Comparison and Analysis of X86 Server and Minicomputer Application in Power Enterprises

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Abstract. With the transition from "centralized" to "distributed" infrastructure and the continuous development of cloud platform construction, the disadvantages of the traditional small-sized rack have emerged. By comparing and analyzing the performance of X86 server and minimal machine, we evaluated the performance of X86 and minicomputer in different applications combined with the actual situation of Gansu Electric Power Company of the State Grid, and then carried out the application migration. The results show that the X86 architecture platform has the ability to replace the minicomputer architecture in a reasonable design in the data center.

1. Introduction

In recent years, the State Grid Corporation of China has proposed the construction plan of "big data, cloud computing, Internet of Things and mobile Internet", and the informatization construction aims to achieve "one platform, one system, multiple channels, and micro-applications." The transformation of the infrastructure of the basic hardware and software environment from "centralized" to "distributed" is an important part of supporting the company's construction. Based on its inherent architectural advantages, minicomputer has excellent performance in processing performance and RAS features, and is widely used in various application systems in the power industry. Although the company has vigorously promoted the construction of x86 servers instead of minicomputers, there are still a large number of existing systems running on minicomputers, which have brought many hidden dangers for the future cloud computing and distributed architecture construction. Currently, based on the advantages of the performance, reliability and cost performance of the X86 cluster architecture, the traditional centralized architecture is becoming more and more clear to the X86 cluster architecture and the distributed architecture \cite{1}. By comparing and analyzing the performance and application of X86 server and minicomputer in X86 system, this paper illustrates the possibility of X86 server replacing minicomputer.

2. Performance Analysis of X86 Servers and Minicomputer

The industry has a variety of indicators to evaluate the performance of the host computer. Representative examples include TPC-C/TPC-E, SPECjbb/SPECjEnterprise, and SAPS, which correspond to database, JAVA and ERP service processing capabilities.
2.1. TPC-C/TPC-E Performance Test

TPC-C is an industry-standard benchmarking project designed to measure the performance and scalability of online transaction processing (OLTP) systems. This benchmark project will test database functions including queries, updates, and queued small batch transactions. TPC-C testing is widely used to measure the performance of the overall system built by the server and the client under the C/S environment, which is made by the TPC (Transaction Processing Corp). It simulates simple database and business logic [2].

TPC-C tests the number of tasks per minute processed by the system, and the unit is tpmC(transactions per minute), which C refers to the C benchmark program in TPC. It is defined as the number of new orders processed by the system per minute. It should be noted that while processing new orders, the system also handles other four types of transaction requests. A new order request is unlikely to exceed 45% of all transaction requests, so when a system's performance is 1000tpmC, the number of requests that it actually handles is more than 2000 per minute.

In recent years, TPC has launched TPC-E, which is also a database transaction processing test that simulates a securities trading system. As with TPC-C, it actually measures the performance of server and database software dealing with online query transaction processing (OLTP). TPC-E test results must provide tpsE value, which is how many TPC-E database transactions are completed per second (transaction per second). Compared with TPC-C test, TPC-E adds application server layer to test model building, and increases the complexity of database structure.

The TPC-C tests are mainly before 2011 and lacks newer CPU test data. The following table shows the TPC-C performance data of some hosts:

| Host  | Model Configuration | TPC-C Value (tpmC) |
|-------|---------------------|---------------------|
| HP DL580G5 | Xeon X7350 2.93GHz, 4CPU(16Core, 16Threads) | 407,079 |
| IBM x3950 M2 | Xeon X7350 2.93GHz, 8CPU(32Core, 32Threads) | 841,809 |
| IBM x3950 M2 | Xeon X74602.67GHz, 8CPU(48Core, 48Threads) | 1,200,632 |
| IBM x3850 X5 | Xeon E7-88702.4GHz, 4CPU(40Core, 80Threads) | 3,014,684 |
| Sun Server X2-8 | Xeon E7-8870 2.40GHz, 8CPU(80Core, 160Threads) | 5,055,888 |
| HP RX5670 | Itanium2 1.5GHz, 4CPU(4Core, 4Threads) | 121,065 |
| HP Superdome | Itanium2 1.5GHz, 64CPU(64Core, 64Threads) | 658,277 |
| HP RX6600 | Itanium2 1.6GHz, 4CPU(8Core, 16Threads) | 372,140 |
| HP Superdome | Itanium2 1.6GHz, 64CPU(128Core, 256Threads) | 4,092,799 |
| IBM p5 570 | POWER5 1.9GHz, 2CPU(4Core, 8Threads) | 203,439 |
| IBM p5 570 | POWER5 1.9GHz, 32CPU(64Core, 128Threads) | 3,210,540 |
| IBM p570 | POWER6 4.7GHz, 2CPU(4Core, 8Threads) | 404,462 |
| IBM p595 | POWER6 5.0GHz, 32CPU(64Core, 128Threads) | 6,085,166 |
| IBM Power 780 | POWER74.14GHz, 2CPU(8Core, 32Threads) | 1,200,011 |

