OFFERING OVERVIEW

Oracle Makes Its Great Database Even Better—and Adds Low Code to It

How Oracle Pushed the Database Toward the Multis and Combined It With APEX Low-Code Service

Holger Mueller
Vice President and Principal Analyst

TABLE OF CONTENTS

EXECUTIVE SUMMARY

This Offering Overview examines Oracle's latest database release, Oracle Database 21c, as well as Oracle's low-code application development offering, Oracle Application Express (APEX). The report describes the underlying market trends, introduces the vendor and presents key differentiators for Oracle's offering. It continues with an analysis of the vendor's strengths and weaknesses and concludes with a set of tangible and actionable recommendations for CxOs.

| Business Themes		
New C-Suite	Data to Decisions	Technology Optimization

ABOUT ORACLE'S AUTONOMOUS DATABASE

Overview

Oracle has a unique vision among those in this technology vendor field, creating the largest integrated "chip-to-click" hardware and software offering—one that ranges from the silicon (the "chip") to the user (the "click") in software-as-a-service (SaaS) products. More recently, in January 2021, Oracle announced the latest version of its database, Oracle Database 21c, at a digital event (see Figure 1).

At the same event, Oracle also unveiled the availability of its low-code application development platform, Oracle Application Express (APEX), as a cloud service. This launch emancipates APEX from a programming language limited to the presence of Oracle Database to a full-fledged, stand-alone programming language.

Both announcements reflect Oracle's strategy, which is to provide the most complete database for enterprises—a database that can handle all kinds of data types and data models, supports all

Figure 1. Andy Mendelsohn Announces Oracle Database 21c
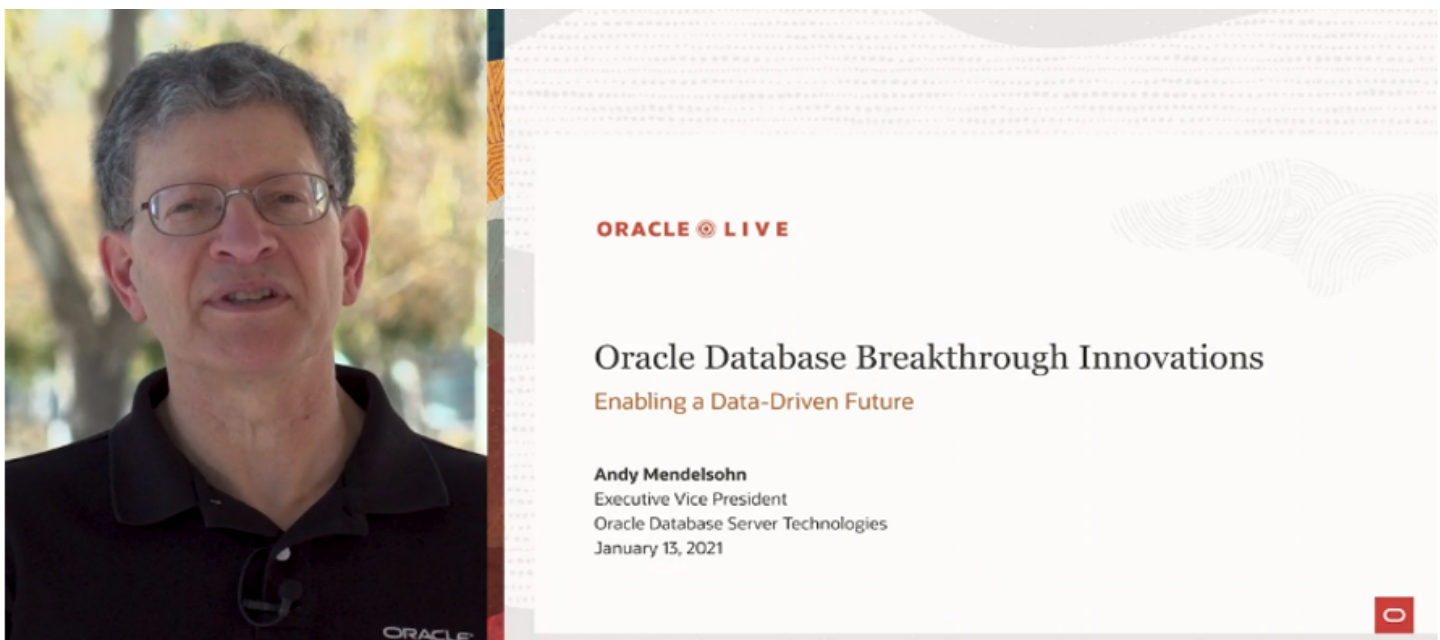
Source: Oracle

modern workload types and enables productive work for developers and analysts. Oracle calls this the "converged" database; at Constellation we call it the "universal" database, because it allows enterprises to do with one single database what they need to do, rather than using multiple specialized databases.

Oracle Database 21c also propels forward Oracle's goal of automating the operation of its database to a level where it becomes "self-driving," effectively managing itself. This is a radical departure from the human-operated administration of a database by database administrators (DBAs). Advances in computer, machine learning (ML) and cloud technologies enabled Oracle to build the world's first and only autonomous database and continue on the path toward full autonomy (see Figure 2).

At the same time, Oracle acknowledges that enterprises operate in the era of business-best-practice uncertainty, meaning that the best practices of the 21st century have not been established. As a consequence, enterprises need to build more software in-house than ever before, and given the likely never-to-be-addressed shortage of developers, it is key to have a low-code offering that is

Figure 2. The Oracle Database 21c Value Proposition

Oracle Database 21c | World's Best Converged Database
For all data-driven application use cases

Any Data
- Relational, JSON, XML, graph, spatial, OLAP, blockchain

Any Workload
- OLTP, analytics, ML, streaming, IoT, In-Memory, multitenant, faster JSON & graphs, etc.

Most Productive
- SQL & transactions on any data
- Java, JavaScript, AutoML, SQL Macros, microservices, events, CI/CD, APEX

Enterprise-Class
- Best performance, scalability, reliability and security for all data and workloads

21ᶜ

26

Source: Oracle

constellation
RESEARCH

tightly coupled with Oracle Database. Oracle has had that offering with APEX for a long time, and it now features APEX more prominently not only for its database customers but also as a service offering that enables enterprises to build low-code offerings independent of whether they are Oracle Database customers already. The value proposition is on building low-code applications, which happen to run on one of the world's best databases—currently in use by 97% of the Fortune 100—with built-in enterprise-class security, scalability and availability.

Market Definition

Since the 1950s, databases have remained not only central to computing but also a foundational layer for enterprise software. The persistent nature of enterprise software requires that the information captured must be available after the user's session. Databases ensure and deliver this persistence.

Moreover, databases must allow software and users to access and process information; how they accomplish this is a key area of differentiation between database providers. At their core, databases organize a collection of data objects, including schemas, tables, queries, reports and views.

With the advent of the cloud, deployment options now reflect the shift of IT loads from on-premises to the cloud. As a result, the availability of next-generation databases in the public cloud will become more attractive as enterprises shift to using next-gen applications.

Constellation's conversations with clients show us that database choices matter. Why? Switching databases is hard and expensive and often poses a risk to business continuity. Leaders must make wise decisions about databases that provide a long-term return on investment, reduce overall operating costs and deliver on enterprise agility.

Market Trends

Constellation has identified seven key market trends for next-generation databases (see Figure 3):

1. **Enterprises expect cloud deployment options.** Customers expect their vendors to have a cloud deployment option. How this is delivered does not matter. For example, offering cloud-native

options, using third-party infrastructure as a service (IaaS), delivering on vendor-run cloud infrastructure or even relying on the infrastructure of a partner are all valid options. Remarkably, all vendors—except those offering the two cloud-native options—make their databases available as on-premises products. Notably, the Hadoop-centric database vendors have been the slowest to offer public cloud deployments, relative to the start date of their first commercial offerings. CxOs expect elasticity of cloud resources and flexibility of licensing models.

