Monitoring of Data-center-platform Service Operation in Power Grid Based on Link Tracking Technology

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***Abstract*—It is difficult to find abnormal location and link combing in the DaaS operation in power grid. In order to solve these problems, we propose a DaaS operation monitoring scheme based on link tracking technology. When a principal requests a DaaS, a uniquely identified TraceID is generated for that principal's request. Every time a resource is invoked by the system, all transactions associated with this TraceID are stored in a log file and processed centrally. Various indicators of each service on the link are monitored by timing monitoring technology according to the time label of TraceID. Finally, through the comparative experiment the feasibility and effectiveness of the link tracking technology in the DaaS monitoring in the power grid are verified, which simulates the data-center-platform service experiment in the power grid. The experimental results show that the combination of link tracking technology, root cause analysis technology and time sequence monitoring technology can effectively solve the problems of abnormal location and link combing.**

Keywords—Data- as - a-service; data-center-platform service in power grid; microservice; link tracking technology

I. Introduction

The analysis field of the all-business unified data center will become the collection center of all-business, all-type and all-time data of the company headquarters and all units. The full-service unified data center provides the application with a unified operating environment, efficient analysis and calculation capability, convenient data query and access service, clear data resource catalog, and flexible data analysis and mining. In the past, the situation of on-demand access, repeated extraction and redundant storage of analytical application data was changed, and the enterprise-level data analysis application supported by "data as the center" realized the transformation from "moving data" to "moving computing". However, there are still problems such as inconsistent cross-service information islands, low quality of enterprise data, redundancy of data sharing, limited business precipitation of data, and inability to effectively accumulate and reuse application data achievements [1]. To solve above problems and the insufficiency, it is necessary to study the new Data-as-a- service(DaaS) model to improve the whole business unified DaaS ability, in order to solve the professional and units are facing in the information construction and application of horizontal business synergy and cross major Data applications difficult problems, and solve the current corporate management and business innovation and rapid development of ascension, and the Data can't efficiently support the prominent contradiction between, effectively improve the unified Data center business management level and ability to share.

As a hot concept in the big data industry, data center platform was first proposed by Ali [2]. Data center refers to the collection, calculation, storage and processing of massive data through data technology, and the unification of standards and caliber. Data center platform realizes data integration and data capability precipitation across business domains through data modeling. Through unified DaaS, data encapsulation and open sharing can be realized to meet the application requirements quickly and flexibly. Data development tools can meet the needs of personalized data and applications, realize the servitization of data applications, and promote data operation [3]. Data center has been widely used in all walks of life [4-7]. Building a data center station has become an effective way to improve the data sharing service level of power grid enterprises [8-9].

As the core of data center platform, DaaS has aroused the research upsurge of domestic and foreign scholars. [10] analyzes the current situation and existing problems of JiangMen mobile information construction, proposes the construction of data exchange center from the perspective of overall height and long-term development, and gives the specific implementation plan and construction content to ensure the smooth implementation of the project. [11] analyzes the overall framework of IDC from the micro perspective and proposed 6 subsystems of IDC. From the macro study of the current domestic IDC development problems, and put forward recommendations. [12] aiming at the current problems of long service speed, low accuracy and weak relevance of big data retrieval, Hot Rank, the ranking optimization algorithm of unstructured data retrieval, was proposed to solve the heat sensitivity problem, improve the accuracy of data search results, and help users quickly find the information they really need. At the same time, the paper designed a big DaaS model based on extended owl-s ontology to solve the problem of unstructured big data management. These technologies and models greatly improve service responsiveness. [13] introduces the important role of DMP in big data application, analyzes the design requirements of DMP system from the perspective of application functions and application scenarios, proposes the architecture and main functions of DMP system, and expounds the typical business process of DMP in RTB application.

