Take the BESIII experiment as an example, data processing computing tasks are divided into simulation jobs,reconstruction operation and three types of analysis jobs. Because of the large amount of input data, the simulation job Small, can be distributed to smaller sites,but the wide area of many domestic sites Network quality varies, if not properly scheduled, will affect the distributed computing power processing efficiency. The rebuild job is usually done on the local cluster at the primary site, The performance of data access and transmission can be achieved by optimizing the internal network environment. now. The input and output data of analysis jobs are usually large, at present Because the scheduling system cannot obtain the real-time quality of the network system, difficult to realize Real-time data input and output for computing tasks, usually to process a batch of, pass Concentrated method of losing batches, and it is necessary to avoid the busy period of the network, Limits the efficiency of data processing [5].LHAASO experiment and future The JUNO experiment will also face the above problems of the BESIII experiment.. High energy Data access and transmission for physical experiment data processing, lack of real-time network status The disadvantages of dynamic collaborative task scheduling will gradually become apparent, urgently need computing power and Network organic integration, realizing the integration of real-time network status and computing power scheduling, Enrich high-energy physics computing task scheduling strategies, improve scheduling accuracy, from And make data access and transmission more efficient [6].

Face " Cloud + Edge + Terminal " Network collaboration and " Concentration - distribution " Calculate Scenario requirements for force collaboration, and to solve the imbalance in the supply of computing power resources. question, the network will occupy a more important position in the new network computing model set. The functionality of the network will be " Connect computing power ", for data center, computing power Provides connection functions between nodes and user terminals; direction " Scheduling computing power ", Allocation and scheduling of computing resources among computing nodes through the network; and even " Organize computing power " to organize heterogeneous computing resources in the entire network Platoon and organizational management [7-8]. New demands have further raised the requirements for nAccording to relevant statistics from the " National Scientific Data Resources Development Report ", The total amount of scientific data resources in my country has exceeded 100PB, high quality supports the country's critical needs, among which, the processing of scientific data becomes the service department The key to learning calculation [1].Scientific data processing also requires network capabilities. further improve, the computing power resources between computing power nodes are processed through the network. Assignment and scheduling, organize heterogeneous computing resources throughout the network to process ocean Quantitative scientific data [2].Data processing models for scientific computing require network-based network-centric, to achieve effective adaptation of

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Propose the overall architecture of computing power network for scientific computing, based on computing and network transmission resources,targeting the fields of high energy physics and astronomy Scientific computing needs such as domains, deploy corresponding computing power in a cloud-network integration manner resource pool, build computing power network system and application demonstration platform,mainly include Edge computing pool resources, computing power gateway node,computing power forwarding node,computing power Network management and control platform and demonstration application [11].

In the edge computing power pool uses virtualization technologies such as KVM and Docker Realize virtualization management and orchestration of basic resources, and access the computing network through the computing power gateway; the computing power gateway, divided into Human resources gateway and computing power user gateway, main Realize functions such as quality detection, SRv 6 routing and data forwarding of computing power network; computing power forwarding The node implements SRv 6 routing and data forwarding functions able, providing SRv 6 links for the computing power network Redundant nodes and data forwarding capabilities, all count The power gateway and forwarding nodes form the SRv 6 computing power routing network; the computing power network management and control platform is implemented Collection and summary of computing resource status information, capital Source orchestration and management, SRv 6 computing power routing orchestration and management, etc.; Demonstration application platform, Based on computing power network management and control platform, application deployment and orchestration interface layer, realizing the computing power network system Application service management platform, for different Applications are scheduled and managed uniformly.

4.2 Computing Power Network for Scientific Computing Deployment Plan

Computing network system for scientific computing and demonstration application platform, plans to adopt NFV/SDN Virtualization technology for construction and system deployment The picture is shown in Figure 2. in, for computing power network User access gateway, using Linux system based on SR+IPv6 technology implementation, for scientific research equipment/science Provide computing power network access capabilities for research users, number Data forwarding capabilities and SRv6 routing orchestration capabilities force. The edge computing power pool uses KVM+QEMU to realize resource management and adjustment at the virtual machine level. Spend, implemented using Docker + Kubernets Container-level resource scheduling, orchestration and management reason. The core cloud platform

is based on platform cloud network resources Connect to edge computing pool, forming an edge, core Two-level computing power network system, supports the number of services Distributed scheduling and management of data on edge and cloud wait. Computing network management and control platform, to realize computing resource status monitoring, Resource arrangement and management, SRv 6 route orchestration and management, etc, for demonstration The application provides resource view and business scheduling functions Serve. Demonstration application platform, realizing computing power network The network system's ability to support demonstration applications.