2. **New designs support in-memory computing.** Moore's Law has not only made hard disk drives (HDDs) cheaper but also has lowered the cost of RAM. The result: Even big multinational enterprises can run large parts—and in some cases all—of their transactional enterprise resource planning (ERP) data in memory. Performance benefits include the ability to process information in real time. Traditional vendors keep a subset of data in (expensive) memory. Consequently, how memory is managed, accessed and consumed is where the vendors differ. Hadoop-based vendors use Apache Spark and Hive. Traditional relational database management system (RDBMS) vendors use memory sparingly and in an organic fashion, moving data to an in-memory database when beneficial for system performance or placed in memory by system administrators. In-

Figure 3. Seven Market Trends Defining Next-Gen Databases
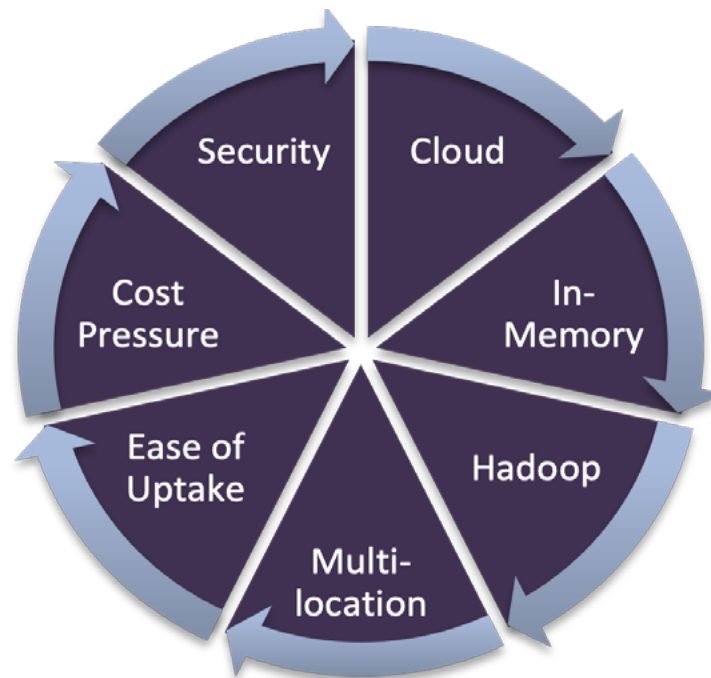
Source: Constellation Research

memory vendors take a more radical approach and place the entire system in memory at all times. Meanwhile, cloud-based vendors, given the novelty of their offering, have not shared their in-memory philosophy; however, given the use cases, Constellation expects the uptake of in-memory options to be similar to that of traditional RDBMS vendors.

3. **Options must coexist and integrate with Hadoop.** Hadoop has profoundly changed the data storage and retrieval market while massively transforming enterprise best practices for analytics. For the first time, enterprises can store all of their electronic information in one place, without knowing what they want to analyze, and remain commercially viable. In addition, data storage and retrieval architecture can bridge data silos.

4. **Globalization and regulation increase requirements for multiple locations.** Enterprises are more global and must act more globally than ever before. With limitations in performance and statutory requirements regarding data residency, database vendors can no longer pass the buck to the customer to solve this challenge. Customers expect solution offerings to support multiple locations where their databases can be operated, either via their own infrastructure or via a partner's.

5. **Implementation plans assume ease of deployment.** Enterprises need to move faster and cannot afford to be slowed down. The speed, ease of deployment and time to go live are key differentiators for database vendors. Critical success factors include helping customers to use a new product effectively, partnering closely with customers during first implementations and making their product easier to deploy. The application of automated machine learning (AutoML) and artificial intelligence (AI) will improve implementation success.

6. **Open source options increase cost pressures on everyone else.** With the rise of mostly open source, cloud-based databases, the cost pressure on other vendors has increased. Vendors see themselves forced to justify the license costs of their traditional databases when the base version of an open source–based database is free. And the revenue potential and wallet share for the add-ons that can be licensed in the open source market are not the same as for the traditionally expensive database licenses. Traditional database vendors already can see the pressure on their license prices. Constellation expects this trend to continue.

7. **Security remains paramount to clients.** Enterprise-grade use requires a set of security capabilities to prevent data breaches and cyberattacks and to avoid potential liability challenges. But enterprises also are ready to experiment and evaluate when only limited security concepts are available; Hadoop databases are an example. In the end, the value of insight gleaned from data often trumps security. However, large-scale and production implementations require an acceptable set of security capabilities. To an increasing degree, enterprises expect security capabilities to be automatically deployed. Finding the right balance between insight and security is key for CxOs.

Oracle Enables Enterprise Acceleration via Its Autonomous Database

Enterprises need to move faster than ever before, an effect Constellation refers to as "enterprise acceleration." Oracle as a vendor enables all nine drivers to enterprise acceleration. With Oracle Autonomous Database, it enables specifically the following ones (see Figure 4):

- **Next-gen apps.** Enterprises need to take advantage of technology progress and build next-generation applications. Autonomous Database supports key database enablement to accelerate the development of these new applications.

Figure 4. The Nine Drivers for Enterprise Acceleration in IT
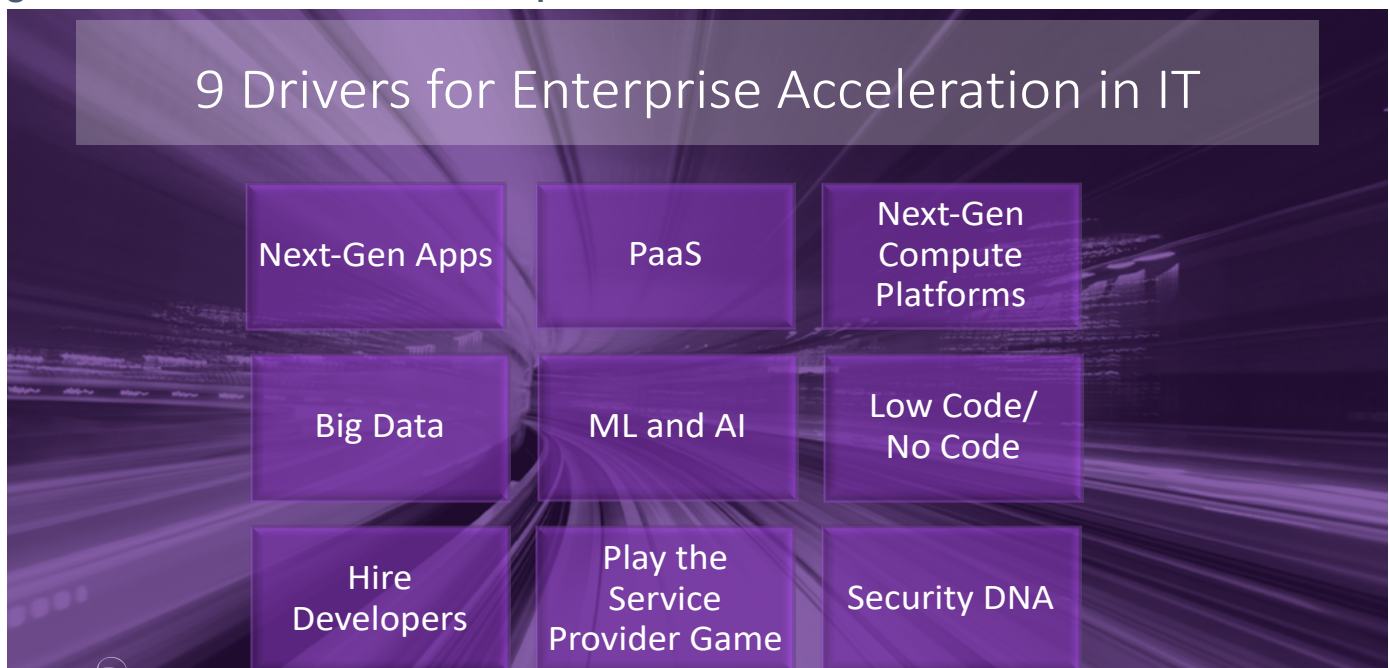
Source: Constellation Research

- **PaaS.** Enterprises utilize platform-as-a-service (PaaS) options to build their next-generation applications. Autonomous Database is part of the Oracle PaaS offering and supports that process.

- **Next-gen compute platform.** Enterprises need workload portability across the public and private cloud as well as on-premises platforms. In combination with Oracle Exadata and Oracle Cloud Infrastructure (OCI), Autonomous Database is powered by a next-gen compute platform.

- **ML/AI.** Autonomous Database is both a consumer and enabler for ML/AI processes. In its automation capabilities, the product is a consumer of ML/AI in its compute, query optimization, self-maintenance, data storage and retention capabilities. Via its built-in ML services, Autonomous Database enables customers to build and test ML/AI models quickly, delivering the important data side of any ML/AI project while keeping key relational data inside the database.

- **Low code/no code.** Along with supporting a long list of general programming languages, Autonomous Database has APEX built in natively, giving enterprises a low-code alternative to classic programming work.

- **Big data/analytics.** Autonomous Database offers native integration to Hadoop and object storage services, thus creating a data lake for analytical purposes that covers relational and nonrelational/object data.

- **Security DNA.** Security is paramount in the connected world that sees peaks of industrial espionage and state-organized data breaches. Autonomous Database automates all key and core security processes and patches that matter for the database.

FUNCTIONAL CAPABILITIES

The Most Complete Universal Database

Constellation calls a database that can serve most of the enterprise use cases a "universal" database, because it can be used universally for all workloads and use cases an enterprise has or will have. Oracle chooses to call its database a "converged" database, which is a different term for the same kind of offering.

A universal database is crucial for any enterprise IT strategy, because it does not require the selection of another specialized, isolated database for each new use case the enterprise will have to implement. Universal, or converged, databases not only need to support multiple database use cases and data types, but they also have to be "good enough" compared to the specialized databases that are their alternative for a single use case. Needless to say, when a universal database outperforms the specialized database, it is a welcome outcome for any CxO in charge of building next-generation applications.