Big DaaS [12], as a data usage mode, encapsulates all kinds of data operations on the basis of unified modeling of big data, and provides ubiquitous, standardized, on-demand retrieval, analysis or visualization delivery services. Big DaaS is not only a new technology, but also a new data resource use model and a new service economy model. Research institutions pointed out that enterprises need big DaaS solutions to automatically track the performance and behavior of their systems, and innovate business strategies through big data analysis to improve the overall operating efficiency of enterprises. Currently, EMC, IBM, Microsoft, Amazon, Google, Oracle and other companies dominate this market space. They mainly provide big data storage and analysis services. [12] studies the DaaS architecture, DaaS data model, DaaS model, and the key technologies of DaaS application. In order to provide a standardized architecture scheme for the construction of DaaS platform, a user-experience-oriented DaaS architecture was designed first. Secondly, in terms of data model, in order to realize the DaaS oriented to unstructured data, an unstructured data model based on subject behavior is designed. In terms of DaaS model, the algebraic model of big DaaS and its combination is established through process algebra, and big DaaS based on extended owl-s semantic ontology is designed. In the aspect of big DaaS application, the processing flow of retrieval, analysis and visualization service is elaborated in detail, and the optimization of big DaaS capability is realized by improving the accuracy and efficiency of retrieval service.

Traditional development patterns package and deploy developed programs into specific applications. The packaged application is copied to the server, and the application is extended by running multiple copies on the back end of the load balancer. In this mode, simple applications become more complex as the business grows. Overly complex applications create additional difficulties for the enterprise. For example, when an application is so complex that no developer can fully understand its architecture, fixing bugs and adding new features can be difficult and time-consuming. In addition, an application can be very difficult to scale when resource conflicts occur between different modules. Finally, when all modules are running in the same process, a bug in any module, such as a memory leak, may bring down the whole process and affect the reliability of the whole application. Micro-service (MS) is a new technology for deploying applications and services [14]. The microservices architecture splits a single application into multiple small services with high cohesion and low coupling, each of which runs independently and is developed and maintained by different teams. Lightweight communication mechanism is adopted between services, which is automatically deployed independently. The architectural pattern of microservices can provide great help for complex enterprise applications [15].

The use of a microservice architecture complicates the monitoring of DaaS operations. The problems existing in the business system based on the microservice system are basically divided into four categories: difficulty in abnormal positioning, difficulty in capacity estimation, excessive resource waste, and difficulty in link combing. For engineers, if they cannot analyze the correct log, they will not be able to track the whole business flow, let alone find the problem quickly. Even if they can locate the problem, they will spend a lot of manpower and time. In order to solve this problem, [16] the concept of tracking tree and span was first proposed, and a complete business call chain was constructed. By rewriting some common component libraries, a nearly transparent tracking business path was achieved. The EagleEye developed by Alibaba can analyze the network invocation log to show a complete invocation chain of network requests, so as to locate the bottleneck of response time or find the relevant exceptions and the source of errors. At the same time, the business side can also invocation the relevant API to bury the point and associate the communication between the business and different systems. [17] studies and analyzes the Dapper system of Google, Zipkin system of Twitter and EagleEye of Alibaba, and builds ETrace system on this basis. When an application fails, the engineer can quickly locate the problem, or when the application response time is too long, the engineer can quickly find the bottleneck through ETrace system. The whole system has both real-time processing and offline processing functions, basically meeting the needs of users in different scenarios.

This paper focuses on the operation monitoring of DaaS operation in power grid. The main research contents are as follows:

- Aiming at the full-service of data-center-platform service operation in power grid, the monitoring indexes suitable for the service operation of data-center-platform service operation in power grid are established from the aspects of DaaS performance and stability.
- Proposed a detection model of service operation in power grid data based on link tracking technology. Collect, store and analyze the invocation event data in the distributed system through link tracking technology, and assist the data center in link combing and abnormal location.

II. Building Monitoring Indicators

A. *Data-center-platform Service Architecture*

The service of power grid data center involves the whole service data, which is integrated and processed to form unified data based on the service demand. The data center consists of three layers: basic data layer, precipitation data layer and DaaS layer. Its structure is shown in figure 1 below:

Basic data layer: in order to realize data collection, sharing and sharing, the basic data layer collects and stores the source data;

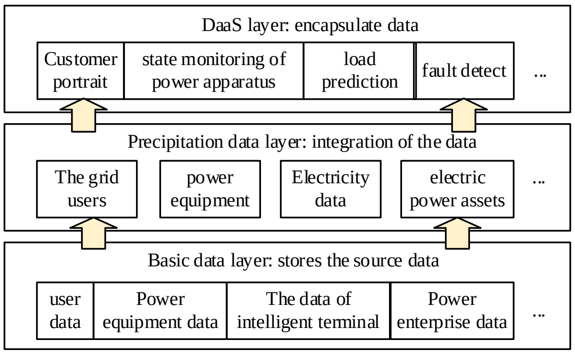

Fig. 1. Main structure of the data-center-platform in the power grid

Precipitation data layer: the whole data which from multiple sources is heterogeneous. The precipitation data layer integrates and processes the basic data and precipitates public data.

