



Ensuring a Fast, Reliable, and Secure Database Through Automation: **Oracle Autonomous Database**

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IN THIS WHITE PAPER

Managing a modern enterprise-class database can be monstrously complicated. If it's a data warehouse, the index structure, partitioning plan, and various server settings must be just right to ensure good performance in handling complex queries. If it's a transactional database, availability and high performance are critical factors that can have real revenue implications. As databases grow in size and complexity, these concerns become compounded.

This white paper examines these issues, the approaches taken to address the issues, and the emergence of a database offering that promises to ensure the best possible availability and response times without requiring any human intervention at all. This offering is called the Oracle Autonomous Database. It works by using machine learning (ML) technology to continually self-tune, relieving database administrators (DBAs) of hundreds of hours of effort devoted to examining performance statistics and making adjustments. Oracle Autonomous Database is on the vanguard of a new class of database, one based on a self-tuning and self-healing database management system (DBMS), delivered as a cloud service.



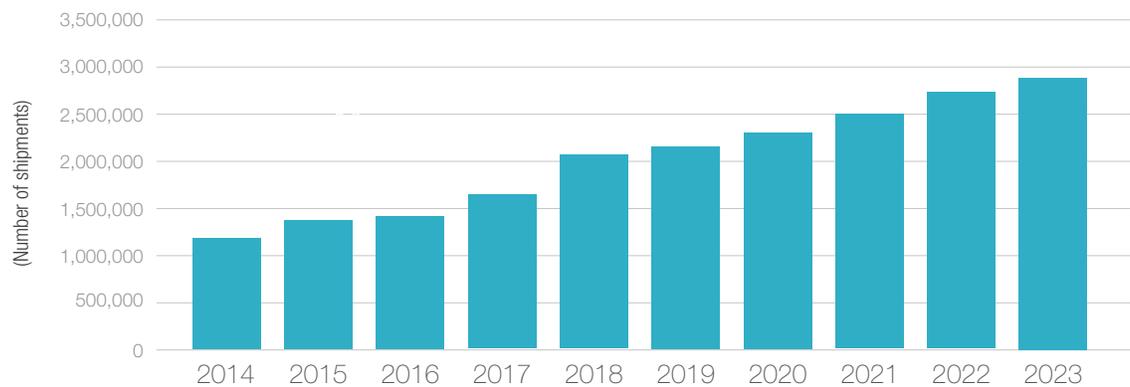


SITUATION OVERVIEW

The Database Management Challenge

Since their inception decades ago, most enterprise datacenters have grown steadily in size and complexity and today operate hundreds of production databases. Despite impressions to the contrary, relational database deployment has continued to increase. IDC expects that the number of server systems deployed to manage databases will increase from 1.2 million in 2014 to 2.9 million in 2023, for a five-year compound annual growth rate of 6.8%, well ahead of the storage market overall. This finding is shown in Figure 1. These databases are applying ever-increasing pressure on both database administration and operations staffs, despite the fact that most organizations have been trimming, not expanding, those staffs.

Figure 1. Worldwide Data Management Server Shipments, 2014–2023



Source: IDC, 2020

While many of these databases serve specialized or minor supporting purposes, many others serve mission-critical functions, processing data that is used to transact business, maintain fruitful customer relationships, and ensure the ongoing smooth operation of the enterprise. When these databases run slowly or worse, crash, they can slow the pace of business, impair customer relations, and cause lost business opportunities. When problems involving data warehouses arise, management can't make critical decisions and may have to "fly blind" while the problems are being addressed, often making poor decisions based on incomplete or inconsistent information.

Database failures can cause a chain reaction of disfunction: In most cases, databases are tied to other databases through either streaming data connections or extract, transform, and load (ETL) processes, so a breakdown on the source end can negatively impact the target. Most datacenters have elaborate procedures in place to minimize the incidence of failure and also to minimize its impact when it does occur. These procedures are largely manual.

Adding to these issues is the fact that although enterprises keep adding applications and their databases, and integrating that data, as well as data from new sources, such as data lakes and external streaming sources, into data warehouses of ever greater complexity, budget constraints prevent the increase in staff necessary to deal with the additional work. As a consequence, the overall quality of operations suffers. Not only does this negatively impact existing functionality, but it inhibits the implementation of new functionality; the database administrator who would set up a new database workload must put off that job because existing databases require so much attention, and there is only so much time in the day.

Threats to the Business Posed by Poor Database Management

When databases are not maintained and tuned fully, problems that represent material risks to the business can arise. These problems include interruptions or delays in data handling that interfere with business transactions and slow down proper decision making.