Oracle (see Figure 5) has executed very well on a universal database strategy that is based on the following key three pillars:

1. **Support any relevant enterprise data type.** A database becomes universal only when it supports at least more than one data type. Oracle's strategy supports its traditional relational origins but also JSON/document, graph, spatial, text, OLAP and XML data types and data modes.

2. **Enable any relevant enterprise workload.** Along with supporting multiple data types, a universal database needs to support the relevant workload types that use those data types, often combining them. For Oracle, this means support for transactional, analytical workloads as well as for ML, Internet of Things (IoT), streaming and blockchain use cases.

3. **Help enterprises achieve enterprise acceleration.** Finally, what matters most is to enable an enterprise to build next-generation applications with a database, as fast as possible, making both developers and data workers as productive as possible. For Oracle, this means enabling modern

Figure 5. The Ambition and State of Oracle's Converged Database Direction

Strategy | Offer Customers The World's Best Converged Database
Future-Proofing Against Changing Business Requirements

Supports Many Data Types and Data Models
Relational, JSON, graph, spatial, text, OLAP, XML

Supports Many Workload Types
Transactions, analytics, ML, IoT, streaming, blockchain

Is Most Productive for Developers and Analysts
Integrated microservices, events, REST, SaaS, ML, CI/CD, Low-Code

Source: Oracle

code constructs such as microservices and event-based architecture, enabling REST-based APIs, helping SaaS use cases, accelerating ML use cases, empowering low-code demands and supporting code delivery via continuous integration/continuous delivery (CI/CD) methods.

Apart from giving the CxOs the peace of mind that any enterprise use case can be powered by Oracle Database 21c, the key benefit of a universal database is that data is not fragmented across multiple various specialized databases. This "universality" makes it easier to generate and operate continuous insights across the different workloads and data types, without having to move data or operate an integration layer. It also means that operation and administration is easier, more efficient and less error-prone—and with that, more secure—to operate.

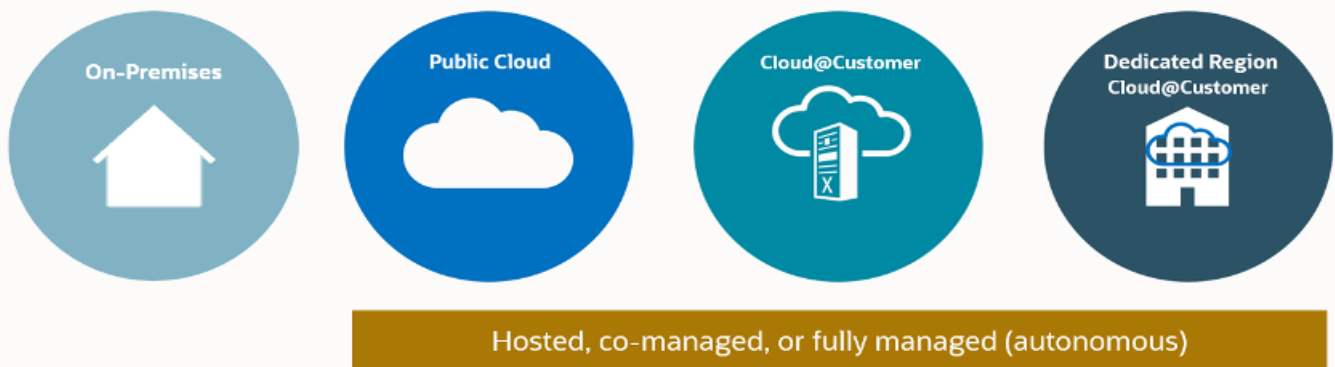## Deployment Flexibility: Your Database Where You Need It

CxOs want deployment flexibility that allows them to deploy data and software assets onto different platforms, from on-premises to the cloud. This gives their enterprises freedom of choice that is often needed from both a statutory/legal and a commercial perspective. Nothing is worse for an enterprise than being locked into a deployment form that no longer delivers benefits.

Oracle offers four different forms of deployment for Oracle Database with the highest degree of Architectural Identicality compared to all other cloud providers (see Figure 6):

- **On-premises: Oracle Database on Oracle Exadata Database Machine.** This is the traditional way of operating IT, with tasks typically performed by employees in-house, including purchasing hardware and licenses and making decisions on support and maintenance. This approach has served enterprises well for many decades. It still delivers value for many enterprises around the world.

- **Public cloud: Autonomous Database on Exadata Cloud Service.** In this public cloud deployment, Oracle runs Autonomous Database on an Exadata-backed Oracle Cloud Infrastructure (OCI), offered as a subscription service. Typically, Oracle manages the complete infrastructure but also allows the customer to take the lead in a comanagement model. In either case, Oracle has no visibility into customer data; the customer manages the data and schema.

Figure 6. Oracle Choice of Deployment for Oracle Autonomous Database

Oracle Database Is Available On-Premises and in the Cloud
Develop and Deploy Anywhere – Extreme Portability

On-Premises · Public Cloud · Cloud@Customer · Dedicated Region Cloud@Customer

Hosted, co-managed, or fully managed (autonomous)

Source: Oracle

- **Cloud@Customer: Autonomous Database on Exadata Cloud@Customer.** With its Cloud@Customer service, Oracle has bridged the benefits of cloud with local deployments. Enterprises still want to operate in their local data centers, usually motivated for performance reasons, statutory demands or solidified traditional best practices. However, by offering to manage or comanage the resource and a pay-per-use subscription service, Oracle created new value for these customers: They do not have to pay capex anymore, and they can rely on Oracle to manage their Oracle Database infrastructure and further benefit from the automation in Autonomous Database.

- **Dedicated Region Cloud@Customer.** Oracle launched Dedicated Region Cloud@Customer in fall 2020, bringing its cloud services—from OCI to SaaS—to on-premises for customers, with Oracle fully managing the offering in the same way as it does any region of Oracle Cloud. This is a unique capability in the database and overall cloud space, giving customers the choice to operate workloads in the public cloud or on-premises.[1]

Constellation assumes that Oracle's experience in managing database loads as a service via the Oracle Cloud@Customer offering was a major motivator for investing more into Autonomous Database management services. Not only was Oracle motivated to provide a high-quality, highly reliable database management service, but it also was motivated to provide that at competitive costs. This is likely to have triggered the realization that self-driving, autonomous databases are superior for customer experience and TCO. This unique situation creates extra motivation for Oracle to operate its Autonomous Database in a reliable and cost-effective way. These factors are key for CxOs to understand when they make database choices, especially when it comes to choosing a universal database.

Oracle Database 21c Innovates in Multimodel Support

Oracle has been providing support for different database models for many past versions of Oracle Database, and Oracle Database 21c continues in that direction. Multimodel support is crucial for

keeping Oracle Database a very strong contender as the leader in the universal database arena, because support for a variety of operating models is key for enterprises.

The key multimodel innovations Oracle adds with Oracle Database 21c (see Figure 7) are:

1. **Support for in-database JavaScript.** A lot of developers know and prefer JavaScript, and this makes it crucial for Oracle to support JavaScript well, ideally better than any other database. Following the leitmotiv of the code coming to the data, Oracle offers the ability to run JavaScript inside the database, thus eliminating expensive configuration and network trips and simplifying operations. The automatic mapping of JavaScript data types to Oracle Database data types and vice versa adds to developer velocity. Developers will be able to use open source JavaScript libraries to further boost their productivity. Unsurprisingly, Oracle supports the execution of SQL from inside JavaScript. Finally, JavaScript runs inside of the Graal Multilingual Engine, Oracle's highly performing polyglot Java engine.

Figure 7. Oracle Database 21c Innovations in the Multimodel Space—in This Case In-Database JavaScript

In-Database JavaScript
Runs on Embedded Graal Multilingual Engine (MLE)

- Run data processing JavaScript inside the Oracle Database, where the data resides
  - Eliminates expensive network round-trips
  - JavaScript data types are automatically mapped to Oracle Database data types and vice versa
- Leverage open-source JavaScript libraries
- Easily execute SQL from JavaScript code
- Enables developers to work efficiently in modern programming languages

Source: Oracle

2. **Increased JSON speed and flexibility.** Oracle's support of native JSON data type allows developers to mix freely JSON data types with relational data, enabling the coming together of the record-centric relational world and the document-centric JSON world. Oracle Database 21c supports the scale-out of ACID transactions on JSON data and allows the indexing of JSON elements for faster access. Again, as with the new JavaScript support, Oracle supports SQL across all JSON formats as well as the ability to run complex joins across multiple JSON documents and collections. With the ability to manage the database JSON capabilities on day one, Oracle reduces TCO on the admin side.