From the above data, we can see:
- Due to the low clock frequency and the small number of single-CPU cores, Itanium2's performance is comparable to that of the contemporary Xeon (RX6600 vs DL580 G5). In recent years, the performance of X86 architecture has been improved rapidly, and now it has developed to 28 cores in a single CPU. But Itanium architecture is growing slowly, from Itanium2 to Itanium3, the number...
of single-CPU cores has only doubled. Therefore, we can predict that the current performance of the minicomputer based on Itanium CPUs has lagged behind the similarly configured X86 server.

- There is a nonlinear relationship between host performance and CPU quantity, such as the 8-way E7 8870 provides about 80% more performance than the 4-way (x3850 vs X2-8).
- If there is a high requirement for the performance of a single host, the selection of a high-end model of a minicomputer is a better choice at that time. Because more than 8-way X86 servers require third-party controllers, only a few vendors, such as SGI, were able to offer such products before 2010.

Selecting 8 X86 servers, 4 Itanium and 2 Power minicomputers, comparing the TPC-C performance curve of these architecture hosts from 2004 to 2010, it can be seen that the performance of X86 servers improved fastest and the performance of minicomputers improved slower.

![Figure 1. The growth trend of TPC-C performance of different architecture hosts.](image)

The TPC-E test data is mainly generated after 2008 and based on the X86 architecture, with only a small amount of minicomputer performance data:

| Host Model   | Configuration                                      | tpsE   |
|--------------|----------------------------------------------------|--------|
| Lenovo SR650 | Xeon Platinum 8180 2.50GHz, 2CPU(56Core, 112Threads)| 6,598.36|
| Lenovo x3850 X6 | Xeon E7-8890 v4 2.20GHz, 4CPU(96Core, 192Threads) | 9,068.00|
| Lenovo x3650 M5 | Xeon E5-2699 v4 2.20GHz, 2CPU(44Core, 88Threads) | 4,938.14|
| Lenovo x3950 X6 | Xeon E7-8890 v3 2.50GHz, 8CPU(144Core, 288Threads) | 11,058.99|
| Lenovo x3850 X6 | Xeon E7-8890 v3 2.50GHz, 4CPU(72Core, 144Threads) | 6,964.75|
| Lenovo x3950 X6 | Xeon E7-8890 v2 2.80GHz, 8CPU(120Core, 240Threads) | 9,145.01|
| IBM x3850 X6 | Xeon E7-4870 v2 2.80GHz, 4CPU(60Core, 120Threads) | 5,576.27|
| IBM x3650 M4 | Xeon E5-2697 v2 2.70GHz, 2CPU(24Core, 48Threads) | 2,590.93|
| IBM x3850 X5 | Xeon E7-8870 2.40GHz, 8CPU(80Core, 160Threads) | 5,457.20|
| IBM x3850 X5 | Xeon E7-4870 2.40GHz, 4CPU(40Core, 80Threads) | 3,218.46|
| IBM x3650 M4 | Xeon E5-2690 2.90GHz, 2CPU(16Core, 32Threads) | 1,863.23|
| Unisys ES7000 | Xeon X7460 2.67 GHz, 8CPU(48Core, 48Threads) | 1,165.56|
| NEC Express5800/1320Xf | Itanium 9150N 1.6 GHz, 32CPU(64Core, 64Threads) | 1,126.49|

Through the test results, the current X86 architecture CPU continues to maintain a faster performance improvement. The same as the 2-way server, the performance of the Platinum 8180 host is 3.54 times that of the E5-2690 host. Although there is a lack of test results for the latest generation
of minicomputers, combined with the data of TPC-C and TPC-E, it can be inferred that the current high-end X86 servers already have the large-scale database application processing capabilities that the previous generation of high-end minicomputers can afford.

Figure 2. The growth trend of TPC-E performance of X86 servers.

2.2. SPECjbb/SPECjEnterprise Performance Test

SPEC (the Standard Performance Evaluation Corporation) is a global, authoritative third-party application performance testing organization, which aims to establish, modify, and identify a series of standards for performance evaluation of server applications. This test is currently one of the industry's standard and authoritative benchmarks and has been supported and participated by many international software and hardware vendors such as Intel, IBM, HP, DELL, SUN, HUA-WEI and so on. Because it embodies the performance and cost index of the software and hardware platform, it has been selected by key industries such as finance, telecommunications, and securities as an authoritative selection indicator for IT systems.