The problems can also include data security issues, since DBMS software vendors are constantly issuing patches to address vulnerabilities. When those patches are not applied in a timely manner, the risk of a data breach looms. Because applying patches manually in the datacenter can be operationally disruptive, and requires extra time and effort, such patches are often batched up, with the result that the database is left at risk for some period of time.

In a large database, the composition of data is in a constant state of flux, requiring constant analysis and tuning to ensure good performance. Failure to do this can result in sluggish performance and even outages if the internal database resources are insufficient to handle the volume of data being processed. Slow or unavailable databases can result in slower transaction rates, less business being done, and lost opportunities.

The problem may be even more acute for analytic databases, such as data warehouses. These are increasingly used to provide a complete view not only of the business but of the business environment, including customers, prospects, competitors, and various secular risks and threats.

For this analytic data to be complete, accurate, and current, the database must be well tuned and constantly adjusted to the shifting requirements of the data being analyzed. This normally requires an enormous ongoing manual effort to ensure not only that the database performs well but that it can be made available to all business users who need access to the data in order to make critical business decisions.

Manually Managed Databases: Costs, Risks, and Limitations

The single largest inhibitor to ideal database configuration is the number of staff that handles the tuning, problem determination and correction, and routine operations (software patches, system maintenance, etc.). Although the databases grow constantly in size and complexity, the size of the staff tends to remain constant. Yet the DBA staff is under constant pressure to maintain excellent performance while constantly adapting the database to the changing needs of applications



and users. Other requirements, such as changes to data organization for application or analytic purposes, often must wait as performance and reliability issues always come first.

In general, the costs and risks associated with enterprise databases may be summarized in the following ways:



Infrastructure cost: This is the cost of acquiring and maintaining the servers, storage, and networking infrastructure required to run the databases. Inefficient database operation can cause excessive expenditures in this area, as implementers attempt to “throw hardware at the problem.”



IT staff productivity: IT staff, including the DBA staff, must work to make the database function with as much performance as possible. The operations staff’s work is fairly routine, but the DBA’s work is complex, requiring much analysis and expert handling of the databases involved. DBAs typically study database statistics to make decisions about such things as which columns to index, what the partitioning strategy should be, and where to locate data in storage. They are expected to keep reviewing and revising the database configuration as operating characteristics change. Because DBAs are also needed to implement new databases for new applications or change databases to meet the needs of changing applications, overworking the DBA team can result in applications that are simply not responsive to the changing needs of the enterprise.



User productivity: If users are exposed to excessive wait times or, worse, to application failure, they can’t get their own work done. This results in extra cost to the business if the user is internal and lost business if the user is external.



Business productivity: When applications don’t meet the needs of the enterprise, when business analysts can’t get the data they need to make key decisions, when employees can’t do their jobs, and when customers are frustrated in their efforts to interact with the system, the result is lost business opportunity and lower revenue.



Other areas: It has often been said that “data is the lifeblood of business.” If the flow of data is slowed or interrupted, there can be other negative consequences that may be hard to track or quantify but nonetheless result in a less efficient and less profitable business.

Business Requirements

Businesses need to ensure that as the database evolves, it continues to adjust optimally to the growing size and complexity of the data. Ideally, as it grows the database must continue to deliver the following capabilities:



Exhibit excellent performance, reliability, and availability.



Enable business users to innovate at the speed of business.



Enable users to have ready access to the latest data in the most useful and relevant forms.

One way to do this is to move database operations to a public cloud service. This transfers the effort associated with ordinary operations from the datacenter IT staff to the cloud service, which can offer guarantees regarding availability and overall system performance. Such guarantees, however, do not necessarily extend to the database. Since the user organization defines the database, the user organization assumes responsibility for its smooth operation, so the larger locus of risk, which is in the work of the operational DBA, persists.

The ideal solution is for the database to be managed as a service, which entirely relieves the responsibility of the DBA staff for tuning and troubleshooting the database. But how is this possible, if the responsibility for overall database definition rests with the user? What is required is technology that can tune and recover a database without human intervention. This is a tall order, since there are many factors involved in these activities, and even experienced and expert DBAs struggle to carry them out. The DBMS can't simply execute rules or scripts. It must actually adapt as the database changes and must learn from successive actions and their consequences.

The system that can do this not only ensures that critical enterprise data is always available, and so operational applications and analytics can work reliably on the latest data, but also enables DBAs to help the database applications development teams and business analysts adapt the system to the ever-changing requirements of the enterprise.

