Feasibility Study on the Use of Self - Controllable Databases in Operator O - Domain Network Management Systems

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Abstract: In an era where independent innovation in the information technology industry is highly valued, the use of domestic databases in operator O - domain network management systems is of great significance for ensuring information security and promoting industry development. This paper analyzes the necessity, development status, and technical origins of domestic databases, conducts laboratory - based exploration tests and real - world network pilot projects, and verifies their performance in O - domain network management systems from multiple dimensions. The research indicates that domestic databases can basically meet the requirements of business scenarios after system adaptation and performance tuning.

Keywords: Operators; O - Domain Network Management Systems; Domestic Databases; Feasibility Study; Application Verification

1. Introduction

In the rapid development of the information technology industry, network management systems are critical to ensuring stable and efficient network operations [1]. With the continuous expansion of network scale and increasing complexity of services, the data volume and types processed by operators' O-domain network management systems have grown explosively, reaching daily data volumes as high as several thousand TB [2,3]. This imposes stringent requirements on the performance, functionality, and security of databases. In the early stages, foreign commercial databases such as Oracle, Informix, and DB2 dominated operators' network management systems [4]. However, over-reliance on foreign databases carries hidden risks, including legal compliance and licensing issues, potential technical restrictions due to international geopolitical changes, and lack of after-sales support for open-source products [5].

In recent years, China has vigorously promoted independent innovation in the information technology industry, providing a rapid development opportunity for domestic databases. In the financial sector, some banks' core business systems have adopted Dameng databases, achieving secure storage and efficient processing of critical data, ensuring the stability of financial transactions and data integrity. In the government sector, Nanda General's databases have facilitated the integration and management of government data, improving the efficiency and quality of public services [6].

The technical development paths of domestic databases mainly include purchasing commercial closed-source code, iterative development based on open-source products, and independent research and development. Currently, domestic database technology and ecosystems are gradually maturing, with expanding market scales and widespread applications in multiple critical fields. Against this backdrop, the use of domestic databases in operators' O-domain network management systems is of profound significance, aligning with national information security strategies and promoting the independent development of the information technology industry [7]. However, the current adoption rate of domestic databases in operators' network management systems remains low, and their adaptability to the complex business scenarios of O-domain systems requires further validation.

Therefore, this paper conducts laboratory-based preliminary tests and real-world network pilot projects to comprehensively evaluate the performance of domestic databases in O-domain network management systems. The aim is to provide a scientific basis for their large-scale application, thereby enhancing the independent innovation capability and core

competitiveness of China's information technology industry.

2. Analysis of Technical Origins of Domestic Databases

The technical origins of domestic databases mainly include three types: purchasing commercial closed-source code, iterating based on open-source products, and independent R&D. Purchasing commercial closed-source code is achieved through the approach of "introduction, digestion, absorption, and then innovation". By drawing on successful experiences and building on the achievements of predecessors, it enables innovation and breaks through the predicament of domestic databases. A main representative is GBace 8T of NanDa Universal Data Technology Co., Ltd. Iterating based on open-source products means developing commercial closed-source or open-source databases with open-source code as the core. This model has already been proven to be a successful experience abroad, and the main representatives include OpenGauss, AntDB, etc. Independent R&D of databases refers to starting from scratch, conducting completely independent research and development, mastering core capabilities, meeting the requirements of independence, innovation, security, and controllability, having full independent intellectual property rights, and being immune to the risks of the industrial supply chain. A main representative is Dameng, etc. The advantages and disadvantages of the three technical origins are shown in Table 1.

Table 1. Advantages and Disadvantages of Technical Origins of Domestic Databases

Purchasing Commercial Closed-Source Code	Iterative Development Based on Open-Source Products	Independent Research and Development
Advantages: Rapid access to key technologies, breaking technical barriers.	**Advantages:** Low development costs, enabling rapid product iteration.	**Advantages:** Mastery of core database technologies, ensuring supply chain and data security.
Disadvantages: Potential risks to data security and business continuity.	**Disadvantages:** Future product development direction depends on open-source license selection.	**Disadvantages:** High investment in time and resources, requiring breakthroughs in industry technology and market barriers.