SPECjbb (Java server benchmark) is a SPEC testing tool to evaluate the performance of server-side JAVA. SPECjbb evaluates the performance of server-side JAVA by simulating a three tier C/S system (primarily middle-tier). This test software runs JVM (Java virtual machine), JIT (Just-In-Ti-me) compiler, fragment collection, threads and other tasks of the operation system. It also measures the performance of CPU, Cache, memory and SMP. SPECjbb reflects the situation of real-world application systems by providing new, enhanced workloads that run in an object-oriented manner.

SPECjbb contains multiple versions, each with different indicators [3]. The latest version is SPECjbb2015, and MultiJVM will test multiple JVMs in one operating system. The max-jOPS performance index score reflects sustainable system-wide throughput, and the critical-jOPS performance index score measures throughput in the case of limited response time.

| Host Model | CPU Model | max-jOPS | critical-jOPS |
|------------|-----------|----------|---------------|
| HP DL120 G9 | Xeon E5-2699 v3 2.3GHz, 1CPU(18Core, 36Threads) | 47,334 | 9,876 |
| IBM S812LC | Power8 3.49GHz, 1CPU(10Core, 80 Threads) | 44,883 | 13,032 |
| Inspur NF5280M4 | Xeon E5-2699A v4 2.4GHz, 2CPU(44Core, 88 Threads) | 122,829 | 39,635 |
| Oracle SPARC T7-1 | SPARC M7 4.13GHz, 1CPU(32Core, 256 Threads) | 120,603 | 60,280 |

The previous table shows that the current X86 servers and the Power minicomputers have the same performance in the JAVA application with the same number of CPUs, but there is still a gap compared
to the SPARC minicomputer. Since most of these applications can improve performance with simple scale-out, the performance requirements for a single host are not high, so minicomputers are rarely used.

SPECjEnterprise (J2EE Application Performance Benchmark) tests the performance of J2EE application server by simulating the automotive supply chain system. The SPECjEnterprise test results must provide the EjOPS value, that is, how many enterprise JAVA operations per second (Enterprise Java Operation Per Second), and the current version is SPECjEnterprise2010.

Table 4. Comparison of SPECjEnterprise 2010 performance between minicomputers and X86 servers.

| Host Model      | CPU Model                                      | EjOPS     |
|-----------------|-----------------------------------------------|-----------|
| IBM Power 780   | Power7 3.86GHz, 8CPU(64Core, 256Threads)      | 16,646.34 |
| Lenovo x3650 M5 | Xeon E5-2697 v3 2.6GHz, 2CPU(28Core, 56Threads)| 19,282.14 |
| Oracle Server X6-2 | Xeon E5-2699 v4 2.2GHz, 2CPU(44Core, 88Threads)| 27,803.39 |

As can be seen from the above table, the X86 server has fully surpassed the Power minicomputer in terms of J2EE performance.

2.3. For SAPS Performance Test

The SAPS benchmark is a benchmarking tool designed specifically for SAP ERP enterprise resource management applications, and the related vendors must pass SAPS test performance as a standard indicator for SAP server configuration. The SAP benchmarking organization publishes various kinds of benchmarks, among which the SAP SD 2-Tier benchmark is used to measure the performance of different hardware vendors plus databases to execute the sales and distribution (SD) module of the SAP enterprise resource management application. The SAP SD 2-tier structure benchmark applies the application server and database server to the same physical server. The test results will be standardized into the SAPS (SAP Application Performance Standard) value of SAP SD application module. SAPS is a hardware-independent performance indicator. The 100 SAPS value is equivalent to 2000 fully business processed order line items per hour in the SAP SD application definition. Each commercial processing order item includes new order creation, invoice generation, order display, change of delivery content, goods entry, listing of orders, and receipt generation. From a technical point of view, it is equivalent to 2400 SAP transactions per hour or 6000 conversations per hour (console change) plus 2,000 entry operations per hour.