DaaS layer: DaaS is demand-oriented, and forms a unified DaaS interface through data encapsulation, so that the data can be open, Shared, and quickly and flexibly meet the needs of the application.

B. *Monitoring Indicators of Data-center-platform Service in Power Grid*

Considering that the service in power grid data involves the whole service data, the monitoring index of DaaS operation is constructed from four aspects of cluster, isolation, micro-service performance and operation by referring to the evaluation standard of DaaS and DaaS model.

Cluster indicators for the performance of the whole cluster, to monitor and record the running state of the cluster, including the number of micro service cluster (including the number of micro services, normal operation and the number of micro service outage), network status (including micro service network can Ping, Ping packet round-trip time), the IP address of the master in the cluster, micro service CPU usage, micro memory usage rate, micro disk usage information service, etc.;

Isolation index is the degree of isolation of resources or data, including the ID and number of various resources of the DaaS, access control list of resources, current allocation status of resources, ID and number of Shared resources of different DaaSs, etc.

Micro service indicators for monitoring all micro service status information, to provide users with each micro service performance parameters, the static information includes: micro service ID, micro service IP addresses, micro active status, number of executor for cluster scheduling, memory footprint information and the remaining percentage, micro disk usage, disk health service status and temperature, disk I/O, CPU load information, the network situation (including HTTP, provide the SSH service is normal), the total number of processes, zombies, currently logged in micro service users, memory Swap usage, etc.

Operation running index for DaaS in the request to be used in the process of running monitoring indicators, including the request DaaS task ID and user ID, name, submit tasks to complete the task executor of micro service, the service IP address, time, finish time, submit a user and task at this time running state (finished, failed, running).

III. MONITORING MODEL BASED ON LINK TRACKING TECHNOLOGY

Fine-grained decoupling micro service architecture is very suitable for building large-scale system, it allows the smart grid select the most appropriate technical services for different, each service can use the most appropriate development language and framework, using the optimal data persistence saving plan, and tuning by an independent service configuration.

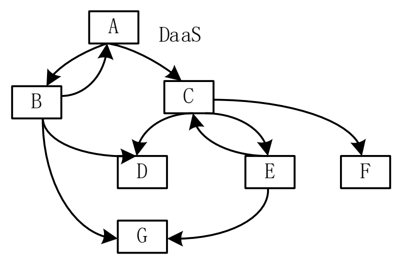

Fig. 2. Microservice invocation chain

For a DaaS, multiple micro services are required to complete one request command. As shown in figure 2, this is A simple microservice request invocation chain that requires microservice B, C, D, E, F and G to coordinate when A user requests DaaS A. A first calls B and C; C needs to call D, E, F; E has to call G to return the result to C; B needs to call D and G. Only after all services have been executed B can return the result of the request to A. If we fail to request A, then any of these links may have problems. If request A delay, we would like to locate which service caused the delay in the execution process, and also want to know what caused the delay, and whether we can reduce the delay. The power grid data center faces the whole service, and there will be a large number of service requests in a short period of time in actual use. If there is no good method to solve the problem, it is easy to cause problems such as link carding difficulty, abnormal positioning difficulty and capacity estimation difficulty.