3. **Availability of immutable blockchain tables.** In Oracle Database 21c, blockchain tables bring the key security benefits of blockchain technology to enterprise applications. These immutable insert-only tables store rows that are cryptographically chained together, effectively rendering the data tamper-proof. The rows can also be digitally signed when inserted. These tamper detection and prevention capabilities can protect against illicit changes by insiders or hackers impersonating administrators or users. Blockchain tables can contain various column types, and are accessed with standard SQL, supporting full analytics and transactions—making it orders of magnitude easier to use, and more functional, than existing blockchain implementations.

4. **Improved graph performance.** In Oracle Database 21c, Oracle has added key optimizations to the database's graph capabilities. Oracle has optimized the memory requirements for larger graphs, and with that allows existing applications to benefit from performance gains. Graph algorithms now can be created and extended via the popular Java programming language, and because Oracle gives customer algorithms the same treatment as the product's embedded algorithms, customers see the same performance for their custom graph algorithms as they do with the out-of-the-box Oracle graph algorithms. Finally, Oracle has improved visualization of the graphs used in the product, an area that requires continuous attention and innovation to achieve better user productivity and higher user experience levels.

Oracle 21c Innovates in Multiworkload Support

Oracle delivers further in another direction that is key for universal databases, and that is the support of diverse workloads. Specifically, with Oracle Database 21c, Oracle adds:

1. **Improved in-memory capabilities.** Many releases ago—in Oracle Database 12c—Oracle introduced the ability to keep any table in memory, effectively creating a dual-format database. The ability to keep the same data in both row and columnar format gives enterprises the best of both worlds for transactional and analytical workloads. In Oracle Database 21c, Oracle also adds the ability of Oracle's Deep Vectorization Single Instruction Multiple Data (SIMD) framework to in-memory processes, which results in performance gains up to a factor of 10. In addition, Oracle has enhanced its optimizer to support the in-memory hybrid format, avoiding potential performance-degrading row-store lookups for less-used, less-popular data. Finally, Oracle Database 21c introduces a self-managing In-Memory Column Store that simplifies and improves efficiency by automatically managing the placement and removal of objects in the In-Memory Column Store, then tracks usage patterns and moves and evicts objects from the column store. In addition, columns are automatically compressed based on usage patterns.

2. **Automated machine learning.** ML is one of the most prominent innovations in the era of Infinite Computing, allowing machines to make sense of data and derive insights. But people qualified to build ML applications are rare, so automatic/autonomous ML is in high demand. Oracle addresses this with its AutoML capabilities (see Figure 8), which identify the best prediction algorithm for each workload; independently derive the most relevant data; and then automatically tune the ML models, identifying the parameters for best performance independently. The result is a software-created ML model that does not require in-depth ML, data-science, data-modeling or similar skills—skills that are all difficult to find and hard to learn. AutoML makes it possible for business users via self-service to enable ML use cases. Moreover, Oracle has bolstered its ML capabilities by adding new algorithms such as MSET-SPRT, XGBoost and the Adam Optimization Solver for neural network algorithms. Automated machine learning is one of the most powerful new capabilities in Oracle Database 21c and not a separate tool or service as is required by other databases from the likes of AWS and Snowflake.

3. **Support for persistent memory.** Oracle already has delivered Oracle Exadata X8M as a platform that extensively leverages the newest form of persistent storage—PMEM. Thanks to native PMEM support, Oracle Database 21c can keep database data and redo in local PMEM, increasing overall performance for its applications. Again, Oracle allows direct SQL access to data in the PMEM file system, giving SQL-savvy professionals more power to do more things. And finally, the new PMEM

Figure 8. Oracle's Easy-to-Use AutoML User Interface
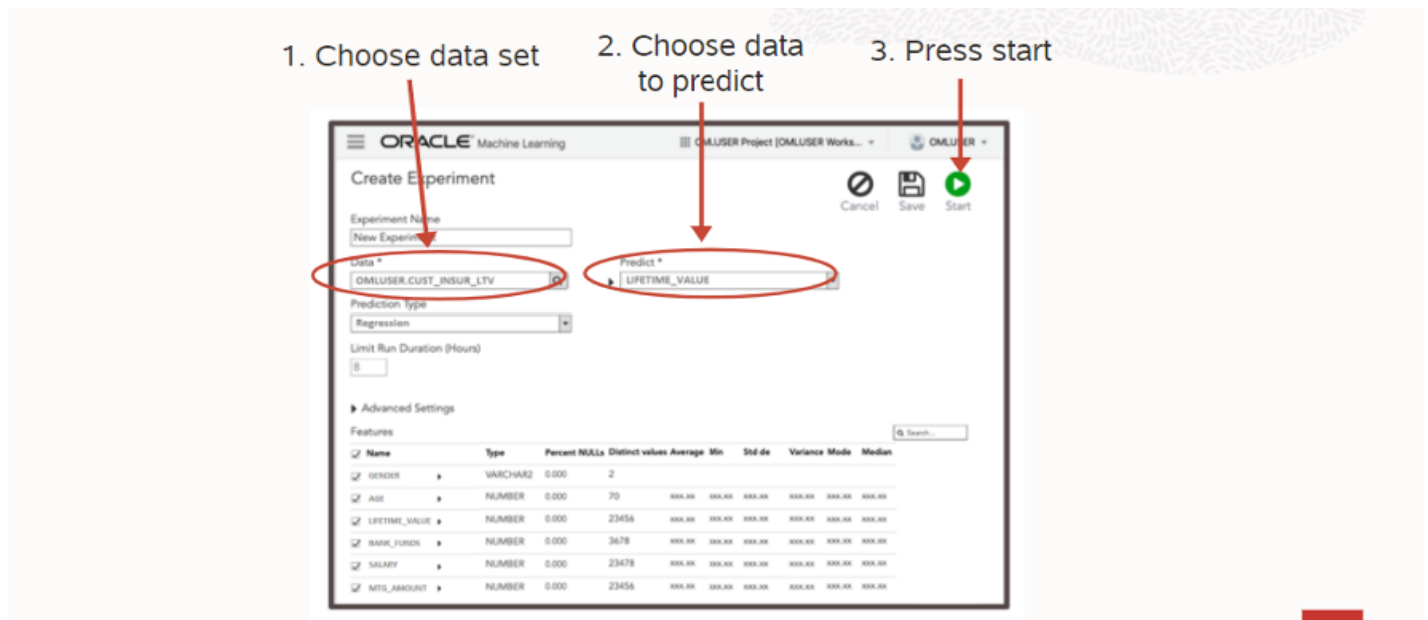
Source: Oracle

capability is helpful with performance. For example, Oracle's database-sharding capability uses PMEM, effectively adding a caching layer to the sharding configuration. The combination of faster and lower-cost persistent memory enables new next-generation use cases for enterprises.

4. **Advanced sharding capabilities.** Sharding in a database has been the secret sauce for many internet-scale use cases, and Oracle added sharding capabilities to its database a few releases back. Internal use cases such as the Oracle BlueKai data management platform (DMP) applications (1 million transactions/second, 1 Tb updates/second, a redo rate of 180 GB/hour on a 2.5 PB total database) make a very compelling proof point. Now, Oracle makes sharding easier to use with the introduction of the Sharding Advisor tool, which helps users efficiently move into a sharded schema; makes suggestions for moving to a sharded schema based on a nonsharded schema and its workload; and provides a prioritized list of sharding opportunities in an existing, nonsharded database.

Oracle Database 21c Innovates With New Multitenancy Capabilities

When Oracle introduced database-side multitenancy back in 2014, it was hard to assess the impact that a multitenancy architecture would have on customers' best practices, database consolidation and

overall TCO (see Figure 9). With multitenancy, enterprises are able to share compute infrastructure more efficiently while running more Oracle Databases, a key driver for database consolidation that is a winner not only on the overall cost side but also on the benefits side, providing easier administration and achievement of insights.

With Oracle Database 21c, Oracle adds the following new capabilities for multitenancy.

- Introduction of multitenant Data Guard. Disaster protection is key for mission-critical applications and Oracle excels at mission-critical workloads. With Oracle Data Guard, Oracle provides protection against failure on both pluggable databases (PDBs) and container databases (CDBs), using real-time apply across standby databases in failover sites to ensure high availability. Prior to Oracle Database 21c, the granularity of the standby database is at the CDB level. This meant that even if only one out of a hundred PDBs in the CDB failed, Data Guard would failover the CDB and all of the PDBs. With Oracle Database 21c, each PDB can optionally be mapped to its own standby database. Therefore, instead of failing over an entire CDB, only the impacted PDB needs to failover, thus reducing the recovery time.