Table 5. Comparison of SAPS performance between minicomputers and X86 servers.

| Host Model      | CPU Model                                      | SAPS     |
|-----------------|-----------------------------------------------|----------|
| IBM Power S824  | Power8 3.52GHz, 4CPU(24Core, 192Threads)      | 115,870  |
| IBM Power E870  | Power8 4.19GHz, 8CPU(80Core, 640Threads)      | 436,100  |
| IBM Power 750   | Power7 3.55GHz, 4CPU(32Core, 128Threads)      | 94,730   |
| IBM Power 760   | Power7+ 3.41GHz, 8CPU(48Core, 192Threads)     | 139,220  |
| IBM Power 780   | Power7+ 3.72GHz, 12CPU(96Core, 384Threads)    | 311,720  |
| IBM Power 795   | Power7 4.0GHz, 16CPU(128Core, 512Threads)     | 384,330  |
| HP RX6600       | Itanium 2 90501.6Ghz, 4CPU(8Core, 16Threads)   | 10,780   |
| HP Superdome    | Itanium 2 90501.6Ghz, 16CPU(32Core, 64Threads) | 28,200   |
| HP Superdome    | Itanium 2 90501.6Ghz, 32CPU(64Core, 128Threads)| 46,380   |
| Oracle SPARC T7-2 | SPARC M74.133Ghz, 2CPU(64Core, 512Threads)   | 168,600  |
| Oracle SPARC M7-8 | SPARC M74.133Ghz, 8CPU(256Core, 2048Threads) | 713,480  |
| Oracle SPARC M6-32 | SPARC M63.6Ghz, 32CPU(384Core, 3072Threads)   | 793,930  |
| System Type        | CPU Model                      | Performance (TPS) |
|-------------------|--------------------------------|-------------------|
| Oracle SPARC M5-32| SPARC M53.6Ghz, 32CPU(192Core, 1536Threads) | 472,600           |
| HPE DL380 G10     | Xeon Platinum 8180M 2.5Ghz, 2CPU(56Core, 112Threads) | 154,020           |
| Dell R940         | Xeon Platinum 8180 2.5Ghz, 4CPU(112Core, 224Threads) | 341,100           |
| Fujitsu 3800B     | Xeon Platinum 8180 2.5Ghz, 8CPU(224Core, 448Threads) | 562,100           |
| Lenovo X3650 M5   | Xeon E5-2699 v42.2Ghz, 2CPU(44Core, 88Threads) | 110,670           |
| Dell R930         | Xeon E7-8894 v42.4Ghz, 4CPU(96Core, 192Threads) | 213,900           |
| Lenovo x3950X6    | Xeon E7-8894 v42.4Ghz, 8CPU(192Core, 384Threads) | 421,230           |
| Dell R730         | Xeon E5-2699 v32.3Ghz,2CPU(36Core, 72Threads) | 87,600            |
| Cisco UCS C460 M4 | Xeon E7-8890 v32.5Ghz, 4CPU(72Core, 144Threads) | 159,130           |
| Lenovo x3950 X6   | Xeon E7-8890 v32.5Ghz, 8CPU(144Core, 288Threads) | 330,930           |
| Dell R720         | Xeon E5-2697 v22.7Ghz, 2CPU(24Core, 48Threads) | 54,120            |
| Cisco UCS C460 M4 | Xeon E7-4890 v22.8Ghz, 4CPU(60Core, 120Threads) | 133,820           |
| IBM x3950 X6      | Xeon E7-8890 v22.8Ghz, 8CPU(120Core, 240Threads) | 271,080           |
| Cisco UCS B200 M3 | Xeon E5-26902.9Ghz, 2CPU(16Core, 32Threads) | 35,680            |
| HP DL560 G8       | Xeon E5-46502.7Ghz, 4CPU(32Core, 64Threads) | 69,550            |
| IBM x3850 X5      | Xeon E7-88702.4Ghz, 8CPU(80Core, 160Threads) | 140,720           |

As can be seen from the above table, in terms of SD application, the performance of Itanium processor is poor, and the performance of 2-way E5 V2 or 4-way E7 has exceeded 32-way Superdome. The performance of the 8-way Xeon E7 V4 is equivalent to that of the same number of Power 8, while the latest Xeon Platinum performance has surpassed Power 8.

2.4. State Grid Actual Business TPS Test

In order to get better rankings, vendors usually provide products with high configuration in all aspects when they participate in the above tests such as TPC, SPEC, and SAPS. They are often not exactly consistent with the configuration used in the real environment [4], so these data cannot fully respond to the actual effects of the two types of hosts. Therefore, the State Grid Corporation of China organized comparison tests between X86 servers and minicomputers. By deploying the PMS 2.0 system database in the hosts under these two architectures, the performance difference of the maximum transaction processing capability (TPS) of the hardware platform in the actual business system of the State Grid is verified.