A. *Link Tracking Technology*

The essence of link tracking technology is the buried point. When accessing the principal's request for DaaS, a uniquely identified TraceID is generated for the principal's request. Every time the system calls the resource, all transactions related to this TraceID are stored in the log file and processed centrally. Link tracking technology is combined with timing monitoring technology to monitor various indicators of each business on the link according to the time label of TraceID. Using link tracking technology, the above invocation chain can be expressed as:

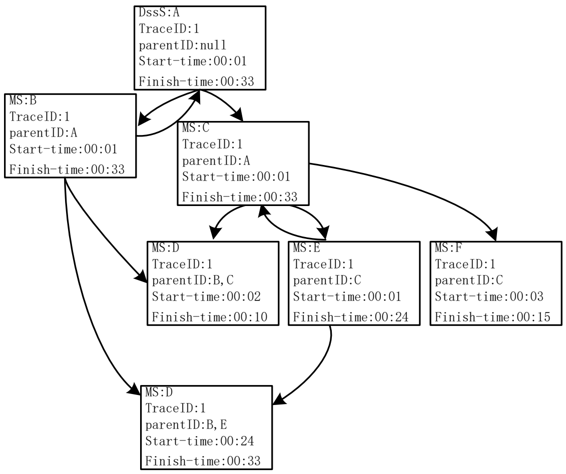

Fig. 3. Microservice invocation chain based on link tracing technology

Only a few important metrics are listed in figure 3: service name, TraceID, parent node that invoked the service, start time, and finish time. When the user requests to invoke DaaS A, A unique TraceID is generated for it, which can be transmitted seamlessly through the system. Through link tracking technology, we can know where business traffic, and collected along the way, a variety of monitoring indicators such as request DaaS task ID and name, start time, finish time, the microservice where the task is done, microservice ID, microservice network (including the provision of HTTP, the SSH service is normal), the number of current request, task running state (finished, failed, running), and other indicators. Under normal circumstances, according to the network condition of the micro-service, we can know whether the micro-service call is successful or not. Understand the current state of the task according to its running state; Based on the start and finish times, we can calculate the execution time of request A and the execution time of each microservice. If A is delayed, link-tracking technology can help us find which server timed out during execution.

B. Monitor Model

Link-tracking technology obtains information by accessing log files. In combination with link tracking technology, timing monitoring technology and root cause analysis technology, various indicators of each business on the link are monitored by timing monitoring technology according to the time label of TraceID. When monitoring index is abnormal, find nearest TraceID nodes which is abnormal in time. We can store the log files stack which related with the TraceID by using returning analysis technology, parsing the log file with different requests by TraceID index. The index results are traversed and then get the call stack, find abnormal root cause and feedback data to data platform. The monitoring model based on link tracking technology is shown in figure 4 below:

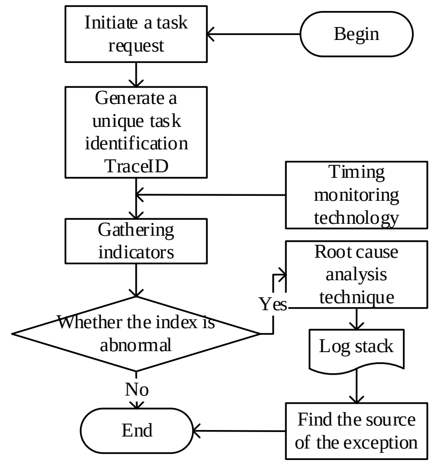

Fig. 4. The monitoring model based on link tracking technology

IV. Experimental Results and Analysis

Netflix Hystrix is an open source library based on the Apache License 2.0 protocol that provides greater fault tolerance for delays and failures by controlling access to remote systems, services, and third-party nodes. Pinpoint is a large distributed system platform based on link tracking technology, processing massive data tracking. This article in Hystrix and Pinpoint 1.73 simulation experiment, we pay the most common user electricity fee as an example, using simulation data to verify the feasibility and effectiveness of link tracking technology in the DaaS operation monitoring.

When A user initiates A request to pay the electricity bill, it first initiates A request to the DaaS A that pays the electricity bill. After receiving the request, A needs to obtain the payment amount, complete the payment request through the third-party platform, and then query the database, update the electricity fee information of the user and feed back to the user. In the whole execution process, because the microservice is the underlying support, the execution of each request is likely to be completed by dozens of microservice. The monitoring indicators selected in this paper during the experiment are as follows: request DaaS task ID and name, start time, finish time, the microservice where the task is done, microservice ID, microservice network (including the provision of HTTP, the SSH service is normal), the number of current request, task running state (finished, failed, running).