Figure 9. Oracle Multitenancy

Source: Oracle

19

constellation
RESEARCH
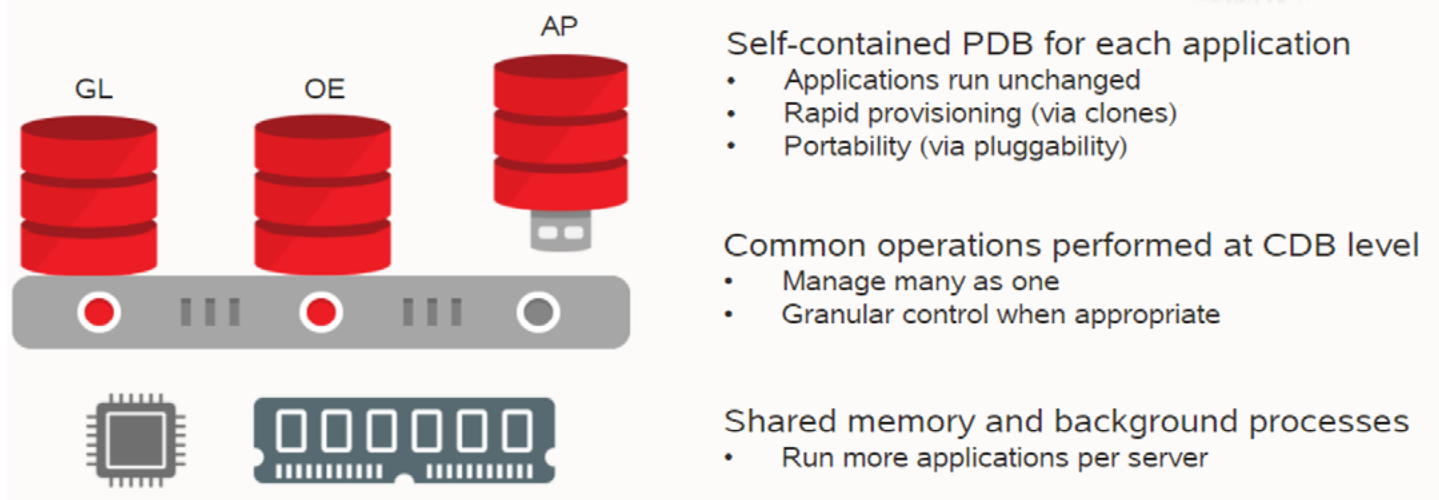
- Improvements to multitenant security. With the introduction of Oracle DbNest, Oracle allows better isolation for both CDBs and PDBs. Computing services are isolated down to the level of processes, CPU, memory, network and file access. DbNest can bring together CDBs and PDBs in their own security realm, which is enforced by operating system capabilities (for instance, for Linux with namespaces, CG Groups, SECComp filtering and so forth). With isolation between "nests," Oracle ensures that a PDB in a nest cannot access other PDBs outside of its nest.

In light of moves made by its primary competitors, Amazon is trying to redefine some terms to suit its needs. AWS uses terms such as "clustering" and "shared nothing" to refer to replication and sharding. AWS can't handle clustering to the extent that Oracle Real Application Clusters (RAC) can, so the company redefines terms to suit what it can actually do. AWS Redshift is the old ParAccel code (a fork of Netezza) and that's a shared-nothing Data Warehouse solution. Clustering was defined by DEC (VAXclusters) decades ago; however, Oracle is the only database vendor that has ever built an active/active, shared-everything clustered database with RAC.

Scale (Size of Compute & Storage for a Single Database)

Rather than scale down and run smaller databases, customers need to realize that overall size is not a limiting factor when running Database 21c in Oracle Cloud Infrastructure (OCI), making it a prime destination for cloud database consolidation. For example, the largest AWS database compute instance is roughly equal to the smallest Exadata Cloud Service X8M (ExaCS) database. Oracle can then scale ExaCS to 32x larger than the largest AWS offering on the compute side.

Replication (Read Replicas, Reader Farms)

The fact is, there is no single source of truth when you're using read replicas. Changes on the master are not reflected immediately on the replicated copies of that master. The technique of deploying read replicas (replicating data) doesn't work in situations with heavy activity because the replicas will be out of date. Customers can use read replicas with Database 21c in OCI, but they can use replication where it makes sense, not as a workaround to an Oracle limitation.

Sharding

Amazon likes to call this "partitioning" instead of the more generally accepted term "sharding" to describe a large logical database that is divided into multiple, smaller, independent databases. This is a great technique, but customers aren't forced into using sharding because of some limitation in ExaCS. Most databases are technically using sharding to overcome issues like scalability, availability and reliability, whereas Oracle is only using sharding when the application actually requires it, and not to cover up holes in the product. For Oracle it's an actual feature, for other databases it's more of a fix.

Availability

AWS doesn't offer any clustering for databases aside from Redshift, so it lacks an availability solution. Clustering is endemic to ExaCS. It was built into Exadata from the very start and is a key differentiator. Amazon uses a form of "clustering" in Redshift, but it's more for Data Warehouse and oriented more toward scalability instead of availability.

Converged Database

AWS advocates using point-solution databases for each application or microservice, which poses a problem for developers. The day-one requirements of an application might dictate use of an OLTP relational database, but later requirements might include operational reporting that simply doesn't work. Day-one requirements might work for a purely relational data model, but later requirements might work better in a document database. With Oracle Database 21c, organizations are not stuck with their early decisions, and they're not stuck with a database that has limited functionality.

Security

Oracle Database 21c is 100% focused on front-door security, meaning all of the advertised security features are available. Database 21c in Oracle Cloud Infrastructure also provides enhanced security at the back door, including comprehensive measures to protect against attacks that attempt to bypass the front-door controls. Exadata itself achieves an unprecedented STIG (Security Technical Implementation Guide) score over 91%, which is unheard of in the industry.

Scaling Up/Down (Single Database)

Scaling up/down is dynamic and immediate on ExaCS within the flexibly provisioned infrastructure (number of ExaCS compute servers). Customers can also scale the provisioned infrastructure from 2 to 32 database servers, which is 32x larger than AWS can achieve. Scaling is done dynamically and nondisruptively, unlike other database cloud providers.

Low-Code Application Development Gets a Boost With APEX Cloud Service

The era of Infinite Computing has created business-best-practice uncertainty. Enterprises need to experiment and find new ways to operate in the 21st century on the new infinite compute platforms. The current, existing best practices, which were based on the finite computing model of the past, often put an enterprise at risk of being disrupted by its competition and certainly do not enable the unique, characteristic elasticity needs of digital transformation.

At the same time, the number of developers available to build these next-generation applications is limited, so enterprises need to look at ways to make developers more productive and also to turn technology-savvy business users into developers. Low-code application platforms are key to organizational success in this critical strategic area. With APEX (Application Express) Oracle has had a low-code platform for more than 20 years.

APEX has a unique architecture because it resides inside Oracle Database as a model-driven execution engine. Because APEX infrastructure and code assets sit together with the data in Oracle Database, APEX has unique differentiating advantages compared with other traditional development platforms (see Figure 10):

- **Applications reside inside the database.** A modern architecture principle is to "bring the code to the data," and that is something APEX literally does. Code and applications are just metadata in Oracle Database.

- **Single-tier combination of data and code.** Data and code sit together on a single tier, allowing faster, simpler and direct access between the two, resulting in easier operation and leading to lower TCO.

Figure 10. The Simplicity of the Oracle APEX Architecture
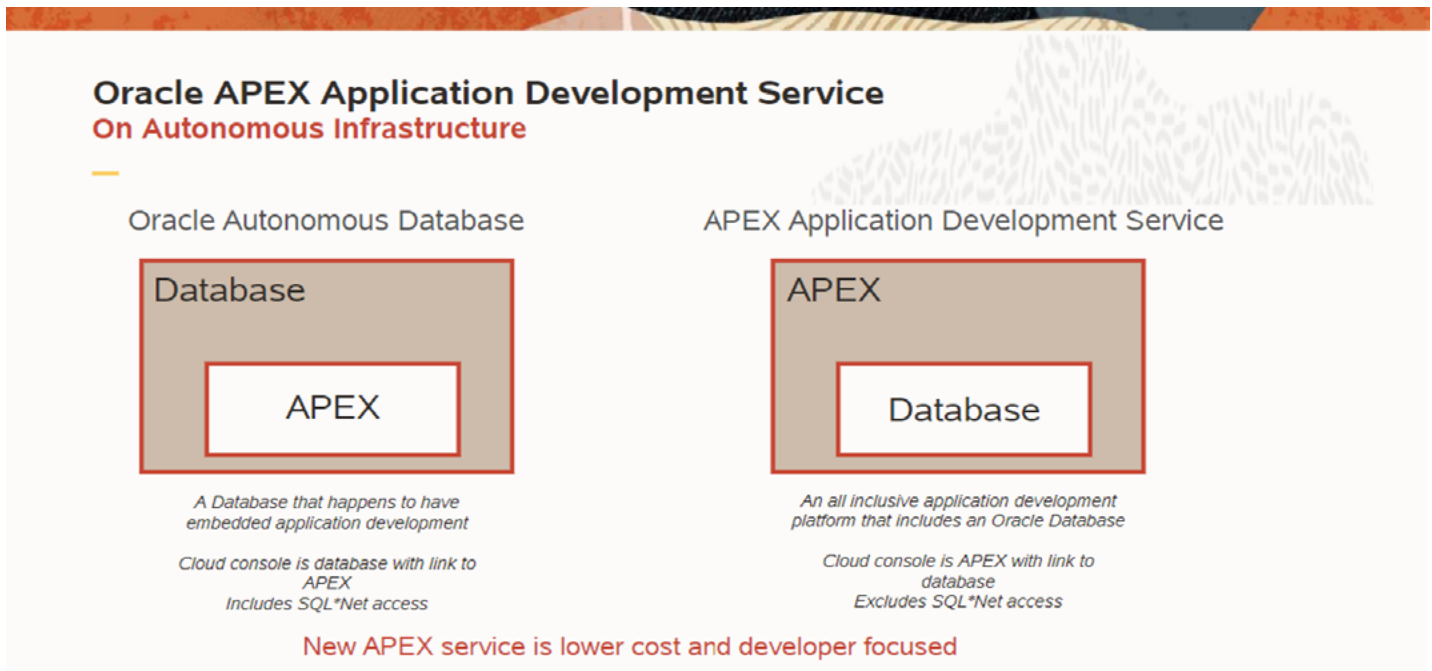

Source: Oracle

- **High performance.** The single-tier combination of data and code results in higher performance compared with approaches that use multiple tiers outside the database code repository.