In today's booming open-source software ecosystem, open-source licenses, as the guidelines for regulating the use, distribution, and modification of software, play a crucial and decisive role in determining the direction of software development. Different open-source licenses have their own distinct characteristics, as shown in Table 2, which profoundly influence the choices of software developers and the development pattern of the software industry.

Table 2. Characteristics of Open-Source Licenses for Domestic Databases

License Name	Requires Original Code for Redistribution	Requires License Attachment	Requires Original Code for Modified Redistribution	Requires Modification Documentation	Requires Source Code Release for Online	Corresponding Database Products
GPL-2.0	√	√	√	√	X	Mysql
BSD	X	√	X	X	X	PostgreSQL
MulanPSL2	X	√	X	X	X	OpenGauss OceanBase

3. System Testing Research

3.1 Design of Domestic Database Verification Plan

In the digital era, databases, as core tools for information storage and management, are critical to the stable operation of various systems. For operators' O-domain network management systems, database selection directly impacts network management efficiency, data security, and business sustainability. To comprehensively evaluate the key characteristics and real-world performance of domestic databases, this study adopts a rigorous methodology, combining laboratory-based preliminary tests and real-world network pilot projects for multi-dimensional verification.

Laboratory tests allow precise measurement and evaluation of database performance indicators in a controlled environment, while real-world pilot projects test database performance under complex network conditions and actual business loads. These approaches complement each other, providing

comprehensive data support for evaluating domestic databases.

The testing process references the "Domestic Database Selection Evaluation Indicator System" formulated by the China Software Testing Center. This authoritative industry standard covers functional, performance, compatibility, reliability, and security dimensions, ensuring objective and accurate evaluation results.

Based on the differences in the technical origins of databases, this study has carefully selected four mainstream domestic databases within the telecommunications industry as the test objects, as shown in Table 3. Given that databases with different technical origins possess varying technical characteristics, advantages, and potential risks, selecting representative databases from different origins for testing can more comprehensively reflect the development levels and application potentials of domestic databases under different technical paths.

Table 3. Validate the Selected Database Products

database	Technology Streams
AntDB	Commercial database products encapsulated based on foreign open-source databases
Gbase	Commercial database products developed based on purchased foreign closed-source products
Dameng	Completely domestically self-developed database products
OpenGauss	Domestic open-source database products developed based on foreign open-source databases

3.2 System Deployment Topology

As shown in Figure 1, the experimental test system's database-related topology architecture includes various tools and server components. Tools are deployed in the local environment, handling database management, system interaction, data migration, and operational monitoring. The local environment connects to a bastion host via VPN for security control and operational auditing. The primary and secondary node servers run the tested domestic databases, with the primary node handling read-write operations and the secondary node assisting with read requests and failover. All components are interconnected to ensure data synchronization and high availability of the database cluster.

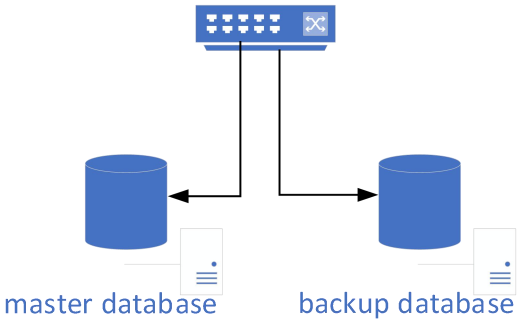

Figure 1. Deployment Environment

4. Testing Process

4.1 Laboratory Testing

In the laboratory preliminary test, in addition to testing the above four domestic databases, the market mainstream open-source database MySQL 5.7 and the commercial database Oracle 11.2.0.4 were also selected for comparative testing with the domestic Database O and Database A respectively. There are a total of 70 test cases, including 25 functional test cases, 4 performance test cases, 7 reliability test cases, 6 security test cases, 15 compatibility test cases, 10 ease-of-use test cases, and 3 extensibility test cases. The test results are shown in Table 4.

1）Database AntDB

Among the 70 test cases, Database AntDB does not support 5 items, which are concentrated in functionality, security, ease of use, extensibility, and compatibility. It shows good performance, with a test support rate of 92.9%.

2) Database Gbase

Among the 70 test cases, Database Gbase does not support 2 items, which are reflected in functionality and maintainability. It shows good performance, with a test support rate of 97.1%.