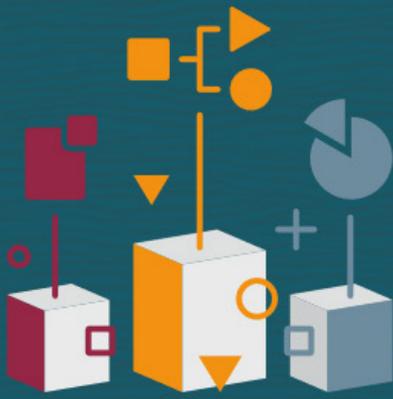
Introducing the Autonomic Class of Database

To make the delivery of a fully self-managing database-as-a-cloud service a reality, one must come to terms with the complexity of the problem. A database cloud service that is manually administered is likely to disappoint when it comes to such things as ensuring scaling, performance, and availability to users at an optimal level; correcting faults as they occur; and anticipating problems before they occur. This is because a large, complex database, such as a data warehouse, cannot be so administered without incurring such a high cost to the service provider that the fee would be unacceptably high.

The answer is to make the database itself self-tuning and self-healing, adapting to changing conditions as they arise. This approach involves autonomic computing. It's not a new idea. Autonomic computing has been applied to problems of systems management and general operations management for some time. It has generally been found inadequate for large, complex systems because, usually, it has been deployed algorithmically, that is, program code or sets of rules determine responses to various situations. Such a technology can, of course, only respond effectively to problems previously seen, defined, and accounted for in the coding. Autonomic database technology such as this has been offered by Oracle and other RDBMS vendors for some time.

The application of autonomic computing to complex systems like data warehouses requires more than algorithmic, rules-driven self-operation. It requires that those systems be able to learn from existing conditions and adapt to them. This involves artificial intelligence driven by machine learning. Oracle has established an early lead in this area by introducing the Oracle Autonomous Database.





Oracle Autonomous Database

Oracle Autonomous Database is a service of Oracle Cloud Infrastructure (OCI). It uses ML technology at several levels:



Database tuning, for optimal performance



Database error correction and recovery, for optimal uptime



Database security, for detecting anomalous or suspicious usage in real time

Oracle Autonomous Database is available for the optimization of several usage models: data warehouse, enterprise OLTP and mixed workload (including analytic-transaction processing), and development databases. This system also features elastic resource utilization, growing and shrinking processor and storage usage (within user-defined limits) as database size and user demand vary, so the system is always the right size and the user only pays for the resources necessary to run the database in an optimal manner.

The user controls only the schema and the data itself. As these change, Oracle Autonomous Database adjusts its setting for optimal performance and operation. Oracle Autonomous Database also takes advantage of Oracle's high-availability (HA) capabilities for continuous operation and optimizes routine operational functions such as backup and patching.

Oracle Autonomous Database is available in two forms: Autonomous Data Warehouse (ADW) and Autonomous Transaction Processing (ATP). Both offer automatic security patching, an adaptive, ML-driven optimization, and automated performance tuning.

This capability also dramatically reduces the amount of staff time required by the database. The lead DBA for a major personal care products maker reckons that the Autonomous Database would save his organization 10–30% staff time, which means that staff effort, on average, would be reduced from full time to 10–20 hours per week. This is less about cost savings and more about having a more effective team. The resulting staff redeployment promises to make the group more flexible and efficient.

Most enterprises do not apply security patches in a timely manner due to the cost and operational disruption that such patching causes, exposing themselves to possible breaches resulting from exploitation of known vulnerabilities. For this reason, the automatic patching feature of this service represents a major benefit, ensuring that security fixes are applied as soon as they are available, usually on a biweekly basis, or even sooner, without the cost, disruption, and risk associated with applying patches in databases running in the datacenter. For QLX, a supplier of data services to sports enterprises and casinos, security is paramount. The company said that the security capabilities of Oracle ADW, and in particular the automatic patching feature, make it a huge win. QLX clients often manage venues that are tied into Homeland Security operations. They have a high level of requirement with respect to access, authentication, and data encapsulation. A hack would be disastrous. This feature makes such an eventuality much less likely.

Users can also choose from three modes of operation: shared and serverless, dedicated or, soon, Cloud at Customer. For the shared and serverless option, the user pays only for resources actually used, though the database shares physical resources with other users' databases (although the resources are shared, users, or "tenants," cannot detect each other's presence). Dedicated service means the database is in its own physical space, which makes this the option for those who want to finely control performance as well as those who require physical isolation for legal reasons.