- **Superior session management.** By combining application and database sessions into a single session, APEX decreases administration overhead and increases ease of use, because a single session is more efficient and easier to manage.

- **Robust as the database.** With APEX residing inside Oracle Database, it benefits from all the robustness of the database itself, making additional hardening and security measures as usually done for a third-party application development framework unnecessary.

- **Scale with the database.** As an enterprise scales its database up (or down), so it scales its APEX environment. This gives CxOs the peace of mind that the application code capability will have the footprint it requires to operate successfully and ensure a positive user experience.

- **Higher developer velocity.** Most importantly, experienced and citizen developers are more productive building next-generation applications with APEX, because there is only a single tier to debug and manage, obliterating the need for DevOps.

At the same event at which Oracle launched Oracle Database 21c, the company also launched its new Oracle APEX Application Development service (see Figure 11). This is a major announcement and changes the way enterprises can use APEX: In the traditional APEX deployment model, an enterprise would buy Oracle Database and get APEX for free. Now, enterprises can decide to use APEX as a low-code development platform, regardless of whether they are an Oracle Database customer, because the cloud-based APEX Application Development service is an all-inclusive development environment that includes Oracle Database as part of the platform.

This is an important emancipation of APEX in terms of product in the Oracle portfolio. It allows APEX to compete on its merits as a low-code platform with other low-code platforms in the application development market. The great differentiator here is that there are no other low-code application development offerings that ship bundled with the world's leading relational database. The benefit

Figure 11. Oracle APEX Application Development Service

Source: Oracle

for CxOs looking for low-code next-generation application development platforms is that they do not have to worry about the scalability of an APEX-built application. Best of all, developers can start building low-code applications for free using the APEX included with Oracle Cloud Free Tier.

Customer References

It is early for customers to get their hands on Oracle Database 21c, but here are some examples of how enterprises are using 21c, other recent Oracle Database releases and APEX capabilities:

- **Aon consolidates sales and marketing data in Oracle Autonomous Data Warehouse.** Headquartered in London, Aon is a US$46 billion global professional services firm that provides a broad range of risk, retirement and health solutions. "We've never been able to see all of our Oracle sales and marketing data in one, unified system. It is a real milestone," said Liesbeth Mulder, global reporting lead at Aon. "Using Oracle Autonomous Data Warehouse and Oracle Analytics Cloud, we've seen performance boosted by 50x to 60x. That makes response times to complex sales queries from 500 power users much faster, and analytics costs are significantly lower than with our on-premises business intelligence tools."

- **Oracle Blockchain Table secures IoT at Angelini Pharma.** Angelini Pharma is one of the largest pharmaceutical companies in Italy. "The Quinaryo XRing solution has been an important step ahead in our IoT strategy to experiment with a wearable device integrated with a data security tool based on a blockchain table solution," said Pietro Berrettoni, digital and innovation head at Angelini Pharma. "With Oracle Blockchain Table, the solution provides tamper-proof records that can easily integrate with other applications without requiring a complex new infrastructure. Oracle Database includes all the tools we know and new features like Oracle Blockchain Table that we can leverage with XRing for sensible data collection."

- **Oracle Database 21c sharding powers BlueKai DMP platform at 1 million transactions per second.** Oracle acquired BlueKai in 2014 and has since then replatformed the DMP solution on Oracle Database, most recently using the sharding capabilities of Oracle Database. BlueKai processes more than 30 billion events per

day, at a redo rate of 180 TB/hour, resulting in a 2.5 PB database size with as many as 22 billion rows in one table. Thanks to Oracle Database 21c sharding, BlueKai is able to keep the average read API call at 1.6 milliseconds and the average write API call at 2.5 milliseconds. "With Oracle Database's converged architecture, we now can use a single data system that drastically reduces complexity, decreases cost and allows us to simplify our data architecture by consolidating logic and data into a single data store that meets a diverse set of needs," said Matt Abrams, general vice president of engineering for Oracle BlueKai.[2]

- "In late 2019, we started leveraging Oracle Autonomous Database with APEX on Oracle Cloud Infrastructure to deliver a mission-critical solution within our Logistics Division," said Giovani Cani, vice president, IT delivery, Wilson Transportation & Leasing Group. "The APEX low-code platform has enabled the delivery team to quickly go from prototype to a final product and rollout within five months. The result was a secure, elegant and responsive web-based solution deployed in four distribution centers being used by more than 250 active users around the clock managing a fleet of 600 assets."

- "Without a doubt, Oracle APEX on Autonomous Database is the gold standard for low-code development platforms. For almost 20 years, we have built our entire business on APEX," said Michelle Skamene, vice president, Insum Solutions. "It has given us a huge competitive advantage, allowing us to deliver beautiful, scalable, feature-rich solutions for our clients in a fraction of the time compared to any other technology we've seen. We're delighted to see this new offering from Oracle, which offers a simple and more affordable entry point into the world of APEX on Autonomous Database and Oracle Cloud."

- "We have used Oracle APEX since its very inception, and in that time we have found it to be the most flexible, powerful, scalable and cost-effective solution available to us. We have based an entire solution development strategy on an APEX platform, and can deliver low-code solutions to a higher quality, lower cost and quicker timescales than the equivalent tools from other providers," said Dermot Murray, vice president of ideation at Inoapps. "The continuous delivery of new capabilities, combined with the

power of the underlying Oracle Cloud database, allows us to deliver a huge range of business use cases both internally and to our customers."

PRICING

Oracle offers a number of options for licensing Oracle Database:

Autonomous Data Warehouse on Shared Infrastructure

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Data Warehouse	$2.5202	$1.680133	OCPU per hour
Oracle Autonomous Database - Exadata Storage	$222.00	$148.00	Terabytes storage capacity per month

Autonomous Data Warehouse on Dedicated Infrastructure

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Data Warehouse - Dedicated	$2.5202	$1.680133	OCPU per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Quarter Rack - X8	$27.2178	$18.1452	Hosted environment per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Half Rack - X8	$54.4355	$36.290334	Hosted environment per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Full Rack - X8	$108.8709	$72.5806	Hosted environment per hour

For Autonomous Data Warehouse on Dedicated Infrastructure:

- Minimum term for subscription to Database Exadata Infrastructure is 48 hours.
- Minimum OCPU purchase is 1 OCPU per database node and up to the maximum
  number of OCPUs per rack.

Autonomous Data Warehouse Bring Your Own License (BYOL)

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Data Warehouse	$0.4839	$0.3226	OCPU per hour
Oracle Autonomous Data Warehouse - Dedicated	$0.4839	$0.3226	OCPU per hour

If you run Oracle Database Enterprise Edition and the required options listed below, then your BYOL requirements are as follows:

- For 1–16 OCPUs of Oracle Autonomous Data Warehouse:

  - For each supported Processor license of Oracle Database Enterprise Edition plus
    Options: Multitenant, you may activate up to 2 OCPUs of the BYOL Cloud Service.

  - For every 25 supported Named User Plus licenses of Oracle Database
    Enterprise Edition plus Options: Multitenant, you may activate 1 OCPU of
    the BYOL Cloud Service.

- For 17 OCPUs or more of Oracle Autonomous Data Warehouse:

  - For each supported Processor license of Oracle Database Enterprise Edition plus
    Options: Multitenant and Real Application Clusters, you may activate up to 2
    OCPUs of the BYOL Cloud Service.

- For every 25 supported Named User Plus licenses of Oracle Database Enterprise Edition plus Options: Multitenant and Real Application Clusters, you may activate 1 OCPU of the BYOL Cloud Service.