Test methods:
- The 8-way X86 servers and the 4-way P570 minicomputers are used to deploy two-node RAC, and database is installed to PMS2.0 system. Using 100, 200, 300, 400, 500 and other different concurrent users to perform test model standard scripts, it can test the device respectively to achieve the maximum transaction processing capability (TPS) value, and record the response time of each service module and the performance index of the device under test such as CPU, memory, and IO.
- Scale the two-node RAC horizontally to three nodes and repeat the above test.

When an 8-way X86 server (Xeon E7-8870 2.40GHz, 80Core, 160 threads) is used as a database, with the increase of concurrent users, the load change and transaction processing capabilities are shown as the following able.
When the 4-way P750 minicomputer (Power7, 32Core, 128 thread) is used as a database, with the increase of concurrent users, the load changes and transaction processing capabilities are shown as the following table.

**Table 7. Minicomputer load and transaction processing data.**

| Concurrent Users | 2 Nodes        |                  | 3 Nodes        |                  |
|------------------|----------------|------------------|----------------|------------------|
|                  | CPU Utilization | TPS Value        | CPU Utilization | TPS Value        |
|                  | Node1  | Node2  | Average | Node1  | Node2  | Node3  | Average | Node1  | Node2  | Node3  | Average |
| 100              | 15.01  | 14.41  | 14.71   | 25.32  | 10.72  | 8.77   | 12.31   | 10.6   | 25.01  |
| 200              | 28.28  | 30.39  | 29.34   | 49.87  | 20.86  | 17.29  | 22.65   | 20.27  | 49.93  |
| 300              | 44.79  | 42.28  | 43.54   | 74.95  | 31.55  | 25.98  | 32.5    | 30.01  | 75.02  |
| 400              | 58.9   | 57.69  | 58.3    | 98.13  | 38.98  | 37.3   | 43.12   | 39.8   | 99.01  |
| 500              | 67.3   | 65.23  | 66.27   | 119.23 | 50.28  | 47.61  | 50.59   | 49.49  | 122.98 |
| Max(700)         | 79.67  | 77.69  | 78.68   | 153.62 | 56.49  | 50.11  | 60.74   | 55.78  | 152.19 |

Combining the data of the above two tables, when the number of concurrent users is relatively small, the overall performance of the 8-way X86 server is superior to about 30% of the P750 minicomputer with the advantages of the number of its CPU kernel. With the increase of the number of concurrent users, the P750 minicomputer has the performance advantage of its single-core CPU, and the performance difference with the 8-way X86 server gradually becomes smaller.

3. Performance Evaluation of X86 Server Substitutes for Minicomputer

3.1. Performance Estimation

Since the performance of minicomputers and X86 servers in different types of business applications is not the same, the following are respective evaluations of the existing business application types of Gansu Electric Power Company.

3.1.1. Database applications

Since the HP minicomputers currently used by Gansu Electric Power Company are all equipped with Itanium2 processors, and comprehensively compare TPC-C performance data, Itanium processors are expanded from 4 ways to 64 ways, with performance data of 372, 140 and 4,092,799 respectively. Considering the expansion efficiency and nonlinear growth of the NUMA architecture, assuming no more than 64 CPUs, the processor every doubling, the database application performance average growth index of N1:

- From $372,140 \times N1 = 4,092,799$, the following can be derived: $N1 \approx 1.82$.

It is estimated that the TPC-C performance of 8-way CPU (equivalent to RX8640) is as follows:
• $372,140 \times 1.82 \approx 677,295$.

The TPC-C performance of 16-way CPU (equivalent to a single Superdome partition) is as follows:

• $372,140 \times 1.82^2 \approx 1,232,677$.

According to the TPC-C and TPC-E performance data of the 8 Xeon E7-8870 2.40GHz host in section I (Sun Server X2-8, IBM x3850 X5, TPC-C and TPC-E are 5,055,888 and 5,457.20 respectively), assuming that the actual performance of the two hosts is the same, then the ratio performance scores of TPC-C and TPC-E is $M$:

• $M = 5,055,888 / 5,457.20 \approx 926.46$.

Assuming that the performance of X86 architecture hosts is similar under TPC-C and TPC-E, and the ratio of the two scores is $m$. Then the TPC-C performance value of E series servers can be estimated.