3) Database Dameng

Among the 70 test cases, Database Dameng does not support 2 items, both of which are in the extensibility testing. The test support rate is 97%.

4) Database OpenGauss

Among the 70 test cases, Database OpenGauss has a total of 7 items that are not supported in terms of functionality, security, ease of use, extensibility, and compatibility. The test support rate is 90%.

Table 4. Database Test Results

database	Unsupported Function Items	rate
AntDB	Storage Mode All-Ciphertext Database Implementation of Shared Storage Cluster Syntax Compatibility	92.9 %
Gbase	Storage Mode Indexing Parameter Recommendations	97.1 %
Dameng	Shared Storage Cluster Implementation Indexing Parameter Recommendations	97%
OpenGauss	Large Object Storage Constraint Management Mandatory Access Control Auxiliary Tools Implementation of Shared Storage Cluster Syntax Compatibility	90%

4.2 Functional Testing of Domestic Databases in the Live O Domain.

The data in the network O - domain is one of the core components of the operator's big data, which is mainly divided into three parts: network device data, network perception data, and network management OSS system data. In terms of professional classification, it covers the core network, wireless network, transmission network, IP bearer network, Internet, home broadband network, enterprise customer network, and network cloud. In terms of network standards, it covers 2G/4G/5G. In terms of detailed classification of types, it is divided into network resources, device alarms, operation and maintenance work orders, business complaints, business perception, network performance, business dial testing, etc. The system topology diagram used in this test is as Fig. 2.

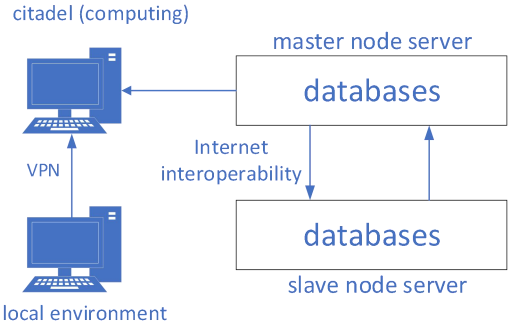

Figure 2. Test Topology Diagram of the Network O Domain System

1) AntDB Database Testing

For the AntDB database, in this platform, it is mainly used to store various data such as data reports, alarms, resources, etc., and supports external query, subscription, and fast calculation functions. In addition, as the production database for the report self-orchestration application, the AntDB database provides the processing capability for a variety of flexible and personalized calculation tasks of self-orchestrated reports.

Table 5. Test Results of AntDB

Function Categories	Function Items	Conclusion
Basic Functionality	6	pass
Maintainability Testing	4	pass
High Availability Testing	6	pass

AntDB is equipped with a multi-modal SQL parsing engine and highly compatible with Oracle syntax. It supports functions such as standard SQL syntax, user-defined functions, views, triggers, and stored procedures, fully meeting business requirements. AntDB provides a variety of data dictionaries, views, and logs, facilitating monitoring and operation and maintenance, and meeting the requirements for maintainability. AntDB offers a comprehensive cluster self-healing solution to ensure second-level automatic failover, achieving business continuity and ensuring data integrity and strong consistency, thus meeting the high availability requirements of production business systems. Through the above tests, this database achieves the expected results, meets the operating requirements of systems within Hebei Province, and shows excellent performance in all indicators.

2) GBASE Database Testing

Pilot Test of Domestic Software for Network Management System - Zhejiang GBASE Test Pilot Project. It mainly involves building a GBASE cluster and conducting functional verification on the basic SQL capabilities, data import and export capabilities, stored procedure and function capabilities, as well as database backup and recovery capabilities of the GBASE cluster. At the same time, it meets the performance, reliability, security and compatibility requirements for the Zhejiang pilot application.

Table 6. Test Results of GBASE

Test Functionality Categories	Test Functional Items	Conclusion
Basic Functions	Data import/export, stored procedures, function development, etc.	Pass
Performance Test	High concurrency, low latency, complex logic business scenarios	not meet expectation
Reliability	Hardware failure recovery capability	Pass
Compatibility	IPV6 testing	Pass

This test encompasses eight modules, including functionality, performance, reliability, security, ease of use, maintainability, extensibility, and compatibility. It also supports clusters for same - city disaster recovery, off - site disaster recovery, and storage sharing. The total number of test cases is 74, and the number of supported test cases is 72, meeting the requirements of this evaluation.