Autonomous Transaction Processing on Shared Infrastructure

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Transaction Processing	$2.5202	$1.680133	OCPU per hour
Oracle Autonomous Transaction Processing - Exadata Storage	$222.00	$148.00	Terabytes storage capacity per month

Autonomous Transaction Processing on Dedicated Infrastructure

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Transaction Processing - Dedicated	$2.5202	$1.680133	OCPU per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Quarter Rack - X8	$27.2178	$18.1452	Hosted environment per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Half Rack - X8	$54.4355	$36.290334	Hosted environment per hour
Oracle Cloud Infrastructure - Database Exadata Infrastructure - Full Rack - X8	$108.8709	$72.5806	Hosted environment per hour

For Autonomous Transaction Processing on Dedicated Infrastructure:

- Minimum term for subscription to Database Exadata Infrastructure is 48 hours.
- Minimum OCPU purchase is 1 OCPU per database node and up to the maximum number of OCPUs per rack.

Autonomous Transaction Processing Bring Your Own License (BYOL)

PRODUCT	PAY AS YOU GO	MONTHLY FLEX	METRIC
Oracle Autonomous Transaction Processing	$0.4839	$0.3226	OCPU per hour
Oracle Autonomous Transaction Processing - Dedicated	$0.4839	$0.3226	OCPU per hour

If you run Oracle Database Enterprise Edition and the required options listed below, then your BYOL requirements are as follows:

- For 1–16 OCPUs of Oracle Autonomous Transaction Processing:

  - For each supported Processor license of Oracle Database Enterprise Edition plus Options: Multitenant, you may activate up to 2 OCPUs of the BYOL Cloud Service.

  - For every 25 supported Named User Plus licenses of Oracle Database Enterprise Edition plus Options: Multitenant, you may activate 1 OCPU of the BYOL Cloud Service.

- For 17 OCPUs or more of Oracle Autonomous Transaction Processing:

  - For each supported Processor license of Oracle Database Enterprise Edition plus Options: Multitenant and Real Application Clusters, you may activate up to 2 OCPUs of the BYOL Cloud Service.

- For every 25 supported Named User Plus licenses of Oracle Database Enterprise Edition plus Options: Multitenant and Real Application Clusters, you may activate 1 OCPU of the BYOL Cloud Service.

APEX Application Development

PRODUCT	UNIT PRICE	METRIC
Oracle APEX Application Development	$0.3226	OCPU per hour
Oracle Autonomous Transaction Processing - Exadata Storage	$118.40	Terabyte storage capacity per month

• Constellation can provide price benchmarking for clients on request.

ANALYSIS AND OBSERVATIONS

Constellation sees the following strengths and weaknesses for Oracle Database 21c (see Figure 12):

Strengths

• **The one-stop database for all database needs.** Oracle has proven that it can build a strong database suite, marketing it as the converged database. Throughout the history of enterprise software, suites have always won, and that rule applies for the database market. CxOs want less complexity and more synergy, and that is what Oracle provides with Oracle Database 21c.

• **Strong innovation momentum.** A traditional challenge for suites has been that they slow innovation. Oracle as shown that this does not have to be the case and has demonstrated strong innovation momentum, adding more use cases, more workloads, more work models and so forth to Oracle Database 21c.

- **Supporting the database usage roles better.** With Oracle Database 21c, Oracle has shown that it cares for all database user roles—not just the traditional DBA but also the application developer (with more prominence for APEX) and the data worker. This is key for better time to value and ROI with any database in general and will help enterprises substantially in this category.

- **Design synergies across software, hardware and cloud.** Oracle is reaping the benefits of its integrated, engineered technology stack, which Constellation has referred to as the "chip-to-click" stack. Oracle's stack approach enables the highest degree of Architectural Identicality compared to all other cloud providers. The resulting synergies allow Oracle Database 21c to operate at similar and often even better levels than the competition from specialized, single-use-type isolated databases.

Weaknesses

- **Perception of Oracle.** At this point of high product maturity, Oracle's largest weakness is the perception of its database as being the leading relational database—and not more. Coupled with the dated concern of vendor lock-in, this forms the largest challenge for Oracle at the moment. The good news for Oracle customers is that this is a marketing perception, not a product challenge—the latter of which tends to be harder to overcome.

- **Inertia of old best practices.** For decades, enterprises have thought in terms of specialized databases because there was no alternative to the approach. Oracle needs to overcome the traditional thinking and demonstrate the value that running n specialized loads within Oracle Database is workable and even financially desirable.

- **Converged, but is it the best in every database category?** Oracle has shown that in many cases its converged database performs better than the specialized databases. Oracle needs to innovate and keep demonstrating this ability, because traditional thinking by CxOs is that software suites come along with a lower level of functionality than the best-of-breed offerings.

- **The competition wakes up.** Oracle has shown superiority with its universal and autonomous databases. Competitors will take note, but so far have not accepted the challenge. When that happens it will be a confirmation of the Oracle strategy and will give CxOs more choices, but it also means Oracle needs to double down to remain the leader for universal and autonomous databases.

Figure 12. Oracle Autonomous Database Strengths and Weaknesses

STRENGTHS	WEAKNESSES
· The one-stop database for all database needs. · Strong innovation momentum. · Supports the database usage roles better. · Provides design synergies across software, hardware and cloud.	· Perception of Oracle. · Inertia of old best practices. · Converged, but is it the best in every database category? · The competition wakes up.

Source: Constellation Research

RECOMMENDATIONS

Constellation has the following recommendations regarding Oracle Database 21c:

1. **Accept the automation imperative and utilize software suites.** Enterprises need to look at automation to increase their productivity and efficiency. The shift from specialized operations to self-driving software is in full swing, and Oracle is a pioneer in this move to autonomous. Enterprises scale by using tools and automation, never via people. Fewer and more-powerful tools reduce complexity, and Oracle Database 21c is such a tool, allowing enterprises to run practically any database load they require. Fast economic turns likely accelerated by pandemic outbreaks increase the pressure to automate and strengthen the automation imperative. That is, if a process can be automated, it should be automated, and capable software suites such as Oracle Database 21c make it faster and easier to automate more, enabling enterprise acceleration for their users.

2. **Oracle Database customers should evaluate Oracle Database 21c.** Existing Oracle Database customers will not have a difficult time deciding whether to adopt Oracle Autonomous Database. Nonetheless, they are advised to perform a cost-benefit analysis. Customers need to consider, though, that 21c is an innovation release that will be supported for a shorter amount of time, and determine if the upgrade has a positive ROI for their enterprise.

3. **Non-Oracle Database customers need to do a cost-benefit analysis for a potential switch to Oracle.** Given Oracle's lead in the universal database category, non-Oracle customers should consider a move to Oracle Database 21c or Autonomous Database. An analysis naturally needs to include the cost of migration, cost for new licenses and cost of long-term operations. Constellation believes Oracle has a very good chance to prevail as a winner in most cases, with application rewrite costs likely being the dealmaker or showstopper. The upside for enterprises will be that this may be the last database migration they have to tackle—provided Oracle keeps up its innovation record for its database, which is highly likely.

4. **CxOs need to consider APEX.** With its stand-alone APEX cloud service, Oracle is sending a clear message that APEX has become a first-class citizen among programming languages. Use cases that

require high scalability and high performance and at the same time need to be created fast and with low cost are prime candidates for APEX projects—for Oracle and non-Oracle customers alike.

5. **Practice commercial prudence.** As always, CxOs need to practice commercial prudence when it comes to platform decisions. One-time costs, ongoing costs and vendor lock-in are the key areas to consider before making platform decisions. Database platform decisions are no exception to the need for commercial prudence in all phases of the buying, adoption and usage cycle.

RELATED RESEARCH

For the CxO perspective on enterprise acceleration, see: Holger Mueller, "Why the C-Suite Must Embrace Enterprise Acceleration," May 2, 2019. https://www.constellationr.com/research/why-c-suite-must-embrace-enterprise-acceleration

For the people-leader perspective on the skills shortage and the need for enterprise acceleration, see: Holger Mueller, "Why People Leaders Must Embrace Enterprise Acceleration," Constellation Research, July 3, 2018. https://www.constellationr.com/research/why-people-leaders-must-embrace-enterprise-acceleration

For the Market Overview on databases, see: Holger Mueller, "Next-Gen Database Market Overview," Constellation Research, November 13, 2017. https://www.constellationr.com/research/next-gen-database-market-overview

For the importance of Infinite Computing, see: Holger Mueller, "Infinite Platforms Power Enterprise Acceleration," Constellation Research, October 11, 2019. https://www.constellationr.com/research/infinite-platforms-power-enterprise-acceleration

For more details on Infinite Computing, see: Holger Mueller, "The Era of Infinite Computing Triggers Next-Generation Applications," Constellation Research, June 1, 2018. https://www.constellationr.com/research/era-infinite-computing-triggers-next-generation-applications

For more on Business Acceleration Clouds (BACs), see: Holger Mueller, "Enterprise Acceleration Creates Imperative for Business Acceleration Clouds," Constellation Research, February 7, 2020. https://www.constellationr.com/research/enterprise-acceleration-creates-imperative-business-acceleration-clouds