1) Docking with high-energy physics experimental applications

After decades of development in domestic high-energy physics develop, on the data processing side, each experiment has been formed into a relatively mature data processing software, Operation A complete set of pipelines at the application level such as programs. Mainstream high-energy physics computing platforms currently use High-throughput computing mode as a computing platform The basis of the degree system, combined with independently developed Chinese Middleware suite, integrated deployment of high-energy physics experiments software, data and other necessary elements for experimental data processing, thus forming a complete combination of application and platform. Similar to traditional scheduling systems, count The computing platform scheduling system mainly consists of queue clusters, scheduler, scheduling collector and compute node group become, fully considering the diversity and scale of resources scalability, as long as any resource is authorized through right, you can freely publish the information to the scheduling system in source collector, to support computing power network and high Can be connected to physical computing platform.

The application of computing power network in the field of high energy physics is shown in Figure 3, the computing power network manages In the computing power pool, according to the scheduling policy of the computing power network slightly, select the appropriate computing power node, and publish Resource collection from the selected node to the computing platform Just use the collector, that is, IaaS (Infrastructure as a Service, infrastructure as a service) to provide computing power services, Original Some scheduling systems do not require changing the original user usage pattern, calculate at the same time Matching work between tasks and computing nodes, still composed of high-energy physics computing platform Finish, this method not only ensures that the computing power network can quickly and effectively distribute computing power Distributed to dispatching system, and at the same time, it can make full use of the cross-platform software and technology accumulated in the field of high-energy physics to ensure the realization of practical applications.

2) Connect with astronomical observation systems

Apply computing network integration innovative technology, combined with the local phase of the VLBI observation station Data processing technology, using computing power network resources to dynamically call to carry out exploration Perform local correlation processing on the detector model, making full use of the idle time of the observation station Computing resources, and then transmit the processed data to the VLBI center for further processing Perform subsequent processing. Typical application deployment in the field of computing network astronomy is shown in Figure 4 shown, study VLBI dynamic networking and the network environment of active and standby VLBI centers middle, using computing power network technology, build dynamic real-time data multi-directional transmission Transmission and computing power distribution system, conduct real-time monitoring and resource allocation of the VLBI network Spend. Switch modes based on the online status and exceptions of the VLBI center, dynamic Adapt data flows and data processing center roles, achieving highly reliable automatic cutting Change target.

The connection between computing power network system and observation system, based on computing power network Demonstration application platform, R&D task scheduling management subsystem, based on PaaS Providing computing power services, according to the requirements of the observation task, computing power network system Directly provide collaborative scheduling services of computing power and transmission resources. Application computing and network integration Innovative technology, combined with the local relevant data processing technology of the observation station, using computing power network resources to dynamically call to carry out local correlation of detector models deal with, making full use of the idle computing resources of the observation station, and then transmit the processed data to the observation center for subsequent processing.. In dynamic networking In the network environment of the active and standby centers, using computing and network integration technology, construction moves State-of-the-art real-time data multi-directional transmission and computing power distribution system, carry out on the observation network Real-time monitoring and resource scheduling. According to the online status and anomalies of the observation center Switch mode, dynamically adjust data flows and data processing center roles, Reality The goal of high-reliability automatic switching is achieved.

5. SUMMARY AND OUTLOOK

Since the computing power network was proposed by the industry, in the government, academia and industry With the joint promotion of the industry, we are ushering in vigorous development, all aspects are entering a critical period of development, and "counting things in the east and calculating things in the west"" The implementation of the project helps build a national integrated computing force network. Computing network serving the development of scientific

computing is a must for future development natural trend, not only can greatly improve the efficiency of scientific computing,it can also be implemented Multidisciplinary collaborative research. Calculation in the face of huge amounts of data for scientific research Require,computing power network can realize efficient transmission of scientific big data,pass calculate, collaboration of resources such as storage and network, Scheduling and Management, building base Scientific computing application demonstration platform based on computing power network, complete scientific big data on-demand flow, intelligent computing and visual analysis processing, supporting major technologies innovative activities, leading future technological development,to help the country become stronger through science and technology.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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