### Table 8. E series server TPC-C performance estimates.

| Configuration                                                                 | TPC-E Value | TPC-C Value |
|-------------------------------------------------------------------------------|-------------|-------------|
| Xeon E7-8890 v4 2.20GHz, 4CPU(96Core, 192Threads)                             | 9,068.00    | 8,401,139   |
| Xeon E5-2699 v42.20GHz, 2CPU(44Core, 88Threads)                              | 4,938.14    | 4,574,989   |
| Xeon E7-8890 v3 2.50GHz, 8CPU(144Core, 288Threads)                           | 11,058.99   | 10,245,712  |
| Xeon E7-8890 v3 2.50GHz, 4CPU(72Core, 144Threads)                            | 6,964.75    | 6,452,562   |
| Xeon E5-2699 v3 2.30GHz, 2CPU(36Core, 72Threads)                             | 3,772.08    | 3,494,681   |
| Xeon E7-8890 v2 2.80GHz, 8CPU(120Core, 240Threads)                           | 9,145.01    | 8,472,486   |
| Xeon E7-4890 v22.80GHz, 4CPU(60Core, 120Threads)                             | 5,576.27    | 5,166,191   |
| Xeon E5-2697 v22.70GHz, 2CPU(24Core, 48Threads)                              | 2,590.93    | 2,400,393   |
| Xeon E7-8870 2.40GHz, 8CPU(80Core, 160Threads)                               | 5,457.20    | 5,055,888   |
| Xeon E7-48702.40GHz, 4CPU(40Core, 80Threads)                                | 3,218.46    | 2,981,774   |
| Xeon E5-2650 2.90GHz, 2CPU(16Core, 32Threads)                               | 1,863.23    | 1,726,208   |

As can be seen from the above table, the performance of single partition (16 CPU) of the Superdome is comparable to that of the 2-way E5 server.

For IBM minicomputer, TPC-C performance data can be estimated by rPerf (Relative performance) [5]. RPerf is an estimate of business processing performance derived from the IBM analytic model, which simulates some operations of the system, such as CPU, cache, and memory, but does not simulate the input / output operations of the disk and network.

Reference to the rPerf value of a Power minicomputer is IBM Power Systems Performance Report(www-03.ibm.com/systems/power/hardware/reports/system_perf.html).

### Table 9. Power7 minicomputer rPerf value.

| Kernel Number | Power7 3.50GHz | Power7+ 4.14GHz | Power7+ 3.80GHz | Power7+ 4.42GHz | Kernel Number | Power 8 4.0GHz |
|---------------|----------------|-----------------|----------------|----------------|---------------|----------------|
According to the TPC-C value of the known device (POWER7 4.14GHz, 2CPU, 8Core, TPC-C value is 1,200,011), the TPC-C values of other devices are estimated in accordance with the same principle of rPerf, and the formula is:

$$TPC_C1 = \frac{(rPerf1 \times TPC_C2)}{rPerf2}$$

Table 10. Power7 minicomputer TPC-C performance estimates.

| Kernel Number | Power7 3.50GHz | Power7 4.14GHz | Power7+ 3.72GHz | Power7+ 4.42GHz | Kerne 1 Number | Power 8 4.0GHz |
|---------------|----------------|----------------|-----------------|-----------------|----------------|---------------|
| 8             | 986,959        | 1,200,011      | 1,116,530       | 1,306,071       | 12             | 2,659,786     |
| 16            | 1,873,658      | 2,350,824      | 2,143,987       | 2,544,819       | 24             | 5,185,962     |
| 24            | 2,705,255      | 3,379,006      | 3,059,583       | 3,656,170       | 48             | 10,112,988    |
| 32            | 3,506,816      | 4,407,083      | 3,976,215       | 4,767,522       |                |               |
| 64            | -              | -              | 7,553,668       | 8,463,050       |                |               |

As can be seen from the above table, the performance of the 4-way Power 7 (32 core) minicomputer is slightly lower than that of the 8-way E7 X86 server performance (80 core and TPC-C value is 5055888).

The performance of the Power 7 minicomputer is equivalent to the E5/7 V2 series X86 server with the same number of CPU [6]. The performance of the Power 8 minicomputer is equivalent to the E7 V3 series X86 server with twice the number of CPU.

3.1.2. SAP and ERP applications

Comprehensive comparison of SAPS performance data, the SAPS value of 16-way Itanium processor is 28,200, lower than 2-way Xeon E5-2690 2.9Ghz server (SAPS value is 35,680). Therefore, the performance of E5 Series 2-way X86 servers is totally beyond that of the RX8640 (8-way Itanium processor).

The performance of 4-way, 8-way Power 7 minicomputers has been lower than the corresponding CPU number of E7 V2 X86 servers. And the performance of 16-way Power 7 minicomputers is lower than 8-way E7 v4 X86 servers.

The performance of the 4-way Power8 minicomputer is comparable to the 8-way E7 X86 server. And he performance of the 8-way Power 8 minicomputer is comparable to that of the 8-way Platinum 8180 X86 server.