Oracle also offers unified database security control center that features security configuration assessment, user risk assessment, user activity auditing, sensitive data discovery, and data masking. This capability is called Oracle Data Safe and is free with all Oracle Cloud Databases.

Oracle Autonomous Database is designed to support natively both structured and unstructured data. Oracle ADW is designed for data warehousing use cases, and Oracle ATP supports transactional databases and mixed workloads.



Oracle Autonomous Data Warehouse

Oracle Autonomous Data Warehouse is a cloud service based on the Oracle Autonomous Database technology. It is a database cloud service configured to operate as a self-managing, self-tuning, and adaptive data warehouse. This cloud service operates in an environment that is entirely under Oracle's control. In this way, the service can provide optimal performance for the workload at hand. The user specifies the ranges of resources, such as processors or storage, but as the system runs, the Oracle Autonomous Database selects a configuration within those parameters that is ideal for the database that it is managing. Oracle Autonomous Database also makes all decisions regarding such things as indexing, partitioning, and the use of Oracle's hybrid columnar compression.

Oracle ADW also optimizes complex SQL and creates data summaries.

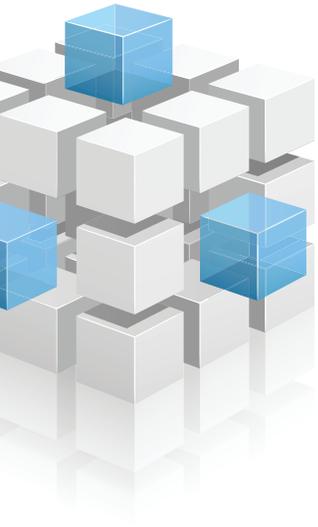
Oracle Autonomous Transaction Processing

Oracle Autonomous Transaction Processing is another cloud service based on the Oracle Autonomous Database technology. It is also self-managing and self-configuring. It dynamically creates indexes and revises index structures, using ML to optimize them based on usage patterns. If an index revision seems to negatively impact performance, it automatically reverts to the prior structure. It optimizes for response time and transaction throughput. As with the ADW, ATP manages the physical resource configuration, optimizing for performance and affordability. Instead of using hybrid columnar compression, ATP keeps transactional data in rows but still optimizes analytic queries on transactional data, and supports data from the Internet of Things (IoT) or for machine learning.

Benefits

Oracle promises the following benefits from using Oracle Autonomous Database:

- Flexible, scalable operations ensure that the users, including business analysts, can get consistently excellent performance reliably on even the largest, most complex, and changeable data warehouses.
- The database remains in continuous operation, even when maintenance is being performed or the operating parameters change. There are no interruptions in service as patches are applied or when the database is being scaled up or down in terms of storage or processors.



- Optimal data security is ensured by virtue of the fact that the database software is always up to date with the latest security patches that are designed to prevent unauthorized data access as well as ML capabilities that constantly monitor for threats.
- Elimination of staff time spent on DB operational administration allows DBAs to focus on the more high-value functions of working with application developers and business analysts to ensure that each Oracle Database has the optimal data required for the enterprise to operate in and adapt to ever-changing business conditions.
- With Oracle Autonomous Database, as more databases are added, there is no additional operational staff time cost because Oracle Autonomous Database performs those functions itself.
- Barring a massive multisite disaster, a database under Oracle Autonomous Database's control should never fail, virtually eliminating downtime.
- The ML capabilities of Oracle Autonomous Database are constantly learning and adapting as the database runs to ensure the best possible performance of the engine and of queries.
- Sophisticated data protection is based on the security capabilities of the Oracle Autonomous Database and its ML features that discover and prevent inappropriate data access.



User Experiences



Forth Smart maintains more than 120,000 vending kiosks in Thailand. These kiosks enable users to add money to prepaid phones, pay bills, perform banking transactions (including making cash withdrawals), and add money to ewallets. Because Thailand is a mostly cash-based society, most people use the kiosks to pay their prepaid phones with cash, get cash, or send money to relatives. The kiosk is configured like a cell phone and communicates through the cell network.

Each transaction is posted to an Oracle Database in the Forth Smart datacenter. It then syncs through GoldenGate to an ADW instance running in OCI. All the analytics are done in OCI because keeping the data in the local datacenter is too risky: Downtime would cost the company \$100,000 per hour.

Forth Smart processes 2 million transactions per day; 60 million per month. All that data must be analyzed, and the load on the data warehouse is highly variable. ADW's self-tuning is a critical feature, as is its encryption capability. The ability to scale up and down temporarily depending on the load has saved Forth Smart a lot of money. Another source of savings is the autonomic control of database settings; human error used to be a major cause of downtime.