For the Market Overview of next-gen compute platforms, see: Holger Mueller, "Next-Gen Computing: The Enterprise Computing Model for the 2020s," Constellation Research, September 14, 2018. https://www.constellationr.com/research/next-gen-computing-enterprise-computing-model-2020s

For a Constellation Shortlist™ of next-generation compute platforms, see: Holger Mueller, "Constellation ShortList Next-Generation Computing Platforms," Constellation Research, February 12, 2020. https://www.constellationr.com/research/constellation-shortlist-next-generation-computing-platforms-1

For more on Oracle Autonomous Database, see: Holger Mueller, "The Automation Imperative Materialized: Oracle Autonomous Database," Constellation Research, July 11, 2020. https://www.constellationr.com/research/automation-imperative-materialized-oracle-autonomous-database

RELATED RESEARCH CONTINUED

For more on Oracle Dedicated Region, see: Holger Mueller, "Oracle Raises the Stakes in the Next-Gen Compute Platform Market," Constellation Research, July 22, 2020. https://www.constellationr.com/research/oracle-raises-stakes-next-gen-compute-platform-market

For more on how Oracle added JSON capabilities to its database, see: Holger Mueller, "New Offering Launch—Oracle Boosts Developer Velocity With Autonomous JSON Database," Constellation Research, August 13, 2020. https://www.constellationr.com/blog-news/new-offering-launch-oracle-boosts-developer-velocity-autonomous-json-database

For more on how Oracle has added observability to its cloud stack, see: Holger Mueller, "Oracle Brings Holistic Observability to the Enterprise," Constellation Research, November 19, 2020. https://www.constellationr.com/research/oracle-brings-holistic-observability-enterprise

For an Offering Overview of Oracle Exadata, see: Holger Mueller, "Oracle Exadata Powers Next-Gen Computing," Constellation Research, June 12, 2019. https://www.constellationr.com/research/oracle-exadata-powers-next-gen-computing

For an Offering Overview of Oracle Exadata X8M, see: Holger Mueller, "Oracle Exadata X8M: The Fastest Oracle Database Platform," Constellation Research, September 25, 2019. https://www.constellationr.com/research/oracle-exadata-x8m-fastest-oracle-database-platform

For an Offering Overview of Oracle Cloud at Customer, see: Holger Mueller, "Oracle Gen 2 Exadata Cloud at Customer Powers Next-Gen Computing," Constellation Research, October 7, 2019. https://www.constellationr.com/research/oracle-gen-2-exadata-cloud-customer-powers-next-gen-computing

For next-generation databases, see: Holger Mueller, "Constellation ShortList Next-Gen Databases—RDBMS for On-Premises," Constellation Research, February 12, 2020. https://www.constellationr.com/research/constellation-shortlist-next-gen-databases-rdbms-premises-3

For a Constellation ShortList of low-code tools and platforms, see: Dion Hinchcliffe and Holger Mueller, "Constellation ShortList Enterprise Low-Code Tools and Platforms," Constellation Research, February 19, 2020. https://www.constellationr.com/research/constellation-shortlist-enterprise-low-code-tools-and-platforms-4

For a Constellation ShortList on IaaS vendors, see: Holger Mueller, "Constellation ShortList Global IaaS for Next-Gen Applications," Constellation Research, February 19, 2020. https://www.constellationr.com/research/constellation-shortlist-global-iaas-next-gen-applications-4

RELATED RESEARCH CONTINUED

For the success of open source, see: Holger Mueller, "How Open Source Won and Will Keep Winning," August 20, 2019. https://www.constellationr.com/research/how-open-source-won-and-will-keep-winning

On the future of code automation, see: Holger Mueller, "The Future of DevOps Is Automated Software Operations," February 12, 2020. https://www.constellationr.com/research/constellation-shortlist-devops-0

For more best-practice considerations for PaaS offerings, see: Holger Mueller, "As PaaS Turns Strategic, So Do Implementation Considerations," Constellation Research, May 9, 2018. https://www.constellationr.com/research/paas-turns-strategic-so-do-implementation-considerations

For more on next-gen applications and PaaS offerings, see: Holger Mueller, "Why Next-Gen Apps Start With a Next-Gen Platform as a Service," April 5, 2018. https://www.constellationr.com/research/why-next-gen-apps-start-next-gen-platform-service

For a Constellation ShortList on PaaS vendors, see: Holger Mueller, "Constellation ShortList PaaS Tool Suites for Next-Gen Apps," Constellation Research, February 19, 2020. https://www.constellationr.com/research/constellation-shortlist-paas-tool-suites-next-gen-apps-3

Also: Holger Mueller, "Constellation ShortList PaaS Suites for Next-Gen Apps," February 27, 2018. https://www.constellationr.com/research/constellation-shortlist-paas-suites-next-gen-apps-3

For additional IaaS and PaaS selection criteria, see: R "Ray" Wang and Holger Mueller, "Key Questions for Every Public Cloud IaaS/PaaS Decision Matrix," Constellation Research, January 24, 2018. https://www.constellationr.com/research/key-questions-every-public-cloud-iaaspaas-decision-matrix

For an example of digital transformation, see: Holger Mueller, "Lufthansa Digitally Transforms the Workplace for Flight Managers," Constellation Research, February 27, 2018. https://www.constellationr.com/research/lufthansa-digitally-transforms-workplace-flight-managers

For an example of digital transformation, see: Holger Mueller, "How Oracle GraalVM Supercharged Twitter's Microservices Platform," Constellation Research, December 11, 2019. https://www.constellationr.com/research/how-oracle-graalvm-supercharged-twitter-s-microservices-platform

ENDNOTES

[1] *For more on Oracle Dedicated Regions, see: Holger Mueller, "Oracle Raises the Stakes in the Next-Gen Compute Platform Market," Constellation Research, July 22, 2020.* https://www.constellationr.com/research/oracle-raises-stakes-next-gen-compute-platform-market

[2] *For more on the Oracle BlueKai solution, see: Shailesh Dwivedi, "Oracle BlueKai Data Management Platform Scales to 1 Million Transactions per Second With Oracle Database Sharding Deployed in Oracle Cloud Infrastructure," January 8, 2021.* https://blogs.oracle.com/database/oracle-bluekai-data-management-platform-scales-to-1-million-transactions-per-second-with-oracle-database-sharding-deployed-in-oracle-cloud-infrastructure

Holger Mueller

Vice President and Principal Analyst

Holger Mueller is vice president and principal analyst at Constellation Research, providing guidance for the fundamental enablers of the cloud, IaaS and PaaS with forays up the tech stack into big data, analytics and SaaS. Mueller provides strategy and counsel to key clients, including chief information officers (CIOs), chief technology officers (CTOs), chief product officers (CPOs), investment analysts, venture capitalists, sell-side firms and technology buyers.

Prior to joining Constellation Research, Mueller was VP of products for NorthgateArinso, a KKR company. He led the transformation of products to the cloud and laid the foundation for new business-process-as-a-service (BPaaS) capabilities. Previously, he was the chief application architect with SAP and was also VP of products for FICO. Before that, he worked for Oracle in various management functions—on both the application development (CRM, Fusion) and business development sides. Mueller started his career with Kiefer & Veittinger, which he helped grow from a startup to Europe's largest CRM vendor from 1995 onward. Mueller has a Diplom-Kaufmann from the University of Mannheim, with a focus on information science, marketing, international management and chemical technology. A native European, Mueller speaks six languages.

🐦 @holgermu   💻 constellationr.com/users/holger-mueller   in linkedin.com/in/holgermueller

ABOUT CONSTELLATION RESEARCH

Constellation Research is an award-winning, Silicon Valley–based research and advisory firm that helps organizations navigate the challenges of digital disruption through business model transformation and the judicious application of disruptive technologies. Unlike the legacy analyst firms, Constellation Research is disrupting how research is accessed, what topics are covered and how clients can partner with a research firm to achieve success. Over 350 clients have joined from an ecosystem of buyers, partners, solution providers, C-suite, boards of directors and vendor clients. Our mission is to identify, validate and share insights with our clients.

Organizational Highlights

· Named Institute of Industry Analyst Relations (IIAR) New Analyst Firm of the Year in 2011 and #1 Independent Analyst Firm for 2014 and 2015.

· Experienced research team with an average of 25 years of practitioner, management and industry experience.

· Organizers of the Constellation Connected Enterprise—an innovation summit and best practices knowledge-sharing retreat for business leaders.

· Founders of Constellation Executive Network, a membership organization for digital leaders seeking to learn from market leaders and fast followers.

www.ConstellationR.com   @ConstellationR

info@ConstellationR.com   sales@ConstellationR.com

San Francisco Bay Area | Boston | Colorado Springs | Ft. Lauderdale | Los Angeles | New York Metro
Northern Virginia | Portland | Pune | Sacramento | San Diego | Sydney | Toronto | Washington, D.C.