3.1.3. Other applications

Non-database and SAP ERP applications lack targeted performance indicators and data. Referring to TPC, SPE-C and SAPS performance data, we can estimate that the performance of E5 Series 2-way X86 servers is equal to or surpass that of the 16-way Superdome minicomputers. And the performance of Power 7 Series minicomputers is comparable to that of the same number of E5/7 v2.

3.2. Analysis of the Measured Data of Performance

When the PMS2.0 system respectively uses a 2-node X86 server and a minicomputer as a database, with the increase of concurrent users, the load changes and transaction processing capabilities are shown as the following table.
Table 11. Comparison of load and transaction processing capability between 2-node X86 server and minicomputer.

| Node Concurrent users | P750 avg_CPU% | TPS | 8-way X86 server avg_CPU% | TPS | CPU Comparison | TPS Comparison |
|-----------------------|--------------|-----|---------------------------|-----|---------------|---------------|
| 2 Nodes               |              |     |                           |     |               |               |
| 100                   | 14.71        | 25.32| 4.14                      | 25.63| 28.14%        | 101.22%       |
| 200                   | 29.34        | 49.87| 8.44                      | 51.11| 28.77%        | 102.49%       |
| 300                   | 43.54        | 74.95| 14.71                     | 74.46| 33.79%        | 99.35%        |
| 400                   | 58.30        | 98.13| 27.35                     | 91.79| 46.91%        | 93.54%        |
| 500                   | 66.27        | 119.23| 43.83                     | 106.31| 66.14%        | 89.16%        |
| 700                   | 78.68        | 153.62| 65.13                     | 119.51| 82.77%        | 77.80%        |

As can be seen from the above table, the 8-way X86 server with 2 nodes, compared with the P750 minicomputer, has the same transaction processing ability for 100 to 300 concurrency, but the CPU utilization of the 8-way X86 server is only about 30% of the P750 minicomputer. Between 400 and 700 concurrent users, the performance of the transaction processing of the 8-way X86 server is less than 20% of the P750 minicomputer, but the CPU utilization of the minicomputer CPU is higher than about 20% of the 8-way X86 server.

When the 3-node X86 server and the minicomputer are used as the database respectively, with the increase of concurrent users, the load change and transaction processing ability are shown as the following table.

Table 12. Comparison of load and transaction processing capability between 3-node X86 server and minicomputer.

| Node Concurrent users | P750 avg_CPU% | TPS | 8-way X86 server avg_CPU% | TPS | CPU Comparison | TPS Comparison |
|-----------------------|--------------|-----|---------------------------|-----|---------------|---------------|
| 3 Nodes               |              |     |                           |     |               |               |
| 100                   | 10.60        | 25.01| 3.39                      | 25.87| 32.01%        | 103.43%       |
| 200                   | 20.27        | 49.93| 5.76                      | 51.57| 28.44%        | 103.29%       |
| 300                   | 30.01        | 75.02| 8.64                      | 76.50| 28.79%        | 101.98%       |
| 400                   | 39.80        | 99.01| 12.38                     | 100.67| 31.11%        | 101.67%       |
| 500                   | 49.49        | 122.98| 18.54                     | 121.43| 37.45%        | 98.74%        |
| 700                   | 55.78        | 152.19| 36.13                     | 140.38| 64.78%        | 92.24%        |

As can be seen from the above table, comparing the 3-node 8-way X86 server with the P750 minicomputer, the transaction processing ability is equal when within 100 to 700 concurrent users, but the CPU utilization of the 8-way X86 server is only 30% of the P750 minicomputer.

3.3. Recommended Configuration
Based on the above estimation and actual test data, the following table lists the corresponding configurations that can be used to replace minicomputers.

Table 13. Performance evaluation of minicomputer migration.

| Node | Database | SAP | others |
|------|----------|-----|--------|
| 8-way Itanium | 2-way E5 | 2-way E5 | 2-way E5 |
| 16-way Itanium | 2-way E5 | 2-way E5 | 2-way E5 |
Although the performance has been approached to or even beyond the minicomputer, but the stability of the X86 server still can not compete with the minicomputer [7], especially the 2-way, 4-way X86 server, is not designed to run the key core business. For various business systems currently running on HP minicomputers of Gansu Electric Power Company, if they are migrated to 2-way X86 servers, the system stability is difficult to meet. However migration to more stable 8-way servers will cause serious waste of host resources. Therefore, it is recommended to migrate the applications which performance requirements can be meet by two-way X86 servers to the computing integrated machine. While ensuring stability, it is also possible to allocate resources on demand and reduce the cost of use.