The advent of Generation 2 of ADW brought major additional benefits. Performance improved, based on the situation, from 2 times to 200 times. Generation 2 also uses much less CPU capacity, with the average usage dipping from 8 CPUs to 3 CPUs most of the time.

SKY TV Brazil

SKY TV Brazil is the largest satellite TV provider in Brazil. It is a subsidiary of DirecTV, which is, in turn, a subsidiary of AT&T. SKY TV Brazil is not affiliated with Sky TV UK. It had been using Oracle Database as a data warehouse in its datacenter. The provider used Oracle Database to understand its customers and drive marketing campaigns using analytic tools from Oracle and SAS. The company “hit the ceiling” with its existing infrastructure in terms of speed and capacity for complex data processing. The load included 10,000 jobs with complex queries as well as online queries. Analytic queries from the analytics team and data scientists were particularly hard to tune. SKY TV Brazil was also running out of storage, with the database topping 80 terabytes.

So, it turned to Oracle ADW. Team members were skeptical at first but soon came around when they saw that the ML-tuned queries used a lot of parallelism, delivering better performance and greatly reducing the amount of effort required to tune the database. The system automatically tuned a query that had previously required 2 hours so that it ran in 14 minutes. The team made a few manual adjustments to that tuned query, and now it runs in 10–12 seconds. The company used to have a critical batch job that took 14 hours to run overnight, making the database inaccessible in the morning hours. Now it runs in just 2 hours, so the database is available all day. Even when new data is being ingested, the performance is fine. Some users think it seems “too good to be true.”

Now, the data warehouse is up to 130 terabytes, and the company has been able to eliminate 90% of the manual activities involved in managing the database, including storage growth planning, partitioning, and running backups.

SKY TV Brazil has started working with Oracle ATP but has no concrete results as of yet.

It was difficult to deal with the skepticism of users and DBAs at first; DBAs wanted to know what was going on in that “black box” and what would happen to their jobs. But now they realize that they have gotten rid of the “boring stuff” and are able to do more productive work. The whole team is looking forward to using Oracle ATP on the order processing system.



FUTURE OUTLOOK

The future of most enterprise data management is in the cloud; this is pretty much a consensus view. The question is, How will that management be done? While cloud services teams can perform routine tasks such as taking backups, applying software patches, and tuning the systems on which the database runs, actually troubleshooting database performance problems or failures may require a level of intervention that is a little too revealing of the enterprise database to the cloud services staff. Also, it is a non-scalable area of work that is likely to contribute to a high service cost for DBaaS.

So, it seems clear that a successful DBaaS must include autonomic features in the DBMS itself, including self-tuning and self-healing operations driven by ML. Oracle Autonomous Database makes Oracle a pioneer in this regard and gives OCI a distinct early advantage.

A hand is shown holding a glowing, digital brain graphic. The brain is composed of white circuitry and binary code (0s and 1s) against a dark blue background. The background of the entire image is a server room with rows of server racks and glowing lights.

CHALLENGES/ OPPORTUNITIES

There can be no doubt that other database software vendors will develop autonomic features similar to those in the Oracle Autonomous Database. At the same time, Oracle has the opportunity to leverage this capability as long as the firm continues to innovate along these lines, offering capabilities that not only match the abilities of the most talented and experienced DBAs but go beyond to provide tuning and recovery capabilities that no human can hope to match.

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CONCLUSION

Enterprise databases are getting more numerous and more complex all the time. Their interdependencies through data integration also sets them up to fall like dominoes in cases of sluggishness or outright failure. To prevent this, enterprises employ armies of operational DBAs to continually monitor, tune, and recover databases. Yet budget constraints often prevent those DBA teams from growing to match the work required, so the higher-value work of making databases more responsive to the needs of the enterprise often fall by the wayside.

Public cloud services offer a partial response to this problem by alleviating the routine work of system, application, and database maintenance, but the work of keeping the databases running with peak performance is still a labor-intensive function. To address this problem, enterprises should consider the following:

-  Make a comprehensive plan for moving all systems not requiring locally resident data to a public cloud service.
-  Consider a locally delivered cloud service appliance, such as Oracle's Oracle Cloud at Customer, for the management of data that must remain local.
-  Tally the costs and risks that are associated with the current manual method of managing enterprise databases in your datacenter. If those costs and risks are unacceptable, consider turning to Oracle Autonomous Database as a means of protecting the enterprise from unnecessary constraints on enterprise performance, productivity, and agility.



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