3) Testing of DaMeng OLTP Database for the Core Network Workbench

Based on the business scenarios of the core network workbench, this time, a comprehensive range of tests were carried out on the DM database. There was a total of 14 test items (including 7 functional test items, 2 performance test items, 2 reliability test items, 1 security test item, 1 compatibility test item, and 1 interface test item). The availability of the DM database was verified, confirming that it can meet the daily production and operation and maintenance requirements of the core network workbench, and it has the stable, efficient, and secure operation guarantee capabilities.

Table 7. Test Results of DaMeng OLTP

Function Categories	Function Items	Conclusion
Basic Functionality	7	support
Performance Testing	2	The batch write took 9 seconds, as expected
Reliability	2	pass
Compatibility	1	pass
Security	1	pass
Interface Testing	1	pass

4) GaussDB Database Testing

This time, the Gaussdb database is used in the application environment of business orchestration to verify the end-to-end localization application of Gaussdb's software and hardware. The reason for choosing GaussDB as the commercial database is that GaussDB is the commercial version of OpenGauss, and OpenGauss is an open-source database. The objective reason why the provincial operation company chooses the commercial database is that there are relatively few operation and maintenance personnel for domestic open-source databases. When problems occur, they cannot be solved. Moreover, the commercial database comes with subsequent operation and maintenance services, which reveals some disadvantages of domestic open-source databases during the operation process.

Table 8. Test Results of GaussDB

Total number of cases Executed Passed	Total number of cases Executed Passed	Total number of cases Executed Passed	Total number of cases Executed Passed
Business Function Validation	5	5	5

4.3 Performance Comparison between Domestic and Foreign Databases

1) Comparison Test Results between the OpenGauss Database and MySQL

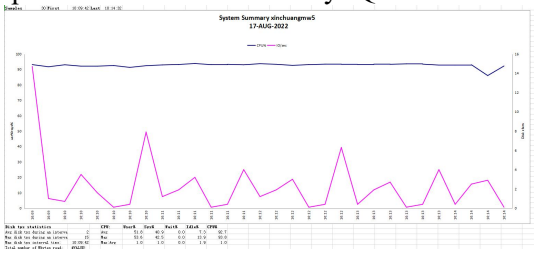

Figure 3. CPU Performance Comparison Between OpenGauss and MySQL

MySQL outperformed OpenGauss in performance, but OpenGauss excelled in functionality and reliability, with fewer unmet requirements (7 vs. 24).

2) Comparison Between AntDB and Oracle

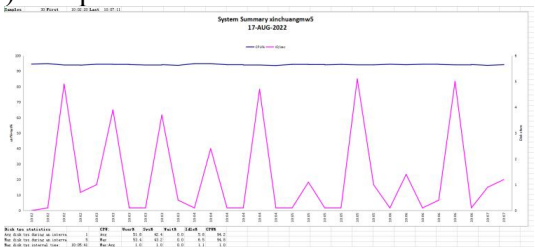

Figure 4. CPU Performance Comparison Between AntDB and Oracle

Oracle had 3 unsupported features, while

AntDB had 4. AntDB outperformed Oracle in load time, TPC-C throughput, data compression ratio, and static data dictionary views. Oracle excelled in shared storage clusters, WITH FUNCTION, and VPD compatibility.

5. Conclusion

Based on laboratory tests and live-network pilot projects, domestic databases can meet the requirements of carrier O-domain network management systems after adaptation and performance optimization. For scenarios where performance falls short, domestic databases can be deployed in less demanding environments. While domestic databases offer cost advantages over foreign commercial counterparts, they lag in talent availability and operational costs compared to foreign open-source alternatives.

Looking ahead, the application of domestic databases in O-domain systems will trend toward intelligence, cloud-native architectures, and ecosystem development. Leveraging AI for adaptive capabilities, cloud platforms for deployment, and partnerships for ecosystem health, domestic databases will provide stable, secure, and efficient solutions for network management, driving independent innovation in China's information technology industry.

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