For an Oracle database that can be migrated to a 4- or 8-way X86 server, it is recommended to use a 3-node RAC mode to ensure system reliability.

### 4. Application Server Selection and Migration Case

#### 4.1. Selection Principles of X86 Server and Minicomputer

Informatization construction is inseparable from the excellent basic platform system [8]. Whether it is to build a strong regulatory integration system to ensure security, economy, high-quality, and efficient operation of the power grid, or to build a unified, efficient information-based production management platform, as well as unified, intelligent, interactive, and efficient information-based marketing management platform, all need strong infrastructure support [9].

In the selection of the application system server, we should start from some key factors, and make a reasonable selection by analyzing these factors on the minicomputer and the X86 server [10].

| Index          | Minicomputer | X86 Server |
|----------------|--------------|------------|
| Reliability    | IBM Power and HP Integrity minicomputers are highly reliable, which can minimize planned and out of schedule downtime and ensure continuous and uninterrupted operation of the system. | The reliability of different brands is uneven, and there is still a certain gap on the whole from IBM or HP minicomputer. |
| Extensibility  | The ability to scale vertically is strong. For large databases that value this capability, minicomputers are a better choice. | The economy of horizontal expansion is better. Middleware and other applications can be constantly stacked to ensure performance and reliability. X86 server is a good choice. |
Overall Performance
1. Minicomputers based on the latest Power8 or SPARC M7 chip has high CPU performance and vertical expansion capability, and the overall performance is outstanding.
2. Minicomputer based on Itanium chip has poor performance

Economical Efficiency
High price, low cost performance
Low price, high cost performance

As can be seen from the above table, the main difference between minicomputers and X86 architecture servers lies in their reliability and extensibility.

Table 15. Vertical expansibility and reliability.

| Vertical Reliability | High Reliability | Next Highest Reliability | Medium Vertical Reliability |
|----------------------|------------------|--------------------------|-----------------------------|
| Minicomputer         | Prioritize X86 Server | Prioritize X86 Server |
| X86 Server           |                  |                          |

From the point of view of comprehensive importance, we should consider the selection basis of the hosts by the deployment mode of the application system.

Table 16. Application patterns and comprehensive importance.

| Comprehensive Importance | Distributed Application Mode | Independent Application Mode | OLTP Feature Database Schema | OLAP Feature Database Schema | Real-time Database Mode | Application and Data Integration Mode |
|--------------------------|------------------------------|------------------------------|-----------------------------|----------------------------|-------------------------|--------------------------------------|
| High                     | X86 Server                   | Minicomputer or X86 Server  | Minicomputer or X86 Server  | Minicomputer or X86 Server | X86 Server              | X86 Server                           |
| Next highest             | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server              | X86 Server                           |
| Medium                   | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server              | X86 Server                           |
| Nonormal                 | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server                   | X86 Server              | X86 Server                           |

From the perspective of comprehensive importance and application deployment model [11], it is possible to initially determine the roughly corresponding target of the servers. When carrying out X86 servers replacement of minicomputers, in order to achieve practical results, it is necessary to combine the business characteristics of the migrated application, and analyze it from the main application system [12]. The following takes an application migration example to illustrate the operability of X86 server instead of minicomputer.

4.2. Migration Case
The power quality monitoring platform database system of the State Grid Corporation, its operating environment is two P750 minicomputer plus Oracle 10g. Due to the limitation of the old hardware and
software resources for a long time, the performance of the system is relatively low, which can not meet the rapid development of business applications in recent years. To this end, the State Grid Corporation of China carried out database migration, which migrated from the original minicomputer environment to the X86 server platform, and upgraded the version of the Oracle database to the Oracle 11g and generated the ADG.

Because of the cross version and cross-platform of database migration, Oracle 11g online transfer table space (Xtts) is used for data migration technology to ensure the security and reliability of the migration process [13]. By replacing two P750 minicomputers with three 4-way X86 servers, the problem of insufficient performance of the power quality database is solved while guaranteeing the stability of the system.

5. Conclusion

In this paper, the performance comparison and evaluation of X86 server and minicomputer are carried out in combination with the various types of business types and application scenarios of the traditional data center minicomputer architecture, and the selection principle of different applications for the minicomputer and the X86 server is discussed. According to the actual situation of Gansu Electric Power Company, the application migration of X86 servers to replace minicomputers is carried out. The results show that X86-based architecture has the capability to replace the traditional minicomputer architecture in a variety of business types and application scenarios in the data center.

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