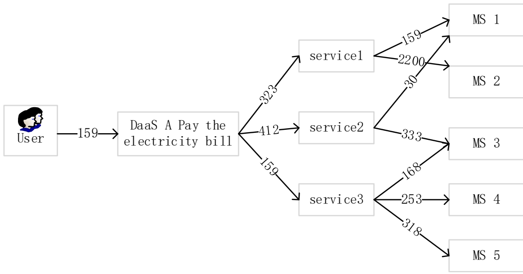

Fig. 5. Simulation user pay electricity fees on Pinpoint platform

The arrows in figure 5 represent the invocation relationship, and the Numbers on the arrows represent the number of invocations. Obviously, when 159 users make a request to pay the electricity bill at the same time, the number of invocations between the different microservices is also different due to the different functions of each microservice. Time delay is a key indicator for users to measure a platform. When the traffic in a certain period is too large, the service cannot respond in time, which may easily cause network congestion and request delay, and reduce users' favorable impression on the platform. Response time and request time are good indicators for this problem.

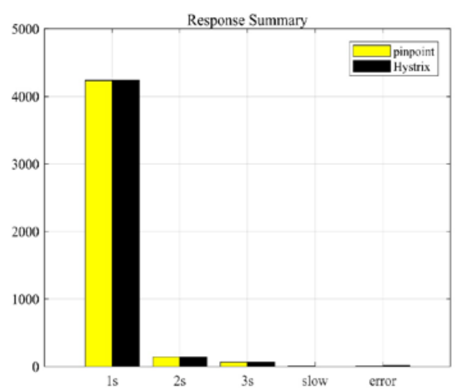

Fig. 6. Response time distribution diagram

Where: horizontal axis represents the service response time, slow means the response time exceeds 3S, and error means the request invocation fails. As shown in figure 6: in Hystrix, when HystrixCommand finds that the request time exceeds the threshold, it quickly activates isolation, circuit breakers, and quickly returns failure information and quickly recovers request instructions. We set the timeout threshold as 3s. In the experiment that simulated users' electricity payment, 4293 responses were completed within 1S, 145 responses were completed within 2S, 62 responses were completed within 3s, and 16 responses were wrong. In Pinpoint platform there are 4293 response is completed in 1S, 145 response completed in 2S, 62 response completed in 3S, 6 response error, 10 response delay. Comparing the experimental results, we found that Hystrix, while having a significant advantage in dealing with service avalanches, could not distinguish whether the service was delayed or actually had a problem. In the whole process of DaaS monitoring, attention should be paid to the service nodes with delayed response and wrong response. By using link tracking technology to query the log, it is found that the 10 response delays all occur in link 1-2. Because the request of microservice MS2 calls the microservice the most times, MS2 is taken as the traffic bottleneck point to focus on monitoring.

Where: the horizontal axis represents the actual time, and the vertical axis represents the time of service invocation. As can be seen from the two figures, when the user initiated the electricity bill request, the success rate of the request was 99.86%, and only 0.14% failed due to network congestion. The monitoring indicator "microservice network situation" shows that the 6 failures occurred on microservice MS2 and microservice MS5 nodes. The TraceID with the closest time in MS2 and MS5 was extracted, and all transactions related to the TraceID were stored in the log file stack by using root cause analysis technology. The log file was analyzed and different requests were indexed according to TraceID. We found that the exception appeared in link 1-2 and link 3-5, as shown in figure 9:

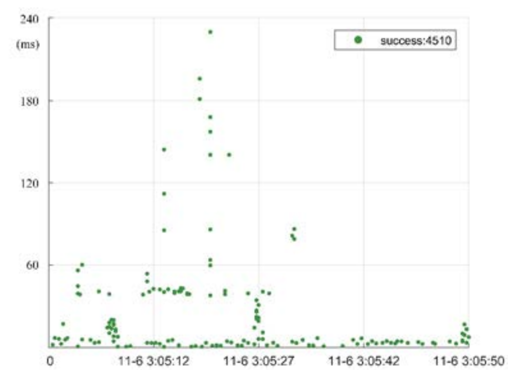

Fig. 7. Number of successful requests

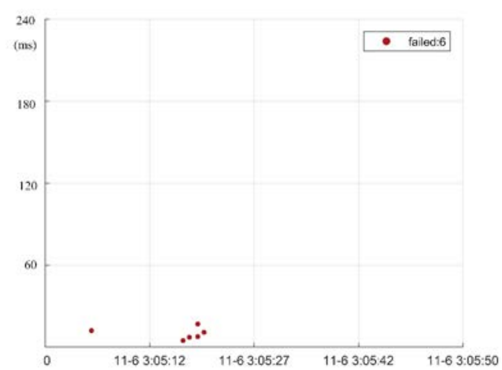

Fig. 8. Number of failed requests

Find abnormal links 1-2 and 3-5 to further check links and error messages. Since the log information involves a lot of contents. In order to display the error information more intuitively, we intercept some important information, as shown in the following table:

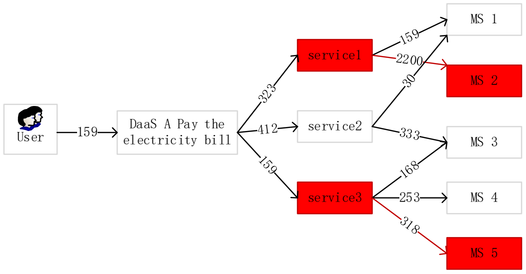

Fig. 9. USES the stack to restore the invocation link

TABLE I. PARTIAL NODE INFORMATION

	Argument	Start time	Finish time
...	...	...	...
service1	*write 0ms; read 0ms*	*11/06 3:05:12 910*	*11/06 3:05:50 726*
service2	*write 0ms; read 0ms*	*11/06 3:05:12 910*	*11/06 3:05:16 183*
service3	*write 0ms; read 0ms*	*11/06 3:05:12 910*	*11/06 3:05:19 331*
MS1	*write 0ms; read 0ms*	*11/06 3:05:12 911*	*11/06 3:05:15 502*
MS2	*write 0ms; read 0ms*	*11/06 3:05:12 911*	*11/06 3:05:15 677*
MS3	*write 0ms; read 0ms*	*11/06 3:05:12 912*	*11/06 3:05:13 005*
MS4	*write 0ms; read 0ms*	*11/06 3:05:12 911*	*11/06 3:05:13 912*
MS5	*write 0ms; read 0ms*	*11/06 3:05:12 912*	*11/06 3:05:14 628*
...	...	...	...
MS2	*error*	-	-
MS2	*error*	-	-
MS2	*error*	-	-
...	...	...	...
MS5	*error*	-	-
MS5	*error*	-	-
MS5	*error*	-	-

As can be seen from the table, a total of 6 request operations failed during the whole link invocation process. Three errors occurred on the MS2 node and three errors occurred on the MS5 node. According to formula (1), the error rate of each node is calculated. According to the settlement results, the error rate of MS5 is higher than that of MS2. Therefore, MS5 is taken as the key monitoring point. Because MS2 was called by a large number of requests within a short time, although its error rate was not high, it was also taken as the key monitoring point in order to ensure the normal operation of the power network data.

$$\beta_i = \frac{error_i}{request_i} \times 100\% \quad (1)$$

In formula (1), $error_i$ represents the total number of errors on node i ; $request_i$ represents The Times of request invocation of node i; β_i is the error rate of the i node.

Microservice architectures typically have many dependencies. In a high-traffic web site, any delay in a single backend can deplete all application resources within seconds. Hystrix enables real-time monitoring of microservice by preventing continuous service invocation failures. But compared to link-tracking, Hystrix does not efficiently combine through links and returns results that do not effectively distinguish the delayed and failed of the microservice.

V. CONCLUSION

We use Pinpoint and Hystrix simulation power network data in pay electricity bill DaaS experiment, compared the two in processing link comb problem and abnormal positioning problem on the performance, verify the feasibility and effectiveness of link tracking technology in the power network DaaS monitoring. The experimental results show that the combination of link tracking technology, root cause analysis technology and timing monitoring technology can accurately and quickly locate the abnormal occurrence point and traffic bottleneck point.

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